Lecture 2

Local Area Network (LAN) Technologies

Learning Objectives

- By the end of this lesson you should be able to
  - Describe the IEEE standard project 802
  - Describe the various LAN technologies

IEEE 802 Family Of LAN Standards

- In 1985, the IEEE approved a series of LAN standards describing several recommendations for implementing LANs at Layer 1 and 2 of the OSI reference model
  - The recommendations are referred to as the IEEE 802 standards
- The IEEE 802 standards do not seek to replace the OSI or TCP/IP model
  - It is a way of specifying functions of the physical and data link layer of major LAN protocols

IEEE 802 Family Of LAN Standards (cont'd)

- Describe three major portions of LANs
  - Specifications of the MAC sublayer of the data link layer
  - Descriptions of the electrical and physical characteristics of the physical layer
  - Specification of the logical link (LLC) sublayer of the data link layer.

IEEE 802 Family Of LAN Standards (cont'd)

- The LLC is a software interface from the data link layer to the network layer
  - Manages the flow of data from a computer as data is sent or received from the device.
- The MAC sublayer actually cross the boundary to the physical layer in their scope of operations and as such are sometimes referred to as physical layer protocols

IEEE 802 Family Of LAN Standards (cont'd)

- The IEEE subdivided the data link layer into two sub-layers namely
  1. Logical link control (LLC): non architecture specific, that is, the same for all IEEE defined LANs
  2. Media access control (MAC): contains a number of distinct modules, each comes from proprietary information specific to the LAN product being used
- The next slide show the relationship of 802 standard to OSI or TCP/IP model

IEEE 802 Family Of LAN Standards (cont'd)

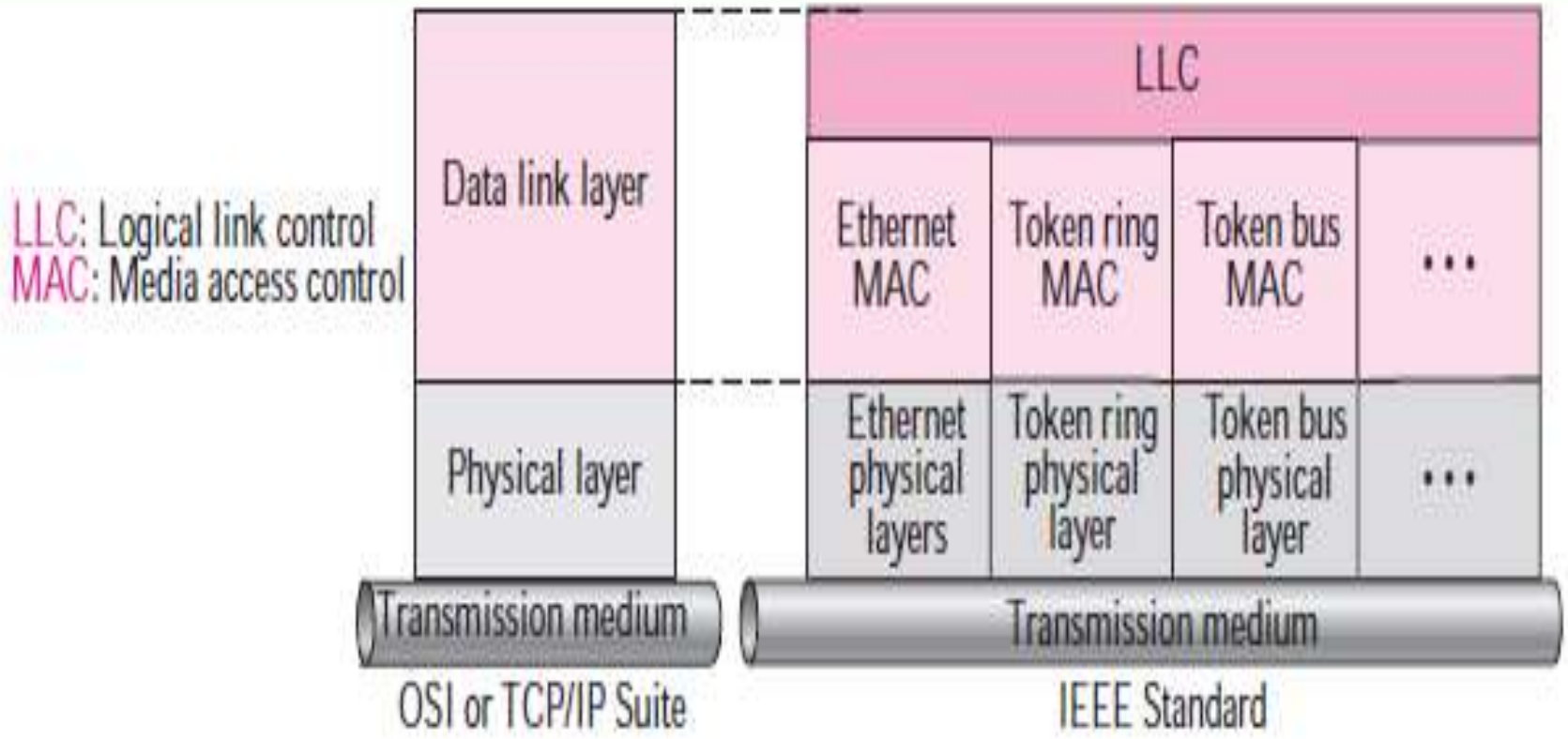


Figure: The relationship of the 802 Standard to OSI or TCP/IP model

IEEE 802 Family Of LAN Standards (cont'd)

- The strength of the IEEE 802 standards is modularity
  - Modularity means subdividing the function necessary for LAN management
  - This allowed the designers to standardize those that can be generalized and to isolate those that must remain specific
- The IEEE family of LAN standards is shown in the next slide

IEEE 802 Family Of LAN Standards (cont'd)

IEEE 802 Standards	
802.1	Systems standard for local and metropolitan area networks
802.2	Logical Link Control (LLC) sublayer
802.3	CSMA/CD access, including MAC sublayer and Physical layer signaling (10Base-2, 10Base-5, 10Base-T, 100Base-T, 1000Base-T, 10Broad-36)
802.4	Token bus. Included in the Manufacturing Automation Protocol suite (MAP)
802.5	Token Ring
802.6	Metropolitan Area Networks. Specifies a dual fiber optic bus with time slots
802.7	Broadband technology
802.8	Fiber-optic technology
802.9	Integrated Voice and Data. Describes use of ISDN devices with LANs.
802.10	LAN security
802.11	Wireless LANs
802.12	100VG-AnyLAN

LAN Technologies

- LAN technology
  - An umbrella term for all the equipments and software protocols, used in local area networks.
  - Primarily applies to ethernet networks
- The technologies to be considered include:
  - Ethernet
  - Token ring
  - FDDI (Fiber Distributed Data Interface)
  - Token bus
  - ATM (Asynchronous Transfer Mode)

Ethernet Technology

Ethernet : Definition

- A highly standardized popular network architecture
- Based on the CSMA/CD transmission protocol
- It is a logical bus network that is implemented both as a physical star and a physical bus network
- Governed by the IEEE 802.3 standard

Ethernet: Origin

- CSMA/CD originated in University of Hawaii in the 1960s
- Cabling and signaling schemes were invented at Xerox
- Subsequently standardized by a group of companies
  - Xerox, Intel and DEC (Digital Equipment Corporation)

Ethernet: Technology

- MAC Types – CSMA/CD
  - There are two Media Access Control(MAC) protocols defined for Ethernet:
    - Half duplex
    - Full duplex

Ethernet: Technology (cont’d)

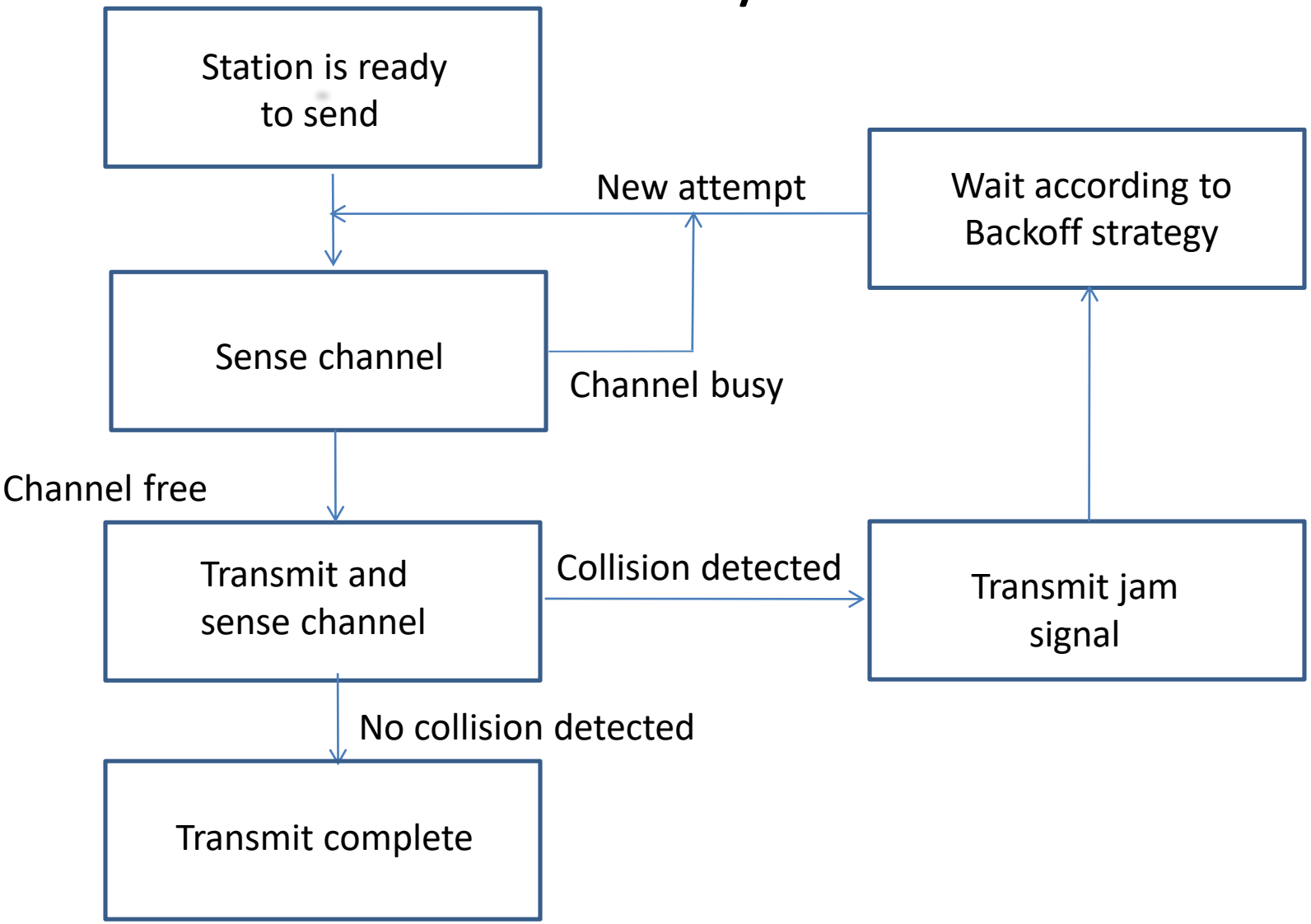
- **MAC Types (Half-Duplex)**
  - Refers to the transmission of data in just one direction at a time
  - Half-Duplex Ethernet is the traditional form of Ethernet that uses the CSMA/CD
  - Half duplex Ethernet assumes that all the "normal" rules of Ethernet are in effect on the local network

Ethernet: Technology (cont'd)

- **Carrier Sense Multiple Access With Collision Detection (Half-Duplex)**
  1. Listen before talk (Carrier Sense)
  2. If free, transmit and monitor transmission.
  3. If busy, defer.
  4. If a collision occurs during transmission, stop transmitting.
  5. Send a jamming signal
  6. Transmitting station waits a random period of time (back-off).
  7. Retry with LBT

Ethernet: Technology (cont'd)

CSMA/CD Flow



Ethernet: Technology (cont'd)

- **MAC Types (Full-Duplex)**
  - Based on the IEEE 802.3x standard, "Full-Duplex" MAC type bypasses the CSMA/CD protocol
  - Full-duplex mode allows two stations to simultaneously exchange data over a point to point link
  - The aggregate throughput of the link is effectively doubled
    - A 10 Mb/s station operating in full-duplex mode provides a maximum bandwidth of 20 Mb/s
    - A full-Duplex 100 Mb/s station provides 200 Mb/s of bandwidth

Ethernet: Technology (cont'd)

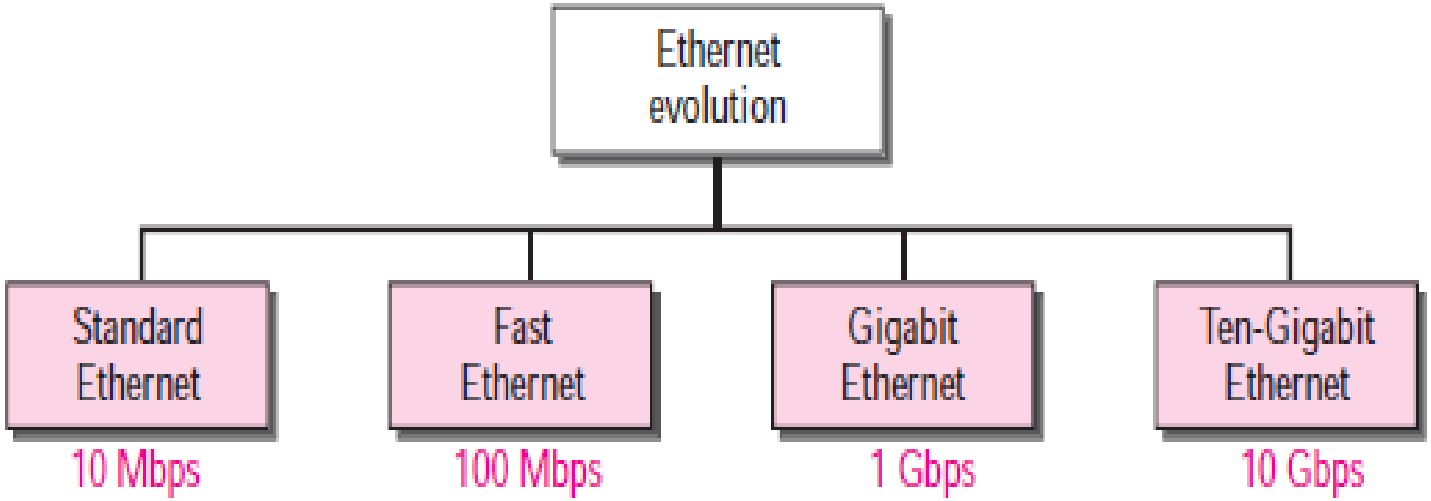
- **MAC Types (Full-Duplex)** [cont'd]
  - Full-duplex operation is restricted to links meeting the following criteria:
    - The physical medium must be capable of supporting simultaneous transmission and reception without interference
      - 10-Base-T, 10Base-FL, 100Base-TX, 100Base-FX, 100Base-T2, 1000Base-CX, 1000Base-SX, 1000Base-LS, and 1000Base-T.
      - The following media specification cannot support full-duplex: 10Base5, 10Base2, 10Base-FP, 10Base-FB, and 100Base-T4.
  - Full-duplex operation is restricted to point to point links connecting exactly two stations.
    - Since there is no contention for a shared medium, collisions cannot occur and the CSMA/CD protocol is unnecessary.
  - Both stations on the link must be capable of, and be configured for full-duplex operation.

Ethernet: Technology (cont'd)

- **MAC Types (Full-Duplex)** [cont'd]
  - Full-duplex operation offers several major advantages:
    - Throughput is doubled by permitting simultaneous transmit and receive.
    - The efficiency of the link is improved by eliminating the potential for collisions.
    - Segment lengths are no longer limited by the timing requirements of half-duplex Ethernet that ensure collisions are propagated to all stations within the required 512 bit times.

Ethernet: Evolution

- Ethernet has gone through four generations



Ethernet: Evolution(cont'd)

- Standard Ethernet (10 Mbps Ethernet)
- Operates in Half-duplex mode (CSMA/CD)
- Summary of implementation is shown below

Characteristics	*10Base5*	*10Base2*	*10Base-T*	*10Base-F*
Medium	Thick coax	Thin coax	2 UTP	2 Fiber
Maximum length	500 m	185 m	100 m	2000 m

Ethernet: Evolution(cont'd)

- Fast Ethernet (100 Mbps Ethernet)
- Operates in both Half-duplex (CSMA/CD is used) and Full-duplex mode (No need for CSMA/CD)
- Summary of implementation

Characteristics	*100Base-TX*	*100Base-FX*	*100Base-T4*
Media	STP	Fiber	UTP
Number of wires	2	2	4
Maximum length	100 m	100 m	100 m

Ethernet: Evolution(cont'd)

- Gigabit Ethernet (1 Gbps Ethernet)
- Operates in both Half-duplex (CSMA/CD is used) and Full-duplex mode (No need for CSMA/CD)
- Summary of implementation

Characteristics	*1000Base-SX*	*1000Base-LX*	*1000Base-CX*	*1000Base-T4*
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

Ethernet: Evolution(cont'd)

- 10 Gigabit Ethernet (10 Gbps Ethernet)
- Operates only in full duplex mode
- CSMA/CD is not used in Ten-Gigabit Ethernet
- Summary of implementation

Characteristics	*10GBase-S*	*10GBase-L*	*10GBase-E*
Media	multi-mode fiber	single-mode fiber	single-mode fiber
Number of wires	2	2	2
Maximum length	300 m	10,000 m	40,000 m

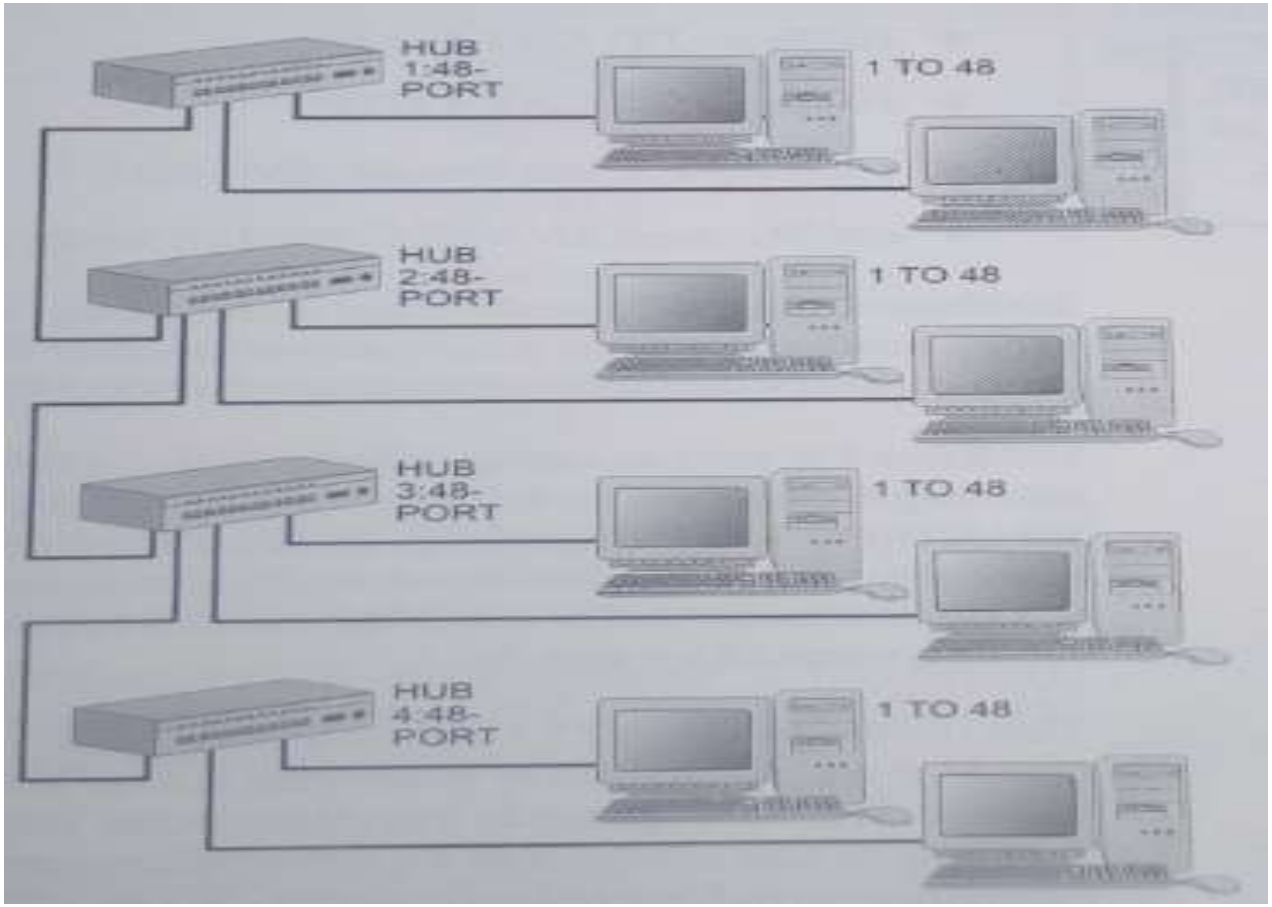
Ethernet: Topology

- Logical bus
- Physical implementation
  - Either Star or Bus
  - Each has its own advantage
- The unit of data traveling on Ethernet is called **frame** (many variations in structure)
- Implemented on **NICs** (Network Interface Cards)

Ethernet: Cabling

- Popular
  - Unshielded Twisted Pair (UTP) (10baseT)
    - Different categories for different speeds
  - Thin coaxial (10base2)
- Others
  - Thick coaxial (10Base5)
  - Shielded Twisted Pair (STP)
  - Optical Fiber (10baseFL)

Ethernet LAN With Repeaters



Token Ring

- A LAN protocol that uses a ring topology and token-passing access methods
- It was originally developed by IBM in 1980 and later submitted to the IEEE to be considered as a standard
- The IEEE 802.5 token ring is the standard and was derived from IBM's token ring network design
- Token ring is a major competitor to Ethernet in the LAN arena
- However, Ethernet has been so successful that even IBM, the originator of token ring technology markets Ethernet hardware

Token Ring (cont'd)

- Ehternet has been winning the LAN war for several reasons:
  - The cost per device for Ethernet is considerably lower than for token ring
    - Token ring NICs cost $300 to $600, compared to less than $100 for ethernet cards
  - Even though token ring is an IEEE standard, it is viewed by many as an IBM proprietary technology
    - Many customers and vendors have moved away from token ring for this reason
  - Token ring is more complex, and management of it requires more technical knowledge
    - This complexity results from the management tools that make it easier to diagnose and correct faults in a token ring-network than in an Ethernet

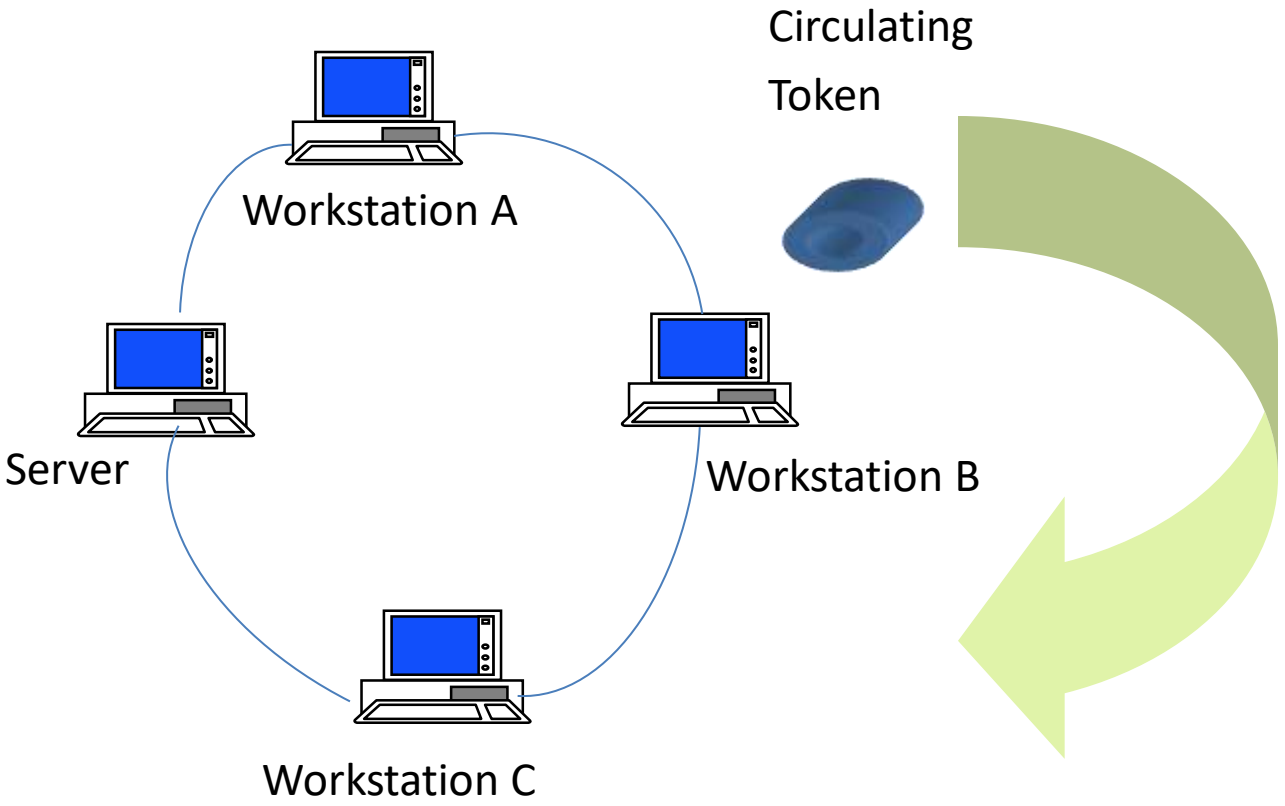
Token Ring (cont'd)

- **Token access control**
  - All networks provides a medium access control method that controls how devices can use a shared medium
  - The method used by token ring is called *Token Access*

- Token ring networks use a physical star topology, yet they use a logical ring topology
  - The transmitter of each device is connected to the receiver of the next device in the ring
  - This enables the devices to pass messages around the ring

Token Ring (cont'd)

Fig3: **Token Passing Protocol in Operation**



- No collisions

Token Ring (cont'd)

- **Comparison with CSMA/CD**
  - Absence of collision
  - Offers a systematic method of transmitting information
  - In theory, it is superior to CSMA/CD
  - More sophisticated to implement
  - Protocols used in the newer and most popular networks are, however, based on CSMA/CD
  - Token ring is preferred over ethernet where access method guarantees that each device will have an equal opportunity to transmit data (deterministic)
    - Ehternet is probalistic, and does not guarantee devices opportunities to transmit each time the token circulates the ring

Token Ring (cont'd)

- **The Token**
  - Data frame or packet that could carry data
  - Circulates around the ring
  - Offers an opportunity for each workstation and server to transmit data

Token Ring (cont'd)

- **The transmitting workstation**
  - Waits for a free token in order to be able to attach the data to be transmitted to the token
  - On finding a free token, attach the following:
    - Sender's address
    - Receiver's address
    - Data block to be transmitted
    - Error checking details
    - etc.

Token Ring (cont'd)

- **At the receiving end**
  - Data is received and checked for errors
  - Outcomes at the receiving end
    - Data received without errors
    - Data received with errors

Token Ring (cont'd)

- **Error free delivery of data**
  - An acknowledgment is attached to the token
  - Acknowledgment is passed to the sender
  - Token is set free for other nodes to transmit information
  - At this time, the next workstation on the ring will receive an opportunity

Token Ring (cont'd)

- **Correcting errors in delivery**
  - A request for retransmission is attached to the token
  - Token carries the message for retransmission to the sender
  - The data is thus retransmitted

- **Token Regeneration**
  - The token is regenerated at regular intervals to sustain the timing of circulation of the token

Token Ring (cont'd)

- **Usage of token passing**
  - Used extensively in ring LANs
    - Especially in the IBM token-ring LAN
  - A version of this protocol is also used on certain types of bus LANs
    - Token-bus networks
  - Used in large fiber-optics backbones
    - Used for the construction of very large networks

Token Ring (cont'd)

- **Usage in practice**
  - Used in backbones
  - Uses in a number of IBM shops
  - Overall, the usage of Ethernet surpasses the usage of Token-Ring networks that are based on the Token-Passing protocol

Token Passing Standards

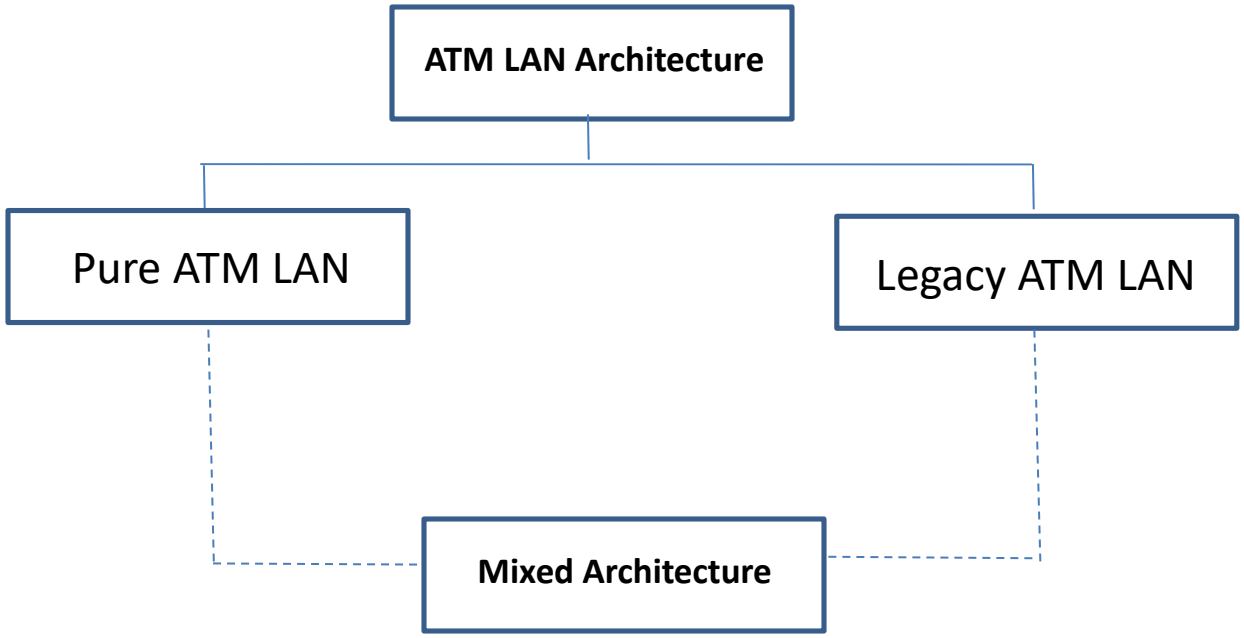
- IEEE 802.5
  - For the token-ring LANs
- IEEE 802.4
  - For the token-bus LANs
- A FDDI protocol is used on large fiber-optic ring backbones

Asynchronous Transfer Mode (ATM) LANs

- A Local Area Network using ATM technology
- ATM is a Wide Area Network Protocol featuring high data rates and equal-sized packets (cells)
  - ATM is suitable for transferring texts, audio, and video data
  - Supports different types of connection between two end users
  - Supports temporary and permanent connections
  - Supports multimedia communication with a variety of bandwidths for different applications
  - Provides high transfer rate of 155 and 622 Mbps
    - This high data transfer rate has attracted the attention for designers who are looking for greater and greater speeds in LAN

ATM LAN Architecture

- Currently, there are two ways to incorporate ATM technology in a LAN architecture
  - Pure ATM LAN
  - Legacy ATM LAN
- A taxonomy of these architectures are illustrated in the fig4



Pure ATM LAN Architecture

- An ATM switch connects stations as shown in fig5

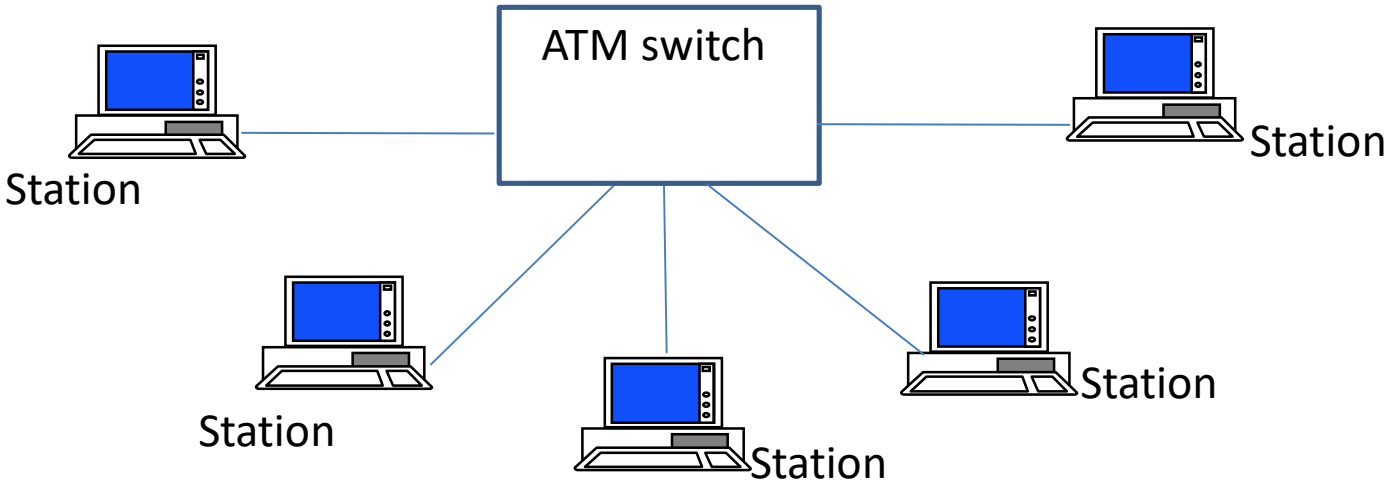


Figure 5

- In this way, station can exchange data at one of two standard rates of ATM technology (155 and 622 Mbps)
- However, the station uses a virtual path identifier (VPI) and virtual circuit identifier (VCI), instaed of a source and destination address
- **Drawbacks**
  - Systems need to be built from the ground up; existing LANs cannot be upgraded into pure ATM LANs

Legacy LAN Architecture

- Use ATM technology as a backbone to connect traditional LANs as shown in fig6 in the next slide
- In this way stations on the same LAN can exchange data at the same rate and format of traditional LANs (Ethernet, token ring)
  - But when two stations on two different LANs need to exchange data, they can do so by using a converting device that changes frame format
- The advantage here is that output from several LANs can be multiplexed together to create a high data rate input to the ATM

Legacy ATM LAN Architecture (cont'd)

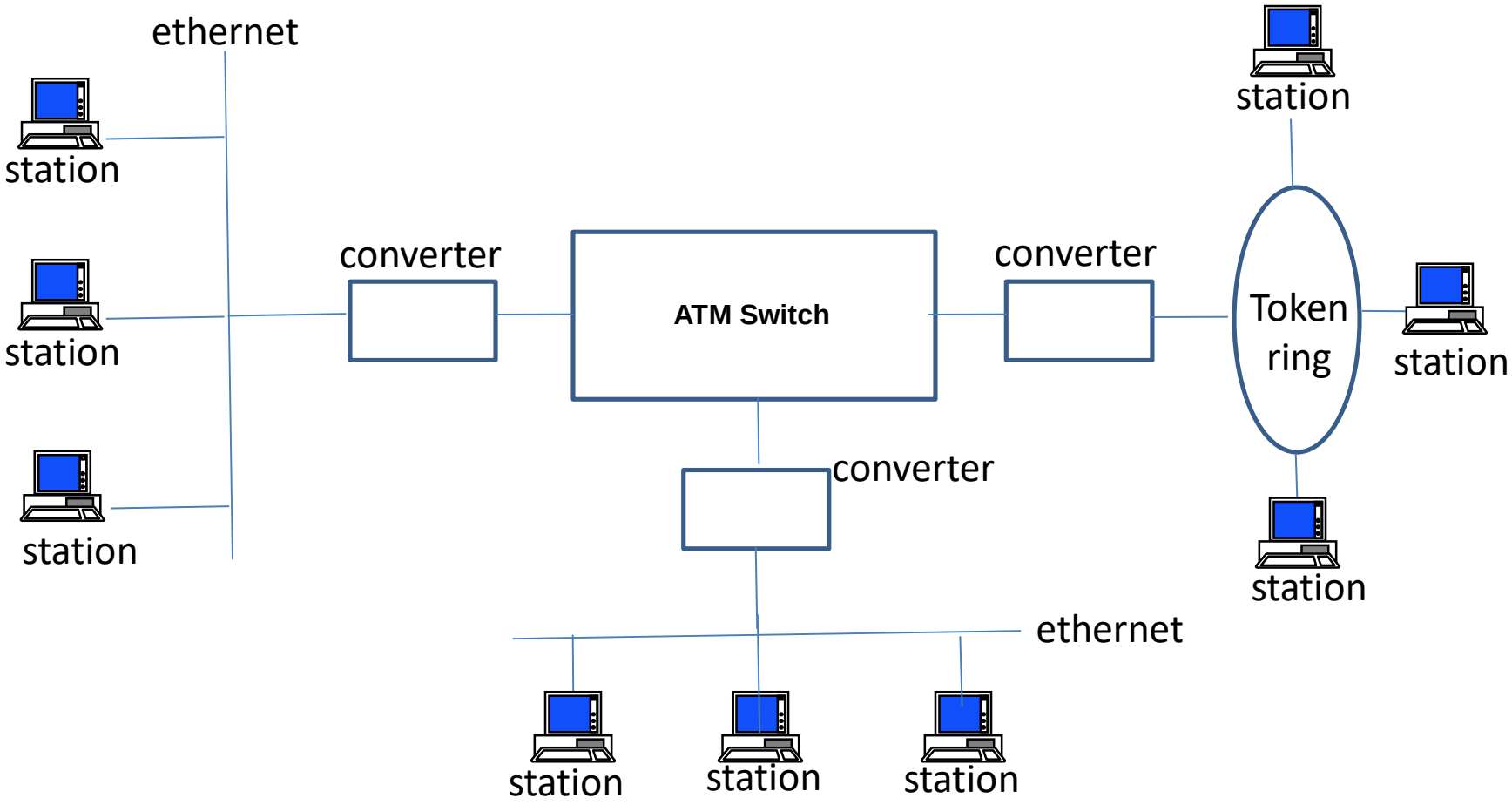
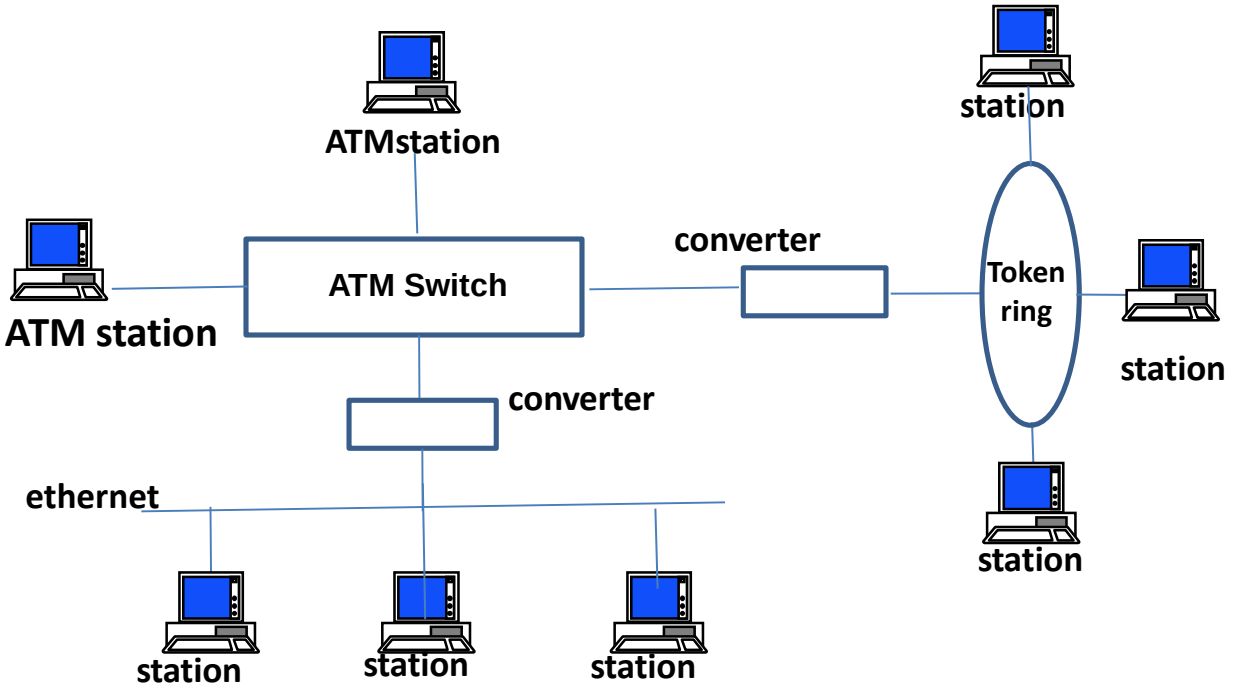


Figure 6: Legacy ATM LAN Architecture

Mixed Architecture

- The mixed-architecture LAN allows the gradual migration of legacy LANs onto ATM LANs by adding more connected stations to the switch as shown in fig7 below:
- This is the best solution of the previous architecture
- This means keeping the existing LANs, and at the same time, allowing new stations to be directly connected an ATM switch



Mixed Architecture (cont'd)

- Again, the stations on a specific LAN can exchange data using the format and data rate of that particular LAN
- The stations directly connected to the ATM switch use an ATM frame to exchange data

End

Thank you