# Network Devices

Functions of network devices

- **Separating (connecting) networks or expanding network**
  - e.g. repeaters, hubs, bridges, routers, brouters, switches, gateways

- **Remote access**
  - Modems

A. Expanding Network

- **Networks cannot be made larger by simply adding new computers and more cables**
  - **Less efficient !!**

- **Can install components to**
  - **segment (divide) large LAN to form smaller LANs**
  - **connect LANs**
- **Required components**
 - **Repeaters, bridges, routers, brouters, switches and gateways**

a. Repeaters and Hubs

- **Repeaters or hubs work at the OSI physical layer to regenerate the network's signal and resend them to other segments**
- **Primitive hub can be viewed as a multiport repeater**
  - **It regenerates data and broadcasts them to all ports**

Weakened signal

Hub

Repeater

Regenerated signal
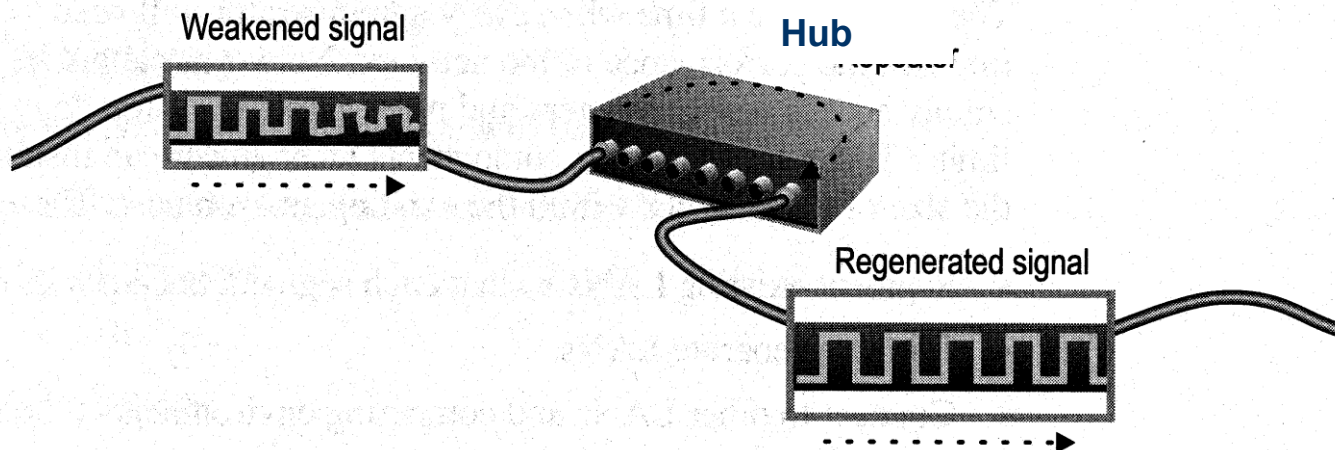
Limitations and Features

- **Cannot** link unlike segments
- **Cannot** join segments with different access methods (e.g. CSMA/CD and token passing)
- **Do not** isolate and filter packets

- **Can** connect different types of media
- The most **economic** way of expanding networks

Thin coax

Fiber-optic
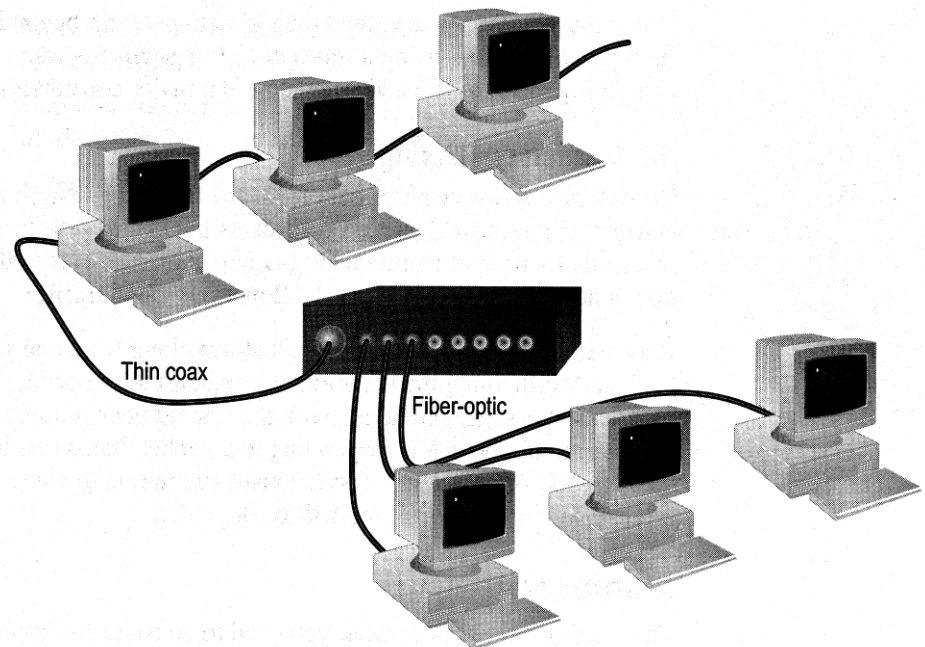
b. Bridges

- **Has one input and one output**
- **Used to isolate network traffic and computers**
- **Has the intelligent to examine incoming packet source and destination addresses**
- **But cannot interpret higher-level information**
- **Hence cannot filter packet according to its protocol**

Segment 1
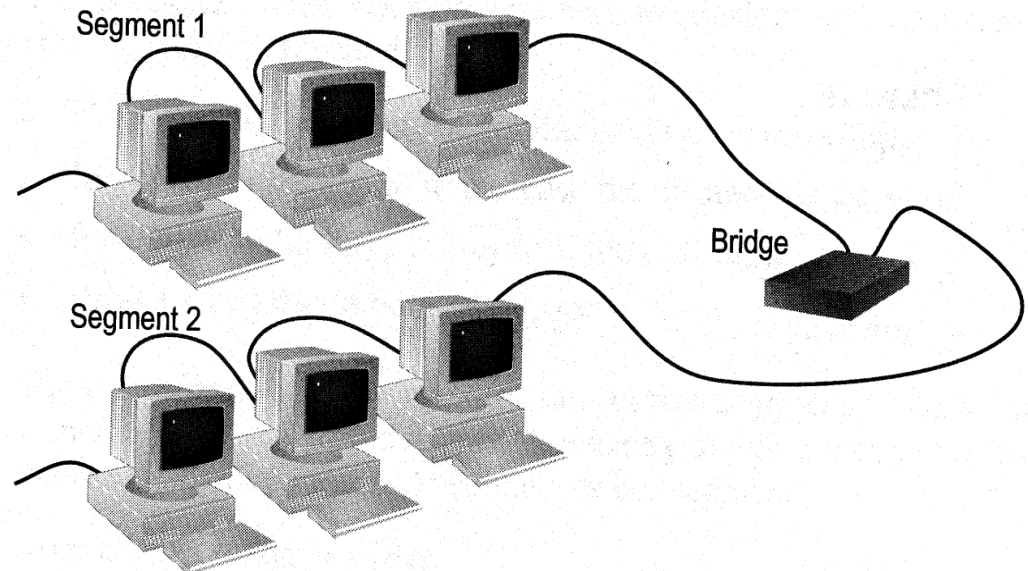
Segment 2
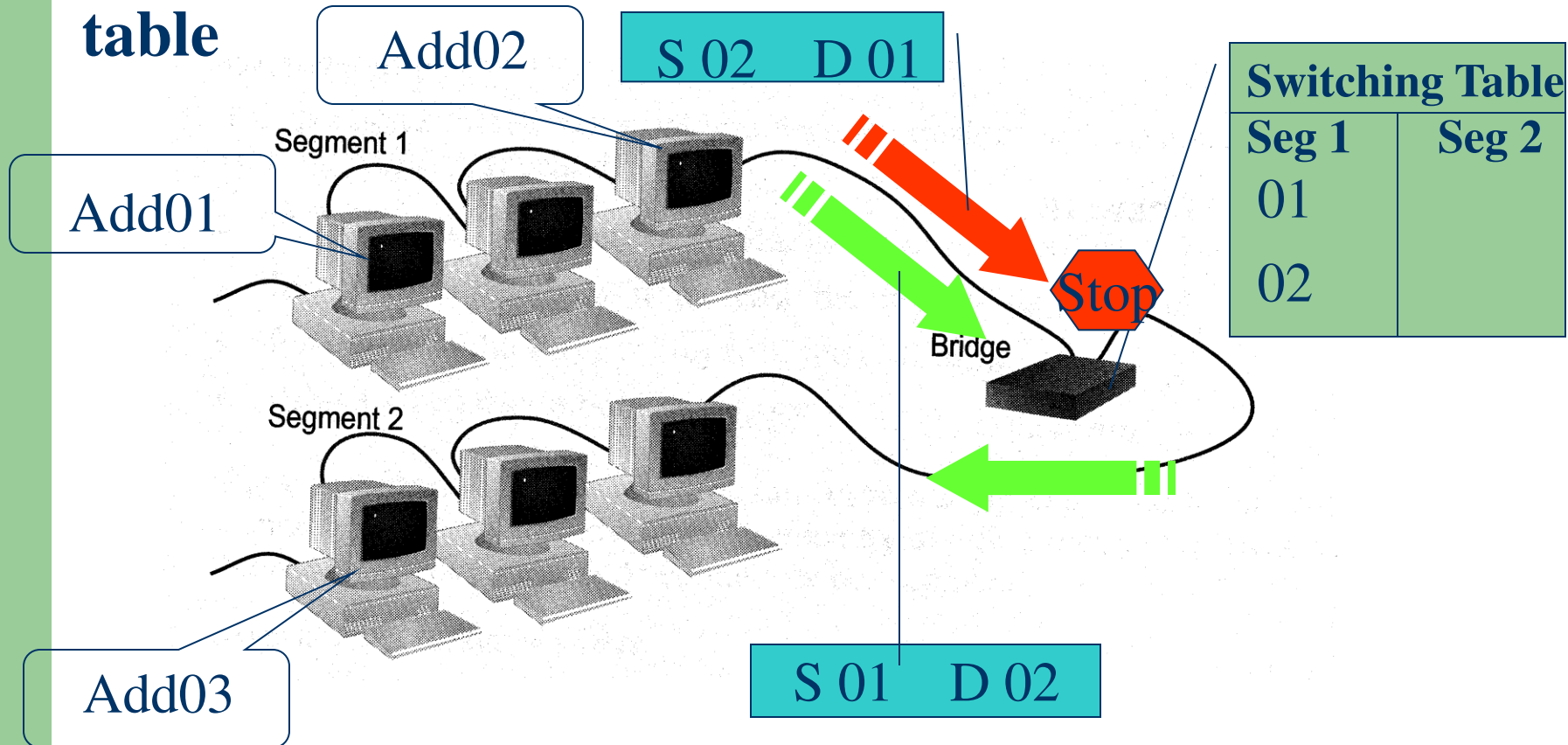
Bridge

How Bridges Work

- **Bridges work at the Media Access Control Sub-layer of the OSI model**
- **Routing table is built to record the segment no. of address**
- **If destination address is in the same segment as the source address, stop transmit**
- **Otherwise, forward to the other segment**

Segment 1

02608c133456

Routing Table

Bridge

Segment 2

02608c133561
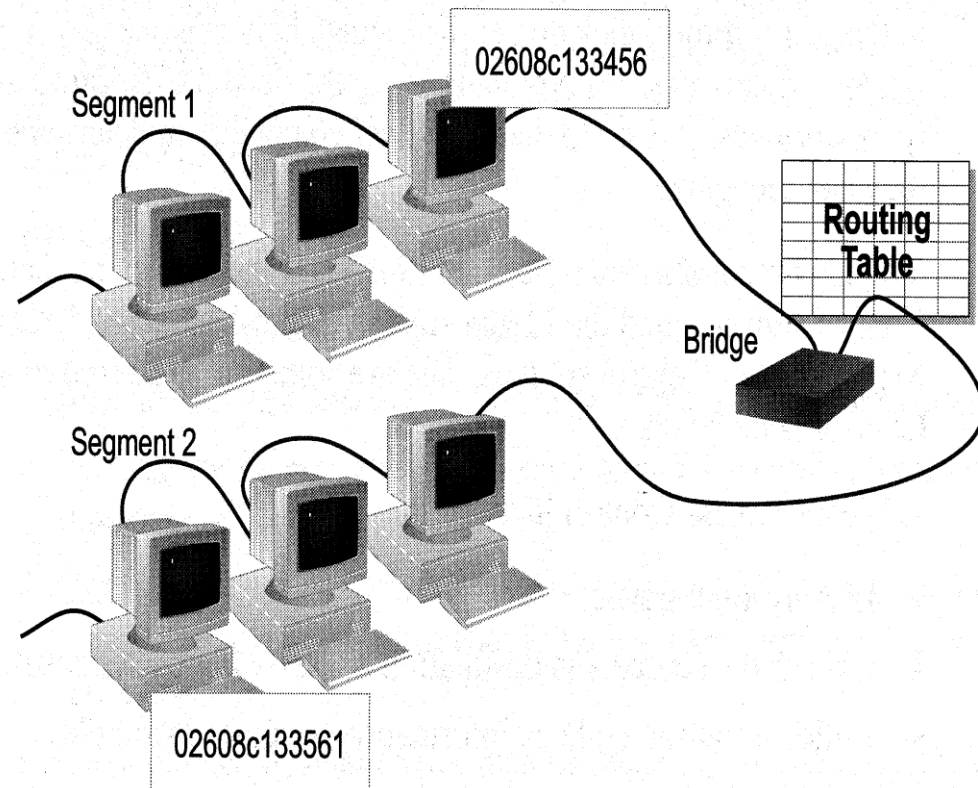
Creating a Switching Table
- **Based on the addresses of the sending computers**
- **New addresses are added if they are not in the table**

Add02

S 02   D 01

Add01

Segment 1

Add03

Segment 2

Bridge

Stop

S 01   D 02

Switching Table	
Seg 1	**Seg 2**
01	
02	

Remote Bridges

- **Bridges are often used in large networks that have widely dispersed segments**
- **Remote bridges can be used to connect remote segments via data-grade telephone line**
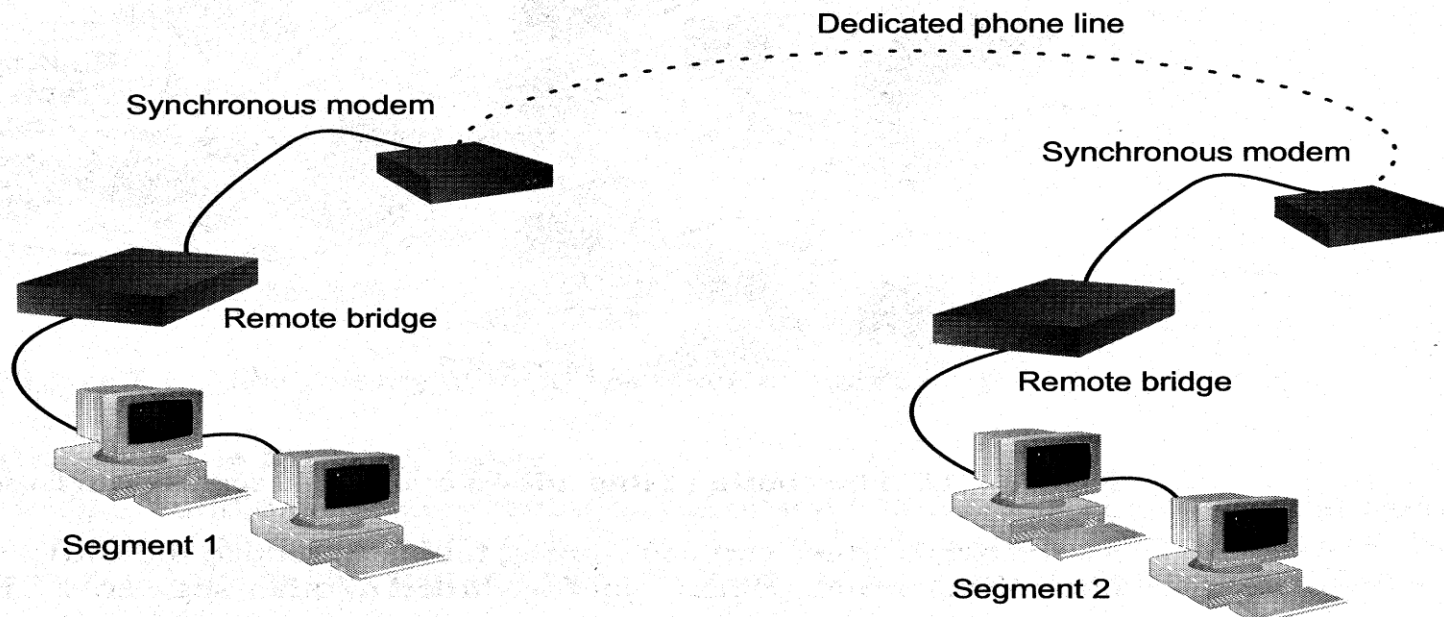
Differences Between Bridges and Repeaters

	Repeaters	*Bridges*
OSI layer	Physical layer	Data link layer
Data regeneration	Regenerate data at the signal level	Regenerate data at the packet level
Reduce network traffic	No	Yes

c. Switches

- Switches operate at the Data Link layer (layer 2) of the OSI model
- Can interpret address information
- Switches resemble bridges and can be considered as multiport bridges
- By having multiports, can better use limited bandwidth and prove more cost-effective than bridge

- **Switches divide a network into several isolated channels**
- **Packets sending from 1 channel will not go to another if not specify**
- **Each channel has its own capacity and need not be shared with other channels**

Switch

Hub

10Mbps

3.3Mbps

3.3Mbps

3.3Mbps

10Mbps

10Mbps

10Mbps
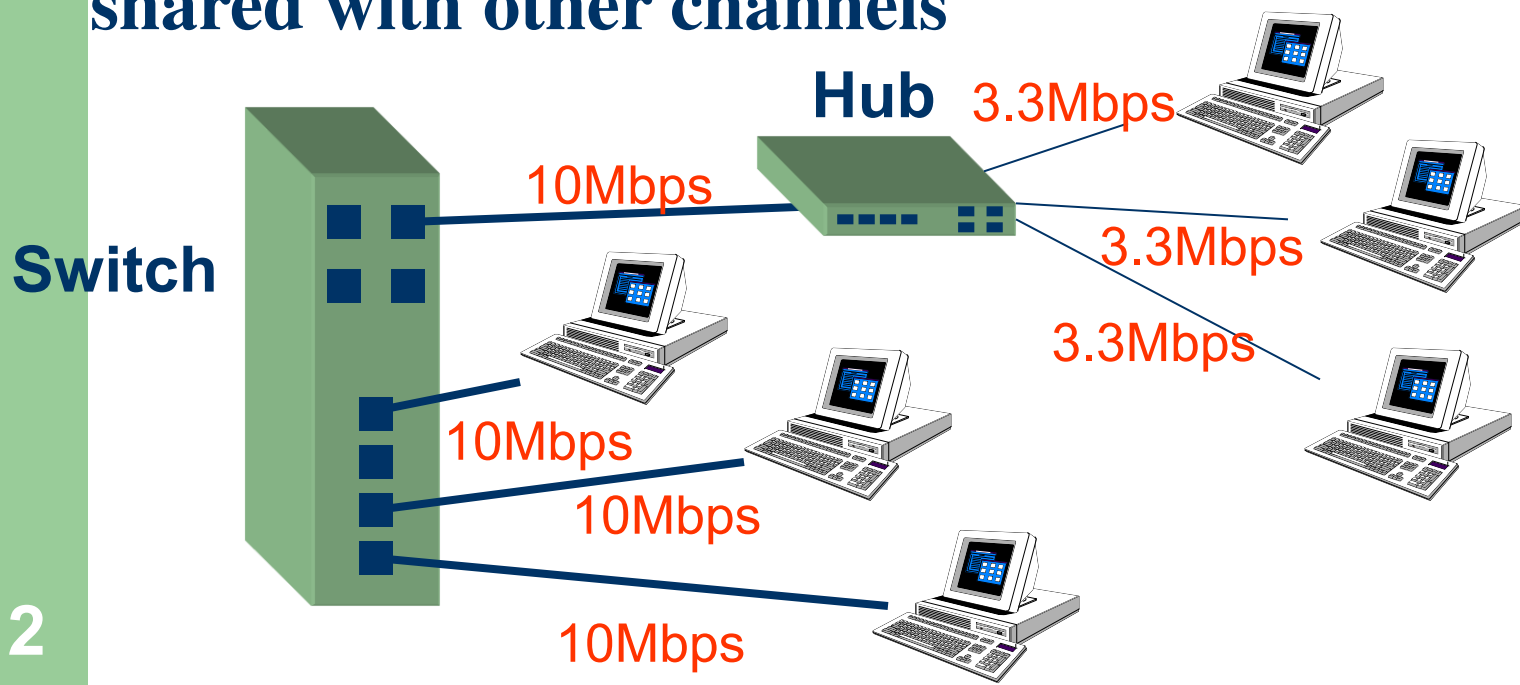
Advantages of Switches

- **Switches divide a network into several isolated channels (or collision domains)**
  - **Reduce the possibility of collision**
    - Collision only occurs when two devices try to get access to one channel
    - Can be solved by buffering one of them for later access
  - **Each channel has its own network capacity**
    - Suitable for real-time applications, e.g. video conferencing
  - **Since isolated, hence secure**
    - Data will only go to the destination, but not others

Limitations of Switches

- **Although contains buffers to accommodate bursts of traffic, can become overwhelmed by heavy traffic**
  - **Device cannot detect collision when buffer full**
    - **CSMA/CD scheme will not work since the data channels are isolated, not the case as in Ethernet**
  - **Some higher level protocols do not detect error**
    - **E.g. UDP**
  - **Those data packets are continuously pumped to the switch and introduce more problems**

Method of Switching - Cut Through Mode

| Preamble		Des. Add	Sour. Add	Length	Data	FCS
7 Bytes	1 Byte	2/6 Bytes	2/6 Bytes	2 Bytes	46 - 1500 Bytes	4 Bytes

- **Read the first 14 bytes of each packet, then transmit**
- **Much faster**
- **Cannot detect corrupt packets**
- **Can propagate the corrupt packets to the network**
- **Best suited to small workgroups**

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Method of Switching - Store and Forward Mode

- **Read the whole packet before transmit**
- Slower than the cut-through mode
- More accurate since corrupt packets can be detected More suit to large LAN since they will not propagate error packets

- Facilitate data transfer between segments of different speed
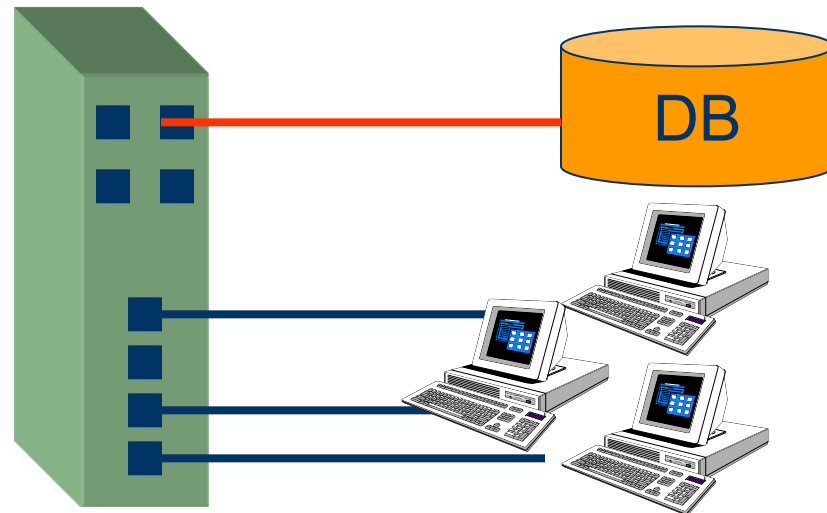
d. Routers

- Layer 2 Switches cannot take advantage of multiple paths

- **Routers** work at the OSI layer 3 (**network layer**)

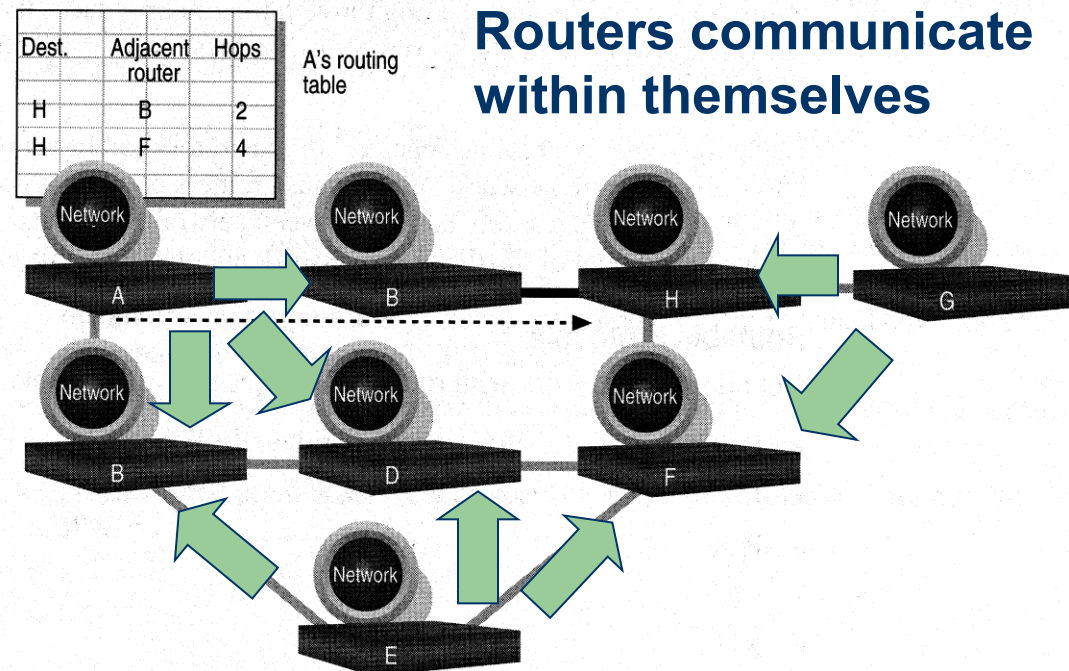- They use the "**logical address**" of packets and routing tables to determine the best path for data delivery
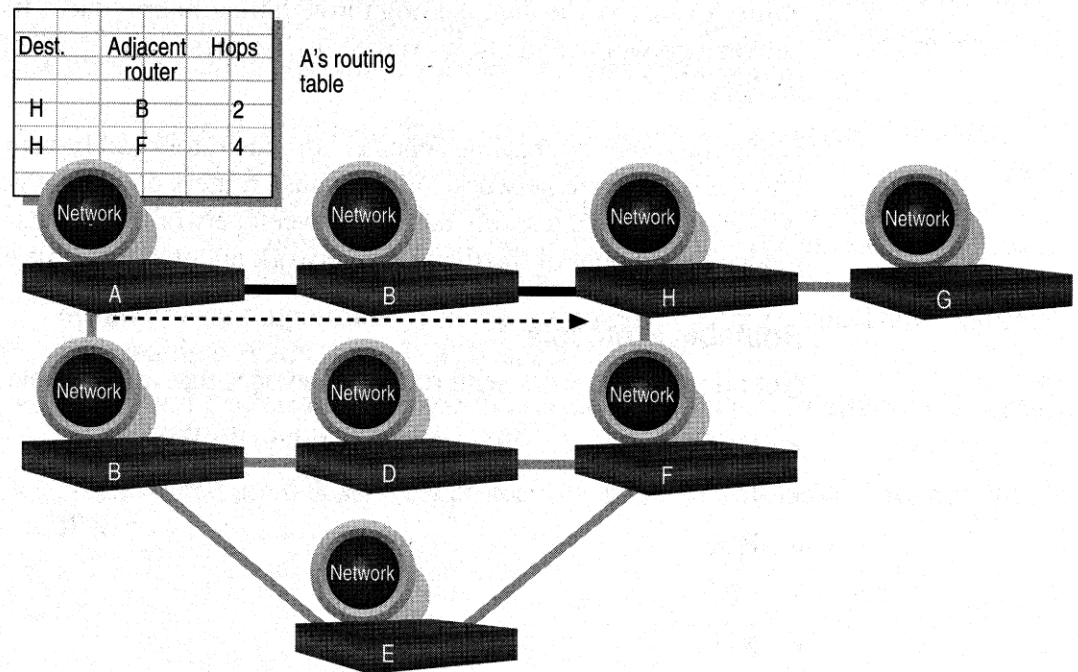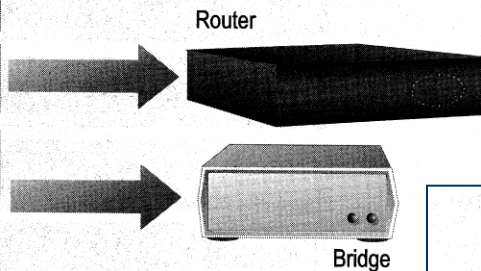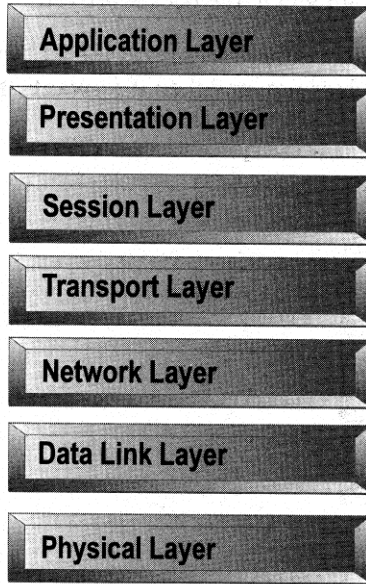
How Routers Work

- **As packets are passed from routers to routers, Data Link layer source and destination addresses are stripped off and then recreated**

- **Enables a router to route a packet from a TCP/IP Ethernet network to a TCP/IP token ring network**

- **Only packets with known network addresses will be passed - hence reduce traffic**

- **Routers can listen to a network and identify its busiest part**

- **Will select the most cost effective path for transmitting packets**
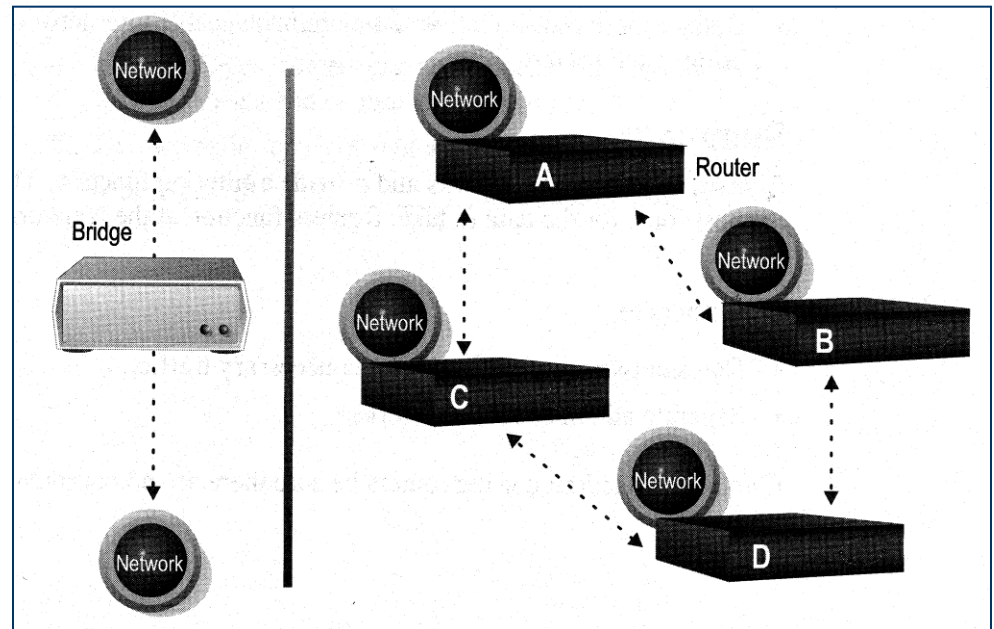
How Routing Table is formed

- **Routing table is formed based on communications between routers using "Routing Protocols"**

  - **Routing Protocols ≠ Routable Protocol**

- **Routing Protocols collect data about current network status and contribute to selection of the best path**

Routers communicate within themselves

Distinguishing Between Bridges and Routers

Application Layer

Presentation Layer

Session Layer

Transport Layer

Network Layer

Data Link Layer

Physical Layer

Router

Bridge

- **Bridges** forward everything they don't recognize
- **Routers** select the best path

- **Routers** are layer 3 devices which recognize network address
- **Bridges** are layer 2 devices which look at the MAC sublayer node address

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Network

Network

Bridge

Router

A

Network

Network

Network

C

B

Network

D

Layer-3 Switches

- **Layer-3 switches operate in both layer 2 (data link layer) and 3 (network layer)**
- **Can perform both MAC switching and IP routing**
- **A combination of switch and router but much faster and easier to configure than router**

Why Layer-3 switches?
- **Traffic of LAN is no longer local**
- **Speed of LAN is much faster**
- **Need a much faster router, however, very expensive**

A Standard Switched Network

*Excerpt from www.intel.com*
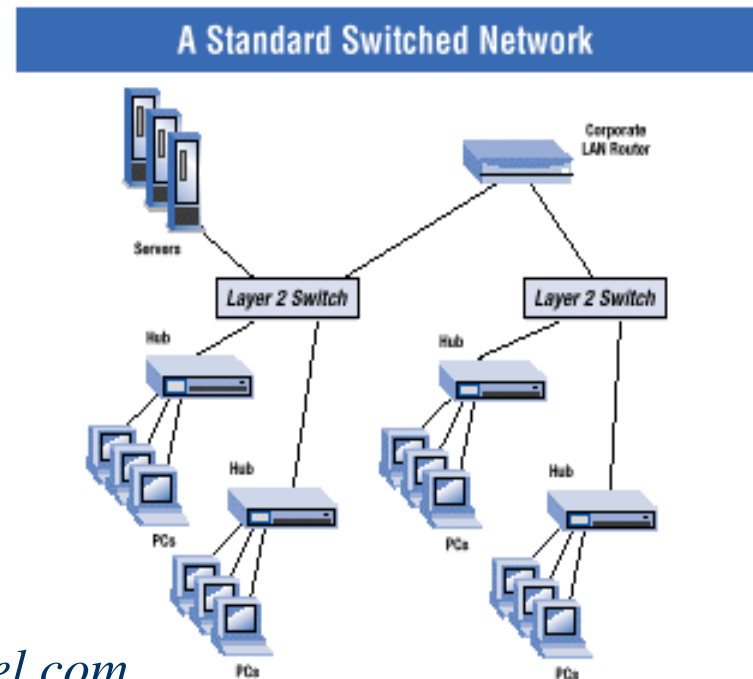
Summary

- **Repeaters** are the least expensive way to expand a network, but they are limited to connecting two segments

- **Bridges** function similar to repeaters, but can understand the node addresses

- **Switches** can be considered as multiport bridges, can divide a network into some logical channels

- **Routers** interconnect networks and provide filtering functions. They can determine the best route

B. Remote Access Devices

1. Modems
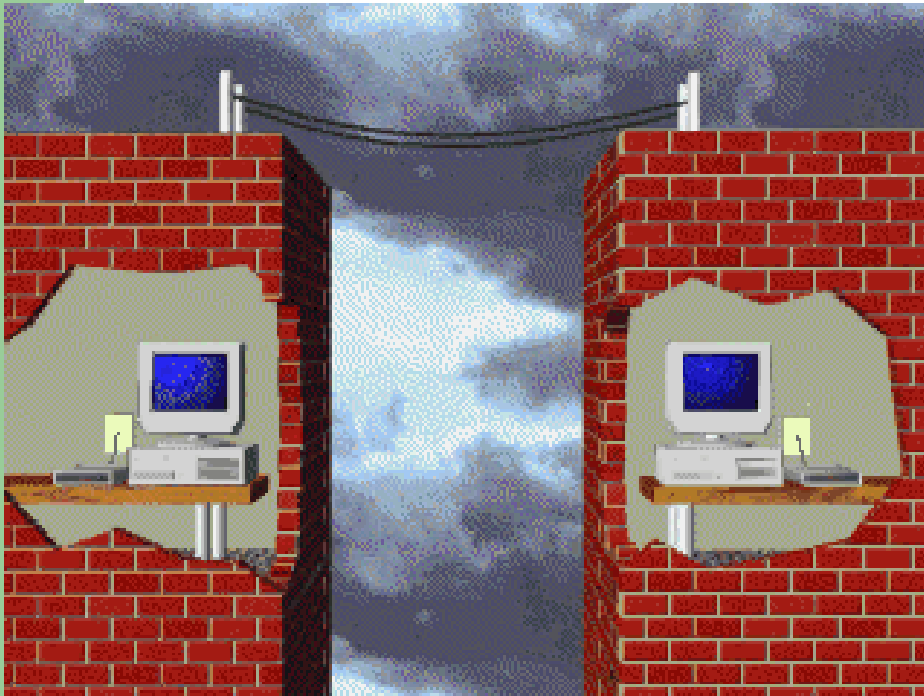
- **Allow computers to communicate over a telephone line**
- **Enable communication between networks or connecting to the world beyond the LAN**

- **Cannot send digital signal directly to telephone line**
- **Sending end: MODulate the computer's digital signal into analog signal and transmits**
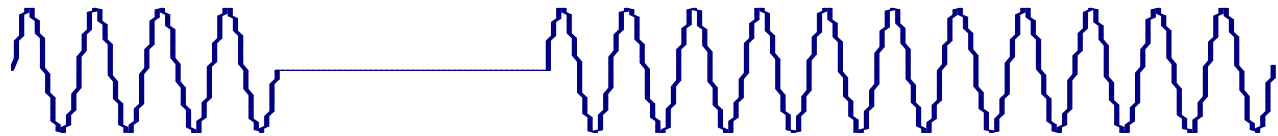- **Receiving end: DEModulate the analog signal back into digital form**

Digital

Modem

Analog

Public telephone network

Digital

Analog
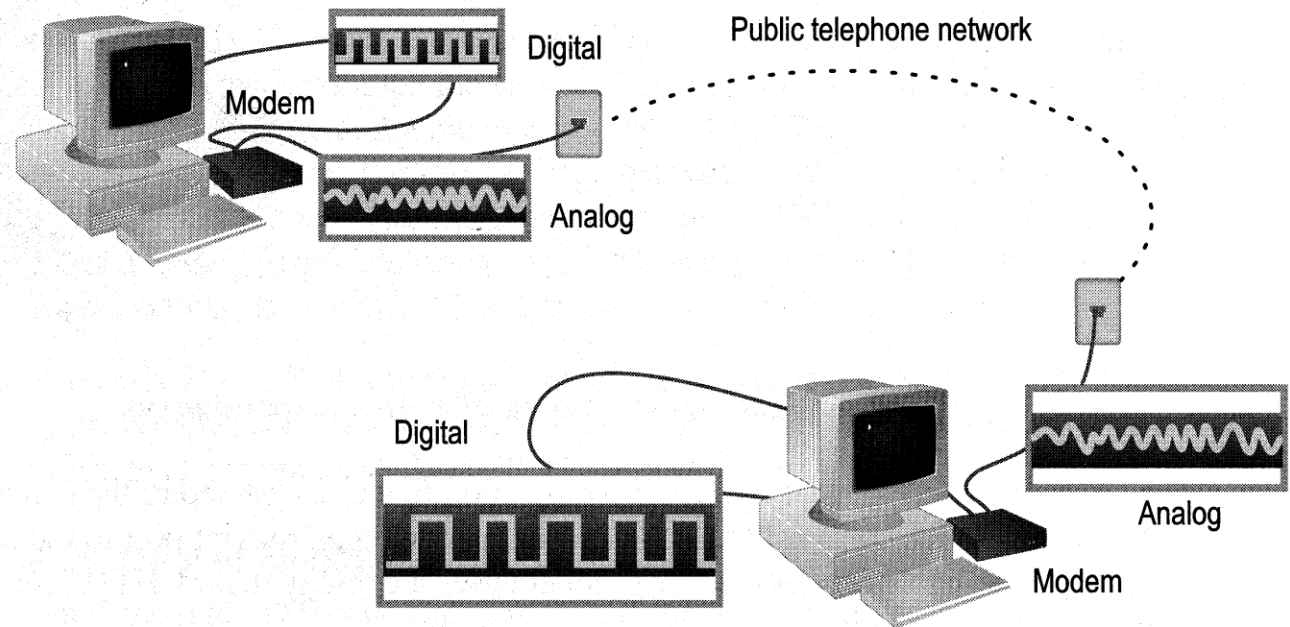
Modem

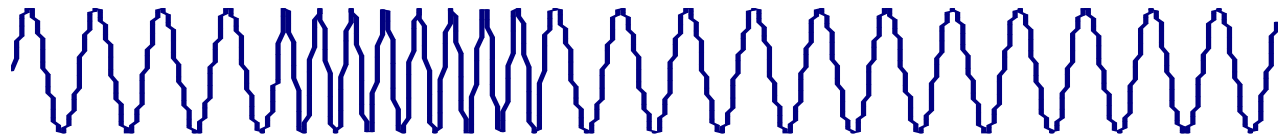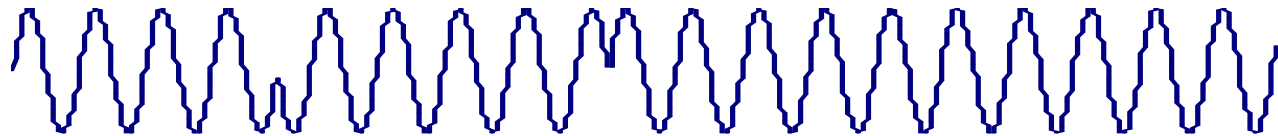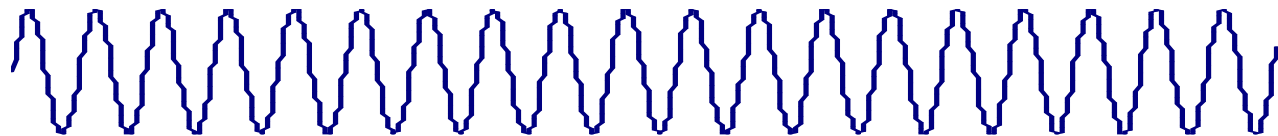|				
1	**0**	**1**	**1**	**1**

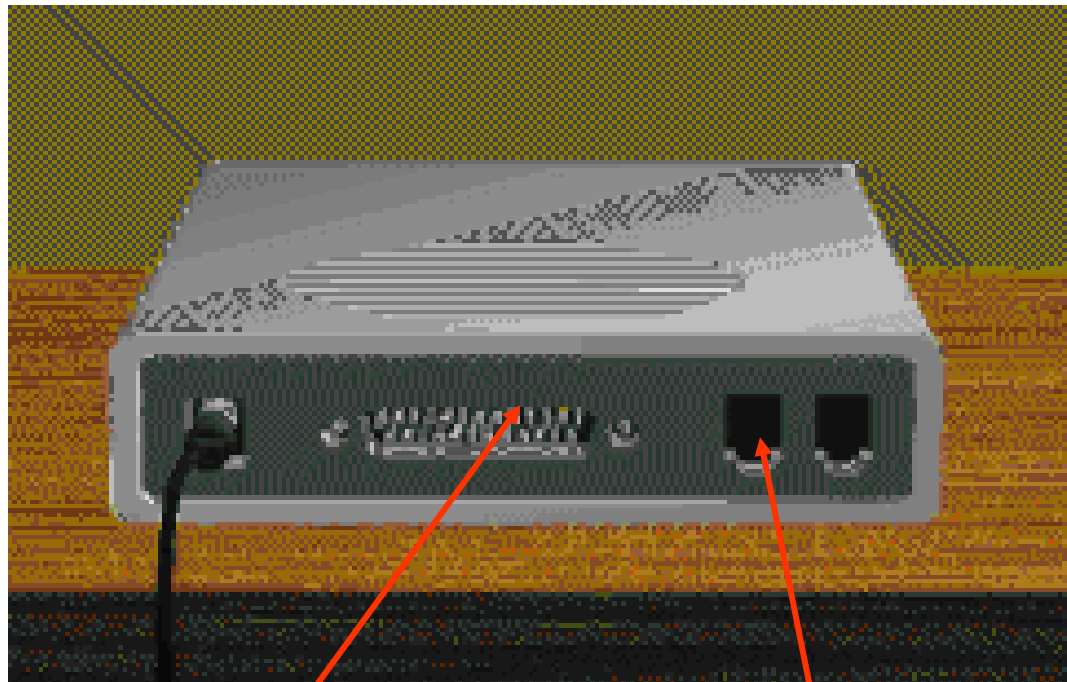**Amplitude Modulation**

Frequency Modulation

Phase Modulation

Normal sine wave

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- **Modems typically have the following I/O interface:**
  - **A serial RS-232 communication interface**
  - **An RJ-11 telephone-line interface (a telephone plug)**

RS-232

RJ-11

Modem Standards

Standard	bps	Introduced	Remarks
V.22bis	2,400	1984	
V.32	9,600	1984	
V.32bis	14,400	1991	
V.32terbo	19,200	1993	Communicate only with another V.32terbo (V.FC)
V.FastClass	28,800	1993	
V.34	28,800	1994	Improved V.FC
V.42bis	115,200	1995	With compression
V.90	56,000	1998	Resolved competition between X2 and Flex56k