Chapter 5

Data Communications and Computer Networks

Objective:-

- ❖ To know basic component used in data transmission
- ❖ To know, what a computer network is and different protocols of networks
- ❖ To know what is Internet and what services the Internet has

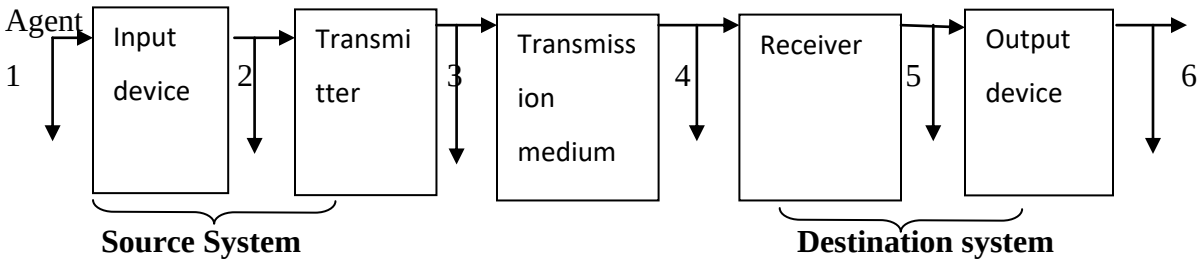
Basics of Data Communication

Data communication: is the process of sharing ideas, information and messages with others in a particular time and place.

- It is exchange of data between two or more parties.
- It includes :
  - Writing and talking
  - Nonverbal communication (such as facial expressions, body language or gestures)
  - Visual communication (the use of images of pictures such as painting, photography, video or film)
  - Electronic Communication
  - Such as telephone calls, electronic mail, cable television, satellite broadcasts.

Data Transmission

The need of information has increased from time to time. This leads to the need of sharing of information among different agents (individual), which may be at different places or locations. Data communication is the exchange of information between two agents. For exchange of information, the information should be transmitted from one point to another through a transmission media called Channel. The following figure shows the different components of data communication.



1. Input information (m)
2. Input data q or signal q(t)
3. Transmitted signal s(t)
4. Received signal r(t)
5. Output data q or signal q (t)
6. Out put information $\overline{m}$

Information is transmitted in a form of packets. The information is divided into packets and one packet is transmitted at a time. When a packet of information is transmitted the sender must be sure that the receiver receives the information and the receiver must check that it receives correct information. The information is transmitted successfully the receiver must send an acknowledgment to the sender.

Mode of transmission

The transmission medium may be physical (it connects the transmitter and receivers through wire) or logical (There are different mode of transmission)

- **Simplex transmission**:

In this transmission, signals are transmitted in only one direction: One station is transmitter and the other is receiver.

- **Half-duplex transmission**

In this transmission signals are transmitted in both directions, both stations may transmit, but only one at a time.

- **Full-duplex transmission**

In this transmission signals transmitted in both directions, both stations may transmit simultaneously. The medium carries signals in both directions at the same time.

Data Transmission Channels

A channel is a medium that carries a signal from the transmitter to the receiver. The range of frequencies that can be transmitted over a transmission medium is called band Width of a channel. The rate of data transmission is directly proportional to the band width.

There are three types of data transmission channels:-

A. **Narrow-band**:-It is the smaller band and has slow data transmission rate. E.g. telegraph line.
B. **Voice- band**: It is the wider band and has better data transmission rate than the narrow band. Ex telephone lines are used for voice-band channel.
C. **Broad-band:** - It is the widest band and has used to transmit large volume of data with high speed.

Ex. (Oxide cable such as TV aerial lead), circuits, communications sate bites and optical fibers are used for broad band channels.

Information is transmitted in the form of analog or digital. Most communication lines are designed to carry analog signals. Digital transmissions are used for telecommunications. Therefore, technique must be used to represent a digital signal in analog carrier. The process of modifying the carrier signal to transmit digital information is called **"Modulation"**. When the transmitted signal is received, the information must be reconverted into digital data. This process is called **"Demodulation"** .These conversions between digital data and analog data are handled by a device called a modem, an acronym for modulator and demodulator.

Types of signals

In communication system, data is transmitted from one point to another by means of electrical signal. There are two types of signals that can travel over the various transmission media.

1. **Analog Signal:** Continuously varying electromagnetic waves that may be propagated over a variety of media. For example, Wire media, twisted pair and coaxial cable.
2. **Digital Signals**
   - Normally, it comprises only two states.
   - It uses separate ON/OFF pulses that create a square rather than a continuous wave.
   - Are considered as sequence of voltage pulses that may be transmitted over a wire medium.
   - Transmits data faster and more accurately than analog signals.

For example, a constant positive voltage level may represent binary 1 and a constant negative voltage level may represent binary 0.

Computer Networks

It is a collection of computers and peripheral devices connected by communication links that allow the network components to work together.

Importance of Networking

1. Resource sharing (To share hardware such as the server To share computer CPU and hard disk)
2. To share databases
3. To share application programs
4. To undertake parallel processing
5. High reliability by having alternative sources of supply.
6. Money saving
7. Increase system performance.
8. Powerful communication medium among widely separated people.

Hardware requirements of a computer network

1. **Computers**

   - A minimum of two computers is required to establish a computer network.

2. **Network Interface Card/Network Adapter Card**

   - It is an expansion card that physically connects a computer to the network.
   - Each computer in the network must have a network card.
   - It takes the data from the computer's internal bus and converts it into standard packets of information that it then sends along the cable.
   - It takes the data from the computer and adds header.
   - When receiving data, it looks at each packet and checks the destination address in the header.
   - If it recognizes its own address, it checks that it has no errors and signals the CPU that there is data to be processed.

3. **Cables**

- Cables are used to physically connect the computers on the network
- Types of cables
  i. Co-axial cables
  ii. Twisted Pair Cables
  iii. Fiber Optics

4. Modem- Modulator/Demodulator

- It lets computers exchange information though telephone lines.
- When transmitting information, the modulator changes the computers digital signal to analog signal.
- When receiving information, the demodulator translates the analog signal
- Back to a digital signal.

Modulator – Digital to Analog

Demodulator – Analog to Digital

Terms used in computer networking

1. *Server* – Computers that provide shared resources to network users.
2. *Clients*- Computers that access shred network resources provided by a server.
3. *Media* – The wires that make the physical connections
4. *Shared data*- Files provided to clients by servers across the network.
5. *Shared printers and other peripherals*– Additional resources provided by the server
6. *Resources*- Any service or device, such as files, printers or other items.

Types of Networks

Based on geographical span of coverage, computer networks are broadly classified into three major categories.

1. Local Area Network (LAN)

- Computers are connected close together to each other with in the same 'local' area (ex. building, office, school ,Lab …)
- computers are connected directly on-premises -usually through wiring and sometimes with infrared signals (similar to your TV remote control) or low-powered radio signals
- It is the basic building block of any computer network.
- It is confined in a limited geographical area.

Characteristics of LAN:

1. Physically limited
2. High bandwidth
3. Inexpensive cable media (Co-axial or twisted pair)
4. Used for data and hardware sharing

2. Metropolitan Area Network (MAN)

- Covers large geographic areas
- Uses Fiber Optics cables

  For example: Colleges, Universities, banks etc.

3. Wide Area Networks (WAN)

- Communication is established through telephone lines, microwave links and satellites etc.
- It has no geographical limit
- It is made up of a number of interconnected LANs. E.g. The internet
- The computers are attached spread apart geographically such as a state, the country, or the world
- Computers in a network are situated in a wider geographical area.
- It may contain a number of local area network
- uses external communication facilities such as phone lines, cable, television lines, or satellite transmission to carry data over longer distance

How to connect

- **On-demand connection:** a phone line that has a dial tone and can be accessed as needed
- **Dedicated communication connection**-connected at all times

Internet

- Internet international network of networks (WAN) that provides access to a vast array of information stored in computer systems throughout the world.
- world wide interconnection scheme for accessing various computer networks from other computers
- It is a network of networks.

Based on the architecture, networks are divided into two broad categories:

1. Peer-to-peer Networks
2. Server –based Networks

The type of network you choose to implement depends on

i. Size of the organization
ii. Level of security required
iii. Level of administrative support available
iv. Amount of network traffic
v. Needs of the networks use
vi. Network budget

1. Peer-to-peer Networks

In the peer-**to-peer** configuration, only two computers are directly connected by cable and one computer can directly access the resources located in the other computer.

- No dedicated server
- Every computer acts as both a client and a server
- Good for 10 or few users
- Less security
- User at each computer determines what data on that computer is shared on the network., also called work groups
- all computers on the network belong to users and are equal as far as the network is concerned
- Computers simply connect with each other in a workgroup to share files, printers and Internet access.
- This is most commonly found in home configurations and is only practical for workgroups of a dozen or less computers

2. Server-Based

- In the workgroup configuration, more than two computers are connected but the maximum number of computers is not greater than ten.
- In server based, one computer can directly access the resources located in other computer provided that the other computer gives permission to use the resources.
- There is usually a Server Machine to which all of the computers log on
- This server can provide various services, including
  – centrally routed Internet Access,

– mail (including e-mail),

– file sharing and printer access,

– ensuring security across the network.

- Supports large number of users
- Needs dedicated server (acts only as a server, but not as a client)
- Security is an issue
- Size is limited by a server and network hardware
- Requires at least one professional administrator.

Feature	Peer-to-pear	Server Based
Cost	$	$$
Complexity	Fairly simple	Can be very complex
Effect on network if the file server goes down	Not Applicable	No user have access to dada stored on the server
Max. number of Computers in network	No more than handfull	Can be hundreds or more
Ease of control or administration	No central point of control	Provides central point of control
Size of business	small	Any size
Ease of backup	Can be complex	Easy b/c all critical data should be on the file server

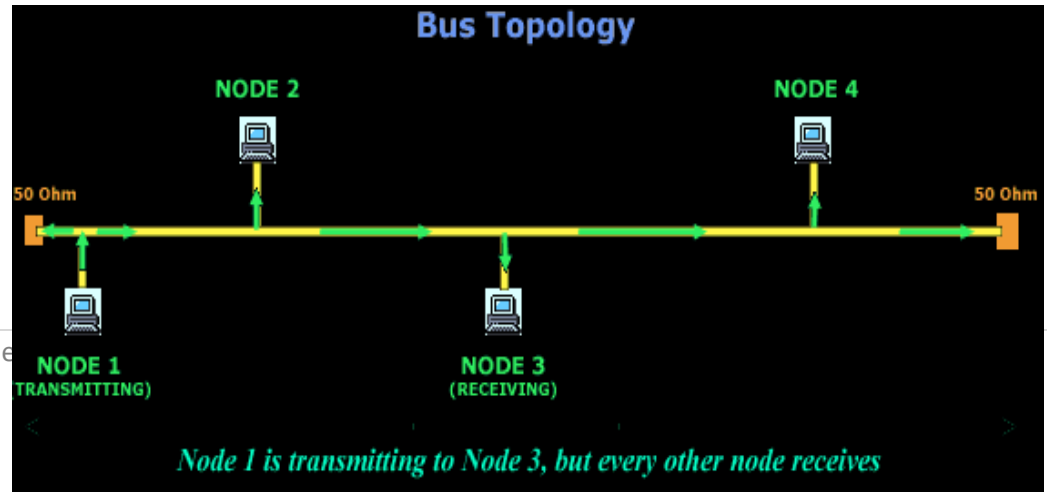
Network Topology

- **Topology**: specifies the geometric arrangement of the network. Common topologies are: **bus, ring, star, mesh**
- **The physical topology** of a network refers to the layout of cables, computers and other peripherals.
- **Logical topology** is the method used to pass the information between the computers

- **Protocol*:*** Specifies a common set of rules and signals the computers on the network use to communicate.
- ***Protocols*** define the format, timing, sequence, and error checking used on the network**.**
- ***Common Protocols are:***
  – **TCP**: Transmission Control Protocol
  – **IP**: Internet Protocol
  – **UDP**: User Datagram Protocol
  – **FTP**: File Transfer protocol
  – **HTTP**: Hyper Text Transfer Protocol

Standard Topologies

1. **Bus Topology**
   - All workstations are connected directly to the main backbone that carries the data.
   - Consists of devices connected to a common, shared cable.
   - Traffic generated by any computer will travel across the backbone and be received by all workstations
   - This works well in a small network of 2-5 computers
   - As the number of computers increases so will the network traffic and this can greatly decrease the performance and available bandwidth of your network
   - Is used for a Local Area Network
   - Is the simplest
   - Messages are detected by all nodes and are accepted by the nodes to which they are addressed.
   - Relies on collision detection or token passing to regulate traffic.
   - If one node fails, the rest of the network can continue to function normally.



Advantages of Bus Topology

- Easy to implement
- Low cost

Disadvantages of Bus Topology

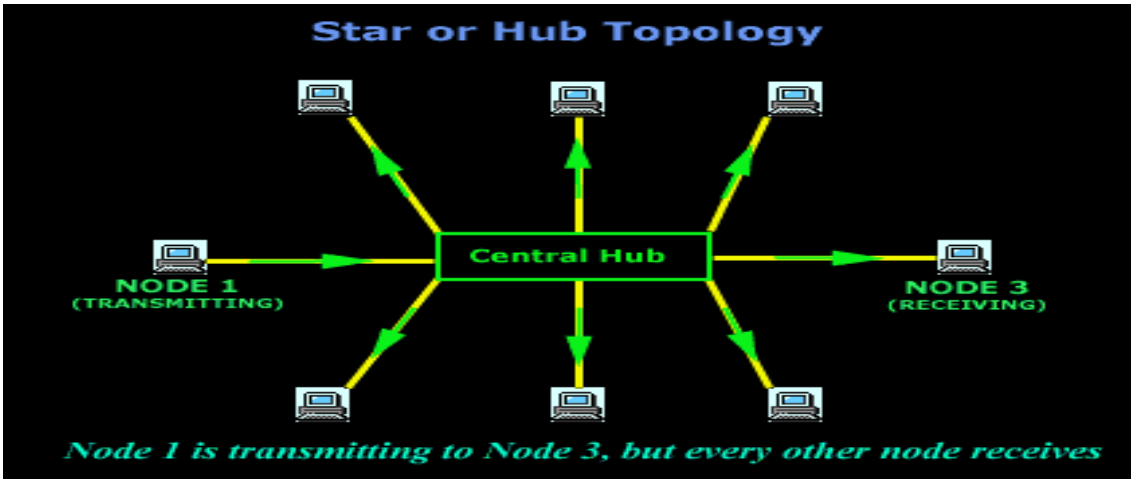
- Limited cable length and workstation
- Difficult to isolate network fault.
- Cable fault affects all workstations

2. Star Topology

- One of the most common network topologies found in most offices and home networks
- Becomes very popular in contrast to the bus type (which we just spoke about), because of the cost and the ease of troubleshooting.
- Cable segments from each computer (node) are connected to a centralized component called a hub.

Hub - is a device that processes and switches the messages from one incoming line to another.

- Signals are transmitted from the sending computer through the hub to all computers on the network.
- Failure of one computer doesn't affect the network
- Failure of the hub affects the network
- Cabling cost is high



Advantage of Star Topology

- Easy to add new workstations
- Centralized control
- Centralized network
- Easy to modify

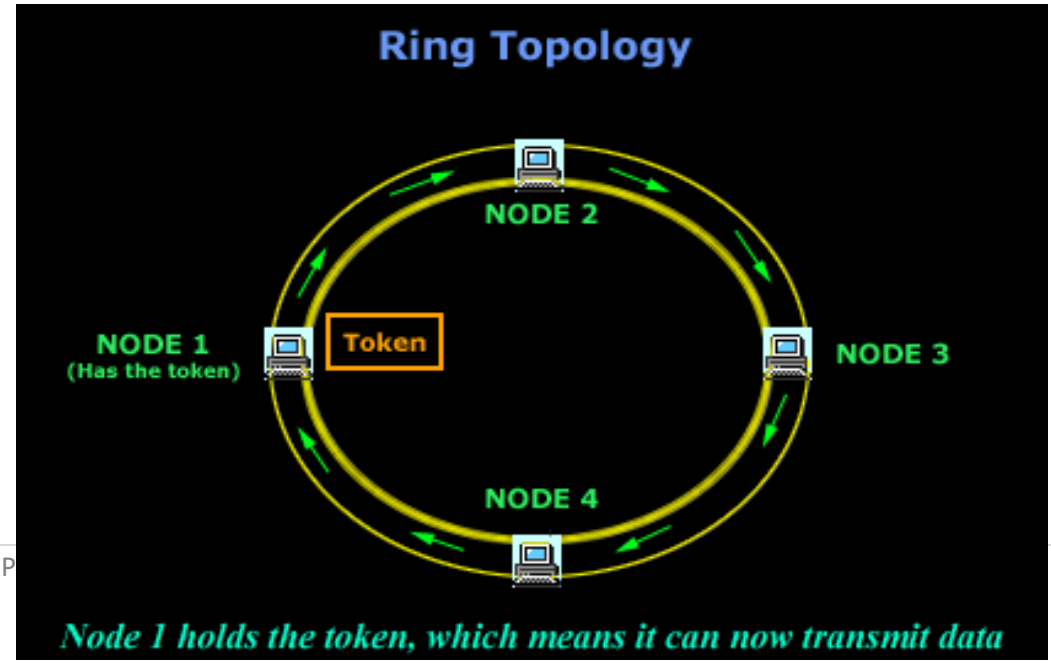
- if one computer on the star topology fails, then only the failed computer is unable to send or receive data

Disadvantages of Star Topology

- Hubs are expensive
- Each computer is connected to a central hub or switch, if this device fails, the entire network fails!

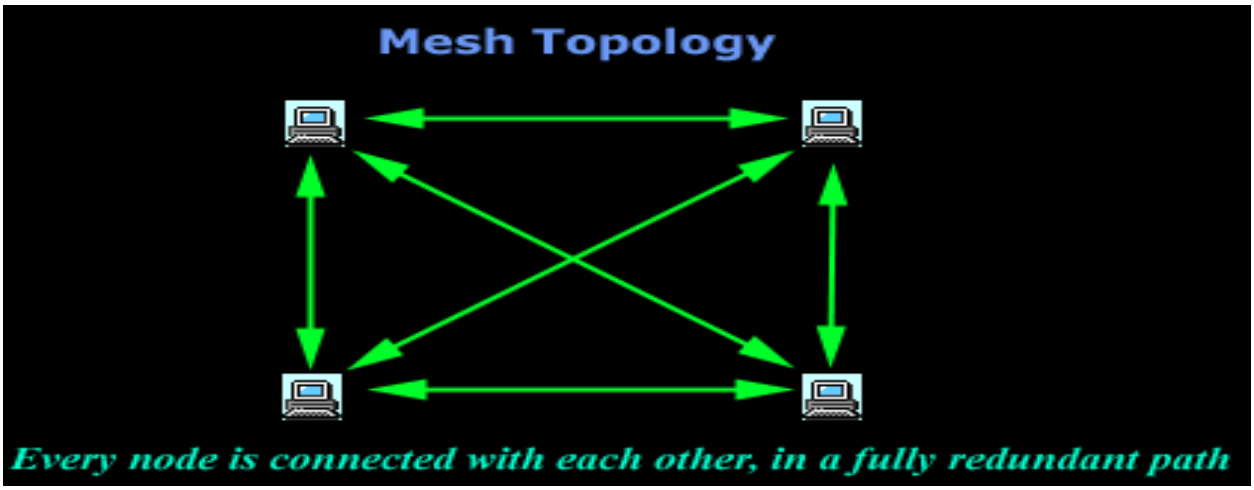
3. Ring Topology

- Computers are connected on a single circle of cable.
- Unlike the bus topology, there are no terminated ends.
- signals travel around the loop in one direction and pass through each computer
- The method by which the data is transmitted around the ring is called token passing
- A *token* is a special series of bits that contains control information
- Each computer acts as a repeater to boost the signal and send it to the next computer.
- Failure of one computer can have an impact on the entire network.
- Allows signals to travel farther by regenerating signals
- Cable failures affect limited users.
- Logically, a ring topology is a circular arrangement of computers where the signals from one node travel around the ring in clockwise direction .Because the signals pass through each computer, the failure of one computer or a break in a cable could bring the entire network failure.

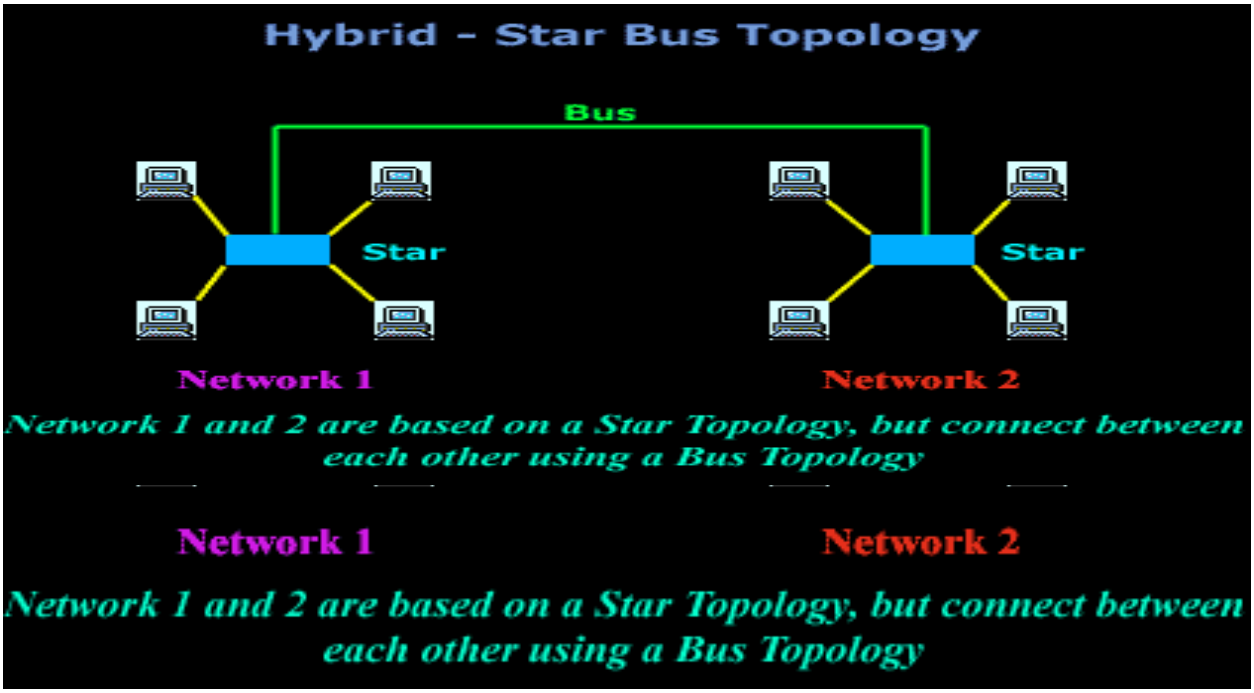


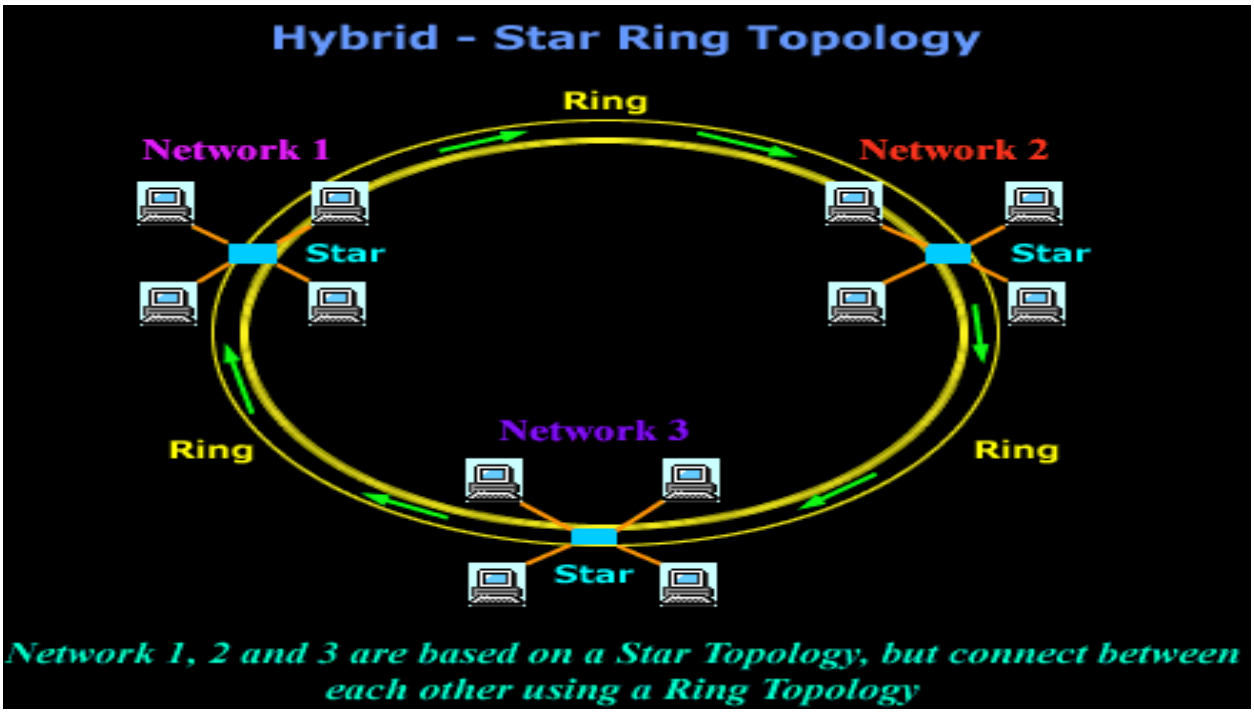
4. Mesh Topology

- Each computer is connected to every other computer by a separate cable.
- Provides redundant paths through the new work



Hybrid Topology Types





Transmission Cables

- The kind of cable or other medium that is used to connect the various computers in a network
- Common types:
  – Twisted-pair wire,
  – Coaxial cable, and
  – Fiber optic cable

1. Twisted-pair wire

- Is a copper wire similar to the common telephone line
- each of the pair of wire are twisted
- It can be Shielded (STP) or Unshielded (UTP)
- UTP:
  – the most popular cable around the world
  – used not only for networking but also for the traditional telephone

2. Coaxial cable

- A type of wire that consists of a center wire surrounded by insulation and then a grounded shield of braided wire.
- The shield minimizes electrical and radio frequency interference.
- more expensive than standard telephone wire much less susceptible to interference and can carry much more data

3. Fiber Optic Cables

- can be used over greater distances
  – 2km without the use of repeaters.
  – one fiber could replace hundreds of copper cables
- high bandwidth
- Low loss of signals
- The diameter could be millionths of a meter.

Comparison

Type	Cost	Speed	Distance
Twisted pair	$	Slow to fast depending the number of pairs used and configuration	Short
Coaxial cable	$$	Fast	Medium
Fiber optic	$$$	Fastest	Longest

Brief Introduction to Internet

Sometime in the mid 1960's, during the Cold War, it became apparent that there was a need for a bombproof communications system**.**

A concept was devised to link computers together throughout the country. With such a system in place large sections of the country could be linked and messages could still get through.

Basically the Internet was an emergency military communications system operated by the Department of Defense's Advanced Research Project Agency (ARPA). The whole operation was referred to as ARPANET.

In time, ARPANET computers were installed at every university in the United States that had defense related funding. Gradually, the Internet had gone from a military pipeline to a communications tool for scientists. As more scholars came online, the administration of the system transferred from ARPA to the National Science Foundation.

Years later, businesses began using the Internet and the administrative responsibilities were once again transferred.

At this time no one party "operates" the Internet, there are several entities that "oversee" the system and the protocols that are involved.

The speed of the Internet has changed the way people receive information. It combines the immediacy of broadcast with the in-depth coverage of newspapers...making it a perfect source for news and weather information.

About the Web

Think of the web as the illustrated version of the Internet. It began in the late 1980's when a Swiss physicist Dr. Berners-Lee wrote a small computer program for his own personal use. This program allowed pages, within his computer, to be linked together using keywords. It soon became possible to link documents in different computers, as long as they were connected to the Internet. The document formatting language used to link documents is called HTML (Hypertext Markup Language.)

The Web remained primarily text based until 1992. Two events occurred that year that would forever change the way the Web looked. Marc Andreesen developed a new computer program called the NCSA Mosaic (National Center for Supercomputing Applications at the University of Illinois) and gave it away! The NCSA Mosaic was the first Web browser. The browser made it easier to access the different Web sites that had started to appear. Soon Web sites contained more than just text, they also had sound and video files.

These pages, written in the hyper-text markup language, have "links" that allow the user to quickly move from one document to another...even when the documents are stored in different computers.

Web browsers "read" the html text and convert it into a page like the one you see on the browser windows.

Each web site has an address, or Uniform Resource Locator (URL). The URL contains a set of instructions that are read by the browser.



The beginning of the URL contains the protocol. This is usually "http" (Hypertext Transfer Protocol) or "ftp" (File Transfer Protocol). The second section of the URL reveals the domain. Directories follow the domain. Lastly is the name of the document. (If no document is named the browser will automatically open any document in the directory named "**default**" or "**index.**"

Internet Services:

- E-mail transfer
- USENET
- World Wide Web (WWW, Web, W3)
- File transfer/access (FTP)
- Remote login/ execution (Telnet)
- Video Conferencing

E-mails

Even with the multimedia excitement of the Web, Electronic Mail (email) is the most frequently used application of the Internet. Many people who have access to the Internet at school, home, and work, use the Internet for no other purpose than to send and receive email.

According to International Data Corporation (IDC), on an average day in the year 2000, 5.1 billion emails are sent in the US and 8.2 billion worldwide. By 2005, 11.5 billion emails are sent each day on average in the US and 26.1 billion worldwide. (This includes

emails sent by individuals for business and personal purposes, but not mass emails sent to large lists.)

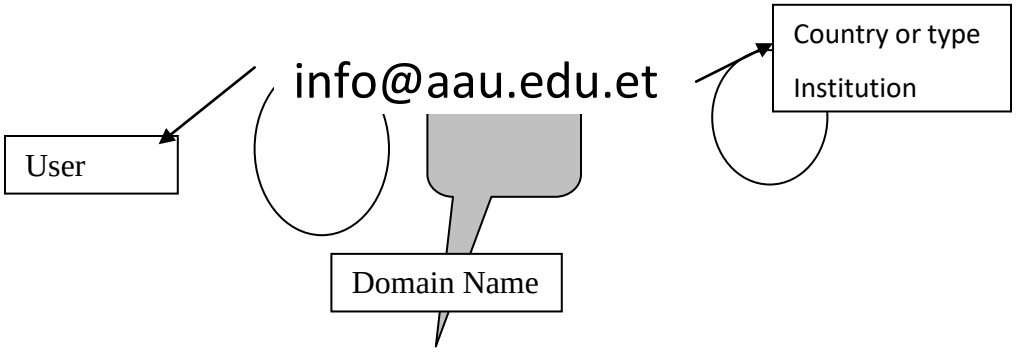
It's all very easy. You create the message, log onto the Internet, and send it. The message first goes to your **Internet Service Provider's mail server**, which in turn sends it to the **recipient's mail server**. On the way your message may go through several servers, each reading the domain name in order to route it to the appropriate server.

The message then remains in the **recipient's mail server** until he requests it by "checking his mail."

Each email address you send is made up of certain components that help route it to the proper recipient:

- Every user, which belongs to the network, has his/her account and computer system that provides the account.
- To send a message
  - User name: identifies the sender or the recipients.
  - Domain name: identifies the computer system on which the user has an account.

    Examples: haile@ethionet.et



The benefits of email are obvious...mostly it's quick. Also, many people feel that the rules for regular mail don't apply to email*, making it less formal, which in turn makes email easier to compose and send.

It's not just friends and coworkers that are receiving email. Wherever you look, the Web is providing email addresses. This has made communication between strangers easier than ever. When you visit a Web site, click on the Web masters email address to let them

know what you think. You can read an interesting article online and immediately send the author an email.

World Wide Web (WWW)

- Is one of the newest Internet services
- The WWW allows you to combine text, a video, graphics, and even animation to make a document a viewed easy.
- Links within WWW documents can take you quickly to other related documents. WWW is a set of sites that you can go o for information.
- The process of sharing common information of the world by the help of the Internet services.
- It requires special software programs like Netscape, Internet Explorer, or others.
- Web Browsers

  For Example: http://www.cnn.com

Use Net

- It is one of the Internet services which allow users from any where on the Internet to participate a discussion groups (News groups). It is an organized electronic mail (e-mail) system, except there is no single user that mail is sent to.
- A world wide distributed discussion group consists of a set of newsgroups.
- Articles or messages are posted to news groups and the articles are then broadcasted to other interconnected computer systems.

Telnet:- It is a program that lets you log into a remote computer directly through the Internet and you can work on that computer.

File Transfer Protocol (FTP)

- This enables you to examine the files of remote hosts on the Internet and to transfer files between your hosts and the others.
- Using FTP programs we can upload or download files. But to do this there should be an admission from the remote computer.
- Helps to transfer files and programs from one system to another.

Video Conferencing

- The Internet is, in its raw form, communication.
- Video conferencing means making a conference on the Internet by individuals who live in different locations.
- The individuals speak and see each other.
- It is similar to conference in a hall except they are at distant.

Ethical and social issues in the information age

Though the advantage of information technology outweighed the disadvantage, there are some issues that come as a result of information technology.

Ethics

Responsibility and accountability

Privacy

- ❖ Property rights to information and intellectual property.
- ❖ The right of an individual to be left alone and control the flow of information about himself or herself.

System quality

- ❖ Integrity of a system (avoiding malfunctioning)

Quality of work life

- ❖ Job satisfaction
- ❖ Responsibility
- ❖ Variety
- ❖ Challenge

Health and safety

- ❖ Stress
- ❖ Computer vision syndrome

IT in the future:

Predicting the future is always risky business. But some things are relatively certain. In the next five to ten years the following will be some of the developments in information technology.

- Network convergence- TV, radio, the Internet and the telephone system into a single integrated network. Why not we use TV to watch video, switch channels and surf the Internet, switch channels again and listen to some music on an FM radio station, and then switch channel again and write a term paper?
- Wireless mobile computing (handheld)- a new generation of wireless digital devices that combine computing and two-way communication capabilities
- Inexpensive supercomputer