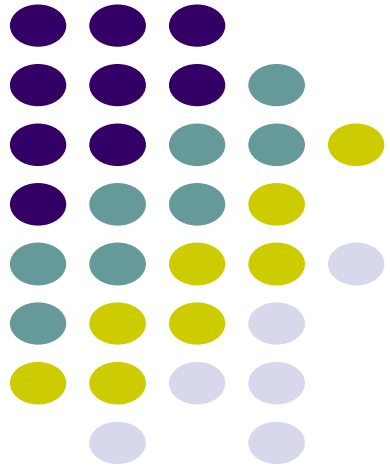
18ECC303J – Computer Communication Networks

Course Credit : 4

Theory : 9 Hours

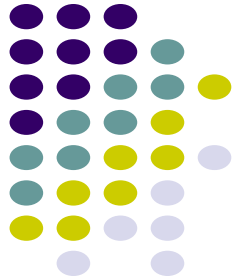


1. Behrouz A. Fehrouzan, "Data communication & Networking", Mc-Graw Hill, 5th Edition Reprint, 2014.

2. Andrew S. Tanenbaum, "Computer Networks", Pearson Education India, 5th Edition, 2013.

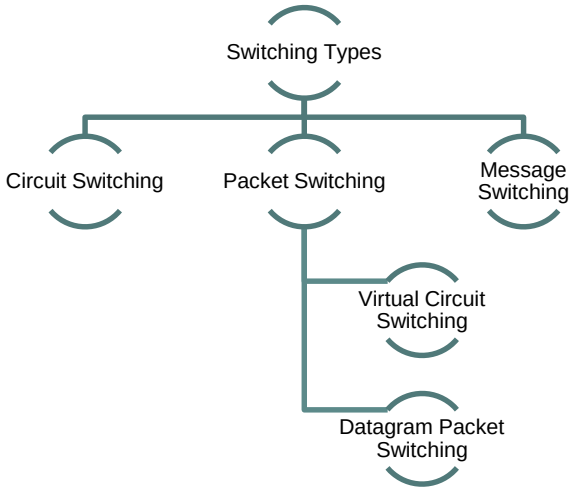
3. William Stallings, "Data & Computer Communication", Pearson Education India, 10th Edition, 2014.

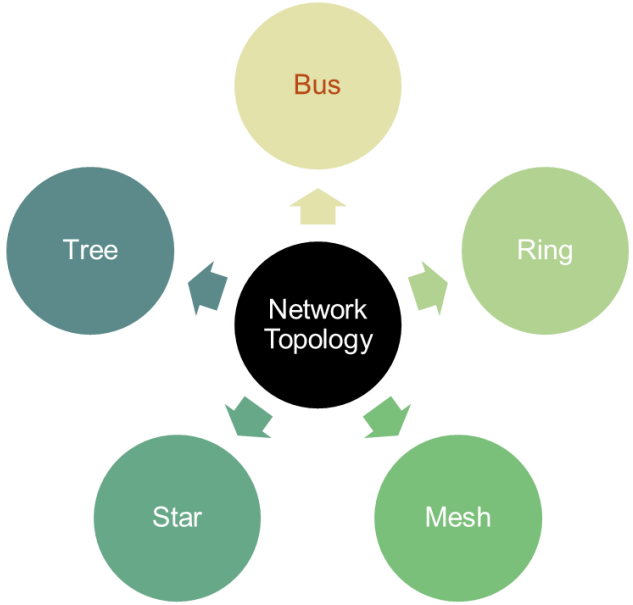
Unit 1 – Data Communication and Networking Basics



- Introduction to Data Communication and Networking
- Data transfer modes-Serial and Parallel transmission
- Protocols & Standards
- Layered Architecture; Principles of Layering & Description
- Brief description of concepts in OSI & TCP/IP model
- Switching Types: Circuit & Packet switching, Message switching, Comparison of switching types
- LAN, MAN & WAN
- Network topologies-Types, Comparison of topologies
- IEEE standards for LAN-Ethernet; Types of Ethernet
- Token Bus, Token Ring and FDDI

Unit 1 – Week 2-Review





Key Parameters	LAN	MAN	WAN
Ownership	private	private or public.	private or public.
Speed	quiet high.	average.	speed is lower than that of LAN.
Delay	short.	moderate.	longer.
Congestion	Low	High	Higher
Fault Tolerance	s higher than WAN.	lower than LAN.	lower than both LAN and MAN.
Maintenance	easy and less costly than WAN.	complex and more costly than LAN.	complex and more costly than both.

Unit 1 – Week 3

Session 7

- IEEE standards for LAN-Ethernet
- Types of Ethernet

Session 8

- Token Bus
- Token Ring

Session 9

- FDDI

Reference Text Books:

1. Behrouz A. Fehrouzan, "Data communication & Networking", Mc-Graw Hill, 5th Edition Reprint, 2014.

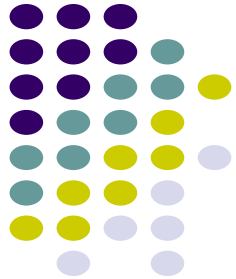
2. Andrew S. Tanenbaum, "Computer Networks", Pearson Education India, 5th Edition, 2013.

Introduction to Data Communication and Networking

Objectives :

To Introduce the students about IEEE standards for LAN-Ethernet; Types of Ethernet, Token Bus, Token Ring and Fiber Distributed Data Interface (FDDI)

- The main objective of data communication and networking is to enable seamless exchange of data between any two points in the world.
- This exchange of data takes place over a computer network.
- To understand the concepts of various switching techniques, types of networks and topology.
- To gain knowledge on IEEE standards for LAN.



IEEE Standards for LAN

IEEE 802.3 and Ethernet

- Very Popular LAN Standard
- A Standard for 1-persistent CSMA/ CD LAN (Carrier Sense Multiple Access/ Collison Detection)
- Covers the physical layer and MAC sublayer protocols

In 1985, the Computer Society of the IEEE started a project, called Project 802, to set standards to enable intercommunication among equipment from a variety of manufacturers.

Project 802 is a way of specifying functions of the physical layer and the data link layer of major LAN protocols.

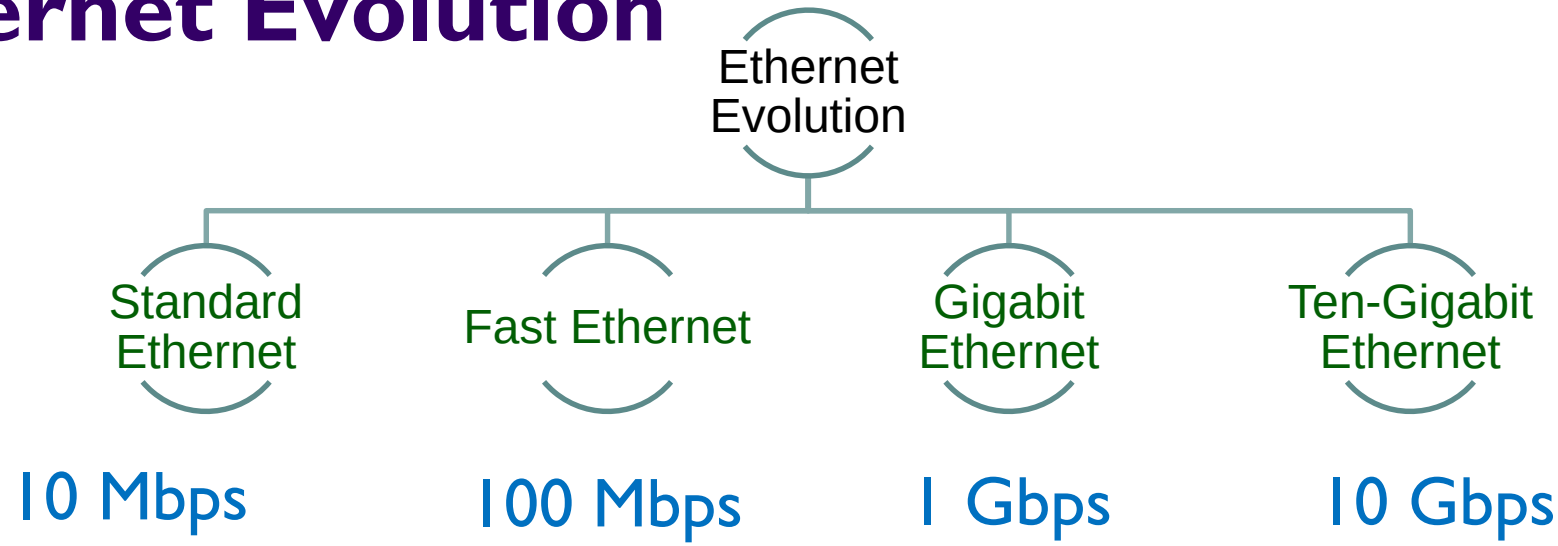
IEEE Standards for LAN – Ethernet

- Physical Layer LAN technology
- The original Ethernet was created in 1976 at Xerox's Palo Alto Research Center (PARC).
- Xerox built a 2.94 Mbps CSMA/CD system to connect over 100 personal workstations on 1-Km cable. This system was called Ethernet through which electromagnetic radiation was once thought to propagate.
- Xerox DEC and Intel came with another standard for 100 Mbps Ethernet.

Ethernet RJ45 connector on an Ethernet cable

Ethernet, IEEE 802.3 has been in use for many years and provides wired connectivity for many data networking applications from home to the largest enterprise systems

Ethernet Evolution

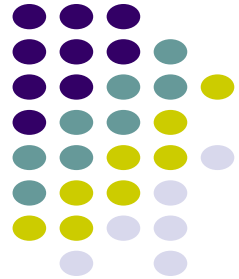


Gigabit Ethernet also known as "gigabit-Ethernet-over-copper" or 1000Base-T or GigE

10 Gigabit Ethernet is based entirely on the use of optical fiber connections.

Other LAN types include Token Ring, Fiber Distributed Data Interface (FDDI), Asynchronous Transfer Mode (ATM) and LocalTalk

Categories of Standard Ethernet



Standard Ethernet Common Implementation

10Base5	10Base2	10Base-T	10Base-F
• Bus	• Bus	• Star	• Star
• Thick Coaxial	• Thin Coaxial	• UTP	• Fiber

10 denotes 10 Mbps

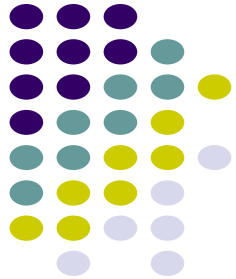
Base represents Baseband

5 represents 500 m

2 denotes 200/185 m

T means Twisted Pair Cable

F means Fiber.



Ethernet Specifications

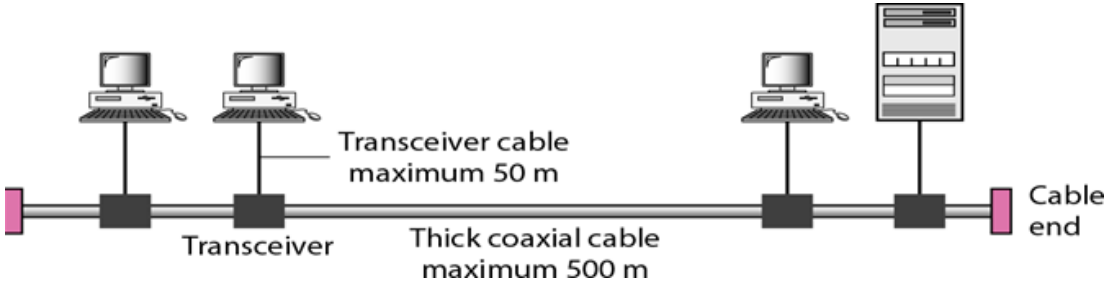
Name	Cable	Max seg. (m)	Nodes per segment	Advantages
10Base5	thick coax	500	100	The Original
10Base2	thin coax	185	30	No hub
10Base-T	twisted pair (UTP)	100	1024	Low Cost
10Base-F	fiber	2000	1024	Long distance

Ethernet Cabling

10Base5
Thick Ethernet or Thicknet

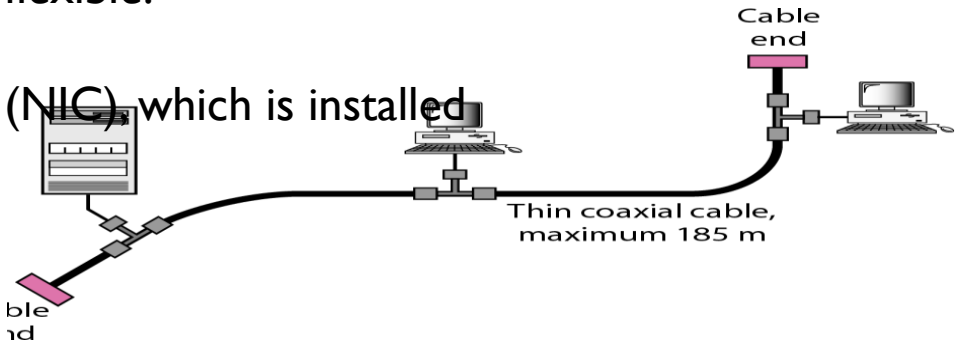
First Ethernet - to use a bus topology with an external transceiver connected via a tap to a thick coaxial cable.

- The transceiver is responsible for transmitting, receiving, and detecting collisions.
- The transceiver is connected to the station via a transceiver cable that provides separate paths for sending and receiving
- This means that collision can only happen in the coaxial cable.
- The maximum length of the coaxial cable must not exceed 500 m



10Base2
Thin Ethernet or Cheapernet

- 10Base2 also uses a bus topology, but the cable is much thinner and more flexible.
- The cable can be bent to pass very close to the stations.
- In this case, the transceiver is normally part of the network interface card (NIC), which is installed



Ethernet Cabling

10Base - T: Twisted pair ethernet

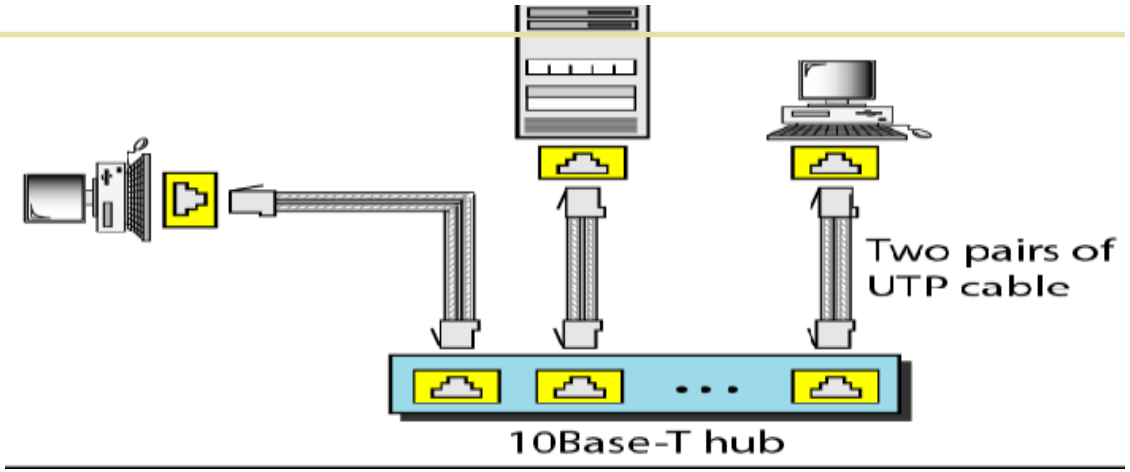
10Base-T uses a physical star topology.

- Two pairs of twisted cable create two paths (one for sending and one for receiving) between the station and the hub. Any collision here happens in the hub.
- Compared to 10Base5 or 10Base2, we can see that the hub actually replaces the coaxial cable as far as a collision is concerned.
- The maximum length of the twisted cable here is defined as 100 m, to minimize the effect of attenuation in the twisted cable.

10Base - F: Fiber Ethernet

Although there are several types of optical fiber 10-Mbps Ethernet, the most common is called 10Base-F.

- 10Base-F uses a star topology to connect stations to a hub.
- The stations are connected to the hub using two fiber-optic cables.



Types of Ethernet

Fast Ethernet - IEEE 802.3u

- Fast Ethernet was designed to compete with LAN protocols such as FDDI or Fiber Channel.
- Fast Ethernet is backward-compatible with Standard Ethernet, but it can transmit data 10 times faster at a rate of 100 Mbps.

Goals:

- Upgrade the data rate to 100 Mbps.
- Make it compatible with Standard Ethernet.
- Keep the same 48-bit address and same frame format.
- Keep the same minimum and maximum frame lengths.

Gigabit Ethernet – IEEE 802.3z

- The need for an even higher data rate resulted in the design of the Gigabit Ethernet protocol (1000 Mbps).

Goals:

- Upgrade the data rate to 1 Gbps.
- Make it compatible with Standard or Fast Ethernet.
- Use the same 48-bit address and same frame format.
- Keep the same minimum and maximum frame lengths.

Ten-Gigabit Ethernet – IEEE 802.3ae

- The IEEE committee created Ten-Gigabit Ethernet and
- called it Standard 802.3ae

Goals:

- Upgrade the data rate to 10 Gbps.
- Compatible with Standard, Fast, and Gigabit Ethernet.
- Use the same 48-bit address and the same frame format.
- Keep the same minimum and maximum frame lengths.
- Allow the interconnection of existing LANs into a MAN or WAN
- Make Ethernet compatible with technologies such as Frame Relay and ATM.

Fast Ethernet - Classification

100Base-TX

- It uses two pairs of twisted-pair cable (either category 5 UTP or STP(Shielded twisted pair).
- For this implementation, the MLT-3(Multi Level Transmit) scheme was selected since it has good bandwidth performance.
- 4B/5B block coding is used to provide bit synchronization by preventing the occurrence of a long sequence of 0s and 1s. This creates a data rate of 125 Mbps, which is fed into MLT-3 for encoding.

100Base-FX

- Uses two pairs of fiber-optic cables.
- Optical fiber can easily handle high bandwidth requirements by using simple encoding schemes.
- Uses NRZ-I(Non-Return-to-Zero Inverted) encoding scheme (bit synchronization problem.)
- To overcome this problem, 4B/5B block coding is used.
- It is cost effective

100Base-T4

- Uses four pairs of category 3 or higher UTP.(not cost efficient compared to Category 5)
- Transmit 100 Mbps.

Autonegotiation: A new feature of Fast Ethernet. It allows a station or a hub a range of capabilities, mode or data rate of operation.

Main Purpose of Autonegotiation

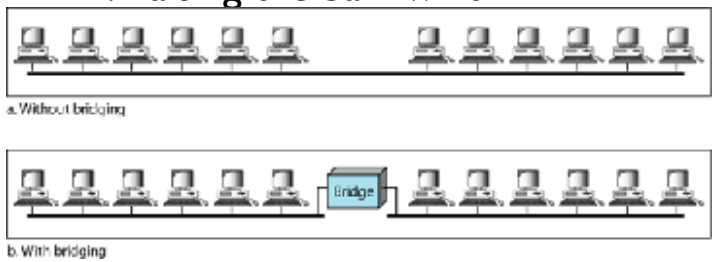
1. To allow incompatible devices to connect to one another.
2. To allow one device to have multiple capabilities.
3. To allow a station to check a hub's capabilities

Changes in the Standard

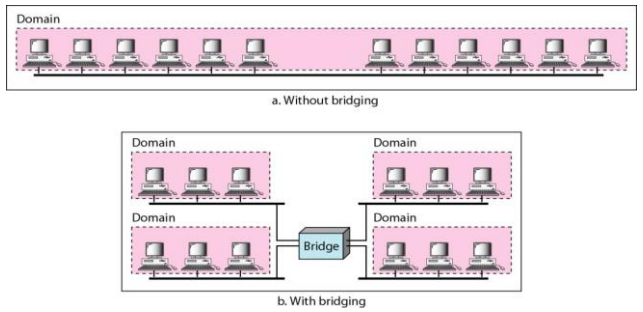
Bridged Ethernet

- The first step in the Ethernet evolution was the division of a LAN by bridges.
- Without bridges, all the stations share the bandwidth of the network
- Bridges have two effects on an Ethernet LAN:

1. Raising the bandwidth

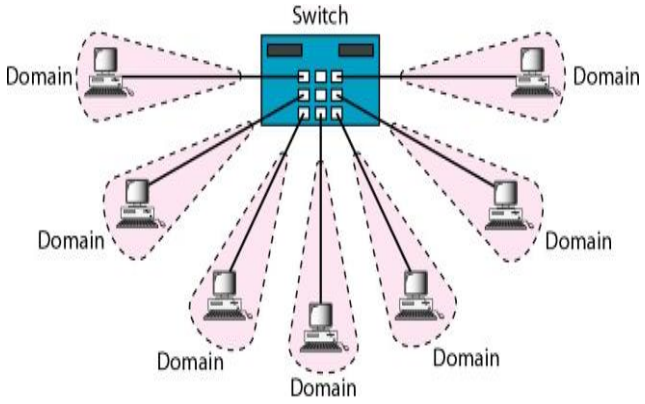


2. Separate collision domains



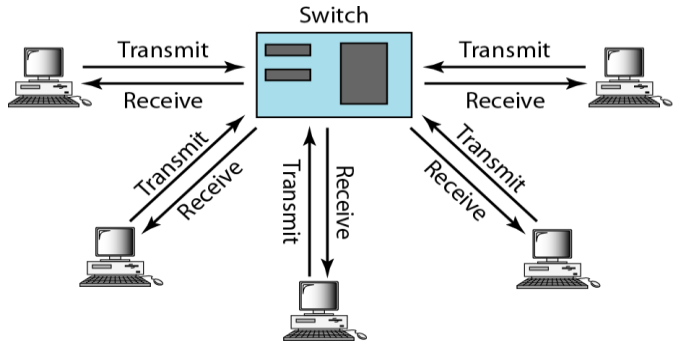
Switched Ethernet

A network switch is a small hardware device that joins multiple computers together within one local area network



Full Duplex Ethernet

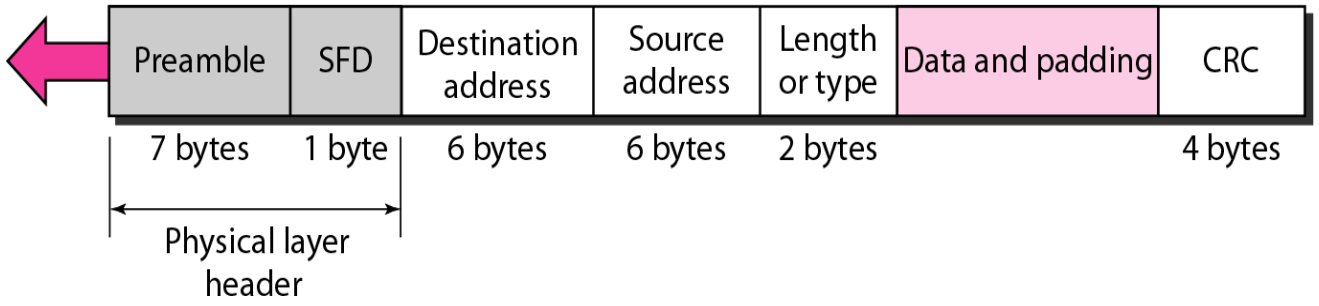
•In full duplex switch there are two links, one for sending and one for receiving,
•No collision – CSMA/CD not required.
•Increases the capacity of each domain from 10 to 20 Mbps



Frame Format – Standard Ethernet

Preamble: 56 bits of alternating 1s and 0s.

SFD: Start frame delimiter, flag (10101011)



Preamble.

- Contains 7 bytes (56 bits) of alternating 0s and 1s
- Alerts the receiving system to the coming frame and enables it to synchronize its input timing. The pattern provides only an alert and a timing pulse

Start Frame Delimiter (SFD).

- The second field (1 byte: 10101011) signals the beginning of the frame.
- Warns the station about the last chance for synchronization.
- The last 2 bits is 11 and alerts the receiver that the next field is the destination address

Destination address (DA)

- The DA field is 6 bytes
- Contains the physical address of the destination station or stations to receive the packet.

Source address (SA)

- It is 6 bytes
- Contains the physical address of the sender of the packet.

Length or Type.

- The original Ethernet - type field to define the upper-layer protocol using the MAC frame.
- The IEEE standard - length field to define the number of bytes in the data field.

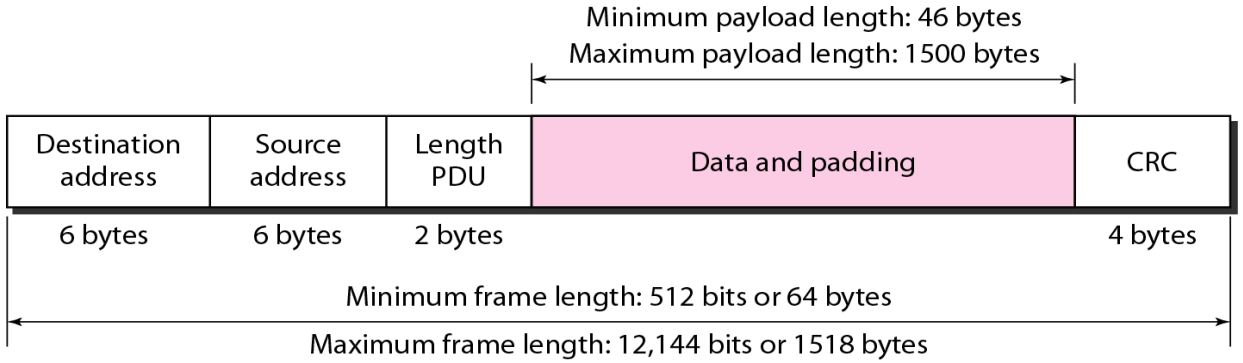
Data.

- Carries data encapsulated from the upper-layer protocols. It is a minimum of 46 and a maximum of 1500 bytes.

CRC.

- Contains error detection information, CRC-32

Frame Length – Standard Ethernet



Ethernet has imposed restrictions on both the minimum and maximum lengths of a frame.

- The minimum length restriction is required for the correct operation of CSMA/CD.
- An Ethernet frame needs to have a minimum length of 512 bits or 64 bytes.
- Part of this length is the header and the trailer.
- If we count 18 bytes of header and trailer (6 bytes of source address, 6 bytes of destination address, 2 bytes of length or type, and 4 bytes of CRC), then the minimum length of data from the upper layer is 64 - 18 = 46 bytes.
- If the upper-layer packet is less than 46 bytes, padding is added to make up the difference.
- The standard defines the maximum length of a frame 1518 bytes.
- If 18 bytes of header and trailer is subtracted, the maximum length of the payload is 1500 bytes.

Review Questions

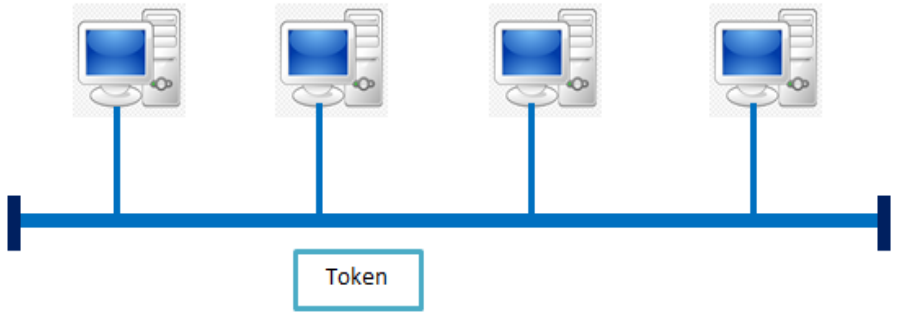
1. What is the minimum and maximum frame length of Ethernet's frame format?
2. What is the speed of Fast Ethernet?
3. 10Base-T – Expand
4. What is the function of last two bit of Start Frame Delimiter?
5. Mention the main purpose of Autonegotiation.

Review Answers

1. Frame length: Minimum: 64 bytes (512 bits) Maximum: 1518 bytes (12,144 bits)
2. 100 Mbps
3. 10 – 10 Mbps ; BASE – Baseband; T - Twisted pair cable
4. The last 2 bits is 11 and alerts the receiver that the next field is the destination address
5. Main Purpose of Autonegotiation
   - To allow incompatible devices to connect to one another.
   - To allow one device to have multiple capabilities.
   - To allow a station to check a hub's capabilities

Token Bus

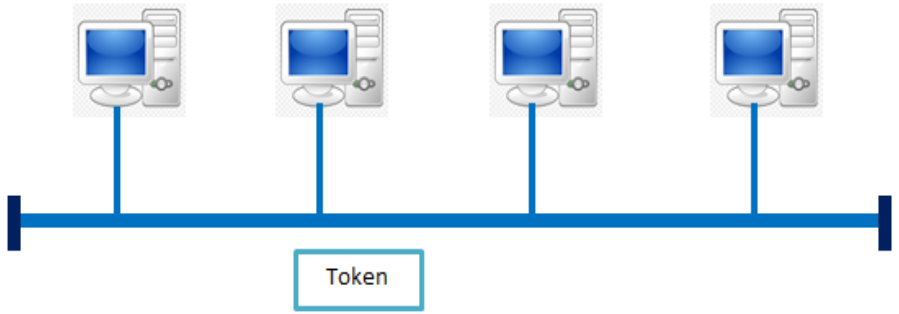
- Token Bus IEEE 802.4 is a standard for implementing token ring over virtual ring in LANs.
- The physical media has a bus or a tree topology and uses coaxial cables.
- A virtual ring is created with the nodes/stations and the token is passed from one node to the next in a sequence along this virtual ring.
- Each node knows the address of its preceding station and its succeeding station.
- A station can only transmit data when it has the token.



In the Token bus system, the stations are physically organized in bus topology but logically organized in a ring topology

Token Bus

- The devices are logically organized into a ring and a token circulates among them.
- A device wanting to send something must wait for the token to arrive.
- The token contains a destination address that specifies which device gets it.
- Each device monitors the bus and reads only those tokens destined for it.

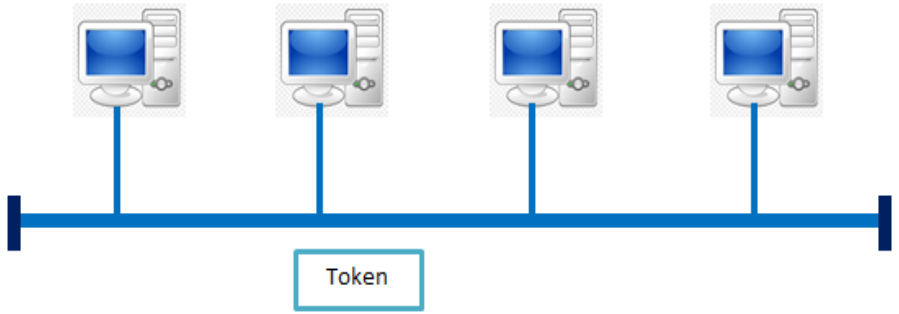


A token is a control frame

In Token Bus Method, a logical ring network is constructed virtually on the bus network

Token Bus

- Each node is assigned a sequential number.
- A token is transmitted from one node to the adjacent node.
- A node that has a request to send a message waits for the arrival of the token that is designated to the node.
- Once the node receives the token, it is possible to send a message during the allotted time.
- When it finishes sending a message or the allotted time has passed, it issues a token that is designated to its adjacent node. And it waits

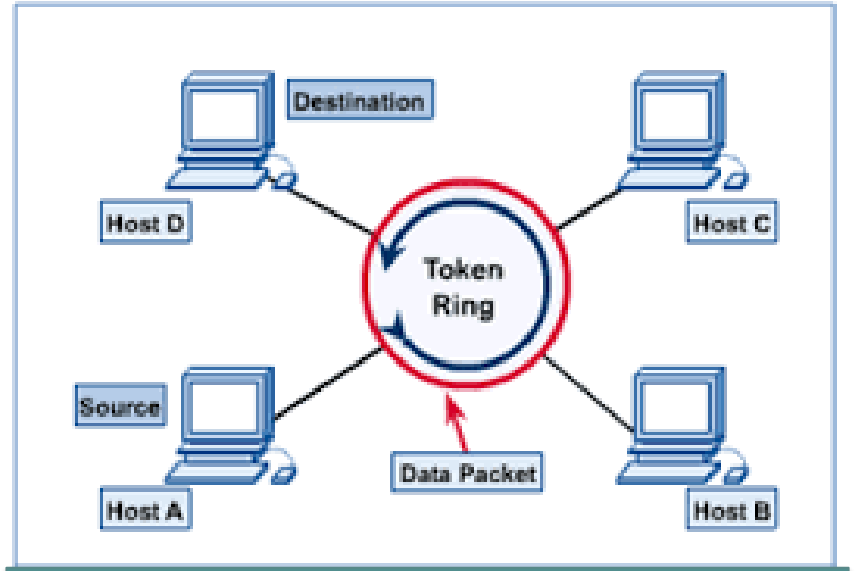


- ✓ When traffic is low, token cycle time is short.
- ✓ When traffic is heavy, token cycle time is long.

In the token-bus method, priority control of transmission is performed by the time token control method.

Token Ring

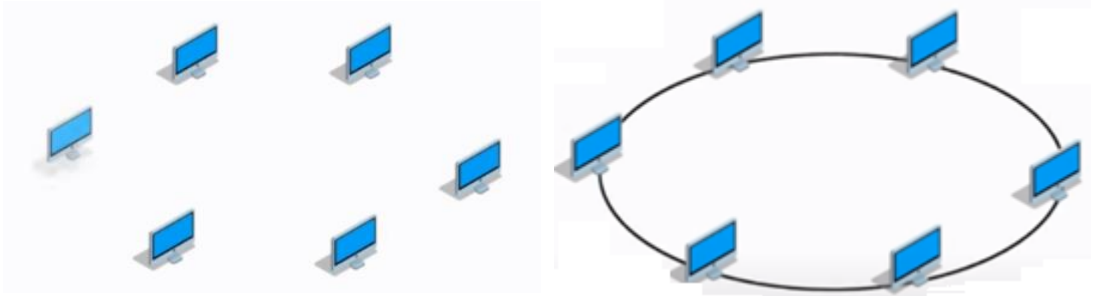
- Token Ring - IEEE 802.5 - Communication protocol in a LAN where all stations are connected in a Ring topology.
- Each station can directly hear transmissions only from its immediate Neighbour.
- Permission to transmit is granted by a message (token) that circulates around the ring.
- A station can send data frames only if it holds a token.
- The tokens are released on successful receipt of the data frame.



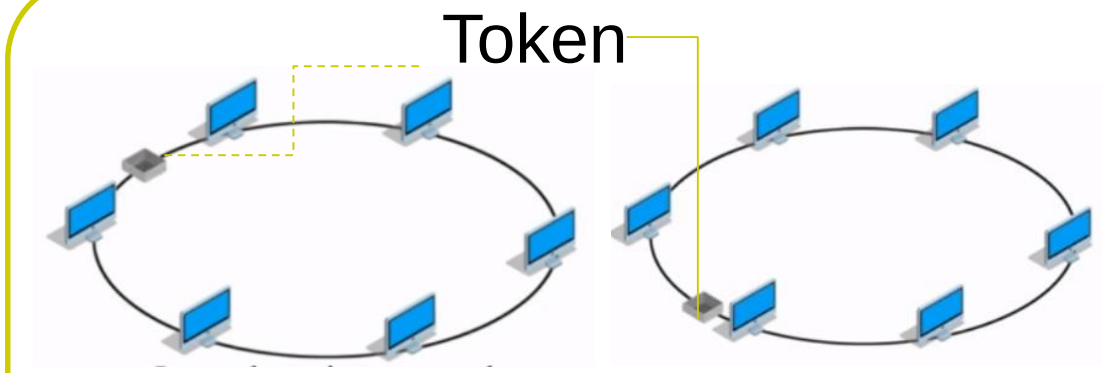
A token is a special frame of 3 bytes that circulates along the ring of stations

TOKEN is a special bit pattern (3 bytes long). There is only one token in the network

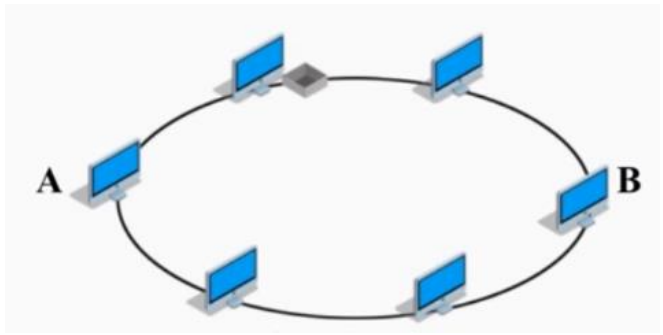
Token Ring Working



❶ Workstations connected in a ring topology

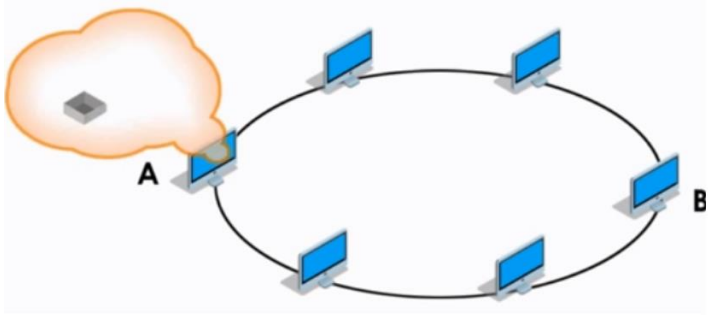


❷ Token Passing



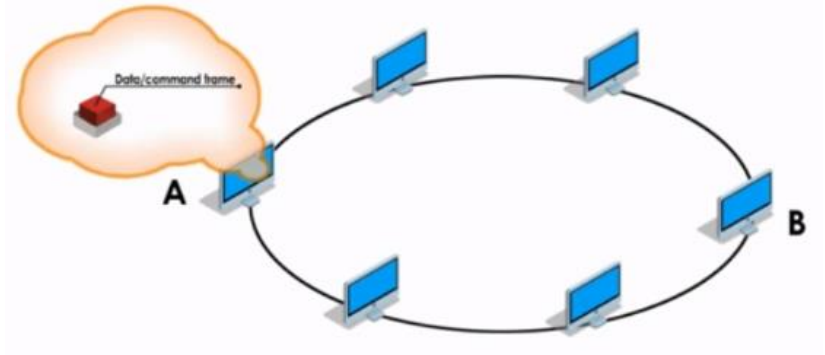
❸

Suppose WS-A wants to transmit some messages to WS- B

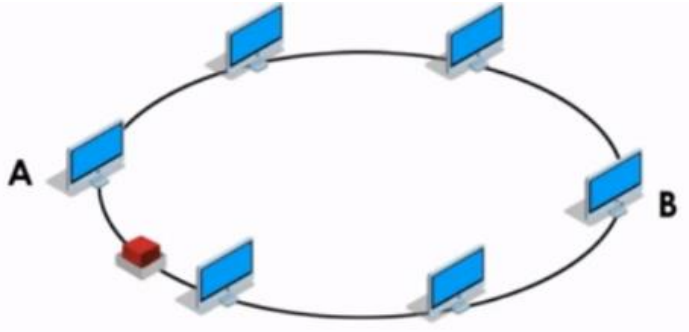


❹ WS-A catches the passing token to attach the data. Now the empty token becomes a data/control frame

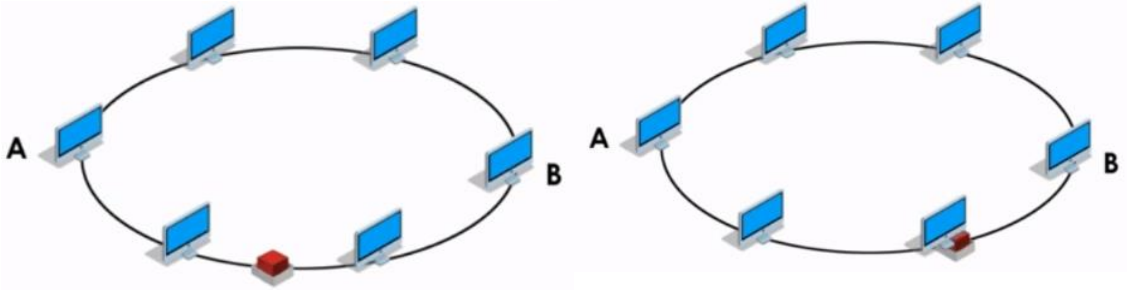
Token Ring Working



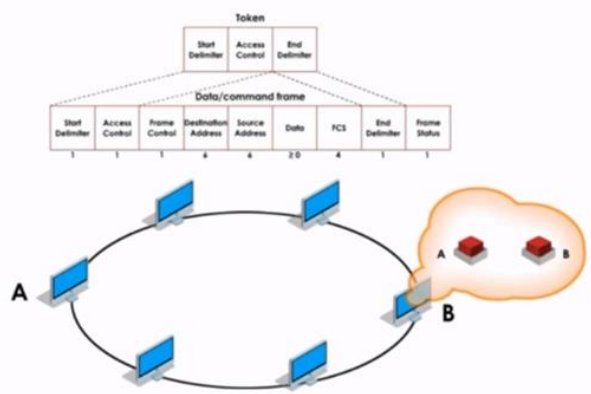
❺ WS-A adds the header information like frame control, destination address, source address, FCS and frame status



❻ Now, token along with the message and header is released back to the ring



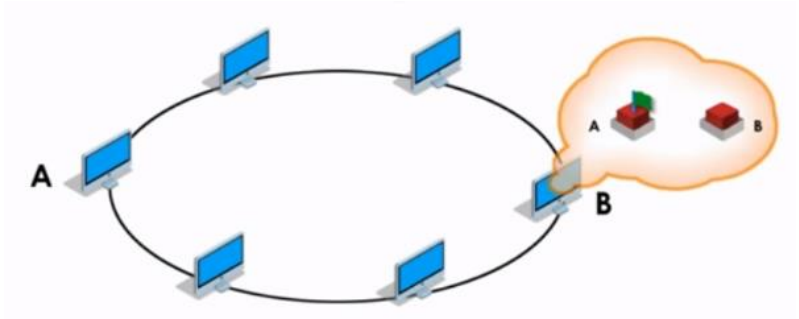
❼ Every WS checks the destination address against their own address. Passes it on, if the address does not match



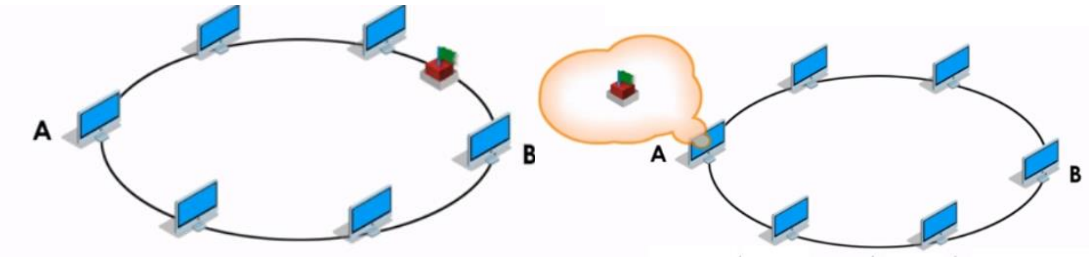
❽ If Matched, WS-B copies the frame.

Token Ring Working

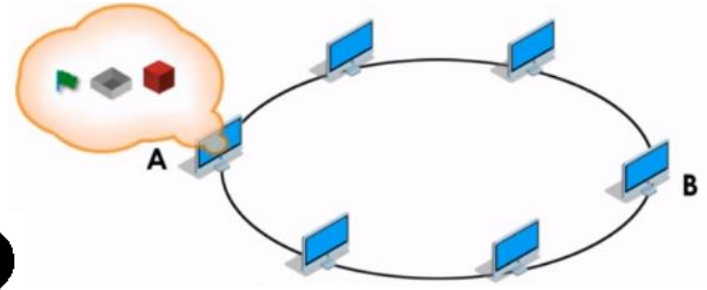
❾



Changes Frame Status – this provides confirmation that the message has been delivered successfully to the destination



❿ Then, releases token with status back to the ring



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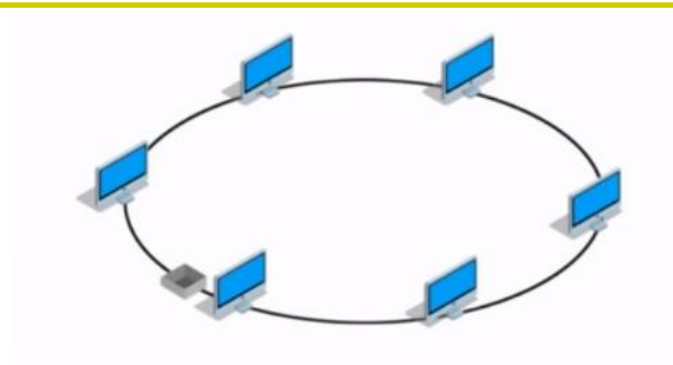
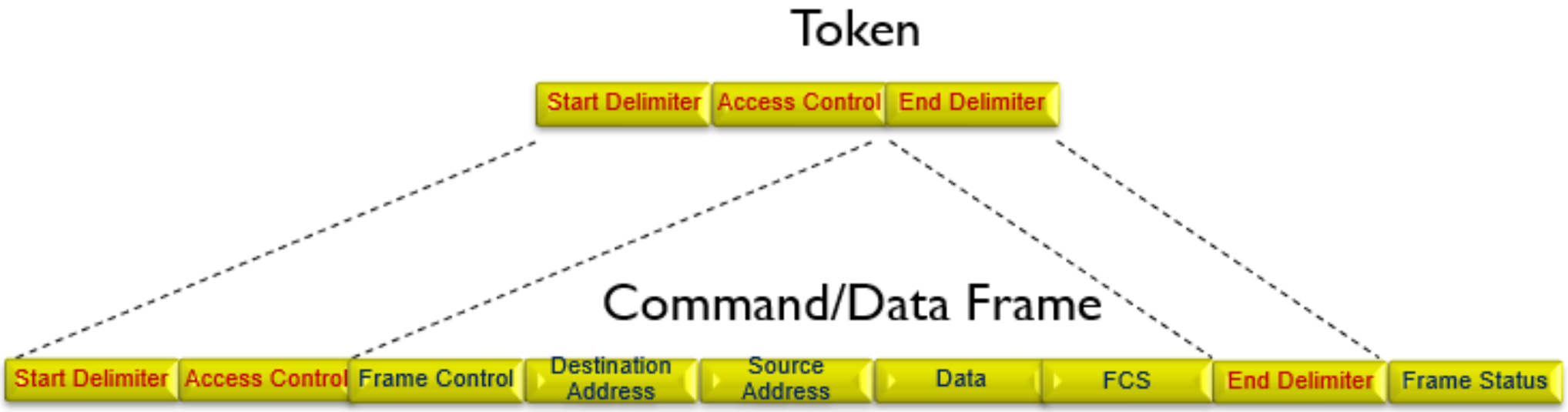
When the token reaches the sender, WS-A removes the message from the token



12

Then, releases a new empty token back to the network

Token and Data Frame



Token Ring

Compared with Ethernet, Token Ring has some better features, such as

- Token passing access method won't cause collisions as Ethernet (CSMA/CD) will.
- Token ring allows for larger frame size than Ethernet.
- Its speed is faster than Ethernet.

Disadvantage :

Very Expensive – so not used widely.

In a token ring, the media access method is called **Token Passing**

Modes of Operation: Listen Mode , Transmit Mode and By-pass Mode

Comparison - Token Bus and Token Ring

Token Ring	Token Bus
It is defined by IEEE 802.5 standard.	It is defined by IEEE 802.4 standard.
The stations are connected by ring topology, or sometimes star topology.	The underlying topology that connects the stations is either bus or tree topology.
The token is passed over the physical ring formed by the stations and the coaxial cable network.	The token is passed along the virtual ring of stations connected to a LAN.
The maximum time for a token to reach a station can be calculated.	It is not feasible to calculate the time for token transfer.
Token ring network does not provide better bandwidth than token bus.	Token bus network provides better bandwidth than token ring.
Token Ring networks are reliable and Star topology is used.	3. Token Bus networks are unreliable and bus topology is used
Token Ring is expensive than Token Bus	Token bus is cheaper than Token Ring
Designed for the large industries	Designed for the offices.

Review Questions

1. Token Bus operates under a collision-free environment similar to _____.

2. In Token Ring, the _____ sets the bit in the frame status field to indicate that the frame has been copied.

3. A frame is _____ at each station in a Token Ring LAN.

   a) examined and encapsulated (b) regenerated and discarded

   (c) encapsulated and modified (d) examined and regenerated

4. Token bus is physically configured like _____.

   (a) Token ring (b) an Ethernet

   (c) FDDI (d) Star

Answers

1. Token Bus operates under a collision-free environment similar to _____. (Token Ring)

2. In Token Ring, the _____ sets the bit in the frame status field to indicate that the frame has been copied. (receiver)

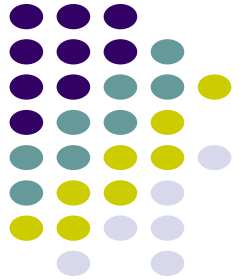
3. A frame is _____ at each station in a Token Ring LAN.

   a) examined and encapsulated
   (b) regenerated and discarded
   (c) encapsulated and modified
   (d) examined and regenerated

4. Token bus is physically configured like _____.

   (a) Token ring
   (b) an Ethernet
   (c) FDDI
   (d) Star

Fiber Distributed Data Interface - FDDI



- FDDI is a fiber based LAN technology.
- FDDI is a token-ring based LAN developed in 1980s.

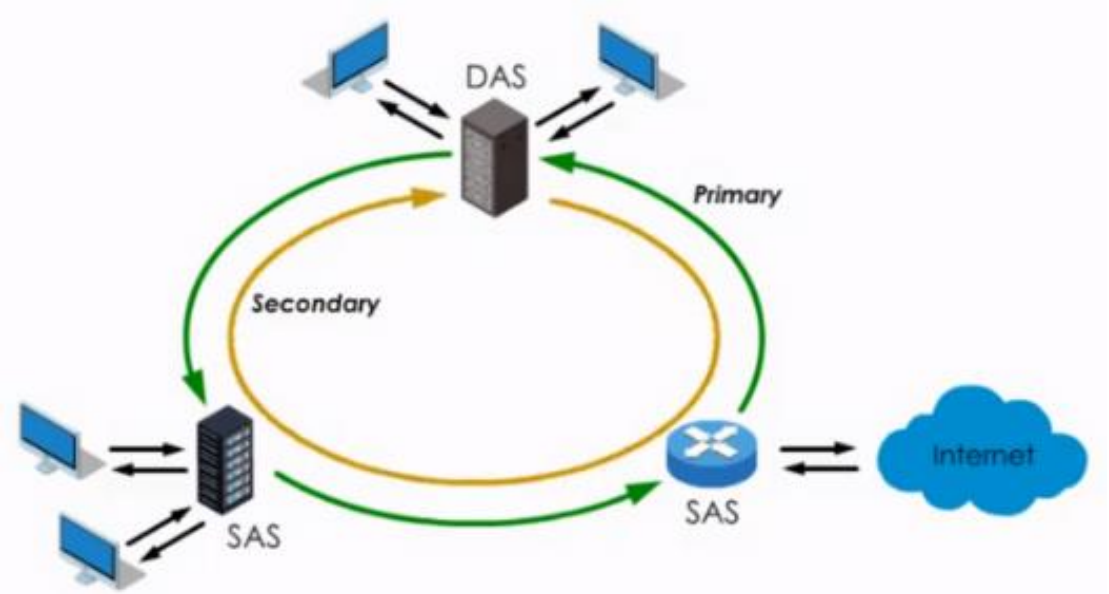
FDDI Features:

- Uses optical fiber as physical medium.
- It operates in the physical and MAC layer of OSI network model.
- Similar to the IEEE 802.5 token ring but runs in a fiber.
- It extends in the range up to 200 km / 120 miles.
- Offers data transmission rate of about 100 Mbps
- Offers up to 1000 connections
- FDDI technology can also be used as backbone for WAN.
- FDDI uses three topologies: Ring, Star and Mesh

FDDI became obsolete because of its cost,, complexity and the advent of Fast Ethernet.

Fiber Distributed Data Interface - FDDI

- FDDI consists of dual rings: primary and secondary rings.
- Traffic on each ring flows in opposite direction.
- Primary ring runs in clockwise direction
- Secondary ring runs in counter clockwise direction
- On FDDI, a SAS is connected to primary ring and a DAS is connected directly to both the primary and secondary rings,
- These stations are concentrators or routers which are the connection points to computer or the Internet

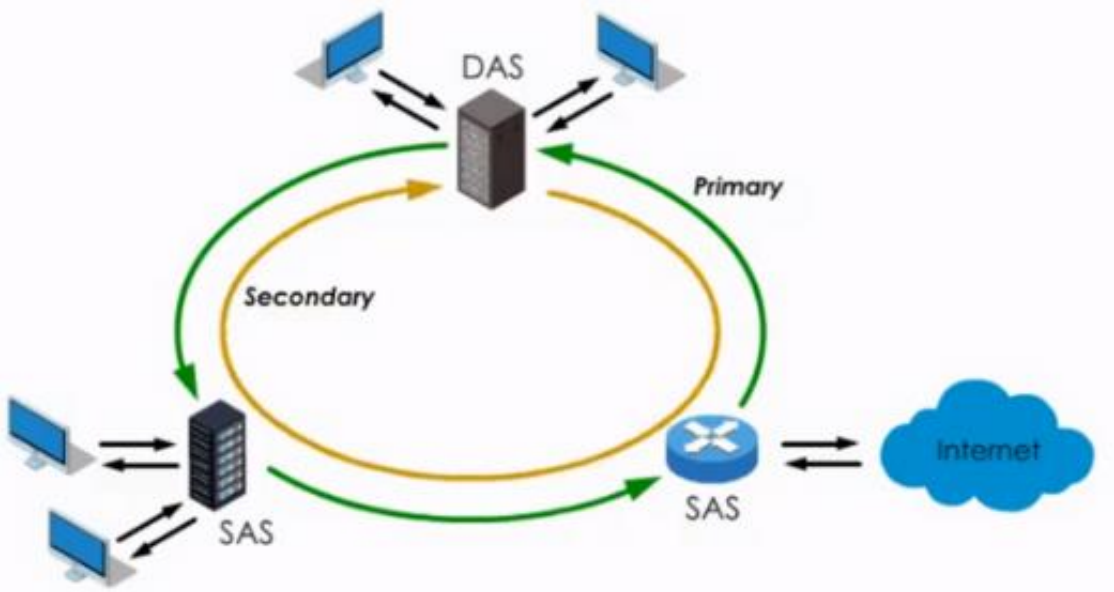


SAS – Single Attachment Station – Used primarily to connect Ethernet LANs or individual servers to FDDI backbones

DAS – Dual Attachment Station - used primarily for network backbones that require fault tolerance.

Primary ring for data and token transmission and a secondary ring that provides backup if the primary ring fails. The primary purpose of the dual rings is to provide superior reliability and robustness.

FDDI Basic Principle



- Token circulates around the ring in a network.
- Any station wants to transmit information holds the token and then transmits the information.
- When it finish it release the token in the ring.
- The time a station holds the token is called as Synchronous Allocation Time (SAT).
- SAT time is variable for each station. The allocation of this time to each station is achieved by Station Management (SMT).
- The function of SMT are Ring Control, Ring Initialization, Station Insertion and Station Removal.
- The feature of transmitting multiple data frames per token capture is known as a capacity allocation scheme

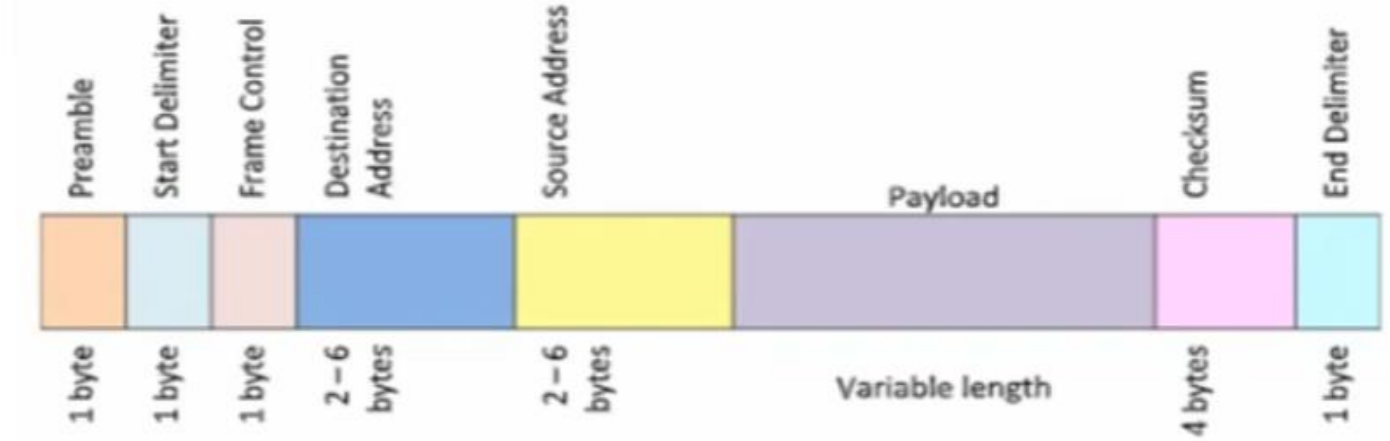
Components

- Single attachment station (SAS)—PCs
- Dual attachment station (DAS)—Servers or routers
- Concentrator

FDDI uses a timed token-passing technology similar to token ring networks as defined in IEEE 802.5 standard.

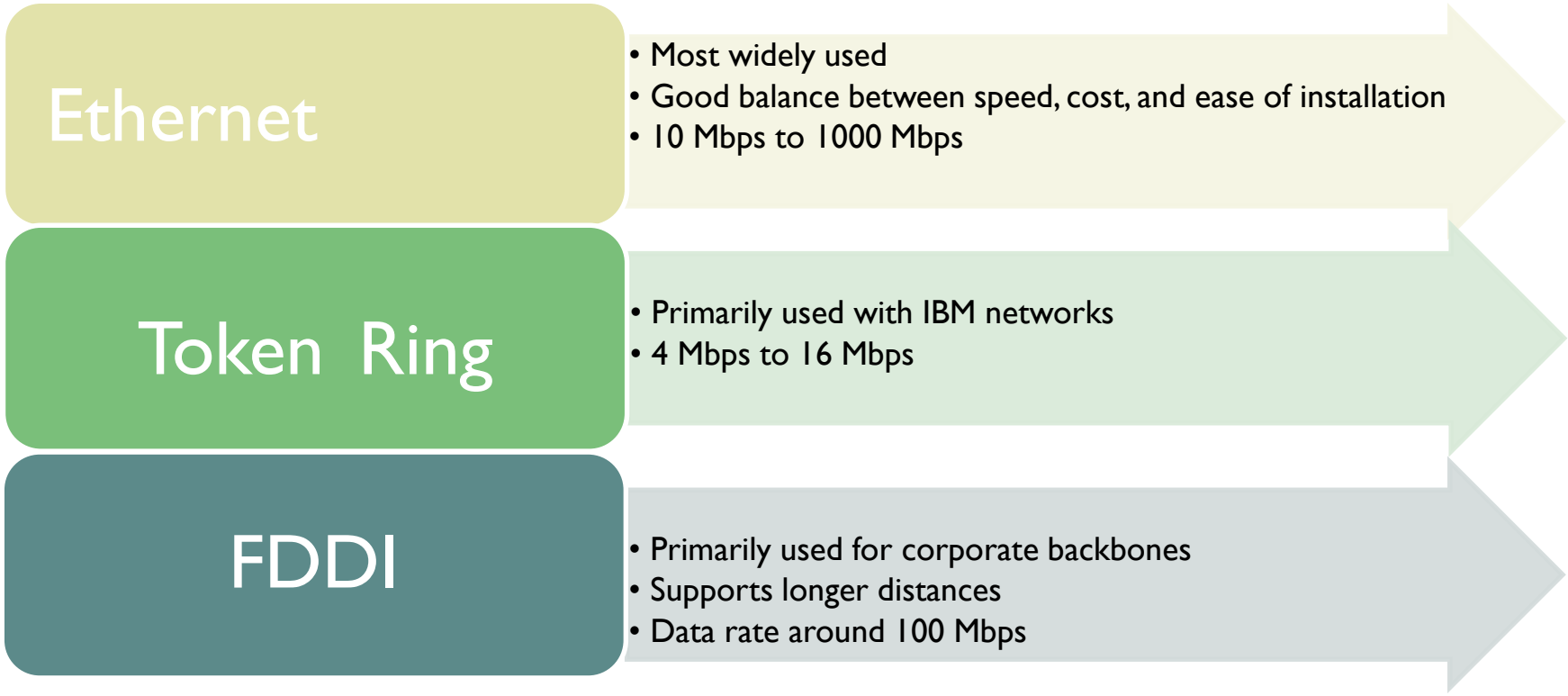
FDDI stations generate a token that controls the sequence in which other stations will gain access to the wire.

FDDI – Frame Format



✓	Preamble	1byte – Synchronization
✓	Start Delimiter	1byte – Marks the beginning of the frame
✓	Frame control	1byte – Specifies whether it is data frame or control frame
✓	Destination Address	2-6 bytes – Specifies address of the destination station
✓	Source Address	2-6 bytes – Specifies address of the source station
✓	Payload	Variable length field that carries the data from the network layer
✓	Checksum	4 bytes – for error detection
✓	End Delimiter	1 byte – Marks the end of the frame

LAN technologies include Ethernet, Token Ring, and FDDI



FDDI uses a timed token-passing technology similar to token ring networks as defined in IEEE 802.5 standard.

FDDI stations generate a token that controls the sequence in which other stations will gain access to the wire.

Review Questions

1. Expand : FDDI and CDDI
2. SAS is a device used in _____
3. FDDI is a token ring based LAN technology. (True / False)
4. FDDI and CDDI uses _____ topology.
5. Token Ring and FDDI both use _____ as an access method.

Answers

1. Expand : FDDI and CDDI
    1. FDDI - Fiber Distributed Data Interface
    2. CDDI - Copper Distributed Data Interface
2. SAS is a device used in _____. FDDI
3. FDDI is a token ring based LAN technology. (True)
4. FDDI and CDDI uses _____ topology. (dual ring)
5. Token Ring and FDDI both use _____ (token passing) as an access method.