



Computer Networks Fundamentals

References

- **Books**
 - Cisco Student Guide ICND1
 - CompTIA Network N10-006 Cert Guide
 - Data and Computer Communications - William Stallings 8th Edition
 - TCP/IP Protocol Suite - Behrouz A. Forouzan 4th Edition
 - Understanding IPv6 – Joseph Davies 2nd Edition

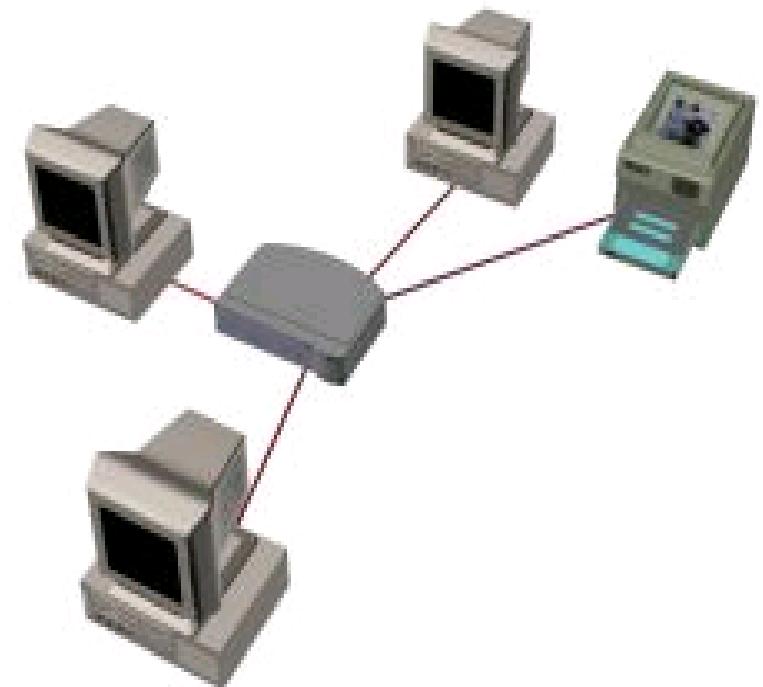
Course Objective

- Introduction to Computer Networks
- OSI Model
- TCP/IP Model
- Ethernet Protocol
- Network Devices
- Network media
- Introduction to Wireless Networks
- Security Fundamentals

What is the Computer Network (CN) ?

Computer Network :

a collection of computers, and other devices, or peripherals connected together through connecting media to perform certain task such as share resources



Benefits of Computer Networks

- **Resources Sharing**
 - File Sharing
 - Devices Sharing
 - Software Sharing with multi-user licenses.
 - Voice and Video calls
- **Shared Internet Access**

Basic Network Terminologies

❖ **NIC (Network Interface Card)**

The hardware that plugs into the motherboard and directly access the network



❖ **Mac address:**

Physical Address, Unique address over the world burned on the NIC card

❖ **IP address :**

Logical Address, identify each device on an IP network layer

❖ **Protocols**

Communication rules that all entity must agree on

Basic Network Terminologies

❖ **Hub**

Allow different nodes to communicate with each other at the same network(Slow the network)



❖ **Switch**

Allow different nodes to communicate with each other at the same network and time without slowing each other



❖ **Router**

Allow different networks to communicate with each other



How to apply networks ?

Networks Classifications

➤ According to Covered Area

- How large is the network?

➤ According to network topology

- How the computer are connected?

➤ According to network model

- What type of model?

Networks Classifications

According to Covered Area
PAN – MAN- WAN-INTERNET

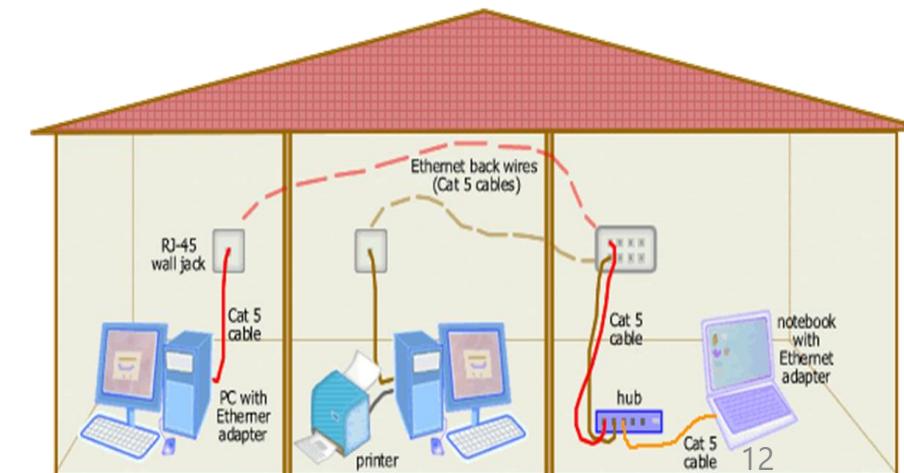
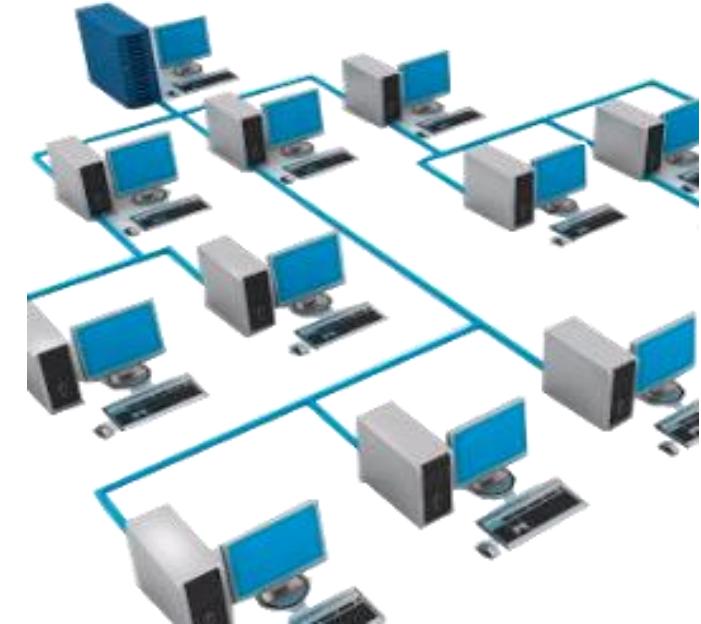
According to Covered Area

- Personal Area Networks (**PAN**)
 - A computer network for interconnecting devices centered on an individual person's workspace.
 - A **PAN** provides data transmission among devices such as computers, smartphones, tablets and personal digital assistants



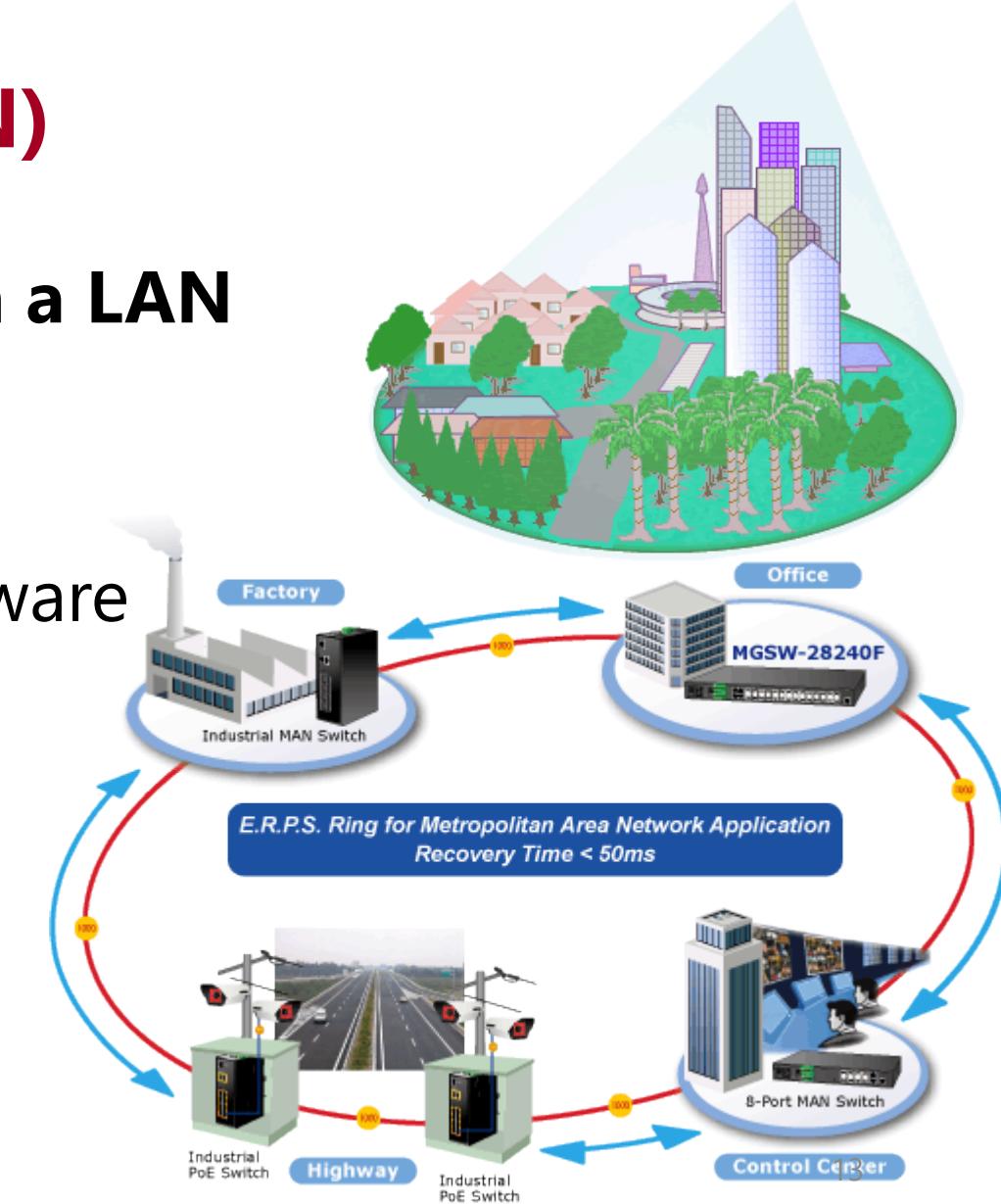
According to Covered Area

- Local Area Networks (**LAN**)
 - a group of computers connected in **small geographical** area
 - a limited area such as a residence, school, laboratory, university campus or office building
 - Allow users to share files and services
 - **High speed** of communications
 - Under your **administrative Control**



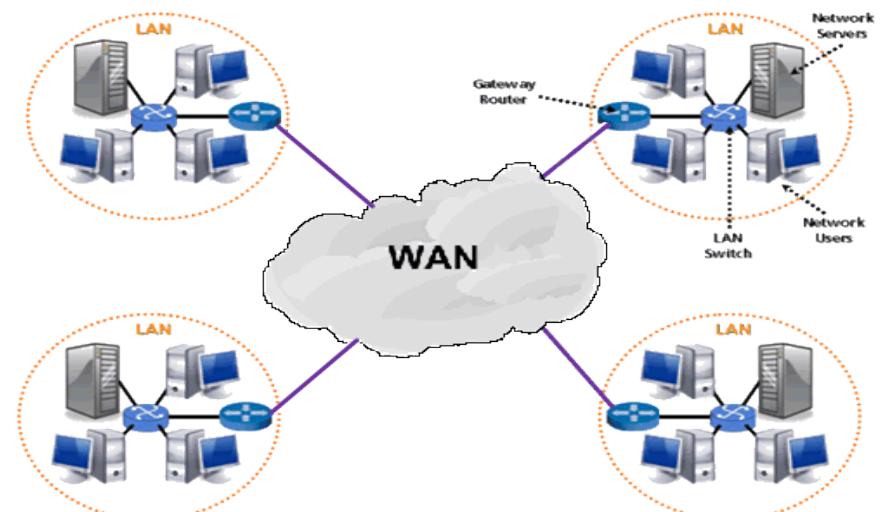
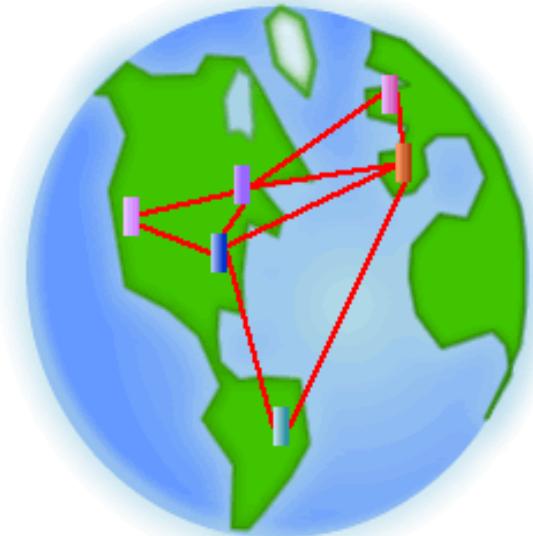
According to Covered Area

- Metropolitan Area Networks (**MAN**)
 - A MAN connects an **area larger than a LAN but smaller than a WAN**
 - such as a **city**.
 - dedicated or high-performance hardware



According to Covered Area

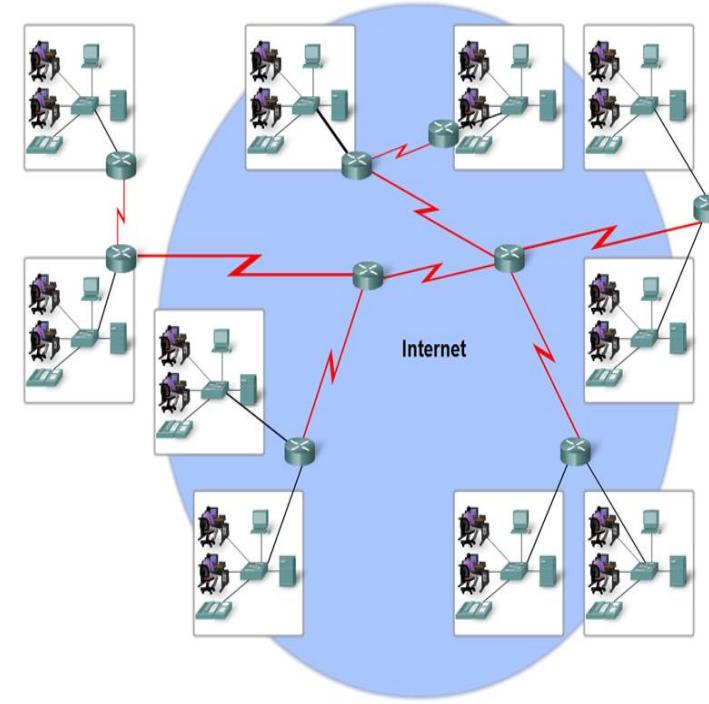
- Wide Area Networks (**WAN**)
 - A WAN is a group of computers connected in **Large geographical** area such as **country**
 - A WAN often connects two LANs (WAN Link)
 - Very low Speed
 - Under your **ISP** Administrative control



Internet

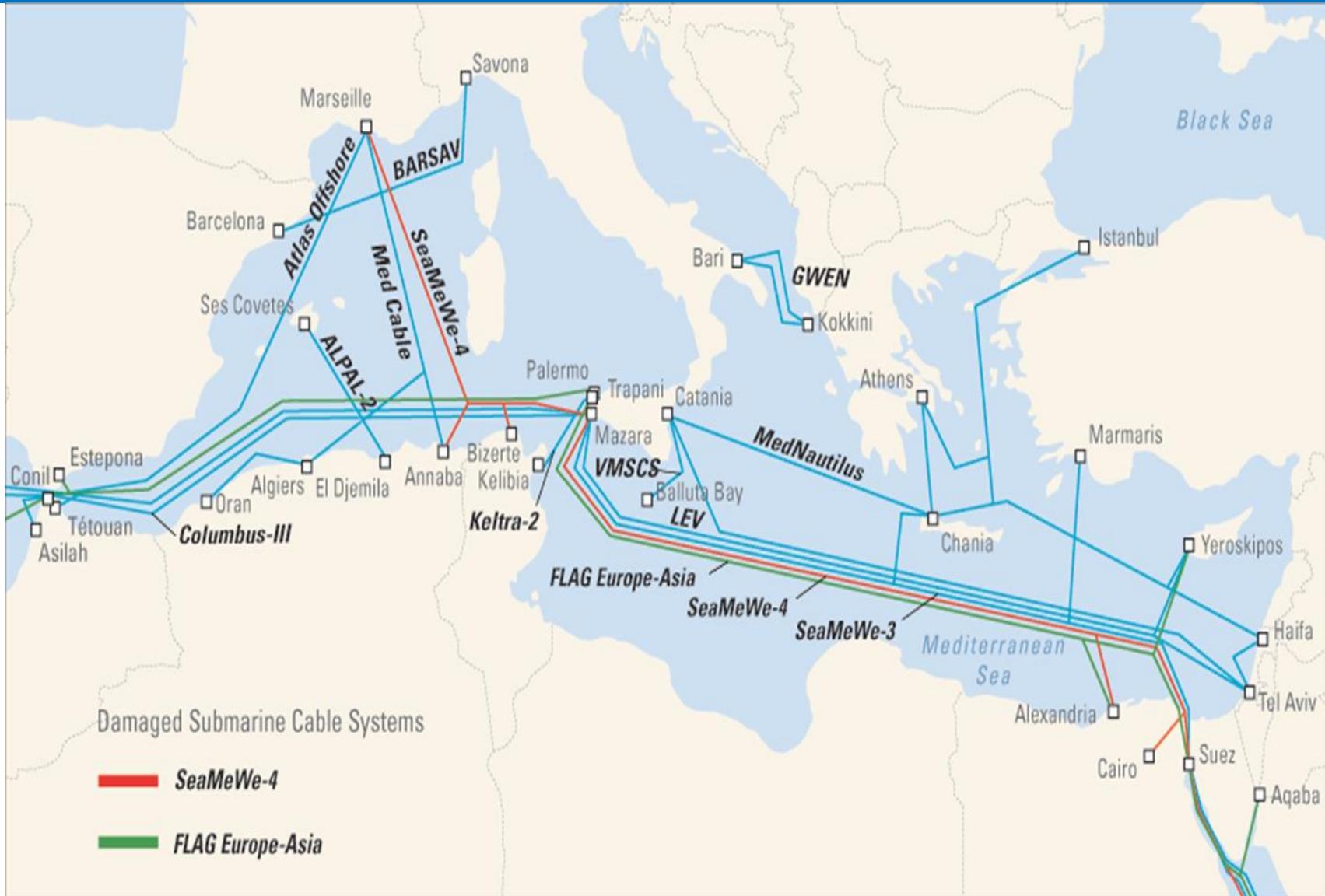
- **Internet (www)**

- The internet is defined as a **global mesh** of interconnected networks
- the most used service on the Internet is the **World Wide Web**
- No one actually owns the Internet
- Many Orgs, ISPs, Companies, Govs own pieces of Internet Infrastructure.
 - ISOC: Internet Society
 - IETF: Internet Engineering Task Forum
 - **ICANN**: Internet Corporation for Assigned Names and Numbers



Internet Gateway in Egypt

- ✓ 1993
 - 9.6Kbps link between the Egyptian Universities Network and France
- ✓ 1994
 - Provide 64Kbps digital access to France



Networks Classifications

According to Network Topology

Bus – Star- Ring- Mesh-Hybrid

Network Topology

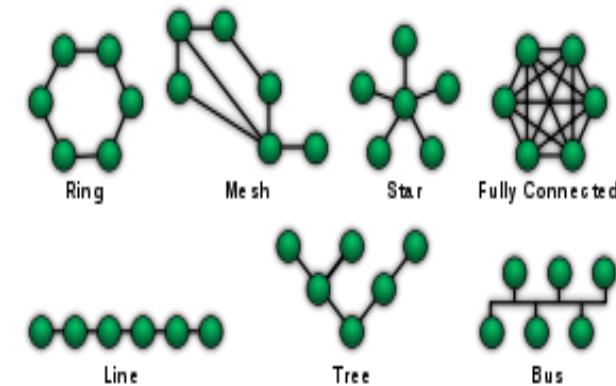
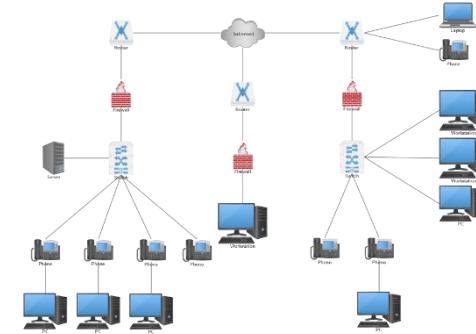
Topology

- refers to the **shape of a network**, or the network's layout.
- Two types of Network topologies:

The physical topology: physical way (how computers connected to each other physically : wired or wireless)

The logical topology: the way the message are sent. (how to send message from device to other)

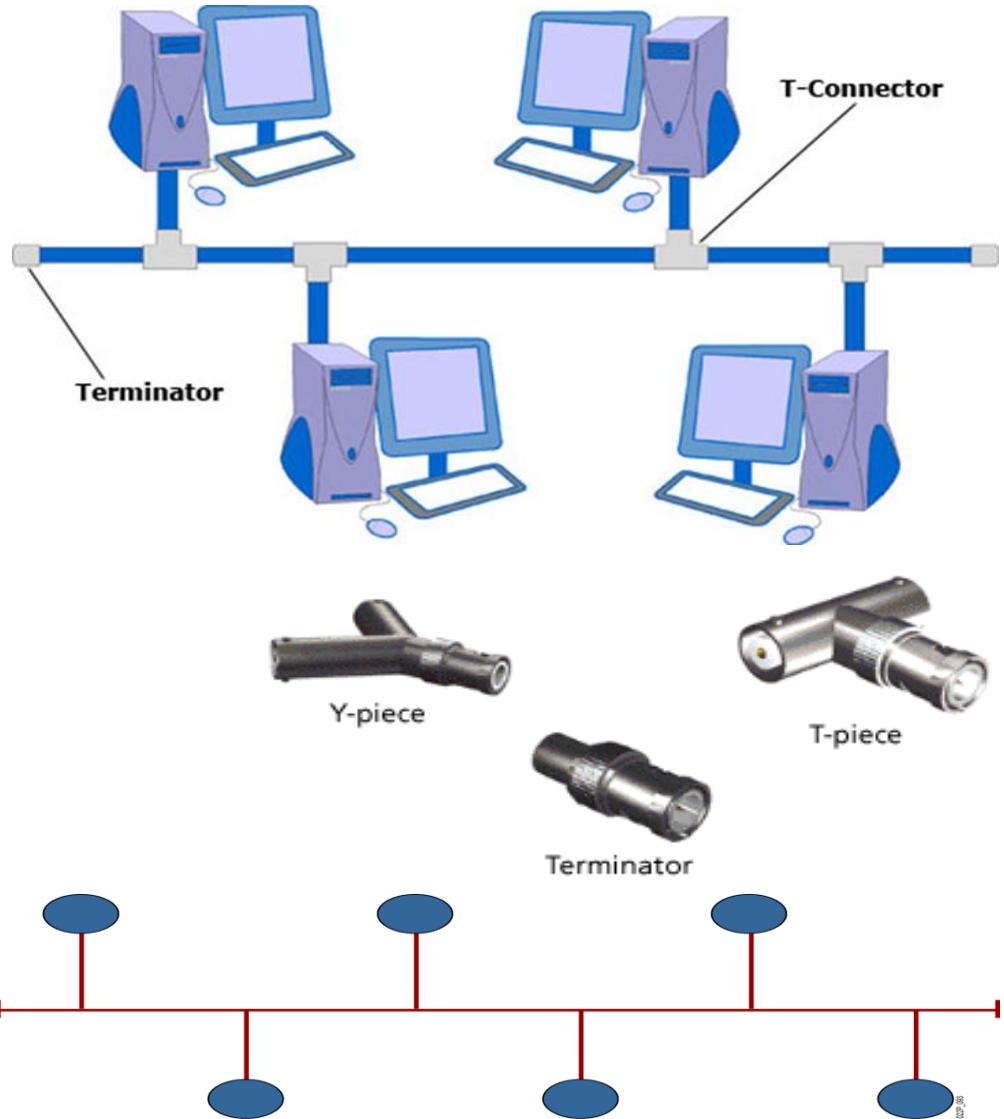
- The choice of topology is dependent upon :
 - ✓ **Type and number of equipment being used**
 - ✓ **Cost**
- Each topology has its own **advantages and disadvantages**.



Network Topology

Bus Topology

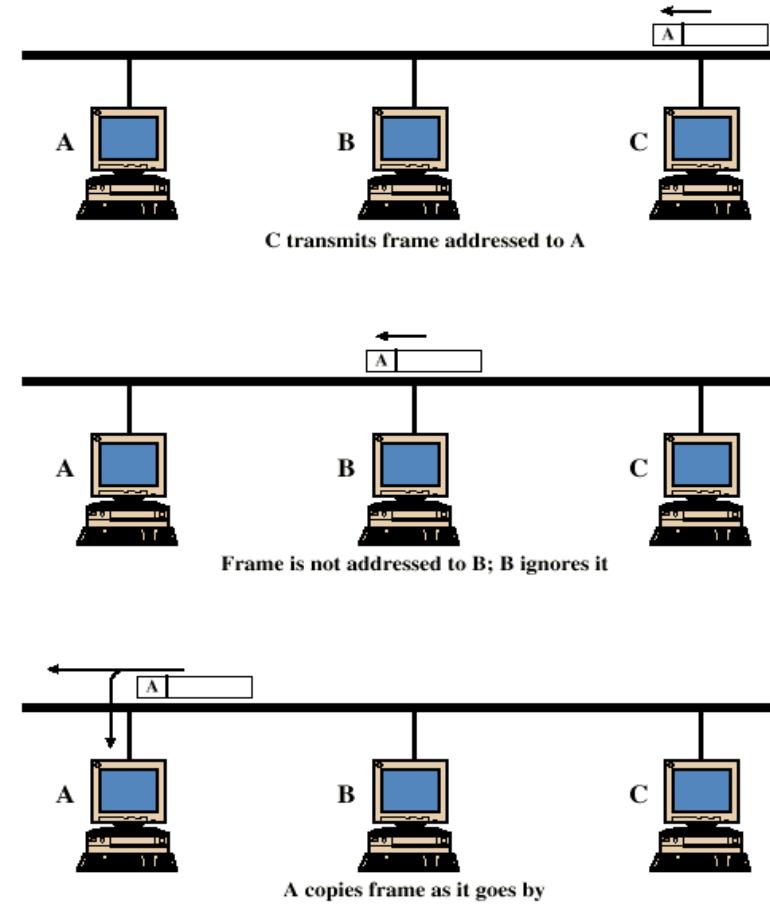
- All devices are connected to a central cable, called the bus or backbone
- Both ends of the network must be terminated with a terminator.
- A barrel connector can be used to extend the network.



Network Topology

Frame Transmission - Bus LAN

- The backbone functions as a shared communication medium
- Device wanting to communicate with another device on the network sends a message onto the backbone
- The message is **heard by all stations**, but only the intended recipient actually accepts and processes the message.
- Terminator absorbs frames at end of medium



Station C wants to transmit a frame of data to station A.

Network Topology

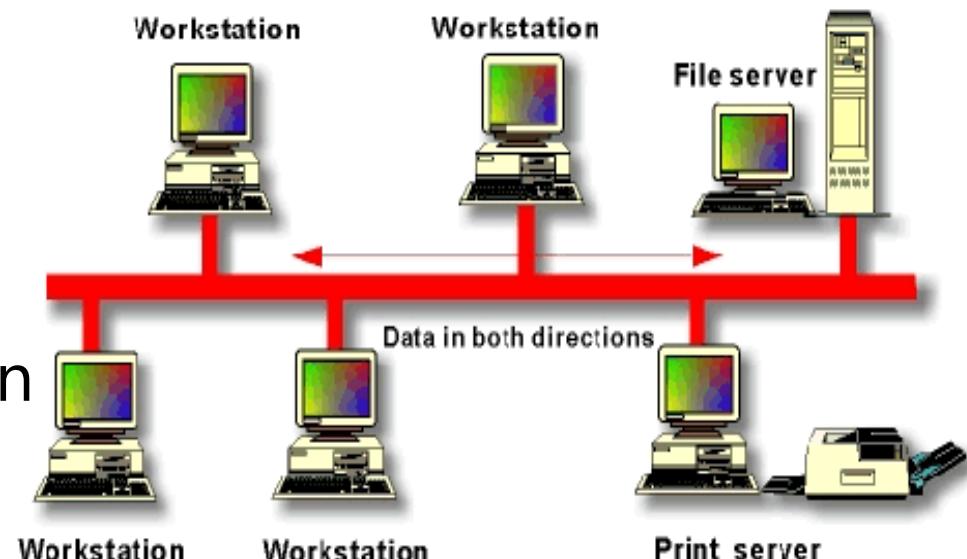
Bus Advantages and Disadvantages

- **Advantages**

- Simple, easy to use and construct
- Requires least amount of cable (less expensive)
- Reliable

- **Disadvantages**

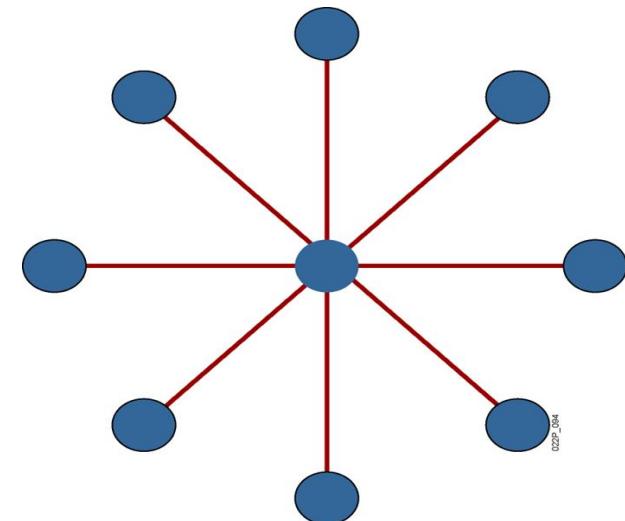
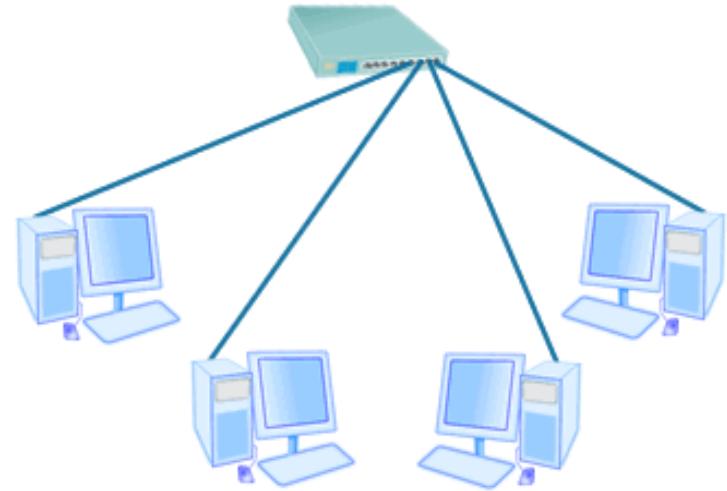
- A faulty cable take the entire LAN down
- Difficult to troubleshoot
- No security
- Slow during peak traffic period



Network Topology

Star Topology

- All the devices are connected to a **centralized unit** such as a Hub or Switch.
- Nodes communicate across the network by passing data through the central device.

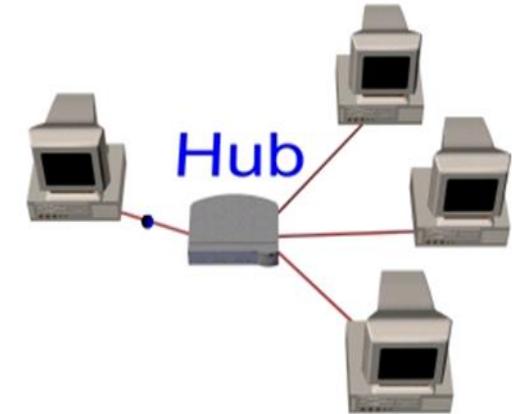


Network Topology

Star Topology types

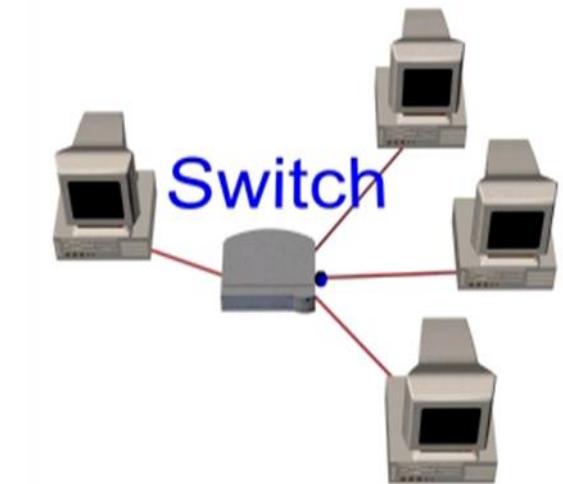
Hubbed Star (Broadcasted Star Topology)

- Central node can broadcast (Hub)
 - Physical star, logically bus
 - **Only one station can transmit at a time**



Switched Star

- Central node can act as frame switch
 - Retransmits only to destination



Network Topology

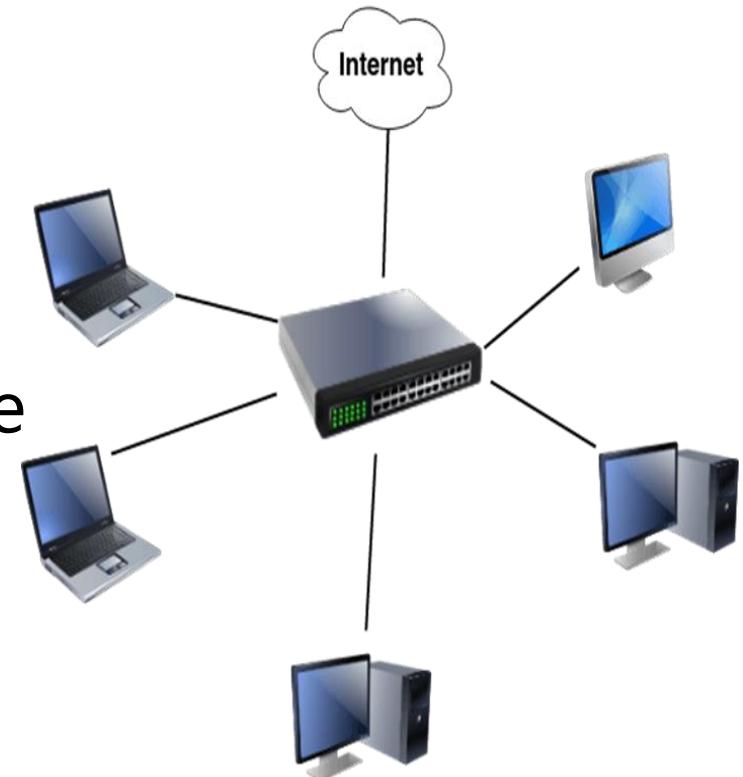
Star Advantages and Disadvantages

Advantages:

- Network not affected if one PC fails
- Network expansion and reconfiguration is simple
- Network management and monitoring can be centralized
- Troubleshooting is easy

Disadvantages

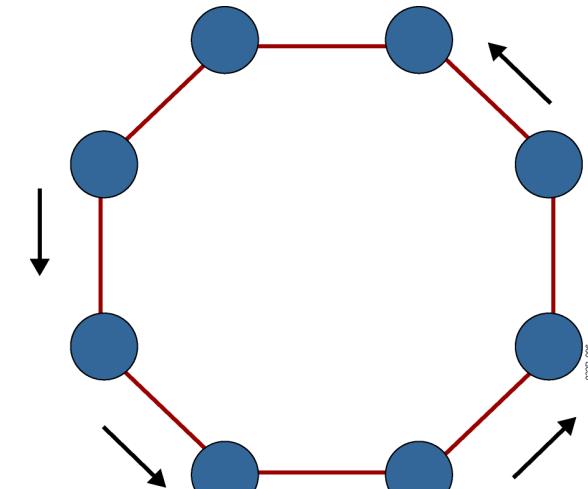
- If the central device fails, all the network fails



Network Topology

Ring Topology

- A cable connects one node to another to form a ring (shape of a closed loop)
- each device is connected directly to two other devices, one on either side of it.
- All messages travel through a ring in the same direction
- **token** is used to transmit data and pass over each station

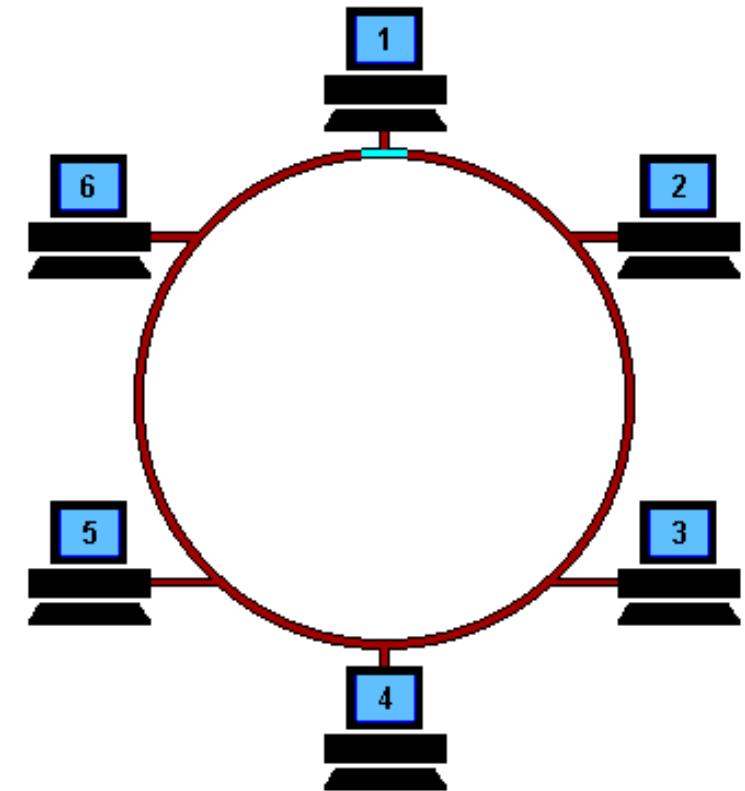


Network Topology

Frame Transmission - Ring LAN

Data transmitted in frames (token)

- ❑ Circulate past all stations
- ❑ Destination recognizes address and copies frame
- ❑ Data is passed one way from device to device.
- ❑ Frame circulates back to source where it is removed
- ❑ **Medium access control** determines when station can insert frame



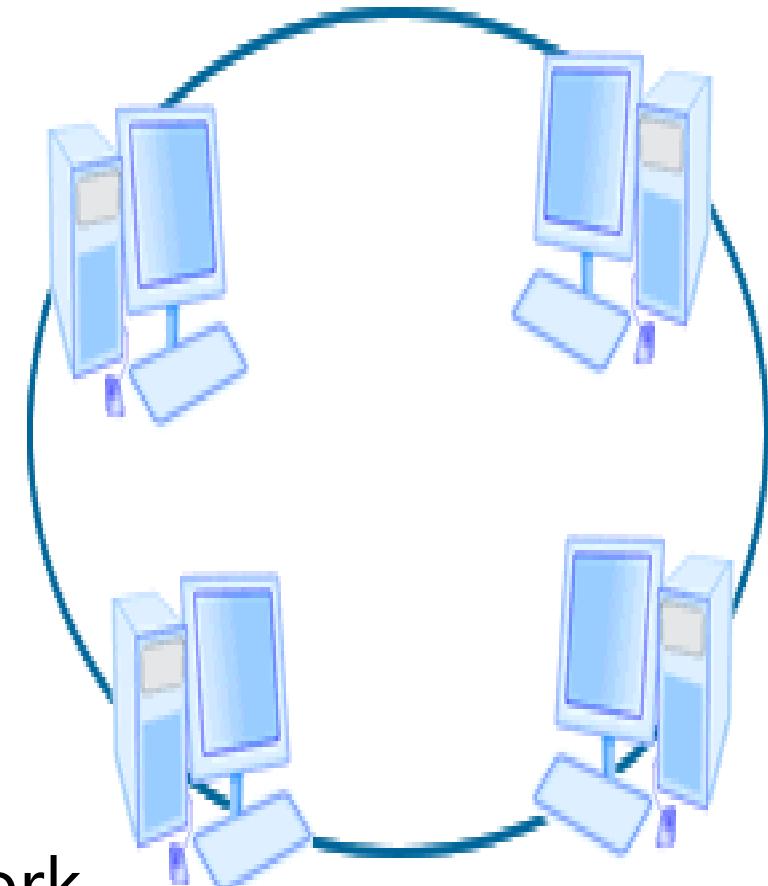
Ring Advantages and Disadvantages

□ Advantages:

- Fair (Equal access for all users)
- Perform **well** under heavy traffic

□ Disadvantages

- Network expansion or reconfiguration will affect the network operation
- If **one node** fails, the entire network fails
- Difficult to troubleshoot
- very bad if we have about **60 pc**, Slow Network



Network Topology

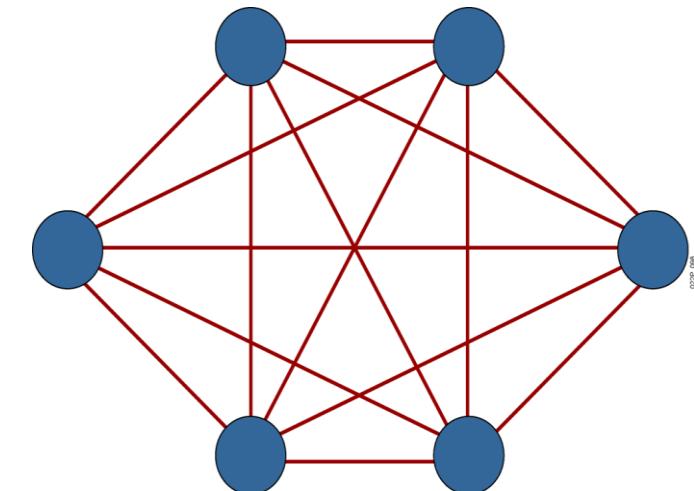
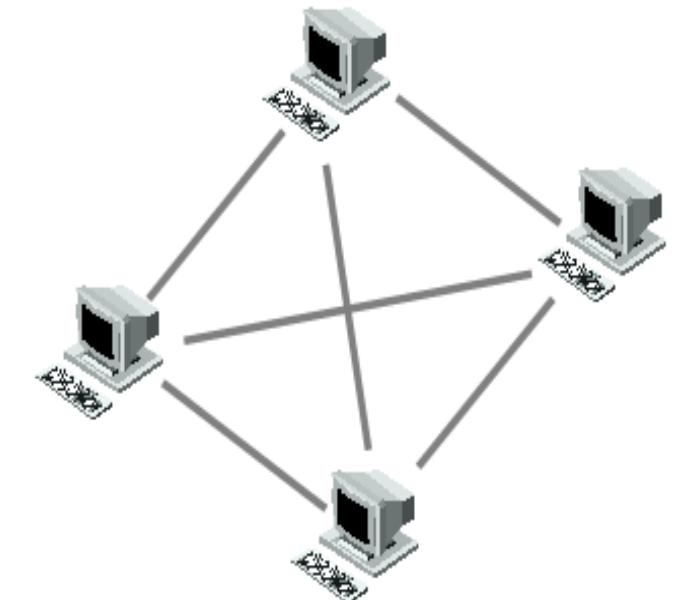
Mesh Topology

- Each device/PC is connected to **every** other device/PC in the network by its own cable
- Amount of cables needed can be calculated by:

$$CN = (D * (D-1)) / 2$$

(where **CN** is **Cables Needed**, and **D** is the amount of **devices** on the network)

- Mesh Types
 - **Full** Mesh
 - **Partial** Mesh



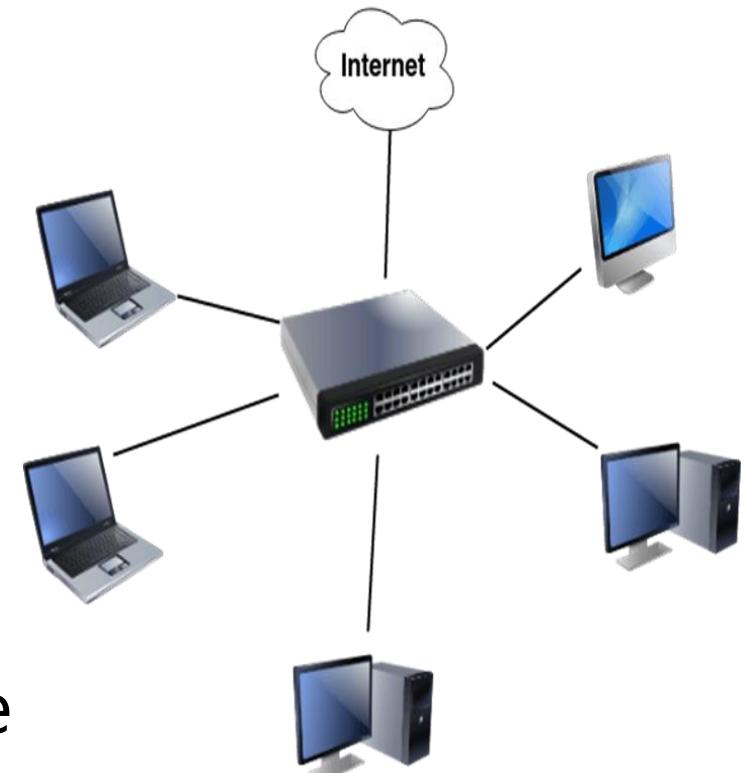
Mesh Advantages and Disadvantages

❑ Advantages:

- Mesh topology boasts the highest fault tolerance of all of the network topologies
- **Redundancy** exist
- **Secure**

❑ Disadvantages

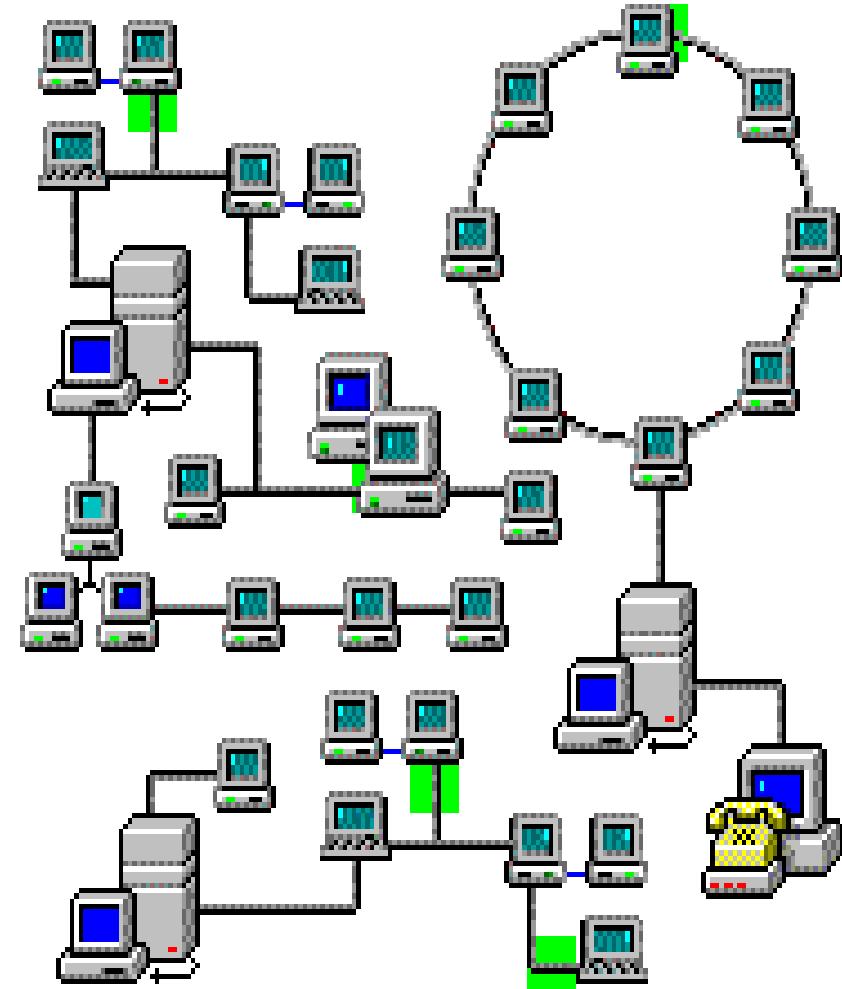
- Because each connection needs its own cable a Mesh topology can get **very expensive**



Network Topology

Hybrid Topology

- Hybrid means that there is more than one topology exist
- Combine bus ,star and ring topologies
- Allow network expansion
- Flexible



Network Topology

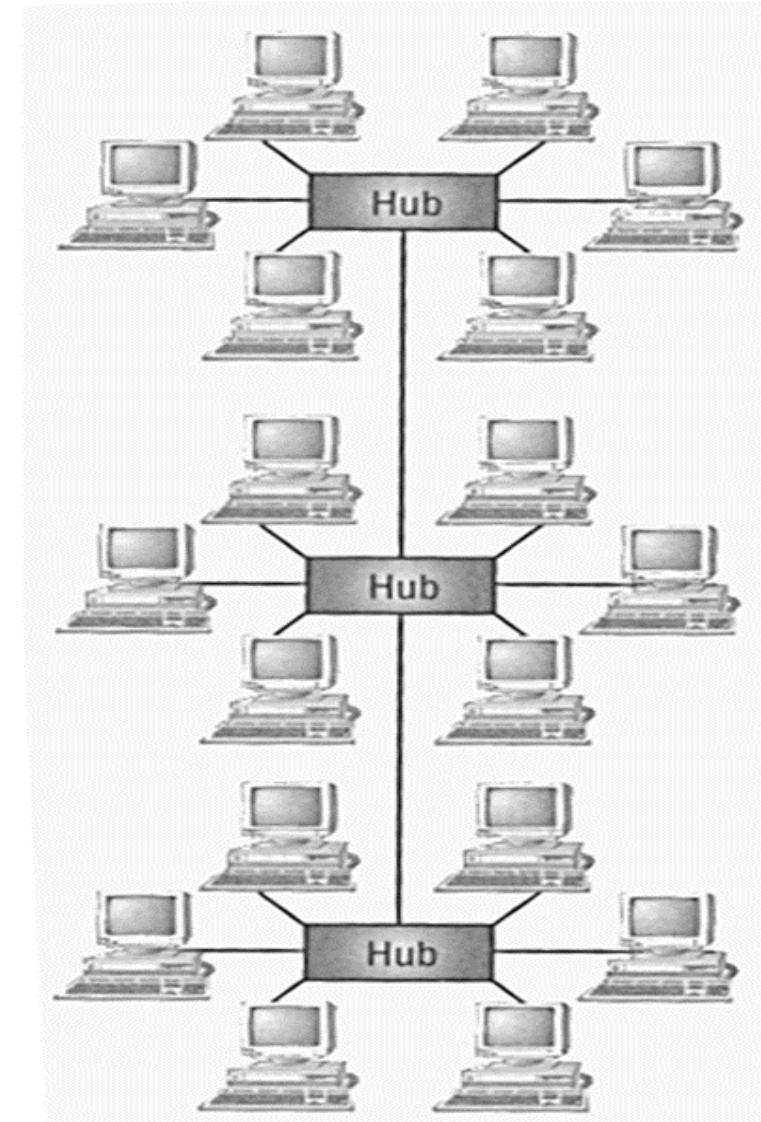
Hybrid Advantages and Disadvantages

❑ Advantages:

- Network **expansion is simple**

❑ Disadvantages

- If hub fails connections between failed hub and other hubs will fail



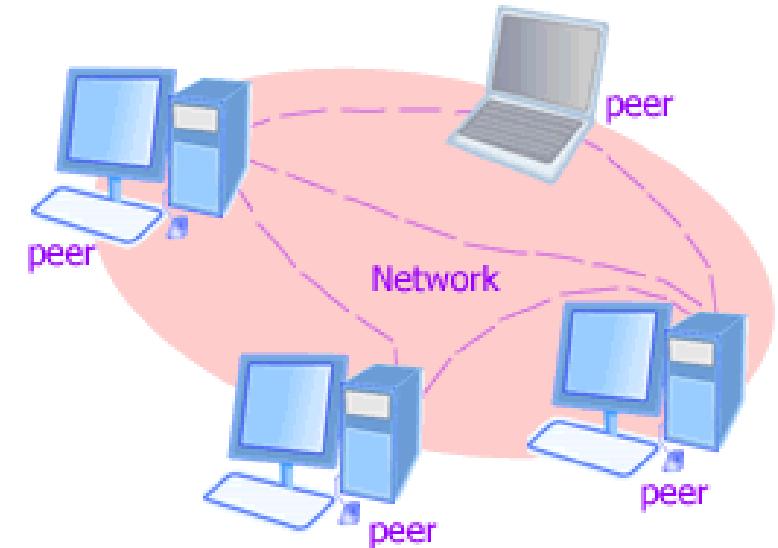
According to Network Model

- Peer to Peer Networks
- Client/Server Networks

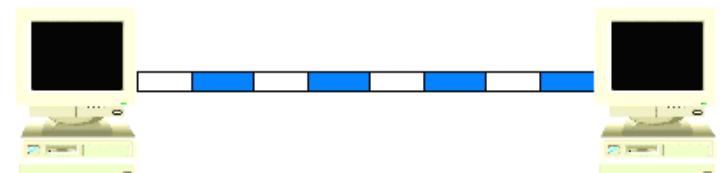
Network Model

Peer-to-Peer Networks

- **No** dedicated resources to present specific service
- **Easy** to work with
- **All nodes are the same** (equal to use the resources)



Example : Windows Workgroup



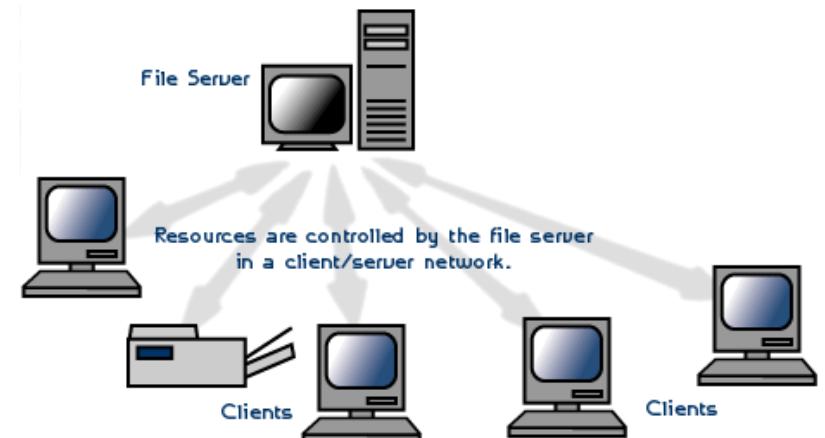
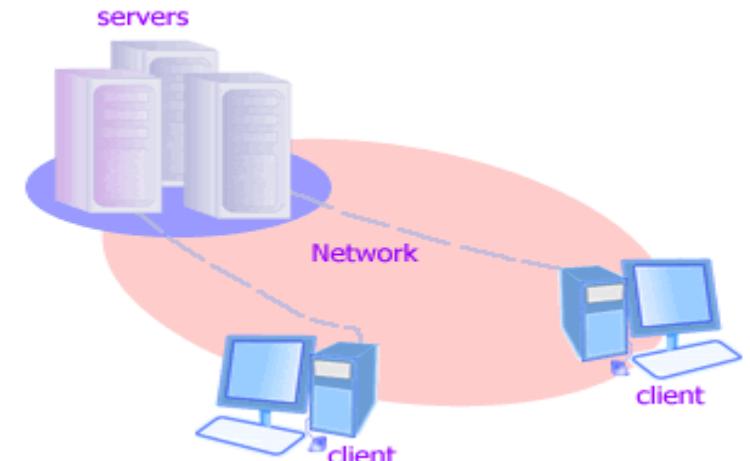
Network Model

Client/Server Networks

- Some nodes (**SERVER**) are dedicated to **present services** to other nodes (**CLIENTS**)
- Server is **more powerful**

Examples:

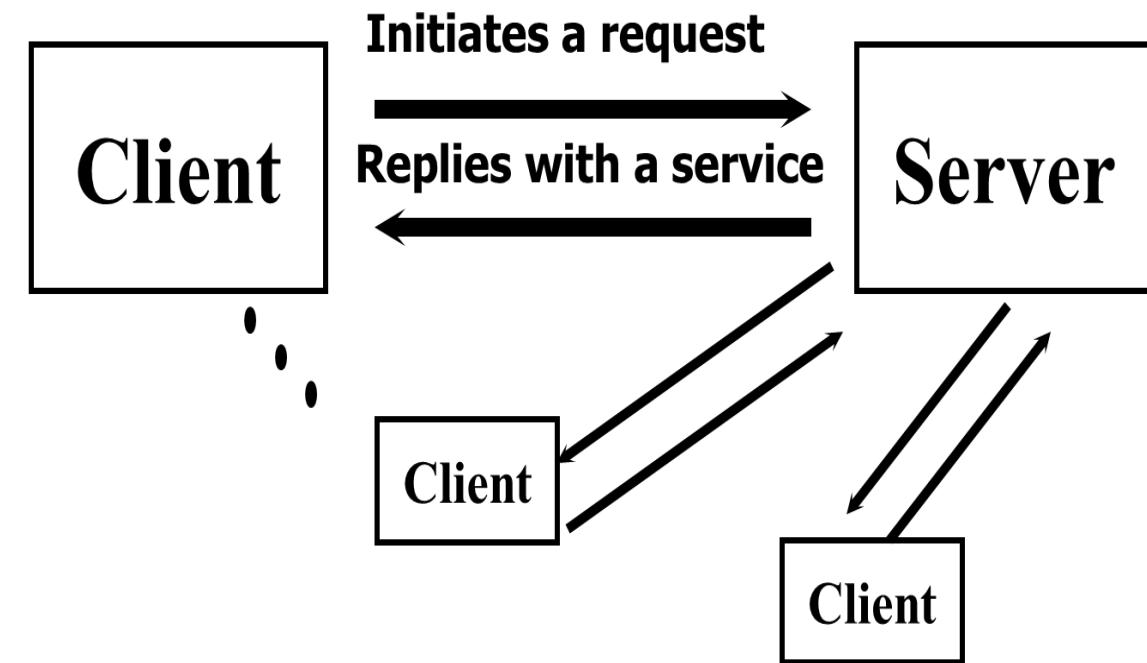
- Mail Server
- Web Server
- File Server
- Print Server



Network Model

Client/Server Networks

- Computers providing the service are called **Servers**
- Computers that request and use the service are called **Client** computers.
- number of servers is very small compared with the number of clients



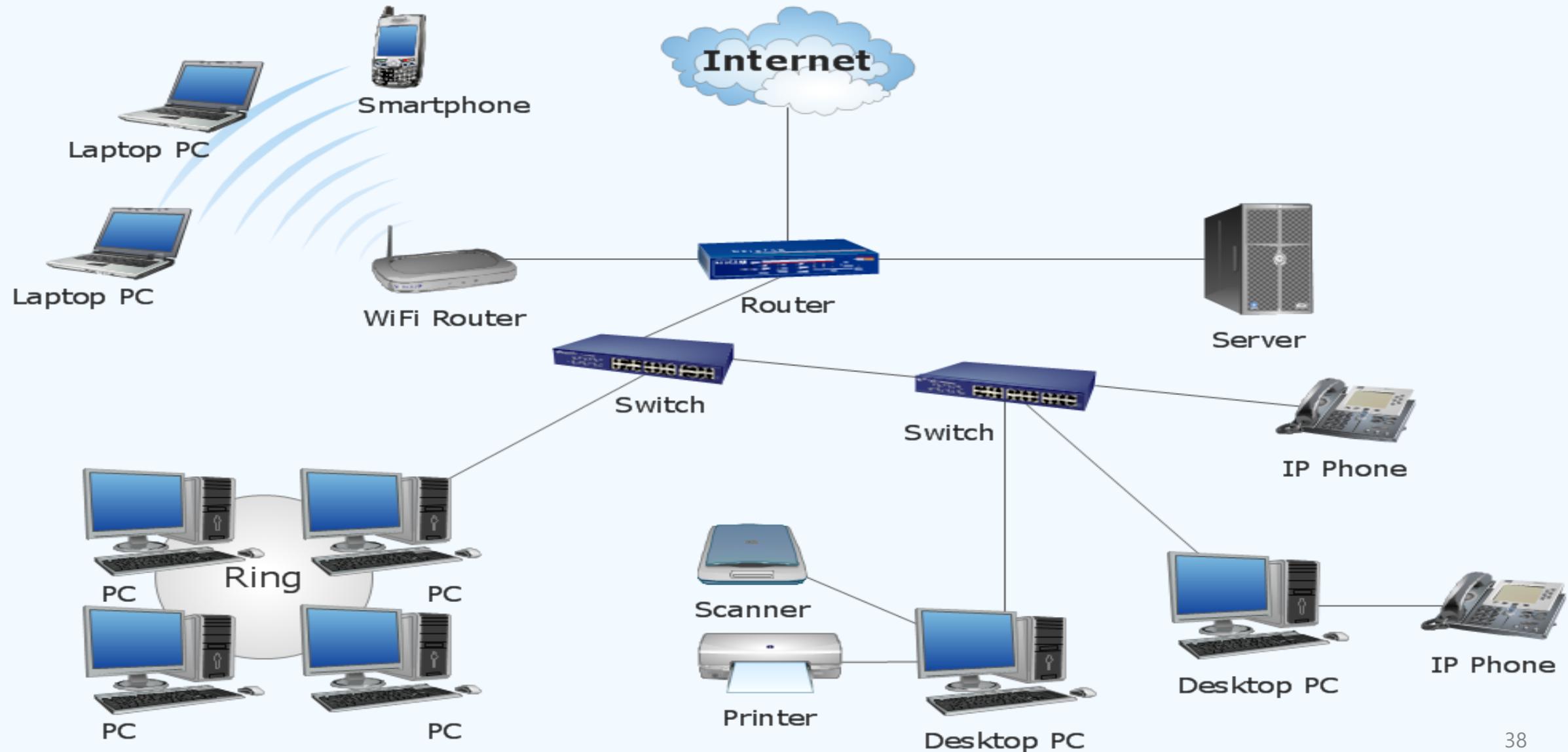
Peer to peer vs client/server model

	Peer to peer	Client/server
Centralization	Local machine no central server	All client machines connect to central server to get service
Storage	Each machine share its files equally with the others	All files and folders are on dedicated storage on the server and client access their files based on database on the server
Cost	inexpensive	Expensive because of server OS license
scalable	In home or small office	Medium/large enterprise
Operating system	Client operating system	Server operating system to handle multiple requests

Building the network

What do you need to build your network?

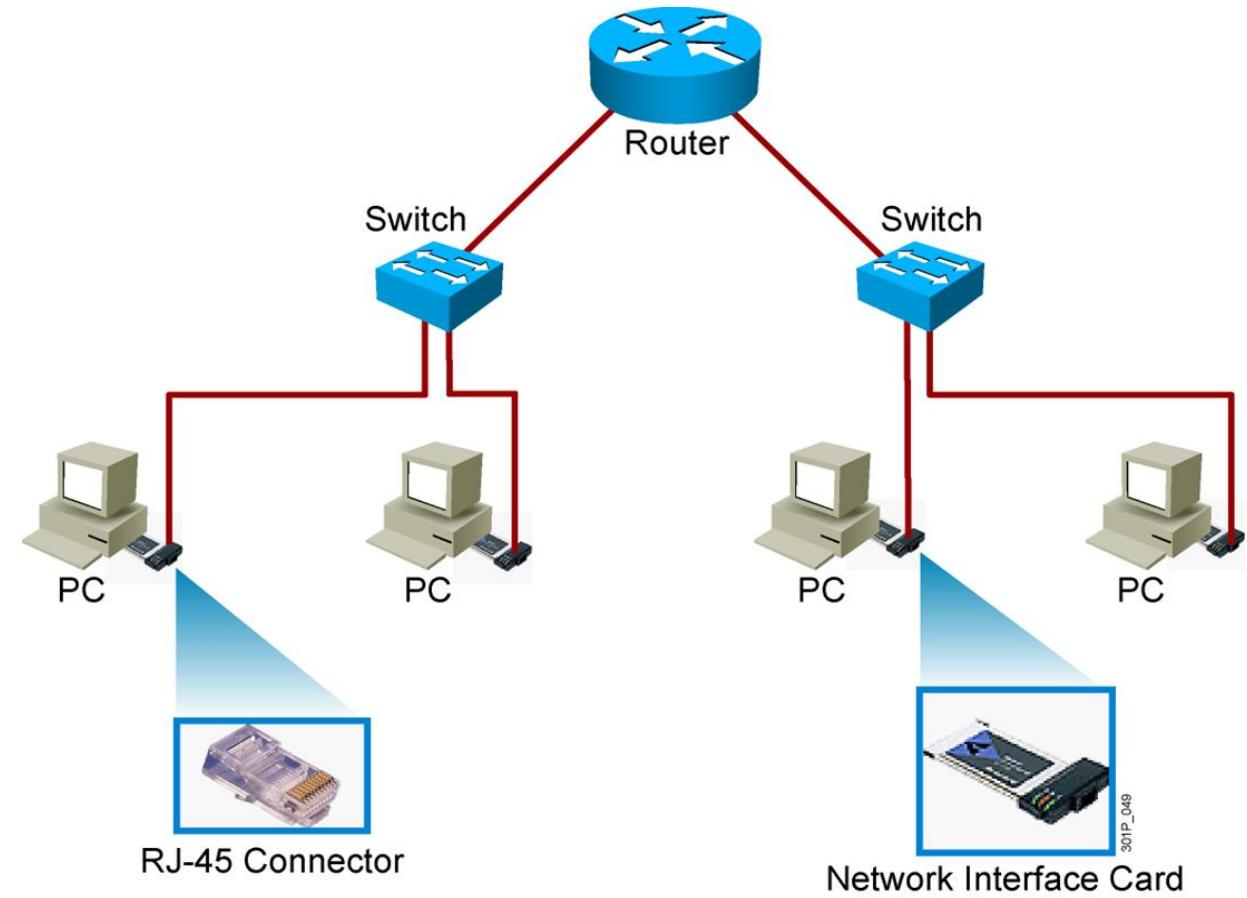
Simple Network



Basic Network Elements

- **Hardware**

- Computers / Peripherals
- NICs
- Connecting Media
- Networking Device(s)
 - Routers
 - Switches
 - Hubs



- **Software**

- Protocols
 - Communication rules that all entity must agree on

Basic Network Elements (Hardware / Software)

□ Hardware

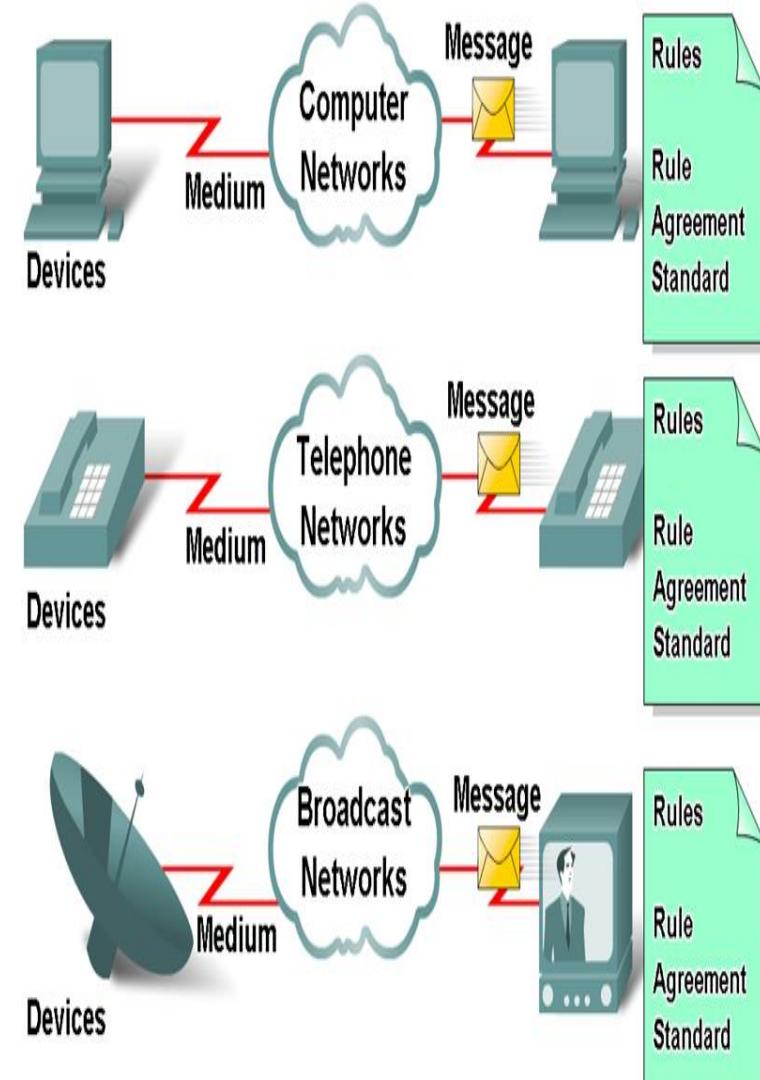
- **Devices** used to communicate with one another
 - Computers – Printers –Phone – Routers - Switches
- **Medium** how the devices are connected together
 - Wired -Wireless –Satellites

□ Software

- **Messages**
Information that travels over the medium
 - Mails-WhatsApp...etc

- Protocols

- Governs how messages flow across network
 - http –https-ftp-rdp



Basic Network Elements (Software)

Software Protocols

Basic Network Elements (Software)

What is Protocols ?

- Communication rules that all entity must agree on it
- Method to connect internetworking elements

Why we need Protocols ?

- To communicate **efficiently**
- **Control** the messages and the messages quantity in the network.

Basic Network Elements (Software)

**Open Systems Interconnection Reference Model
OSI RM**

Basic Network Elements (Software)

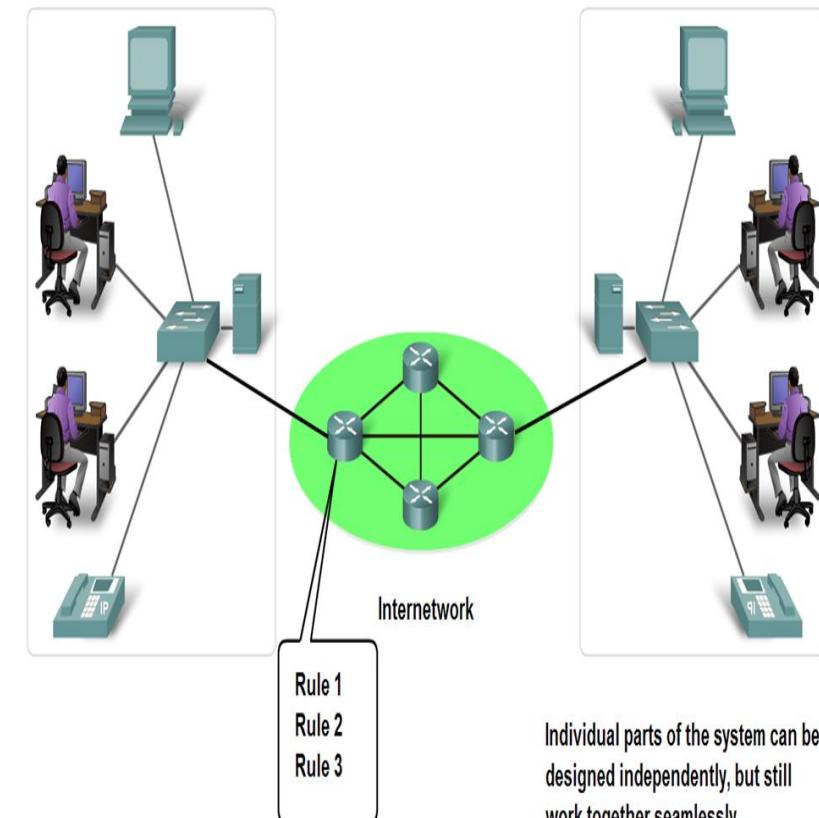
OSI Reference Model

- OSI: Open Systems Interconnect
- OSI/RM was defined by ISO in 1983
 - International Organization for Standardization
- OSI Three practical functions
 - Give developers **universal concepts** so they can develop protocols
 - Explain the framework **used to connect heterogeneous systems** (Client/server can communicate even if they have **different OS**)
 - Describes the **process** of packet creation
- The OSI reference model breaks this approach into **layers**.

Benefits of using a layered model

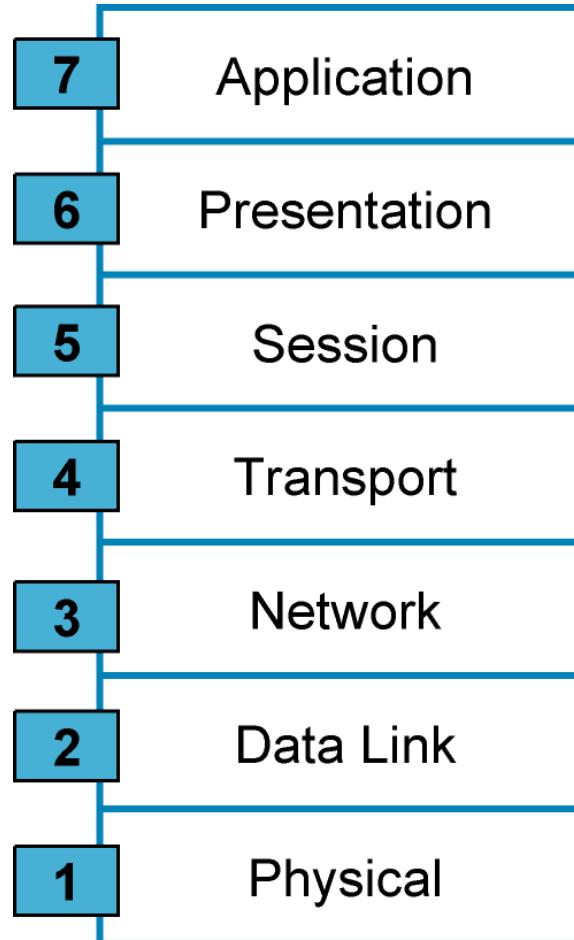
- It divides the network communication process into Layers, so **easier to troubleshooting.**
- It allows **multiple-vendor** development through standardization of network components.
- It **allows various types** of network hardware and software to **communicate**.
- **Changes in one layer do not affect other layers** because of layer separation
- Layers **interact** with each other.

Using a layered model helps in the design of complex, multi-use, multi-vendor networks.



Basic Network Elements (Software)

Why a Layered Network Model?

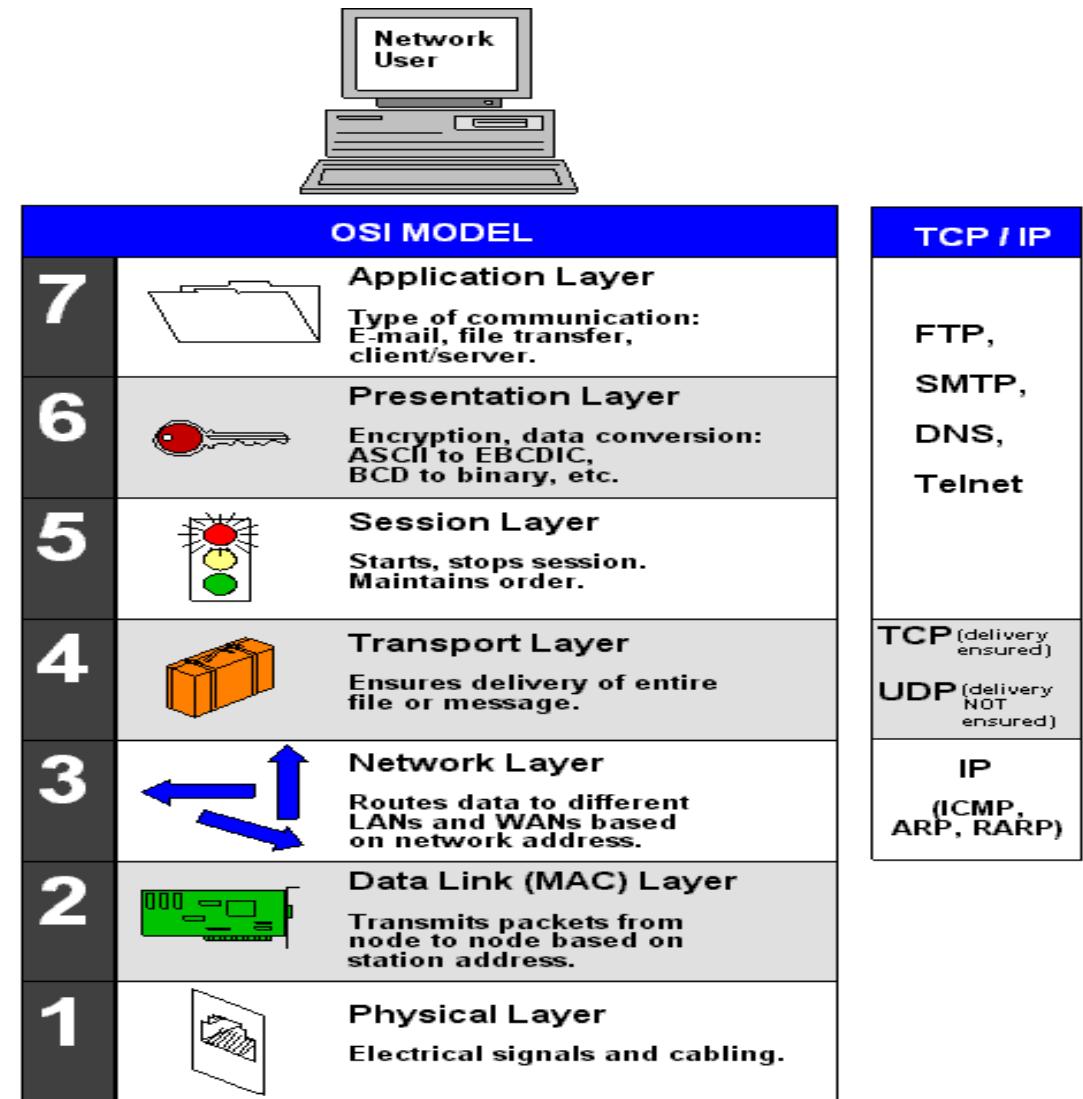


- Reduces complexity
- Standardizes interfaces
- Facilitates modular engineering
- Simplifies teaching and learning

Basic Network Elements (Software)

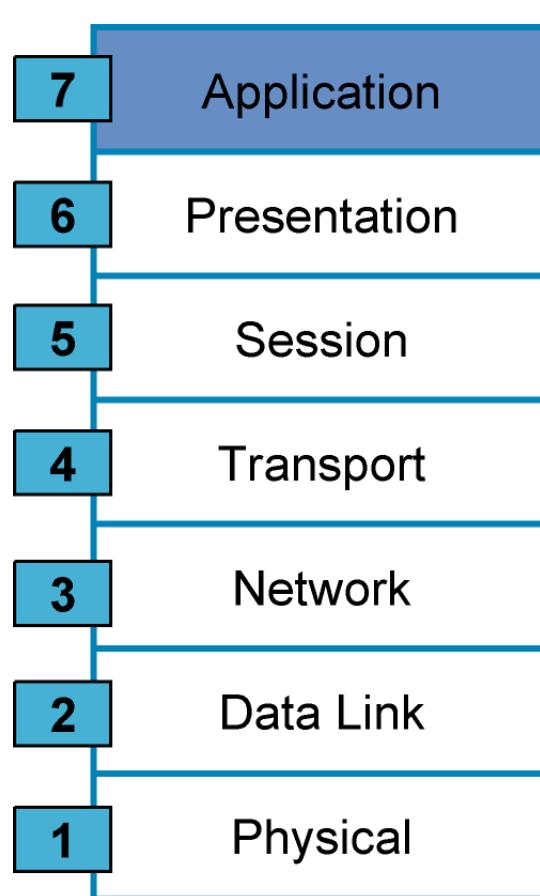
OSI (7-Seven Layers)

- Application
- Presentation
- Session
- Transport
- Network
- Data Link
- Physical



Basic Network Elements (Software)

The Seven Layers Functions (Cont.)



Network Processes to Applications

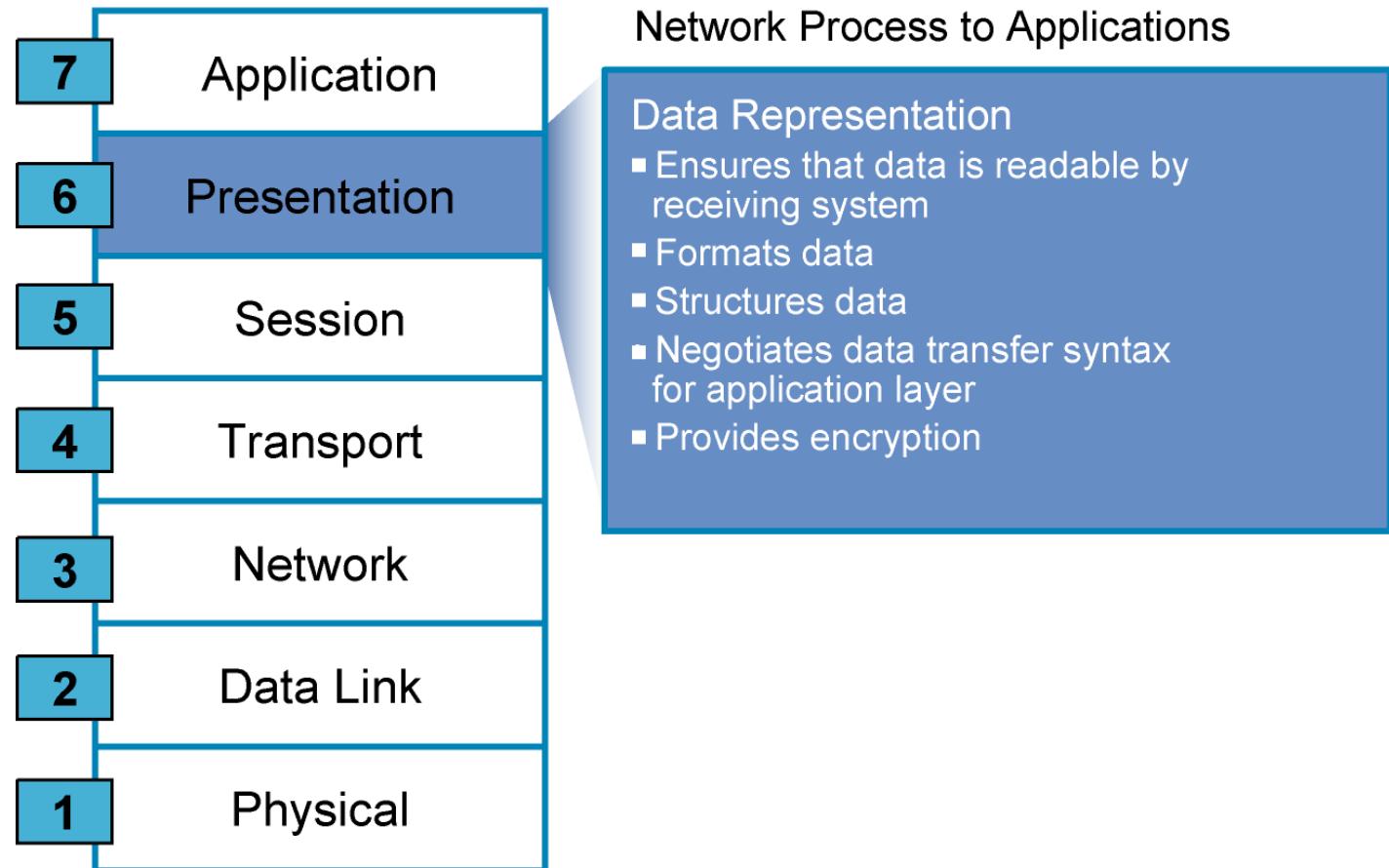
- Provides network services to application processes (such as electronic mail, file transfer, and terminal emulation)
- Provides user authentication

◊ Application Layer

- ◊ Interface to end users
- ◊ File transfer
- ◊ Network management
- ◊ Email
- ◊ Many other services
- ◊ Protocols
 - ◊ HTTP (Hyper Text Transfer Protocol)
 - ◊ FTP (File transfer Protocol)
 - ◊ SMTP (Simple Mail transfer Protocol)
 - ◊ POP3 (Post office transfers Protocol)
 - ◊ Telnet/SSH (secure Shell)
 - ◊ RTP (Real-time Protocol)

Basic Network Elements (Software)

The Seven Layers Functions (Cont.)

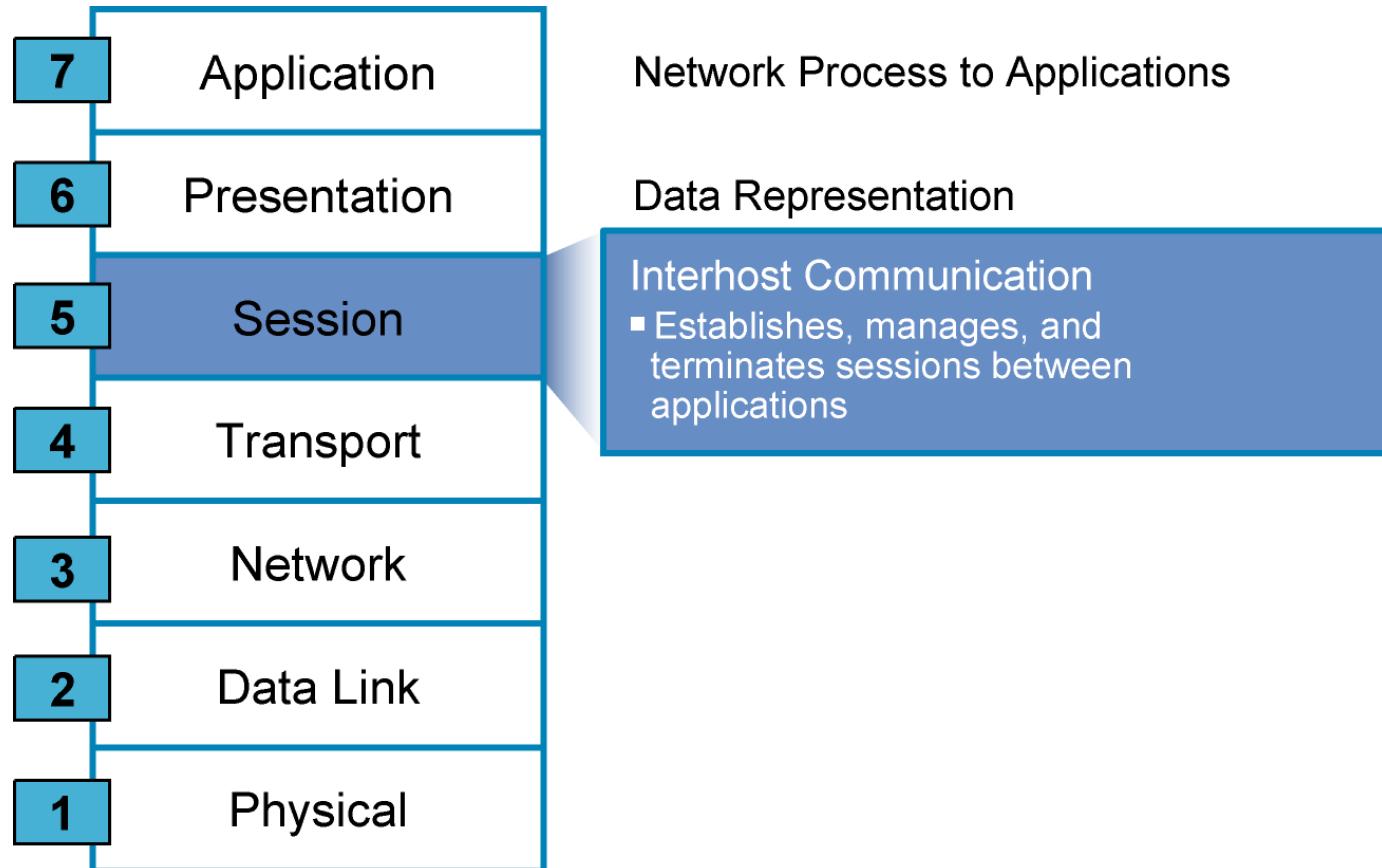


◊ Presentation Layer

- ◊ Finding common presentation between source and Destination
- ◊ Provide transformation of data to support standardized application interface
- ◊ Coding or Translation of data (ex: EBCDIC to ASCII)

Basic Network Elements (Software)

The Seven Layers Functions (Cont.)

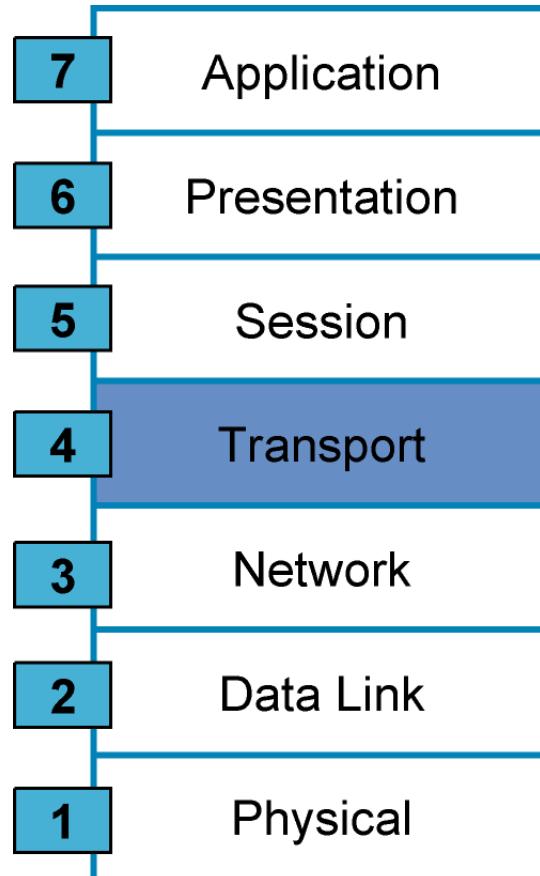


◊ Session Layer

- ◊ Establishes, manages and terminates sessions (connections) between cooperating applications
- ◊ Synchronization (add checkpoints into a stream of data)
- ◊ Controls the sessions between the local and remote applications

Basic Network Elements (Software)

The Seven Layers Functions (Cont.)



Network Process to Applications

Data Representation

Interhost Communication

End-to-End Connections

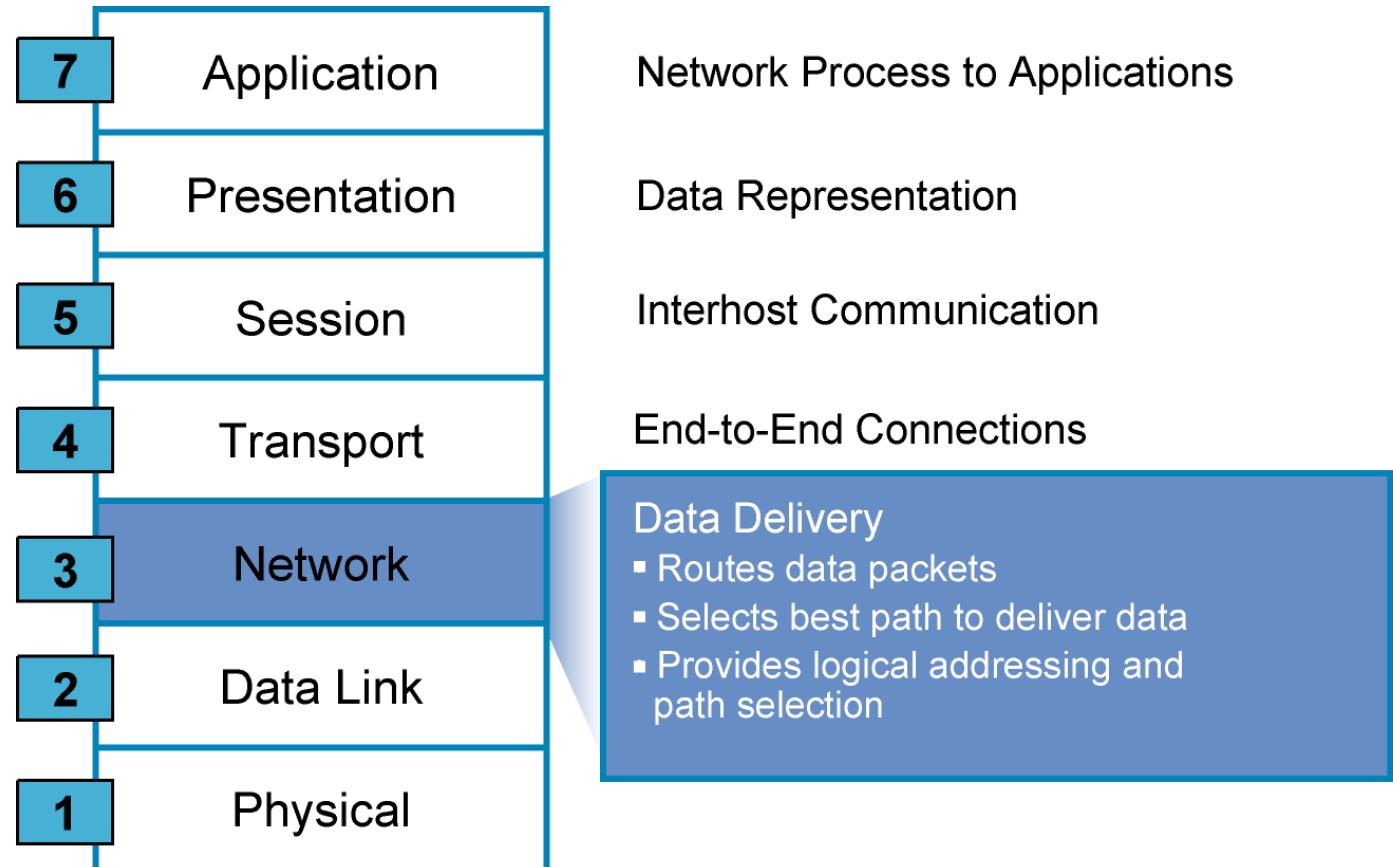
- Handles transportation issues between hosts
- Ensures data transport reliability
- Establishes, maintains, and terminates virtual circuits
- Provides reliability through fault detection and recovery information flow control

◊ Transport Layer

- ◊ Organize data into **Segments**
- ◊ Provide reliable transport between end systems (source and destination hosts)
- ◊ End-to-end **error recovery**
- ◊ End-to-end **flow control**

Basic Network Elements (Software)

The Seven Layers Functions (Cont.)

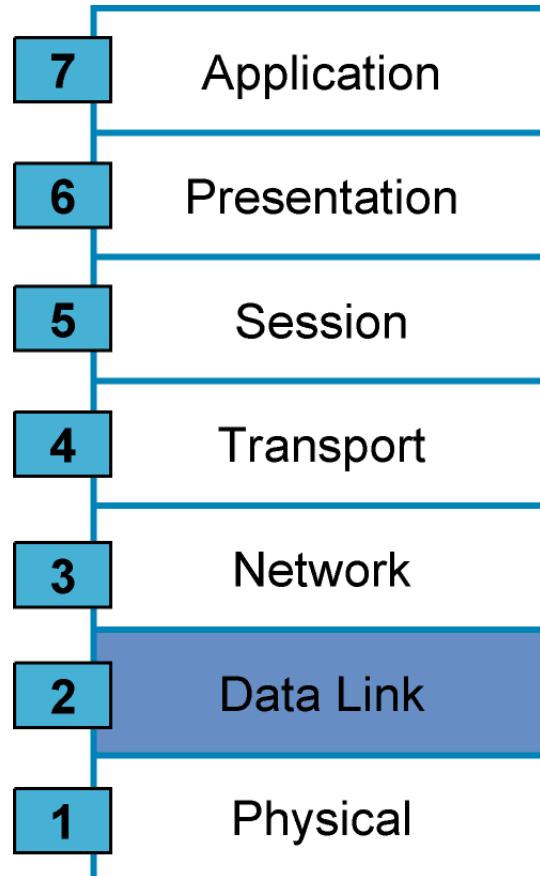


◊ Network

- ◊ Organize data into **datagram (packets)**
- ◊ It is responsible for the Internet Protocol **Addressing (IP)** (Addressing)
- ◊ It know the **best path** for the destination (**Routing**)
- ◊ End-to-end Addressing

Basic Network Elements (Software)

The Seven Layers Functions (Cont.)



Network Process to Applications

Data Representation

Interhost Communication

End-to-End Connections

Data Delivery

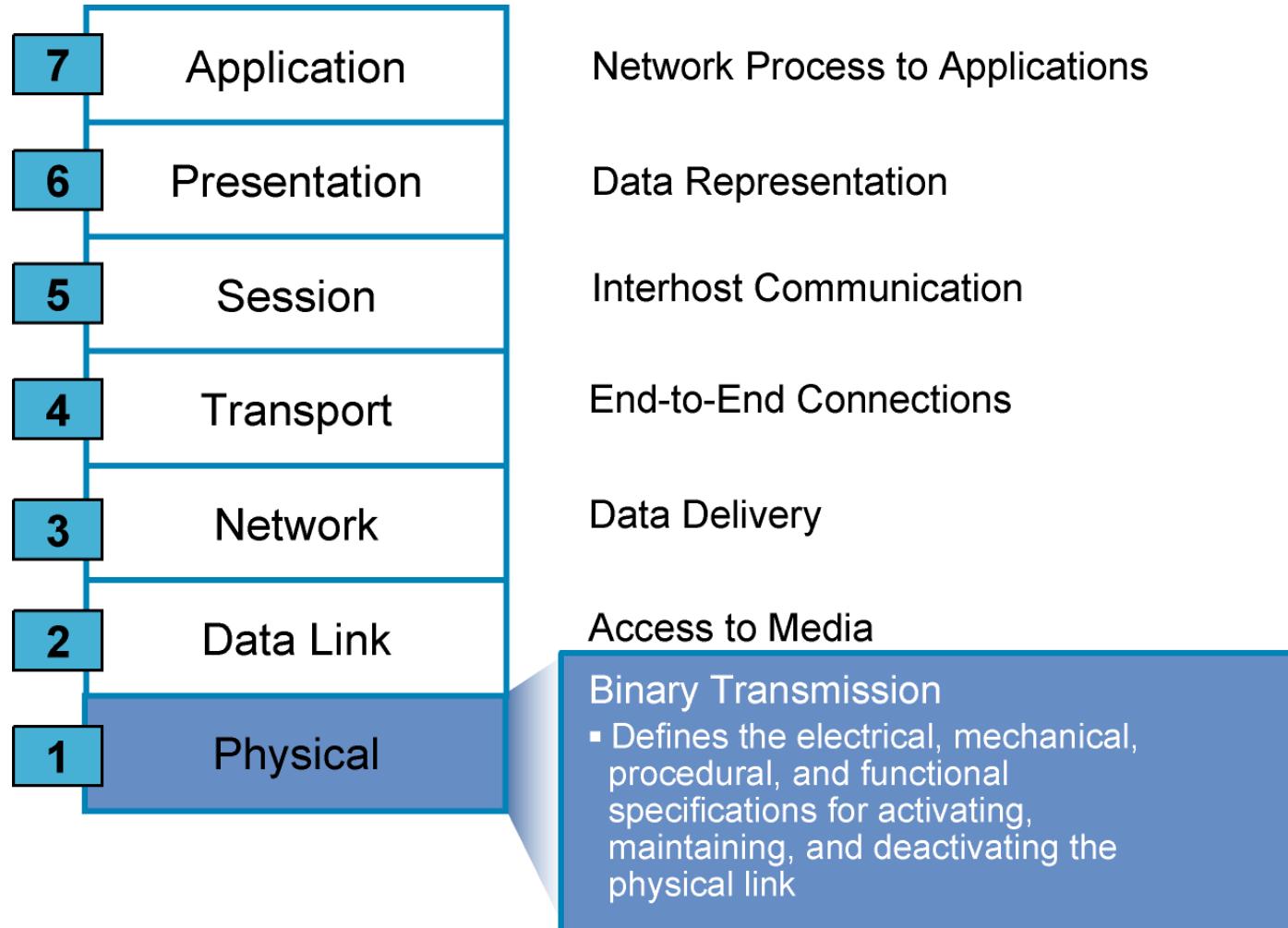
Access to Media

- Defines how data is formatted for transmission and how access to the network is controlled
- Provides error detection

- ◊ **Data link**
 - ◊ Reliable data transfer across a **physical link** (Error Control)
 - ◊ Organize the data into **Frames**, to be put on the physical medium
 - ◊ Check the Frame For errors
 - ◊ **Hop to hop** addressing

Basic Network Elements (Software)

The Seven Layers Functions (Cont.)

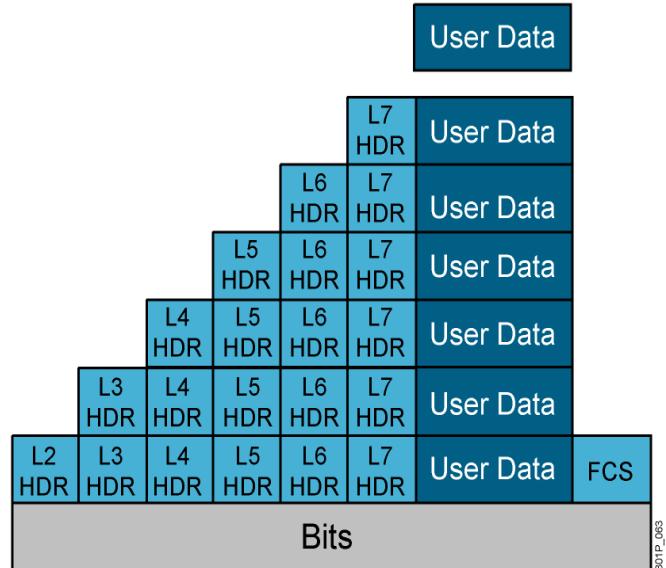
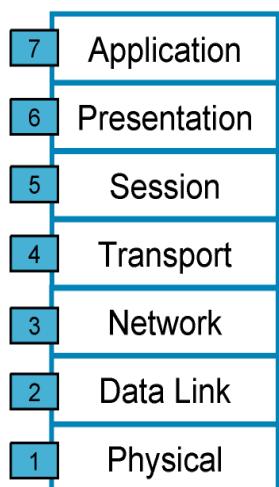


◊ Physical

- ◊ Transmission of unstructured **bit stream** over the physical link
- ◊ Deals with the mechanical and electrical specifications of the interface and transmission media (cables and connectors)
- ◊ Representation of bits

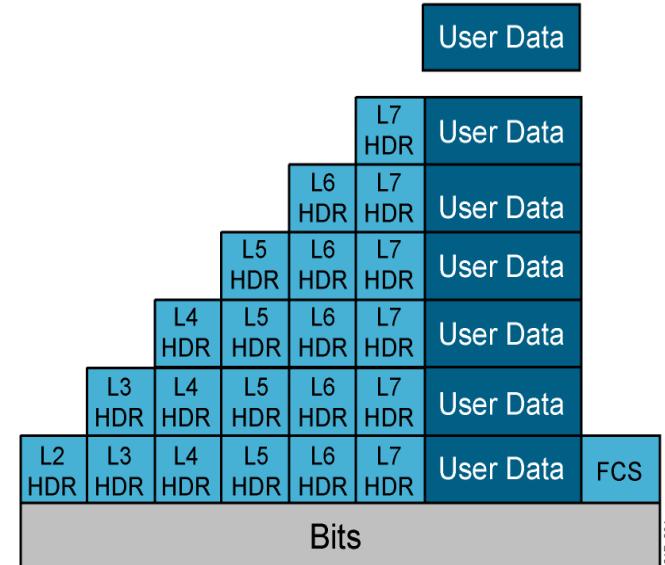
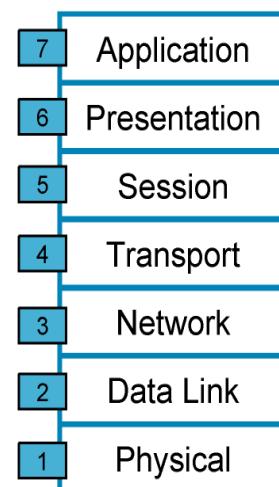
Basic Network Elements (Software)

Data Encapsulation



HDR = Header

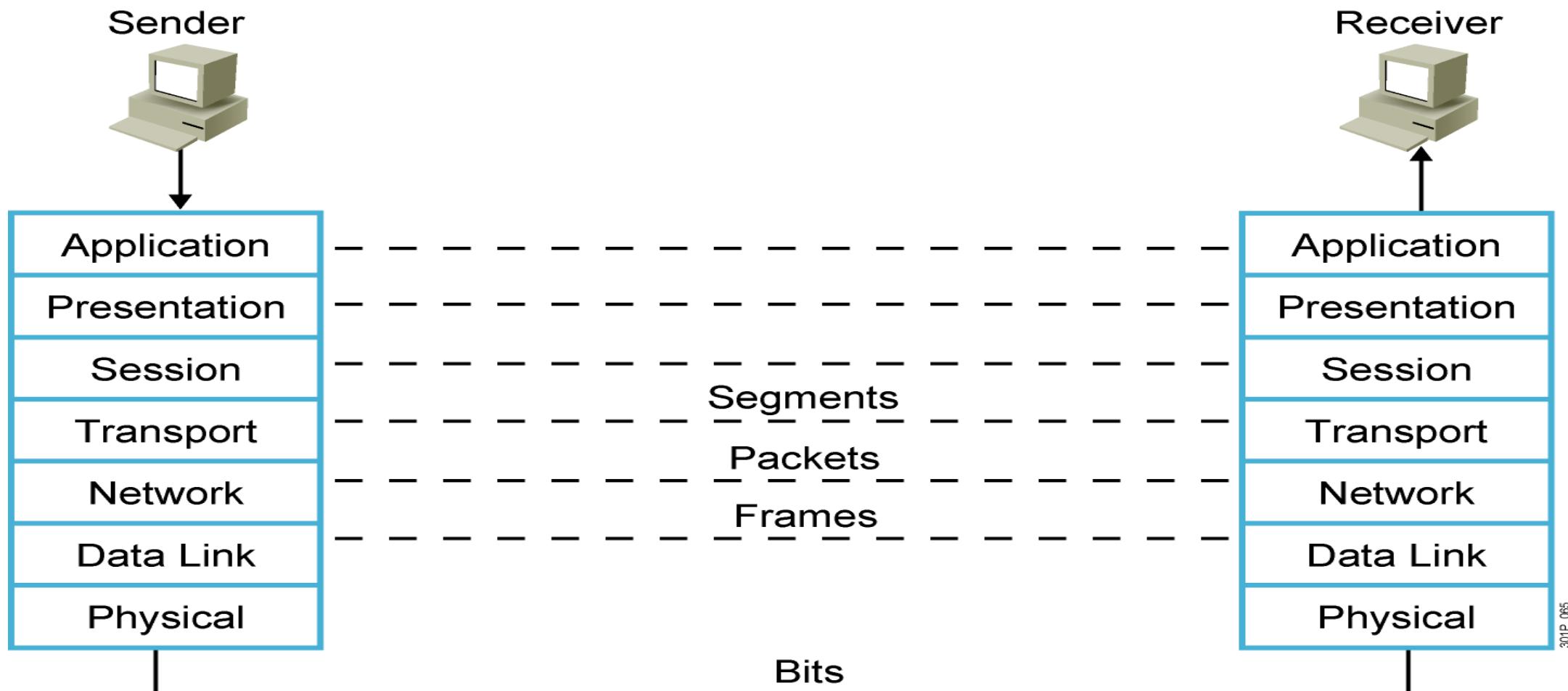
Data De-Encapsulation



HDR = Header

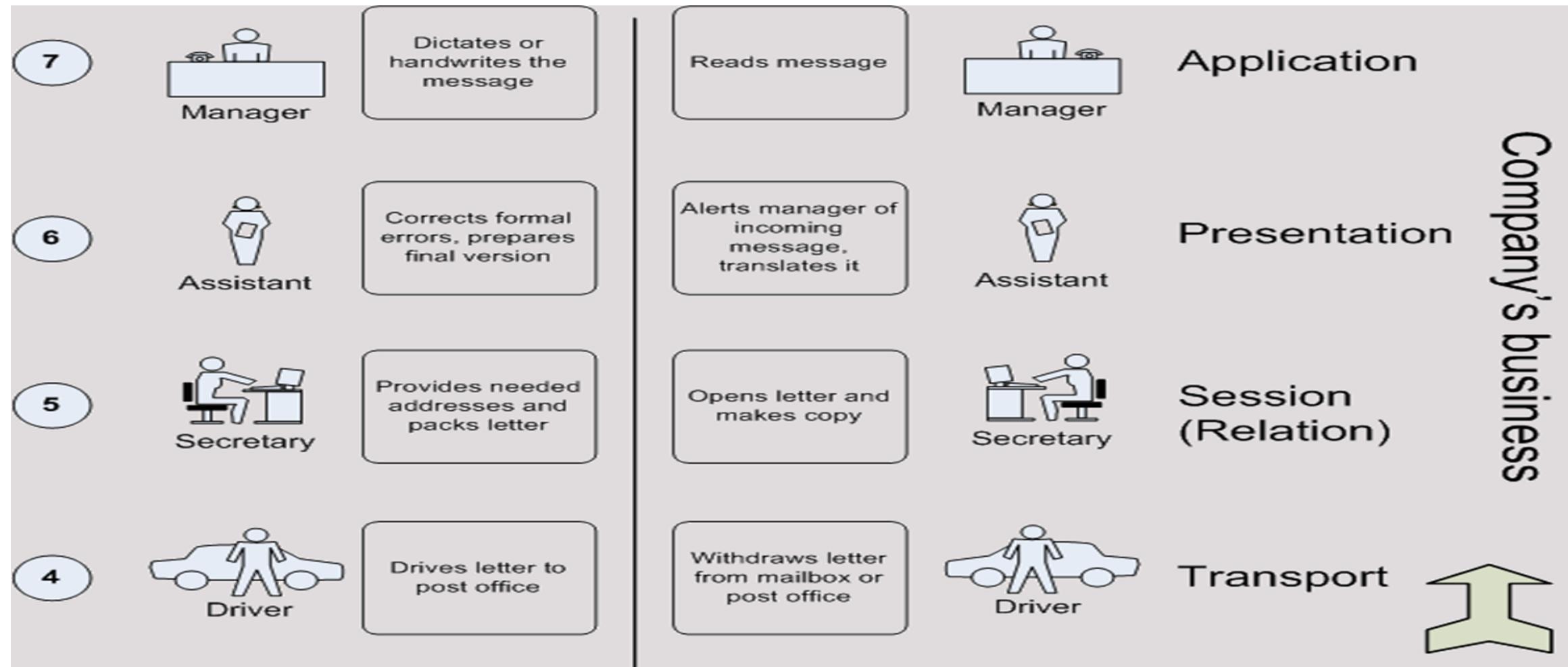
Basic Network Elements (Software)

Peer-to-Peer Communication



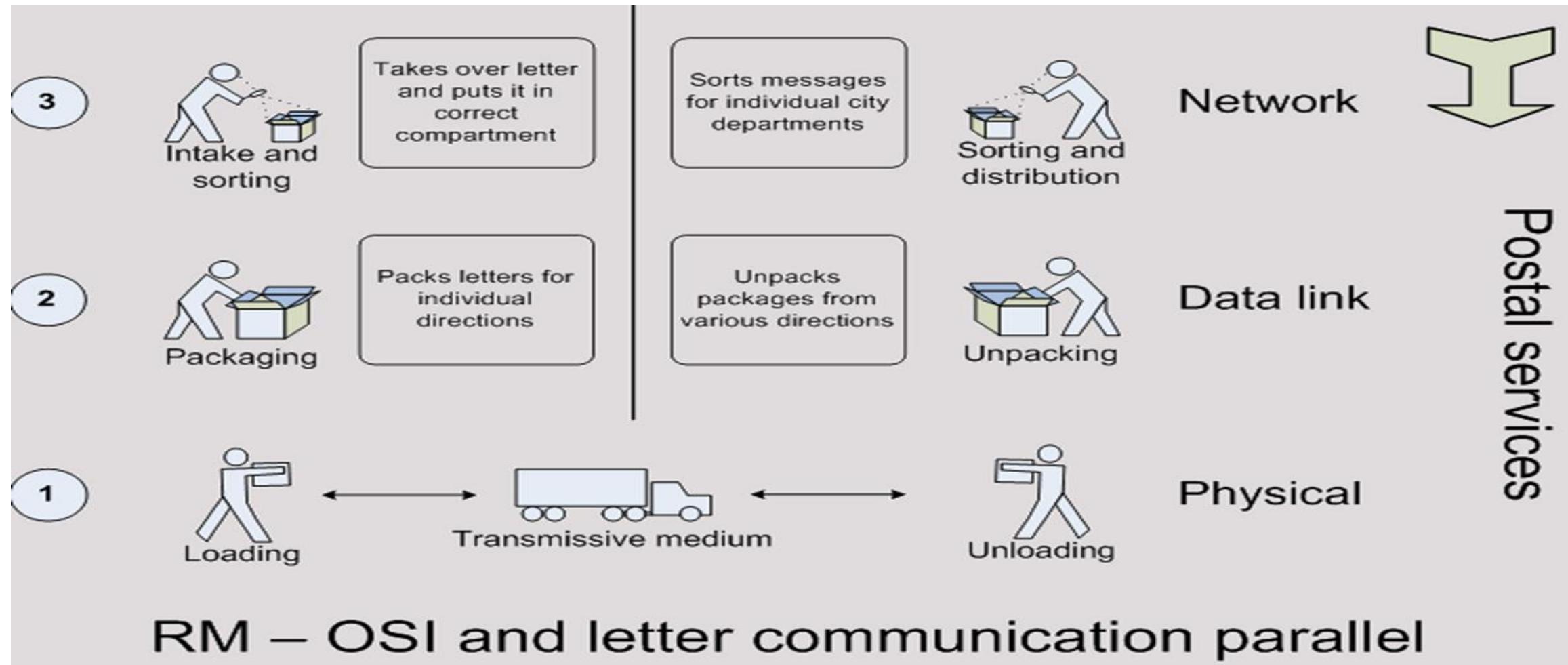
Basic Network Elements (Software)

OSI Exercise



Basic Network Elements (Software)

OSI Exercise



Thanks