第16章 高速局域网

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参考文献

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Contents

- Introduction
- High Speed LANs
- Ethernet
- Token Ring
- Fibre Channel

16. 0 Introduction

- Range of technologies
  - Fast and Gigabit Ethernet
  - Fibre Channel
  - High Speed Wireless LANs

16.1High Speed LANs — Why High Speed LANs?

- Office LANs used to provide basic connectivity
  - Connecting PCs and terminals to mainframes and midrange systems that ran corporate applications
  - Providing workgroup connectivity at departmental level
  - Traffic patterns light
    - Emphasis on file transfer and electronic mail
- Speed and power of PCs has risen
  - Graphics-intensive applications and GUIs
- MIS organizations recognize LANs as essential
  - Began with client/server computing
  - Now dominant architecture in business environment
    - Intranetworks

Frequent transfer of large volumes of data

16.1 High Speed LANs — Applications Requiring High Speed LANs

- Centralized server farms
  - User needs to draw huge amounts of data from multiple centralized servers
  - E.g. Color publishing
    - Servers contain tens of gigabytes of image data
    - Downloaded to imaging workstations
- Power workgroups
  - Small number of cooperating users
    - Draw massive data files among workstations
    - E.g. Software development group testing new software version or computer-aided design (CAD) running simulations
- High-speed local backbone
  - Processing demand grows
  - LANs proliferate at site
  - **High-speed interconnection** is necessary

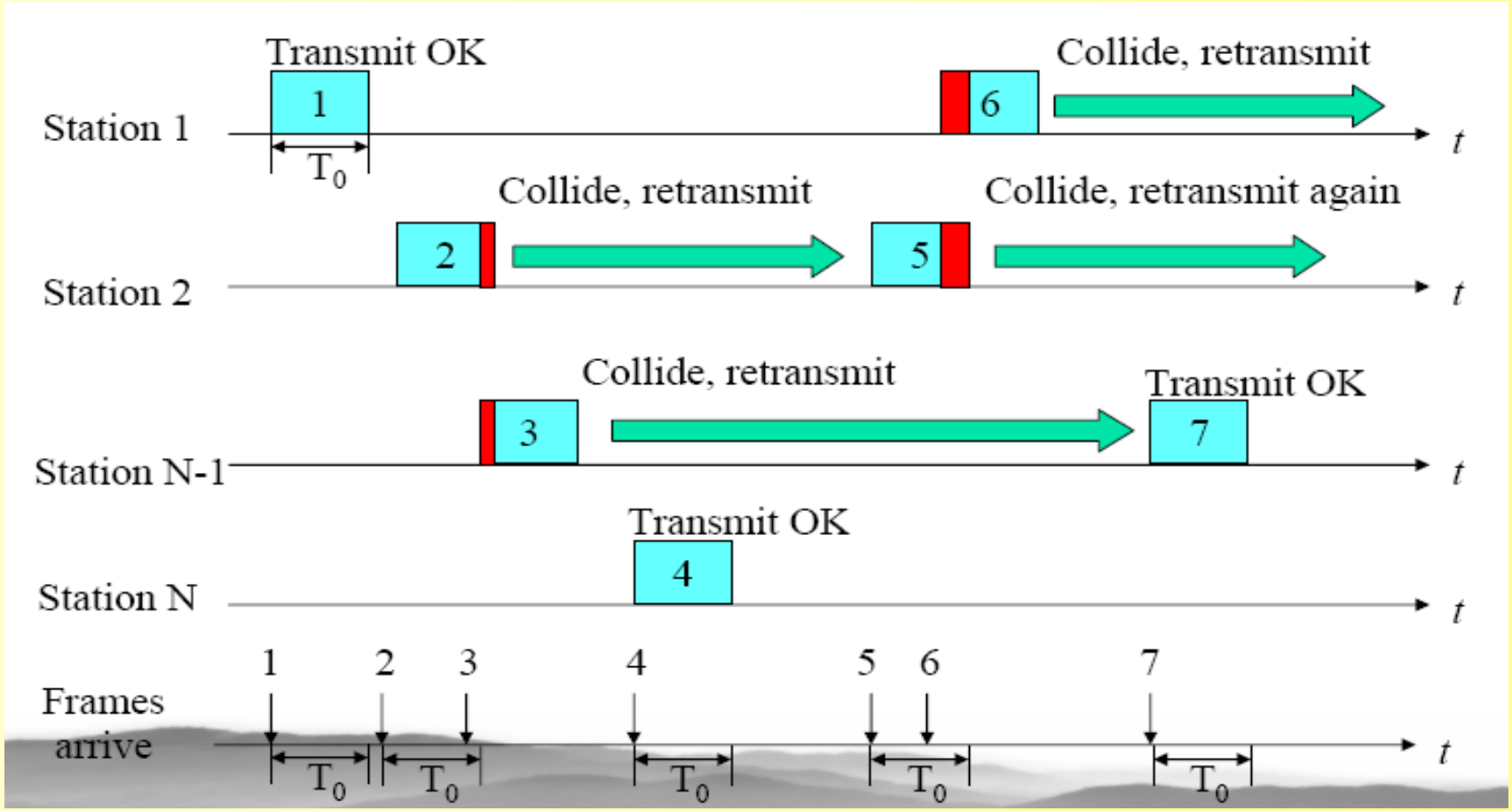
16.2 Ethernet

- ALOHA
- Slotted-ALOHA
- CSMA
  - Nonpersistent
  - 1-persistent
  - p-persistent
- CSMA/CD

CSMA/CD — ALOHA

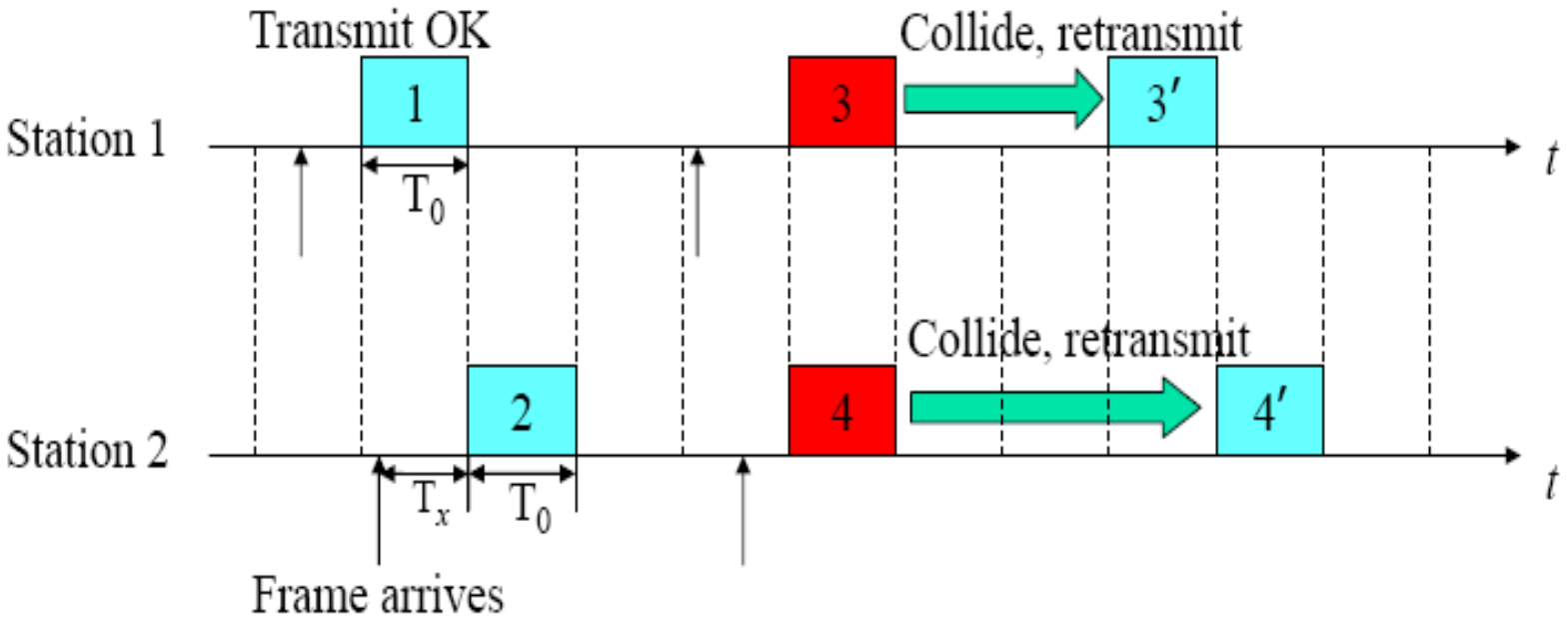
- Sender
  - When station has frame, it sends
  - Station listens (for max round trip time) plus small increment
  - If ACK, fine. If not, retransmit
  - If no ACK after repeated transmissions, give up
- Receiver
  - Use frame check sequence (as in HDLC)
  - If frame OK and address matches receiver, send ACK
  - Otherwise, the receiver just ignore the frame.
- Frame may be damaged by noise or collision
  - Another station transmitting at the same time
- Max utilization 18%

Illustration of ALOHA



Slotted ALOHA

- Time in uniform slots equal to frame transmission time
- Need central clock (or other sync mechanism)
- Transmission begins at slot boundary
- Frames either miss or overlap totally
- Max utilization 37%

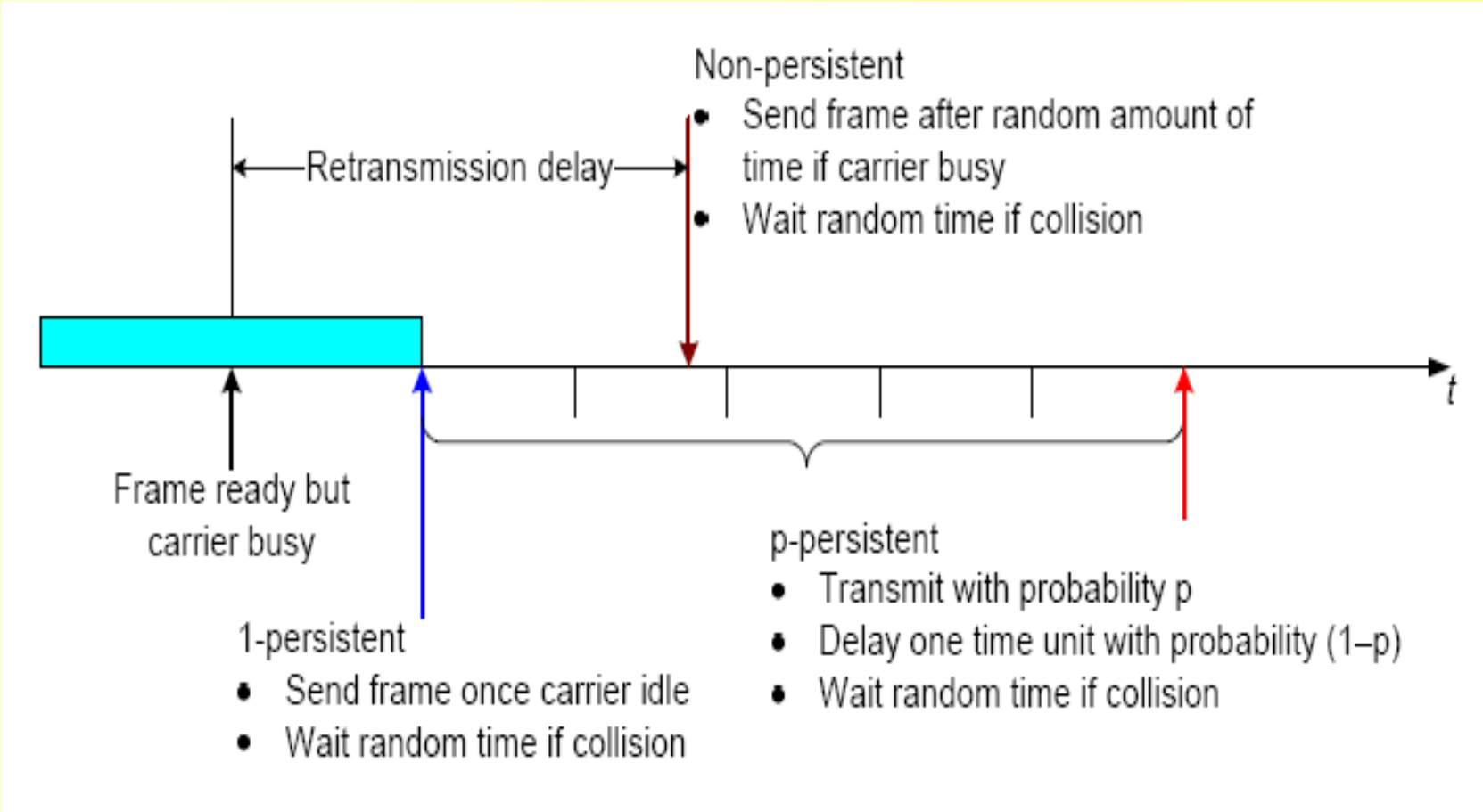

Transmit OK
Collide, retransmit
Station 1
1
3
3′
t
T0
Collide, retransmit
Station 2
2
4
4′
t
Tx
T0
Frame arrives

- Suppose
  - Propagation timeis much less than transmission time
  - All stations know that a transmission has started almost immediately
- Method
  - First listen for clear medium (carrier sense)
  - If medium idle, transmit
  - Wait reasonable time (round trip plus ACK contention)
  - No ACK then retransmit
- If two stations start at the same instant, collision
- Max utilization depends on propagation time(medium length) vs. frame length
  - Longer frame and shorter propagation gives better utilization

Nonpersistent CSMA

- Station wishing to transmitlistens
  - 1.If medium is idle, transmit; otherwise, go to 2
  - 2.If medium is busy, wait amount of time drawn from probability distribution (retransmission delay) and repeat 1
- Random delays reduces probability of collisions
  - Considertwo stations become ready to transmit at same time while another transmission is in progress
  - If both stations delay same time before retrying,both will attempt to transmit at same time
- Capacity is wasted because medium will remain idle following end of transmission
  - Even if one or more stations waiting
- Nonpersistentstations are deferential

Nonpersistent CSMA



1-persistent CSMA

To avoid idle channel time, 1-persistent protocol used

- A station wishing to transmit listens and obeys following:

1. If medium idle, transmit; otherwise, go to step 2
2. If medium busy, listen until idle; then transmit immediately

- 1-persistent stations selfish
- If two or more stations waiting, collision guaranteed
  - Gets sorted out after collision

P-persistent CSMA

- Compromise that attempts to reduce collisions Like nonpersistent
- And reduce idle time Like1-persistent

- Rules:

1. If medium idle, transmit with probability p, and delay one time unit with probability (1 – p)
   - Time unit typically maximum propagation delay
2. If medium busy, listen until idle and repeat step 1
3. If transmission is delayed one time unit, repeat step 1

- What is an effective value of p?

Value of p? (1)

- Avoid instability under heavy load
- n stations waiting to send
- End of transmission, expected number of stations attempting to transmit is number of stations ready times probability of transmitting
  - np
- If np > 1, on average, there will be a collision
- Repeated attempts to transmit almost guaranteeing more collisions
- Retries compete with new transmissions
- Eventually, all stations trying to send
  - Continuous collisions; zero throughput

Value of p? (2)

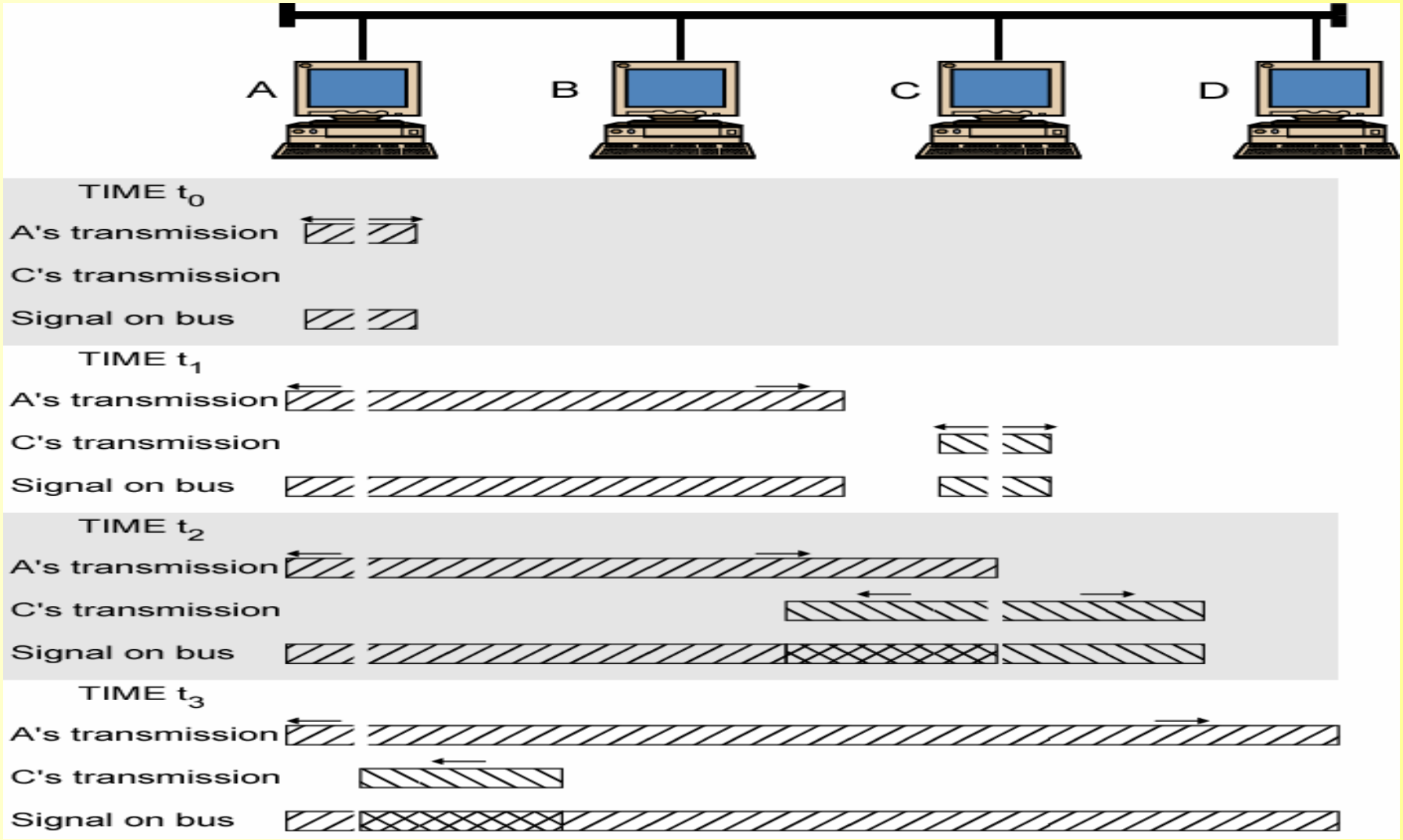
- So np < 1 for expected peaks of n
- If heavy load expected, p small
- However, as p made smaller, stations wait longer
- At low loads, this gives very long delays

CSMA/CD

- With CSMA, collision occupies medium for duration of transmission
- Stations listen whilst transmitting

1. If medium idle, transmit, otherwise, step 2;
2. If busy, listen for idle, then transmit;
3. If collision detected, jam then cease transmission;
4. After jam, wait random time （backoff）then start from step 1;

CSMA/CD operation



Which Persistence Algorithm?

- IEEE 802.3 uses 1-persistent
- Both nonpersistent and p-persistent have performance problems
- 1-persistent (p = 1) seems more unstable than p-persistent
  - Greed of the stations
  - But wasted time due to collisions is short (if frames long relative to propagation delay
  - With random backoff, unlikely to collide on next tries
  - To ensure backoff maintains stability, IEEE 802.3 and Ethernet use binary exponential backoff

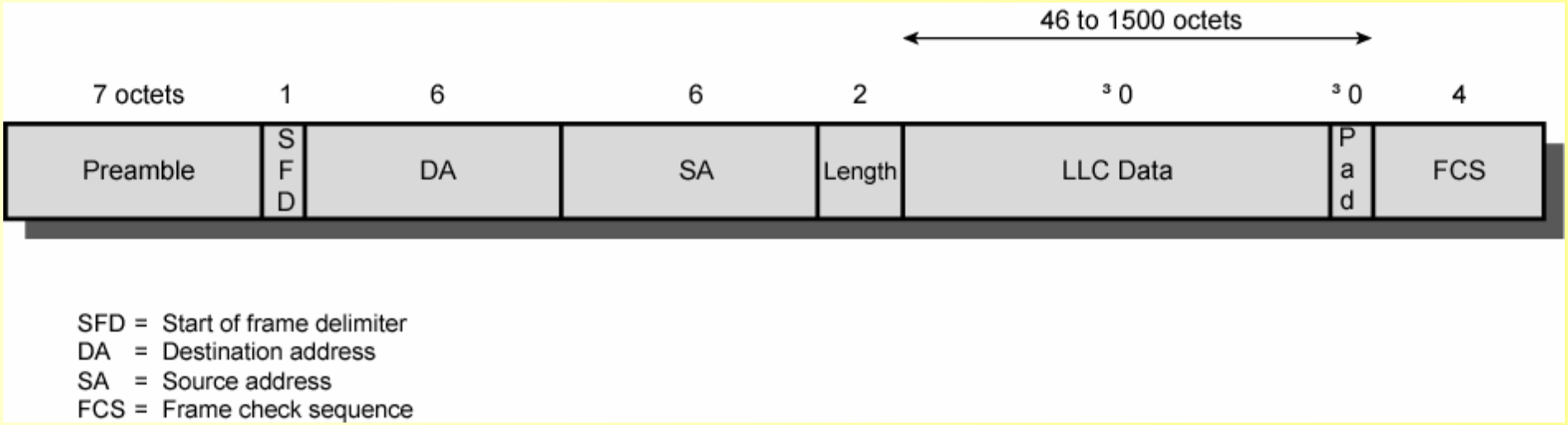
Binary Exponential Backoff

- Attempt to transmit repeatedly if repeated collisions
- First 10 attempts, mean value of random delay doubled
- Value then remains same for 6 further attempts
- After 16 unsuccessful attempts, station gives up and reports error
- As congestion increases, stations back off by larger amounts to reduce the probability of collision.
- 1-persistent algorithm with binary exponential backoff efficient over wide range of loads
  - Low loads, 1-persistence guarantees station can seize channel once idle
  - High loads, at least as stable as other techniques
- Backoff algorithm gives last-in, first-out effect
- Stations with few collisions transmit first

Collision Detection

- On baseband bus, collision produces much higher signal voltage than signal
- Collision detected if cable signal greater than single station signal
- Signal attenuated over distance
- Limit distance to 500m (10Base5) or 200m (10Base2)
- For twisted pair (star-topology) activity on more than one port is collision
- A special collision presence signal is generated

IEEE 802.3 Frame Format



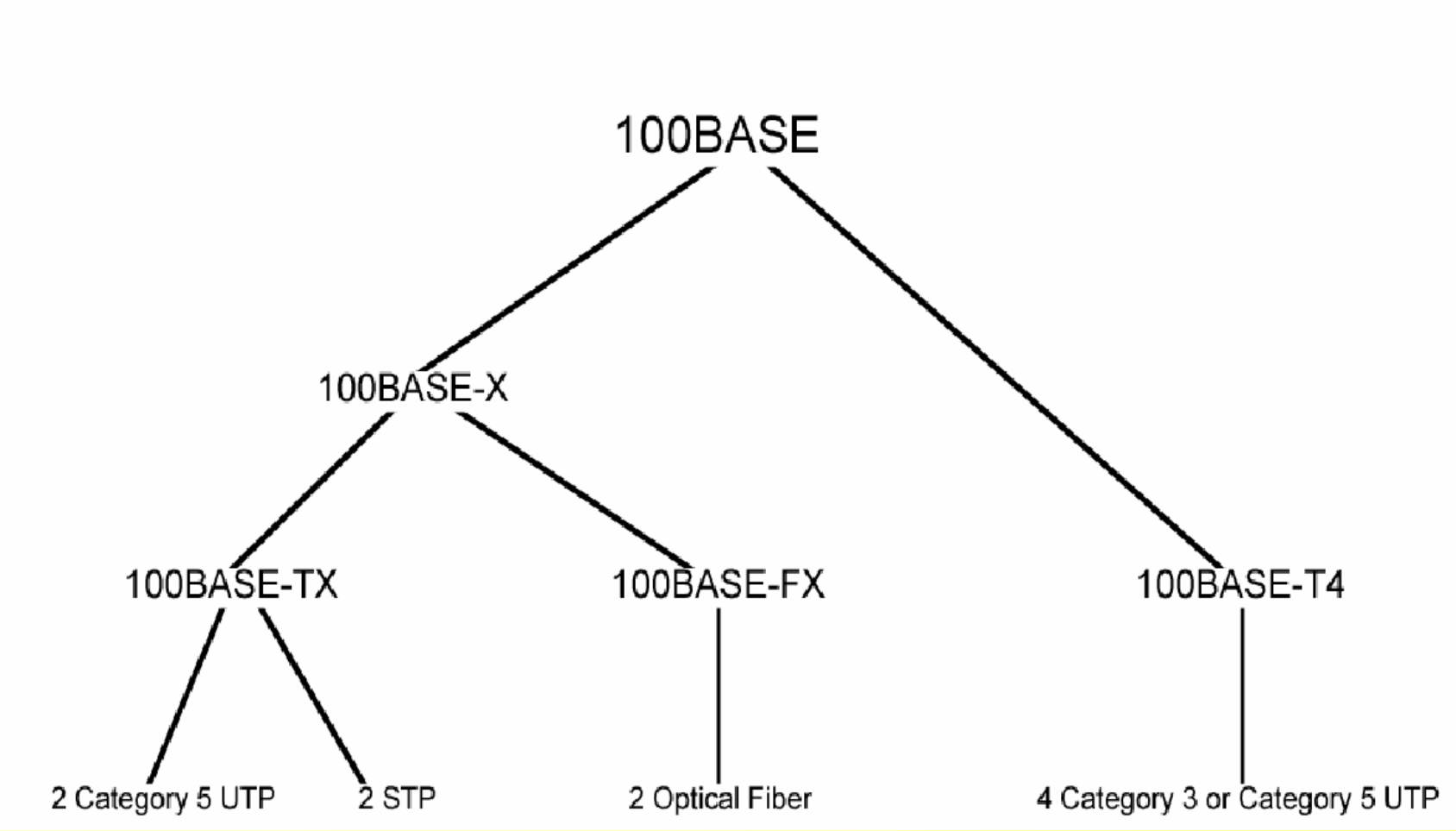
SFD = Start of frame delimiter
DA = Destination address
SA = Source address
FCS = Frame check sequence

10Mbps Specification (Ethernet)

<data rate><Signaling method><Medium>

	10Base5	10Base2	10Base-T	10Base-F
Medium	Coaxial	Coaxial	UTP	850nm fiber
Signaling	Baseband	Baseband	Baseband	Manchester
	Manchester	Manchester	Manchester	On/Off
Topology	Bus	Bus	Star	Star
Nodes	100	30	-	33

Fast Ethernet 100BASE-T Options



- IEEE专门成立了快速以太网研究组评估以太网传输速率提升到100 Mbps的可行性。
- 100Base-T和100VG—AnyLAN(适用于令牌环网)。

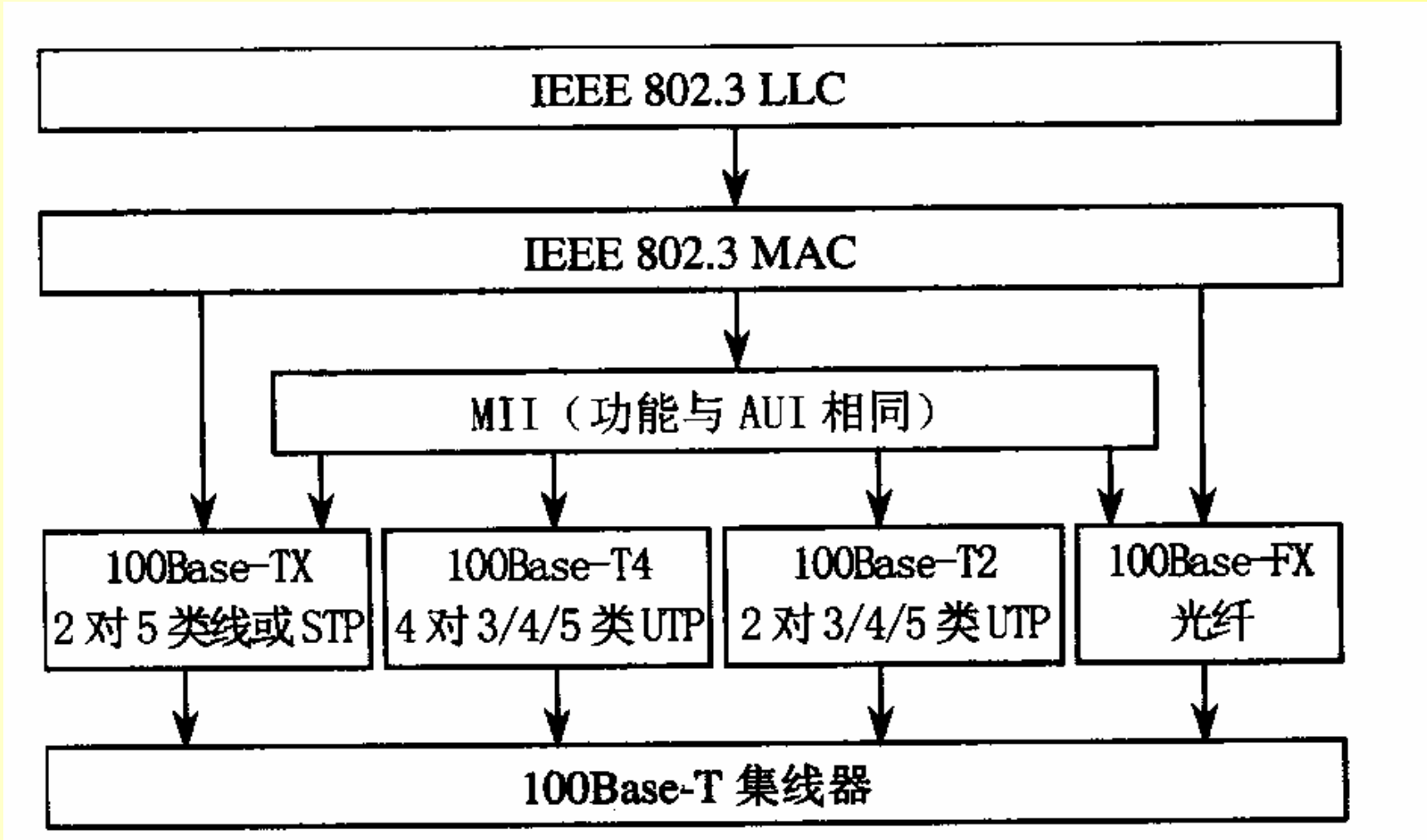
快速以太网特点

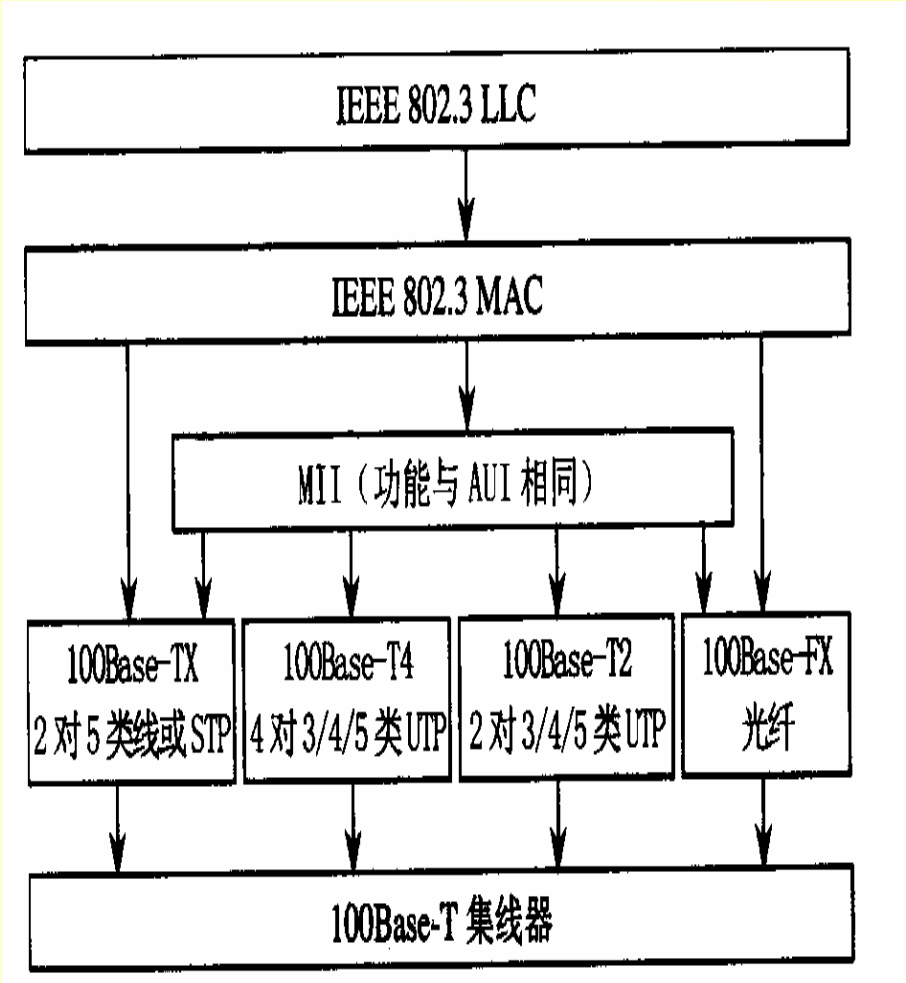
- 采用所有一般以太网做介质，从而保护了现有网络投资。
- 采用现在流行的SNMP的网管软件和以太网管理信息库(MIB，Management Information Base)，所以完全兼容于现有的网管产品。
- 由于采用CSMA/CD协议，可与10Base-T并行工作，避免了协议转换造成的系统开销，因此效率更高。
- 快速以太网还提供全双工通信，总带宽达到200 Mbps。
- 快速以太网有自动协商的功能，能够自动适应电缆两端最高可用的通信速率，能方便地与10 Mbps以太网连接通信。

快速以太网保留了传统以太网的所有特性

- **相同的数据帧格式**。快速以太网的IEEE 802.3u标准在LLC子层使用IEEE 802.2标准
- **相同的介质访问控制方式**。在MAC子层使用CSMA/CD方法，
- **相同的组网方法。**

- 将每个比特的发送时间由100 ns降低到10 ns。
- 在物理层做了一些必要的调整，定义了新的物理层标准(100Base-T)。
- 定义Medium Independent Interface(MII）。将MAC子层和物理层分开。


IEEE 802.3 LLC
IEEE 802.3 MAC
MII（功能与 AUI 相同）
100Base-TX
2 对 5 类线或 STP
100Base-T4
4 对 3/4/5 类 UTP
100Base-T2
2 对 3/4/5 类 UTP
100Base-FX
光纤
100Base-T 集线器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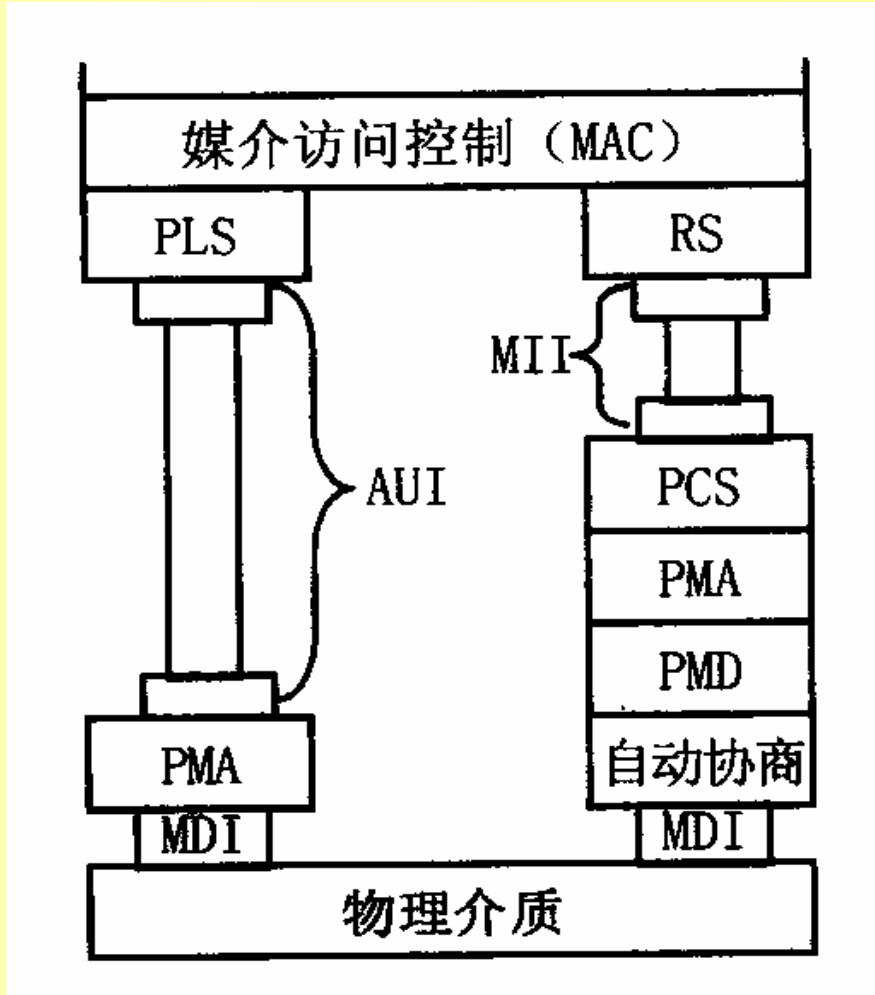

媒介访问控制（MAC）
PLS
RS
MII
AUI
PCS
PMA
PMD
自动协商
PMA
MDI
MDI
物理介质

增加了自动协商功能(Auto Negotiate)

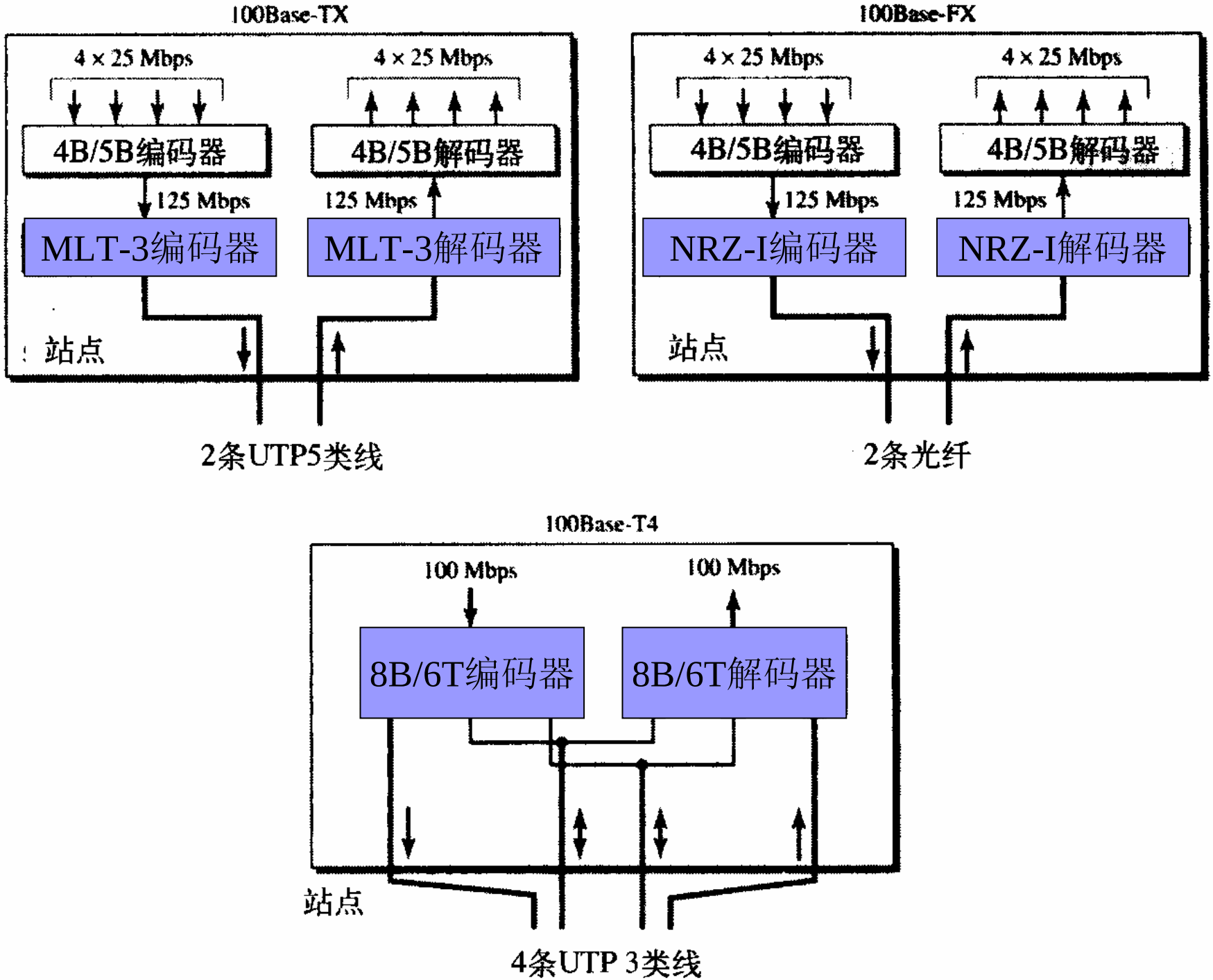
- 快速以太网被设计成能够同时支持10 Mbps和100 Mbps两种工作速度。
- 自动协商的内容
  - 辨识双方是10Mbps、100Mbps还是双速设备
  - 确认双方模式是半双工、全双工还是支持两种模式
  - 确认双方的物理层规范类型

100BASE-X Media

- Two physical medium specifications
- 100BASE-TX
  - Two pairs of twisted-pair cable
  - One pair for transmission and one for reception
  - STP and Category 5 UTP allowed
  - The MTL-3 signaling scheme is used
- 100BASE-FX
  - Two optical fiber cables
  - One for transmission and one for reception
  - Intensity modulation used to convert 4B/5B-NRZI code group stream into optical signals
  - 1 represented by pulse of light
  - 0 by either absence of pulse or very low intensity pulse

100BASE-T4

- 100-Mbps over lower-quality Cat 3 UTP
  - Taking advantage of large installed base
  - Cat 5 optional
  - Does not transmit continuous signal between packets
  - Useful in battery-powered applications
- Can not get 100 Mbps on single twisted pair
  - Data stream split into three separate streams
    - Each with an effective data rate of 33.33 Mbps
  - Four twisted pairs used
  - Data transmitted and received using three pairs
  - Two pairs configured for bidirectional transmission
- NRZ encoding not used
  - Would require signaling rate of 33 Mbps on each pair
  - Does not provide synchronization
  - Ternary signaling scheme (8B6T)


100Base-TX
4 × 25 Mbps
4 × 25 Mbps
4B/5B编码器
4B/5B解码器
125 Mbps
125 Mbps
MLT-3编码器
MLT-3解码器
站点
2条UTP5类线
100Base-FX
4 × 25 Mbps
4 × 25 Mbps
4B/5B编码器
4B/5B解码器
125 Mbps
125 Mbps
NRZ-I编码器
NRZ-I解码器
站点
2条光纤
100Base-T4
100 Mbps
100 Mbps
8B/6T编码器
8B/6T解码器
站点
4条UTP 3类线

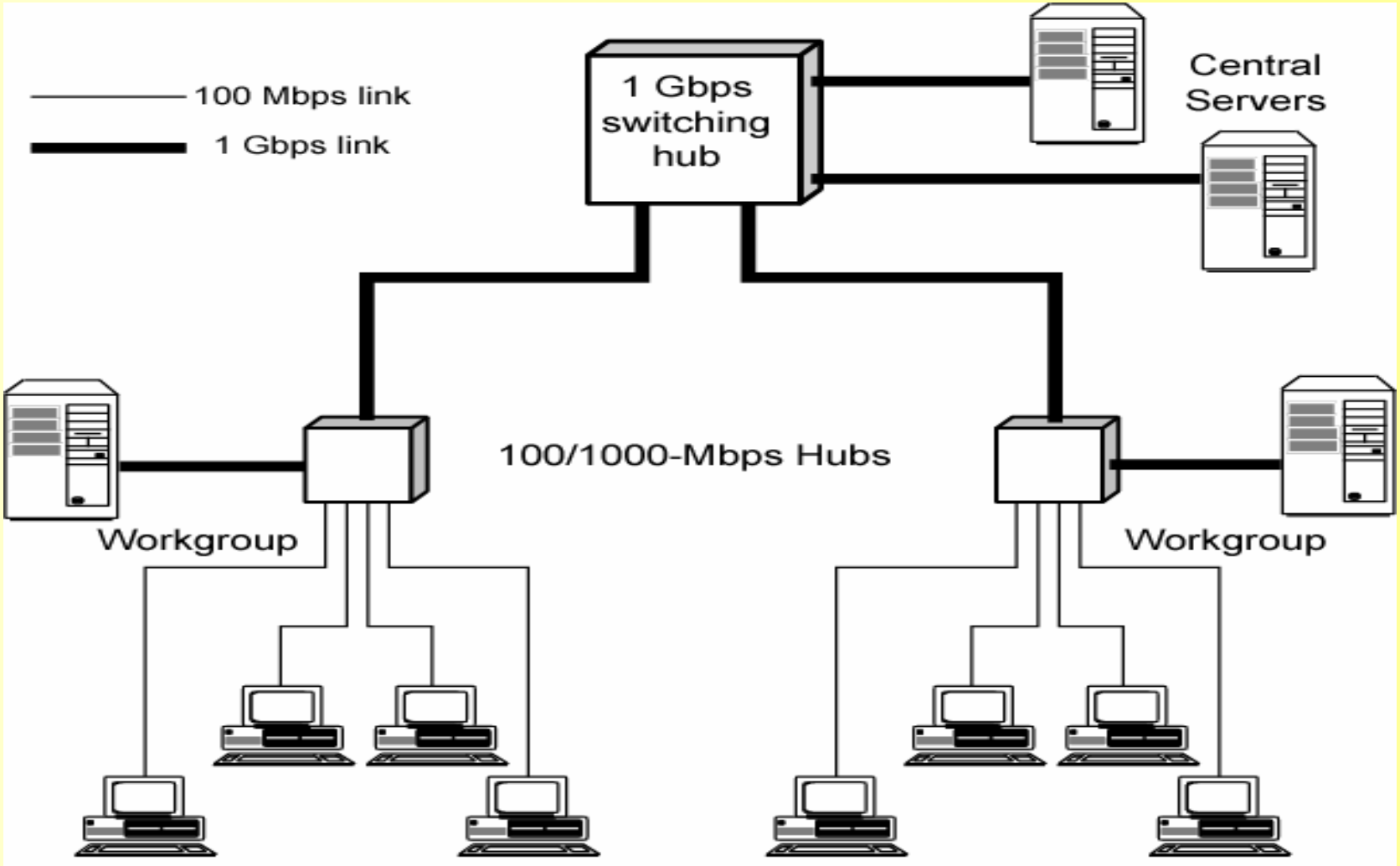
Full Duplex Operation

- Traditional Ethernet half duplex
  - Either transmit or receive but not both simultaneously
- With full-duplex, station can transmit and receive simultaneously
- 100-Mbps Ethernet in full-duplex mode, theoretical transfer rate 200 Mbps
- Attached stations must have full-duplex adapter cards
- Must use switching hub
  - Each station constitutes separate collision domain
  - In fact, no collisions
  - CSMA/CD algorithm no longer needed
  - 802.3 MAC frame format used
  - Attached stations can continue CSMA/CD

Mixed Configurations

- Fast Ethernet supports mixture of existing 10-Mbps LANs and newer 100-Mbps LANs
- E.g. 100-Mbps backbone LAN to support 10-Mbps hubs
  - Stations attach to 10-Mbps hubs using 10BASE-T
  - Hubs connected to switching hubs using 100BASE-T
    - Support 10-Mbps and 100-Mbps
  - High-capacity workstations and servers attach directly to 10/100 switches
  - Switches connected to 100-Mbps hubs using 100-Mbps links
  - 100-Mbps hubs provide building backbone
    - Connected to router providing connection to WAN

Gigabit Ethernet Configuration



千兆以太网

- 对传输速度更高的需求使得千兆以太网(1000Mbps)应运而生。IEEE委员会称之为标准802.3z。
- 千兆以太网设计的目标:
  1. 将数据速率升级到1千兆。
  2. 使其与标准以太网或快速以太网相兼容。
  3. 使用相同的48位地址。
  4. 使用相同的帧格式。
  5. 保留帧长度的最大值和最小值。
  6. 支持快速以太网中定义的自动协商。

全双工模式

- 在全双工模式中，有一个中心交换机将所有的电脑或其他交换机连接起来。
- 每个交换机的每个进入端口都有缓存区，使数据在传输前得以存储。
- 在这种模式中不存在冲突。也就是说CSMA/CD是不必要的。电缆长度的最大值取决于电缆中信号的衰减程度，而不是冲突检测过程。

半双工模式

- 传统方法
- 载波扩展方法
- 帧突发方法

Gigabit Ethernet - Differences

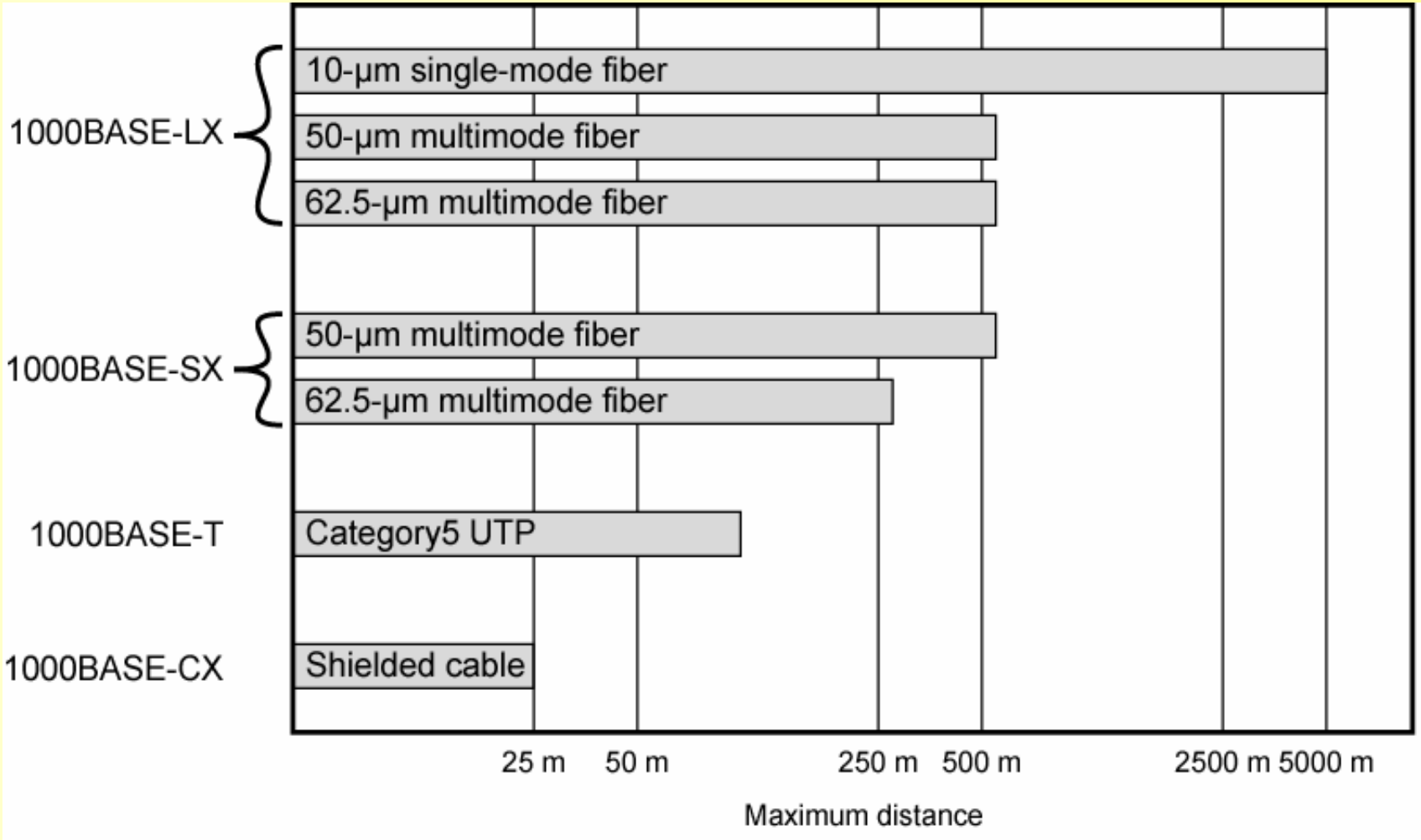
- Carrier extension
- At least 4096 bit-times long (512 bit-times for 10Mbps/100Mbps)
  - The frame length of a transmission is longer than the propagation time at 1 Gbps
- Frame bursting
  - Frame bursting avoids the overhead of carrier extension
  - A single station has a number of small frames ready to send
  - 1500 bytes

Gigabit Ethernet – Physical

- 1000Base-SX
  - Short wavelength, multimode fiber
- 1000Base-LX
  - Long wavelength, Multi or single mode fiber
- 1000Base-CX
  - Copper jumpers <25m, shielded twisted pair
- 1000Base-T
  - 4 pairs, cat 5 UTP

- Signaling - 8B/10B

Gbit Ethernet Medium Options (log scale)



10Gbps Ethernet - Uses

- High-speed, local backbone interconnection between large-capacity switches
- Server farm
- Campus wide connectivity
- Enables Internet service providers (ISPs) and network service providers (NSPs) to create very high-speed links at very low cost
- Allows construction of (MANs) and WANs
  - Connect geographically dispersed LANs between campuses or points of presence (PoPs)
- Ethernet competes with ATM and other WAN technologies
- 10-Gbps Ethernet provides substantial value over ATM

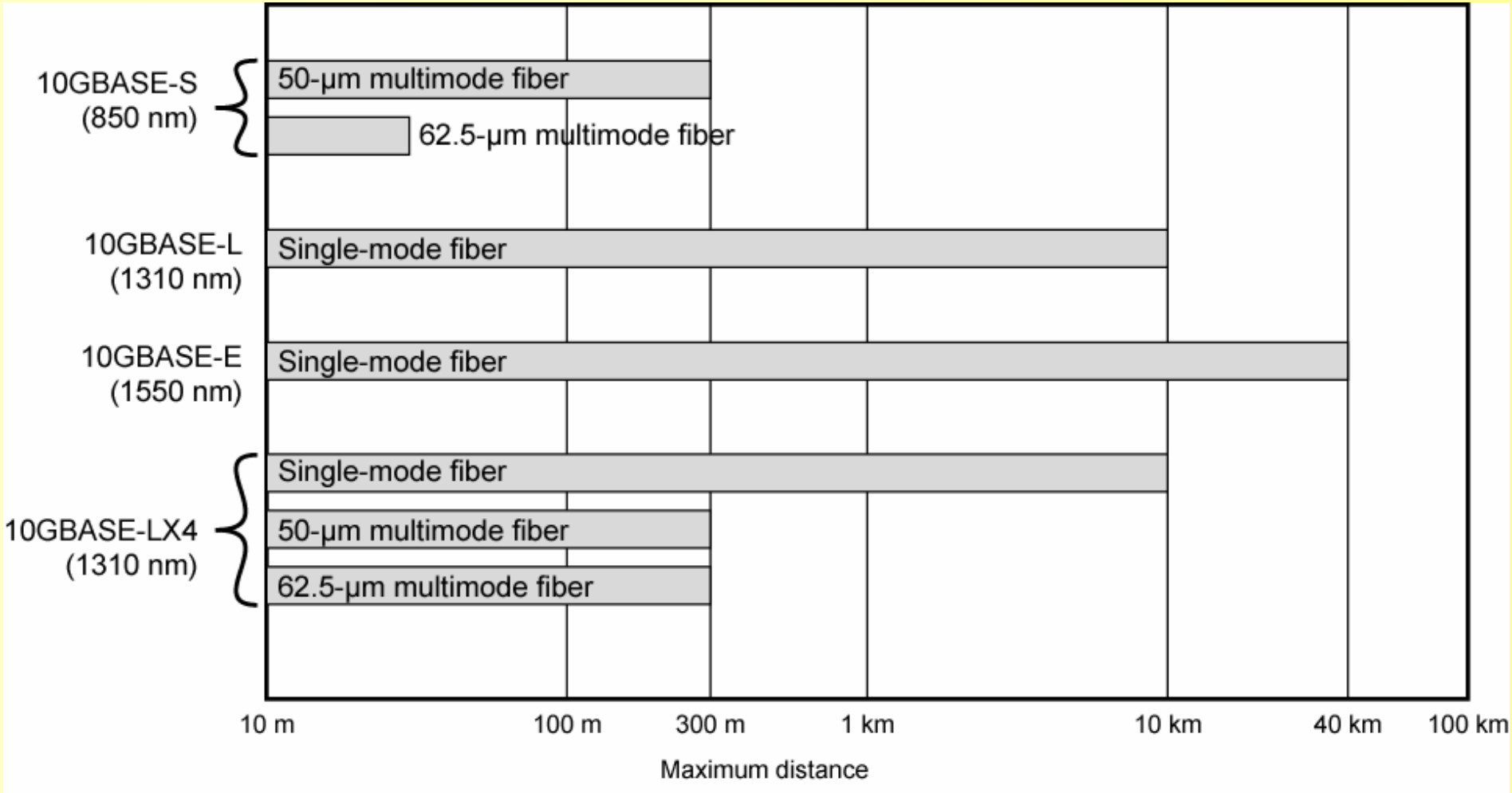
10Gbps Ethernet - Advantages

- No expensive, bandwidth-consuming conversion between Ethernet packets and ATM cells
- Network is Ethernet, end to end
- IP and Ethernet together offers QoS and traffic policing approach ATM
- Advanced traffic engineering technologies available to users and providers
- Variety of standard optical interfaces (wavelengths and link distances) specified for 10 Gb Ethernet
- Optimizing operation and cost for LAN, MAN, or WAN

10Gbps Ethernet - Advantages

- Maximum link distances cover 300 m to 40 km
- Full-duplex mode only
- 10GBASE-S (short):
  - 850 nm on multimode fiber
  - Up to 300 m
- 10GBASE-L (long)
  - 1310 nm on single-mode fiber
  - Up to 10 km
- 10GBASE-E (extended)
  - 1550 nm on single-mode fiber
  - Up to 40 km
- 10GBASE-LX4:
  - 1310 nm on single-mode or multimode fiber
  - Up to 10 km
  - Wavelength-division multiplexing (WDM) bit stream across four light waves

10Gbps Ethernet Distance Options (log scale)



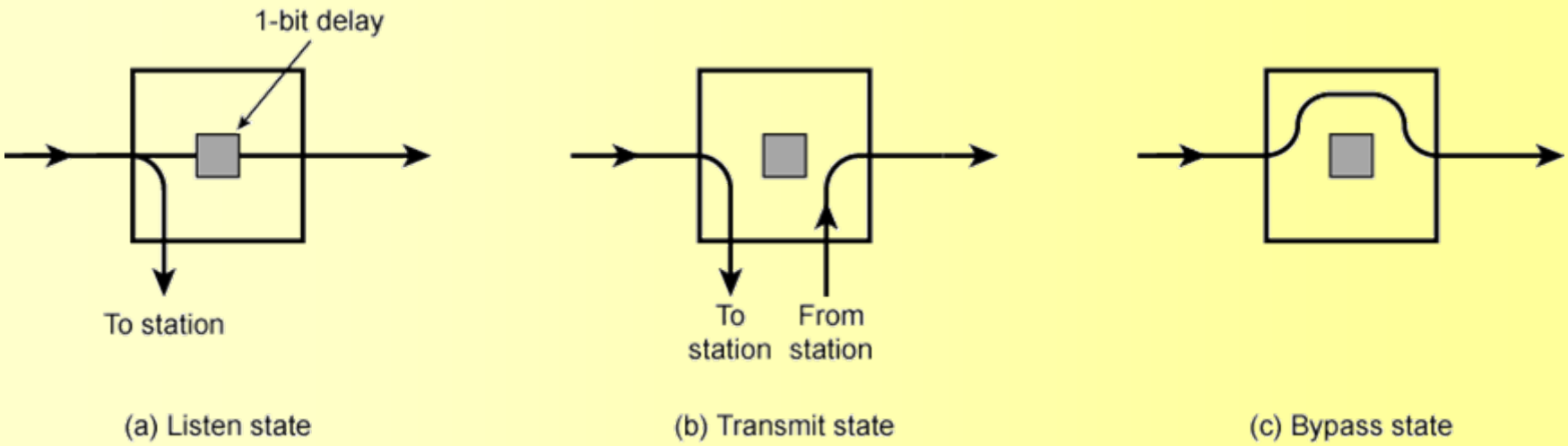
16.3 Token Ring (802.5)

- Developed from IBM's commercial token ring
- Because of IBM's presence, token ring has gained broad acceptance
- Currently, large installed base of token ring products
- Never achieved popularity of Ethernet
- Market share likely to decline

Ring Operation

- Each repeater connects to two others via unidirectional transmission links
  - Form single closed path
- Repeater acts as attachment point
- Data transferred bit by bit from one repeater to the next
  - Repeater regenerates and retransmits each bit
  - Repeater performs data insertion, data reception, data removal
- Frame removed by transmitter after one trip round ring

Ring Repeater States



(a) Listen state

(b) Transmit state

(c) Bypass state

Listen State Functions

- Scan passing bit stream for patterns
  - Address of attached station vs. destination address
  - Token permission to transmit
- Copy incoming bit and send to attached station
  - If destination address matched
  - Whilst forwarding each bit
- Modify bit as it passes
  - e.g. to indicate a packet has been copied (ACK)

Transmit State Functions

- When
  - Station has data
  - Repeater has permission
- May receive incoming bits
  - If ring bit length shorter than frame
    - Pass back to station for checking (ACK)
  - May be more than one frame on ring
    - Buffer other's frame for retransmission later

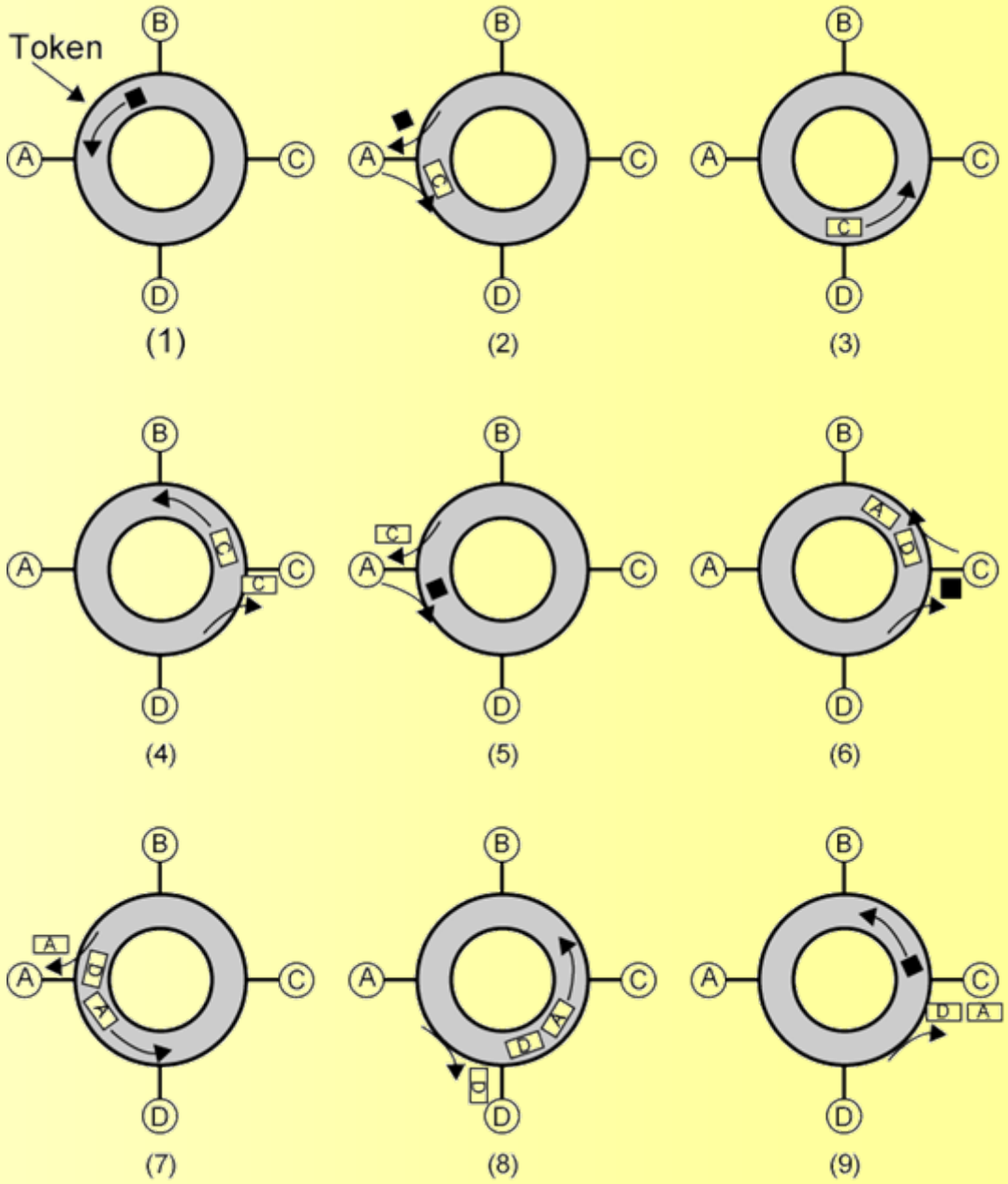
Bypass State

- Signals propagate past repeater with no delay (other than propagation delay)
- Partial solution to reliability problem
- Improved performance

802.5 MAC Protocol

- Small frame (token) circulates when idle
- Station waits for token
- Changes one bit in token to make it *SOF* for data frame
- Append rest of data frame
- Frame makes round trip and is absorbed by transmitting station
- Station then inserts new token when transmission has finished (leading edge of returning frame arrives)
- Under light loads, some inefficiency
- Under heavy loads, round robin

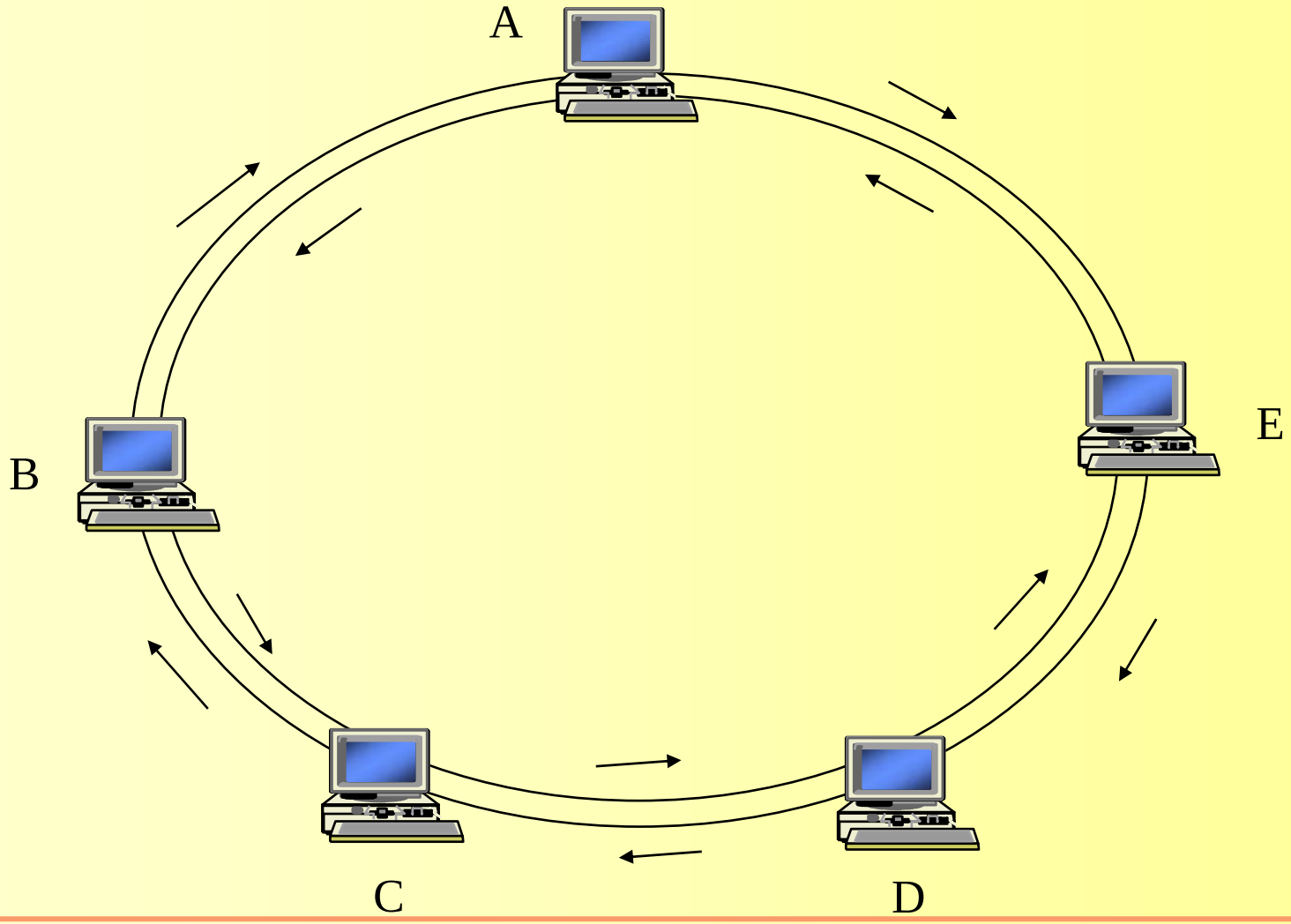
Token Ring Operation



FDDI

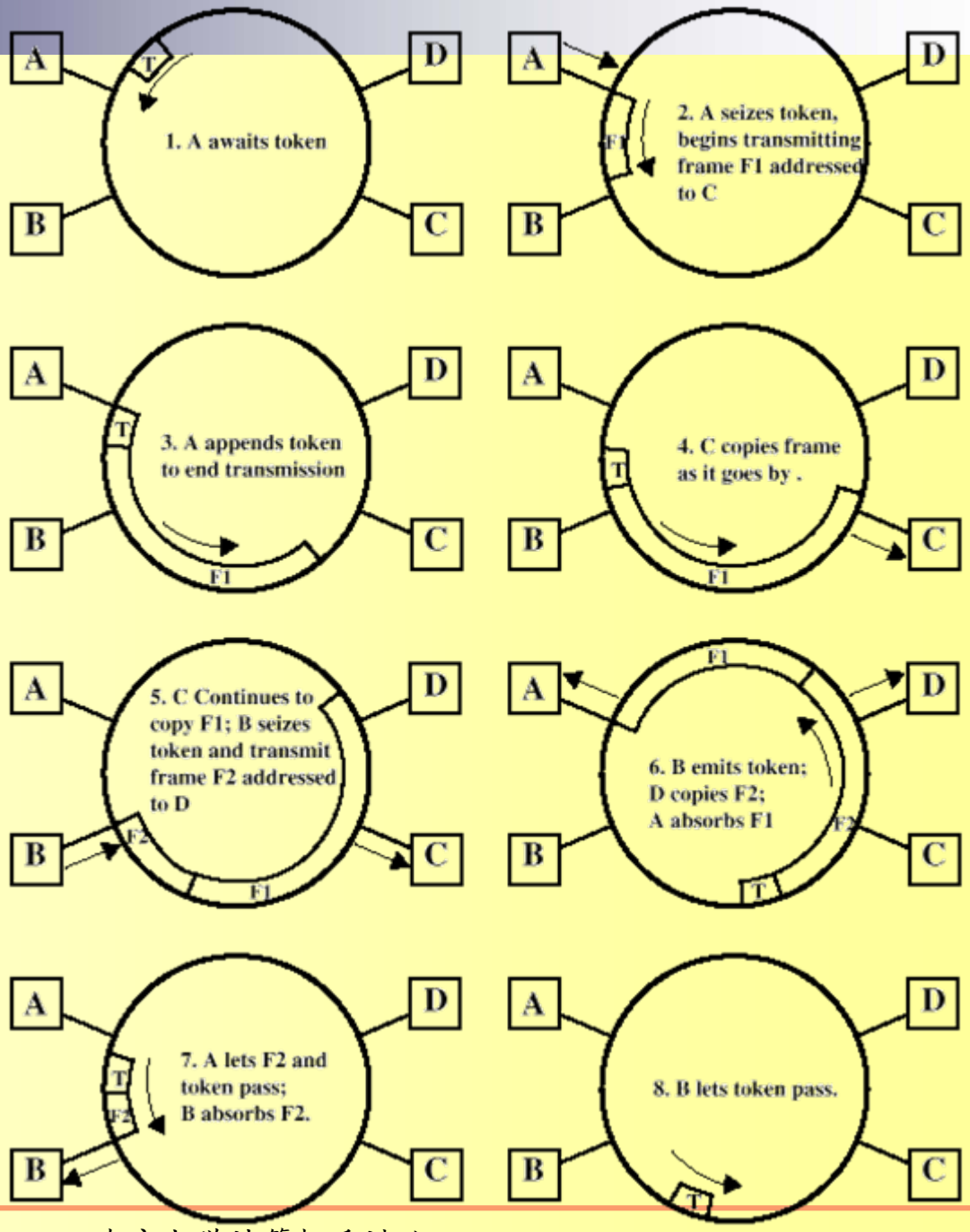
- 100 Mbps Token Ring
- Use multi-mode or single-mode optical fiber transmission links
- Span up to 200 kms and permits up to 500 stations
- LAN and MAN applications

FDDI Token Ring



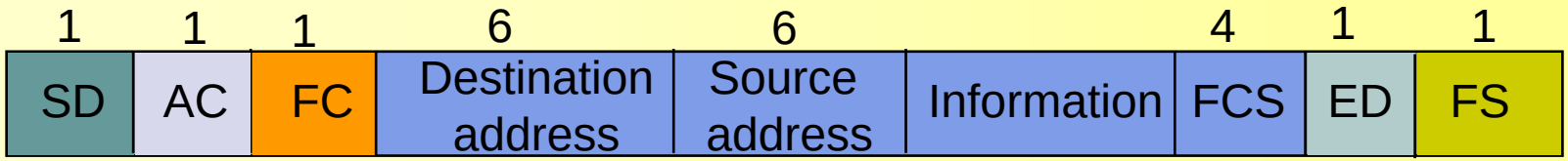
FDDI Operation

- 在一圈的过程中，每个准备好要发送数据的站都可以发送数据。
- 环路上存在一个以上的数据帧。与802.5的主要区别。



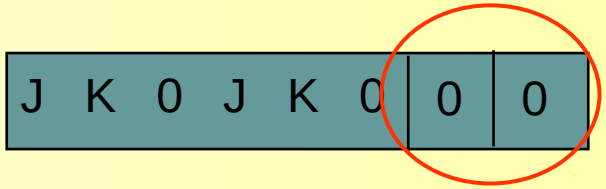
Token Ring Frame Format (1)

Data frame format



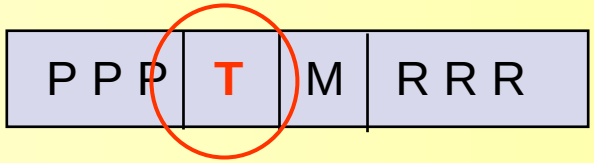
Token frame format

Starting Delimiter



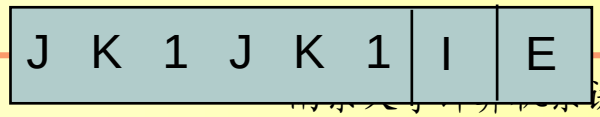
J, K non-data symbols (line code)
J begins as "0" but no transition
K begins as "1" but no transition

Access Control



PPP=priority; **T=token bit**
M=monitor bit; RRR=reservation
T=0 token; T=1 data

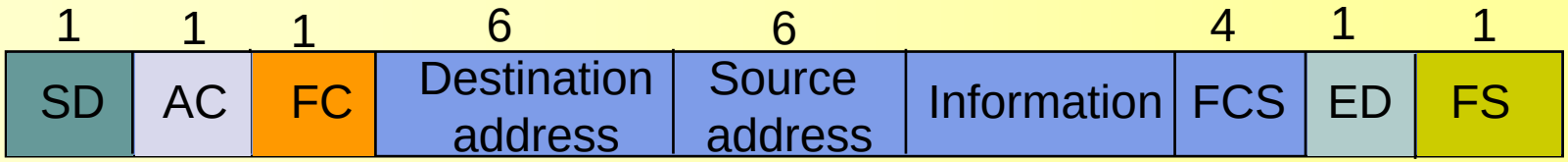
Ending Delimiter



I = intermediate-frame bit
E = error-detection bit

Token Ring Frame Format (2)

Data frame format



Frame control

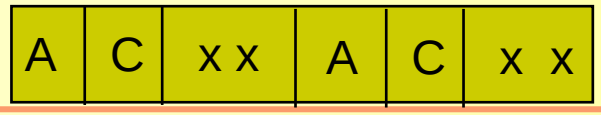
FF = frame type; FF=01 data frame
FF=00 MAC control frame
ZZZZZZ type of MAC control

Addressing — 48 bit format as in 802.3

Information — Length limited by allowable token holding time

FCS — CCITT-32 CRC

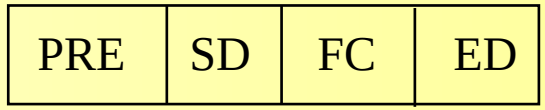
Frame Status



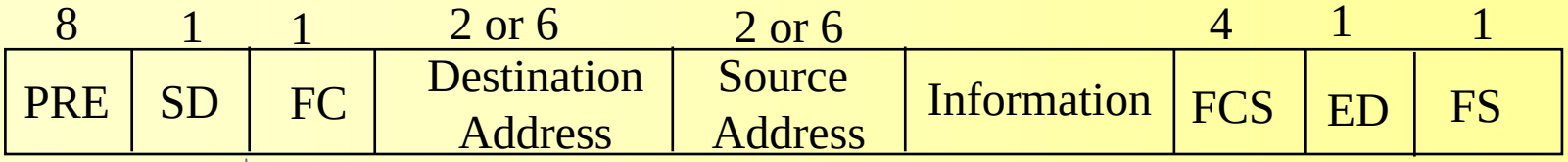
A = address-recognized bit
xx = undefined
C = frame-copied bit

FDDI Frame Format

Token Frame Format



Data Frame Format



Preamble

Frame Control

CLFFZZZZ

C = Sync / Async
L = Address length (16 or 48 bits)
FF = LLC/MAC control/reserved frame type

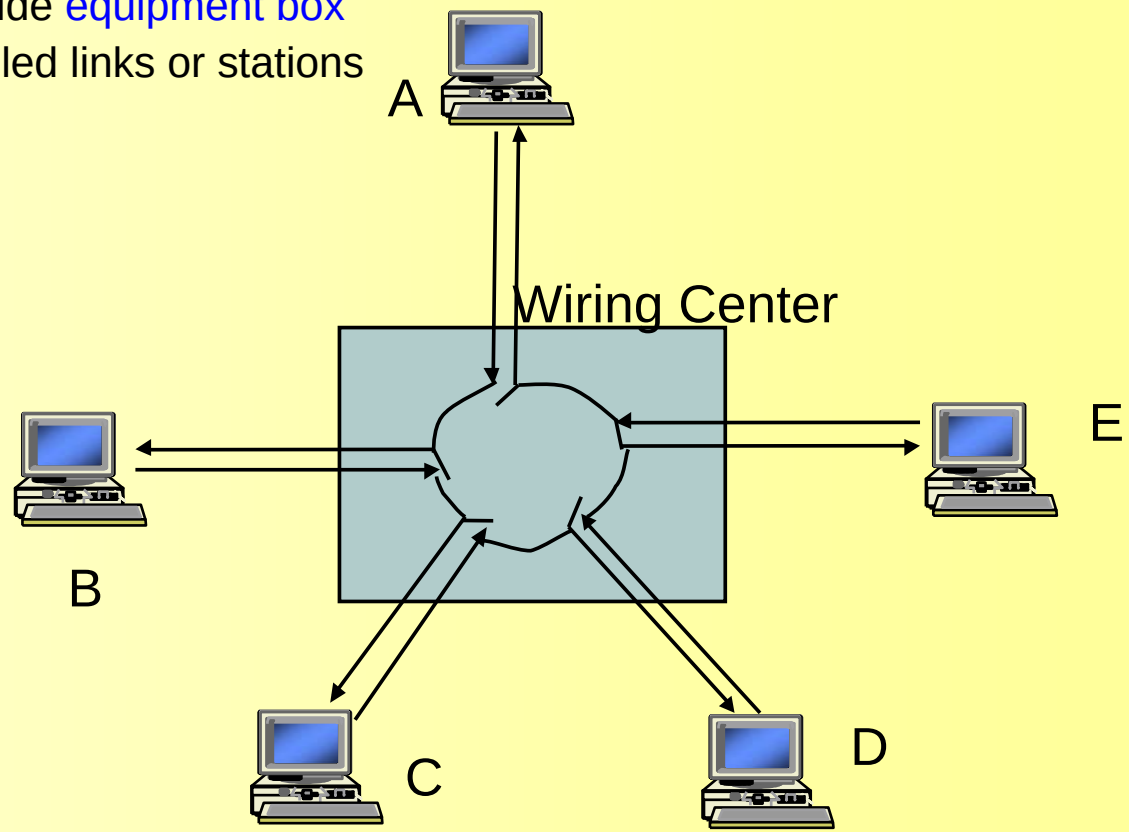
- No AC field
- FC changed
- Add PRE field
- DA and SA changed

Potential Ring Problems

- Break in any link disables network
- Repeater failure disables network
- Installation of new repeater to attach new station requires identification of two topologically adjacent repeaters
- Timing jitter
- Method of recovering lost token required
- Method of removing circulating frames required
- Mostly solved with star-ring architecture

Star Topology Ring LAN

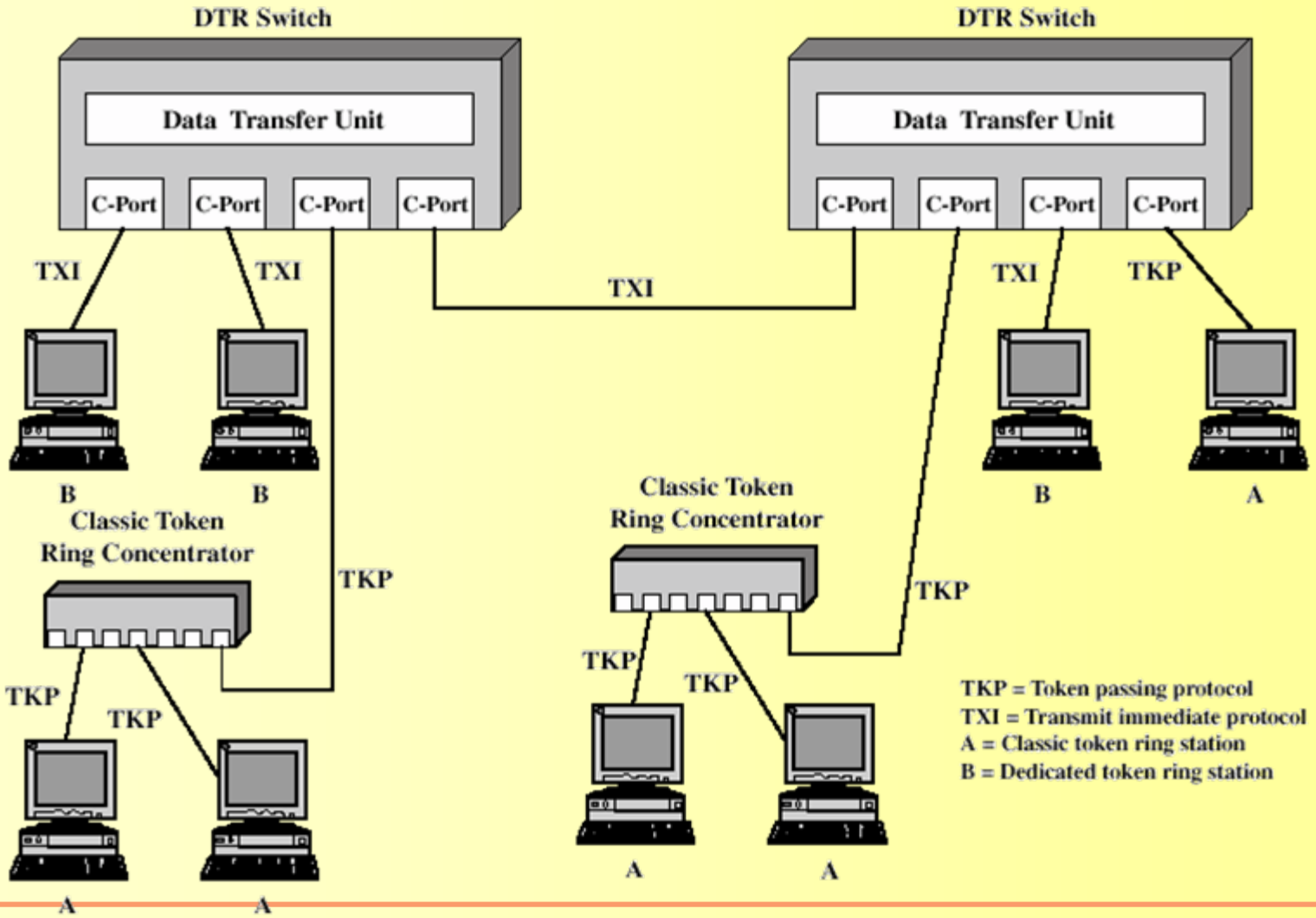
- Stations connected in star fashion to wiring closet
  - Can use existing telephone wiring
- Ring implemented inside equipment box
- Relays can bypass failed links or stations



Dedicated Token Ring

- Central hub
  - Also acts as switch
- Full duplex point to point link
- Concentrator acts as frame level repeater
- No token passing

A Dedicated Token Ring Configuration



802.5 Physical Layer

Data Rate (Mbps)	4	16	100	100	1000
Medium	UTP, STP, Fiber	UTP, STP, Fiber	UTP, STP	Fiber	Fiber
Signaling	Differential Manchester	Differential Manchester	MLT-3	4B5B NRZI	8B/10B
Max Frame Len	4,550	18,200	18,200	18,200	18,200
Access Control	TR or DTR	TR or DTR	DTR	DTR	DTR

- Note: 1 Gbit specified in 2001
  - Uses 802.3 physical layer specification

16.4 Fibre Channel – Background

- I/O channel
  - Direct point to point or multipoint communications link
  - Hardware based
  - High Speed
  - Very short distance
  - User data moved from source buffer to destination buffer
- Network connection
  - Interconnected access points
  - Software based protocol
  - Flow control, error detection, and recovery
  - End systems connections

Fibre Channel

- Best of both technologies
- Channel oriented
  - Data type qualifiers for routing frame payload
  - Link level constructs associated with I/O operations
  - Protocol interface specifications to support existing I/O architectures
    - e.g. SCSI (Small Computer System Interface)
- Network oriented
  - Full multiplexing between multiple destinations
  - Peer to peer connectivity
  - Internetworking to other connection technologies

Fibre Channel Requirements

- Full duplex links with two fibers per link
- 100 Mbps to 800 Mbps on single line
  - Full duplex 200 Mbps to 1600 Mbps per link
- Up to 10 km
- Small connectors
- High-capacity utilization, distance insensitivity
- Greater connectivity than existing multidrop channels
- Broad availability, i.e. standard components
- Multiple cost/performance levels, from small systems to supercomputers
- Carry multiple existing interface command sets for existing channel and network protocols

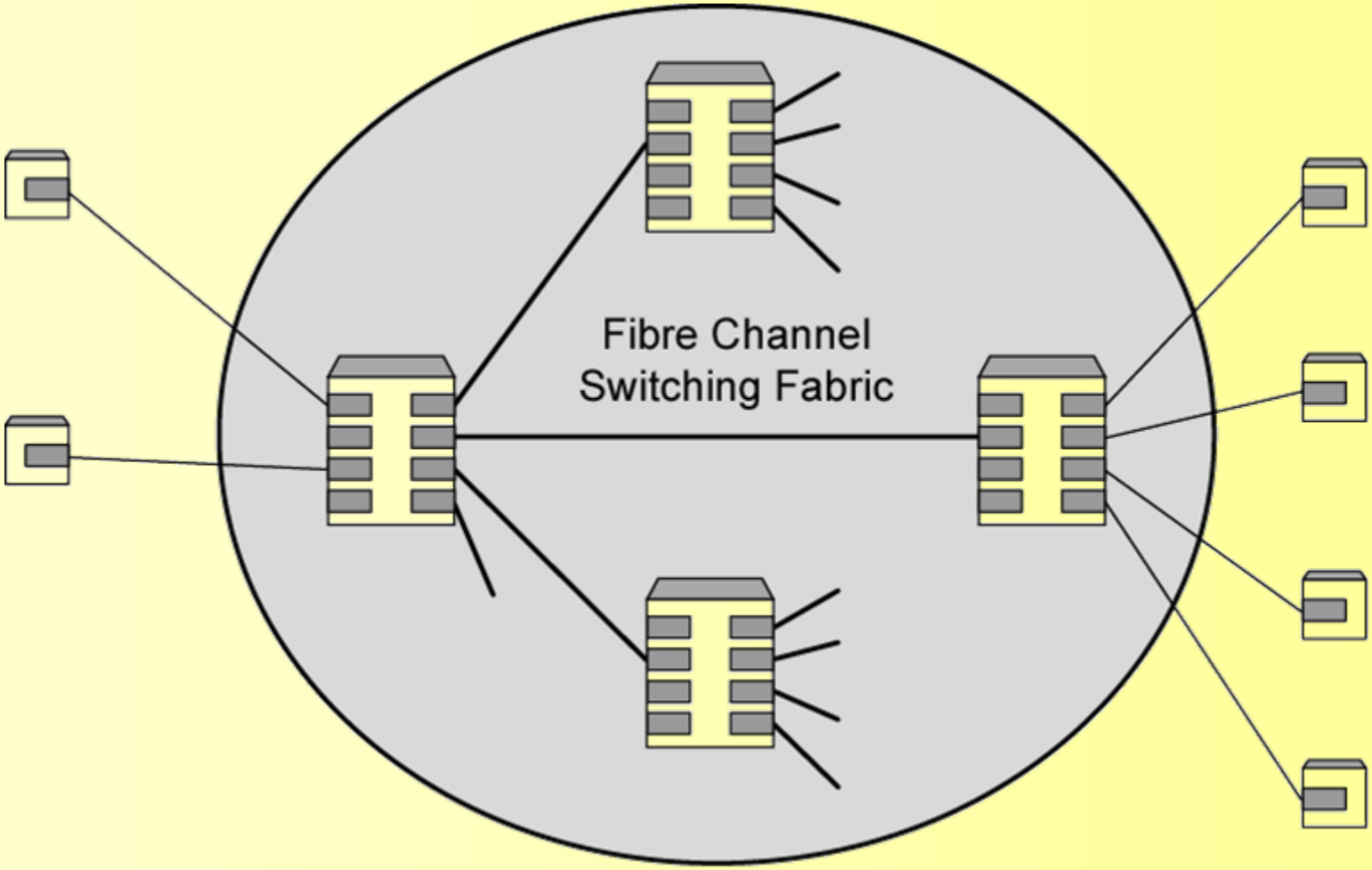
Fibre Channel Facilities

- Uses generic transport mechanism based on point-to-point links and a switching network
- Supports simple encoding and framing scheme
- In turn supports a variety of channel and network protocols

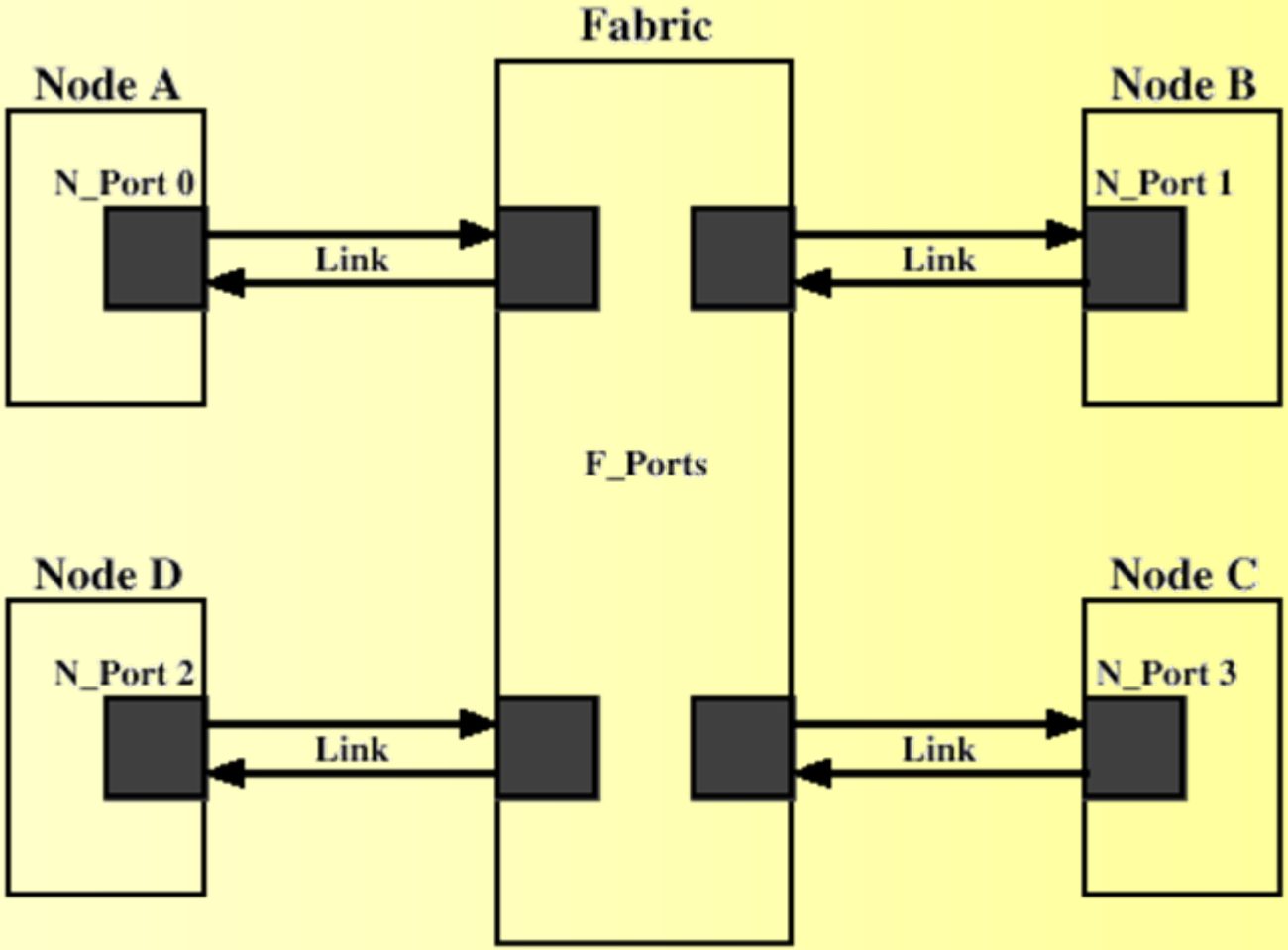
Fibre Channel Elements

- End systems – Nodes
  - Include one or more N_ports for interconnection
- Switched elements – the network or fabric
  - Collection of switched elements form the network or fabric
  - Each switched element has multiple F_ports for interconnection
- Communication across point-to-point links
  - Bidirectional links between ports

Fibre Channel Network



Fibre Channel Port Types



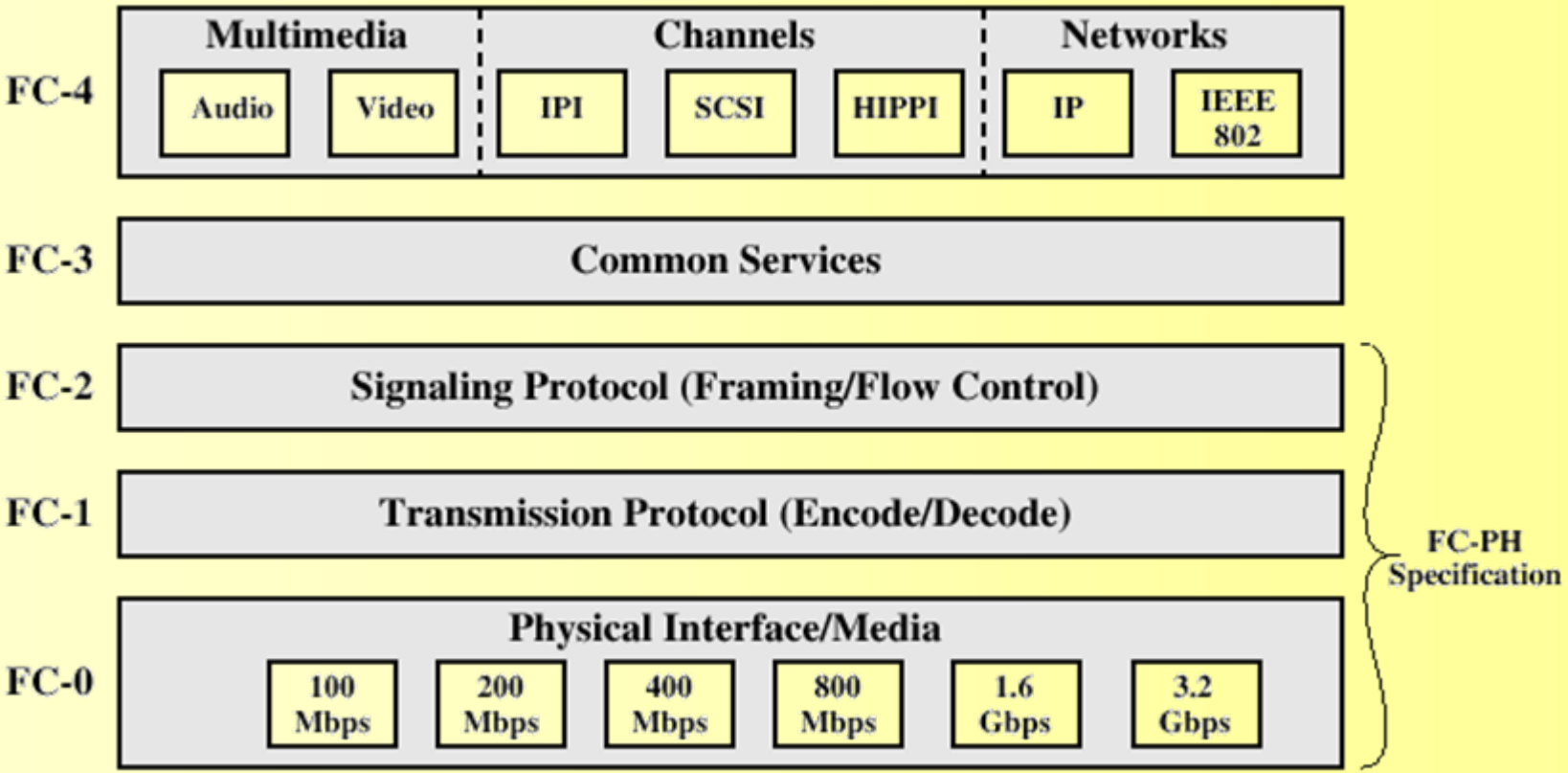
Fibre Channel Protocol Architecture (1)

- FC-0 Physical Media
  - Optical fiber for long distance
  - coaxial cable for high speed short distance
  - STP for lower speed short distance
- FC-1 Transmission Protocol
  - 8B/10B signal encoding
- FC-2 Framing Protocol
  - Topologies
  - Framing formats
  - Flow and error control
  - Sequences and exchanges (logical grouping of frames)

Fibre Channel Protocol Architecture (2)

- FC-3 Common Services
  - Including multicasting
- FC-4 Mapping
  - Mapping of channel and network services onto fibre channel
  - e.g. IEEE 802, ATM, IP, SCSI

Fiber Channel Levels



Fibre Channel Physical Media

- Provides range of options for
  - Physical medium
  - Data rate on medium
  - Topology of network
- Shielded twisted pair, video coaxial cable, and optical fiber
- Data rates 100 Mbps to 3.2 Gbps
- Point-to-point from 33 m to 10 km

FC-0 Nomenclature

Speed—Medium—Transmitter-Distance

400	400 MByte/s
200	200 MByte/s
100	100 MByte/s
50	50 MByte/s
25	25 MByte/s
12	12.5 MByte/s

SM	Single Mode
M5	Multimode (50 μm)
M6	Multimode (62.5 μm)
TV	Video coaxial cable
MI	Miniature coaxial cable
TP	Shielded twisted pair
TW	Twinax - copper

LL	Long wave (1300 to 1550 nm) laser
SL	Short wave (750 to 850 nm) laser
SN	Short weve laser (750 to 850 nm) without open fibre control
LE	Long wave (1300 to 1550 nm) LED (light-emitting diode)
EL	Emitter-coupled logic (ECL)

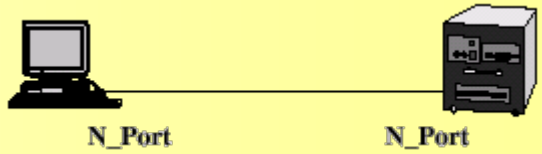
L	Long distance (10 km)
I	Intermediate distance (2 km)
S	Short distance ((100m)

Commonly used:
- 100-TW-S-EL
- 100-M5-I-SL
- 100-SM-L-LL

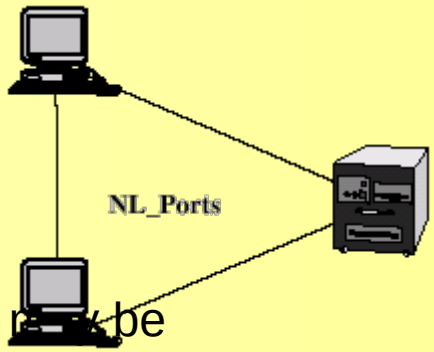
Fibre Channel Fabric

- General topology called fabric or switched topology
  - Arbitrary topology includes at least one switch to interconnect number of end systems
  - Or a switched network of many switches, some supporting end nodes
- Routing transparent to nodes
  - Each port has unique address
  - When data transmitted into fabric, edge switch uses destination port address to determine location
    - Either delivers frame to node attached to same switch
    - Or transfers frame to adjacent switch to begin routing to remote destination

Alternative Topologies (No Switches)

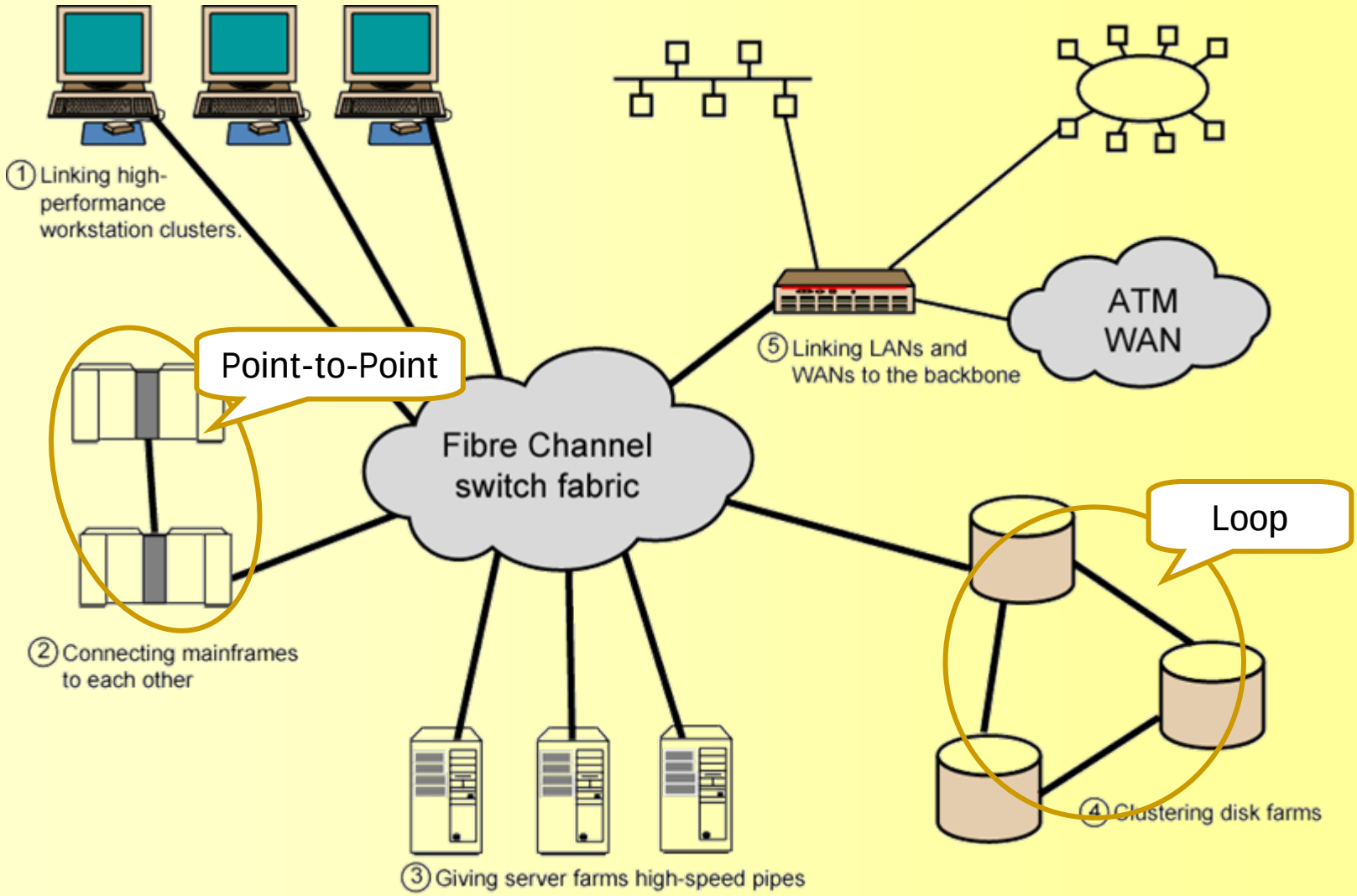


- Point-to-point topology
  - Only two ports
  - Directly connected, with no intervening switches
  - No routing
- Arbitrated loop topology
  - Simple, low-cost topology
  - Up to 126 nodes in loop
  - Operates roughly equivalent to token ring



- Topologies, transmission media, and data rates may be combined

Five Applications of Fibre Channel



Fabric Advantages

- Scalability of capacity
  - As additional ports added, aggregate capacity of network increases
  - Minimizes congestion and contention
  - Increases throughput
- Protocol independent, Distance insensitive
- Flexibility
  - Switch and transmission link technologies may change without affecting overall configuration
- Burden on nodes minimized
  - Node responsible for managing point-to-point connection between itself and fabric
  - Fabric responsible for routing and error detection

Fibre Channel Prospects

- Backed by Fibre Channel Association
- Interface cards for different applications available
- Most widely accepted as peripheral device interconnect
  - To replace such schemes as SCSI
- Technically attractive to general high-speed LAN requirements
  - Must compete with Ethernet and ATM LANs
- Cost and performance issues should dominate the consideration of these competing technologies

作业

- 16.2
- 16.6
- 16.11