BROADBAND AND HIGH SPEED NETWORKS

1 Data Communication Networks

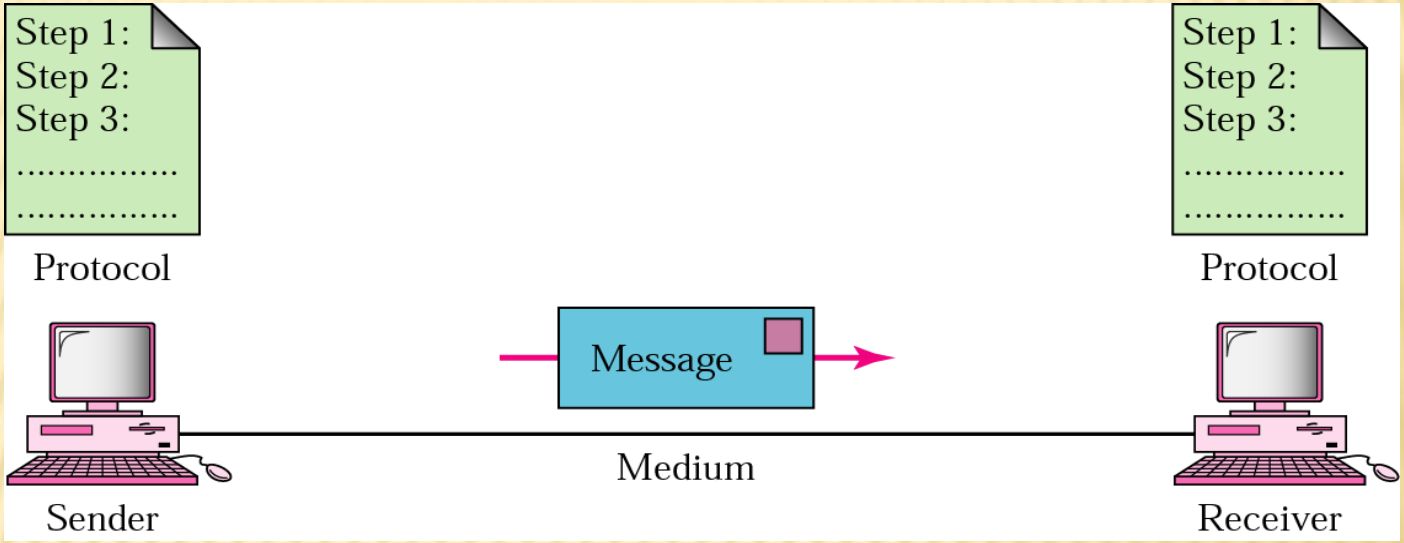
INTRODUCTION TO DATA COMMUNICATION NETWORKS

Data communications are the exchange of data between two devices via some form of transmission medium such as a wire cable.

The effectiveness of a data communication system depend on four fundamental characteristics:

- Delivery
- Accuracy
- Timelines
- Jitter

FIVE COMPONENTS OF DATA COMMUNICATION



1. Message
2. Sender
3. Receiver
4. Medium
5. Protocol

WHAT IS BROADBAND?

- Narrowband
  - The highest speed modem used with a traditional telephone line, known as a 56K modem, offers a maximum data transmission rate of about 45,000 bits per second (bps).
  - For example, using a 56K modem connection to download a 10-minute video or a large software file can be a lengthy and frustrating exercise.
- Broadband
  - By using a broadband high-speed Internet connection, with data transmission rates many times faster than a 56K modem, users can view video or download software and other data-rich files in a matter of seconds.
  - Broadband access provides a continuous “always on” connection (no need to “dial-up”) and a “two-way” capability — that is, the ability to both receive (download) and transmit (upload) data at high speeds.

TRANSMISSION TECHNOLOGIES

Digital Subscriber Line (DSL)

Cable Modem

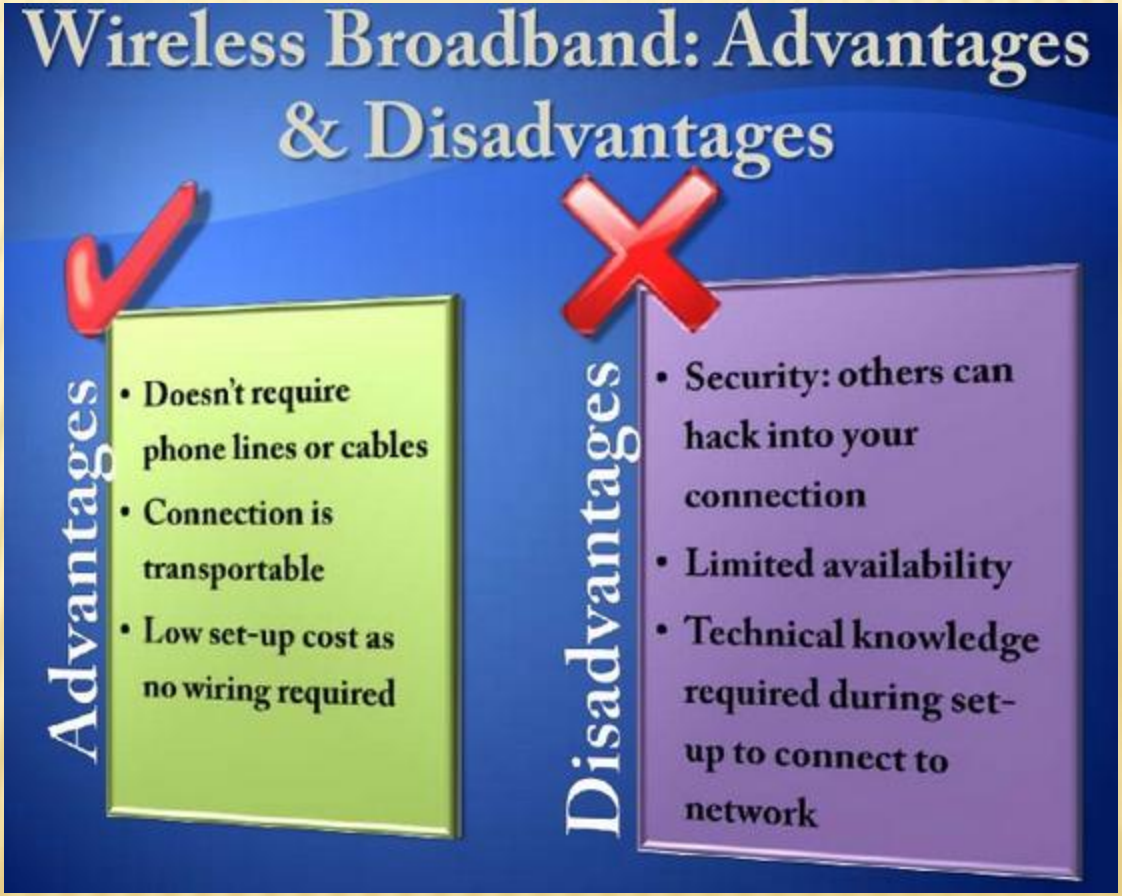
Fiber

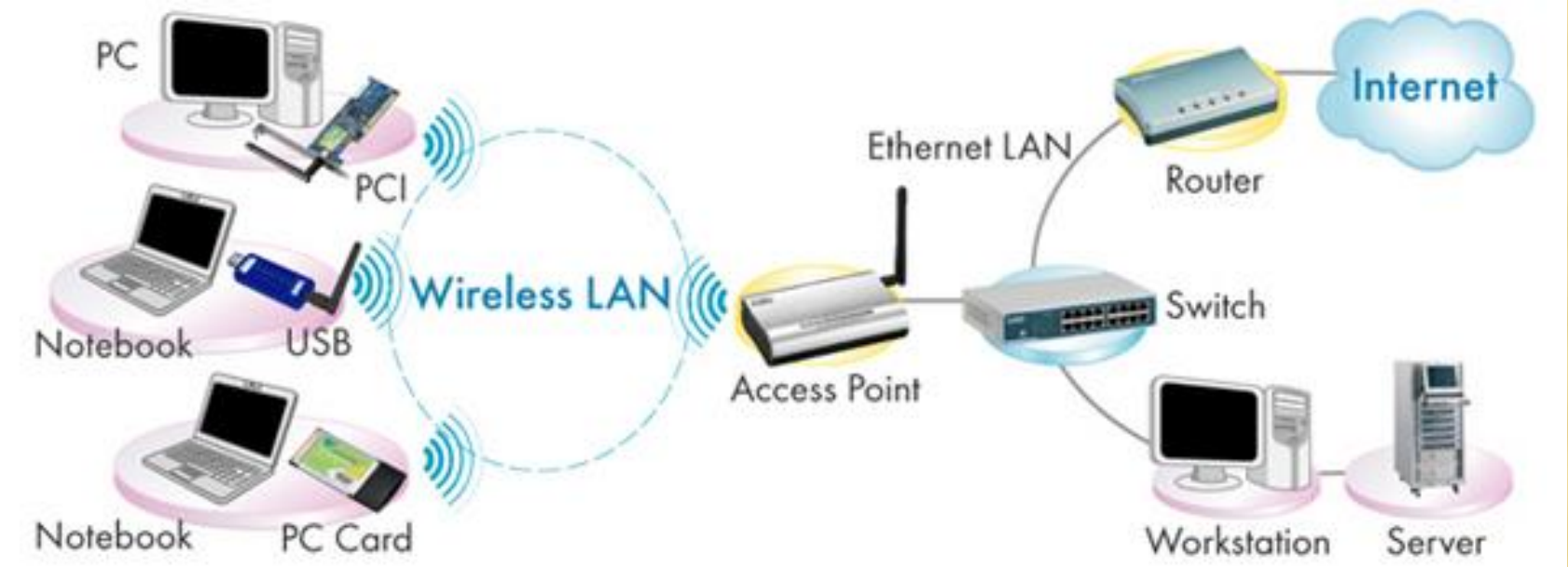
Wireless

Satellite

Broadband over Powerlines (BPL)

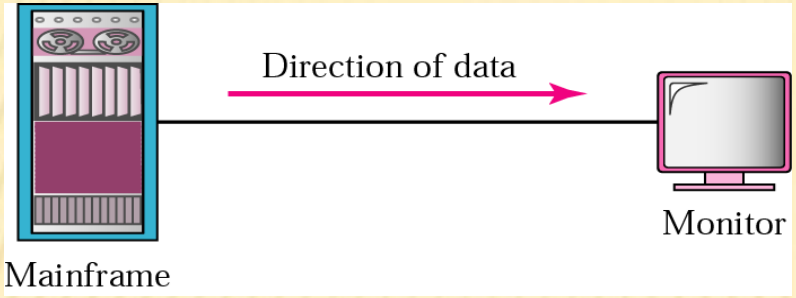

DSL
Advantages
• Fast connection
• Uses the same line as a phone but allows calls to be made at the same time
• Always on
• All computers within a building can surf using a wireless routers
• Security
Disadvantages
• Usually quicker download speeds than upload
• Distance sensitive
• Quality of phone line affects service
• Speeds slower at peak hours


Wireless Broadband: Advantages & Disadvantages
Advantages
• Doesn't require phone lines or cables
• Connection is transportable
• Low set-up cost as no wiring required
Disadvantages
• Security: others can hack into your connection
• Limited availability
• Technical knowledge required during set-up to connect to network

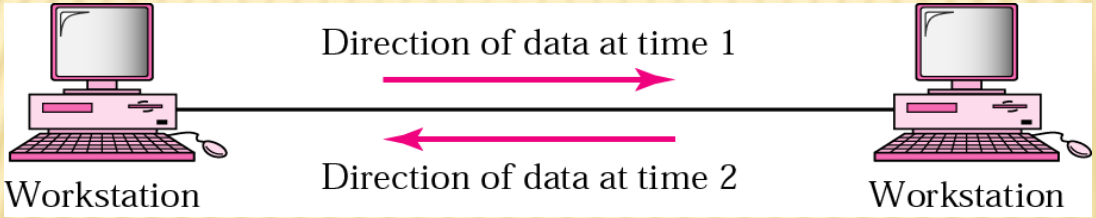


The Access Point establishes an infrastructure mode for networking between all wireless clients and Ethernet resources.

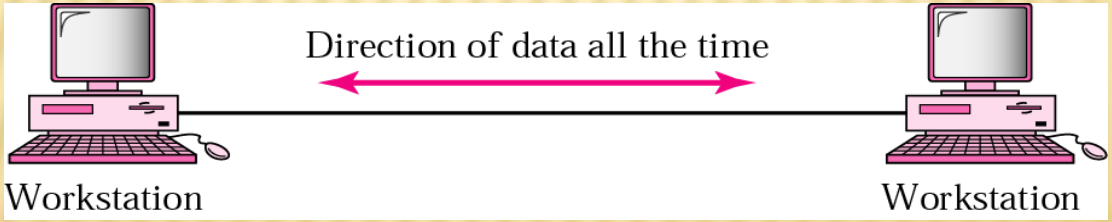
DIRECTION OF DATA FLOW



Simplex



Half Duplex



Full Duplex

NETWORKS: KEY ISSUES

- **Network criteria**
  - **Performance**
    - Throughput
    - Delay
  - **Reliability**
    - Data transmitted are identical to data received.
    - Measured by the frequency of failure
    - The time it takes a link to recover from a failure
  - **Security**
    - Protecting data from unauthorized access

BROADBAND APPLICATIONS

- **Broadband Video**
  - Video on Demand
  - Audio on Demand
  - Gaming
  - Multimedia Messaging
  - Interactive Program Guide
  - Pay Per View
  - Internet on TV
  - Video Telephony
  - Personal Video Recorder
  - Walled Garden
- **General Internet Access**
  - Browsing
  - File Downloading
  - Messaging
  - Games
- **Audio and Video**
  - Audio delivery
  - Internet Telephony
  - Video Conference
  - Audio Delivery
  - Video Delivery
- **New Applications**
  - Peer-to-Peer Applications
  - Distance Learning
  - Distributed Work
  - Home Content

BROADBAND INTERNET APPLICATIONS

- Transform the Internet
  - Broadband access, along with the content and services it might enable, has the potential to transform the Internet — both what it offers and how it is used.

  For example, a two-way high speed connection could be used for interactive applications such as
    - online classrooms
    - online showrooms
    - Online health clinics

- Broadband Internet
  - An “always on” connection could be used to monitor some applications remotely through the Web.
    - Monitor home security
    - Home automation
    - Patient health

- Video applications
  - The high speed and high volume that broadband offers could also be used for bundled services offered over a single line.
    - Video
    - Live TV
    - VoD

BROADBAND APPLICATIONS

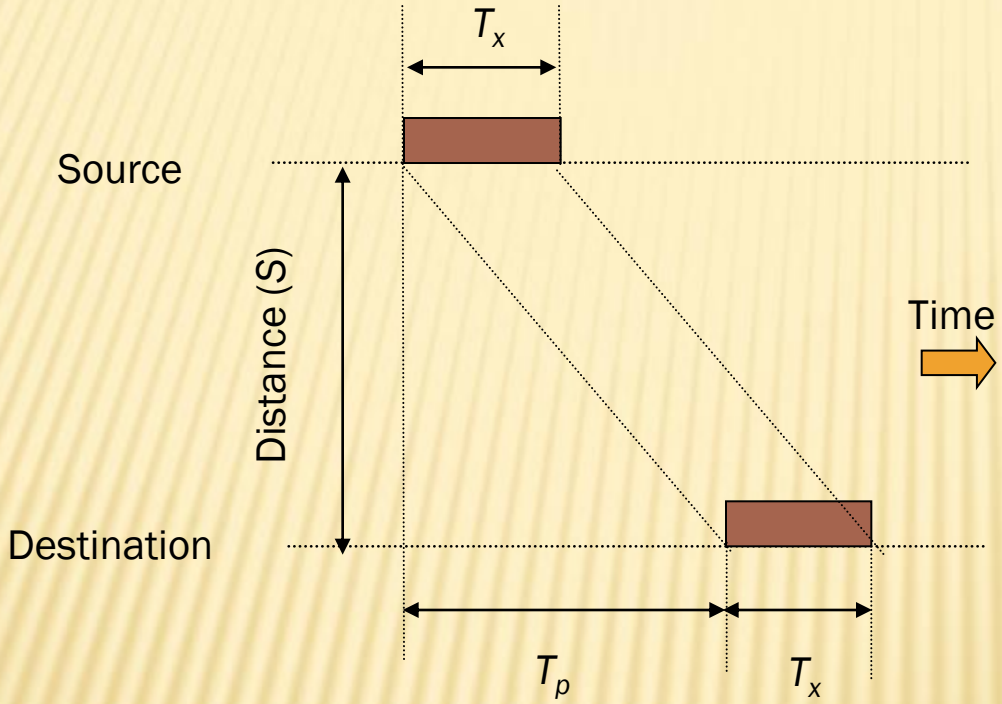
Service category	Annual revenue potential
Continuing education	$3.0 billion
Movies on demand	$2.3 billion
Long distance to any phone per month[3]	$1.9 billion
TV shows on demand	$1.6 billion
Home health monitoring	$1.1 billion
Video monitoring of older relative's facility	$1.0 billion
Access to employer's network	$936 million
Unified messaging (work)	$832 million
Fitness enthusiasts' service	$797 million
Unified messaging (personal)	$762 million

Top Ten Services by Revenue Potential

CHARACTERISTICS OF HIGH-SPEED NETWORKS

1. Long *propagation delay* (*Tp*) compared to the *transmission delay* (T_x).
2. Limited Processing.
3. The use of optical transmission medium and components.
4. Low error rates.
5. Abundant bandwidth.

CHARACTERISTICS OF HIGH-SPEED NETWORKS



$T_P = S/V$

T_P Propagation Delay
S Link Length
V Propagation peed

$T_X = N/R$

T_X Transmission Delay
N Number of bits
R Rate of transmission

T_P Propagation Delay is the amount of time it takes for the head of the signal to travel from the sender to the receiver. It can be computed as the ratio between link length (s) and propagation speed (v) over the specific medium.

T_X Transmission Delay N Number of bits R Rate of transmission

CHARACTERISTICS OF ARCHITECTURE AND PROTOCOLS OF HIGH-SPEED NETWORKS

1. *Simple Algorithms:* The networks protocols should be simplified to reduce processing overhead.
2. *End-to-End protocols:* Shift the processing from the internal nodes of the networks to the edge nodes.
3. *Regular Topologies:* To simplify routing.
4. *Fault Tolerant:* Availability of alternative paths between a source and a destination. Thus, the network is more sensitive to failures.
5. *Limited Buffering:* Large number of packets will flow through the high speed network, Thus, it is impractical to provide enough buffer to store all packets.
6. *Simplified Error Control:* The error rate of a fiber-optic is extremely low. This mean that *end-to-end, forward* error control will be preferred over hop-by-hop, feedback error control protocols.
7. *Trade-offs between Bandwidth and Delay:* The bandwidth in high-speed network is not a limited resource. This creates the opportunity to use some algorithms which waste the bandwidth to achieve better performance.

   Design for speed, not for bandwidth optimization
8. *Choosing Appropriate Protocols:* If an error is detected, the user will have to retransmit not just the *bad packet*, but also several megabytes worth of packets that came afterward. Clearly, this is a massive waste of resources.
9. *Simple Packet Layout:* The header should contain as few fields as possible.

TRANSMISSION TECHNOLOGY

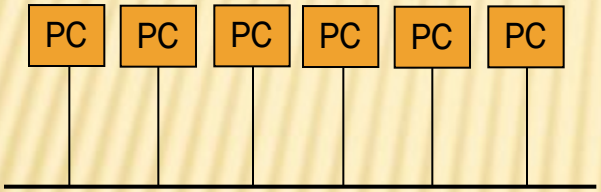
1. Broadcast Networks:

- Broadcast networks have a single communication channel that is shared by all the machines on the network.
- Short messages, called *packets* are sent by any machine and received by all the others.
- An *address field* within the packet specifies for whom it is intended.
- Upon receiving a packet, a machine checks the address field. If the *packet id* intended for itself, it process the packet; if the packet is intended for some other machine, it is just ignored.

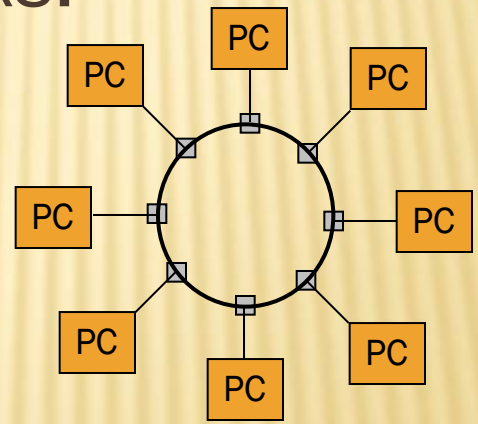
TRANSMISSION TECHNOLOGY

1. Broadcast Networks (*Continued*):

- Two broadcast networks:



Bus



Ring

TRANSMISSION TECHNOLOGY

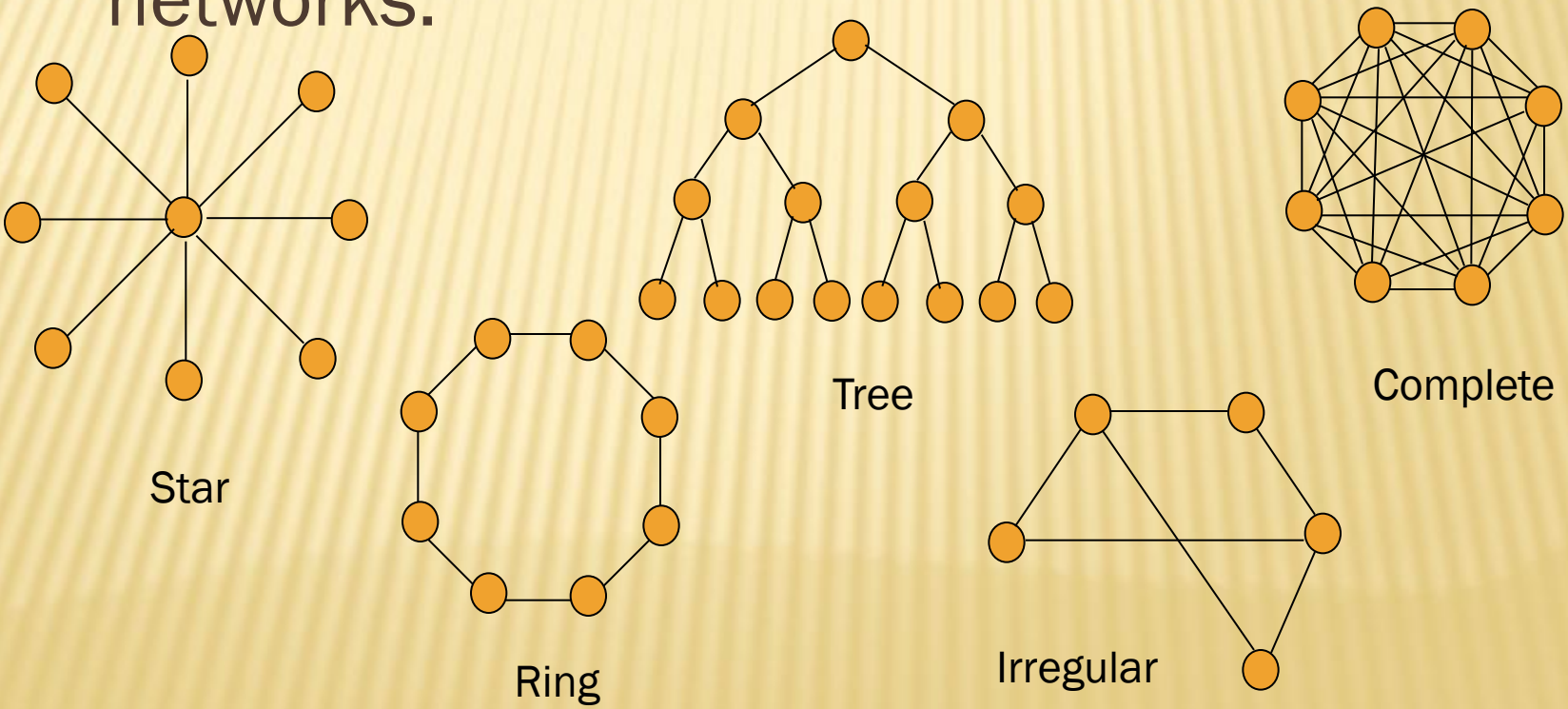
2. Point-to-Point Networks:

- Point-to-point networks consists of many connections between individual pairs of machines.
- To go from a source to a destination, a packet may visit one or more intermediate machines.
- Often there are multiple routes between a source and a destination, therefore, *routing algorithms* are needed to select shortest path.

TRANSMISSION TECHNOLOGY

2. Point-to-Point Networks (*Continued*):

- Some possible topologies for point-to-point networks:



NETWORK ARCHITECTURE

- Networks may be categorized by their geographical coverage.
  - *Local Area Networks* (LAN)
  - *Metropolitan Area Networks* (MAN)
  - *Wide Area Networks* (WAN)

LANS, MANS, AND WANS

One early solution was the creation of local-area network (LAN) standards which provided an open set of guidelines for creating network hardware and software, making equipment from different companies compatible.

What was needed was a way for information to move efficiently and quickly, not only within a company, but also from one business to another.

The solution was the creation of metropolitan-area networks (MANs) and wide-area networks (WANs).

CLASSIFICATION OF INTERCONNECTED PROCESSORS

Distance Between CPUs	Location of CPUs	Name
0.1 m	Printed circuit board Personal data asst.	Motherboard Personal Area Network (PAN)
1.0 m	Millimeter Mainframe	Computer Systems Network
10 m	Room	Local Area Network (LAN) Your classroom
100 m	Building	Local Area Network (LAN) Your school
1000 m = 1 km	Campus	Local Area Network (LAN) Stanford University
100,000 m = 100 km	Country	Wide Area Network (WAN) Cisco Systems, Inc.
1,000,000 m = 1,000 km	Continent	Wide Area Network (WAN) Africa
10,000,000 m = 10,000 km	Planet	Wide Area Network (WAN) The Internet
100,000,000 m = 100,000 km	Earth-moon system	Wide Area Network (WAN) Earth and artificial satellites

LOCAL AREA NETWORKS (LANS)

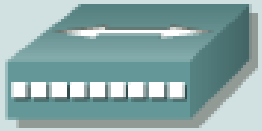
LANS are designed to:

- Operate within a limited geographic area
- Allow multi-access to high-bandwidth media
- Control the network privately under local administration
- Provide full-time connectivity to local services
- Connect physically adjacent devices

Using:

Router

Bridge



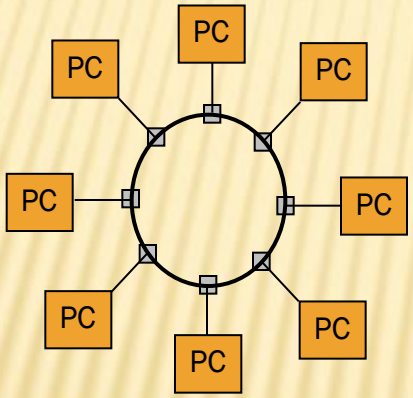
Hub

Ethernet Switch

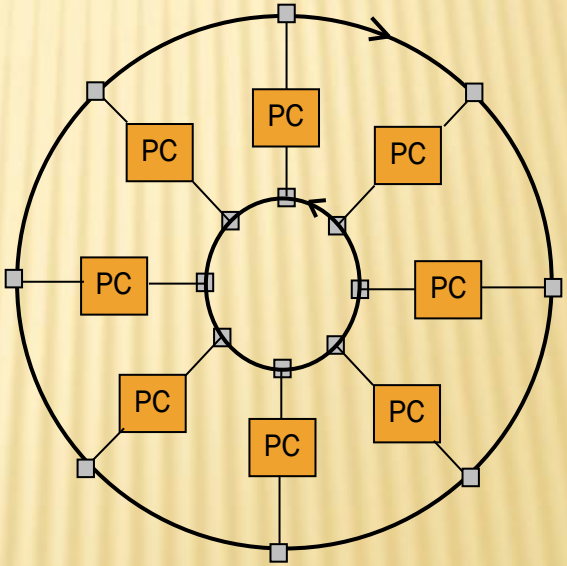
Repeater

LOCAL AREA NETWORKS

- The topologies for the broadcast LANs such as:

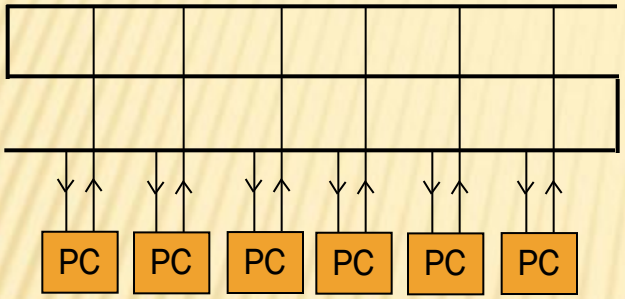


Single Ring
(IEEE 802.5)

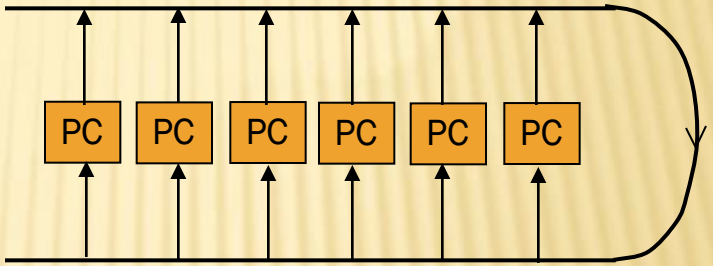


Dual Ring (FDDI)

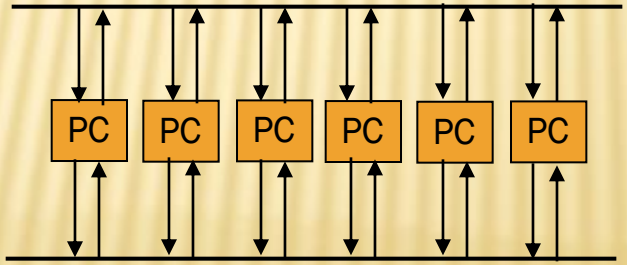
LOCAL AREA NETWORKS



Single Bus (Expressnet)

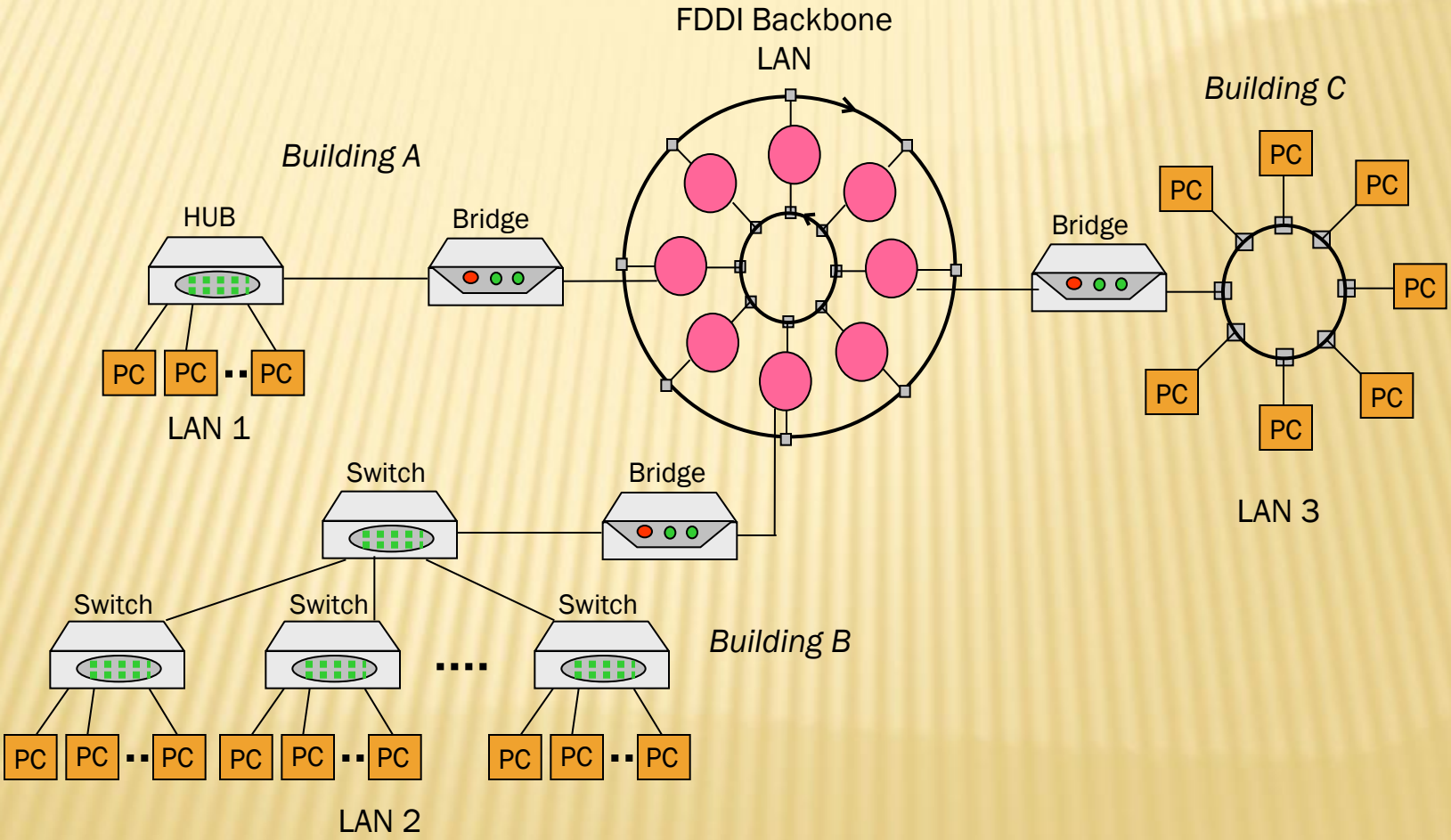


Single Bus (D-Net)



Dual Bus (Fastnet)

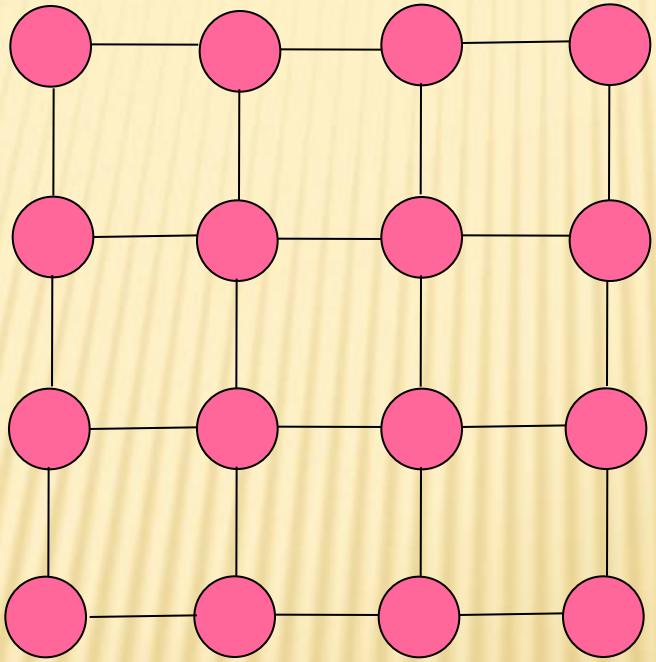
LOCAL AREA NETWORKS



METROPOLITAN AREA NETWORKS (MANS)

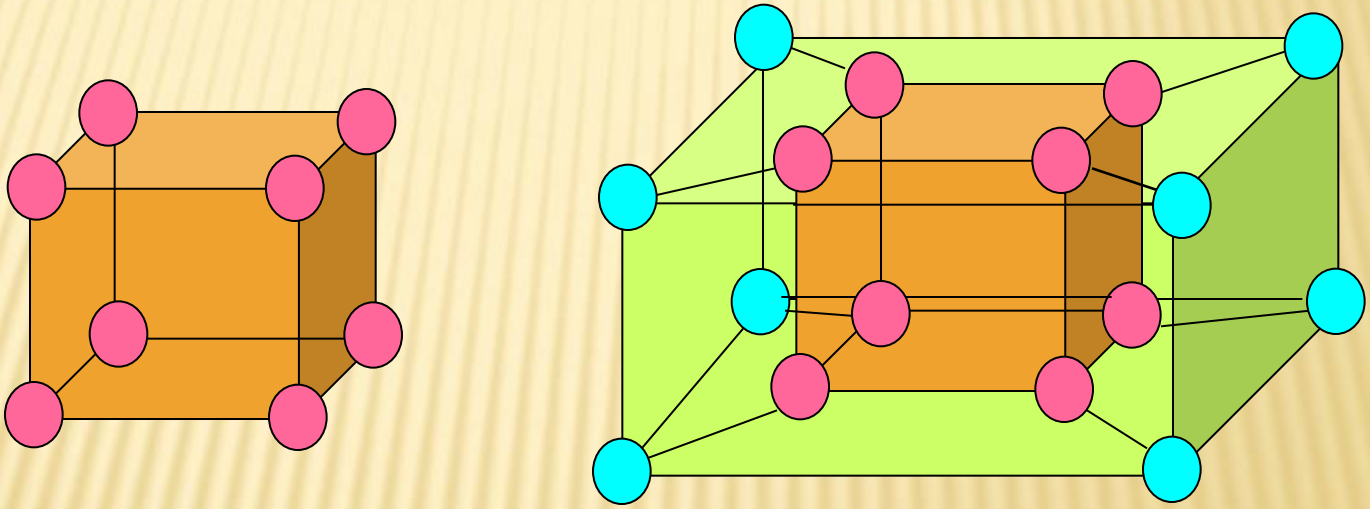
- A MAN is used to connect networks located over wider a region than a LAN.
- Complexity of routing can be reduced by adopting a regular topologies.
- Examples of MAN topologies:
  - Mesh Network
  - Hypercube Network
  - Manhattan Street Network
  - Shuffle-Exchange Network
  - Tree Network
  - Star Network

METROPOLITAN AREA NETWORKS



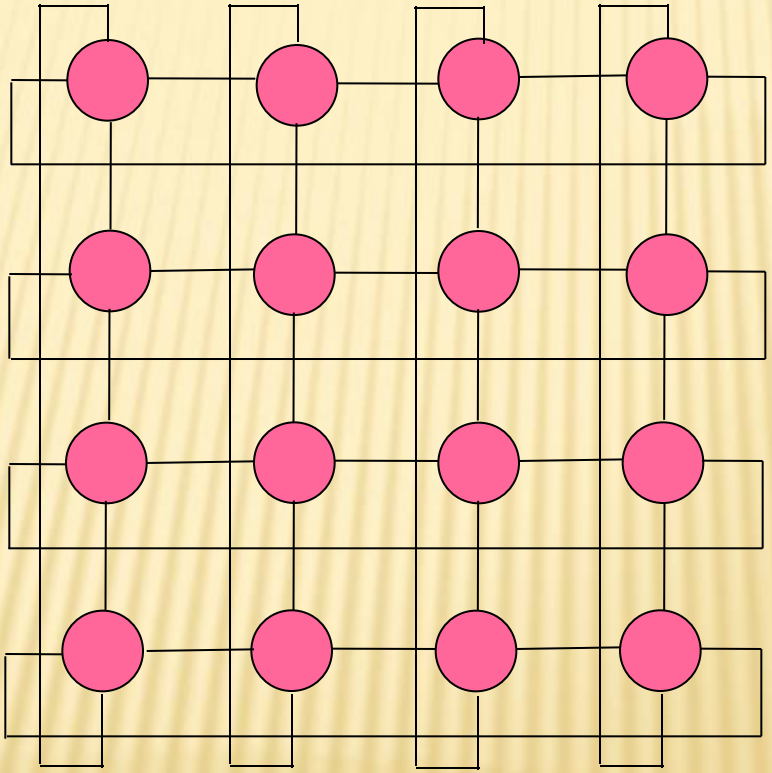
Mesh Networks

METROPOLITAN AREA NETWORKS



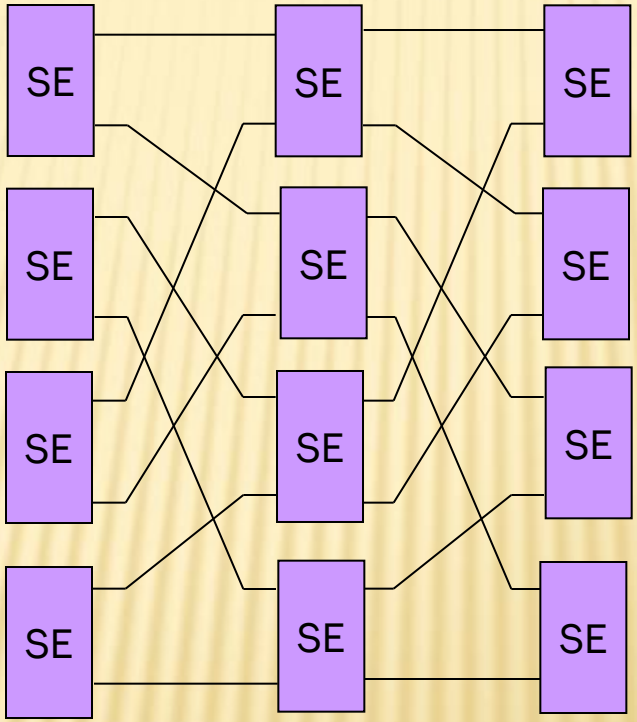
Hypercube Networks

METROPOLITAN AREA NETWORKS



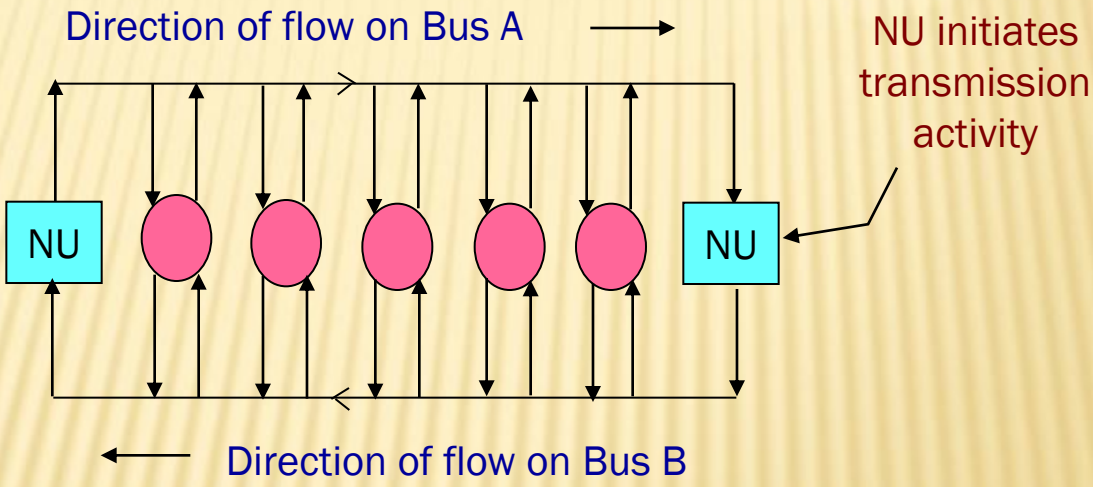
4-by-4 Manhattan Street Network

METROPOLITAN AREA NETWORKS



Shuffle-Exchange Network

METROPOLITAN AREA NETWORKS



Distributed Queue Dual Bus - DQDB (IEEE 802.6)

WIDE AREA NETWORKS (WANS)

WANS are designed to:

- Operate over a large geographical area
- Allow access over serial interfaces operating at lower speeds
- Provide full-time and part-time connectivity
- Connect devices separated over wide, even global areas

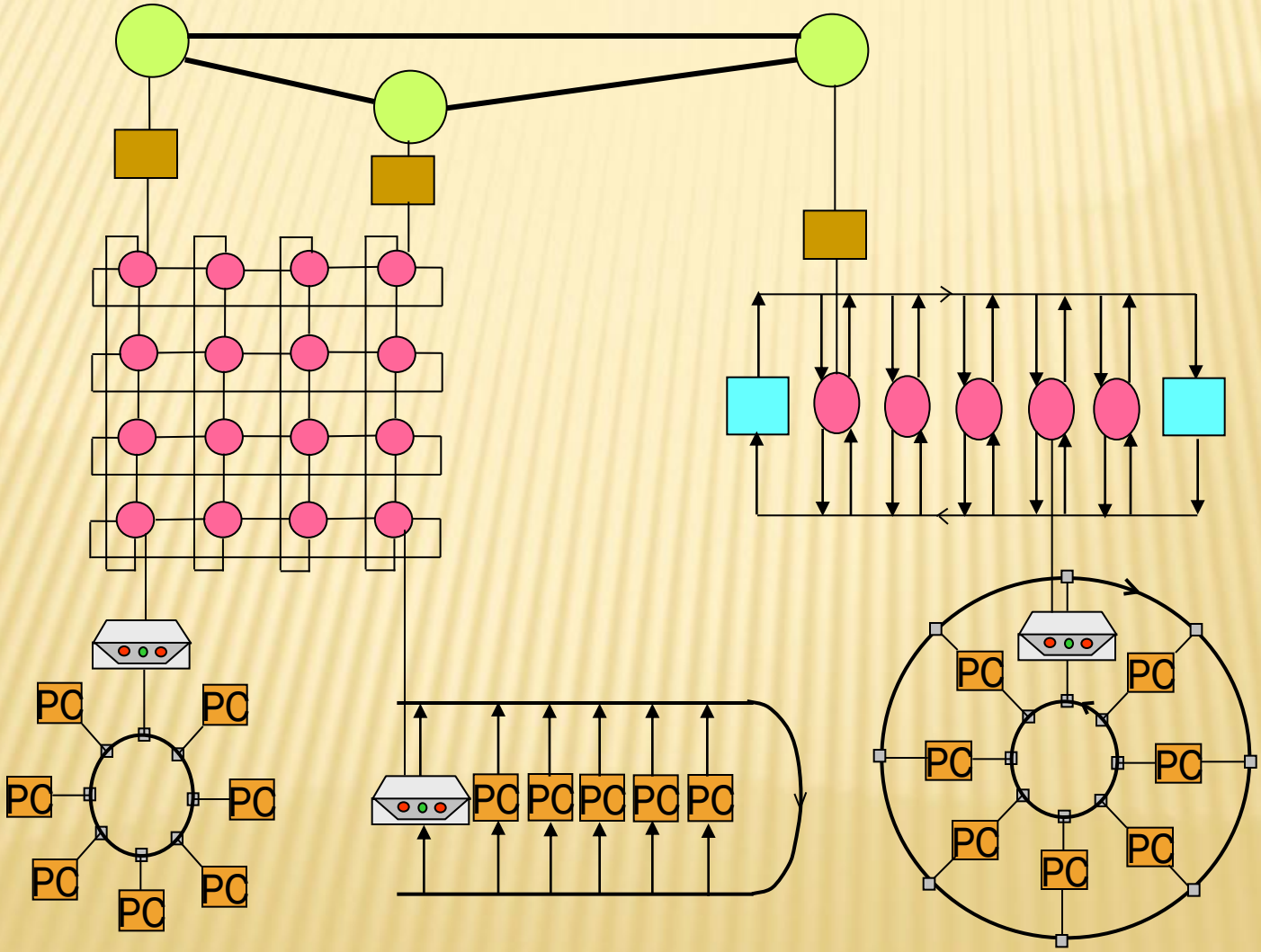
Using:

Router

Communication Server

Modem CSU/DSU TA/NT1

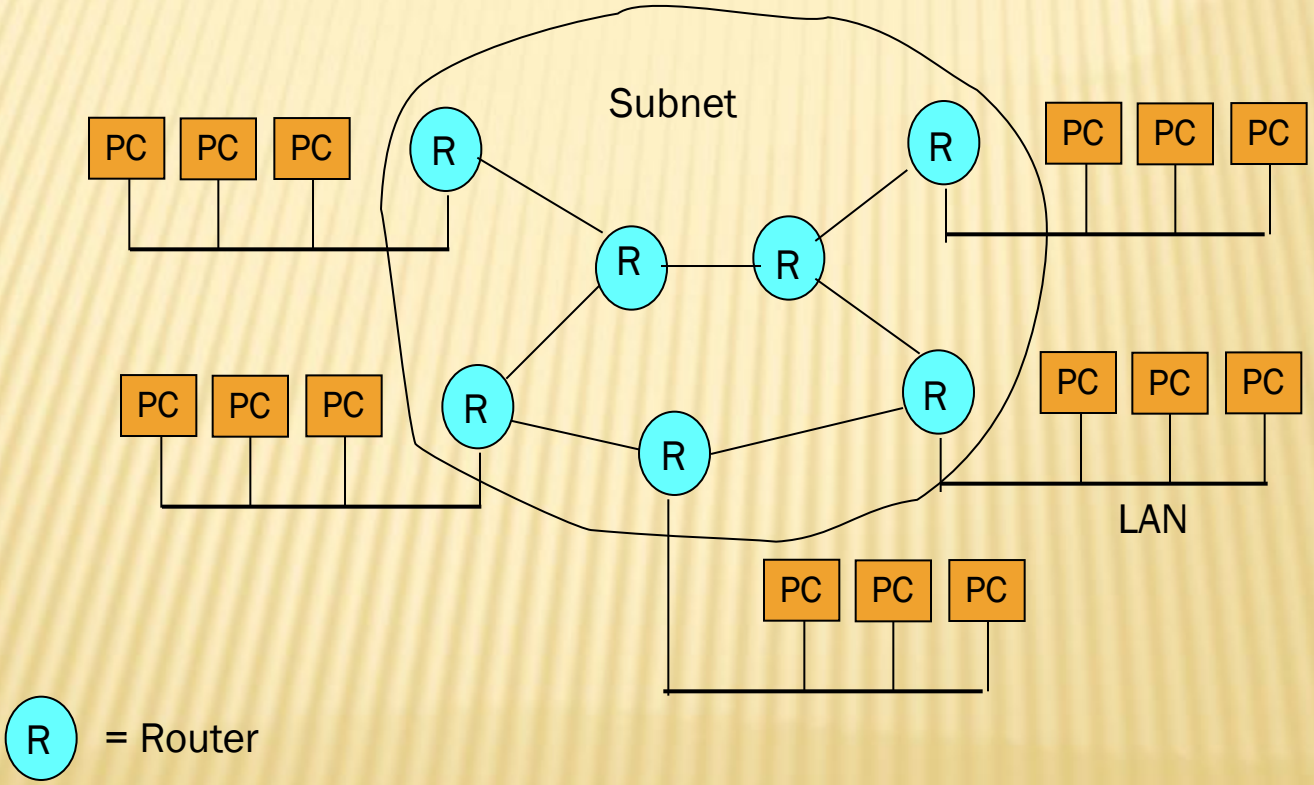
WIDE AREA NETWORKS



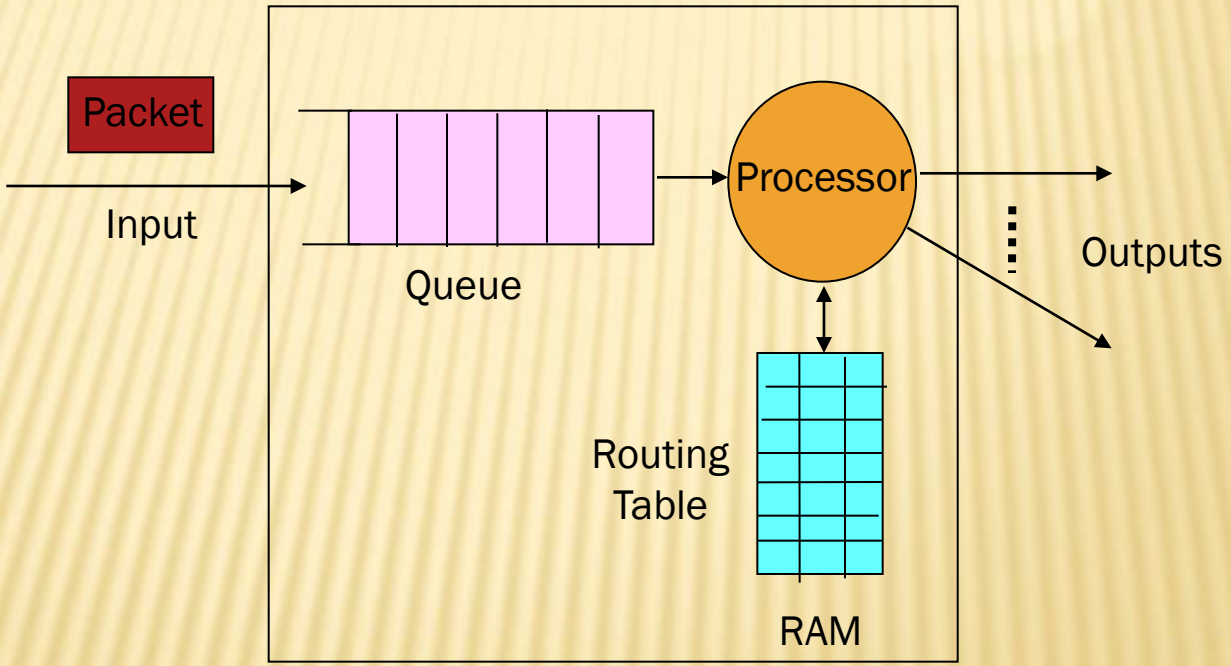
WIDE AREA NETWORKS

- Hosts are interconnected with a *communication subnet*, or shortly a *subnet*.
- A subnet is to carry messages from host to host.
- A subnet consists of *transmission lines* and *switching elements (Router)*.
- Routers are used to connect two or more transmission lines. When data arrive on an incoming line, the switching element must choose an outgoing line to forward them on.
- WANs typically have irregular *point-to-point* topologies.

WIDE AREA NETWORKS



WIDE AREA NETWORKS



A structure of a router

WIDE AREA NETWORKS

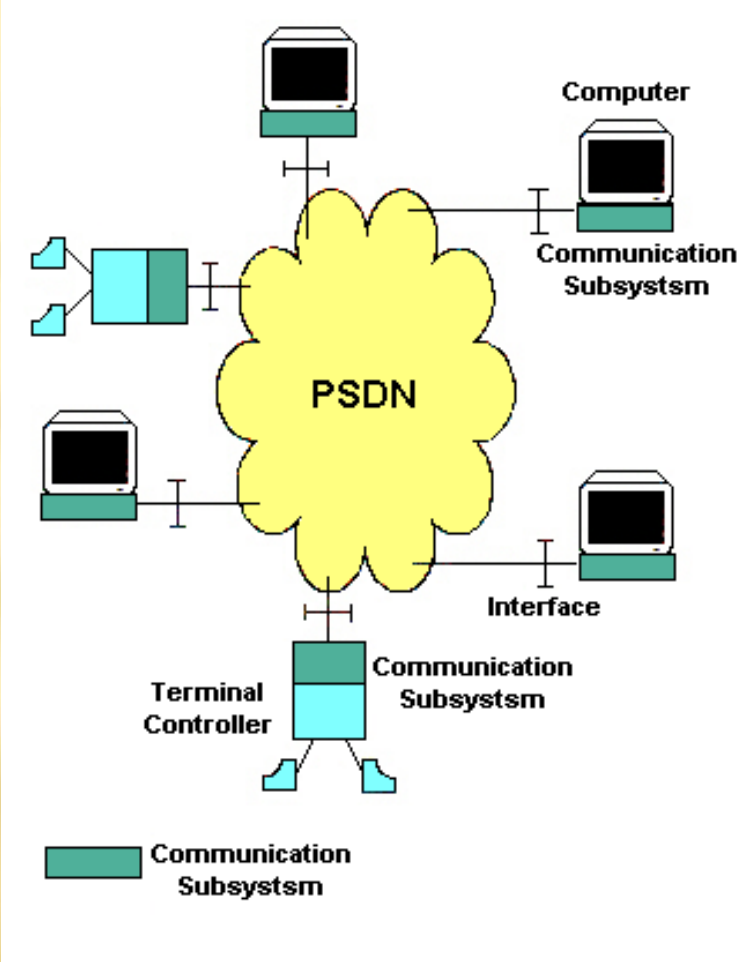
Examples of WANs:

- Private networks using leased lines.
- Public Switched Data Network (PSDN).
- Integrated Services Digital Networks (ISDNs).
- Worldwide Internetwork.
- Broadband Multiservice Networks.

WIDE AREA NETWORKS

PSDN:

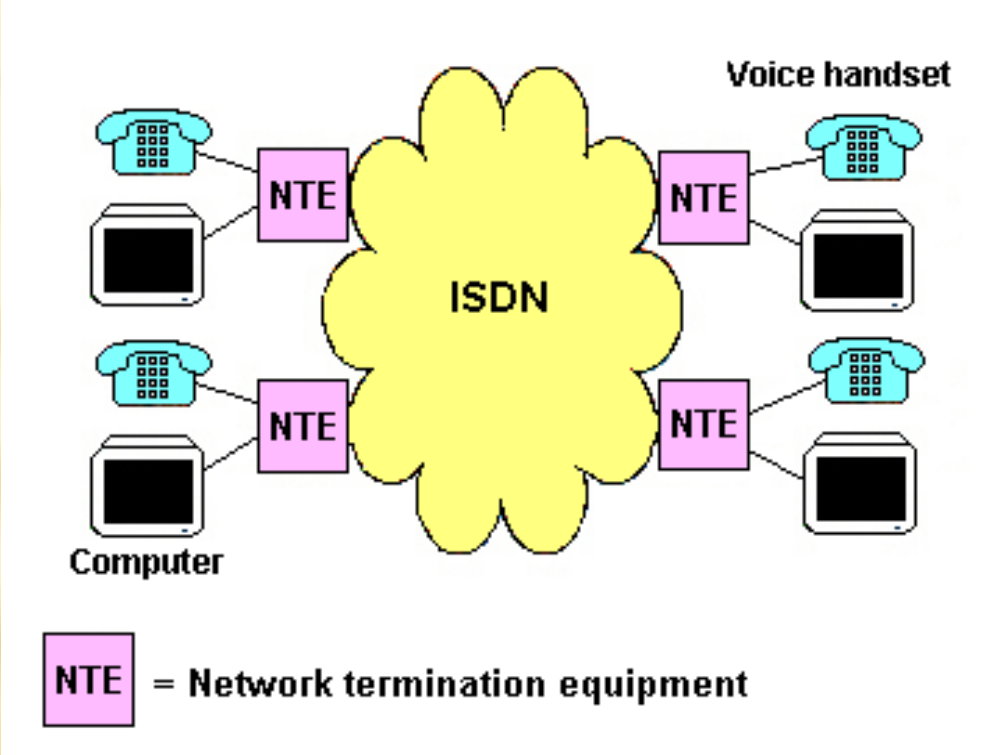
Public switched data network



WIDE AREA NETWORKS

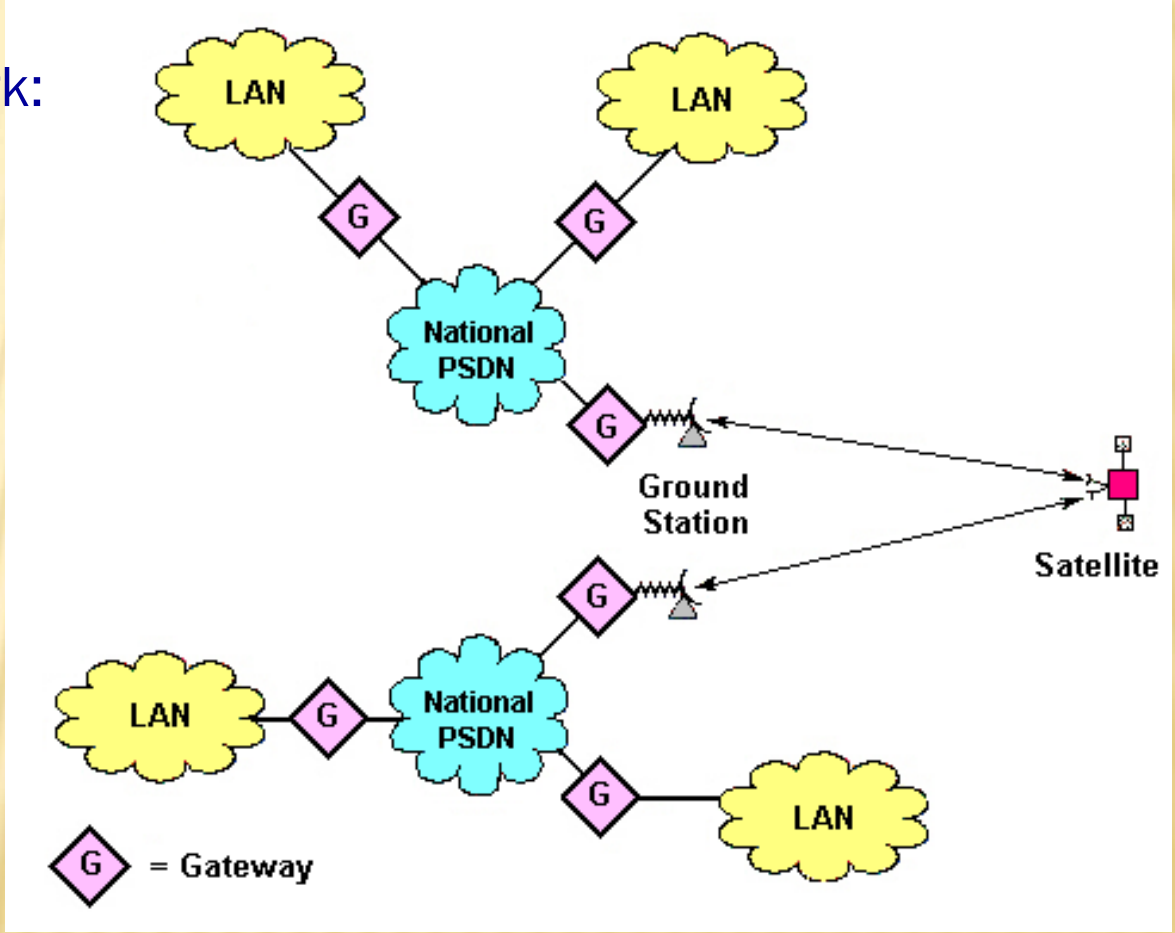
ISDN:

Integrated Services for Digital Network



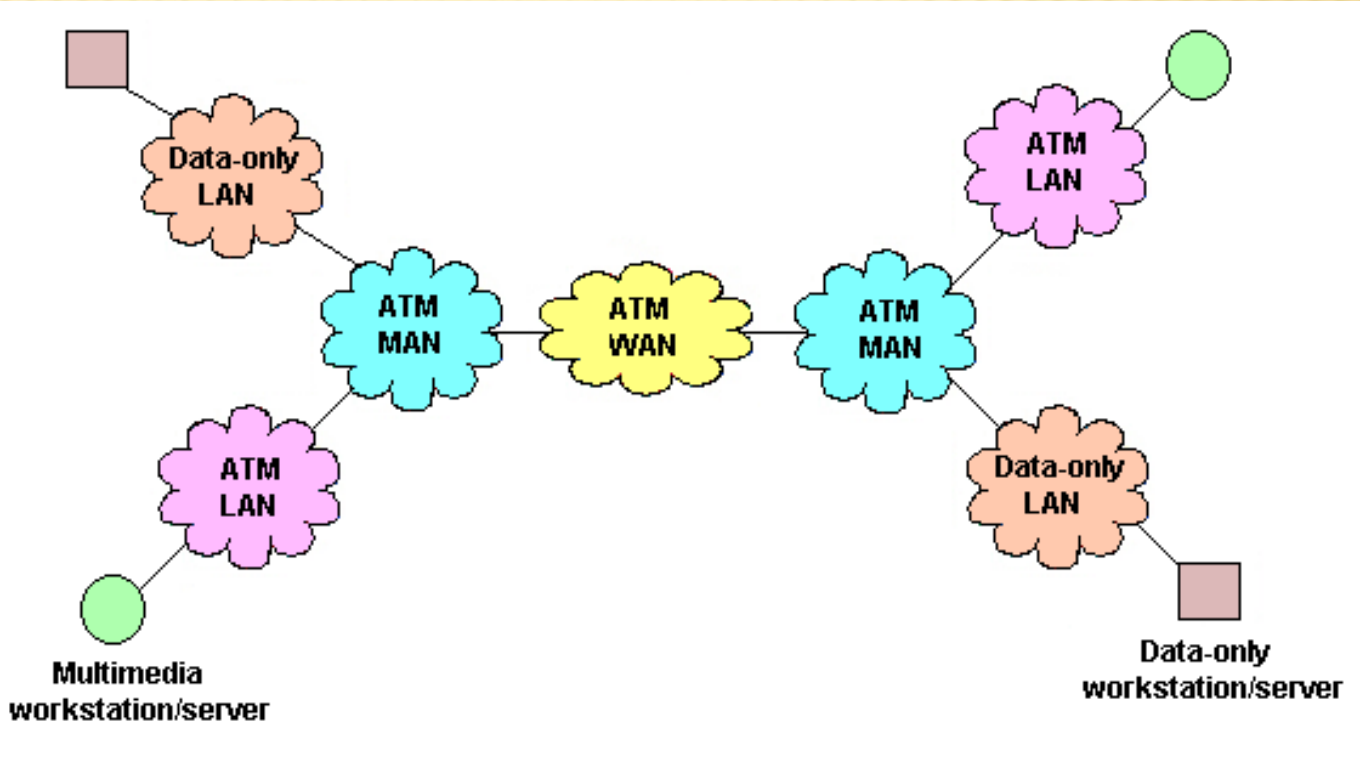
WIDE AREA NETWORKS

Worldwide Internetwork:



WIDE AREA NETWORKS

Broadcast Multiservice Networks



WIDE AREA NETWORKS

Broadband Multiservice Networks:

- Broadband means high transmission bit rates.
- Multiservice: Voice, Video, and Data.
- It supports multimedia applications such as:
  - Video Telephony.
  - Video Conferencing.
- Standard for transmission and switching:

  Asynchronous Transfer Mode (ATM).