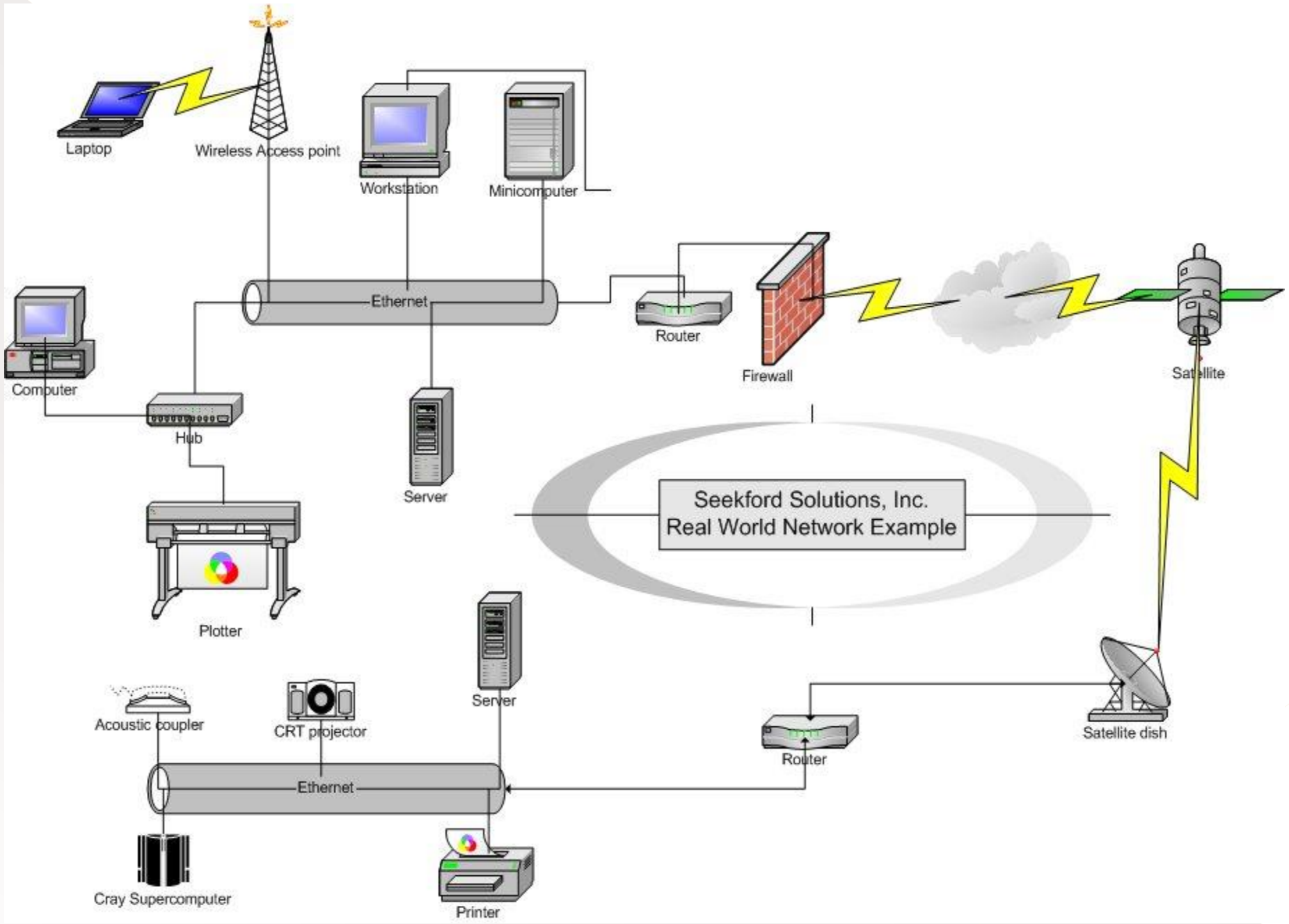
NETWORKING

- Types of networks
- Components of a network
- Seven layers of the OSI model.


Laptop
Wireless Access point
Workstation
Minicomputer
Ethernet
Router
Firewall
Satellite
Computer
Hub
Server
Seekford Solutions, Inc.
Real World Network Example
Plotter
Server
Acoustic coupler
CRT projector
Router
Satellite dish
Ethernet
Cray Supercomputer
Printer

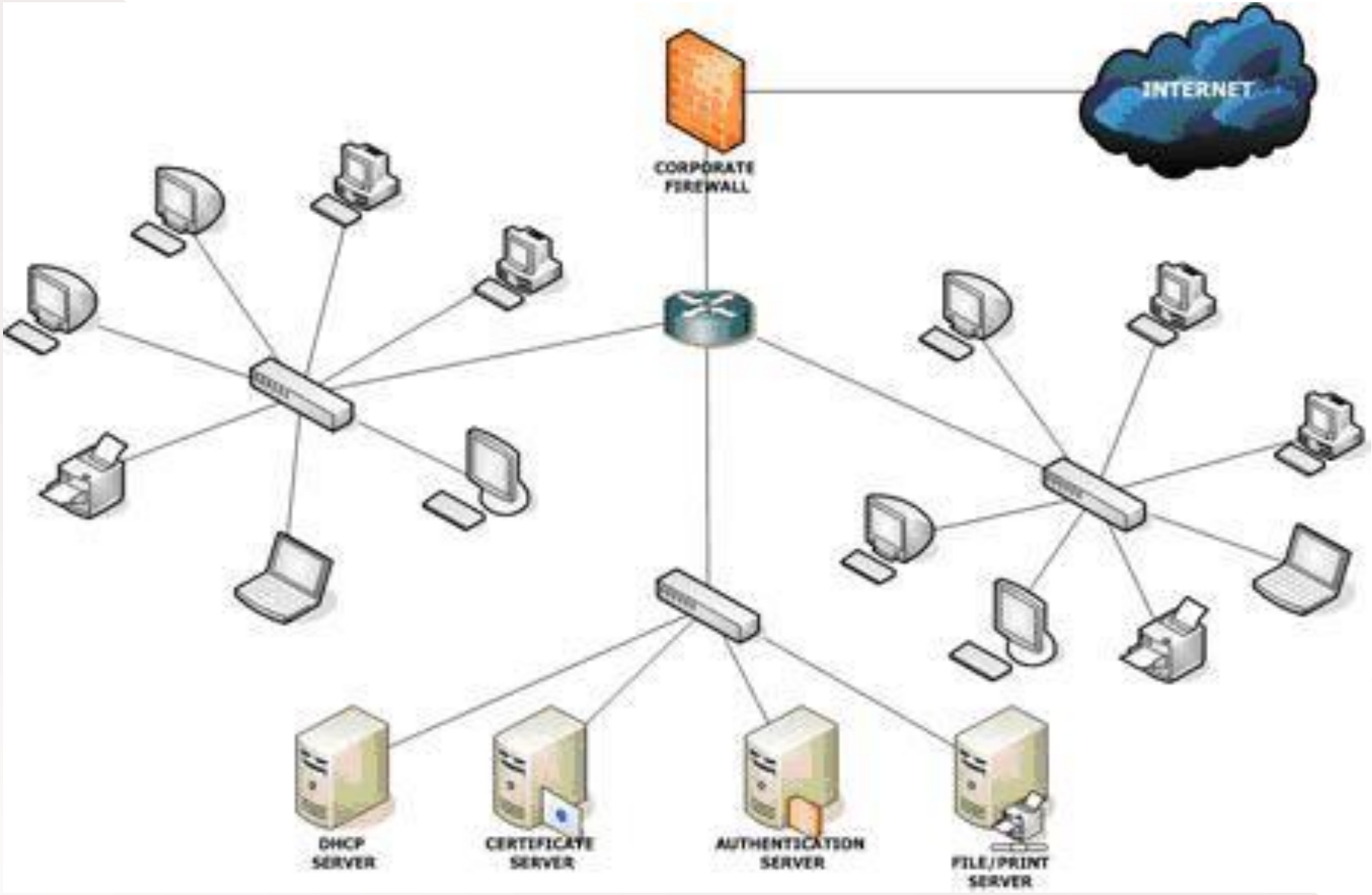
- A **computer network** consists of two or more computers that are linked in order to share resources, exchange files or allow electronic communications to take place.

- The computers on a network may be linked through cables, telephone lines, radio waves, satellites, fiber optics or infrared light beams.

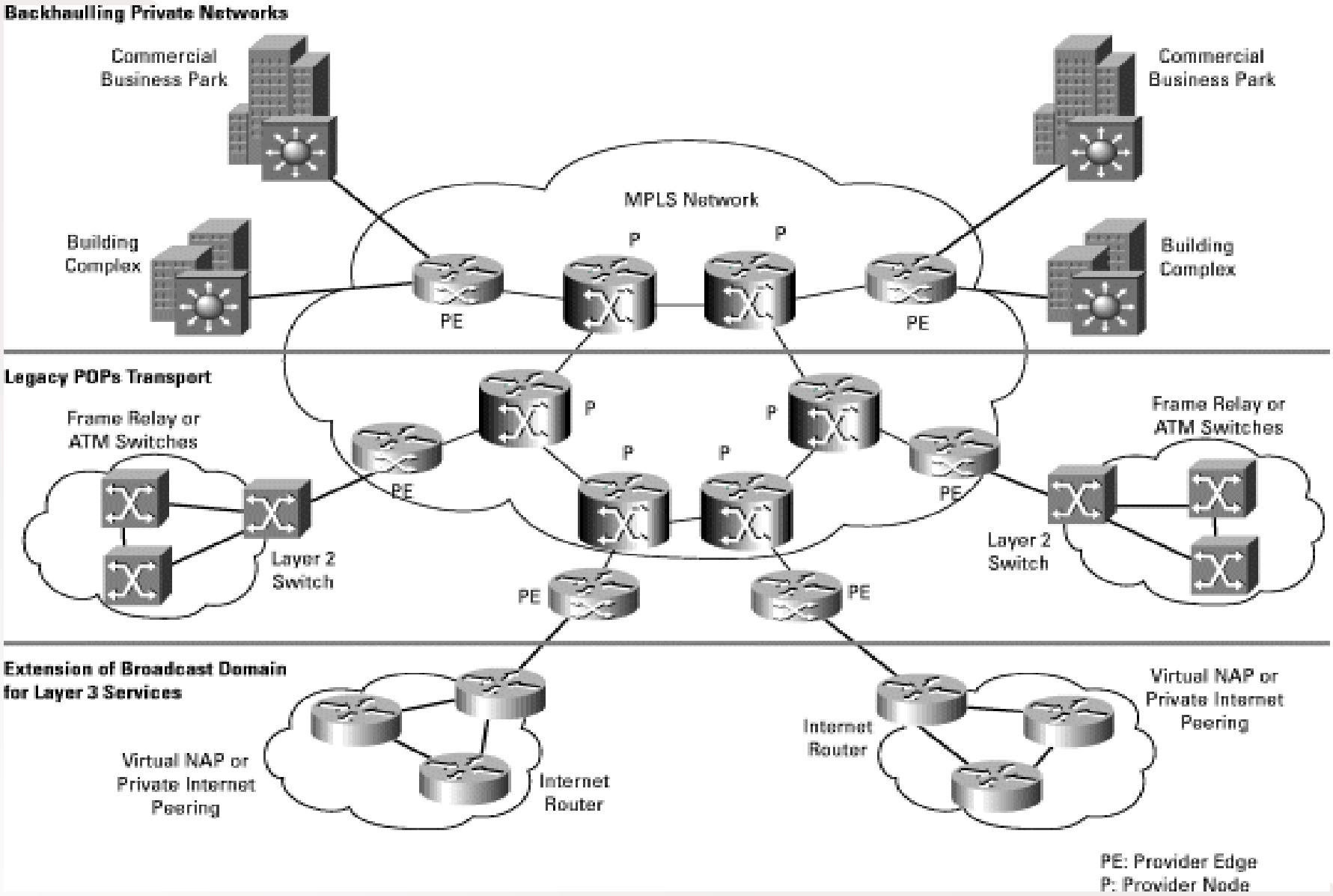
The three basic types of network include:

- Local Area Network (LAN)
- Metropolitan Area Network (MAN)
- Wide Area Network (WAN)

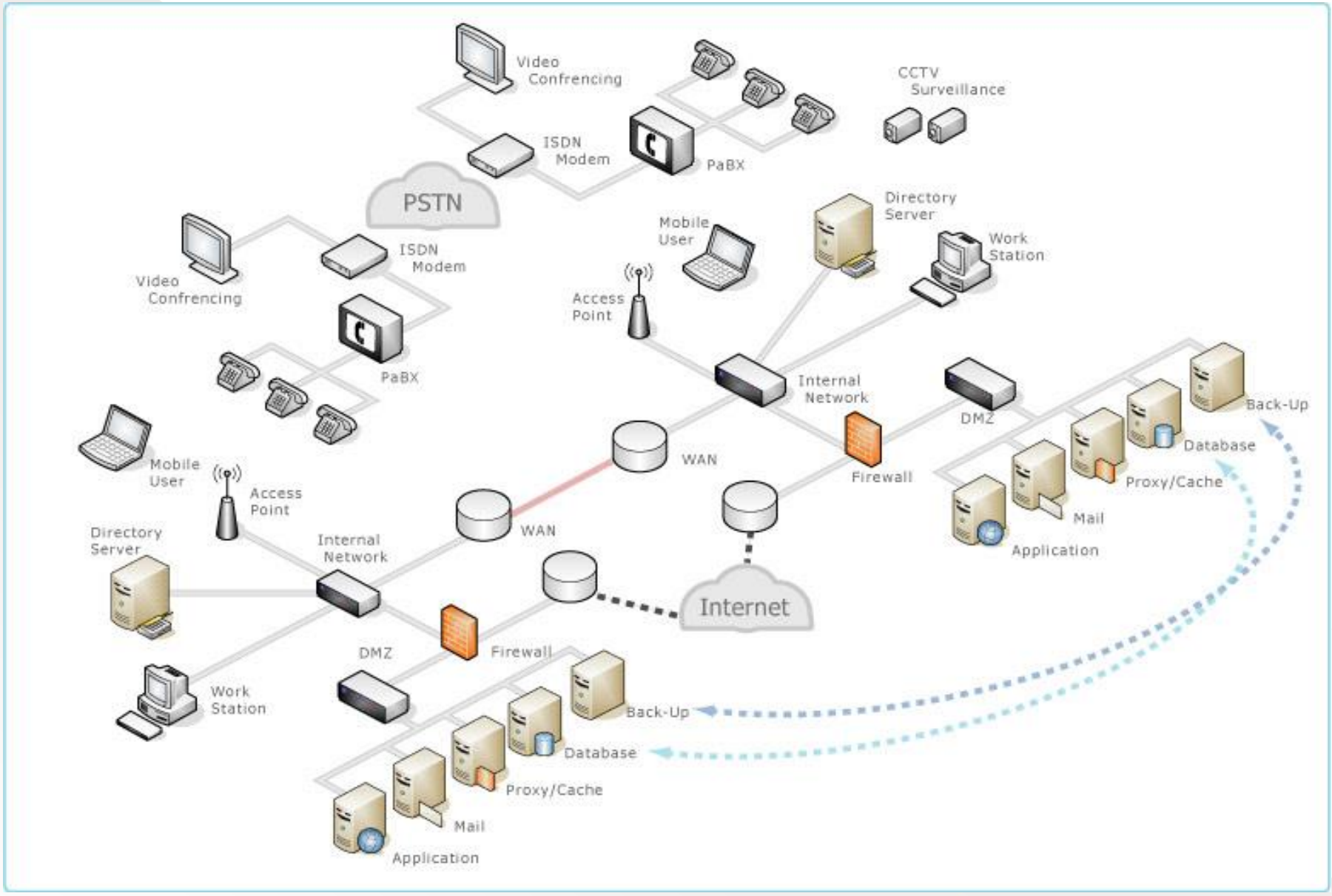
Local Area Network



METROPOLITAN AREA NETWORK



WIDE AREA NETWORK



Advantages of Networking

- Speed
- Cost
- Security
- Centralized software management
- Resource sharing
- Electronic Mail
- Flexible access

- Workgroup computing - Workgroup software (such as Microsoft BackOffice) allows many users to work on a document or project concurrently.

PROTOCOLS

A protocol is a set of rules that governs the communications between computers on a network.

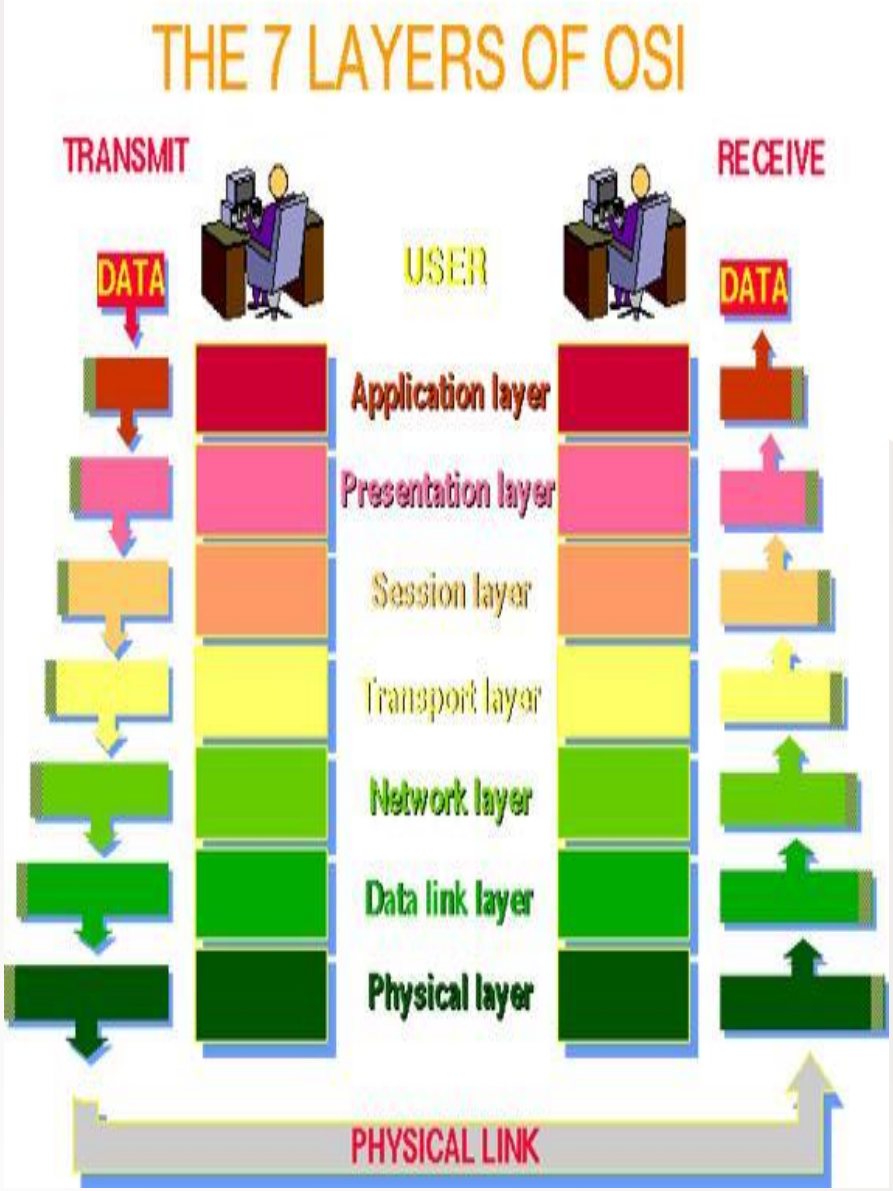
Protocols regulate the following characteristics of a network:

- Access method
- Physical topologies
- Types of cabling
- Speed of data transfer.

OSI Model

- The open system Interconnection (OSI) is an international standard that defines information exchange between the computers and other devices on the network.
- OSI is a seven layer communication protocol stack.
- Each layer performs a specific function and then pass on the data to another layer.

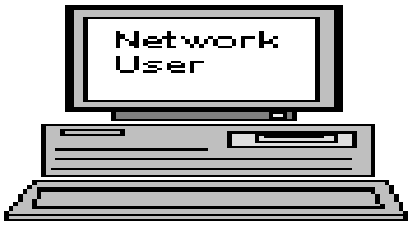
The seven layer OSI reference model



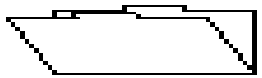
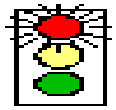
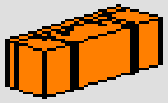
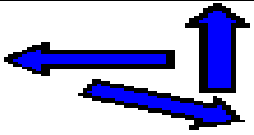
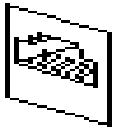
NB

It is easy to recollect the OSI layers with the acronym:

All people seem to need data processing



OSI MODEL

7		**Application Layer** Type of communication: E-mail, file transfer, client/server.
6		**Presentation Layer** Encryption, data conversion: ASCII to EBCDIC, BCD to binary, etc.
5		**Session Layer** Starts, stops session. Maintains order.
4		**Transport Layer** Ensures delivery of entire file or message.
3		**Network Layer** Routes data to different LANs and WANs based on network address.
2		**Data Link (MAC) Layer** Transmits packets from node to node based on station address.
1		**Physical Layer** Electrical signals and cabling.

Physical Layer

The physical layer (layer 1) governs the physical connections between computers on a network. It defines:

- Type of signaling method such as digital or analog.
- The electrical and optical characteristics of the transmission signal.
- Transmission characteristics such as half duplex or full duplex.
- Data rate **(bandwidth)** such as 10 Mbps, 100 Mbps, or 1,000 Mbps.
- Network layout (topology) such as star, bus, ring, etc.

Data Link Layer

- The data link layer (layer 2), prepares data for the physical layer .

- The data link layer is also responsible for:
  - Organizing data bits into frames.
  - Address information known as MAC addressing
  - Error correction and retransmission.
  - How the data bits access a transmission medium.

Network Layer

- The Network layer is responsible for routing, switching, and controlling the flow of data between nodes.

Services provided by the network layer include:

- Adding network and node addressing information to a series of **data packets** prior to handing off the packet of information to the data link layer.
- Support services to the transport layer and data preparation for the data link layer.
- Route discovery and determination of the best route for data between two separate network locations.

Transport Layer

- The Transport layer converts messages into segments and also breaks large segments into smaller segments that can be handled by lower layers.

- It provides error checking to guarantee error free data delivery.

- It provides acknowledgment of successful transmissions and requests retransmission if some packets gets damaged or corrupted.

Session Layer

- Session layer establishes, manages, and synchronizes the communication between two nodes.
- Two nodes can exchange information only after a session has been established between them.
- A session is a logical connection between the two nodes.
- The Session layer can also control the direction in which the data flows.

Presentation Layer

- The Presentation layer is responsible for encoding and decoding data in a mutually agreeable format.
- It encrypts the data, which enables security.
- It compresses the data, which enables to reduce the size of the data packet.

Application Layer

- The Application layer provides the interface between the end user and the network.
- The processes or applications of this layer generate the data packets to be delivered.
- Common applications and protocols that operate on this layer include e-mail, FTP, and Telnet (teletype network).

ETHERNET

- The Ethernet protocol is by far the most widely used.
- Ethernet uses an access method called Carrier Sense Multiple Access /Collision Detection (**CSMA/CD**).
- Each computer listens to the cable before sending anything through the network.

- **TCP/IP** protocols are the standards around which the Internet developed.

Some of the common protocols specified by the TCP/IP reference model layers. Some of the most commonly used application layer protocols include the following:

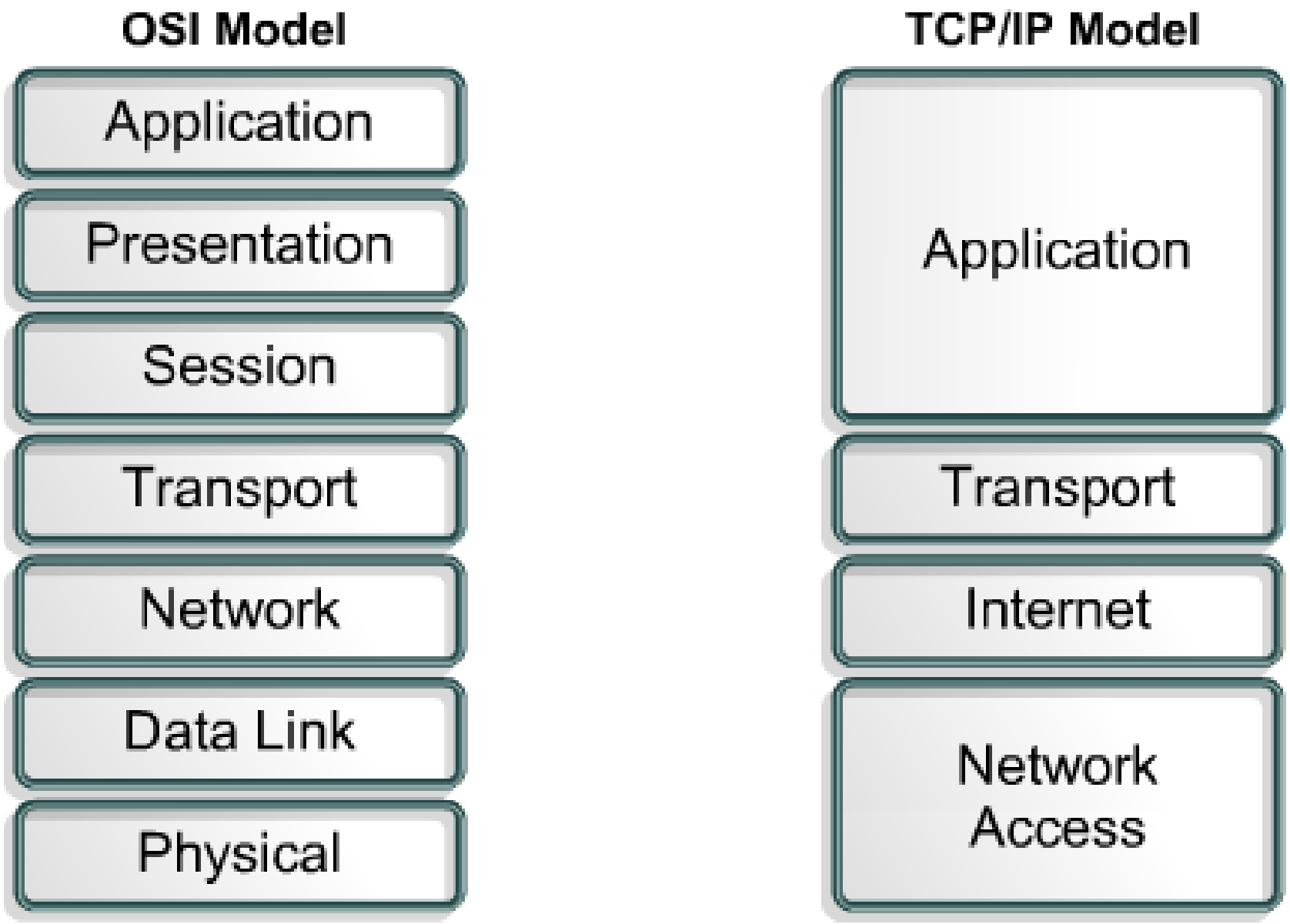
File Transfer Protocol (FTP)

Hypertext Transfer Protocol (HTTP)

Simple Mail Transfer Protocol (SMTP)

Domain Name System (DNS)

Trivial File Transfer Protocol (TFTP)


OSI Model
Application
Presentation
Session
Transport
Network
Data Link
Physical
TCP/IP Model
Application
Transport
Internet
Network Access

Ethernet Standard	Media Type(s) Supported	Description
10BASE5	Thicknet or thick Ethernet	10 Mops Ethernet over thicknet with a maximum cable segment length of 500 meters.
10BASE2	Thinnet or thin Ethernet	10 Mbps Ethernet over thinnet with a maximum cable segment length of 185 meters'
10BASE-T	Categories 3-6 UTP	10 Mbps Ethernet over UTP cabling, usually cats. Uses two of the twisted pairs
100BASE-T	Categories 3-6 UTP	100 Mops Ethernet over UTP cabling, usually cats or cat5e. Uses two of the twisted pairs
100BASE-FX	Fiber optic cable	100 Mbps Ethernet over fiber optic cable
100BASE-T4	Category 3 UTP	Obsolete. Was designed to use all four of the twisted pairs of cat3 UTP Cabling.
1000BASE-T	Category 5-6 UTP	1 Gbps over cat 5 or greater. Uses all four of the cabling's twisted pairs. Generally implemented on cat5e or greater
10GBase-LX4 SMF or MMF	SMF or MMF	10 Gbps over

Networking Hardware

- This includes all the computers, NICs and other equipment needed to perform data processing and communication within the network.

Basic components of a Network

- Two or more PCs
- Additional resources (printers, scanners etc)
- Transmission medium: cables, fibre optic, wireless
- Network interface cards (NICs)
- Wiring Concentrator: hubs/repeaters, bridges, switch, router etc

NETWORK INTERFACE CARD (NICs)

- NICs translate data from your computer to a format that is acceptable to the transmission medium of the LAN and vice versa.

- NICs build frames, which are manageable data chunks that the LAN medium can accommodate.

- NICs function at the data link layer of the OSI model.
- Their installation in a computer provides the computer with a unique data link layer address known as a MAC address.
- Examples include Ethernet cards, local talk connectors and token ring cards

NIC


3C905B-TXNM
FAST ETHERLINK
XL PCI
EA:00105A655F62
SN:60PD655F62
3Com
PERFORMANCE
3Com 40-0483-004
9840S 16852437
LUCENT 40-04834

Types of NICs.

- Ethernet NICs are used in workstations and servers on Ethernet LANs and can support data transmission rates of 10 Mbps, 100 Mbps, or 1000 Mbps.

- Token Ring NICs are used in Token Ring LANs and are available in 4 Mbps, 16 Mbps. and 100 Mbps configurations.

- FDDI (Dual-attach FDDI Board Fibre Distributed Data Interface) NICs are generally reserved for connecting servers to high-speed campus networks, and their data rate is standardized at 100 Mbps.

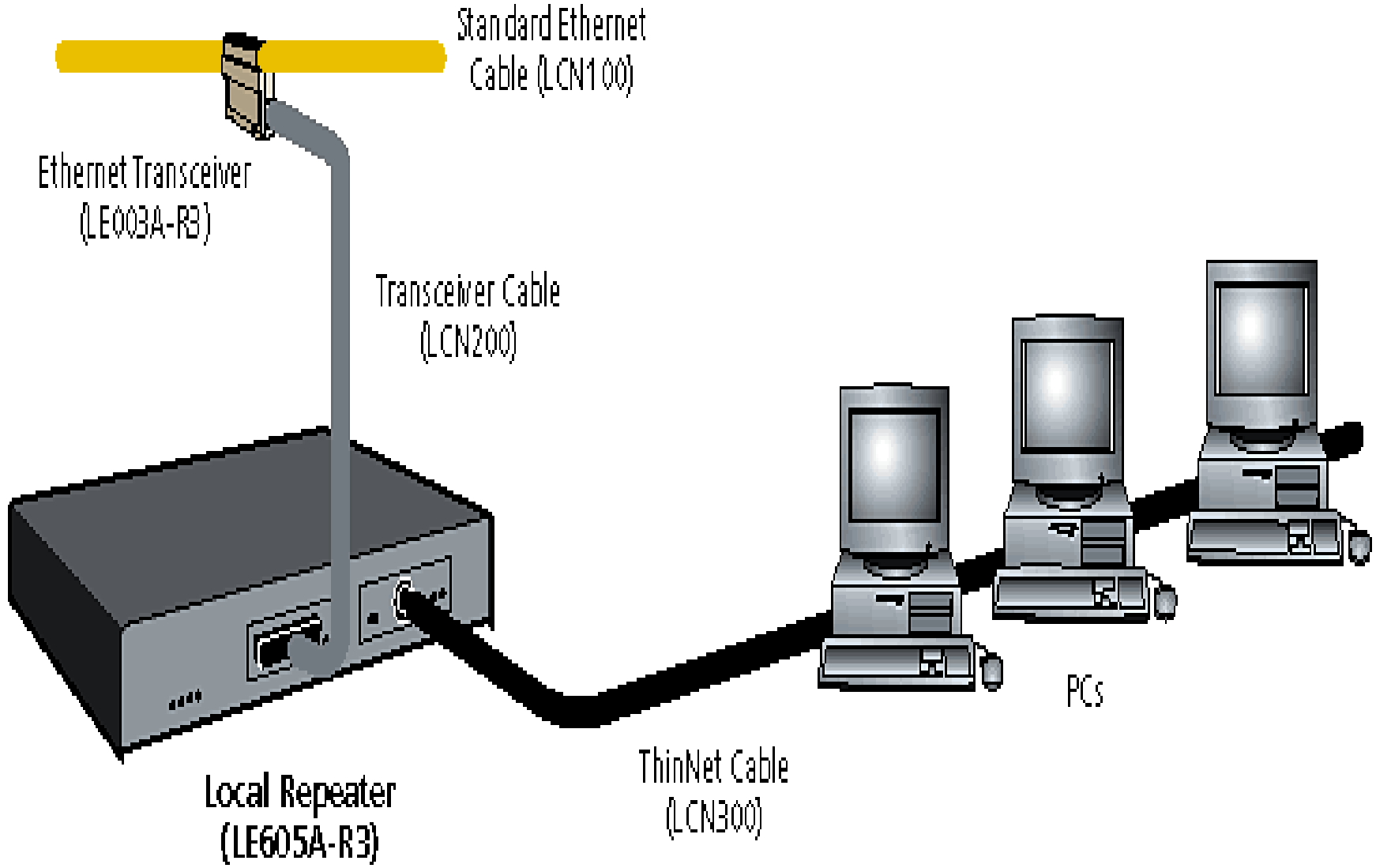
- ATM NICs are generally used in applications similar to FDDI NICs and are available in a variety of data rates.
- Network interface cards have a unique, 48-bit address known as a media access control (MAC) address.
- A Media Access Control address (MAC address) is a unique identifier assigned to most network interface cards (NICs) by the manufacturer for identification.
- The address is represented as a series of six, eight bit fields such as af:00:ce:3a:8b:Oc.

REPEATERS

- Network engineers implement repeaters to overcome signal attenuation(lost of signal strength) over long cable segments.

- Repeaters are an OSI physical layer device and their functionality can be built into hubs or switches.

- Repeater electrically amplifies the signal it receives.


Standard Ethernet
Cable (LCN100)
Ethernet Transceiver
(LE003A-R3)
Transceiver Cable
(LCN200)
PCs
ThinNet Cable
(LCN300)
Local Repeater
(LE605A-R3)

Repeater

HUBS

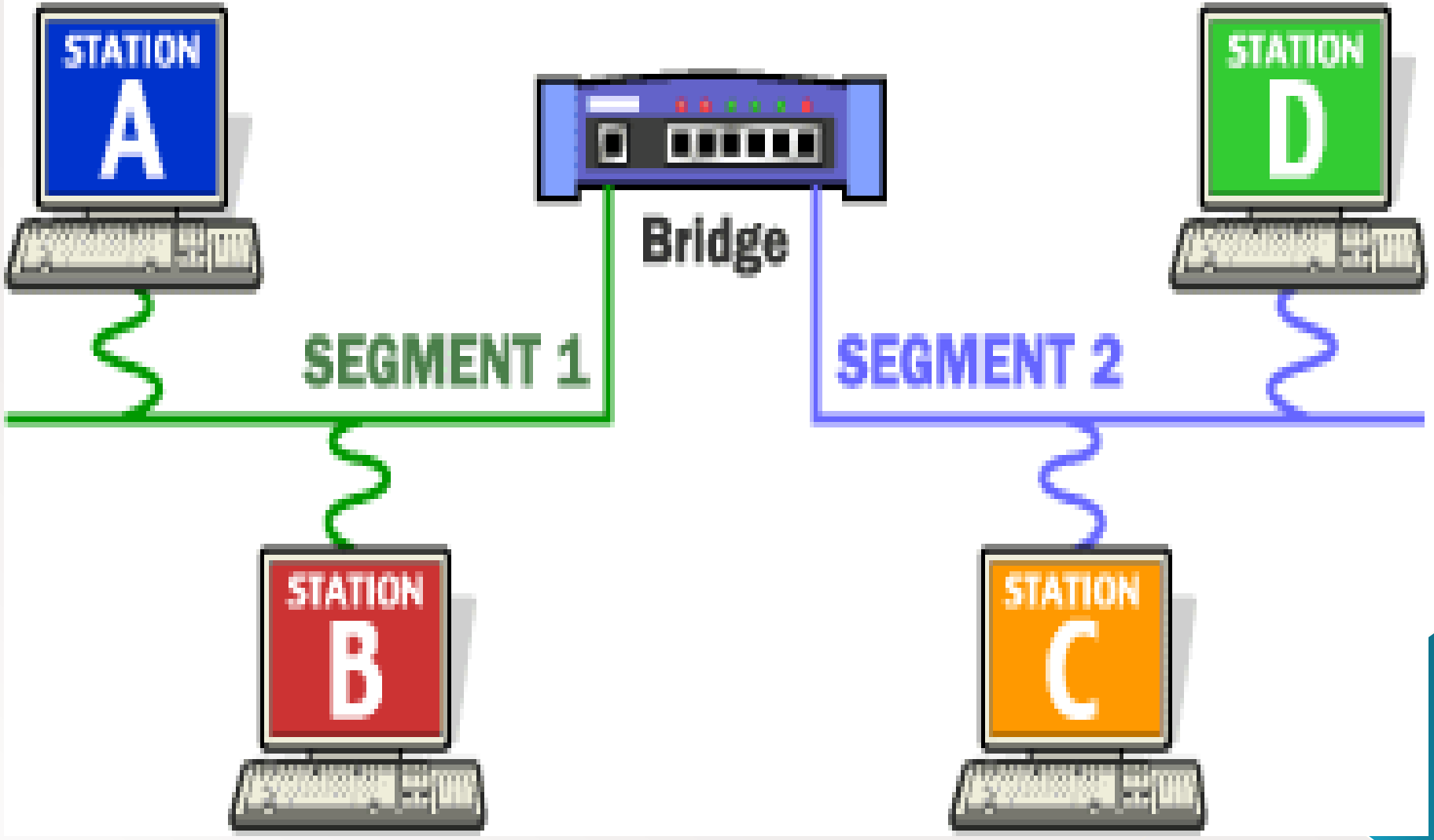
- Hubs are OSI layer 1 hardware devices that act as a connection point for servers, workstations, printers, and other computing devices.

- Various types of hub technologies exist including stand-alone hubs, stackable hubs, enterprise hubs, and network managed hubs.

Bridges

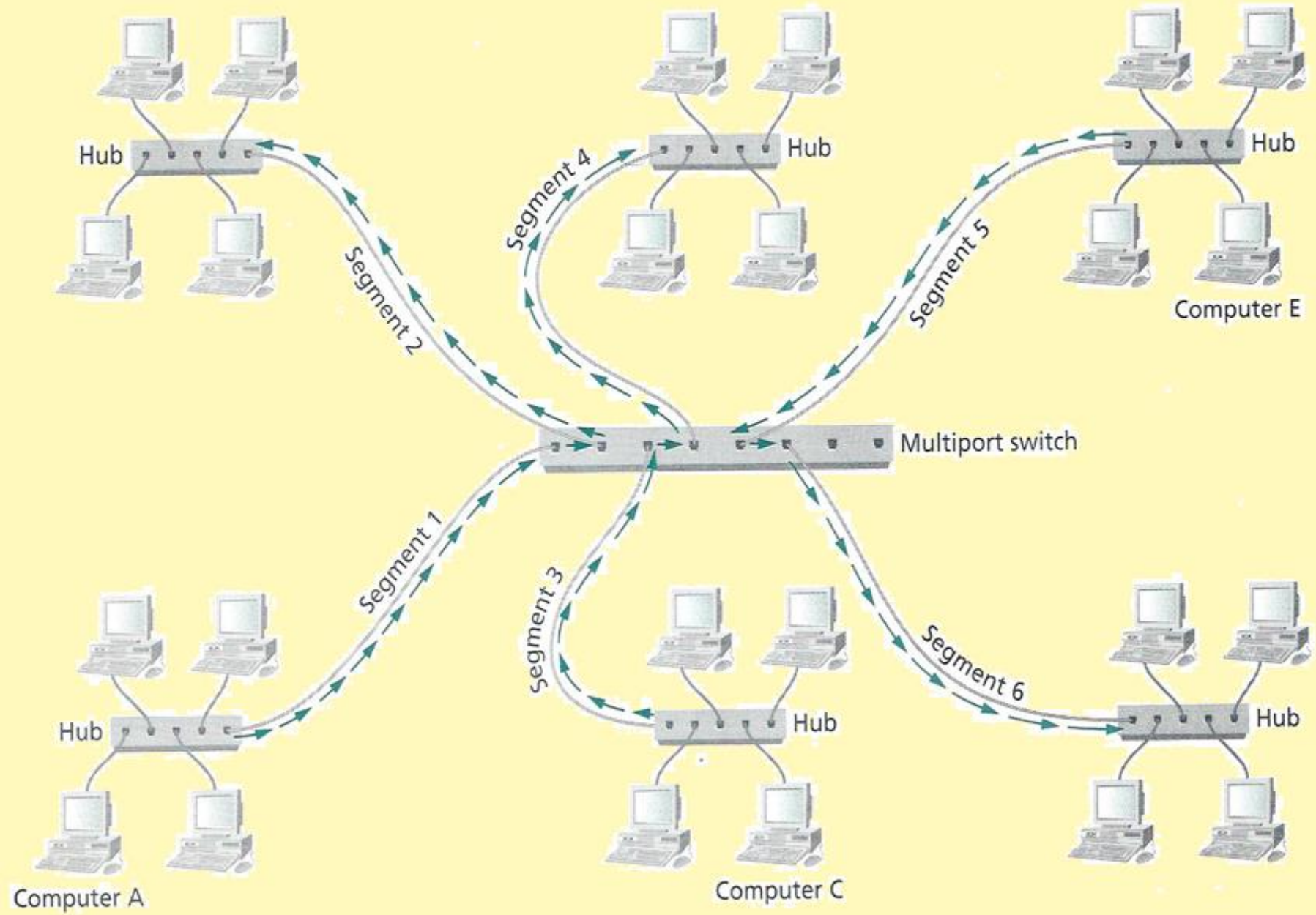
- Bridges connect two or more LAN segments.
- Bridges are OSI layer 2 devices that use MAC addresses to direct and filter traffic between LAN segments.
- A bridge monitors the information traffic on both sides of the network so that it can pass packets of information to the correct location.

An Ethernet Bridge Connecting Two Segments



SWITCHES

- Switches are OSI layer 2 devices that evolved from bridge technology.
- Switches can read frames from multiple ports and create simultaneous forwarding paths.
- Both switches and bridges have the following in common:
  - Both switches and bridges build MAC address tables.
  - Both perform frame flooding
  - Forwarding
  - Filtering


Hub
Hub
Hub
Hub
Hub
Hub
Segment 1
Segment 2
Segment 3
Segment 4
Segment 5
Segment 6
Multiport switch
Computer A
Computer C
Computer E

Differences between switches and bridges

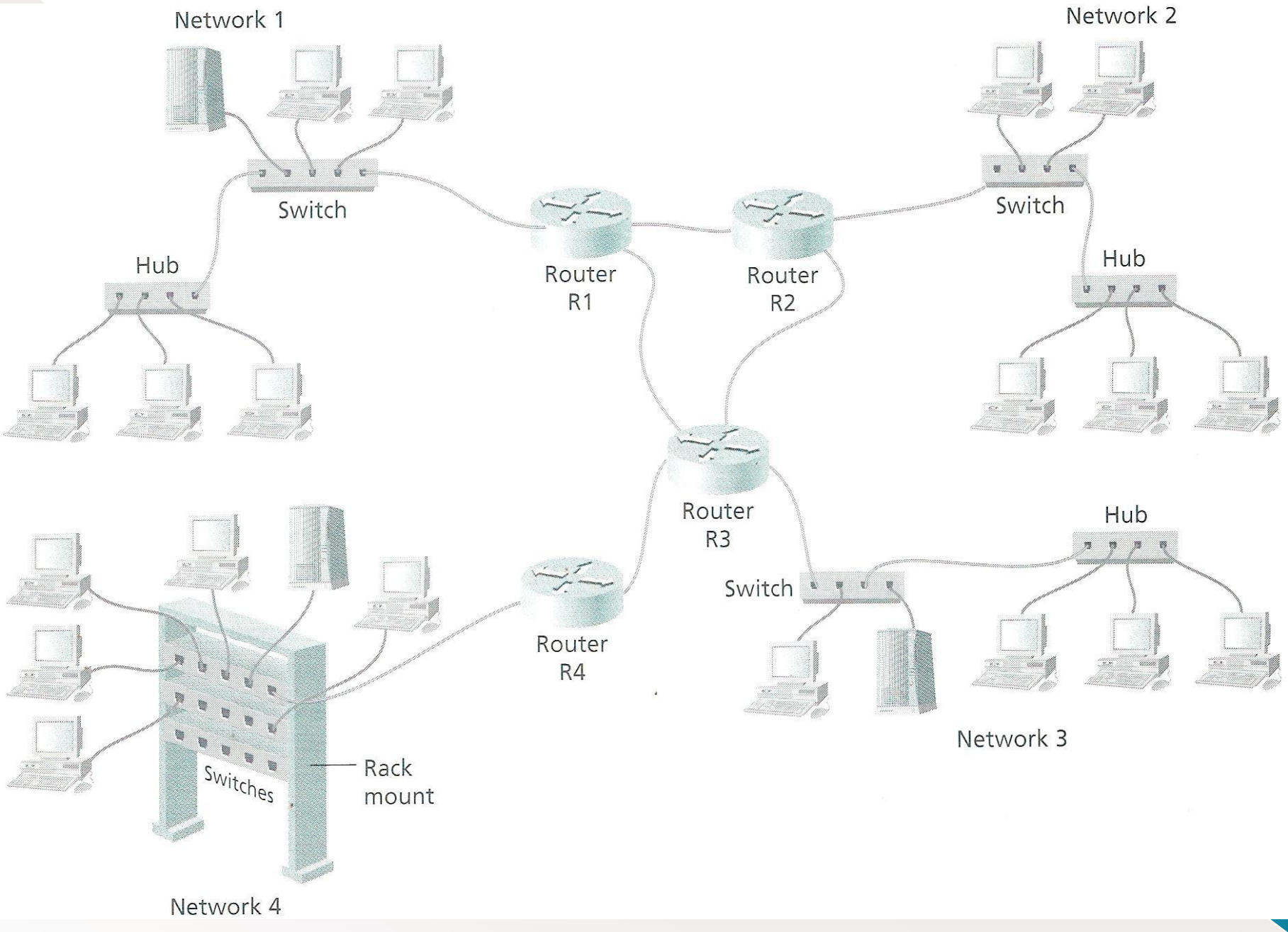
- Bridges are typically connected to hubs or other bridges but switch ports can be directly connected to individual PCs and servers or to hubs, bridges, other switches, and routers.

- Bridges can process and forwarding one frame at a time. Switches can read and forward multiple frames simultaneously.

Routers

Routers are OSI layer 3 devices.

- A router connects two or more networks, with separates broadcast domains.
- Directs data packets to their destinations based on IP addresses and across the best possible route.


Network 1
Network 2
Switch
Switch
Hub
Hub
Router
R1
Router
R2
Router
R3
Router
R4
Switch
Hub
Switches
Rack
mount
Network 3
Network 4

Routers are implemented for the following reasons:

- To establish a path over which computers on one network can communicate.

- Determine the best path for transmission of packets.
- Improve the security of a LAN.
- Provide scalability for growing networks.
- To connect the LAN to distant networks.

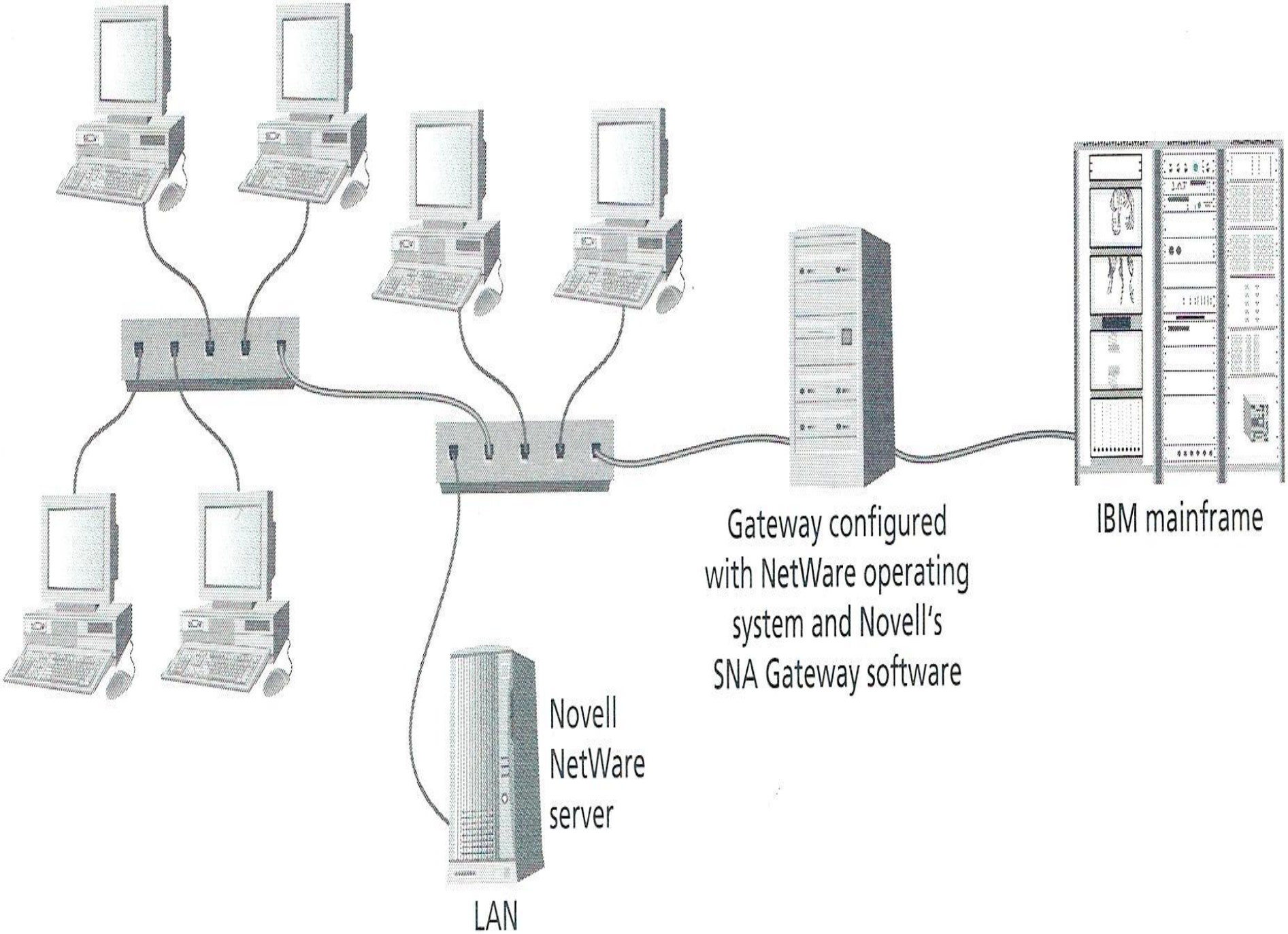
GATEWAY

- A gateway is hardware or software or a combination of both that provides protocol translation or connectivity between different systems.

- Gateways provide connectivity between different network environments and operate at OSI layer 3 and above.

Gateways perform functions such as service:

- connectivity between separate systems
- conversion of frame sizes between different networks
- protocol translation
- data format conversion
- A common implementation of a gateway is between a LAN and a legacy mainframe network


Gateway configured with NetWare operating system and Novell's SNA Gateway software
IBM mainframe
Novell NetWare server
LAN

Some of the other types of gateways you might come across include:

- **E-mail gateways:** Provide the necessary e-mail service translations between local area network e-mail systems and external e-mail providers.

- **Internet gateways:** Provide internal networks that don't use TCP/IP with the protocol translation required to access an IP network or the Internet

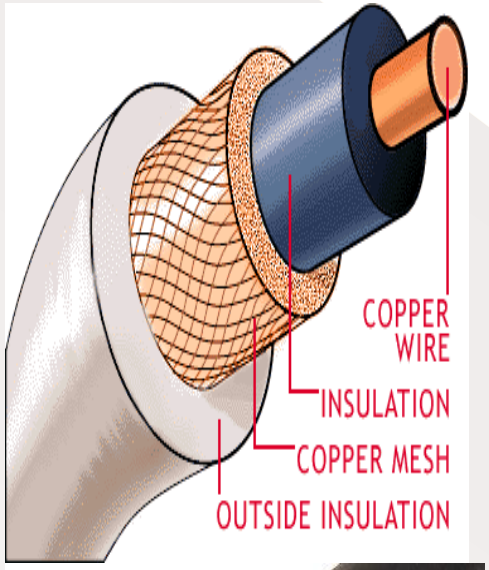
NETWORK CABLES

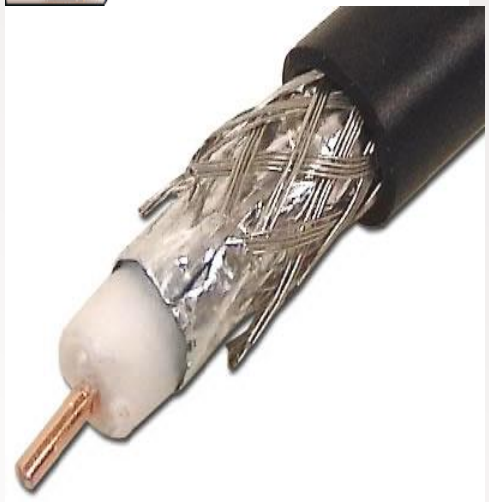
Types of cables used in networks include:

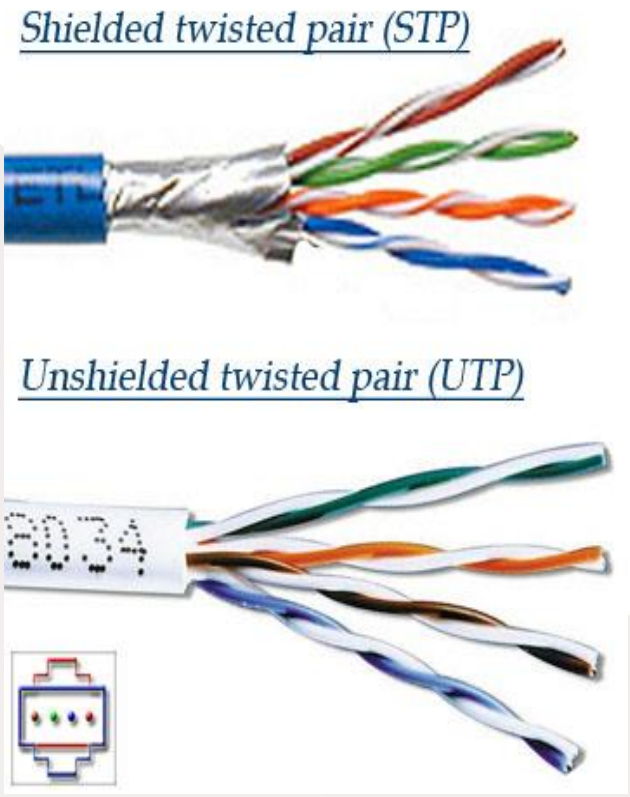
- Unshielded twisted pair (UTP) cable
- Shielded Twisted pair (STP) cable
- Coaxial cable
- Fibre Optic cable
- Wireless LANs

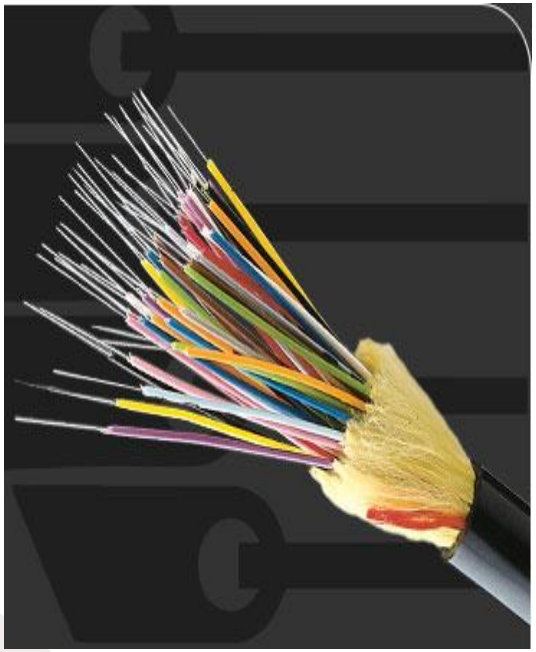
NETWORK CABLES

COAXIAL CABLE



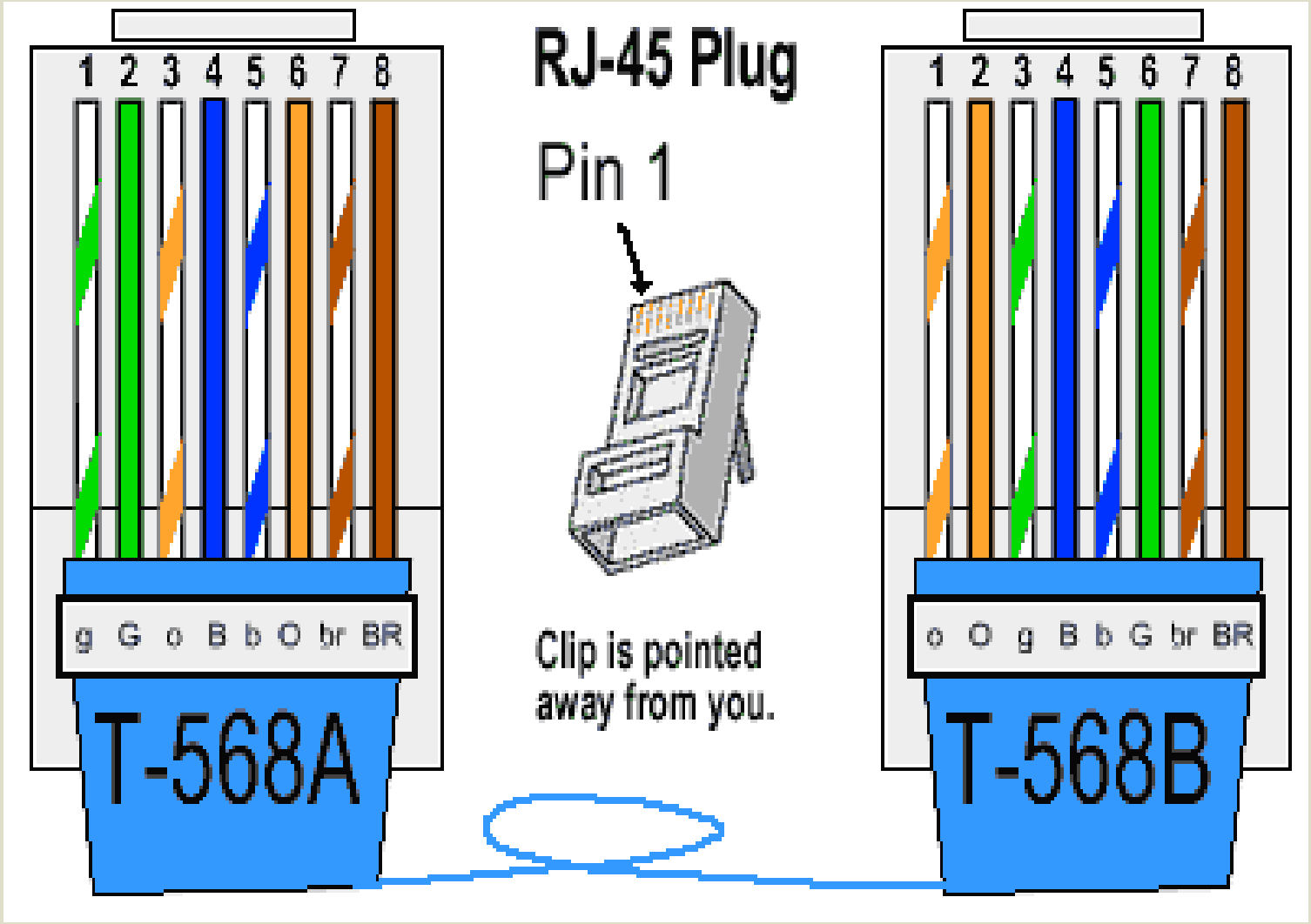




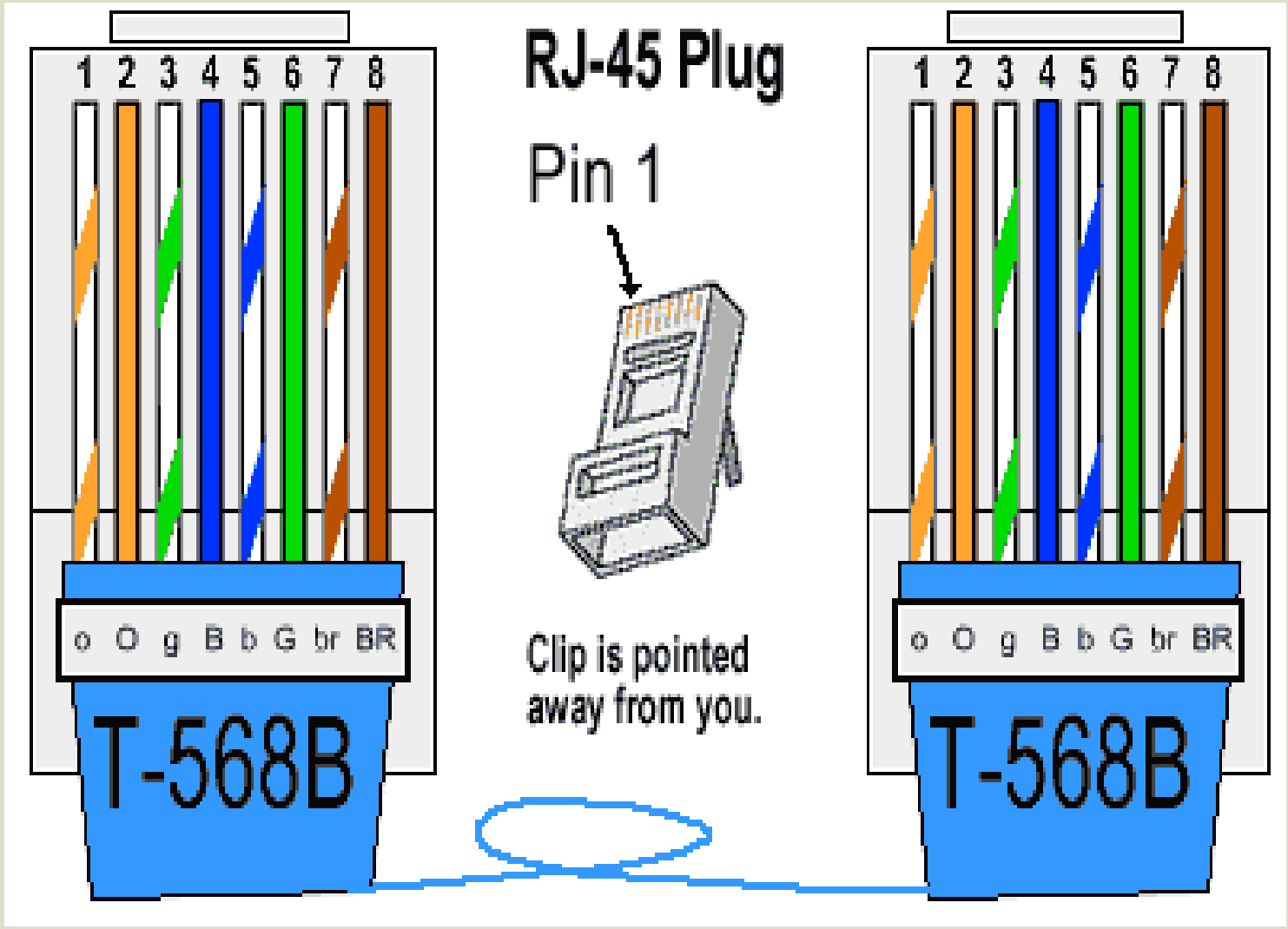


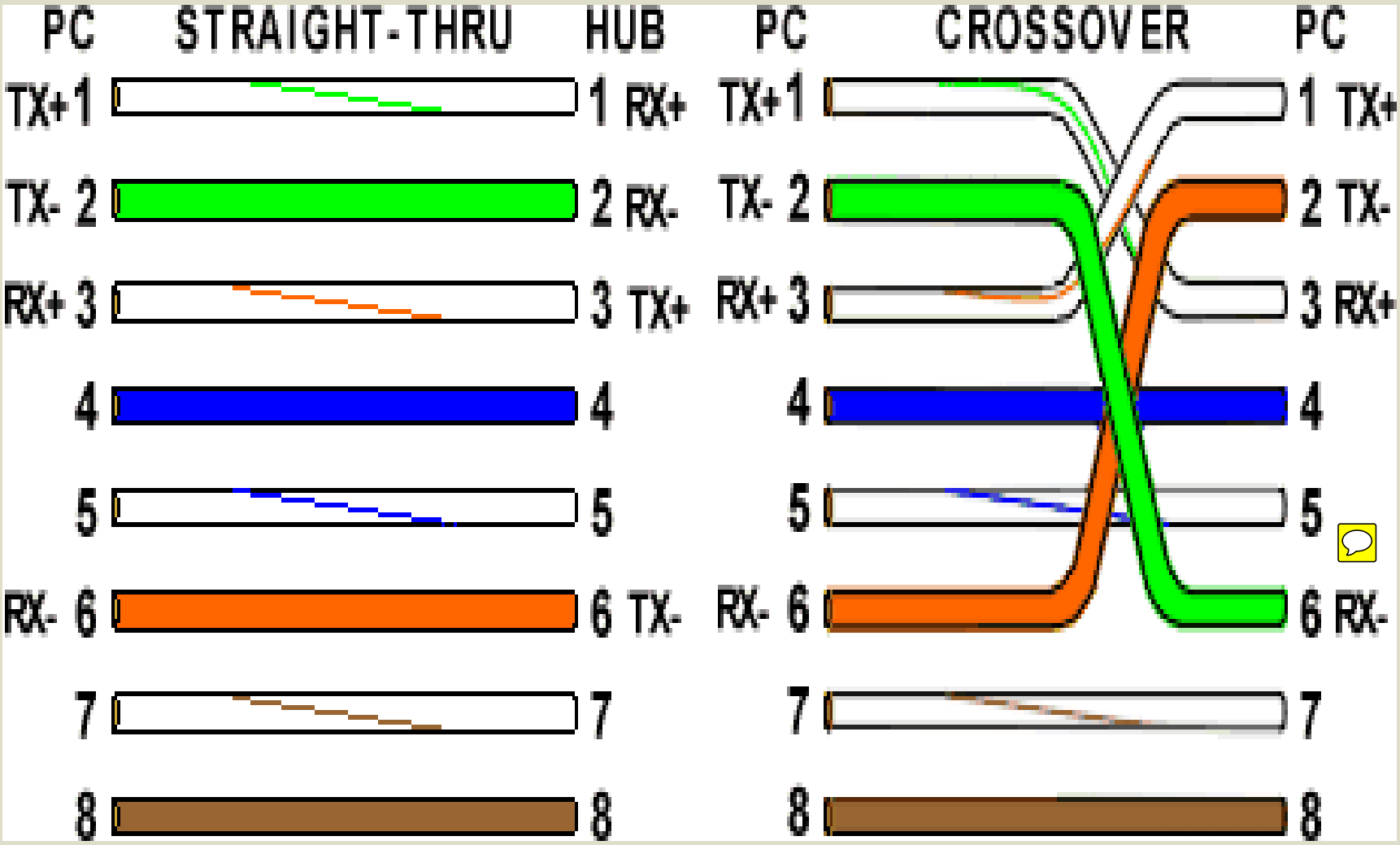
FIBER OPTIC CABLE

RJ-45 Crossover Ethernet Cable



T-568B Straight-Through Ethernet Cable




PC
STRAIGHT-THRU
HUB
PC
CROSSOVER
PC
TX+ 1
TX- 2
RX+ 3
4
5
RX- 6
7
8
1 RX+
2 RX-
3 TX+
4
5
6 TX-
7
8
TX+ 1
TX- 2
RX+ 3
4
5
RX- 6
7
8
1 TX+
2 TX-
3 RX+
4
5
6 RX-
7
8

Media Type	Maximum Data Rate	Where Used
Cat 1 UTP	less than 1 Mbps	Home telephone lines
Cat 2 UTP	4 Mbps	4 Mbps Token Ring networks, Older POTS lines--1983-1993
Cat 3 UTP	10 Mbps	4 Mbps Token Ring networks, 10 Mbps Ethernet LANs, and POTS lines Installed after 1993
Cat 4 UTP	100 Mbps	4 or 16 Mbps Token Ring networks, 10 Mbps Ethernet LANs, some 100 Mbps Ethernet LANs
Cat 5 UTP	1,000 Mbps`	4 or 16 Mbps Token Ring networks, 10 and 100 Mbps Ethernet LANs, 1 Gbps Ethernet LANs-with four pairs ATM at 155 Mops, FDDI
Cat 5e UTP	1 Gbps	10, 100, and 1,000 Mbps Ethernet ATM at 155 Mbps
Cat 6 UTP	10 Gbps	High-speed multimedia applications over future Ethernet LANs with speeds greater than 1 Gbs

Network Topology

Topology is the map or layout of a network.

The two main topologies are:

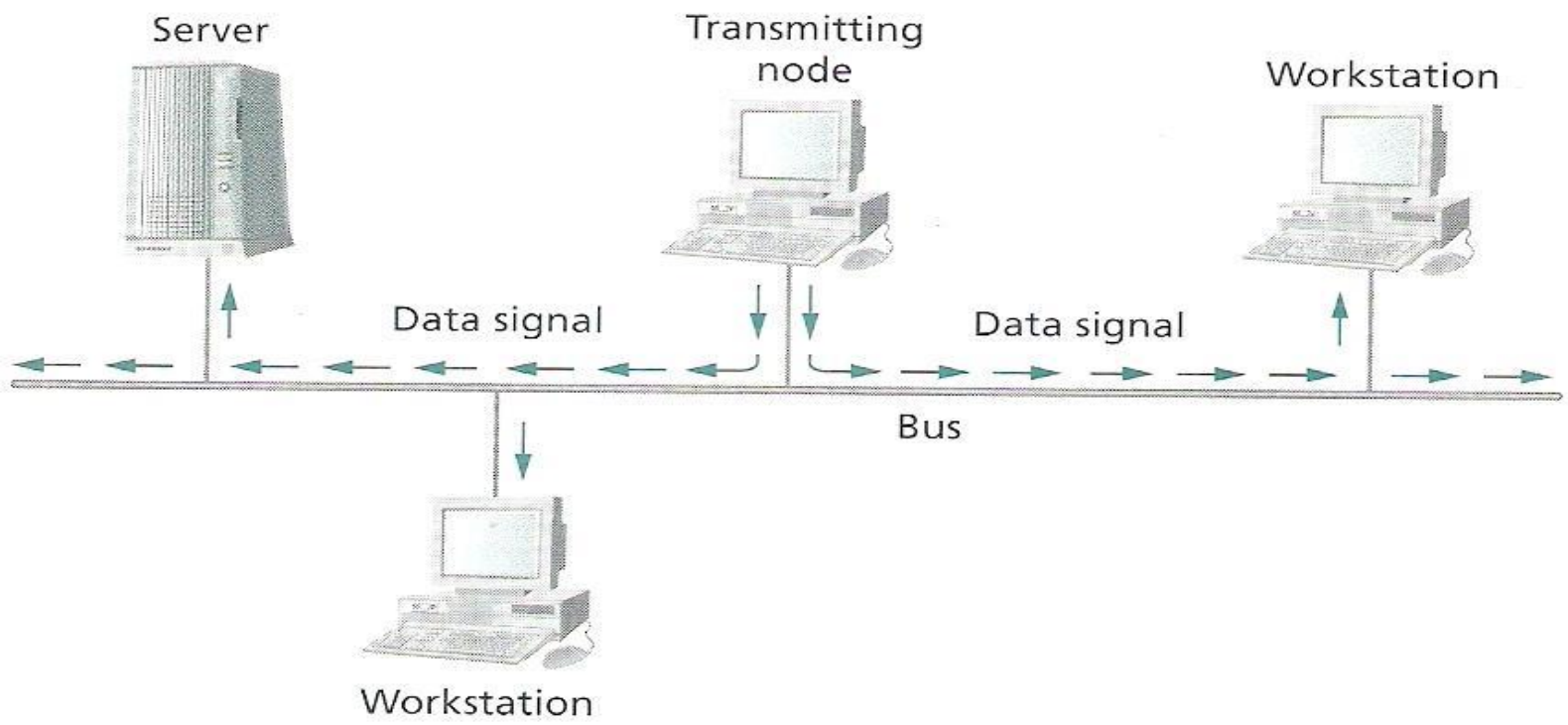
- **Physical topology:** defines the actual structure or configuration of the cables, computers and other peripherals that you can see or touch.

- **Logical topology:** defines the conceptual network layout, which can be taught as the way that data travels or flows across the network.

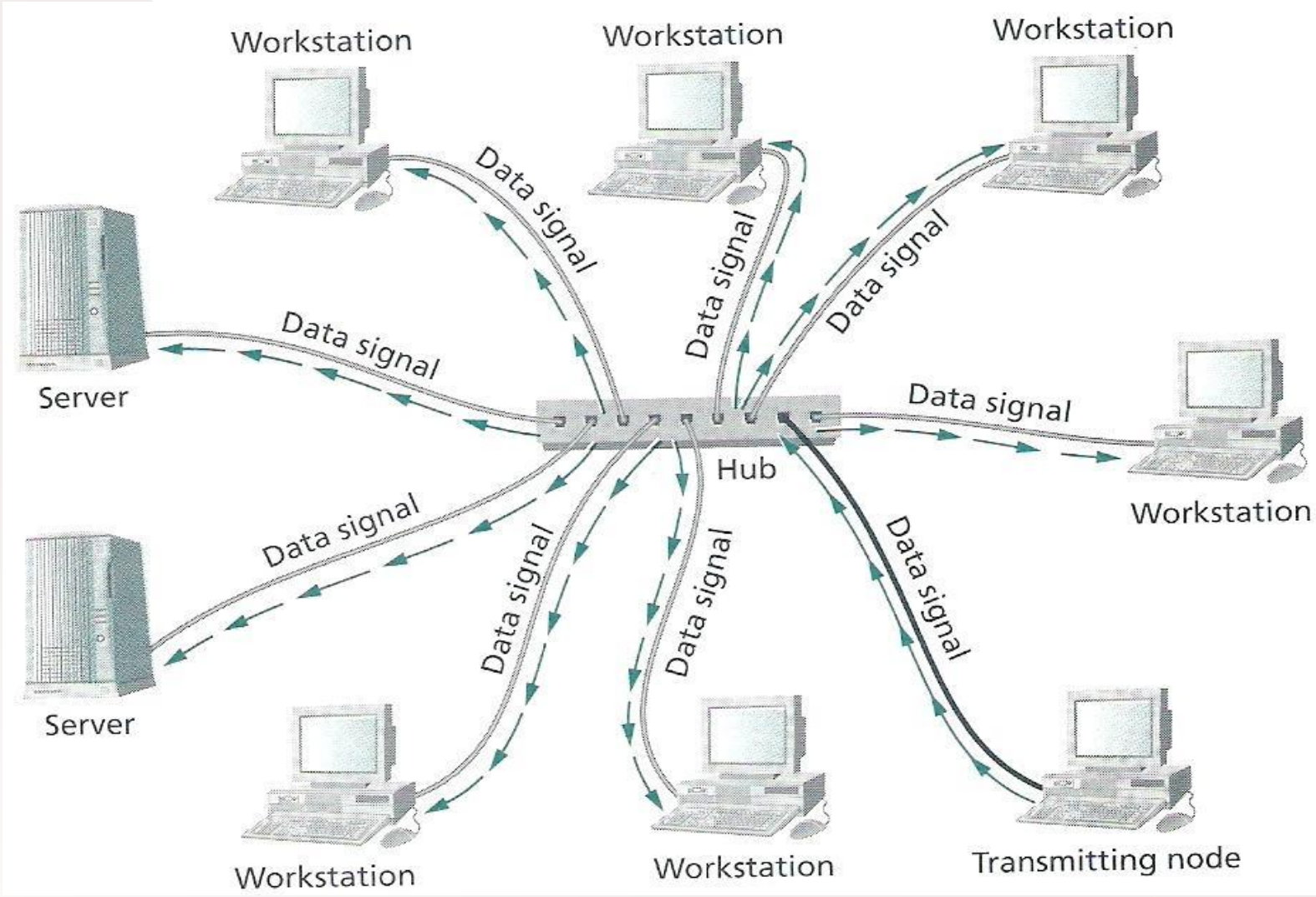
Main types of Physical topologies

- Linear bus
- Star
- Star-wired ring
- Tree

BUS TOPOLOGY



STAR TOPOLOGY



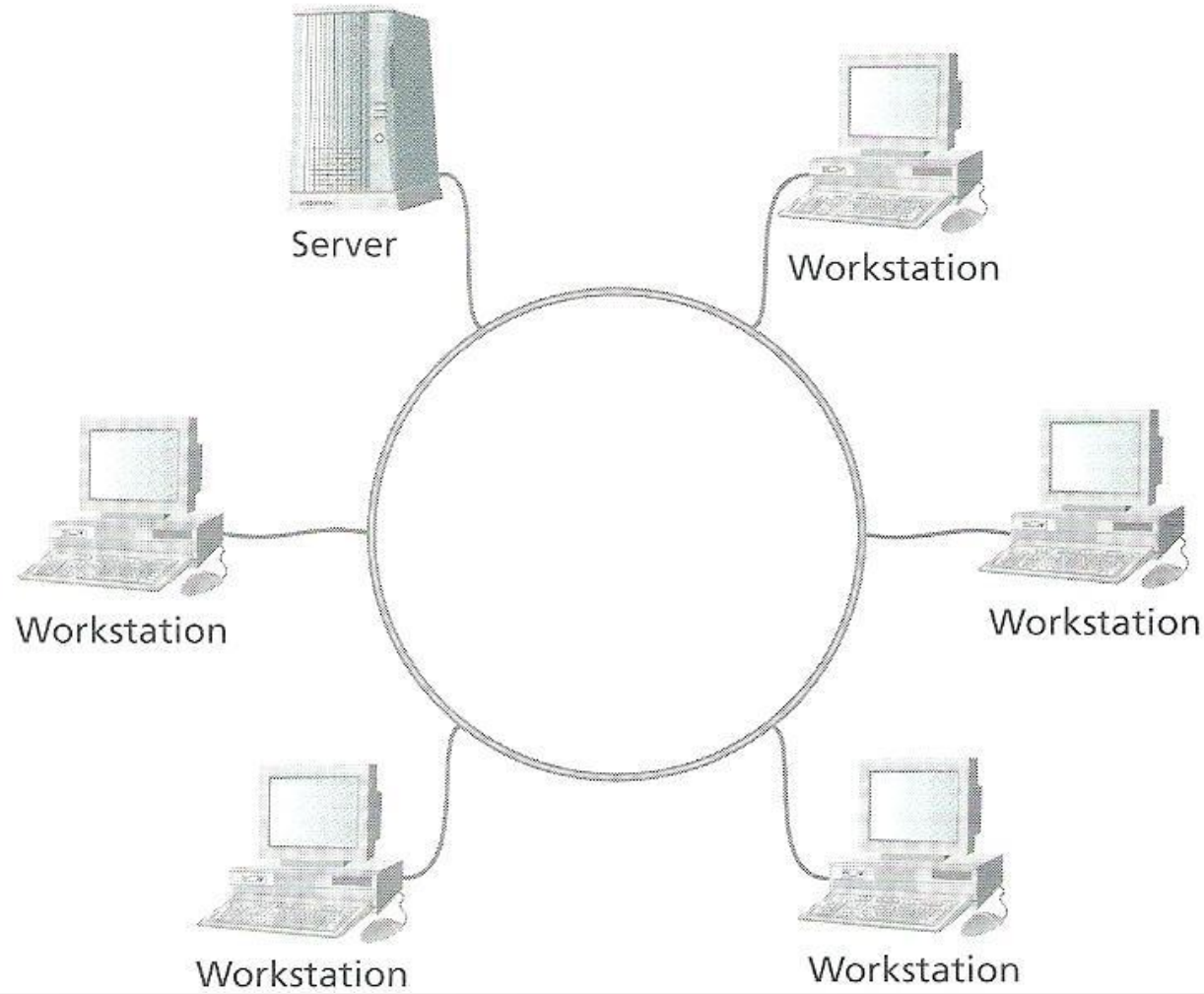
Advantages Star-star topology:

- Device connectivity to the LAN can be achieved through a centralized device.
- If any single cable segment fails in a star topology, the network continues to function.

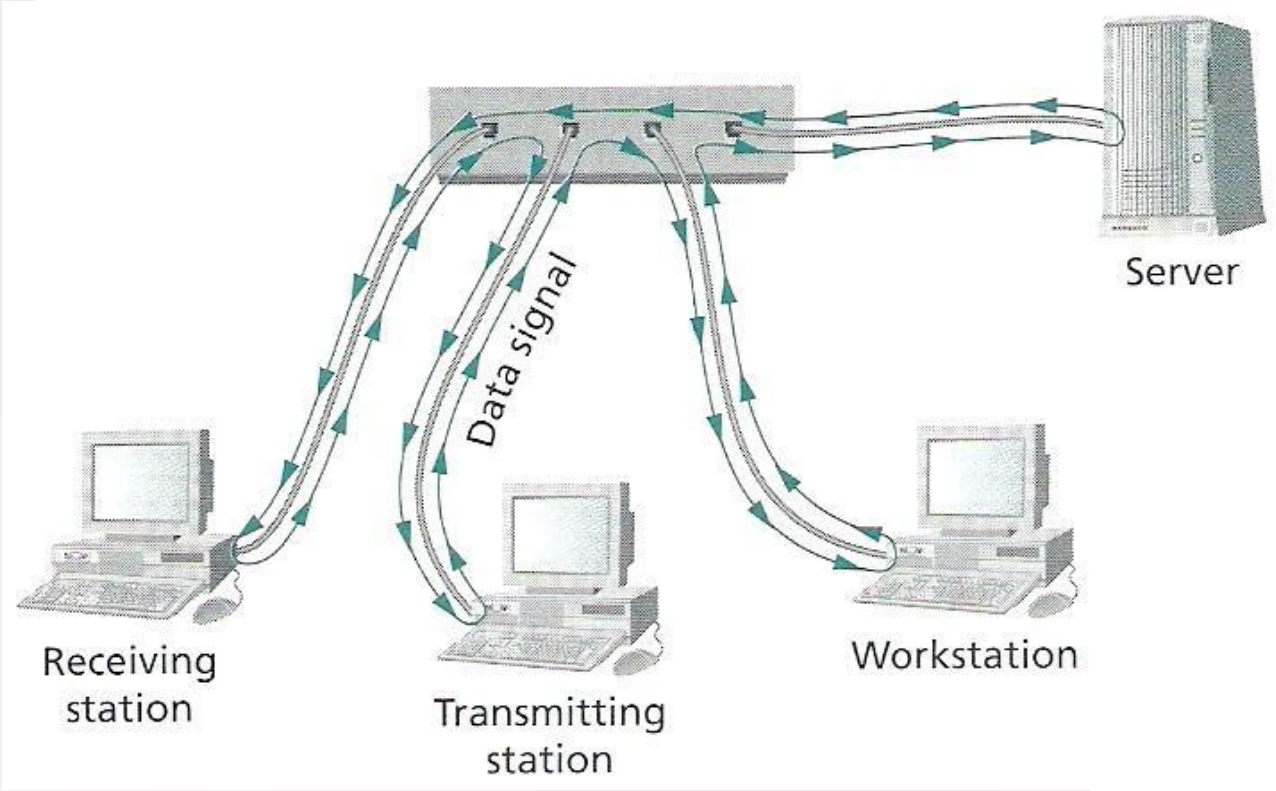
Disadvantages:

- Data transmission across the network will cease, if the centralized hub or switch fails.
- It requires significant amounts of cable, since cables are to be run to each computing device on the LAN.

RING TOPOLOGY



Physical Star/Logical Ring Topology



PHYSICAL TOPOLOGIES CHART

Physical Topology	Common Cable	Common Protocol
Linear Bus	Twisted Pair Coaxial Fiber Optic	Ethernet Local Talk
Star	Twisted Pair Fiber Optic	Ethernet Local Talk
Star-Wired ring	Twisted Pair	Token ring
Tree	Twisted Pair Coaxial Fiber Optic	Ethernet

LAN CONFIGURATIONS

Peer-to-peer

In a peer-to-peer LAN, each computer acts as both a client and a server. When a computer requests a service, it's acting as a client. When a computer provides services, it's acting as a server.

Client dominant

With client-dominant LANs, most of the application processing and data manipulation is performed at the client, and the server stores files.

Client/Server

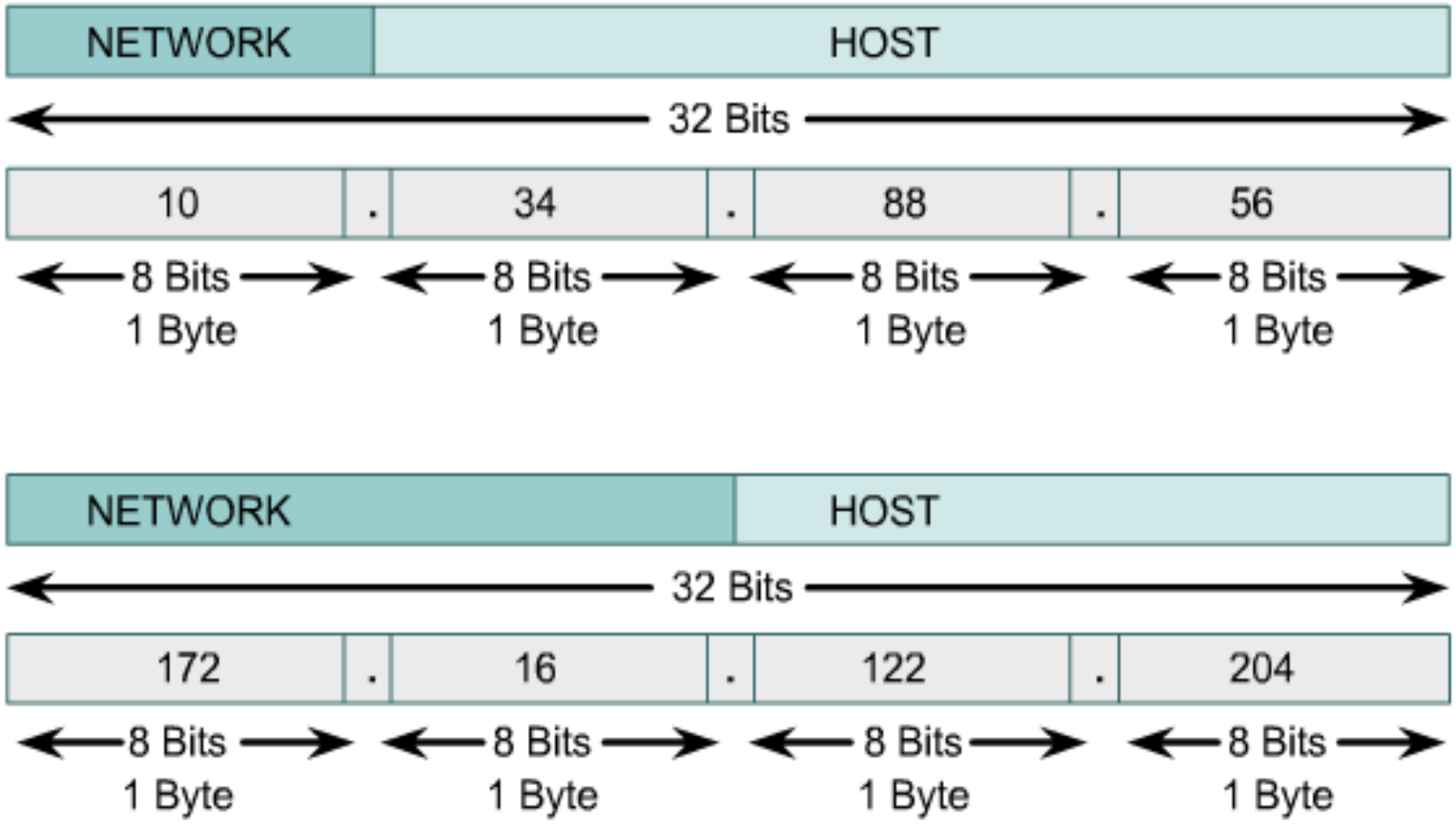
In a client/server LAN, some of the application processing and data manipulation are reserved for the server while other processing takes place on the client.

IP Addressing

- It is a unique identifying string expressed as four decimal numbers ranging from 0 to 255, separated by periods, with each of the four numbers representing 8 bits of the address for a total length of 32 bits for the whole address.
- Examples:
  - 192.168.7.20
  - 10.25.30.5

Class A Networks

- Class A addresses can range from 0 to 127 in the first octet meaning 128 possible networks.
- You can have up to 126 possible networks. 2 are invalid (network name and broadcast)
- Each network can have up to 16,777,214 hosts or nodes.
- The default subnet mask for Class A networks is 255.0.0.0.
- From 10.0.0.0 to 10.255.255.255 are private class B addresses.


NETWORK
HOST
32 Bits
10
.
34
.
88
.
56
8 Bits
1 Byte
8 Bits
1 Byte
8 Bits
1 Byte
8 Bits
1 Byte
NETWORK
HOST
32 Bits
172
.
16
.
122
.
204
8 Bits
1 Byte
8 Bits
1 Byte
8 Bits
1 Byte
8 Bits
1 Byte

Class B Networks

- Ranges from 128 to 191.
- Can have up to 16,382 possible networks.
- Each of which can have up to 65,534 nodes.
- The default subnet mask is 255.255.0.0.
- **The address 127.0.0.0 is left for loopback.**
- It's used for the special purpose known as loopback
- Loopback is a diagnostic test used to verify that a node can send and receive IP data transmissions.
- From 172.16.0.0 to 172.31.255.255 are private class B addresses.

Class C Networks.

- First octet ranges from 192 to 223.
- It's possible to have up to 2,097,150 networks
- Each network can have up to 254 nodes.
- The default subnet mask is 255.255.255.0.
  - E.g: From 192.168.0.0 to 192.168.255.255

Class D and Class E Networks

Class D is used for IP multicasts.

- Address ranges is from 224.0.0.0 to 239.255.255.255

Class E is reserved for future use, or research and development purposes.

- Address ranges is from 240.0.0.0 to 254.255.255.254

Netmask

- Determines which portion of the IP address is the network address and the host or node address
  - For example:
    - IP address: 12.128.1.2
    - Netmask: 255.0.0.0
    - Network address: 12.0.0.0

Gateway Address

A Gateway Address is the IP address through which a particular network, or host on a network be may be reached.

Domain Name Service (DNS) Server

Is a type of network server that helps to point domain names or the hostname to their associated IP address.

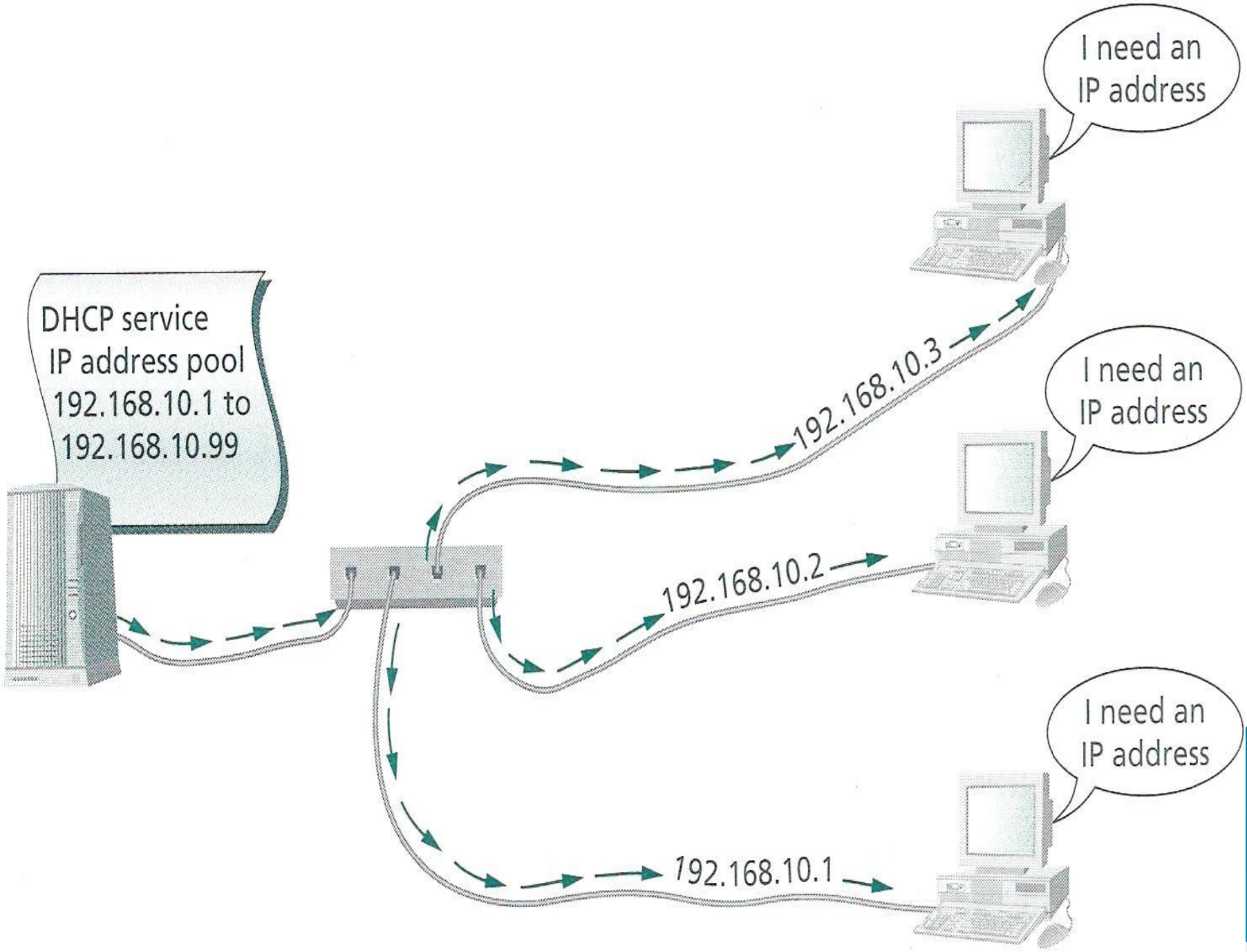
Broadcast Address

IP address which allows network data to be sent simultaneously to all hosts on a given sub-network

Assigning IP addresses.

- Every device on an IP network requires an IP address. IP addresses can be assigned manually (static) or by using DHCP (Domain host configuration protocol).

- Manual assignments are time consuming and error prone.
- Automatic assignments through DHCP are convenient and a big time saver for network technicians.


I need an IP address
DHCP service IP address pool 192.168.10.1 to 192.168.10.99
192.168.10.3
I need an IP address
192.168.10.2
I need an IP address
192.168.10.1

Networking Operating Systems (NOS)

- A network operating system is the software that interfaces between server hardware and the network to which the server is attached.
- Provides users with controlled access to shared services on a network.
- NOS that run on servers include: Novell Netware, Microsoft Windows(NT, 2000 server, 2003 server, 2008 server), Linux, Unix, Sun Solaris