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Introduction to Computer Networks

Computer Network means an interconnection of autonomous (standalone) computers for information exchange. The connecting media could be a copper wire, optical fibre, microwave or satellite.

Networking Elements - The computer network includes the following networking elements:

1. At least two computers
2. Transmission medium either wired or wireless
3. Protocols or rules that govern the communication
4. Network software such as Network Operating System

Network Criteria:
The criteria that have to be met by a computer network are:

1. Performance - It is measured in terms of transit time and response time.

- Transit time is the time for a messa avel from one device to another

- Response time is the elapsed time between an inquiry and a response.

Performance is dependent on the following factors:

- The number of users
- Type of transmission medium
- Capability of connected network
- Efficiency of software

2. Reliability - It is measured in terms of

- Frequency of failure
- Recovery from failures
- Robustness during catastrophe

3. Security - It means protecting data from unauthorized access.

Goals of Computer Networks: The following are some important goals of computer networks:

1. **Resource Sharing -** Many organization has a substantial number of computers in operations, which are located apart. Ex. A group of office workers can share a common printer, fax, modem, scanner etc.

2. **High Reliability -** If there are alternate sources of supply, all files could be replicated on two or, machines. If one of them is not available, due to hardware failure, the other copies could be used.

3. **Inter-process Communication -** Network users, located geographically apart, may converse in an interactive session through the network. In order to permit this, the network must provide almost error-free communications.

4. **Flexible access -** Files can be accessed from any computer in the network. The project can be begun on one computer and finished on another.

   Other goals include Distribution of processing functions, Centralized management, and allocation of network resources, Compatibility of dissimilar equipment and software, Good network performance, Scalability, Saving money, Access to remote information, Person to person communication etc.,

- Types of area networks - LAN, MAN and WAN

The **Network** allows computers to **connect and communicate** with different computers via any medium. LAN, MAN and WAN are the three major types of the network designed to operate over the area they cover. There are some similarities and dissimilarities between them. One of the major differences is the geographical area they cover, i.e. **LAN** covers the smallest area; **MAN** covers an area larger than LAN and **WAN** comprises the largest of all.
There are other types of Computer Networks also, like :

- PAN (Personal Area Network)
- SAN (Storage Area Network)
- EPN (Enterprise Private Network)
- VPN (Virtual Private Network)

Local Area Network (LAN) - LAN or Local Area Network connects network devices in such a way that personal computer and workstations can share data, tools and programs. The group of computers and devices are connected together by a switch, or stack of switches, using a private addressing scheme as defined by the TCP/IP protocol. Private addresses are unique in relation to other computers on the local network. Routers are found at the boundary of a LAN, connecting them to the larger WAN.

Data transmits at a very fast rate as the number of computers linked are limited. By definition, the connections must be high speed and relatively inexpensive hardware (Such as hubs, network adapters and Ethernet cables). LANs cover smaller geographical area (Size is limited to a few kilometers) and are privately owned. One can use it for an office building, home, hospital, schools, etc. LAN is easy to design and maintain. A Communication medium used for LAN has twisted pair cables and coaxial cables. It covers a short distance, and so the error and noise are minimized.

Early LAN's had data rates in the 4 to 16 Mbps range. Today, speeds are normally 100 or 1000 Mbps. Propagation delay is very short in a LAN. The smallest LAN may only use two computers, while larger LANs can accommodate thousands of computers. A LAN typically relies mostly on wired connections for increased speed and security, but wireless connections can also be part of a LAN. The fault tolerance of a LAN is more and there is less congestion in this network. For example : A bunch of students playing Counter Strike in the same room (without internet).

Metropolitan Area Network (MAN) - MAN or Metropolitan area Network covers a larger area than that of a LAN and smaller area as compared to WAN. It connects two or mor ▲ uters that are apart but resides in the

same or different cities. It covers a large geographical area and may serve as an ISP (Internet Service Provider). MAN is designed for customers who need a high-speed connectivity. Speeds of MAN ranges in terms of Mbps. It's hard to design and maintain a Metropolitan Area Network.

The fault tolerance of a MAN is less and also there is more congestion in the network. It is costly and may or may not be owned by a single organization. The data transfer rate and the propagation delay of MAN is moderate. Devices used for transmission of data through MAN are: Modem and Wire/Cable. Examples of a MAN are the part of the telephone company network that can provide a high-speed DSL line to the customer or the cable TV network in a city.

Wide Area Network (WAN) - WAN or Wide Area Network is a computer network that extends over a large geographical area, although it might be confined within the bounds of a state or country. A WAN could be a connection of LAN connecting to other LAN's via telephone lines and radio waves and may be limited to an enterprise (a corporation or an organization) or accessible to the public. The technology is high speed and relatively expensive.

There are two types of WAN: Switched WAN and Point-to-Point WAN. WAN is difficult to design and maintain. Similar to a MAN, the fault tolerance of a WAN is less and there is more congestion in the network. A Communication medium used for WAN is PSTN or Satellite Link. Due to long distance transmission, the noise and error tend to be more in WAN.

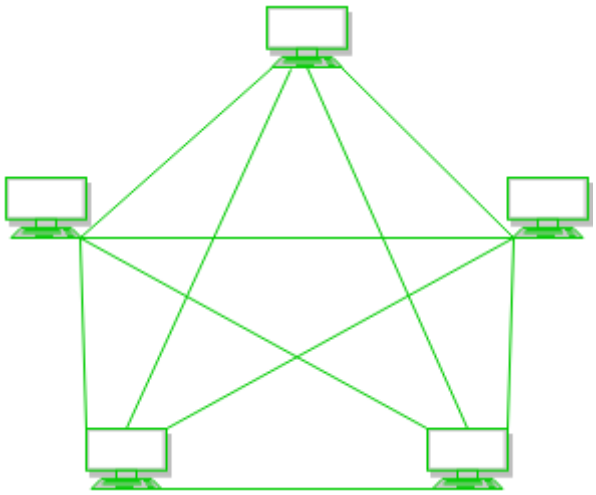
WAN's data rate is slow about a 10th LAN's speed, since it involves increased distance and increased number of servers and terminals etc. Speeds of WAN ranges from few kilobits per second (Kbps) to megabits per second (Mbps). Propagation delay is one of the biggest problems faced here. Devices used for transmission of data through WAN are: Optic wires, Microwaves and Satellites. Example of a Switched WAN is the asynchronous transfer mode (ATM) network and Point-to-Point WAN is dial-up line that connects a home computer to the Internet.

Conclusion - There are many advantages of LAN over MAN and WAN, such as LAN's provide excellent reliability, high data transmission rate, they can easily be managed, and shares peripheral devices too. Local Area Network cannot cover cities or towns and for that Metropolitan Area Network is needed, which can connect city or a group of cities together. Further, for connecting Country or a group of Countries one requires Wide Area Network.

Network Topologies

The arrangement of nodes in a network generally follows some pattern or organization. Each of these patterns have their set of advantages/disadvantages. Such arrangements are called collectively referred to as network **topologies**. Some of the popular network topologies are as follows:

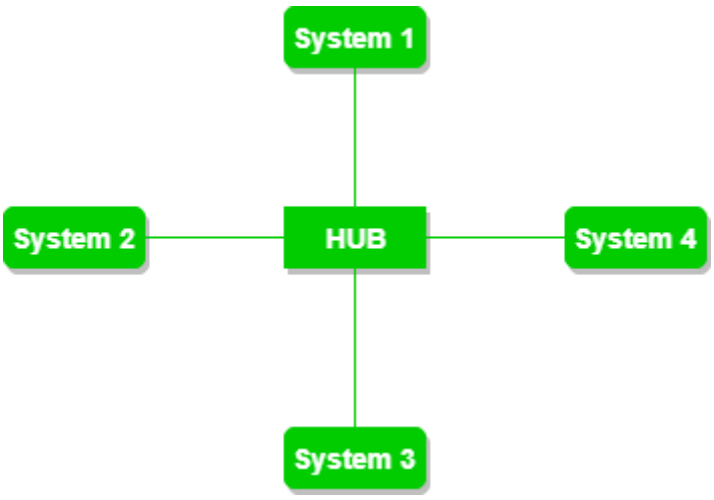
Mesh



Key points:

1. Robust & Easy fault-detection.
2. Installation is difficult & Expensive (fully-connected ~ lots of cable required = ${}^{n}C_{2}$).

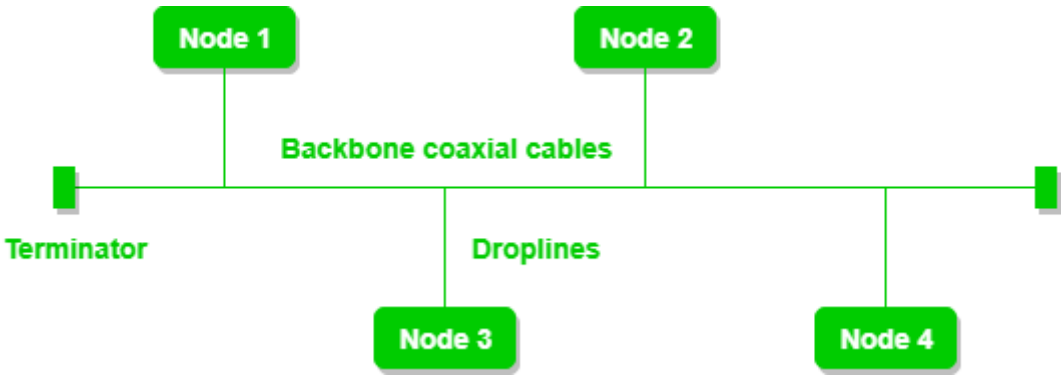
Star



Key points:

1. Easy & Cheap Installation (n cables required). Also device needs to have only 1 port.
2. Single point-of-failure (central node).

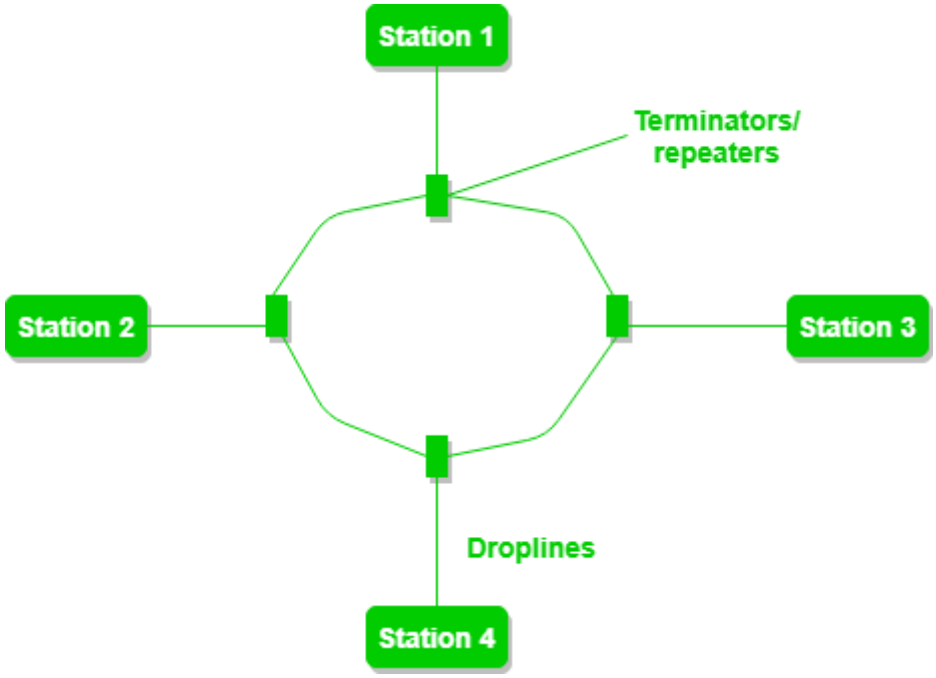
Bus



Key points:

1. Easy & Cheap Installation (n + 1(main-line) cables required).
2. Single line-of-failure (main-line).
3. Heavy Traffic causes collisions.

Ring



Key points:

1. Easy & Cheap Installation (1 line).
2. Difficulty in Troubleshooting.
3. Addition/Removal of nodes disturbs the topology.

Hybrid

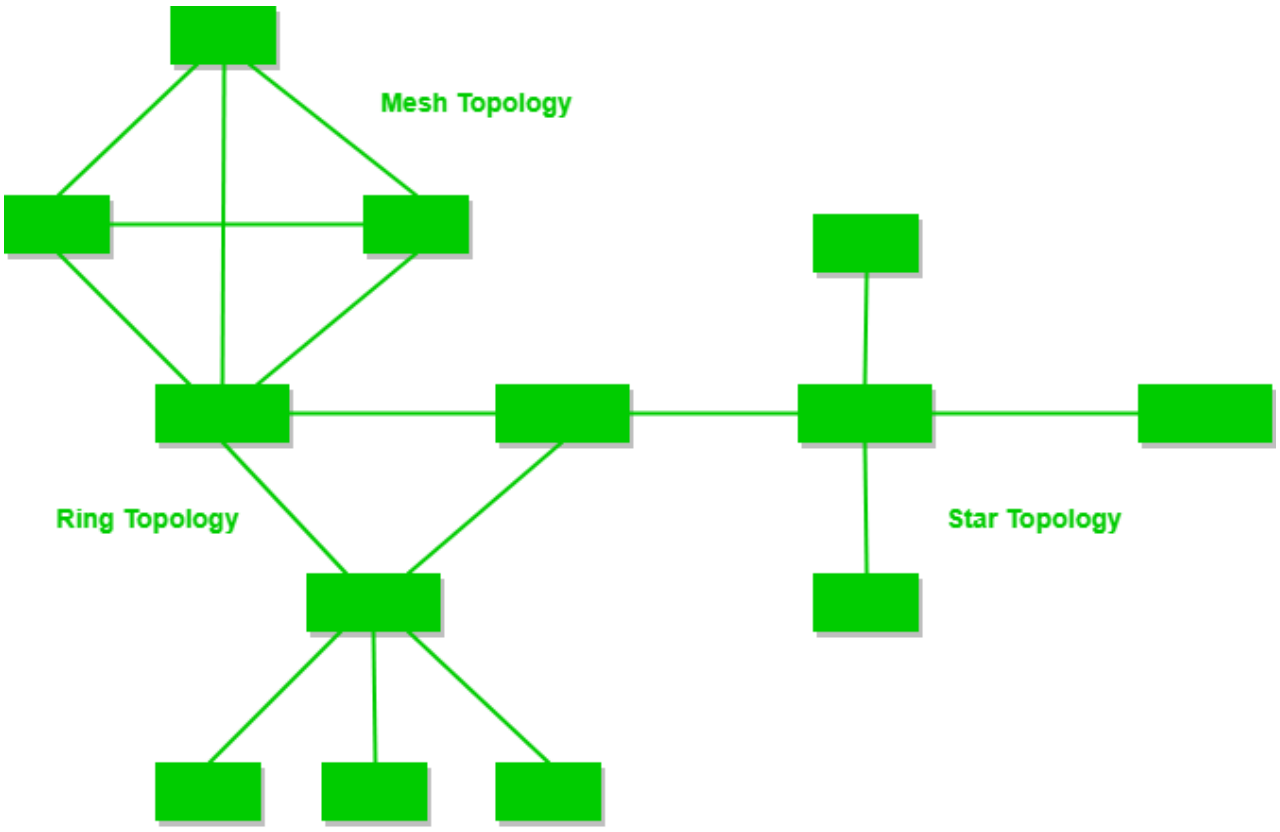


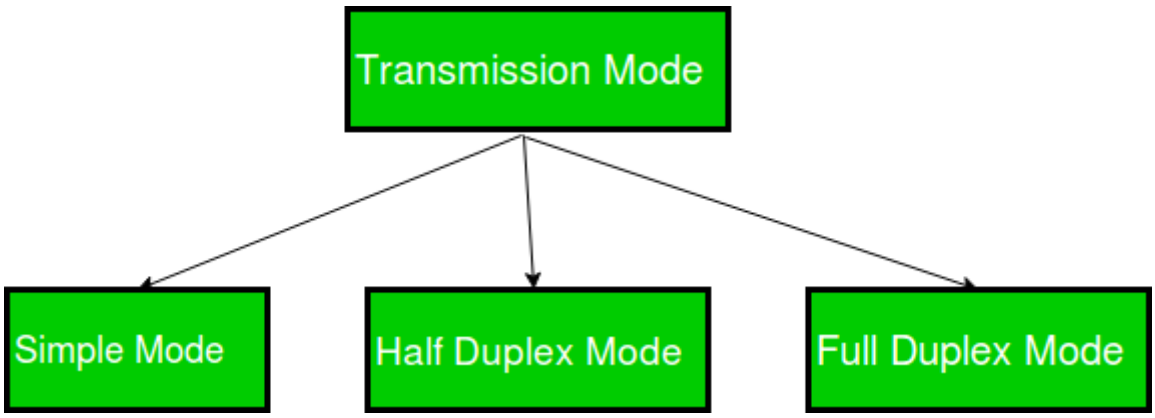
Figure - A Hybrid Topology

Key points:

1. Combination of all topologies (according to requirement).
2. This kind of topology is scalable and can serve a variety of requirements
3. Due to intermixing of Ring, Bus, Star etc. topologies, it is difficult to develop. (As each of the individual topologies have their own rules and concepts ~ collision detection, protocols for data transfer etc.).

- Transmission Modes in Computer Networks (Simplex, Half-Duplex and Full-Duplex)

Transmission mode means transferring of data between two devices. It is also known as communication mode. Buses and networks are designed to allow communication to occur between individual devices that are interconnected. There are three types of transmission mode:-

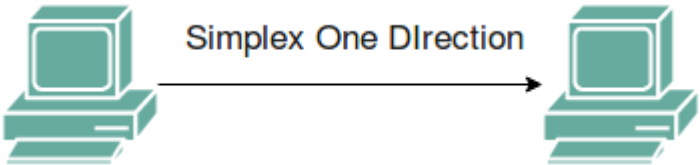


These are explained as following below.

1. Simplex Mode -

In Simplex mode, the communication is unidirectional, as on a one-way street. Only one of the two devices on a link can transmit, the other can only receive. The simplex mode can use the entire capacity of the channel to send data in one direction.

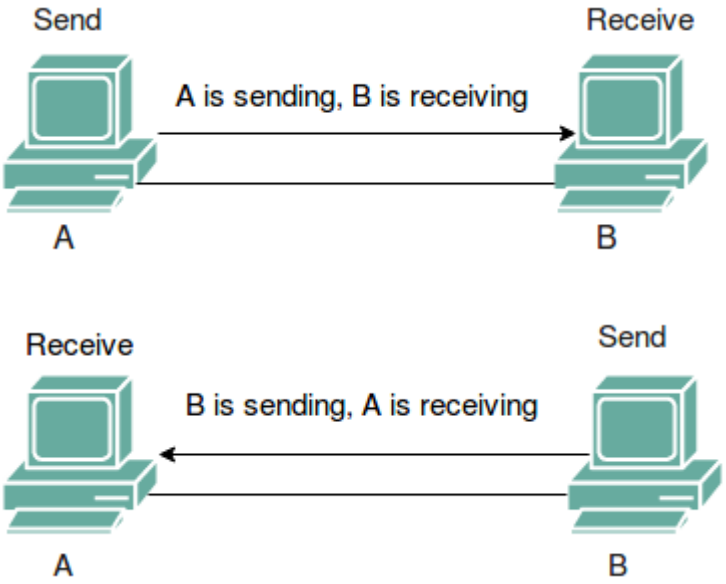
Example: Keyboard and traditional monitors. The keyboard can only introduce input, the monitor can only give the output.



2. Half-Duplex Mode -

In half-duplex mode, each station can both transmit and receive, but not at the same time. When one device is sending, the other can only receive, and vice versa. The half-duplex mode is used in cases where there is no need for communication in both direction at the same time. The entire capacity of the channel can be utilized for each direction. Example: Walkie- talkie in which message is sent one at a time and messages are sent in both the directions.

```
Channel capacity=Bandwidth * Propagation Delay
```



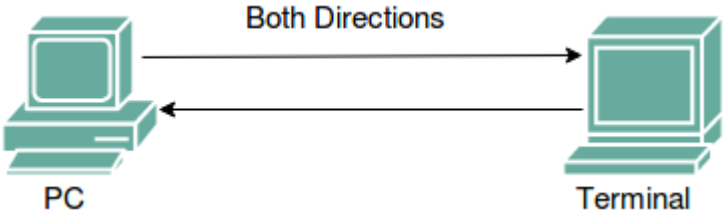
3. Full-Duplex Mode -

In full-duplex mode, both stations can transmit and receive simultaneously. In full_duplex mode, signals going in one direction share the capacity of the link with signals going in other direction, this sharing can occur in two ways:

- Either the link must contain two physically separate transmission paths, one for sending and other for receiving.
- Or the capacity is divided between signals travelling in both directions.

Full-duplex mode is used when communication in both direction is required all the time. The capacity of the channel, however must be divided between the two directions. Example: Telephone Network in which there is communication between two persons by a telephone line, through which both can talk and listen at the same time.

```
Channel Capacity=2* Bandwidth*p          tion Delay
```



References- Data Communication and Network,5th Edition,Behrouz A.Forouzan.

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- TCP/IP vs OSI Model

TCP/IP and OSI are reference models which divides the various responsibilities into a logical separation of layers. Practical implementations in devices are based on these 2 popular models. The difference amongst them lies in the no. of layers and their respective responsibilities:

TCP/IP MODEL
Application Layer
Transport Layer
Internet Layer
Network Access Layer

OSI MODEL
Application Layer
Presentation Layer
Session Layer
Transport Layer
Network Layer
Data Link Layer
Physical Layer

Brief description of each model:

OSI Model It stands for *Open Systems Interconnection*. It comprises of 7 layers with the following responsibilites (starting from the lowest layer):

- **Physical Layer**: It is responsible for actual physical transmission of data (through channels). It recieves/transmits signals and then converts it to physical bits (0 & 1). It handles *bit-synchronization* (using clock), *bit-rate* control (no.of bits/sec), physical *topology* and *transmission mode* (simplex, half-duplex, full-duplex).
- **Data-link Layer**: It is responsible for *Node-to-Node* delivery of packets, *Framing*, *Error control*, *Flow control*, *Physical Addressing (MAC)*. Upon recieving packets from network layer, it encapsulates it within a frame with the hardware (MAC) address of the reciever (obtained via *ARP* ~ Address Resolution Protocol).
- **Network Layer**: It is responsible for *Logical Addressing* (IPv4/v6) and *Routing*. Various routing algorithms are implemented at this layer, which determines the IP for the next hop in routing.
- **Transport Layer**: It is responsible for *End-to-end* delivery of packets. It also does *Segmentation & Reassembly* of packets(done if packet-size exceeds MTU ~ Max. Transmission Unit). It also does *multiplexing/de-multiplexing* of packets according to the application (using port no.). TCP/UDP (*Connection vs. Connection-less*) protocol is implemented at this layer.
- **Session Layer**: It is responsible for *Session Management* (Establishment, Maintenance, Termination), *Authentication*, *Security*, *Synchronization* & Restoration (check-points are established, such that upon re-connection state is resumed from the last saved point) and *Dialog Control* (synchronization when multiple parties are interacting ~ conference).
- **Presentation Layer**: It is responsible for *Translation* (e.g. ASCII to EBCDIC), *Encryption/Decryption* and *Compression*.
- **Application Layer**: Implements application-specific protocols (HTTP, HTTPS, FTP, SMTP etc.) They produce the data, interacts with the user (input and display of data). e.g. Browsers, Skype, Messaging Apps.

TCP/IP Model It comprises of 4 layers with the following responsibilities (starting from the lowest layer):

- **Network Access Layer**: It is a combination of the Physical and Data-Link Layer, and is responsible for data transmission and hardware addressing (MAC).
- **Internet Layer**: It is the counterpart of OSI's Network layer, and is responsible for routing and logical addressing. (IP, ICMP, ARP).
- **Transport Layer**: Maintains End-to-end connectivity. It is a counterpart of the OSI's transport layer, and has the same responsibilites (TCP vs. UDP).
- **Application Layer**: Application-specific protocols are implemented here. (HTTP, HTTPS, FTP, SMTP etc.)

The differences amongst these two is tabulated as:

TCP/IP	OSI
TCP refers to Transmission Control Protocol.	OSI refers to Open Systems Interconnection.
TCP/IP has 4 layers.	OSI has 7 layers.
TCP/IP is more reliable	OSI is less reliable
TCP/IP does not have very strict boundaries.	OSI has strict boundaries
TCP/IP follow a horizontal approach.	OSI follows a vertical approach.
TCP/IP uses both session and presentation layer in the application layer itself.	OSI uses different session and presentation layers.
TCP/IP developed protocols then model.	OSI developed model then protocol.

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