"COMMUNICATION AND DATA TRANSMISSION NETWORKS"

Ing. Manuel Benites

10 LAN Networks

c. Project 802 and standards

d. Network comparison

11 Switching

a. Circuit switching

b. Packet switching

c. Message switching

12 Telephone Line Applications

a. PPP protocol

b. ISDN service

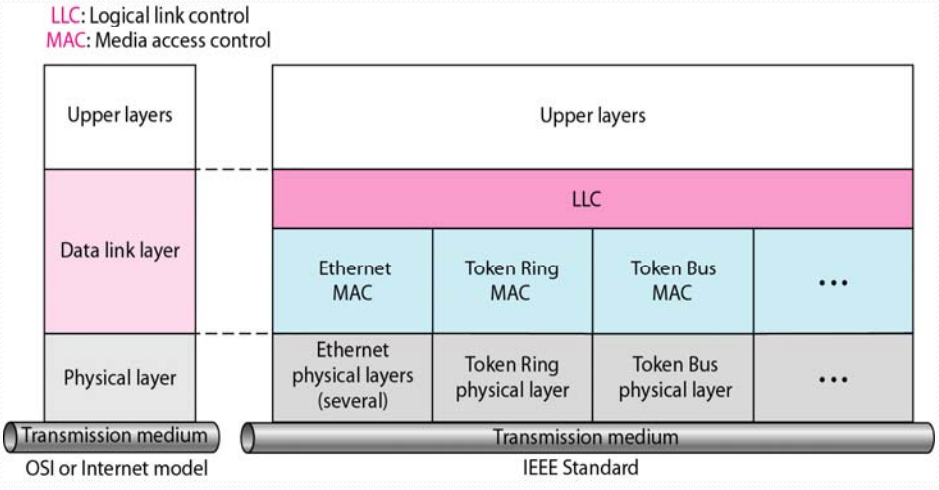
10 **LAN Networks**
c. Project 802 and standards

IEEE STANDARDS

In 1985, the IEEE Computer Association started Project 802, consisting of a set of standards for the interconnection of equipment from different manufacturers. Project 802 is a way of specifying the functions of the physical and link layers in most LAN protocols.

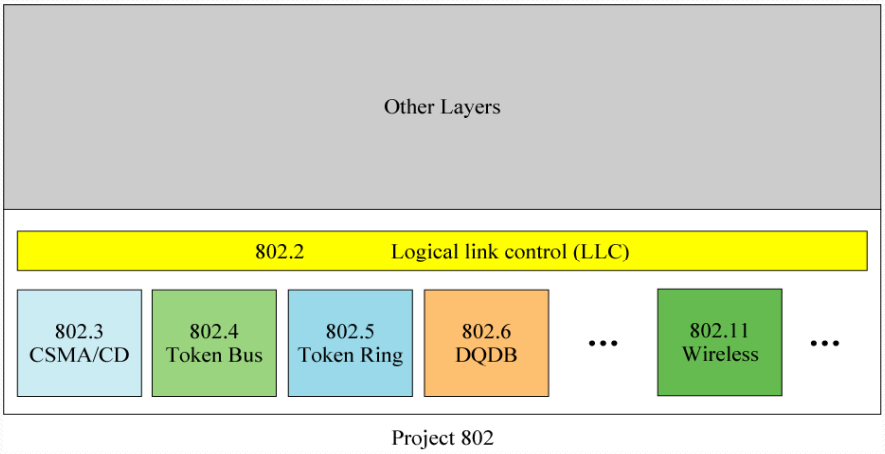
10 **LAN Networks**
c. Project 802 and standards

IEEE standard for LANs



10 **LAN Networks**
c. Project 802 and standards

IEEE Standards for LANs



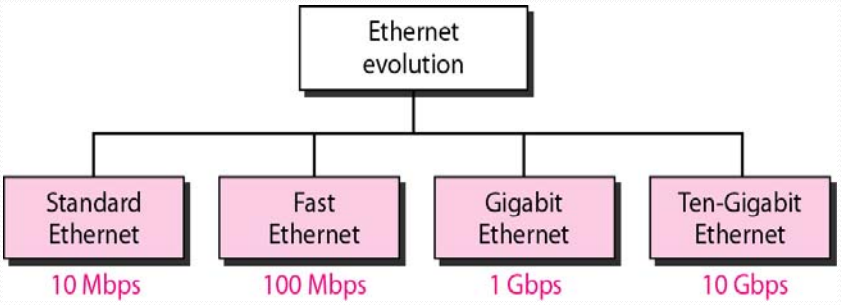
10 **LAN Networks**
c. Project 802 and standards

ETHERNET STANDARD

The original Ethernet standard was created in 1976 by the Xerox Palo Alto Research Centre (PARC). Since then, it has gone through four generations.

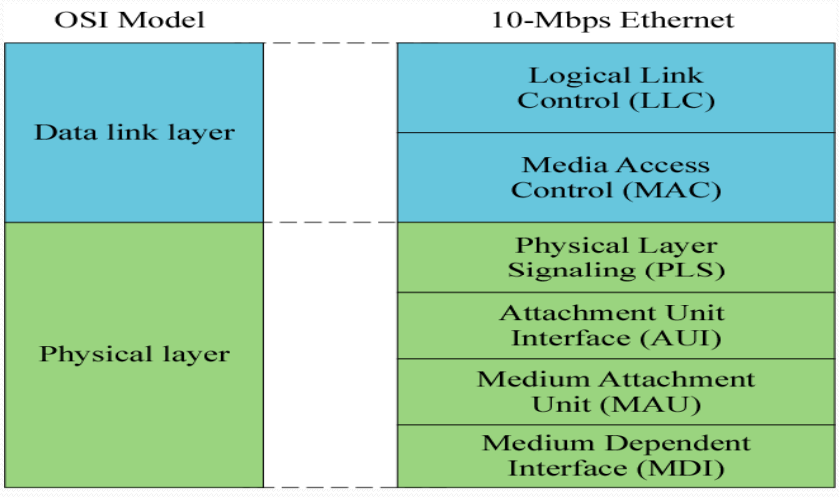
10 **LAN Networks**
c. Project 802 and standards

Ethernet evolution in four generations

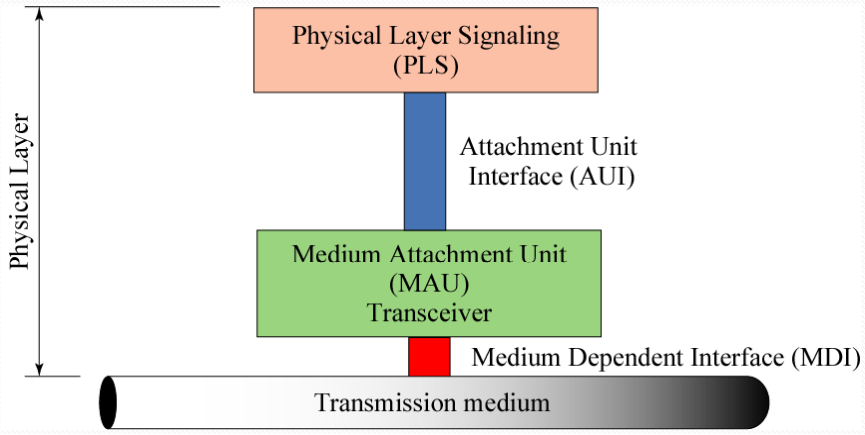


10 **LAN Networks**
c. Project 802 and standards

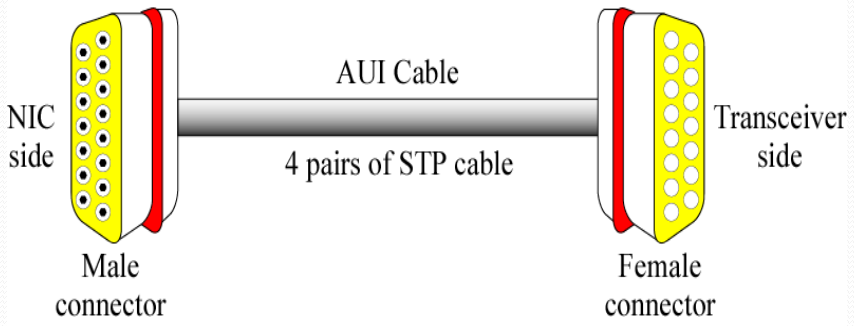
Layers in the 10-Mbps Ethernet



Physical Layer



AUI Cable



10 LAN Networks
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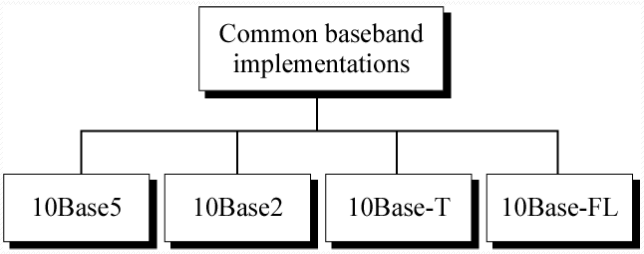
Categories of 10-Mbps, Baseband Ethernet



10 LAN Networks
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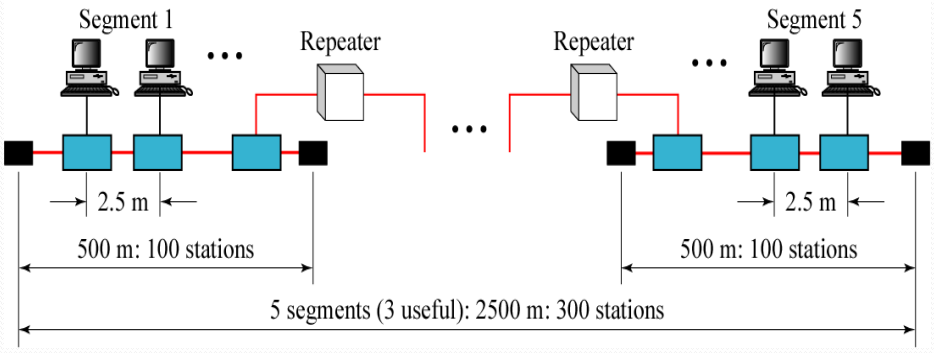
Segments in 10Base5



10 LAN Networks
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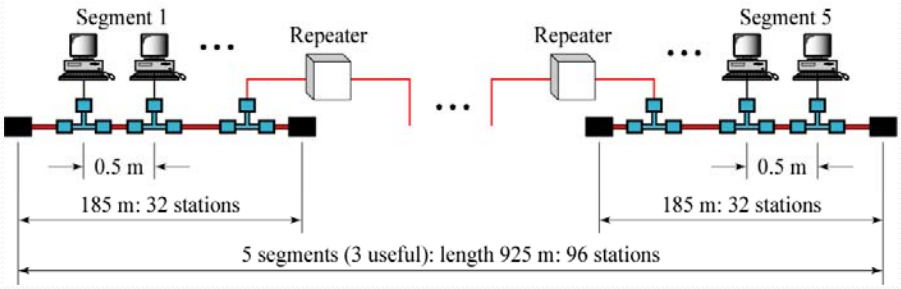
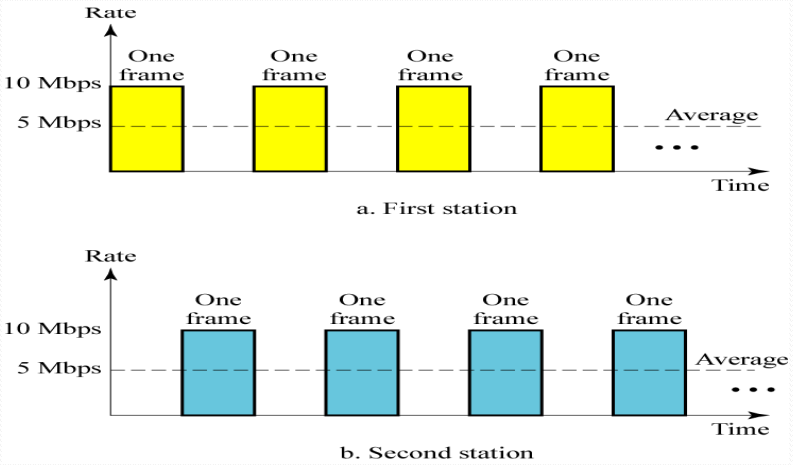
Segments in 10Base2



10 LAN Networks
c. Project 802 and standards

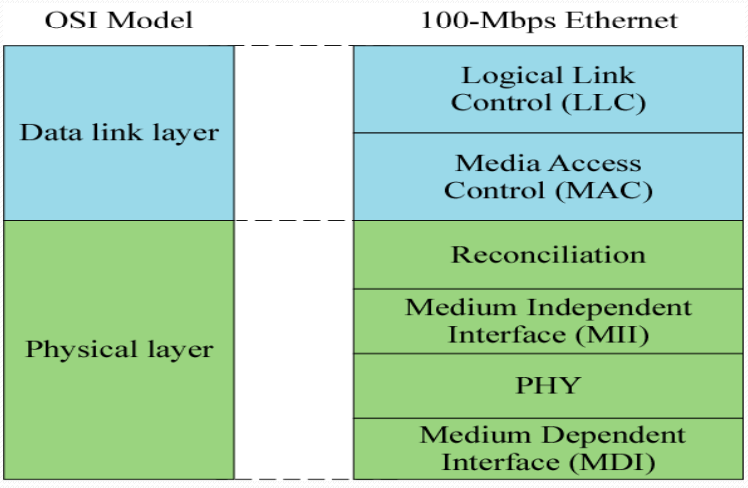
Bandwidth Sharing



Fast Ethernet was designed to compete with LAN protocols such as FDDI or Fiber Channel. IEEE created Fast Ethernet under the name 802.3u. It is compatible with the Standard Ethernet, but can send data ten times faster, at a rate of 100 Mbps.

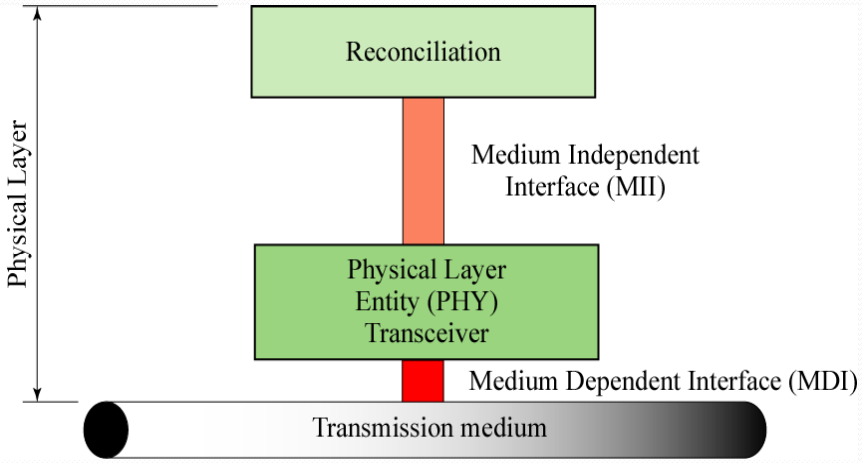
10 LAN Networks
c. Project 802 and standards

Fast Ethernet layers



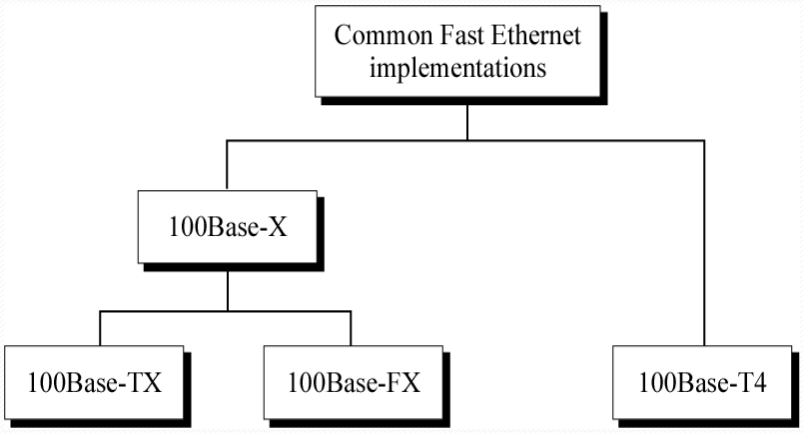
10 **LAN Networks**
c. Project 802 and standards

Fast Ethernet physical layer



10 **LAN Networks**
c. Project 802 and standards

Fast Ethernet implementations

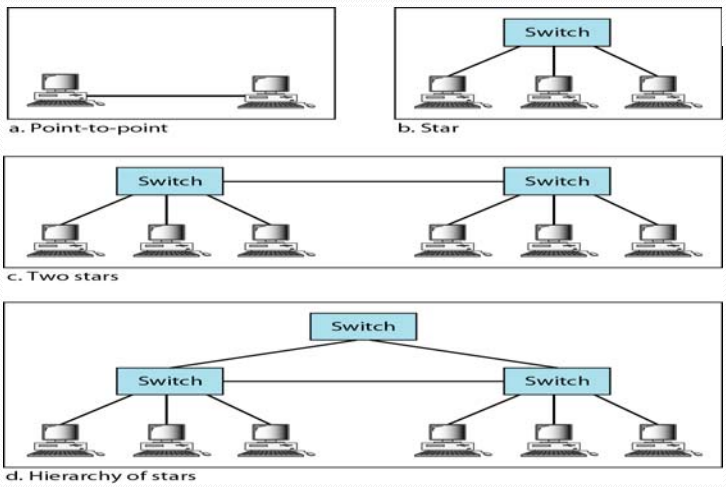


10 LAN Networks
c. Project 802 and standards

The need to send data at a higher rate resulted in the creation of the Gigabit Ethernet protocol (1000 Mbps). The IEEE Committee called it Standard 802.3z.

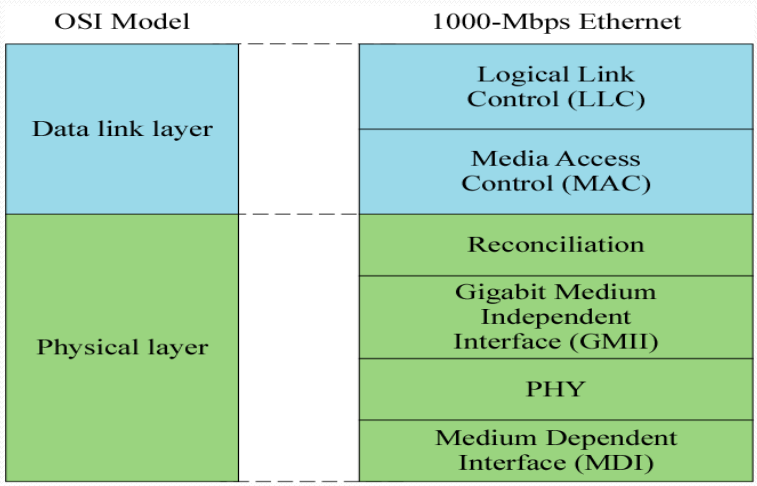
10 LAN Networks
c. Project 802 and standards

Gigabit Ethernet topologies



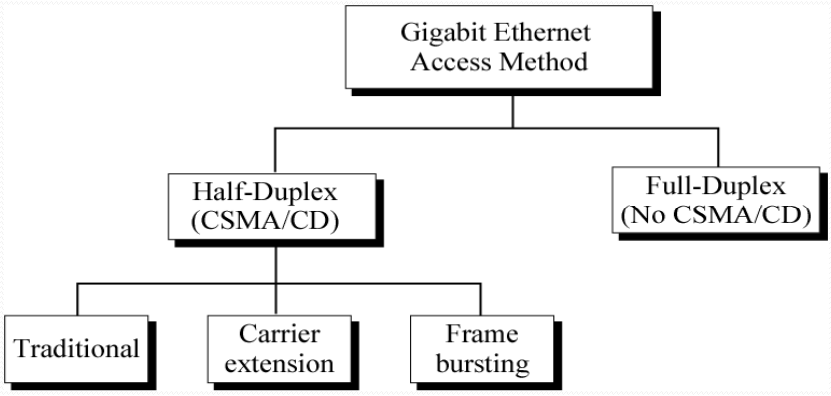
10 **LAN Networks**
c. Project 802 and standards

Gigabit Ethernet layers



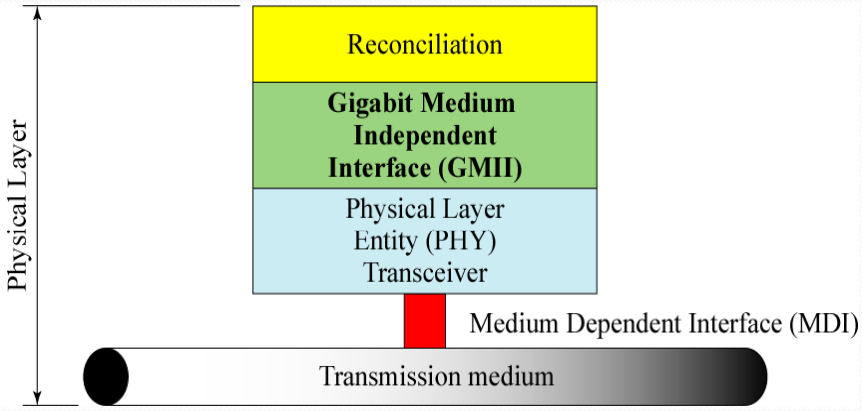
10 **LAN Networks**
c. Project 802 and standards

Two approaches to medium access in Gigabit Ethernet



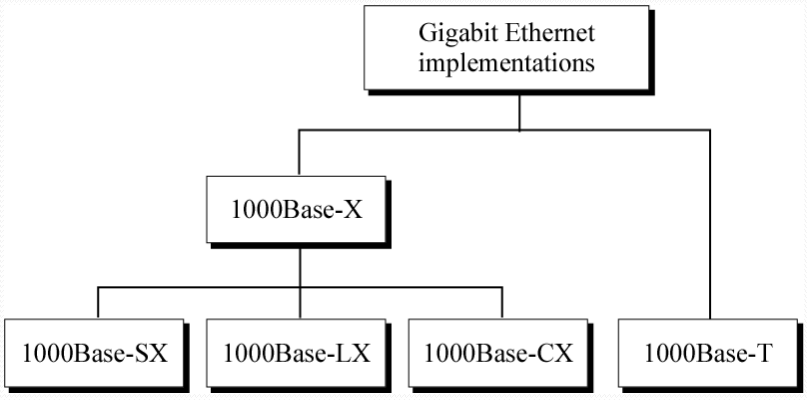
10 **LAN Networks**
c. Project 802 and standards

Gigabit Ethernet physical layer



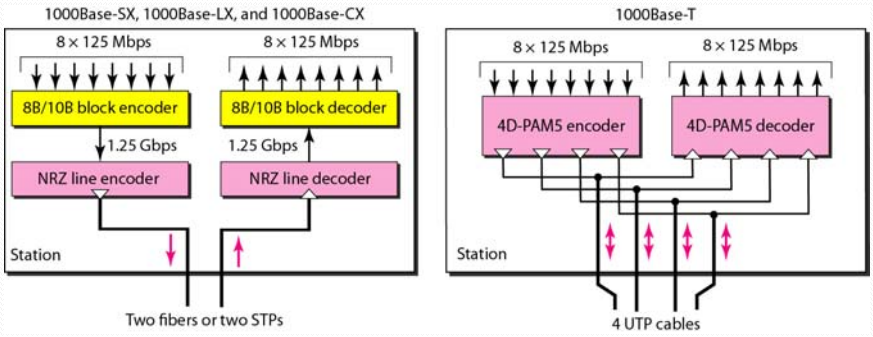
10 **LAN Networks**
c. Project 802 and standards

Gigabit Ethernet implementations



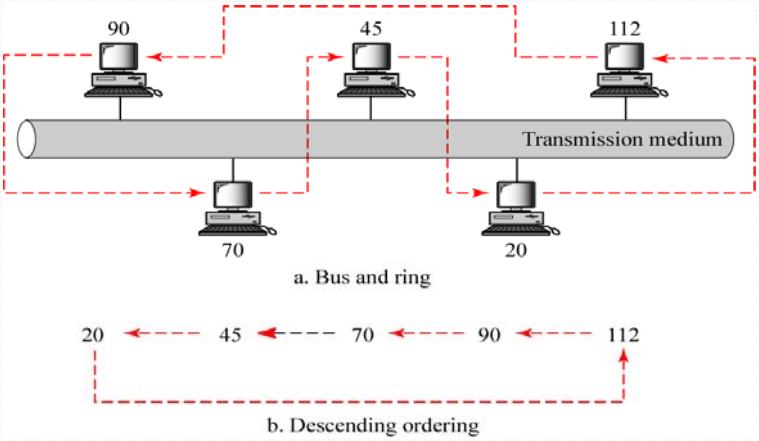
10 LAN Networks
c. Project 802 and standards

Coding in *Gigabit Ethernet* implementations



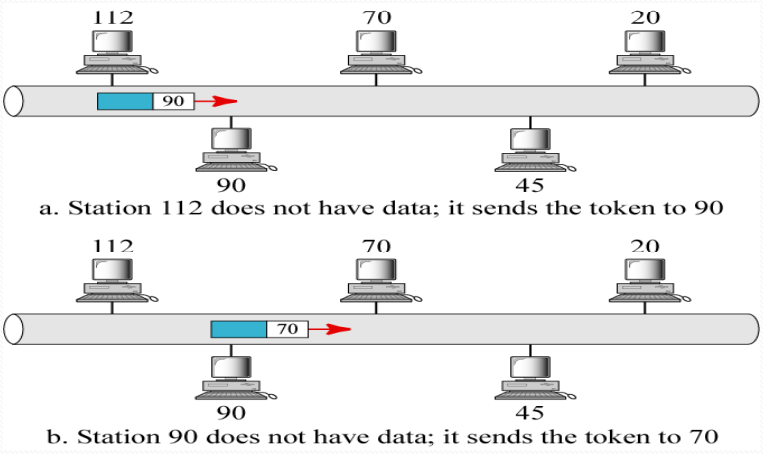
10 LAN Networks
c. Project 802 and standards

A Token Bus Network



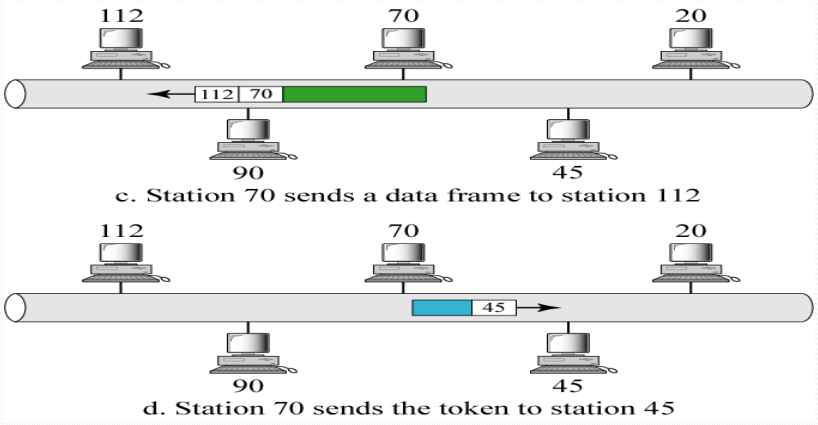
10 LAN Networks
c. Project 802 and standards

Token Passing in a Token Bus Network



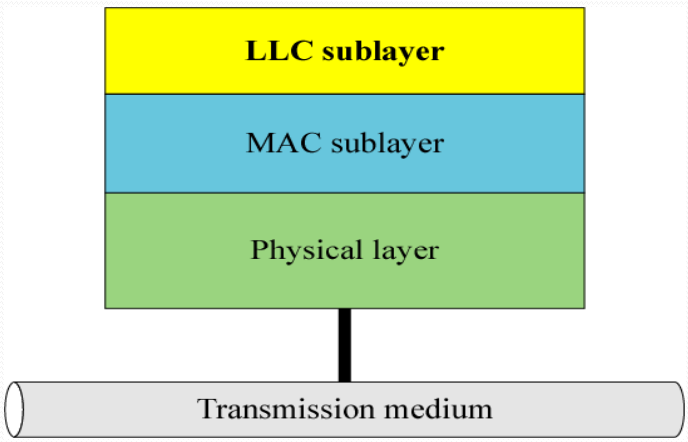
10 LAN Networks
c. Project 802 and standards

Token Passing in a Token Bus Network



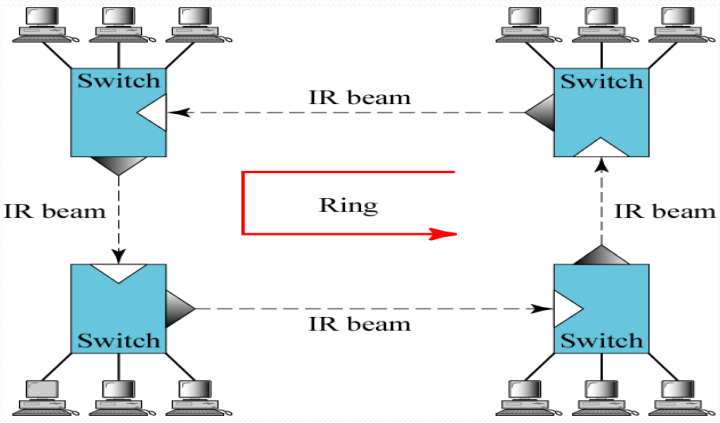
10 **LAN Networks**
c. Project 802 and standards

Token Bus layers



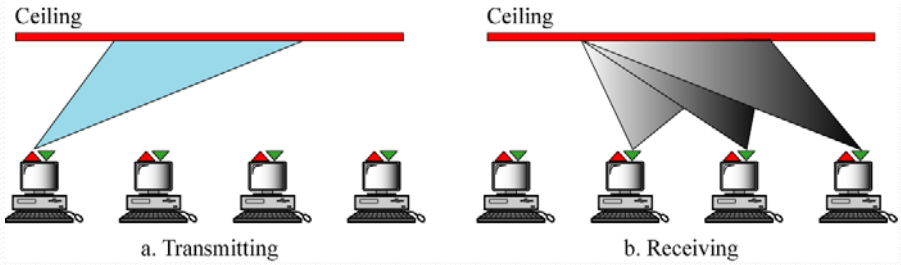
10 **LAN Networks**
c. Project 802 and standards

802.11 Point-to-point infrared LAN

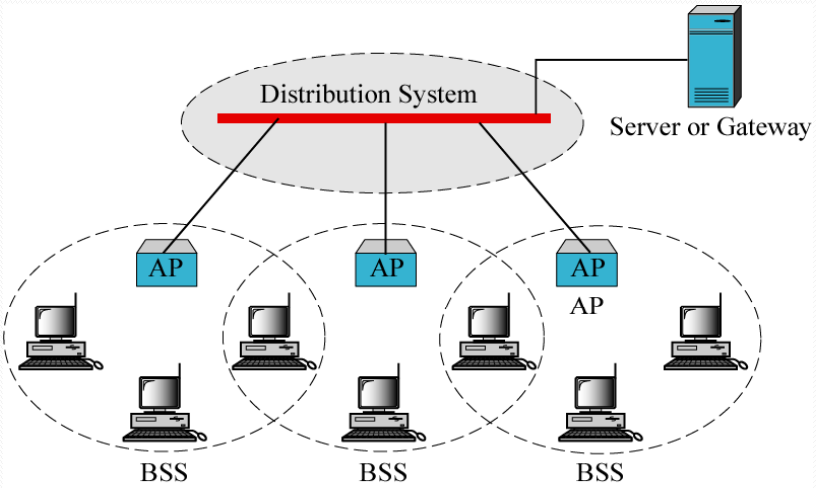


10 LAN Networks
c. Project 802 and standards

Diffuse infrared LAN

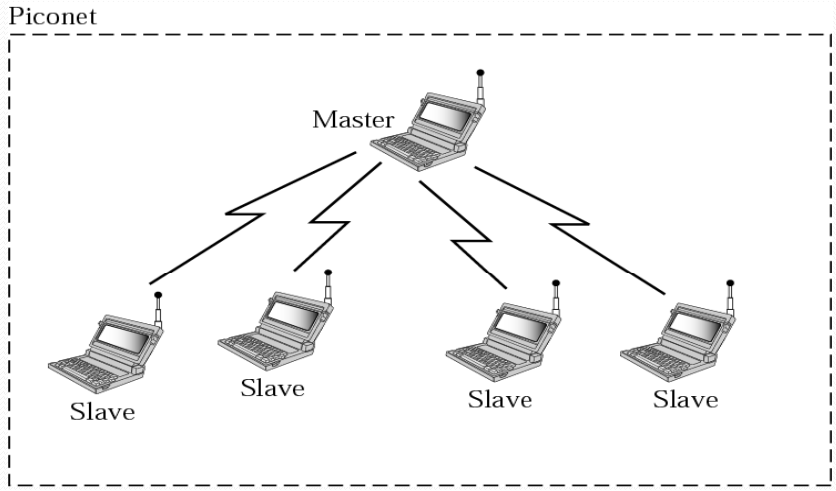


10 LAN Networks
c. Project 802 and standards

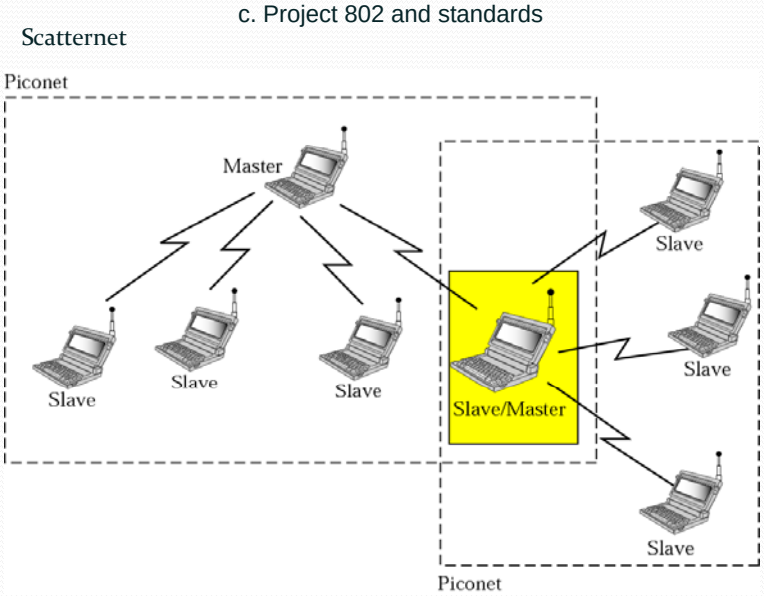


10 LAN Networks
c. Project 802 and standards

IEEE 802.15: BLUETOOTH LANs



10 LAN Networks
c. Project 802 and standards



10 LAN Networks
d. Comparison of networks

Comparison of Standard Ethernet implementations

Characteristics	*10Base5*	*10Base2*	*10Base-T*	*10Base-F*
Media	Thick coaxial cable	Thin coaxial cable	2 UTP	2 Fiber
Maximum length	500 m	185 m	100 m	2000 m
Line encoding	Manchester	Manchester	Manchester	Manchester

10 LAN Networks
d. Comparison of networks

Comparison of *Fast Ethernet* implementations

Characteristics	*100Base-TX*	*100Base-FX*	*100Base-T4*
Media	Cat 5 UTP or STP	Fiber	Cat 4 UTP
Number of wires	2	2	4
Maximum length	100 m	100 m	100 m
Block encoding	4B/5B	4B/5B	
Line encoding	MLT-3	NRZ-I	8B/6T

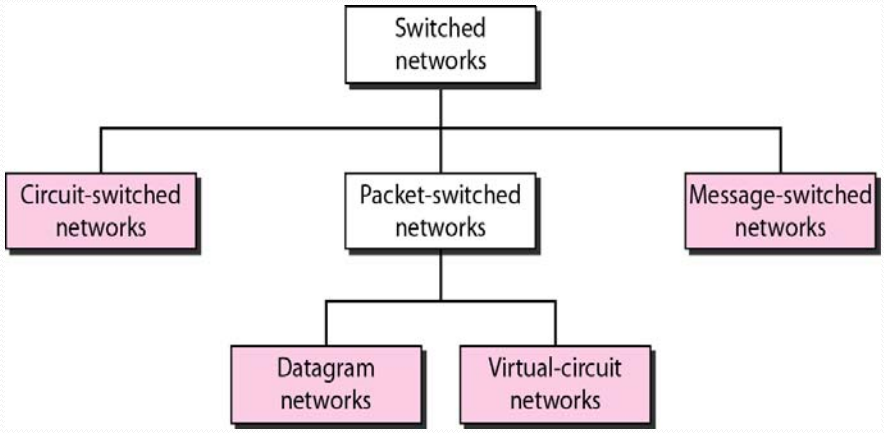
10 **LAN Networks**
d. Comparison of networks

Comparison of Gigabit Ethernet implementations

Characteristics	*1000Base-SX*	*1000Base-LX*	*1000Base-CX*	*1000Base-T*
Media	Fiber short-wave	Fiber long-wave	STP	Cat 5 UTP
Number of wires	2	2	2	4
Maximum length	550 m	5000 m	25 m	100 m
Block encoding	8B/10B	8B/10B	8B/10B	
Line encoding	NRZ	NRZ	NRZ	4D-PAM5

11 **Network Switching**
a. Circuit switching

Switched networks

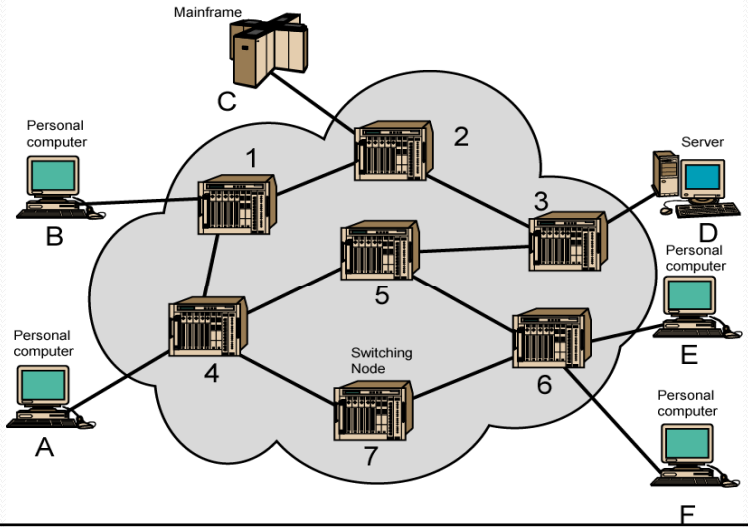


Network Switching

- Long-distance transmission is normally done over a switched-node network.
- Nodes are not related to the contents of the data.
- The end devices are stations
  - Computer, terminals, telephone, etc.
- A collection of nodes and connections make up a communication network.
- Data will be switched from one node to the other.

- Nodes may be connected only to other nodes.
- Node-to-node links are usually multiplexed.
- Usually, networks are partially connected
  - Some redundant connections are implemented to enhance reliability.
- There are two different switching technologies
  - Circuit switching
  - Packet switching

11 **Network Switching**
a. Circuit switching



11 **Network Switching**
a. Circuit switching

Circuit switching

- Communication between two stations
- Three phases
  - Establishment
  - Transfer
  - Disconnection
- Switching and channel capacity to establish a connection.

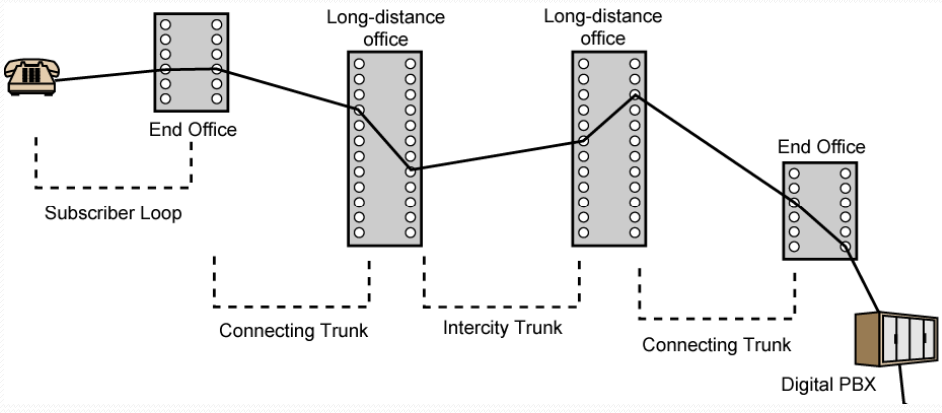
11 **Network Switching**
a. Circuit switching

Circuit switching

- Inefficient
  - Capacity of the dedicated channel while connected
  - If there are no data, the capacity is lost
- Setting up the connection takes time
- Once connected, the transfer is seamless
- Developed for voice traffic (telephony)

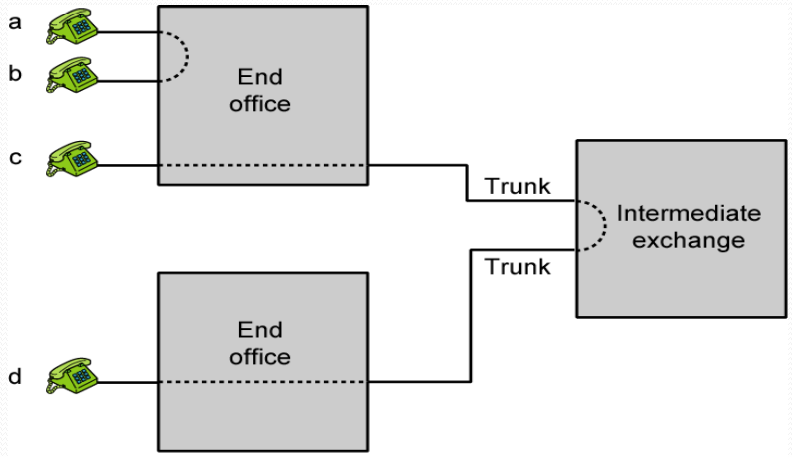
11 **Network Switching**
a. Circuit switching

Public circuit switching network



11 Network Switching
a. Circuit switching

Setting-up a circuit



11 Network Switching
a. Circuit switching

In-channel signalling

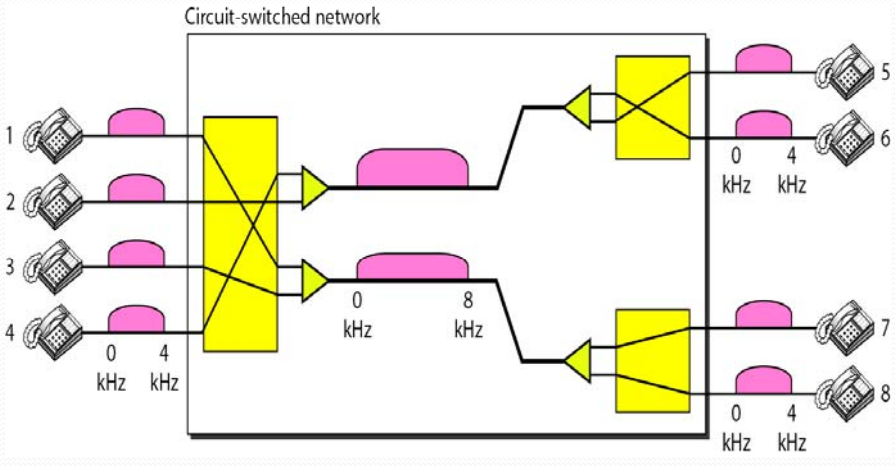
- Uses the same channel for signalling and for the call
  - Does not require additional transmission facilities
- In-band
  - Uses the same frequencies as the voice channel
  - Can go where the voice channel goes
  - Impossible to establish a call in a defective channel
- Off-band
  - Voice signals do not use the whole 4kHz bandwidth
  - Narrow-band signal used for control
  - Needs additional electronics
  - Low signal rate (narrow bandwidth)

11 Network Switching
a. Circuit switching

- Control signals are carried over channels that are independent from voice channels
- One control signal channel can carry signals to a number of subscriber channels.
- Common control channel for those subscriber lines
- Associated medium
  - Closed common channel for trunk lines between switches
- Dissociated mode
  - Additional nodes (signal transfer points)
  - They are really two separate networks

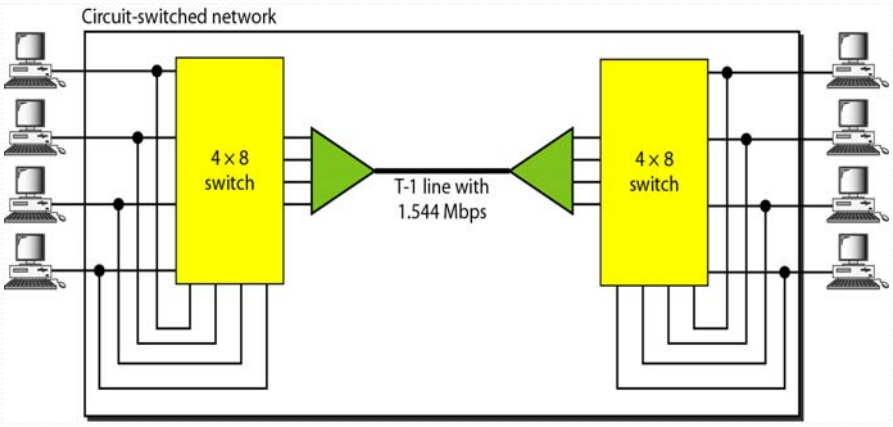
11 Network Switching
a. Circuit switching

Example of a circuit-switching network



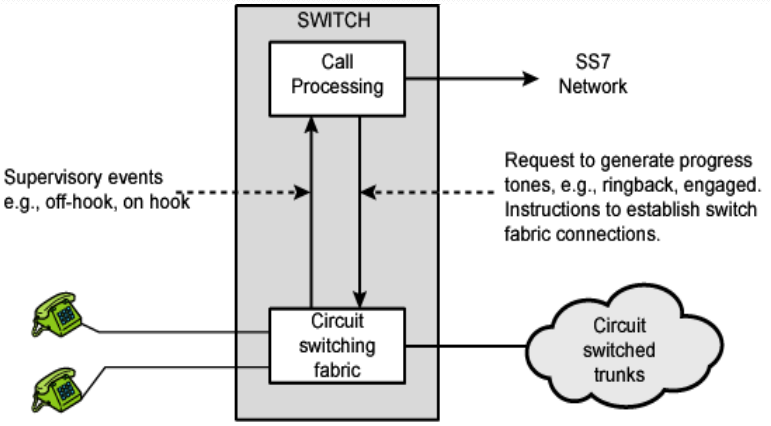
11 Network Switching
a. Circuit switching

Example of a circuit-switching network



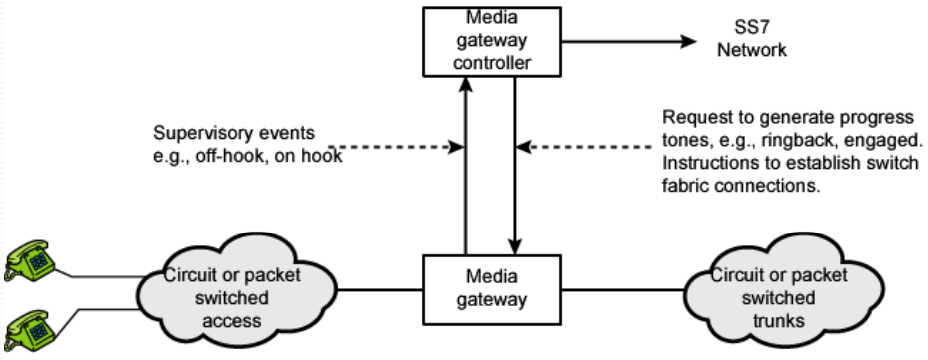
11 Network Switching
a. Circuit switching

Traditional Circuit Switching



11 **Network Switching**
a. Circuit switching

Softswitch



11 **Network Switching**
b. Packet switching

Packet-switching principles

- Circuit switching is designed for voice communications.
  - Resources dedicated to a particular call
  - Many times, the time of a data connection is wasted.
  - Fixed data rate.

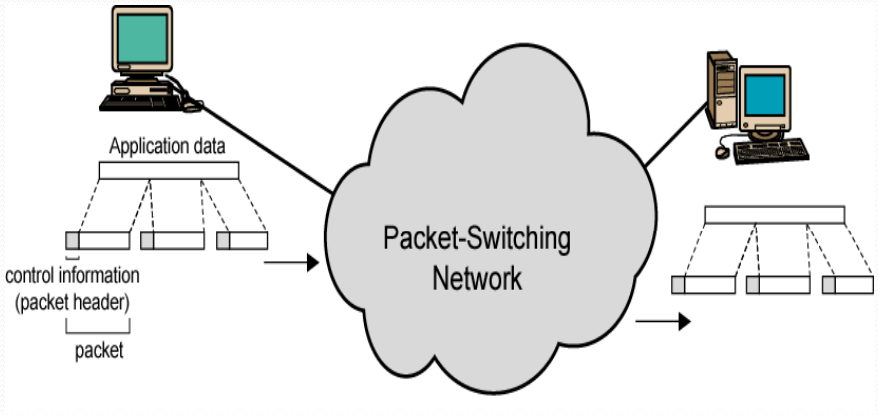
11 **Network Switching**
b. Packet switching

Packet-switching basic operation

- Data is sent in small packets
  - Typically 1,000 octets
  - Longer messages are divided in a series of packets
- Each packet contains a portion of user data and some control information
- Information control
  - Routing (addressing) information
- Packets are received, briefly stored (buffer) and sent to the next node (store and forward)

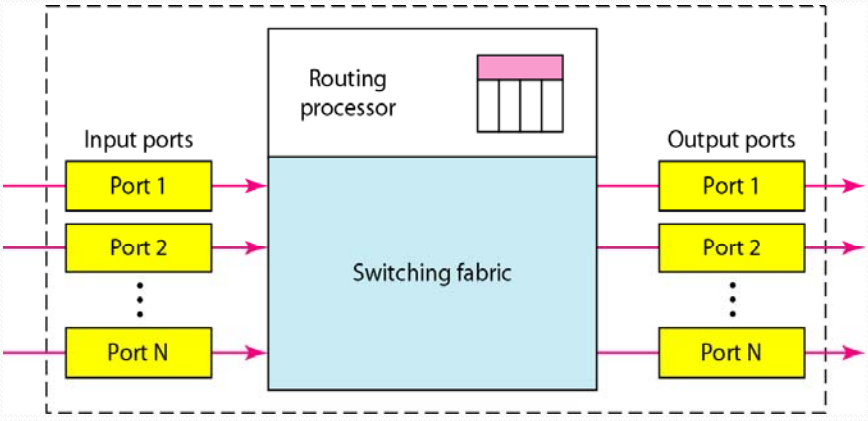
11 Network Switching
b. Packet switching

Use of packets



11 Network Switching
b. Packet switching

Packet-switching components



Advantages

- Line efficiency
- The link between nodes can be shared by several packets.
  - Packet queues are formed and packets are sent as soon as possible
- Data rate conversion
  - Each station connects to the local node at its own rate
  - The data buffer in the nodes must match rates
- Packets are accepted even if the network is busy
  - Delivery may lower the rate
- Priorities may be used

Packet-switching technique

- The station divides large messages into packets
- Packets are sent to the network one at a time
- Packets are handled *via* two paths:
  - Datagrams
  - Virtual circuits

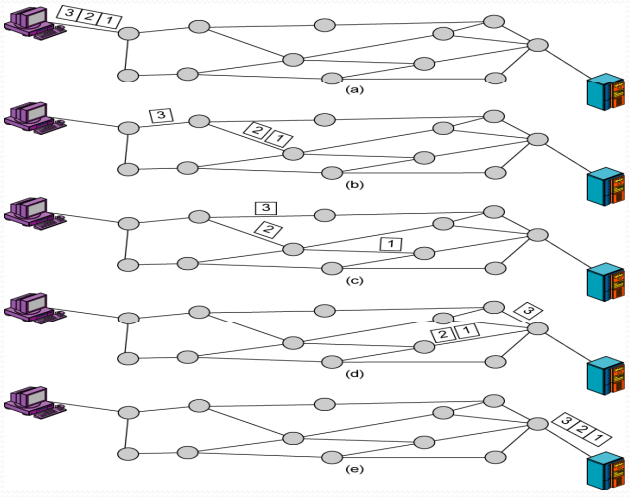
11 **Network Switching**
b. Packet switching

Datagram

- Each packet is handled independently.
- Packets may take any practical route.
- Packets may arrive in a different order.
- Packets can get lost.
- Packets are received for re-ordering and recovery of lost ones.

11 **Network Switching**
b. Packet switching

Datagram packet-switching diagram



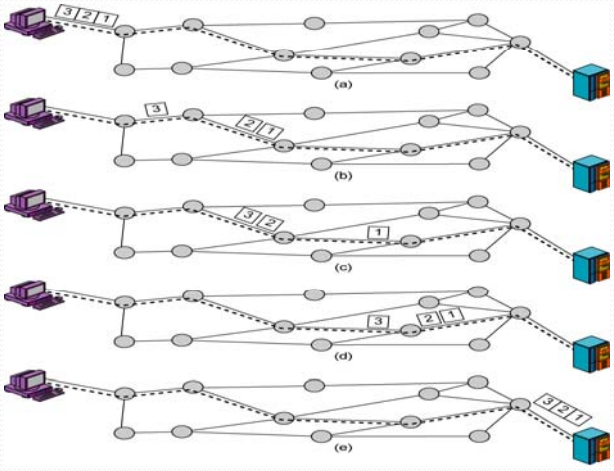
11 **Network Switching**
b. Packet switching

Virtual-circuit packet switching

- Pre-planned routes are established before packets are sent
- The call-start request and the call-acceptance request require the establishment of a connection for packet delivery
- Each packet contains a virtual circuit identifier instead of the destination address
- Routing decisions for each packet are not required
- Clear requirement concerning circuit breakdown
- Does not require a dedicated path

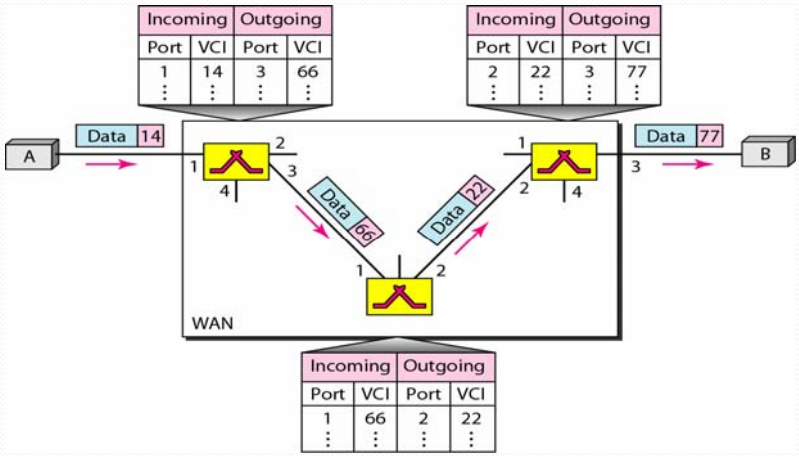
11 **Network Switching**
b. Packet switching

Virtual circuit packet-switching diagram



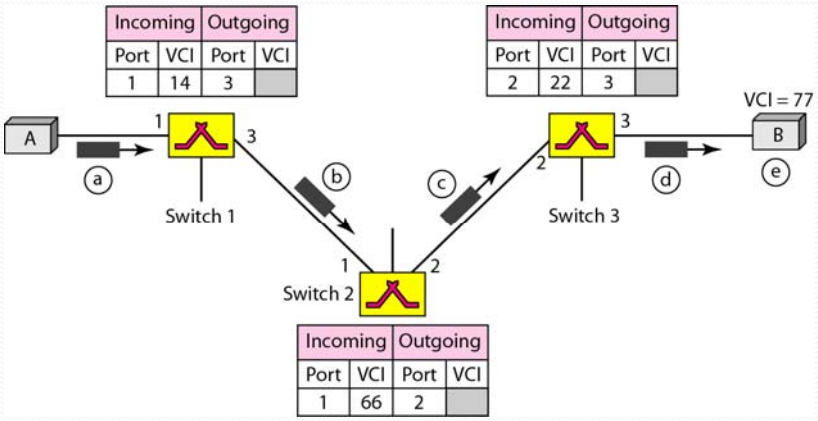
11 Network Switching
b. Packet switching

Source-to-destination data transfer in a virtual circuit switching network



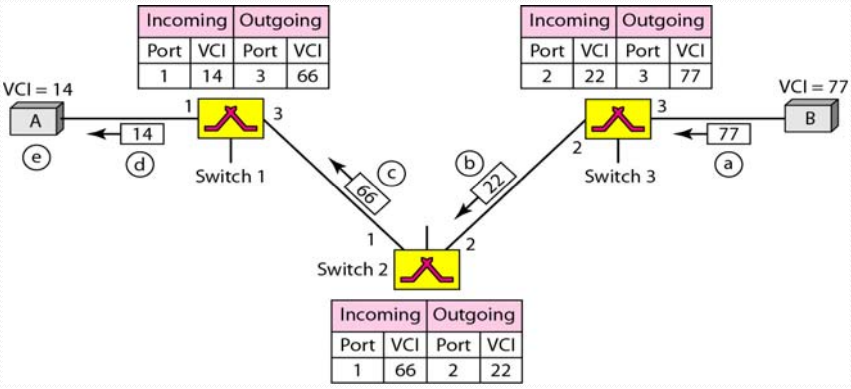
11 Network Switching
b. Packet switching

Setup requirement in a virtual circuit switching network



11 Network Switching
b. Packet switching

Setup acceptance in a virtual circuit switching network



11 Network Switching
b. Packet switching

Virtual circuits *versus* Datagram

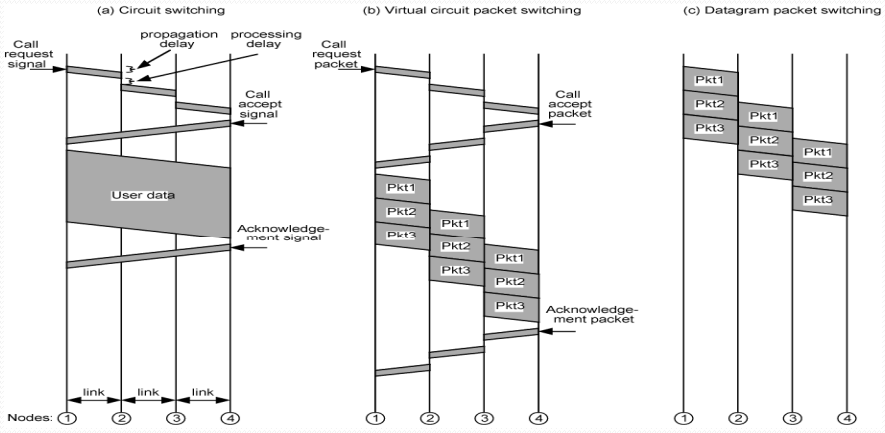
- **Virtual Circuits**
  - Networks can provide sequencing and error control
  - Faster delivery of packets
    - No need for making routing decisions
  - Loss of reliability
    - If a node is lost, all circuits through that node are lost too
- **Datagram**
  - There is no call setup phase
    - The lesser the packets the better the performance
  - More flexible
    - Routing may be used for avoiding congestion in parts of the network

Packet switching *vs* circuit switching

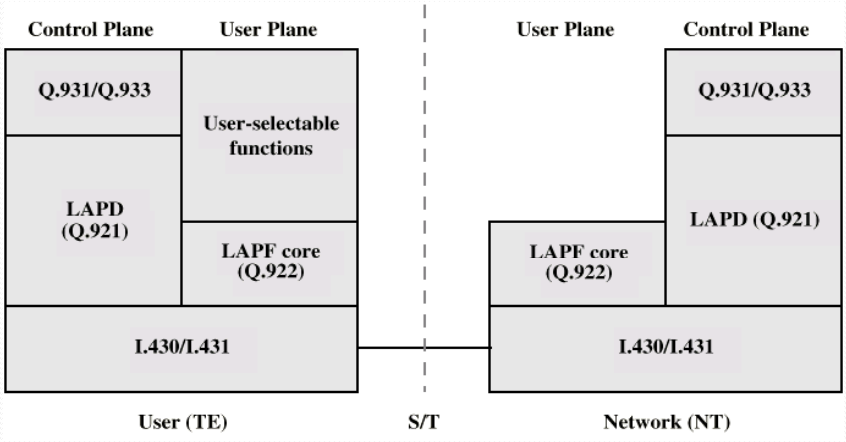
- Performance
  - Propagation delay
  - Transmission time
  - Node delay

11 **Network Switching**
b. Packet switching

Schedule of events



Frame Relay Protocol Architecture



11 Network Switching
b. Packet switching

Control plane

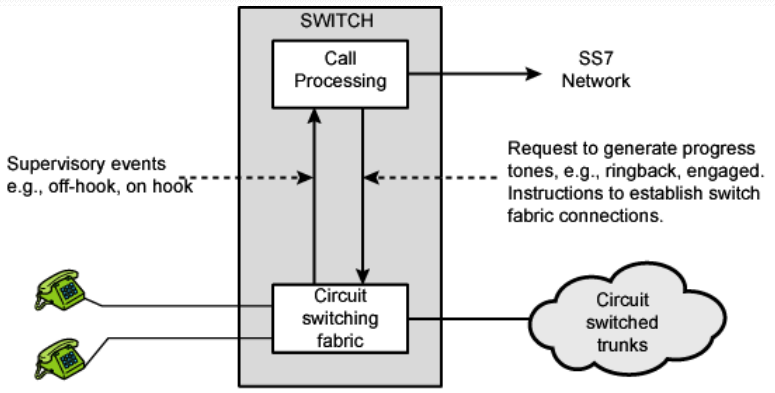
- Between the network and the subscriber
- Separate use of the logic channel
  - Similar to co-channel signalling for switching services
- Data link layer
  - LAPD (Q.921)
  - Reliable control
  - Flow and error control
  - Between the user (TE) and the network (NT)
  - Used for exchanging Q.933 control message signals

11 **Network Switching**
b. Packet switching

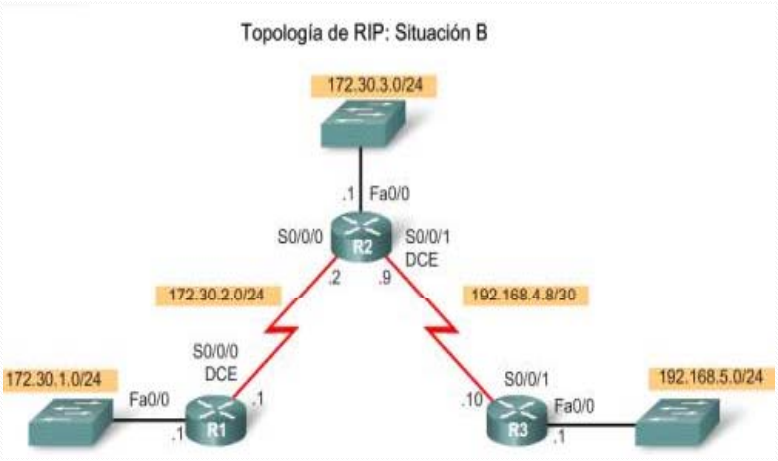
User plane

- End-to-end functionality
- Transfer of information between terminals
- LAPF (Link Access Procedure for Frame Mode Bearer Services) Q.922
  - Delimination of frames, alignment and seamlessness
  - Frame multiplexing and demultiplexing using addressing fields
  - Each frame is an integer number of octets (zero insertion/removal of bits)
  - Frames are neither too short or too long
  - Transmission error detection
  - Congestion control functions

12 **Telephone Network Applications**
a. PPP protocol

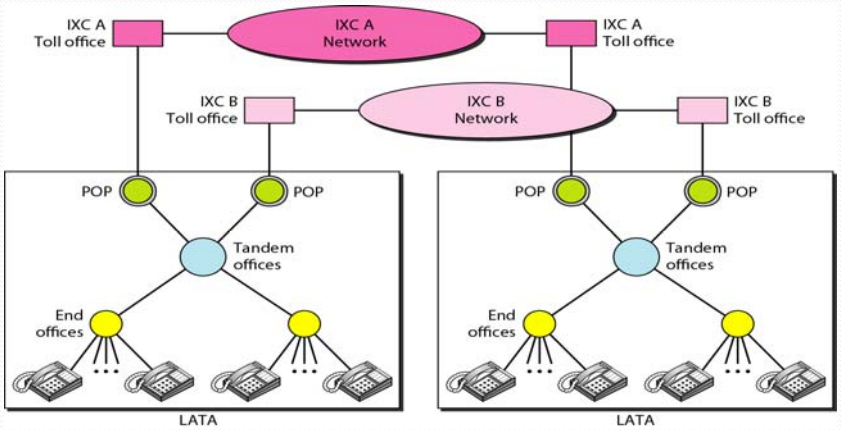


12 **Telephone Network Applications**
a. PPP protocol

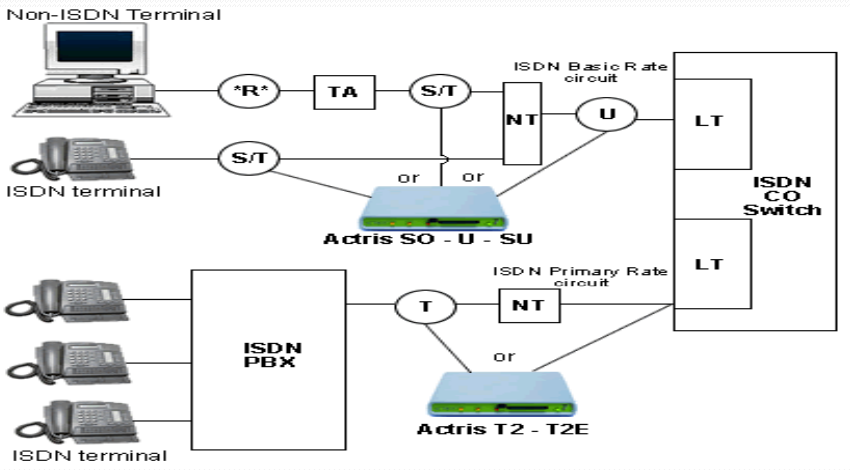


12 **Telephone Network Applications**
a. PPP protocol

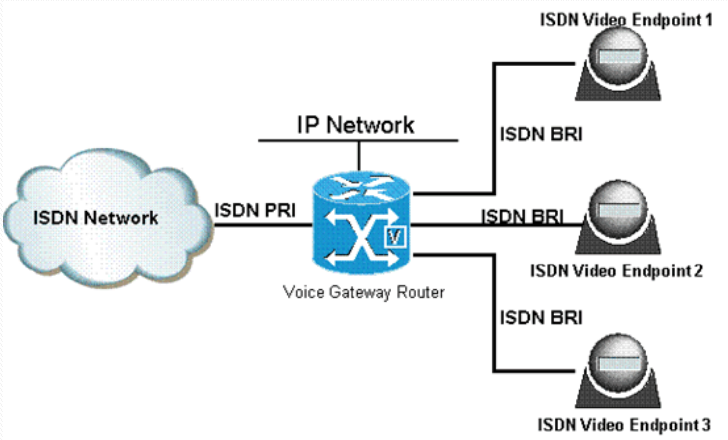
Points of presence (POPs)



12 **Telephone Network Applications**
b. ISDN service



12 **Telephone Network Applications**
b. ISDN service



12 Telephone Network Applications

b. ISDN service

ISDN Physical Interface Diagram