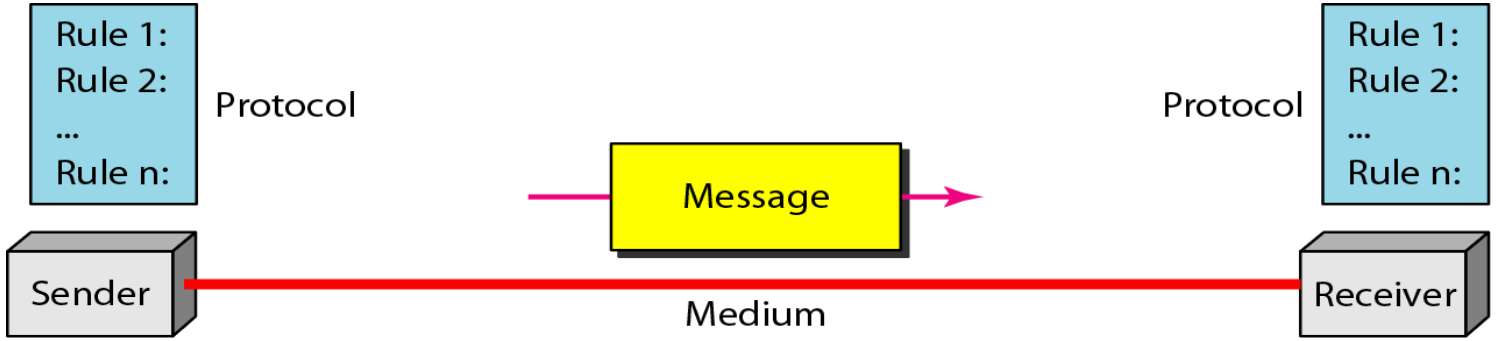
1. Introduction

Data Communication

- When we communicate, we are sharing information. That sharing can be local or remote. Local communication usually occurs face to face, while remote takes place over distance.
- Information are always in terms of **DATA**.
- **Data** refers to information presented in whatever form is agreed upon by parties creating and using the data.
- **Data communication** are the exchange of data between to devices via some form of transmission medium such as a wire cable.
- Communication device must be part of a communication system made up of combination of hardware and software. Effectiveness of data communication depends upon four fundamental characteristics:
  - **Delivery**: The system must deliver data to the correct destination. Data must be received by the intended device or user.
  - **Accuracy**: the system must deliver data accurately. Data that have been altered in transmission and left uncorrected are unusable.
  - **Timeliness**: the system must deliver data in timely manner. Data deliver late are unusable. in the same order that they are produced, and without significant delay. This king of delivery is called **real-time transmission**.
  - **Jitter**: Jitter refers to the variation in the packet arrival time. It is the uneven delay in the delivery of audio and video packets.

Cont…

- **Component of data communication**

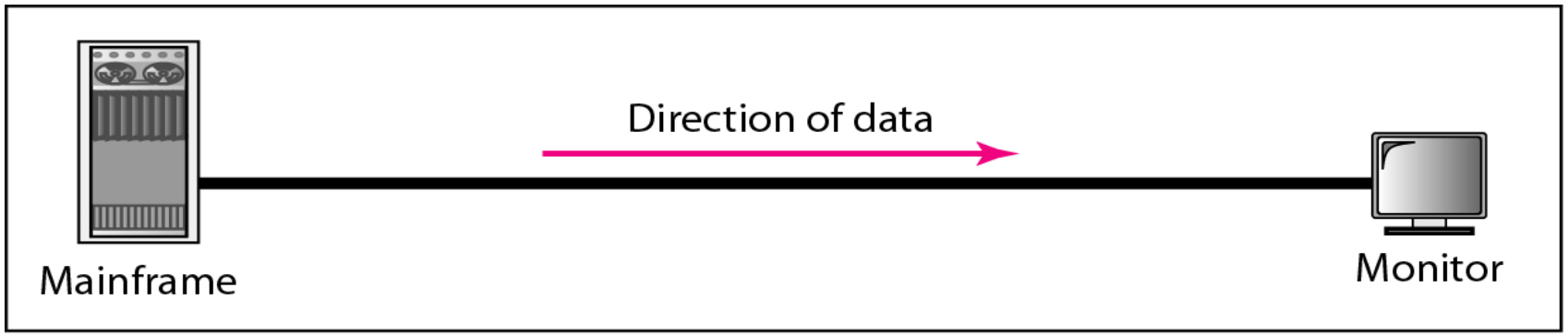


  - **Message**: The message is the information to be communicated. Popular forms of information include text, numbers, pictures, audio and video.
  - **Sender**: the sender is device that sends the data message. It can be a computer, workstation, telephone handset, video camera, and so on.
  - **Receiver**: The receiver is the device that receives the message. It can be a computer, workstation, telephone handset, video camera, and so on.
  - **Transmission Medium**: The transmission is the physical path by which a message travels from sender to receiver. Ex. twisted pair, coaxial cable, fiber-optic cable, and radio waves.
  - **Protocol**: A protocol is a set of rules that govern data communications. It represents an agreement between the communicating devices.

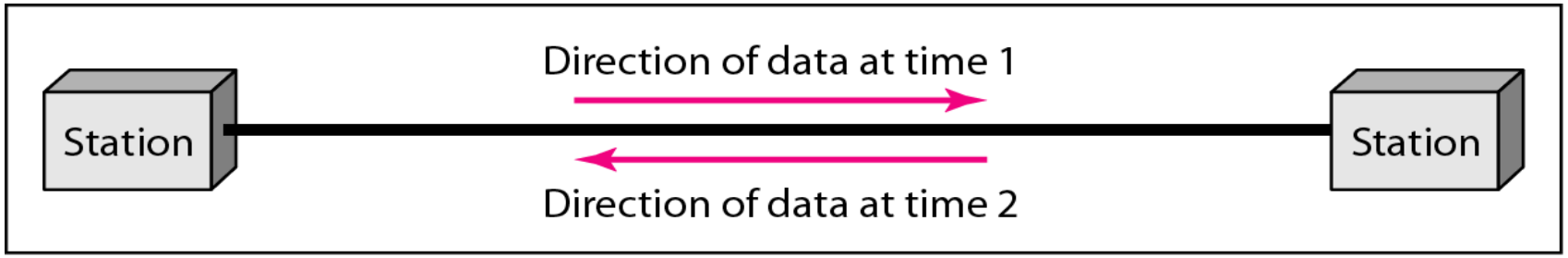
Cont…

- Data Representation
  - Text
    - Data are represented in form of bit. E.g. 0, 1.
    - Different bit pattern is known as code.
    - Today's codding system in Unicode 32 bit.
  - Number
    - Numbers are also represented in bit format.
    - Number is directly converted into binary number.
  - Images
    - It is represented in form of matrix of pixel.
  - Audio/Video
    - It is continues data.
    - Used to recording or broadcasting of sound or music.
- Data Flow
  - Simplex
    - One way traffic only, one device transmits and one devices.
    - Communication is unidirectional, as on one way street. Ex. Keyboard and traditional monitor.
    - E.g. keyboard -> monitor.

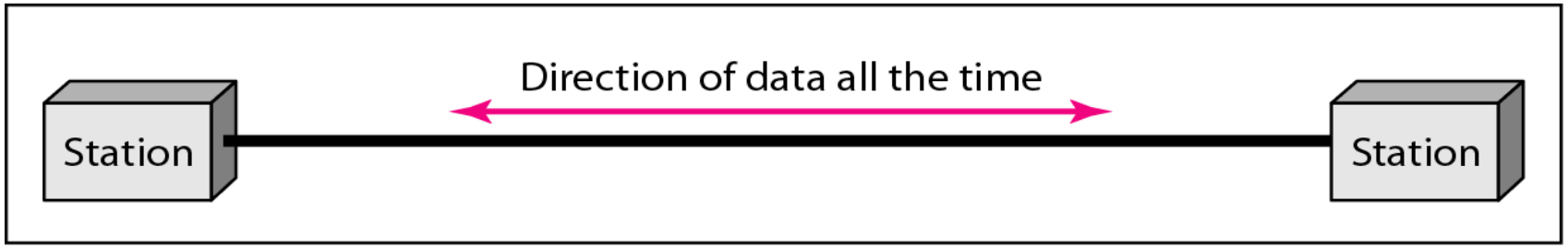
Cont...



a. Simplex



b. Half-duplex



c. Full-duplex

Cont…

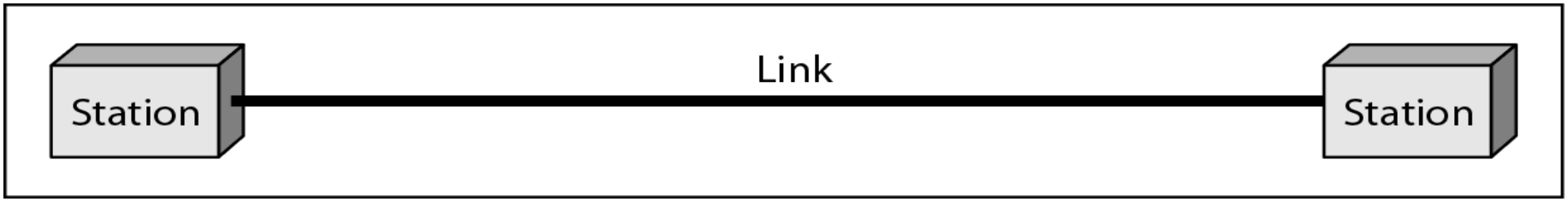
- Half-duplex
  - Each station can both, transmit and receive, but not at same time. When one device is sending than other can only receive and vice versa.
  - E.g. walkie-talkies
- Full-duplex
  - Both station can transmit and receive simultaneously.
  - E.g. Telephone

Networks

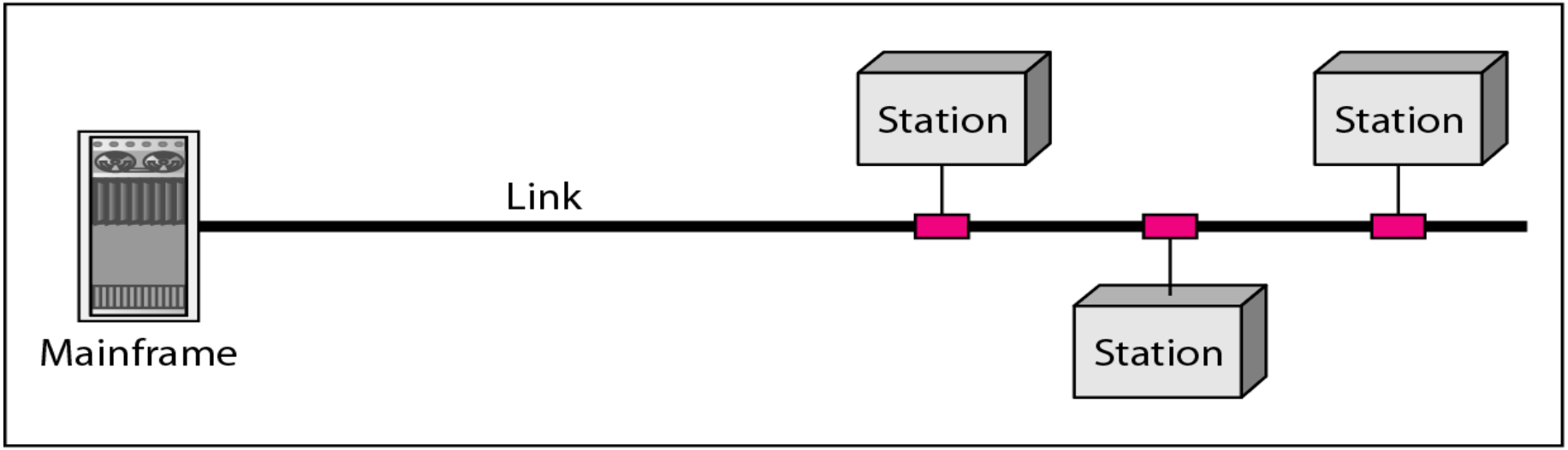
- **Network**: a set of devices connected by communication link.
- **Node**: Computer, printer or any dives capable of sending or receiving data.
- **Computer Network**: collection of autonomous(work independent) computer that are interconnected with each other or exchanging information with each other.
- ***Network Criteria:***
- **Distributed Processing:**
  - In which task is divided among multiple computers.
  - Instead of one single large machine is responsible for all, separate handle a subset.
- **Performance**:
  - Measure is two way transit time and response time.
  - Transit time: Amount of time required for a message to travel from one device to another.
  - Response time: Elapsed time between an inquiry and response.
  - It depends upon number of users, type of transmission medium, capacity of connected h/w, efficiency of s/w.
  - It is evaluated by throughput and delay.
- **Reliability measured by**:
  - Frequency of failure
  - Time it takes a link to recover from failure

Cont...

- **Security**:
  - Protecting data from unauthorized access
  - Protecting data from damage and development
  - Implement procedures for recovery.
- **Types of connection**



a. Point-to-point



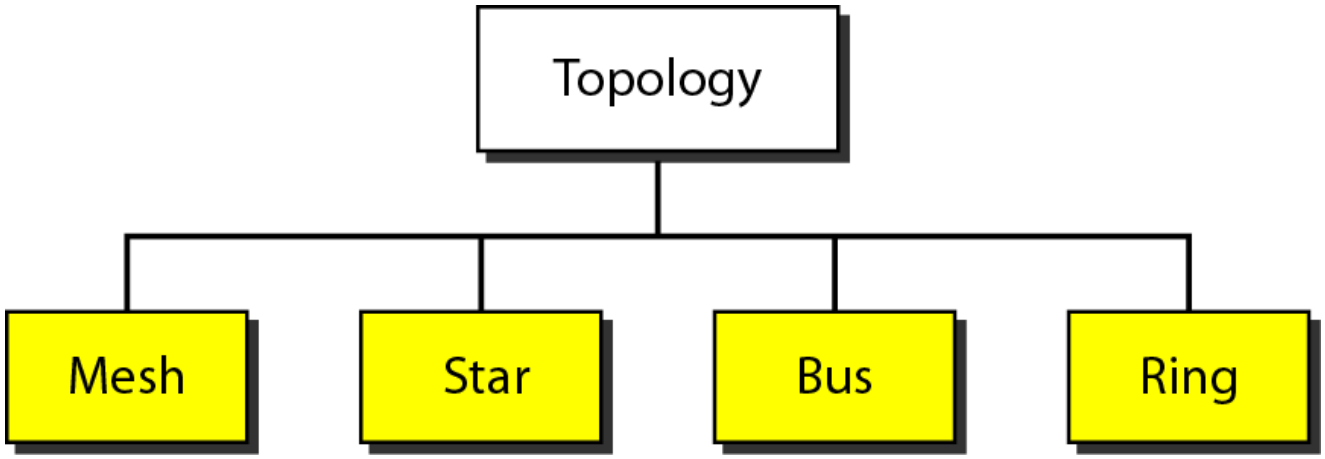
b. Multipoint

Cont…

- Point-to-point
  - Provide dedicated link between two devices.
  - The entire capacity of channel is reserved for transmission between two device.
  - Ex. TV remote control.
- Multipoint
  - More than two device share a single link.
  - Capacity of the channel is either
    - Spatially shared connection: devices can use the link simultaneously
    - Timeshare connection: users must take turns.

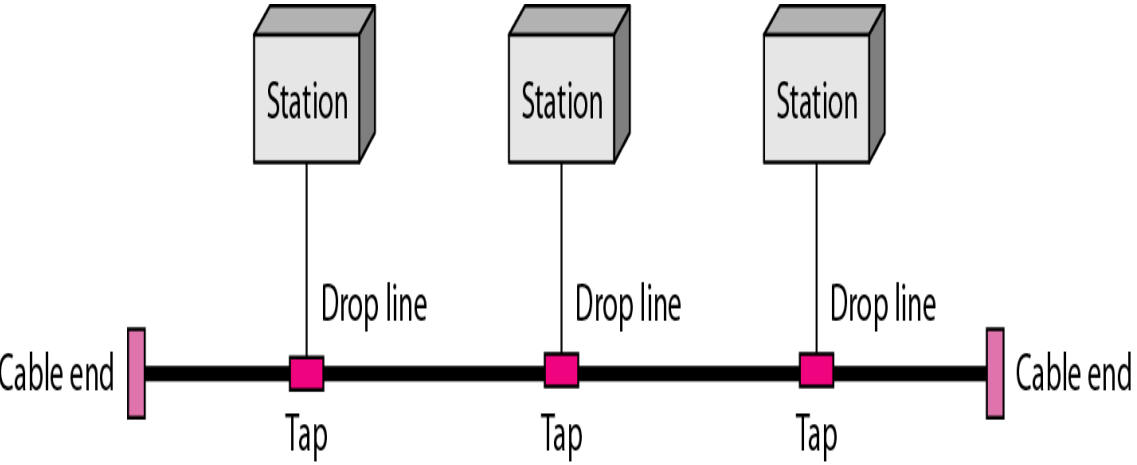
Topology

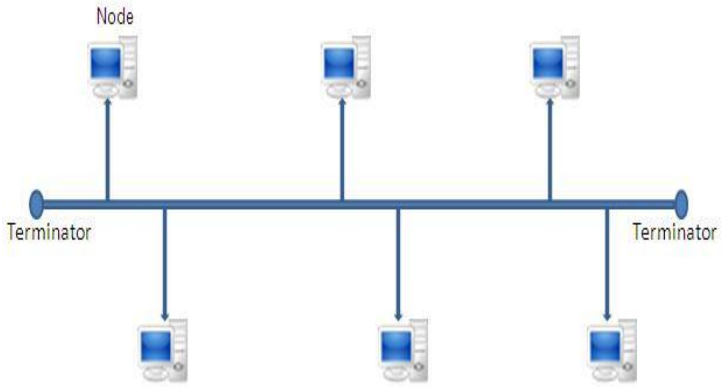
- **Topology**
  - The way in which the connections are made (shape of network) is called topology of network.
  - Geometric representation of the relationship of all the links and linking devices.
- **Network topology**
  - Refers to physical layout of the network, the location of the computer and how cable is run between them.
- ***Physical topologies***: describe how the cables are run.
- ***Logical topologies***: describe how the network messages travel.
- **Physical topology**



Bus topology

- It is multipoint connection.
- One large cable act as **backbone** to link all the devices in network.
- Nodes are connected to cable by drop lines and taps.





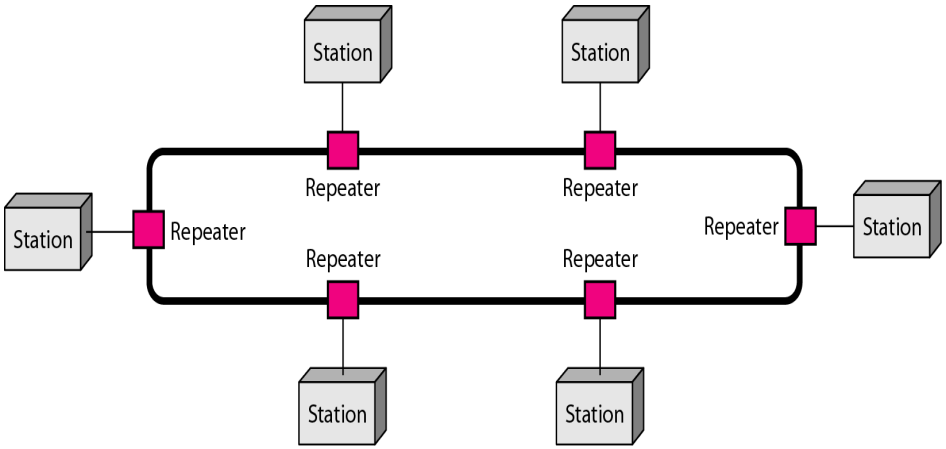
- Drop line is a connection running between the device and the main cable and tap is connector.
- Signals are travelled through backbone , some of its energy is transformed into heat so it becomes weaker and weaker as it travels farther and farther so there is limit on number of taps.
- It is implemented on limited distance between each node, such as LAN within department or building.

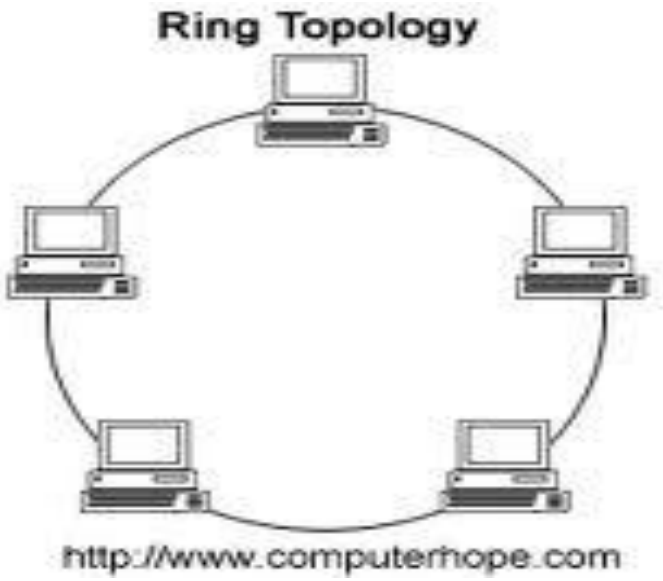
Cont…

- **Advantages of bus topology**
  - Easy to install.
  - Connecting a computer to a linear bus is easy.
  - This topology requires least amount of cabling to connect the computer so, less expensive than other cabling arrangements.
  - It is easy to extend a bus since two cables can be jointed into one larger cable with connector.
- **Disadvantages of bus topology**
  - Entire network shuts down if there is a break in the main cable and difficult for reconnection.
  - adding new device is difficult because signal reflection at tap can cause degradation in quality and it can be controlled by limiting the number and spacing of devices connected to a given length of cable.
  - Terminators are required at both ends of the backbone cable.
  - Difficult to identify the problem if the entire network shuts down.
  - Not meant to be used as a stand alone solution in a large building.

Ring topology

- It is point – to – point connection with only the two devices on either side of it.
- Signal passed along the ring in one direction, from device to device until it reaches its destination.
- Each device in ring communicate with repeater (**repeater** is an electronic device that receives a signal and retransmits it. **Repeaters** are used to extend transmissions so that the signal can cover longer distances).
- The ring topology is continues path for data with no logical beginning or ending point and thus no terminators.
- Network may be either unidirectional or bidirectional.



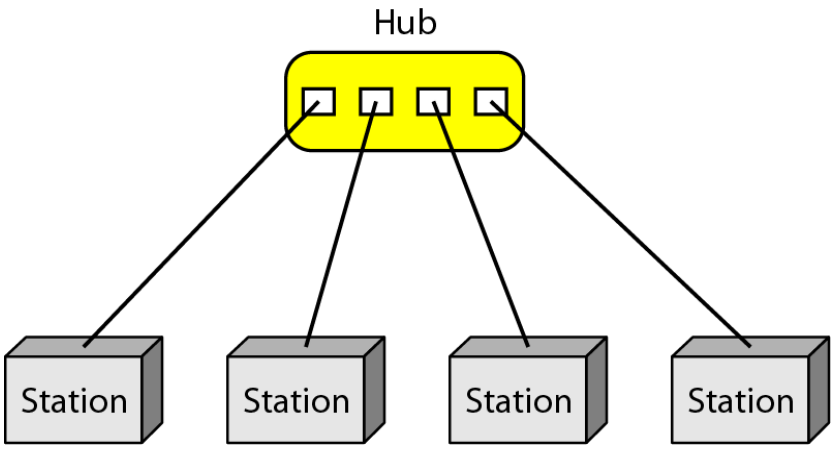


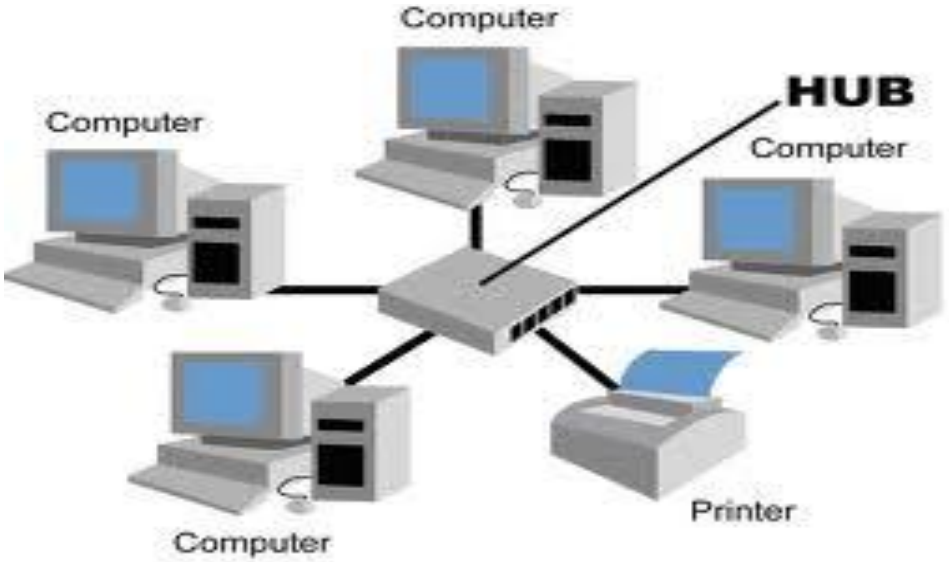
Cont…

- **Advantages of ring topology**
  - It is easy to install and configure.
  - Every computer is given equal access to the ring. No single computer can monopolies the network.
- **Disadvantage of ring topology**
  - Failure in any cable or node breaks the loop and can take down the entire network.
  - Maximum ring length and number of nodes are limited.

Star topology

- It is point – to – point connection only to a central controller, usually called hub (A **hub** is a common connection point for devices in a **network**. **Hubs** are commonly used to connect segments of a LAN. A **hub** contains multiple ports. When a packet arrives at one port, it is copied to the other ports so that all segments of the LAN can see all packets).
- It is oldest communications design method.
- A network uses star topology if all computer attached to a central point.
- If one device want to send data to another device than first it have to send that data to a central device than that central device will send that data to other connected device.



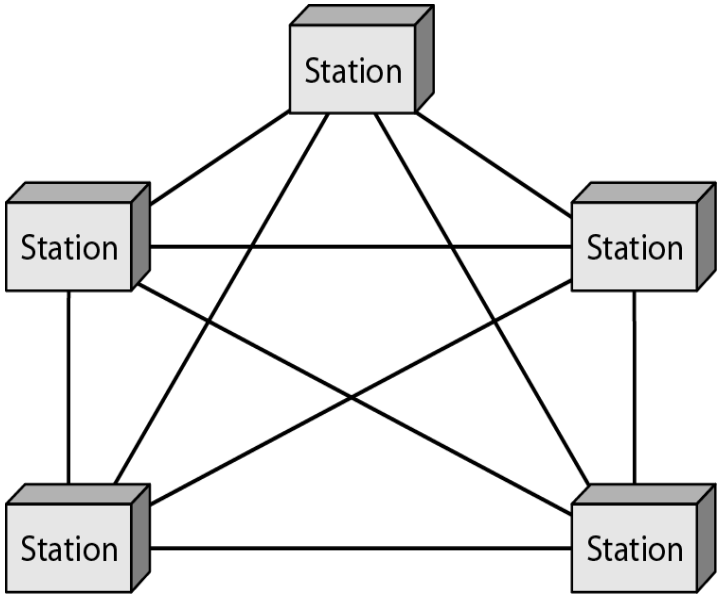


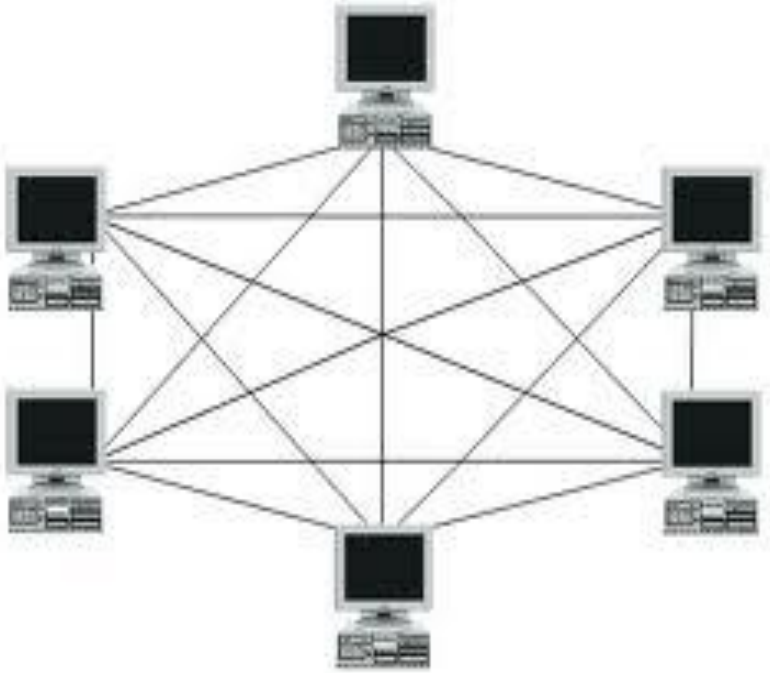
Cont…

- **Advantage of star topology**
  - It is easy to install and wire.
  - The network is not disturbed even if a node fails or is removed from the network.
  - Fault detection and removal of main parts are easier in star topology.
- **Disadvantages of star topology**
  - It requires longer length of cable.
  - If the hub fails, nodes are attached to it are disabled.
  - The cost of hub make network expensive as compared to bus and ring topology.

Mesh Topology

- It is point – to – point connection.
- The mesh topology has a direct connection between every pair of devices in the network.
- Communication becomes very simple because there is no competition for common line.
- If two device want to communicate, they do communication directly without involving other device.



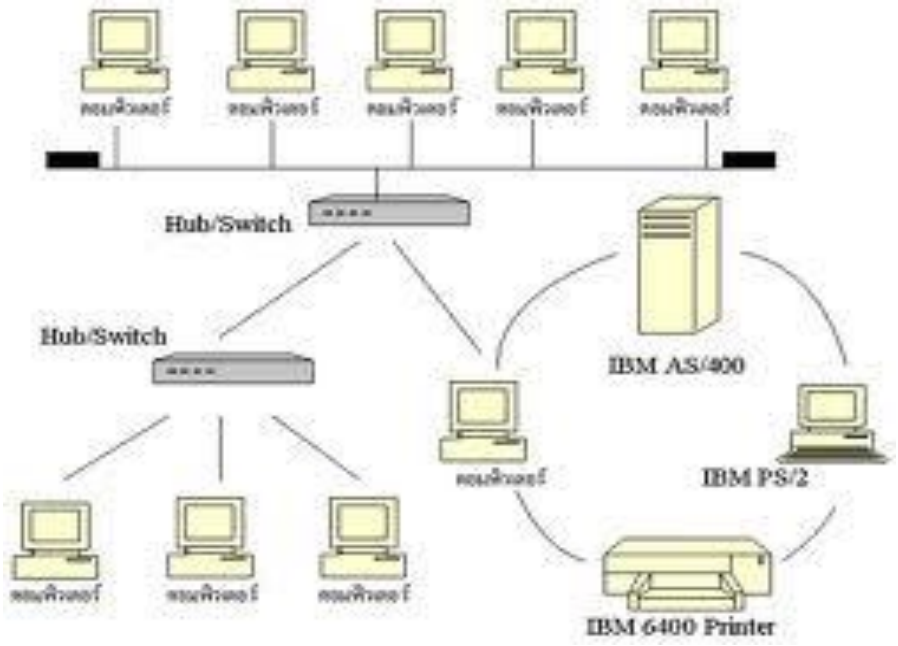


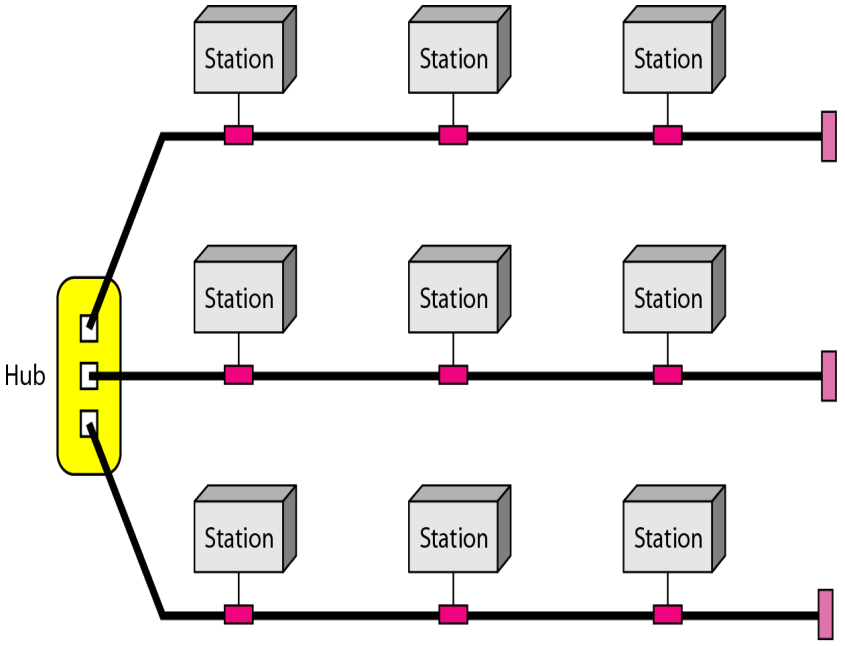
Cont…

- Advantages of mesh topology
  - The use of large number of links eliminates network congestion.
  - If one link become unusable it does not disable the entire system.
- Disadvantages of mesh topology
  - The amount of required cabling is very high.
  - As every node is connected to the other, installation and reconfiguration is very difficult.
  - The amount of hardware required in this type of topology can make it expensive to implement.

Hybrid topology

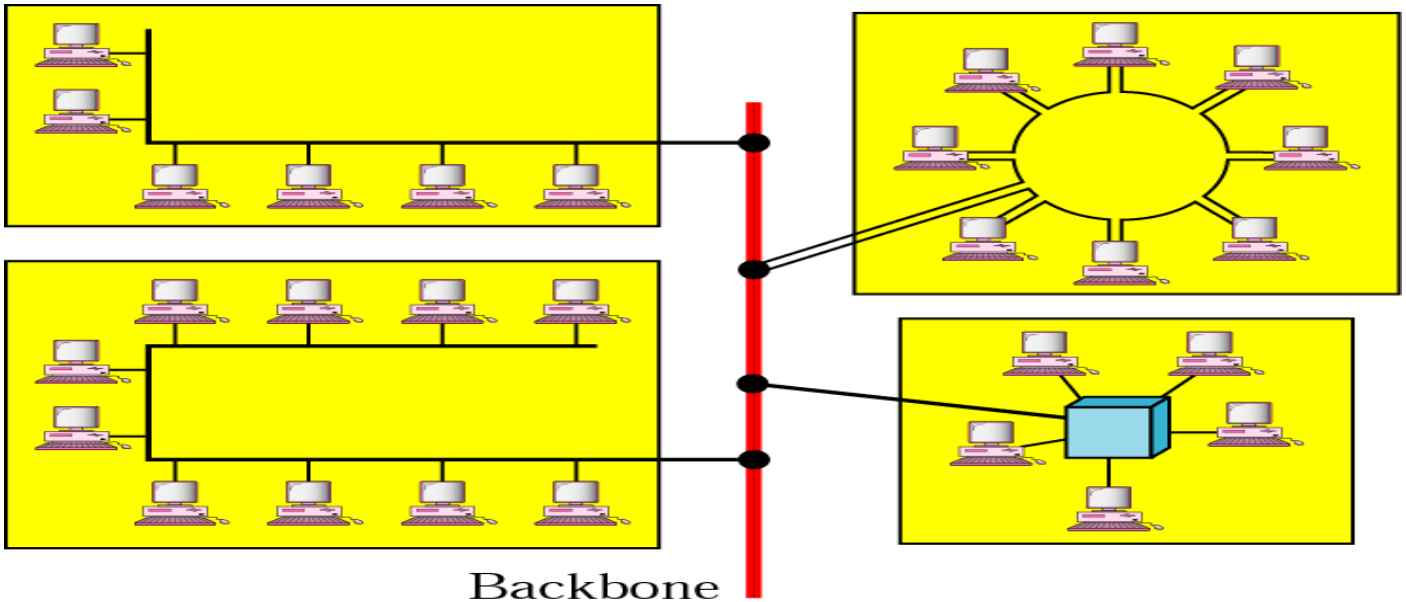
- Combination of various topologies.
- It has a common bus, sometimes called **backbone**, which allows users to access mainframe or computer and high volume accessed storage.





Categories of network

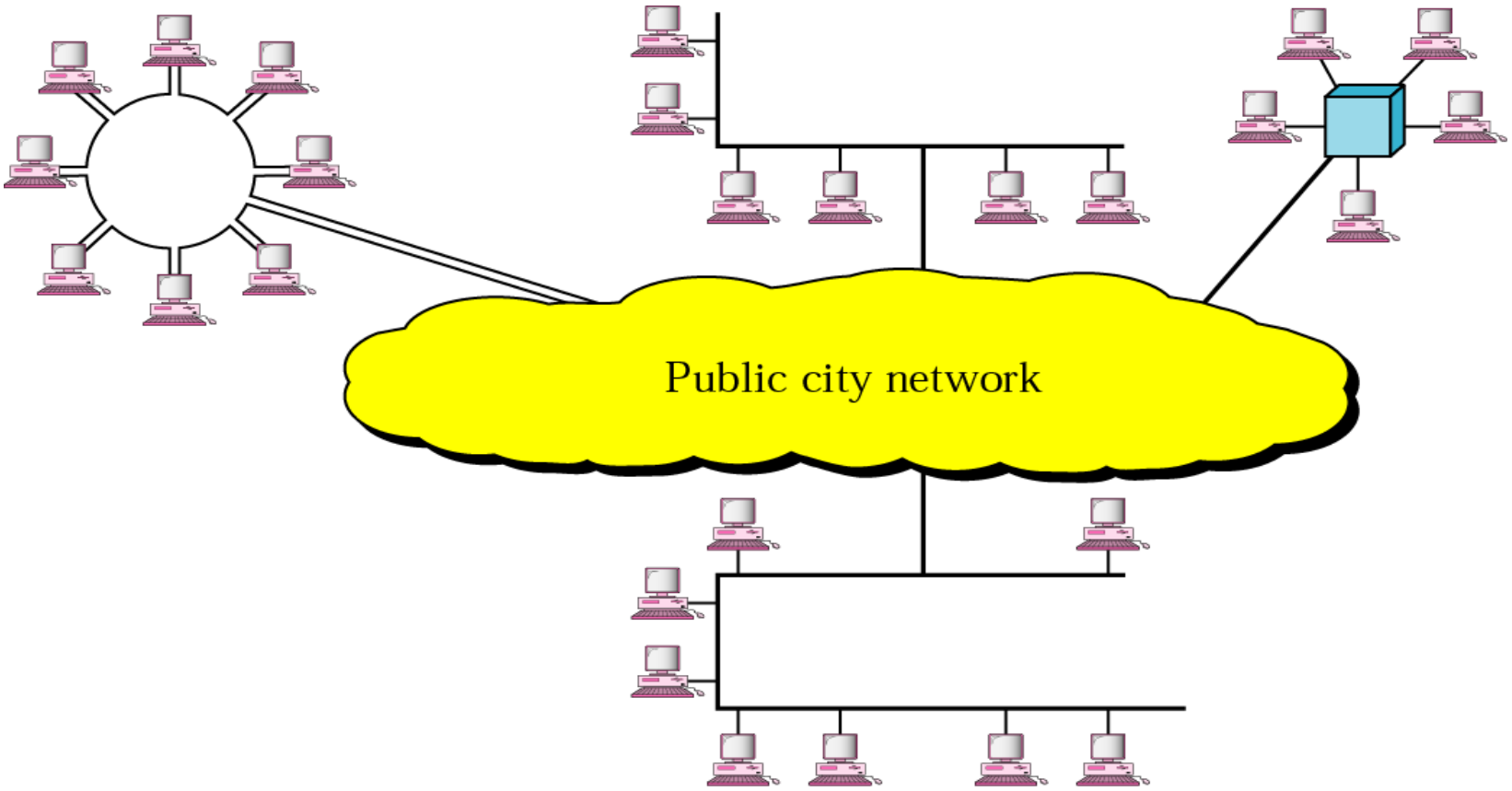
- Based on metrics
    - LAN (Local Area Network)
    - MAN (Metropolitan Area Network)
    - WAN (Wide Area Network)
- LAN
  - Refer as privately owned or privet data networks.
  - It is used to links device in single office, building or campus.
  - Limited to few kilometers.
  - Topology: Bus, Ring, Star



b. Multiple-building LAN

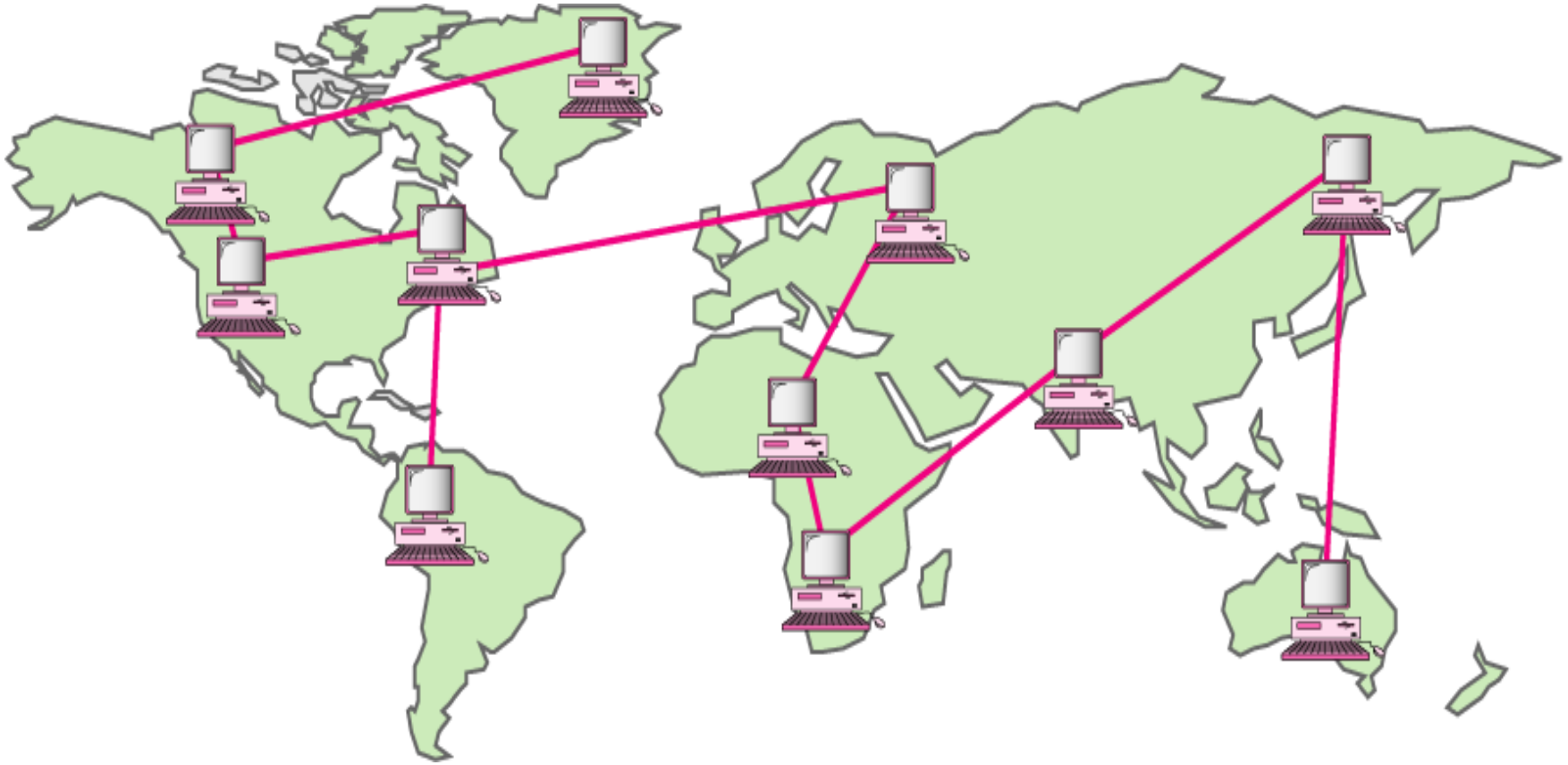
Cont…

- MAN
  - Bigger version of LAN and uses similar technology.
  - Owned and operated by privet company.
  - Design to extend over an entire city.
  - It may be connecting number of LANs into large networks.
  - It is link using fiber optics connection.



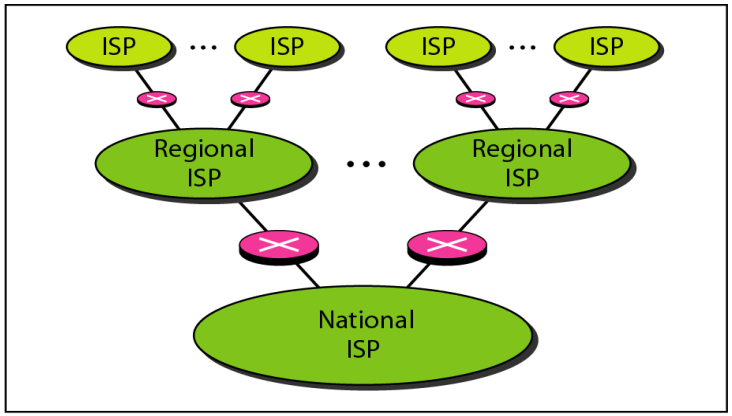
Cont…

- WAN
  - Provides long transmission of data, voice, image and video information over large geographic area that may comprise a country, a continent or even the whole world.
  - It is connected across distance of more than 30 miles.

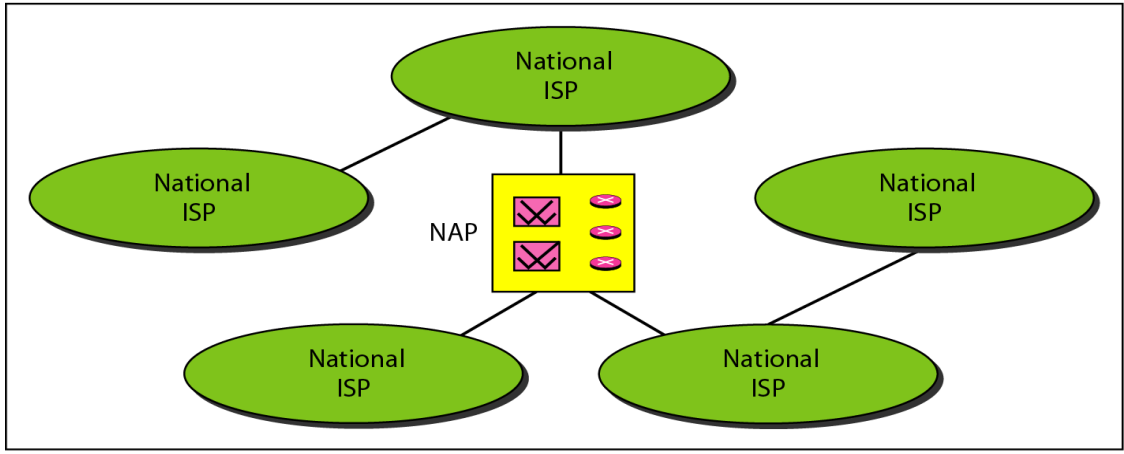


The Internet

- The Internet has recolonized many aspect of our daily lives.
- It has affected by the way we do business as well as the way we spend our free time.
- The internet is communication system that has brought a wealth of information to our fingertip and organized it for our use.
- **Internet Today**
- ISP (Internet Service Provider)
- NISP (National ISP)
- NAP (Network Access Point)



a. Structure of a national ISP



b. Interconnection of national ISPs

OSI Model

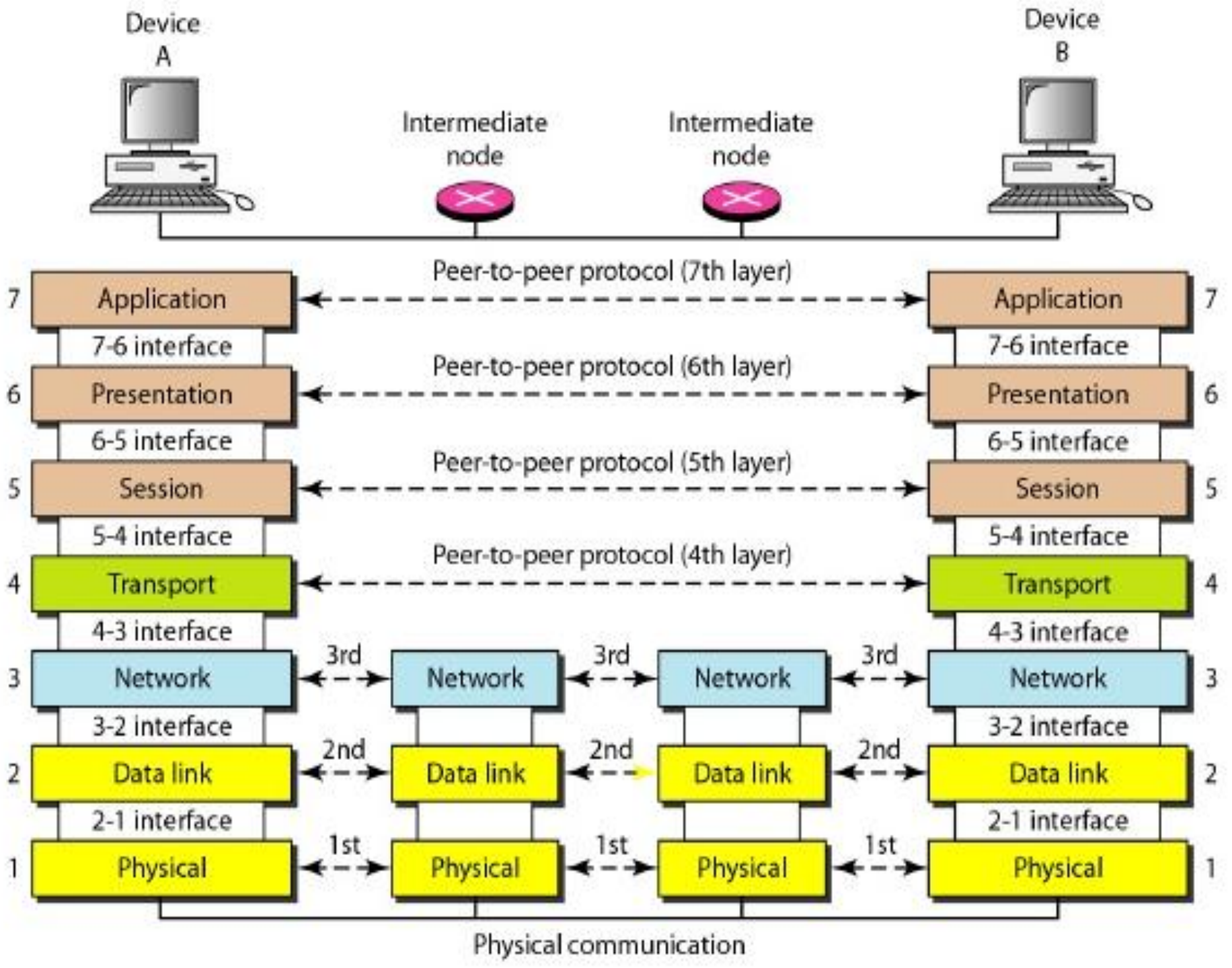
- ISO- International Standard Organization
- OSI- Open System Interconnection
- ISO is the organization while OSI is the model.
- ISO standard that covers all aspects of network communications is the OSI model.
- An open system is a set of protocols that allows any two different systems to communicate regardless architecture (hardware/software).
- The purpose of OSI model is to show how to facilitate communication between different system without requiring changes to the logic of the underlying hardware and software.
- OSI model is layered framework for design of network systems that allows communication between all types of computer system.
- It consist of 7 separate but related layers.

Cont…


7. Application
6. Presentation
5. Session
4. Transport
3. Network
2. Data Link
1. Physical

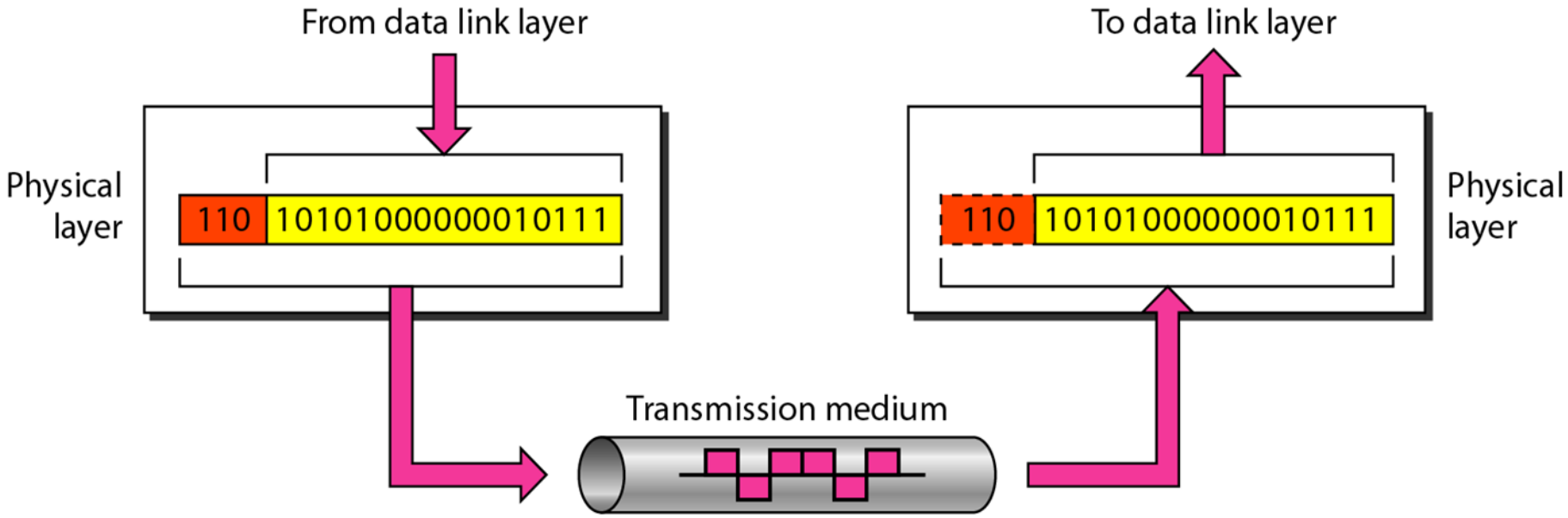
Cont…

- Layered Architecture
  - Message travels from A to B, it may pass through many intermediate node but this intermediate nodes usually involve only the first thee layers of the OSI model.
  - Each layer calls upon the services of the layer just below it.
  - The processes on each machine that communicate at a given layer are called peer – to – peer processes.
- Peer – to – peer process
  - At the physical layer communication is direct, device A sends a stream to bit to device B through intermediate node.
  - Each layer in the sending device adds its own information to the message it receive from the layer just above it and passes the whole package to the layer just below it.


Device A
Device B
Intermediate node
Intermediate node
Peer-to-peer protocol (7th layer)
Peer-to-peer protocol (6th layer)
Peer-to-peer protocol (5th layer)
Peer-to-peer protocol (4th layer)
7
Application
7-6 interface
6
Presentation
6-5 interface
5
Session
5-4 interface
4
Transport
4-3 interface
3
Network
3-2 interface
2
Data link
2-1 interface
1
Physical
3rd
2nd
1st
Physical communication

Physical Layer

- The physical layer is responsible for movement of individual bits from one hop (node) to the next.



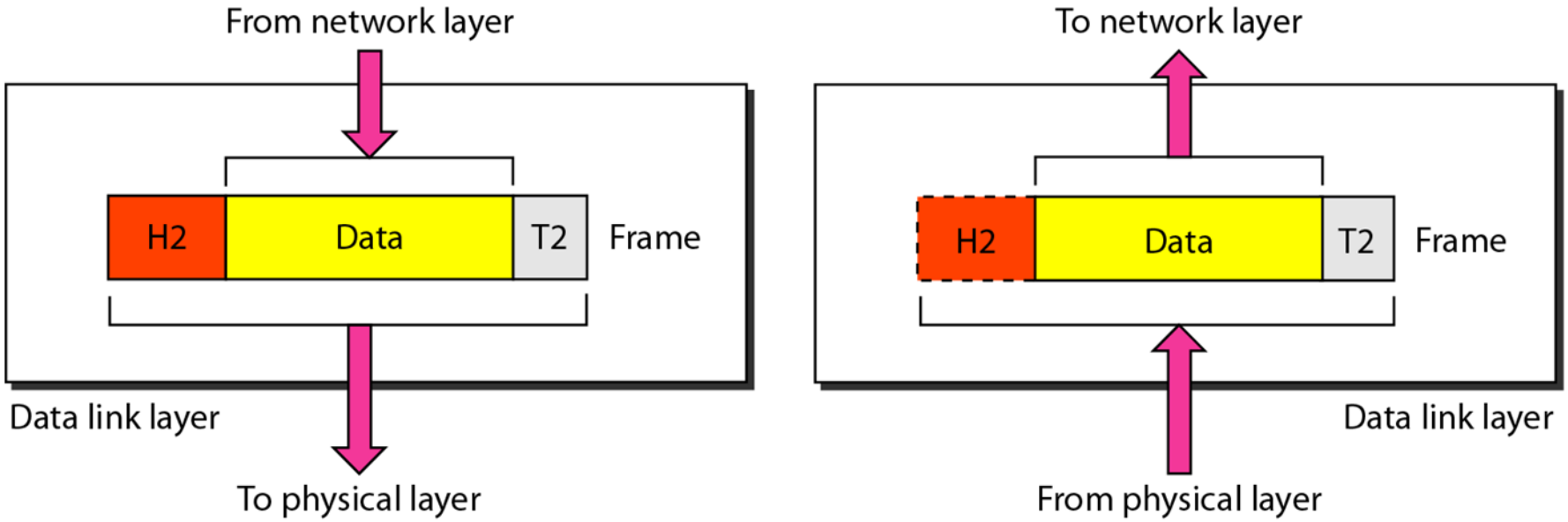
- It concerned with the following (responsibilities):
  - Physical characteristics of interfaces and medium:
    - Define the characteristics of the interface between device and transmission medium.
    - Define type of transmission medium.
  - Representation of bits:
    - Data consist of a stream of bits (sequence 0 or 1)
    - Bit must be encoded into signal (electrical or optical)

Cont…

- Data Rate:
  - Number of bit sent each second is called transmission rate
- Synchronization of bit:
  - Sender and receiver clock must be synchronized used same bit rate.
- Line configuration
  - Concerned with connection of device
    - Point – to – point : dedicated link
    - Multipoint: link is shared among several device
- Physical topology:
  - Define how device are connected in network
    - Bus, ring, mesh, star, hybrid
- Transmission mode:
  - Define the direction of transmission between two device
    - Simples, half duplex and full duplex

Data Link Layer

- It is responsible for moving frames from one hop to next hop.



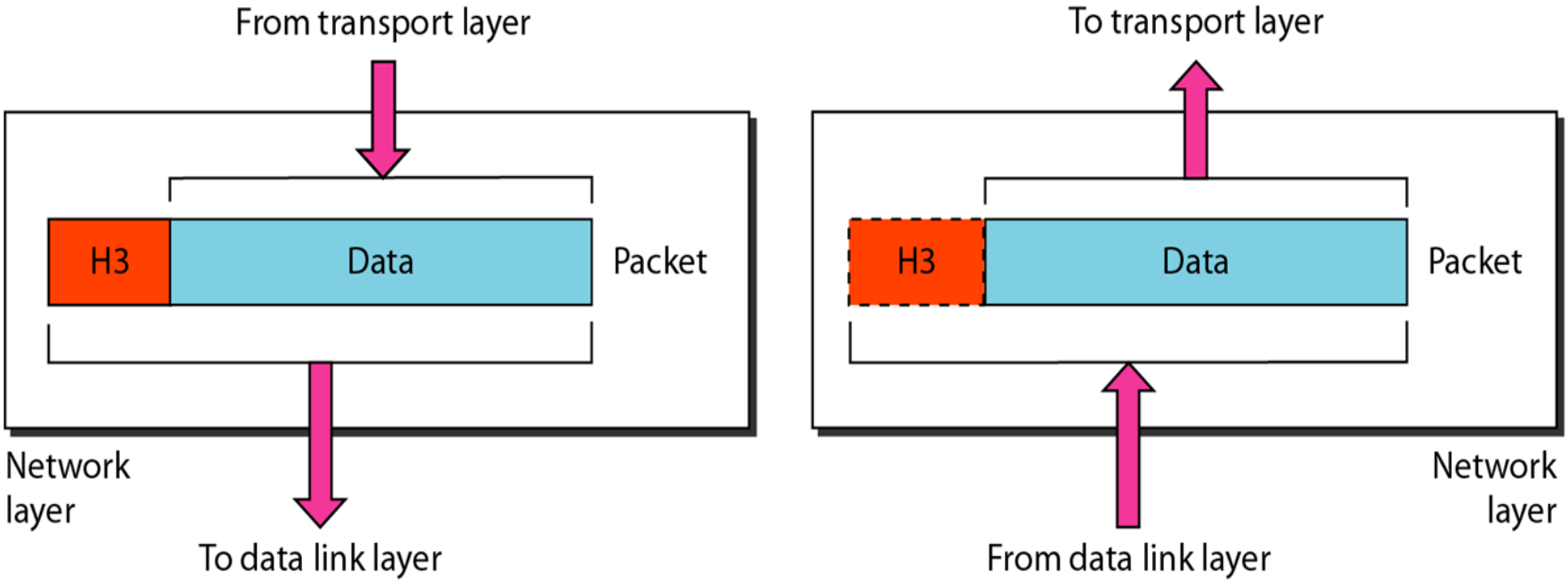
- It concerned with following responsibilities:
  - Framing:
    - Divides the stream of bits received from the network layer into manageable data units called Frame.
  - Physical addressing
    - Adds header to frame to define the sender and/or receiver.

Cont…

- Flow control
  - Imposes a flow control mechanism to avoid overwhelming the receiver (rate at which data are absorbed by receiver is less than the rate of data produced in the sender).
- Error control
  - Adds reliability to the physical layer: by adding mechanism to detect and retransmit damage or lost frames.
  - Uses a mechanism to organize duplicate frames.
  - Achieve through a trailer added to the end of frame.
- Access control
  - Two or more devices are connected to the same link, data link layer protocol are necessary to determine which device has control over the link at time.

Network Layer

- Network layer is responsible for the delivery of individual packets from the source to destination.



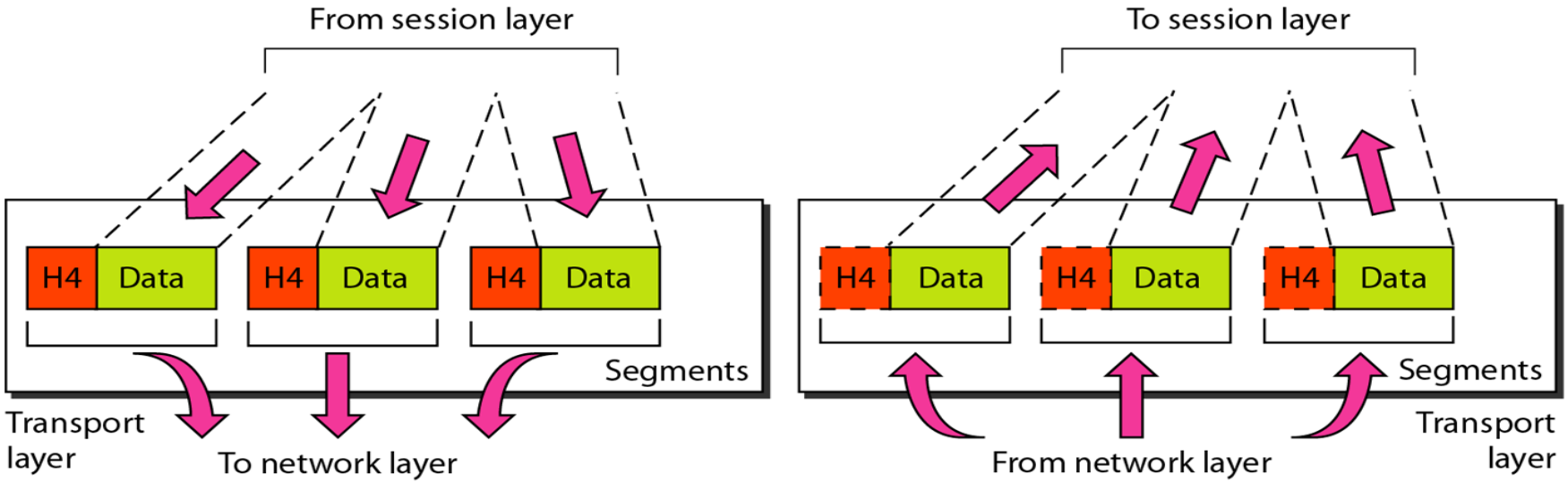
- The network layer is responsible for the delivery of packets from the source to destination.
- Data link layer oversees the delivery of the packet between two system on the same network, the network layer ensure that each packet gets from its point of origin to its final destination.

Cont…

- Responsibility
  - Logical addressing
    - Adds a header to the packet coming from the upper layer, includes the logical addresses of the sender and receiver.
  - Routing
    - One of the functions of network layer provides the mechanism to route or switch the packets to their final destinations.
    - In internetwork or large network the connecting device is called router or switch.

Transport Layer

- The transport layer is responsible for the delivery of a message from one process to another.
- Process – to – process delivery of entire message.
- Process is an application program running on a host machine.



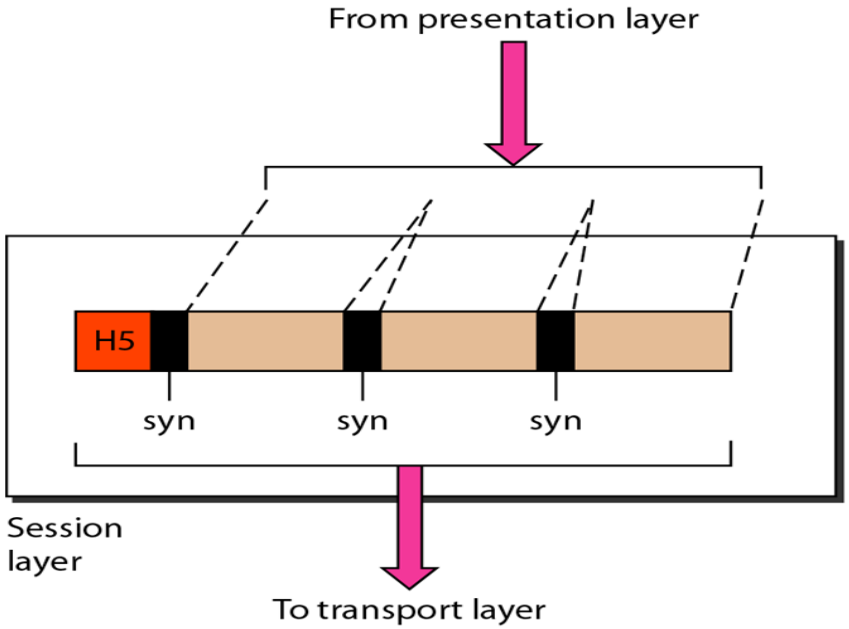
- Responsibility
  - Service point addressing
    - Header include service point address or port address.
    - Gets the entire message to the correct process to the computer.
  - Segmentation and reassembly
    - A message is divided into transmittable segments, with unique sequence number.

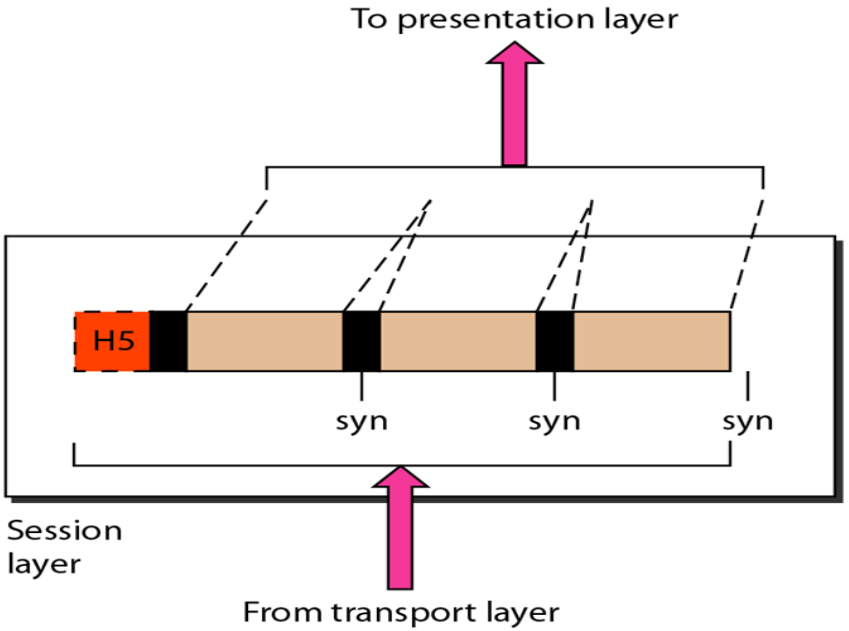
Cont…

- Connection control
  - Layer can be connection less or connection oriented.
- Flow control
  - End to end rather than across a single link.
- Error control
  - Process to process rather than single link
  - Error correction is achieved through retransmission.

Session Layer

- The session layer is responsible for dialog control and synchronization.
- The session layer is network dialog controller: it establish, maintain and synchronizes the interaction among communicating system.





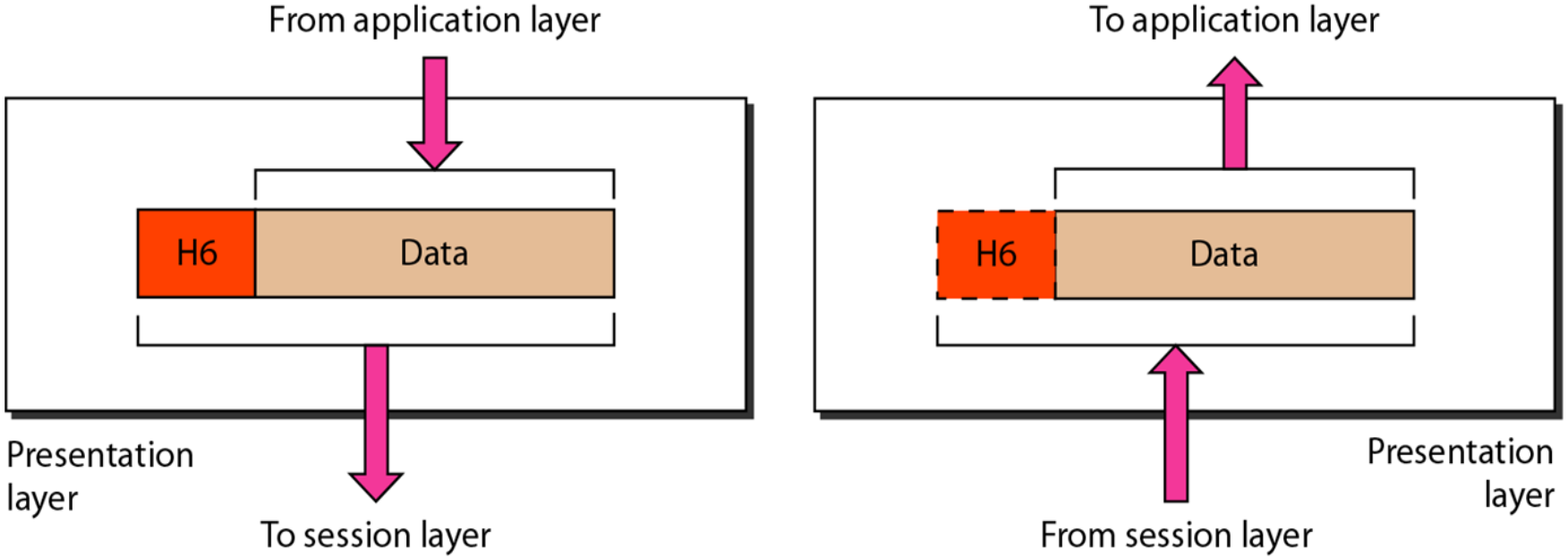
- Responsibility
  - Dialog control
    - Allows two system to enter into a dialog: allows the communication between two processes to take place in either half-duplex or full-duplex.

Cont…

- Synchronization
  - Allows a process to add checkpoints, or synchronization points to a stream of data.

Presentation Layer

- The presentation layer is responsible for translation, compression and encryption.
- Concerned with syntax and semantics of the information exchanged between two system.



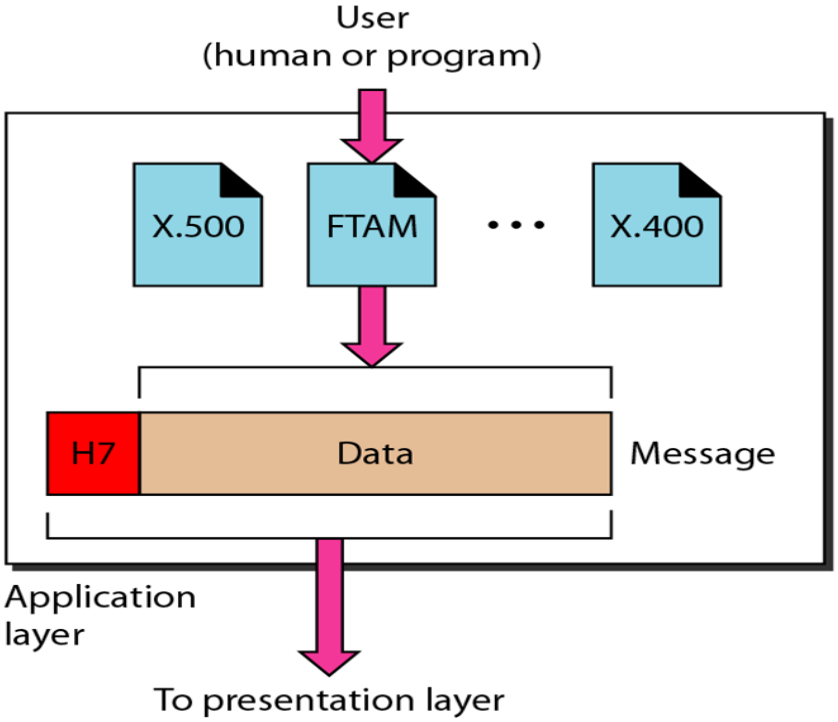
- Responsibility
  - Translation
    - Different computers use different encoding system, the layer is responsible for interoperability between different encoding method.

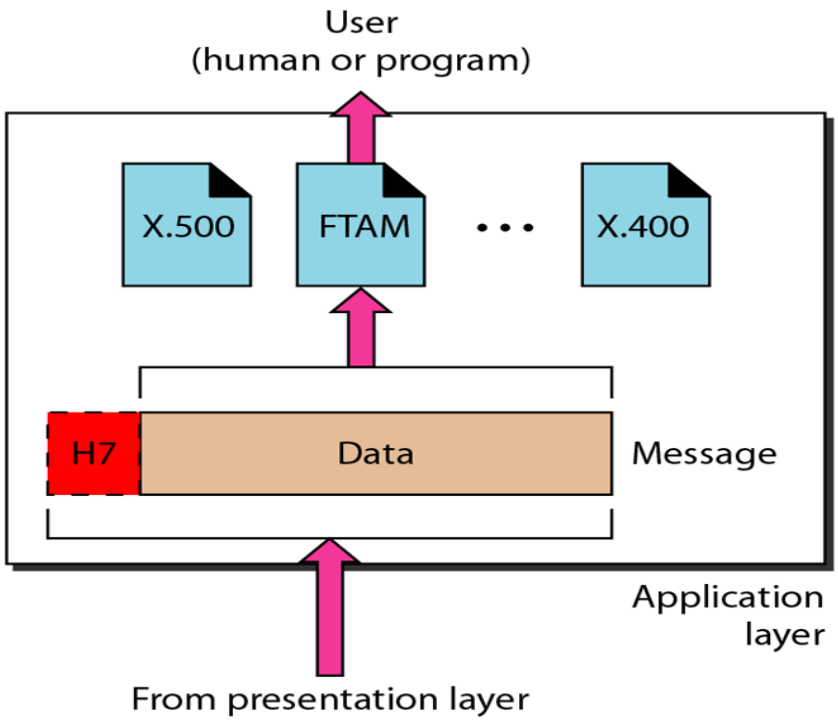
Cont…

  - At sender changes information from its sender dependent format into common format, at receiver changes the common format into its receiver dependent format.
- Encryption
  - A system must be able to ensure privacy to carry sensitive information.
  - Encryption: sender transforms the original information to another form and pass message over network.
  - Decryption: reverses the original process to transform the message back to its original form
- Compression:
  - Data compression reduces the number of bits contain in the information.
  - Important in the transmission of multimedia such as text, audio, video.

Application Layer

- The application layer is responsible for providing services to the user.





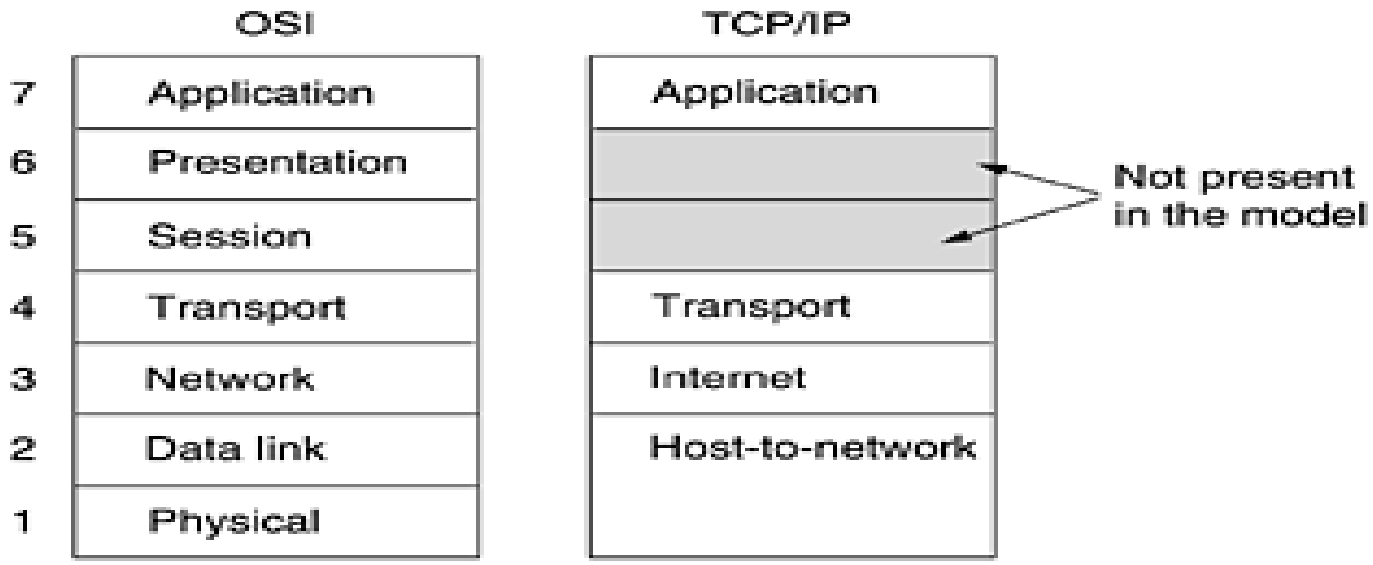
- Responsibility
  - Network Virtual Terminal
    - Network virtual terminal is a software version of a physical terminal, and it allow user to log on to a remote host, for that the application creates a software emulation of a terminal at a remote host.

Cont…

- Mail Services
  - Provides the basis for email forwarding and storage.
- File transfer, access and management
  - Allows a user to access file in remote host, to retrieve files from a remote computer for use in local computer, and to manage a control files in a remote computer locally.
- Directory services
  - Provides distributed database sources and access for global information about various objects and services.

TCP/IP

- TCP/IP protocol suits was developed prior to the OSI model.
- It have 4 layers
  - Host – to – network
  - Internet
  - Transport
  - Application

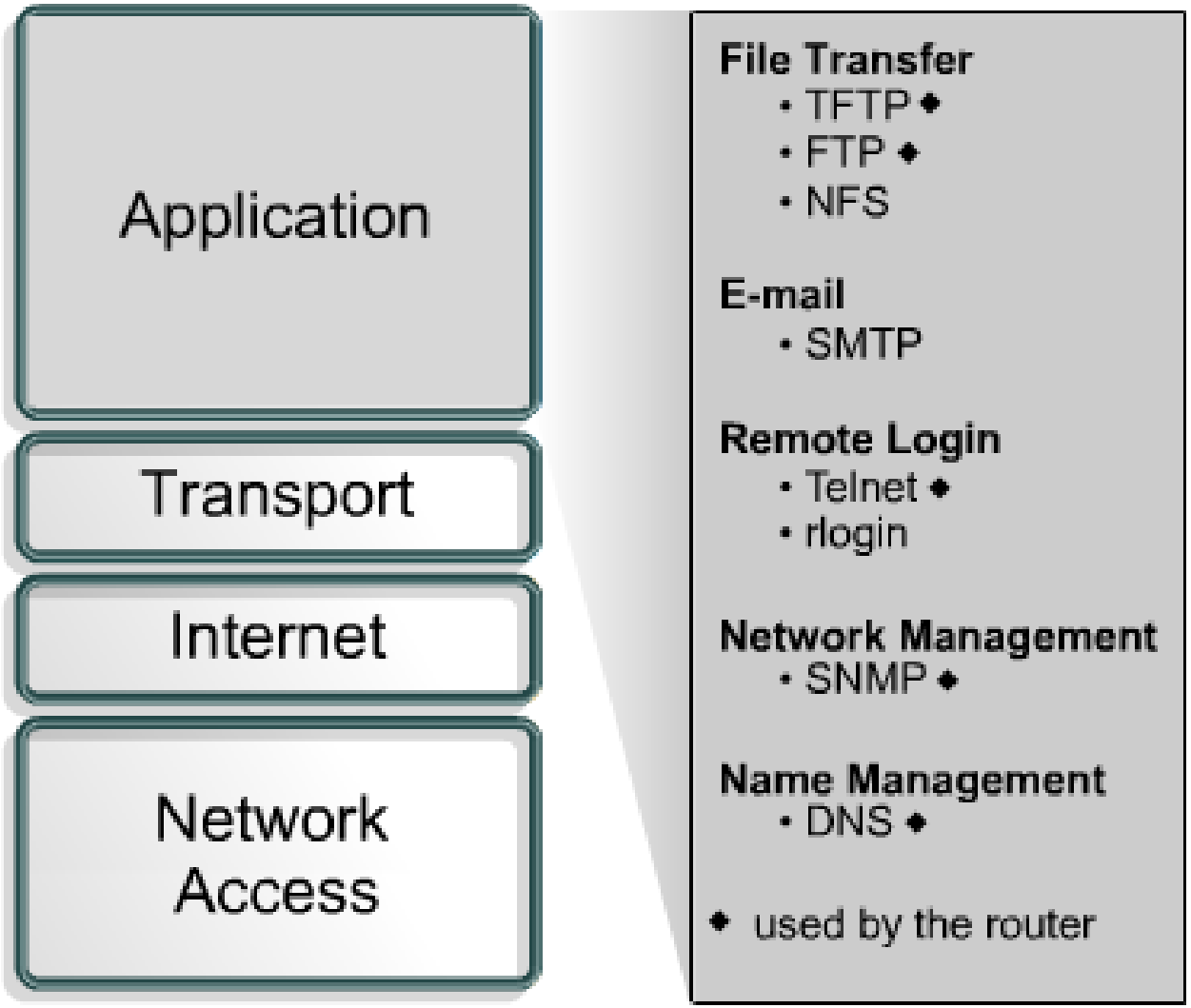


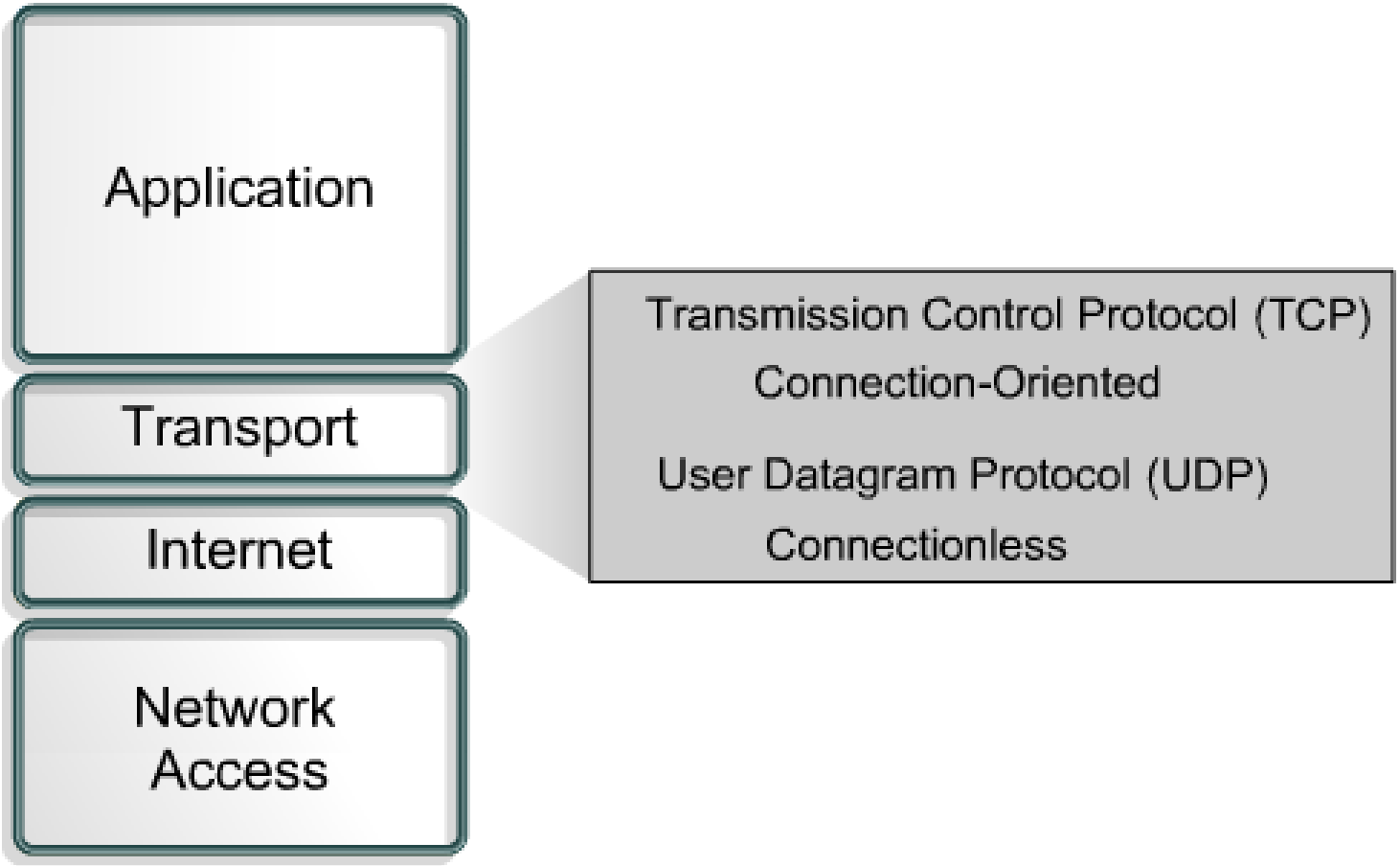
Cont…

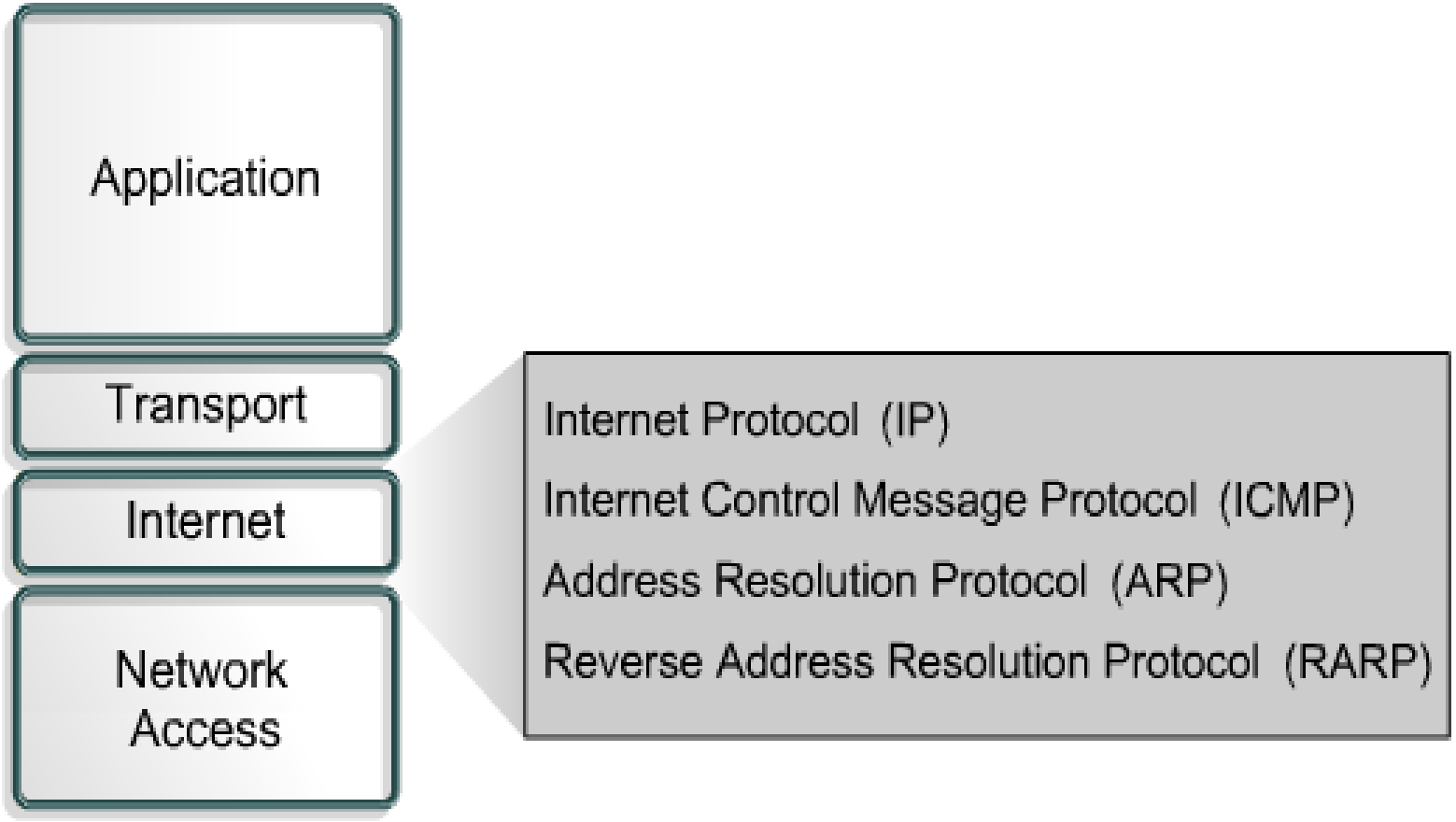
- Host – to – Network Layer
  - Combination of physical and data link layer
  - The network in TCP/IP is can be local area network or a wide area network.
- Network Layer
  - It supports the internetworking protocol.
  - IP layer includes ARP, RARP, ICMP network layer physical link to media.
  - ARP: Address Resolution Protocol
    - Used to associate logical address with physical address.
  - RARP: Reverse address Resolution Protocol
    - It allows a host to discover its internet address when it knows only its physical address.
  - ICMP: Internet Control Message Protocol
    - This mechanism used by hosts and gateway to send notification of datagram problem back to the sender.
- Transport Layer
  - It represented by two protocols: TCP and UDP.
  - Delivery of message from one process to another process.

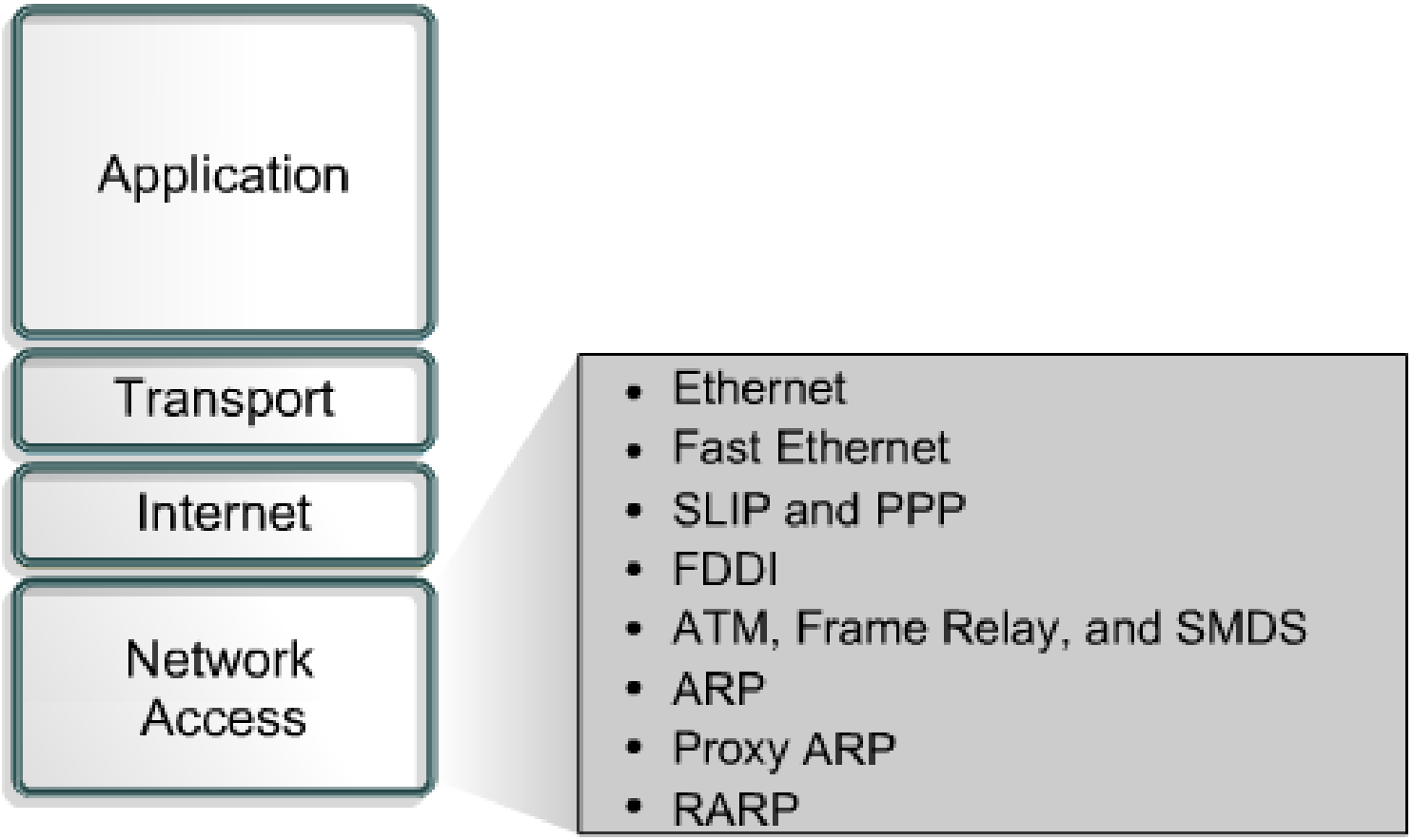
Cont…

  - UDP: User Datagram Protocol
    - It adds only port address, checksum, error control and length information to data from upper layer.
  - TCP: Transmission Control Protocol
    - Provide full transport layer service to application.
    - It divides stream of data into smaller unit called **Segment**.
    - Each segment includes a sequence number for recording after receipt, together with an acknowledgement number for segment received.
- Application Layer
  - Application layer of TCP/IP includes functionality of session and presentation layer of OSI model.
    - Like encoding, dialog control, compression.
  - Application layer includes file transfer, email, remote login, network management , name management.


Application
Transport
Internet
Network Access
File Transfer
• TFTP ◆
• FTP ◆
• NFS
E-mail
• SMTP
Remote Login
• Telnet ◆
• rlogin
Network Management
• SNMP ◆
Name Management
• DNS ◆
◆ used by the router


Application
Transport
Internet
Network Access
Transmission Control Protocol (TCP)
Connection-Oriented
User Datagram Protocol (UDP)
Connectionless


Application
Transport
Internet
Network Access
Internet Protocol (IP)
Internet Control Message Protocol (ICMP)
Address Resolution Protocol (ARP)
Reverse Address Resolution Protocol (RARP)


Application
Transport
Internet
Network Access
Ethernet
Fast Ethernet
SLIP and PPP
FDDI
ATM, Frame Relay, and SMDS
ARP
Proxy ARP
RARP

OSI vs TCP/IP

- Similarity :
  - Both have layers.
  - Both have application layer though they include very different services.
  - Both have comparable transport and network layers.
  - Both assumes packets are switched. This means that individual packets may take different path to reach same destination.
- Difference:
  - TCP/IP combines the presentation and session layer issues into its application layer.
  - TCP/IP combines the OSI data link and physical layers into the network access layer.
  - TCP/IP appears simple because it has fewer layers.
  - TCP/IP protocols are the standards around which the internet developed, so the TCP/IP model gains credibility just because of its protocol.

Protocols

- Protocol: Rules and Regulations
  - A set of rules that governs the Data Communication.
  - For communication to occur, entities must agree upon the protocol.
- Key elements of protocol:
  - Syntax: structure or format of data
  - Semantics: meaning of each section in the structure.
  - Timing: when and how fast data should be send.

Standards

- Standards is essential in
  - Creating/maintaining open and competitive markets
  - Guaranteeing national/international interoperability
- Two categories:
  - De Jure ("by law" or "by Regulation") standards
  - De Fecto ("by fact" or "by convention") standards
    - Proprietary standards: Closed standards
    - Nonproprietary standards: Open standards
- Standard comities
  - ISO (international organization for standardization)
    - Voluntary international organization
  - ANSI (American National Standard Institute)
    - Private non-profit corporation in US.
  - IEEE (Institute of Electrical and Electronics Engineers)
    - The largest engineering society in the world.
  - EIA (Electrical Industries Alliance)
    - Non-Profit organization in US

Standards

- ITU (International Telecommunication Union)
  - Formerly, CCITT formed by UN
- IETF (Internet Engineering Task Force)