Part 4

LAN SYSTEMS (2)

Ethernet (CSMA/CD)

- Carriers Sense Multiple Access with Collision Detection (CSMA/CD)
- Ethernet
- IEEE 802.3

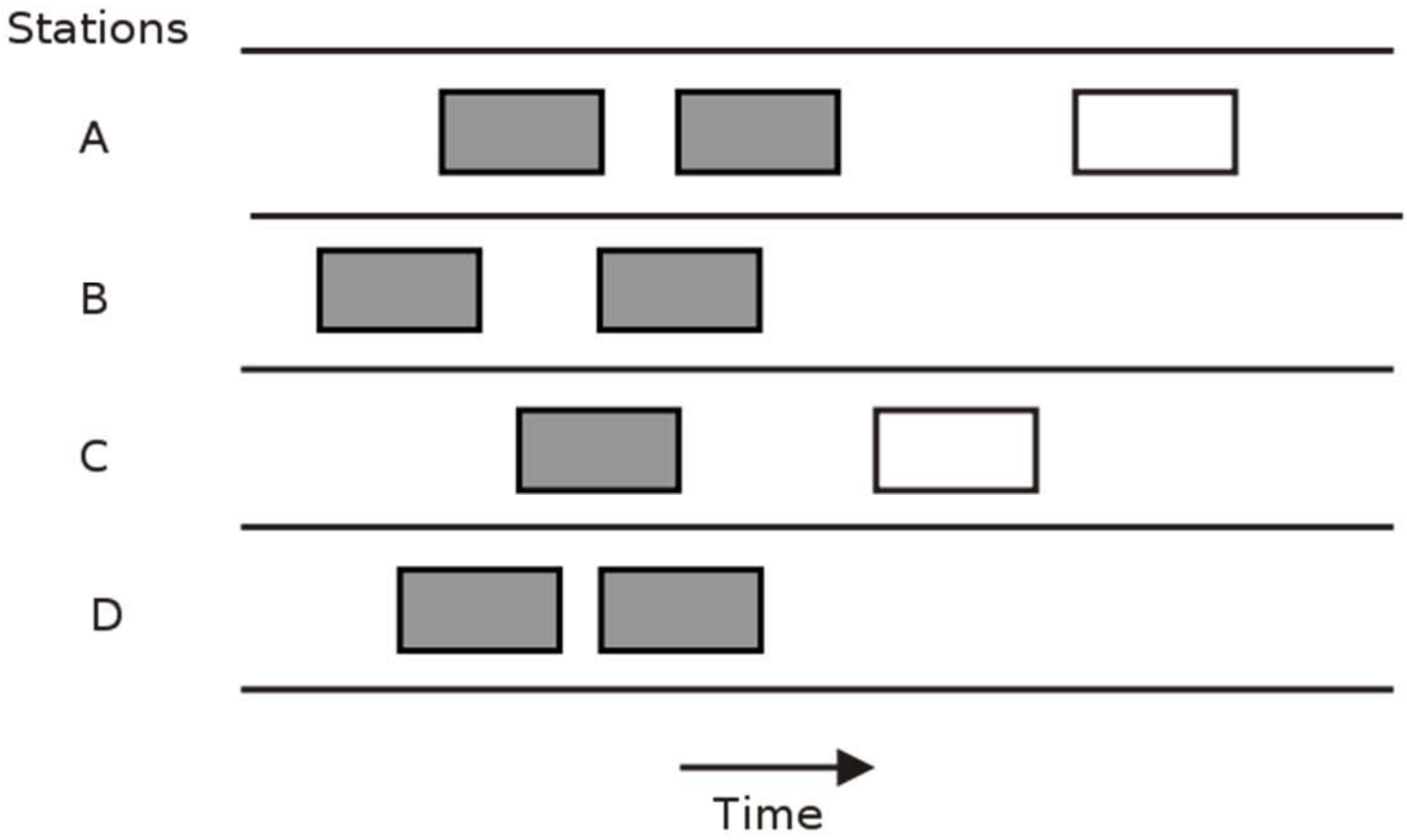
IEEE802.3 Medium Access Control

- Random Access
  - Stations access medium randomly
- Contention
  - Stations content for time on medium

ALOHA

- Packet Radio
- 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:
  - Frame check sequence (as in HDLC)
  - If frame OK and address matches receiver, send ACK
- Frame may be damaged by noise or by another station transmitting at the same time (collision)
- Any overlap of frames causes collision
- Max utilization 18%

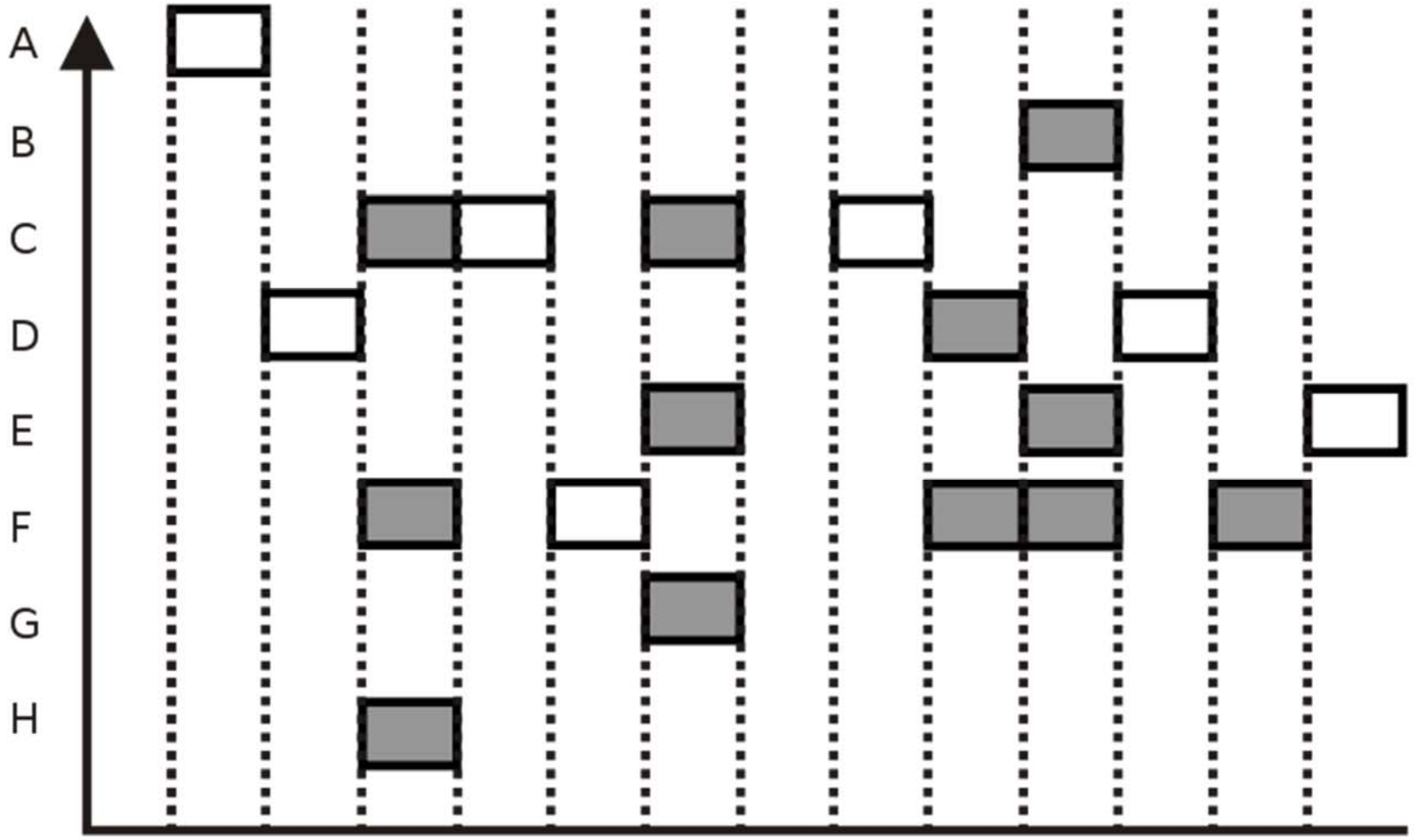
ALOHA



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%

Slotted ALOHA



Slotted ALOHA protocol (shaded slots indicate collision)

CSMA

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

If Busy?

- If medium is idle, transmit
- If busy, listen for idle then transmit immediately

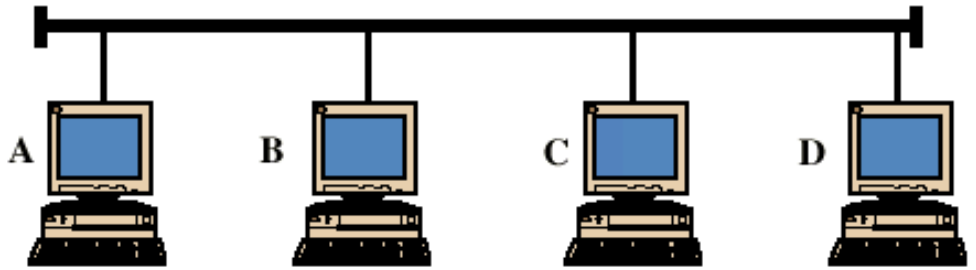
- If two stations are waiting, collision

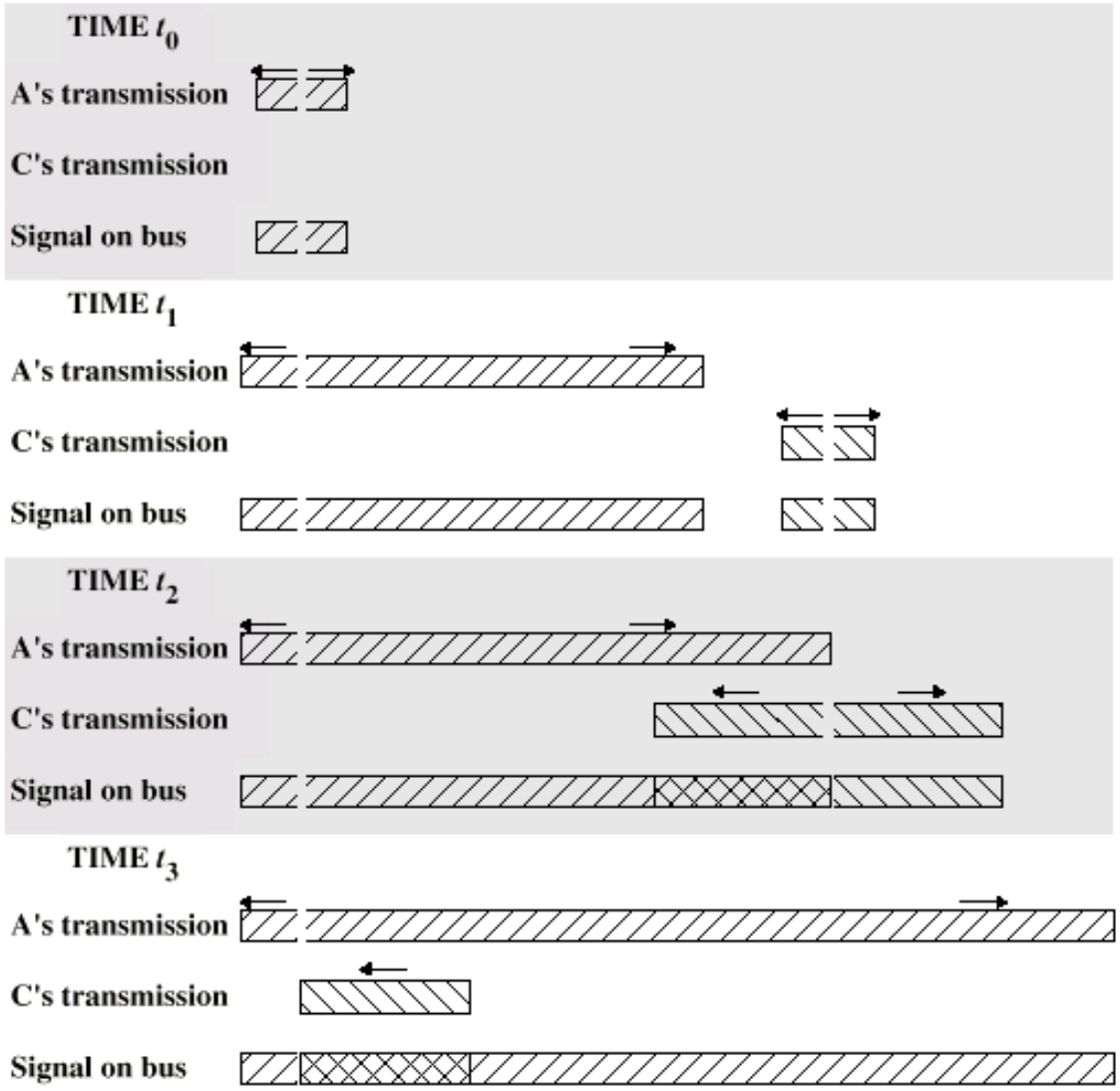
CSMA/CD

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

- If medium idle, transmit
- If busy, listen for idle, then transmit
- If collision detected, jam then cease transmission (*for twisted-pair star topology*)
- After jam, wait random time then start again (*for twisted-pair star topology*)
  - Binary exponential back off

CSMA/CD Operation

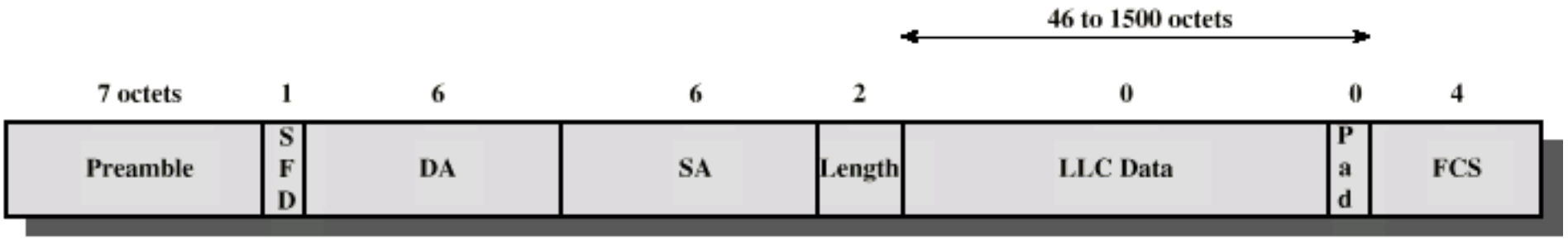




Collision Detection

- 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
- Special collision presence signal

IEEE 802.3 Frame Format



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

10Mbps Specification (Ethernet)

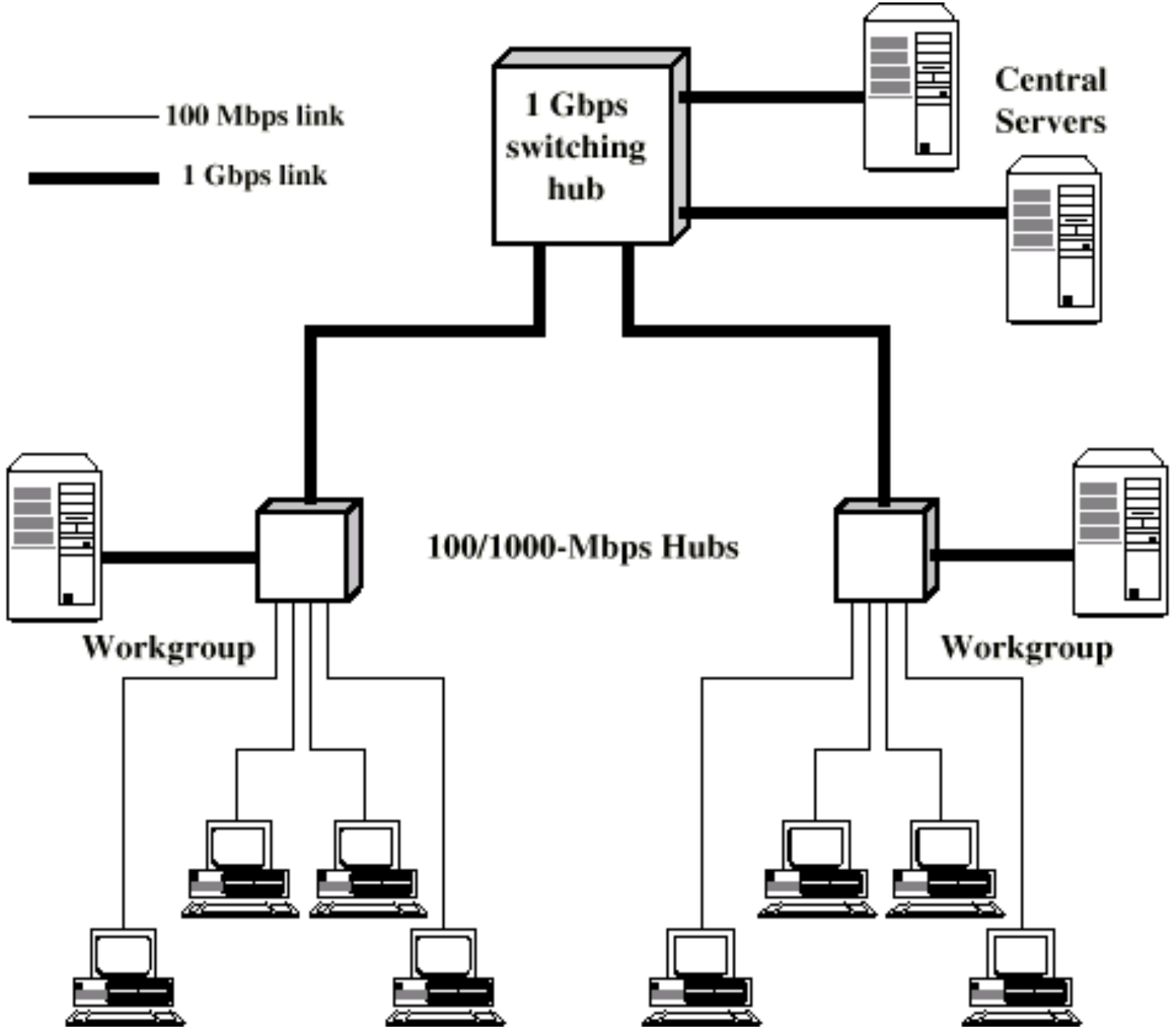
- <data rate><Signaling method><Max segment length>

	10Base5	10Base2	10Base-T	10Base-FP
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

100Mbps (Fast Ethernet)

	100Base-TX		100Base-FX	100Base-T4
	2 pair, STP	2 pair, Cat 5UTP	2 optical fiber	4 pair, cat 3,4,5
	MLT-3	MLT-3	4B5B,NRZI	8B6T,NRZ

Gigabit Ethernet Configuration



Gigabit Ethernet - Differences

- Carrier extension
- At least 4096 bit-times long (512 for 10/100Mbps)
- Frame bursting: allow for multiple short frames to be transmitted consecutively, up to a limit, without relinquishing control for CSMA/CD between frames. Frame Bursting avoids the overhead of carrier extension when a single station has a number of small frames ready to send.

Gigabit Ethernet - Physical

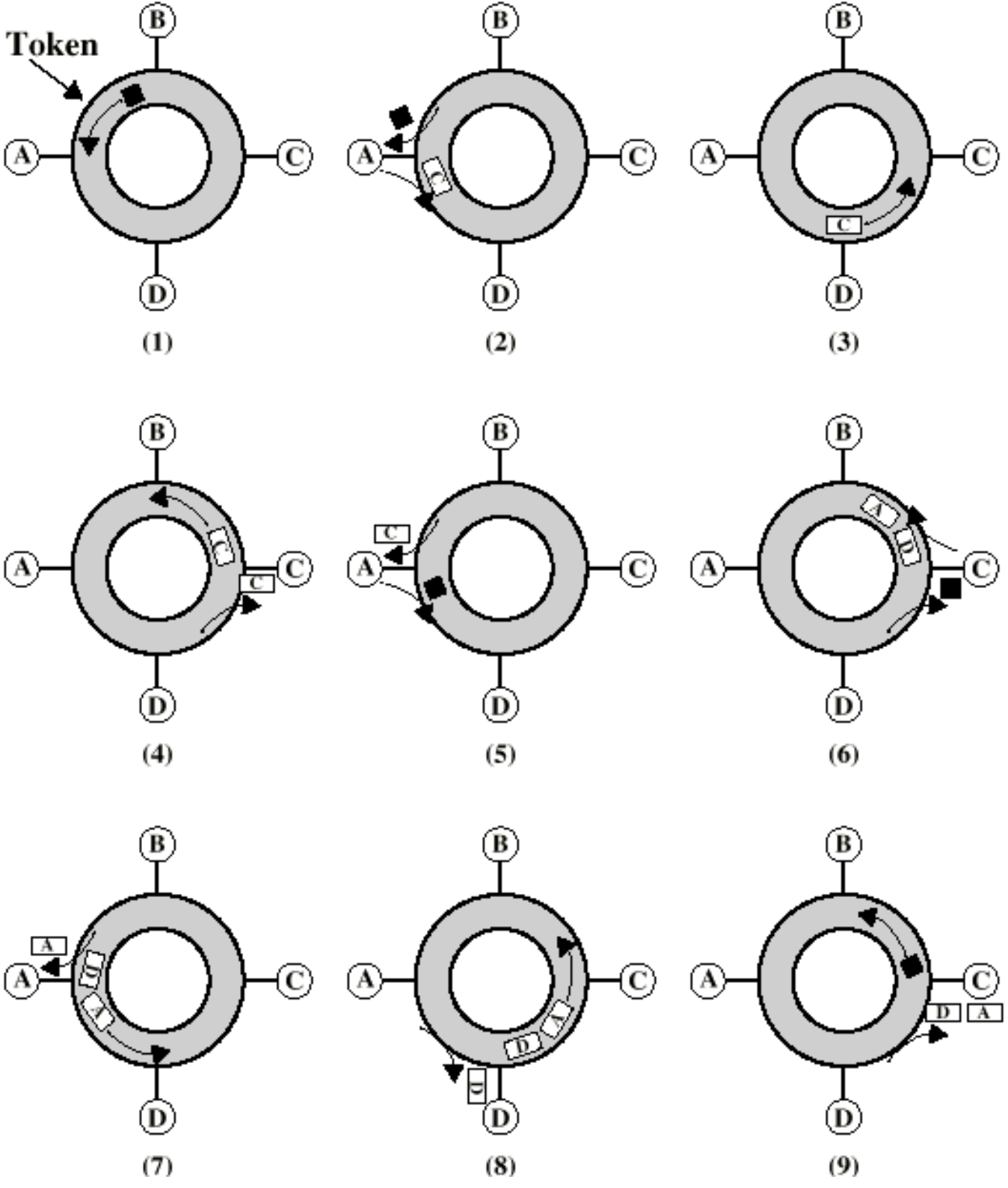
- 1000Base-SX
  - Short wavelength, multimode fiber
- 1000Base-LX
  - Long wavelength, Multi or single mode fiber
- 1000Base-CX
  - Copper jumpers <25m, shielded twisted pair
- 1000Base-T
  - 4 pairs, cat 5 UTP

- Signaling - 8B/10B

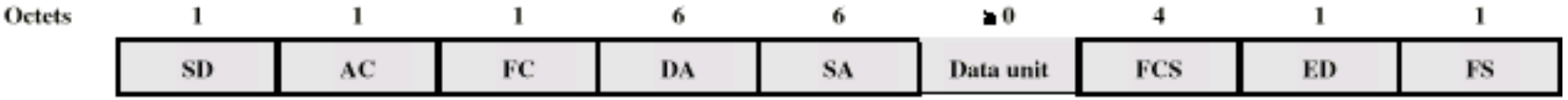
Token Ring (802.5)

- 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 and leading edge of returning frame arrives
  - Under light loads, some inefficiency
  - Under heavy loads, round robin

Token Ring Operation



Token Ring MAC Frame



SD = starting delimiter
AC = access control
FC = frame control
DA = destination address
SA = source address
FCS = frame check sequence
ED = ending delimiter
FS = frame status

(a) General Frame Format

(b) Token Frame Format

J, K = non-data bits
I = intermediate frame bit
E = error-detected bit

(c) Ending Delimiter Field

PPP = priority bits
T = token bit
M = monitor bit
RRR = reservation bits

(c) Access Control Field

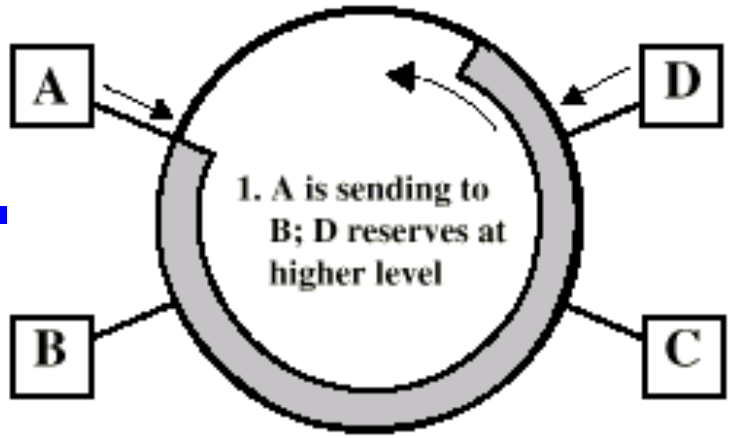
A = Address recognized bit
C = Frame copied bit
rr = reserved

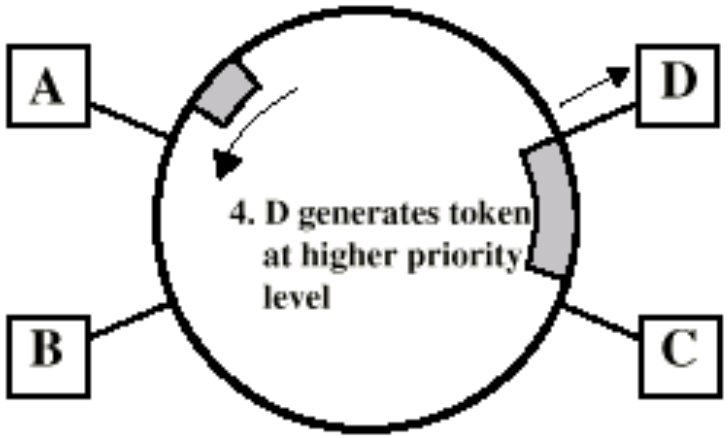
(e) Frame Status Field

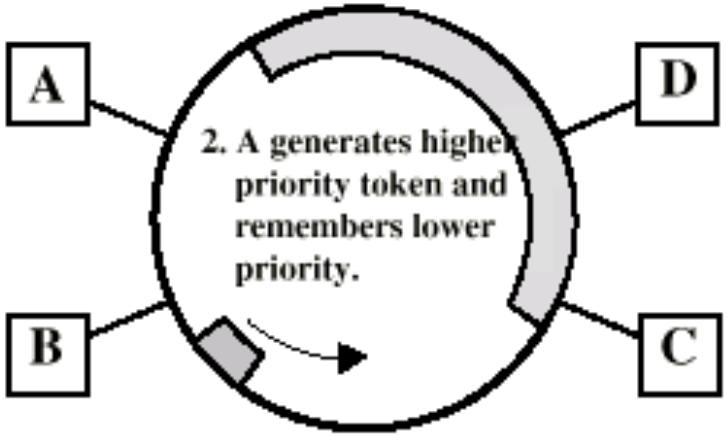
FF = frame-type bits
ZZZZZZ = control bits

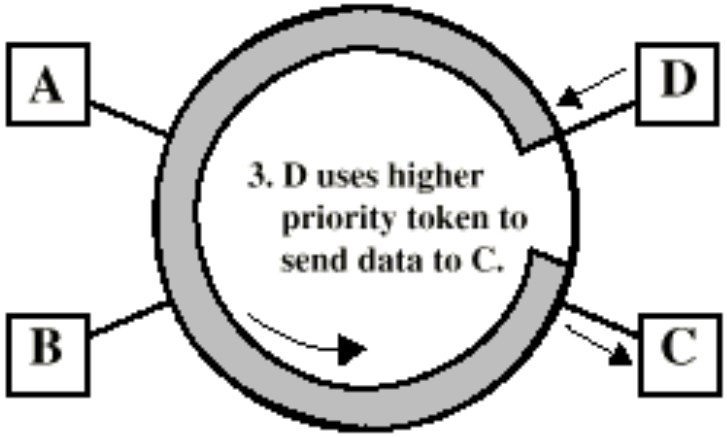
(d) Frame Control Field

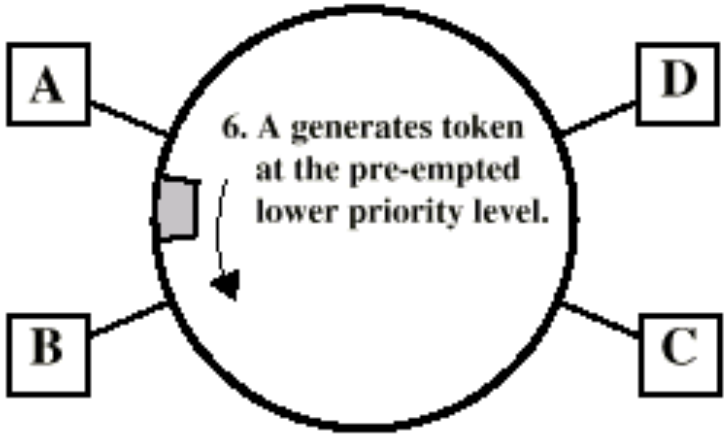
Priority Scheme











Dedicated Token Ring

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

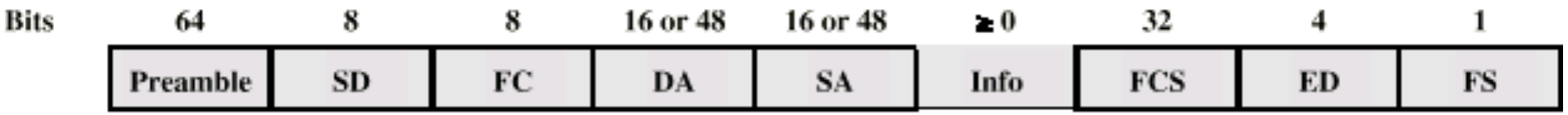
802.5 Physical Layer

Data Rate	4	16	100
Medium	UTP,STP,Fiber		
Signaling	Differential Manchester		
Max Frame	4550	18200	18200
Access Control	TP or DTR	TP or DTR	DTR

FDDI

- 100Mbps
- LAN and MAN applications
- Token Ring

FDDI MAC Frame Format



(a) General Frame Format

(b) Token Frame Format

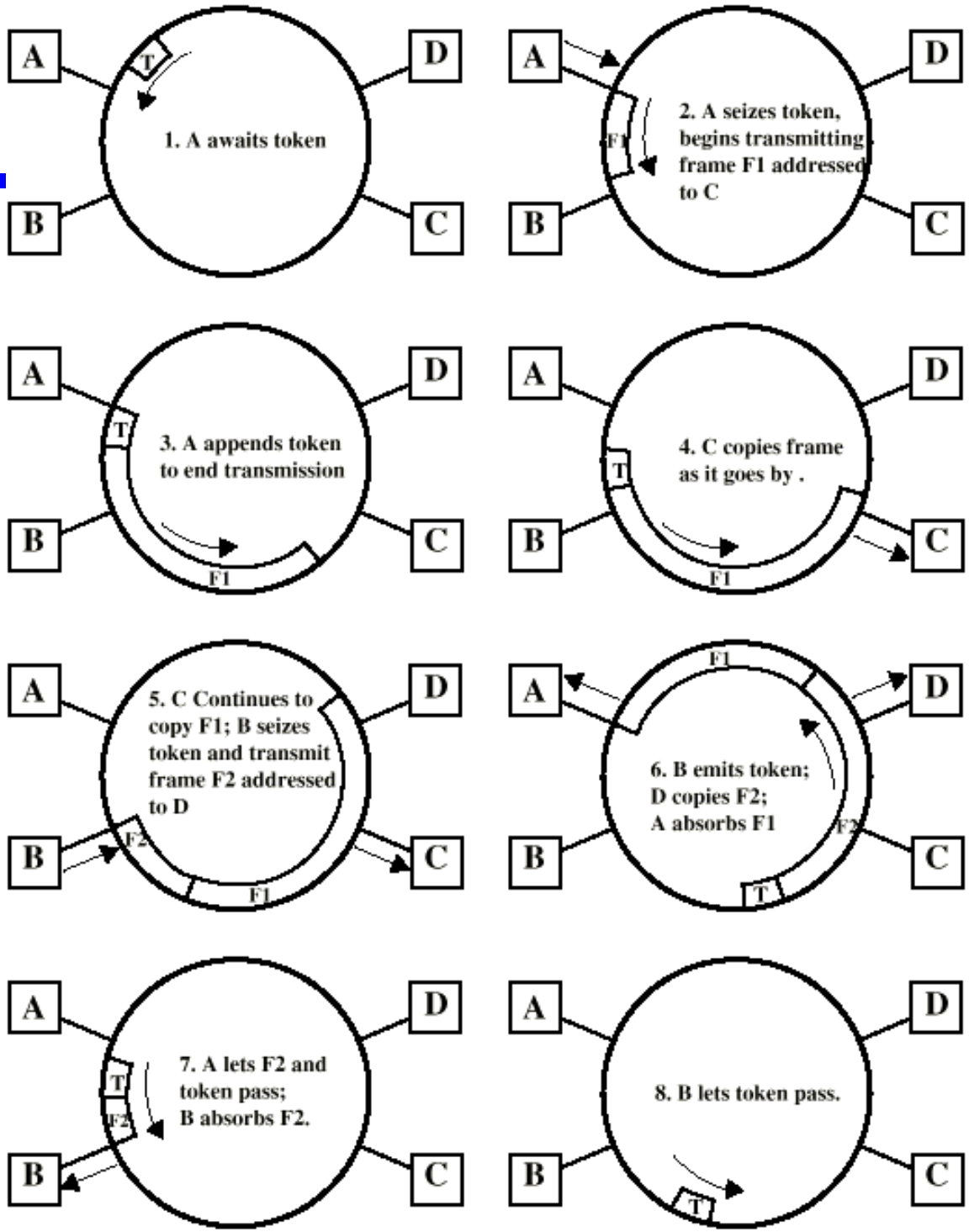
SD = starting delimiter
FC = frame control
DA = destination address
SA = source address
FCS = frame check sequence
ED = ending delimiter
FS = frame status

FDDI MAC Protocol

- As for 802.5 except:

- Station seizes token by aborting token transmission
- Once token captured, one or more data frames transmitted
- New token released as soon as transmission finished (early token release in 802.5)

FDDI Operation



FDDI Physical Layer

Medium	Optical Fiber	Twisted Pair
Data rate	100	100
Signaling	4B/5B/NRZI	MLT-3
Max repeaters	100	100
Between repeaters	2km	100m

LAN Generations

- First
  - CSMA/CD and token ring
  - Terminal to host and client server
  - Moderate data rates
- Second
  - FDDI
  - Backbone
  - High performance workstations
- Third
  - ATM
  - Aggregate throughput and real time support for multimedia applications

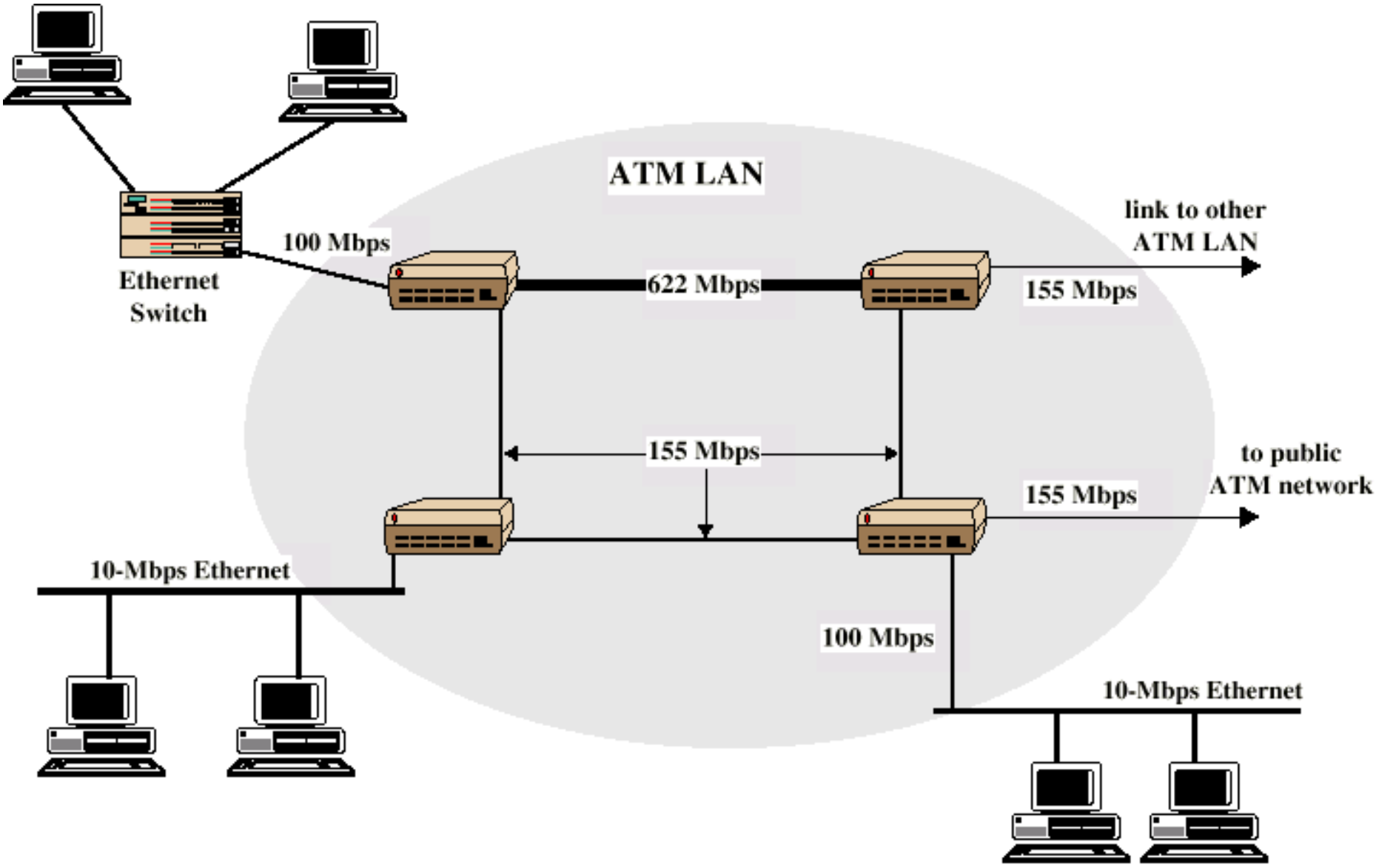
Third Generation LANs

- Support for multiple guaranteed classes of service
  - Live video may need 2Mbps
  - File transfer can use background class
- Scalable throughput
  - Both aggregate and per host
- Facilitate LAN/WAN internetworking

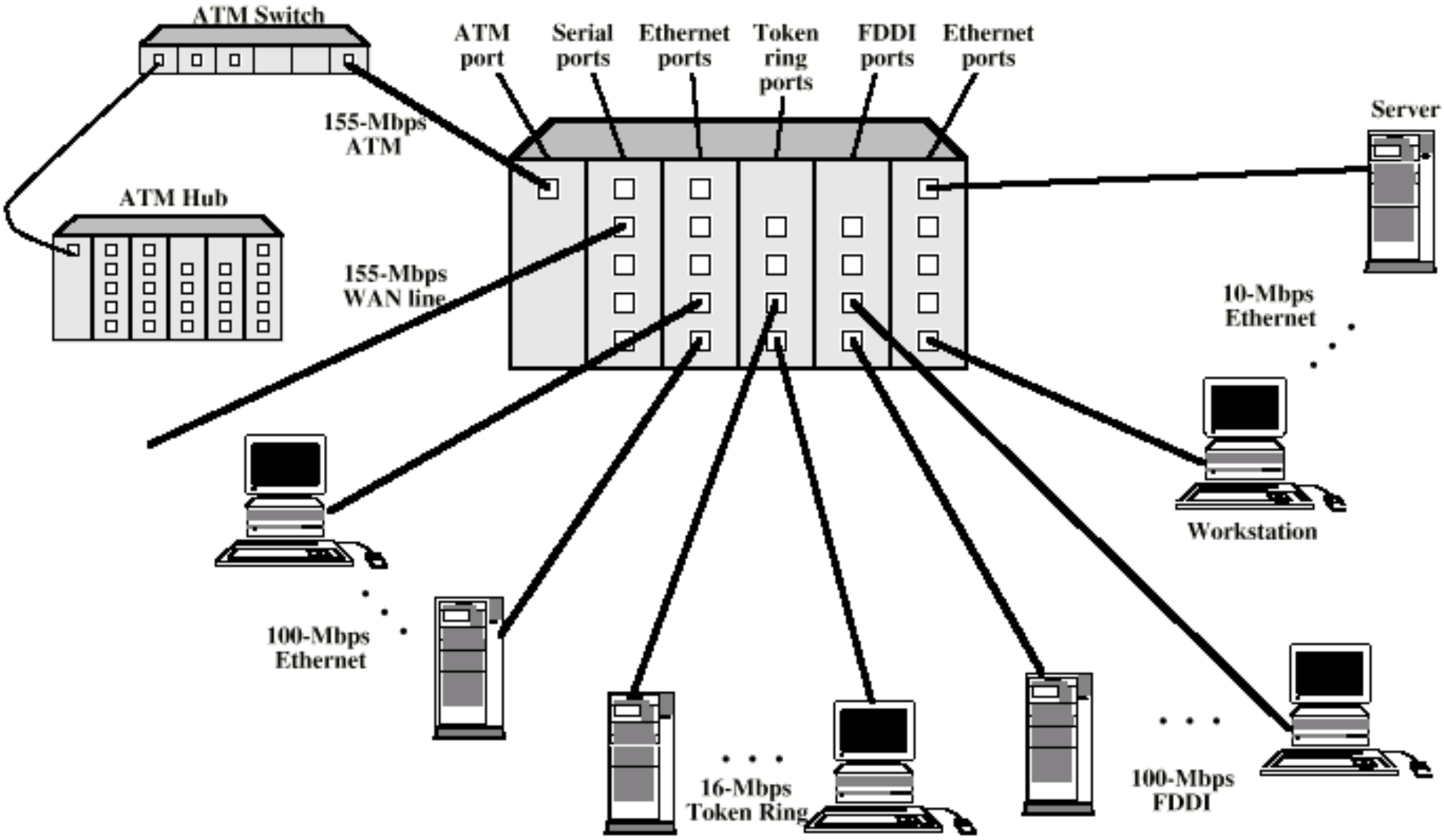
ATM LANs

- Asynchronous Transfer Mode
- Virtual paths and virtual channels
- Preconfigured or switched
- Gateway to ATM WAN
- Backbone ATM switch
  - Single ATM switch or local network of ATM switches
- Workgroup ATM
  - End systems connected directly to ATM switch
- Mixed system

Example ATM LAN



ATM LAN HUB


ATM Switch
ATM port
Serial ports
Ethernet ports
Token ring ports
FDDI ports
Ethernet ports
155-Mbps ATM
Server
ATM Hub
155-Mbps WAN line
10-Mbps Ethernet
Workstation
100-Mbps Ethernet
16-Mbps Token Ring
100-Mbps FDDI

Compatibility

- Interaction between end system on ATM and end system on legacy LAN
- Interaction between stations on legacy LANs of same type
- Interaction between stations on legacy LANs of different types

Fiber Channel - Background

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

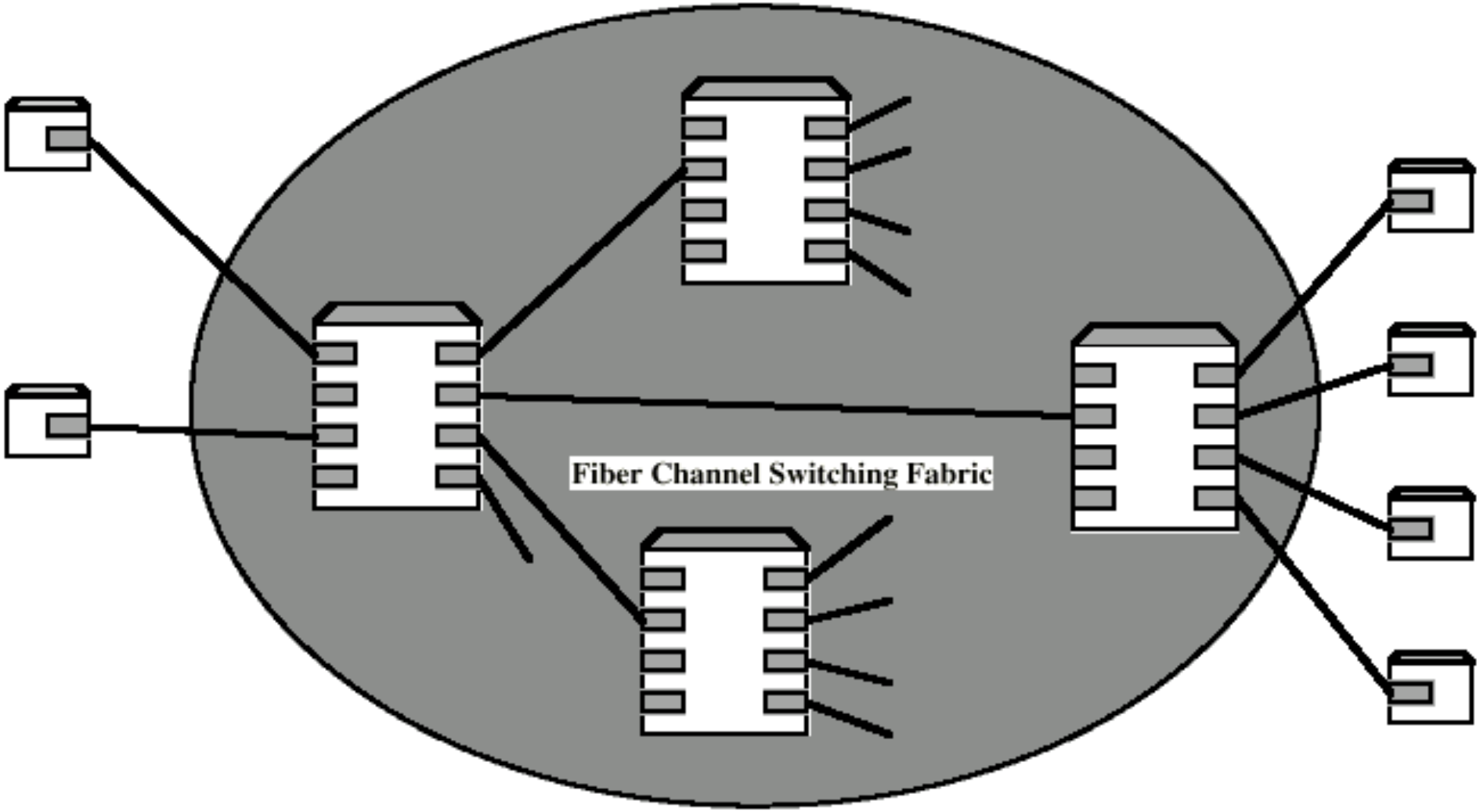
Fiber Channel

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

Fiber Channel Elements

- End systems - Nodes
- Switched elements - the network or fabric
- Communication across point to point links

Fiber Channel Network



Fiber 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)

Fiber Channel Protocol Architecture (2)

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

Wireless LANs

- IEEE 802.11
- Basic service set (cell)
  - Set of stations using same MAC protocol
  - Competing to access shared medium
  - May be isolated
  - May connect to backbone via access point (bridge)
- Extended service set
  - Two or more BSS connected by distributed system
  - Appears as single logic LAN to LLC level

Types of station

- No transition
  - Stationary or moves within direct communication range of single BSS
- BSS transition
  - Moves between BSS within single ESS
- ESS transition
  - From a BSS in one ESS to a BSS in another ESS
  - Disruption of service likely

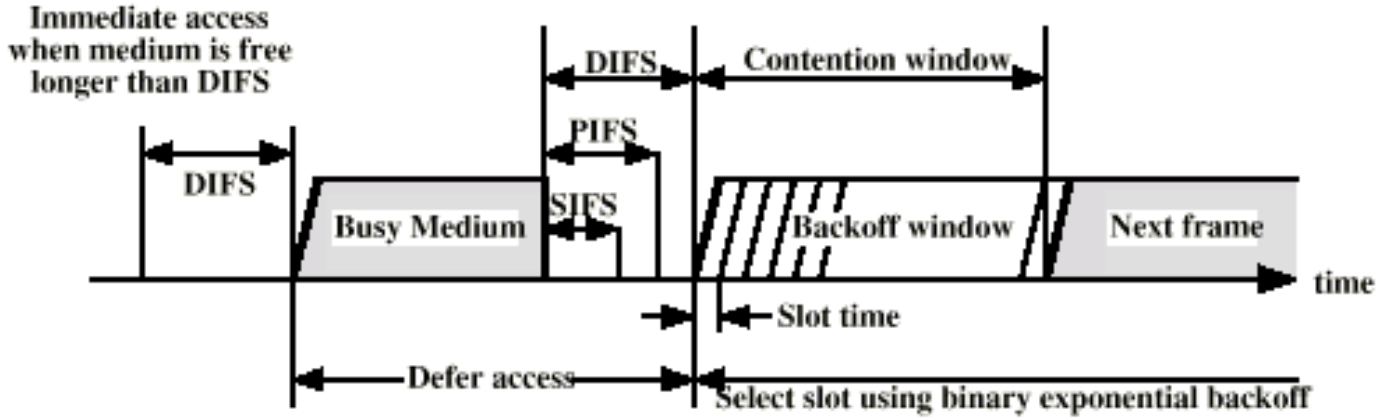
Wireless LAN - Physical

- Infrared
  - 1Mbps and 2Mbps
  - Wavelength 850-950nm
- Direct sequence spread spectrum
  - 2.4GHz ISM band
  - Up to 7 channels
  - Each 1Mbps or 2Mbps
- Frequency hopping spread spectrum
  - 2.4GHz ISM band
  - 1Mbps or 2Mbps
- Others under development

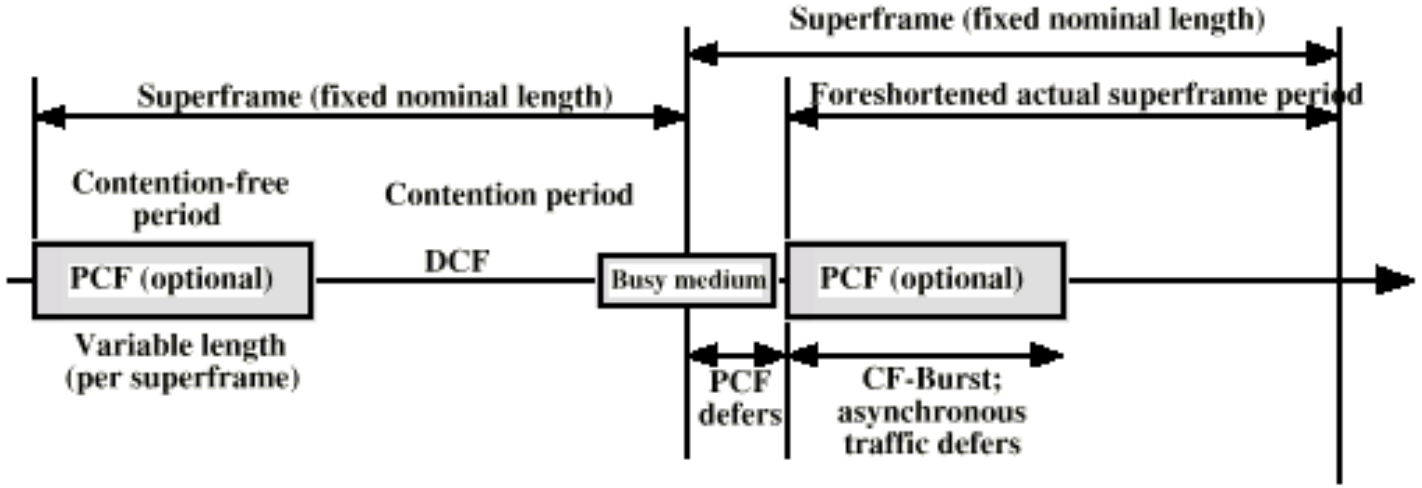
Media Access Control

- Distributed wireless foundation MAC (DWFMAC)
- Distributed coordination function (DCF)
  - CSMA
  - No collision detection
- Point coordination function (PCF)
  - Polling of central master

802.11 MAC Timing

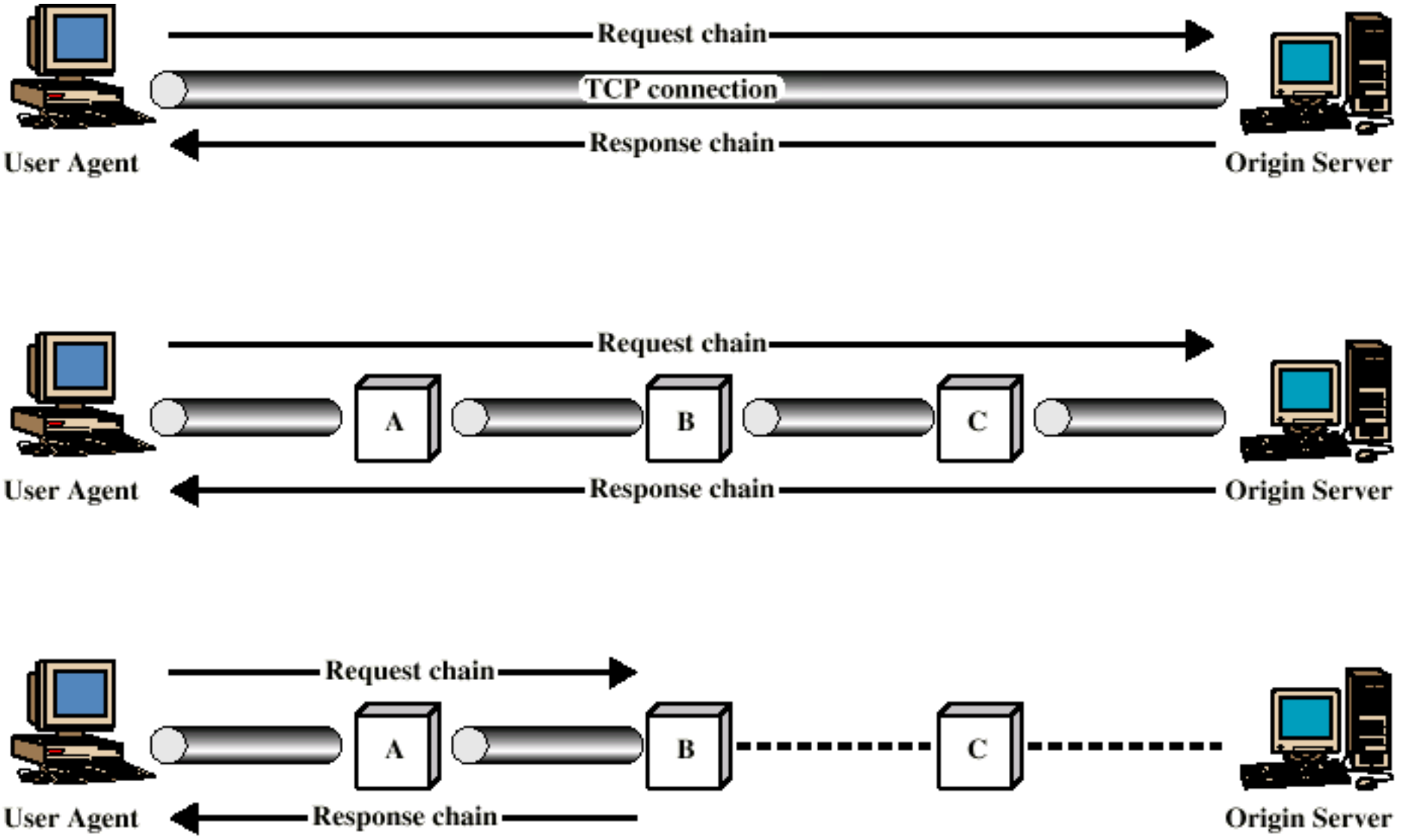


(a) Basic Access Method



(b) PCF Superframe Construction

Examples of HTTP Operation



Intermediate HTTP Systems