Data and Computer Communications

Chapter 16 – High Speed LANs

Eighth Edition

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Why High Speed LANs?

- speed and power of PCs has risen
  - graphics-intensive applications and GUIs
- see LANs as essential to organizations
  - for client/server computing
- now have requirements for
  - centralized server farms
  - power workgroups
  - high-speed local backbone

Medium Access Methods

- In a LAN, all stations are connected to a shared transmission medium
  - Simultaneous attempts to access the medium by more than one station is possible
  - Similar to a meeting
  - Collision
- Medium access control (MAC)
  - Defines the procedure a station should follow when it needs to send a frame

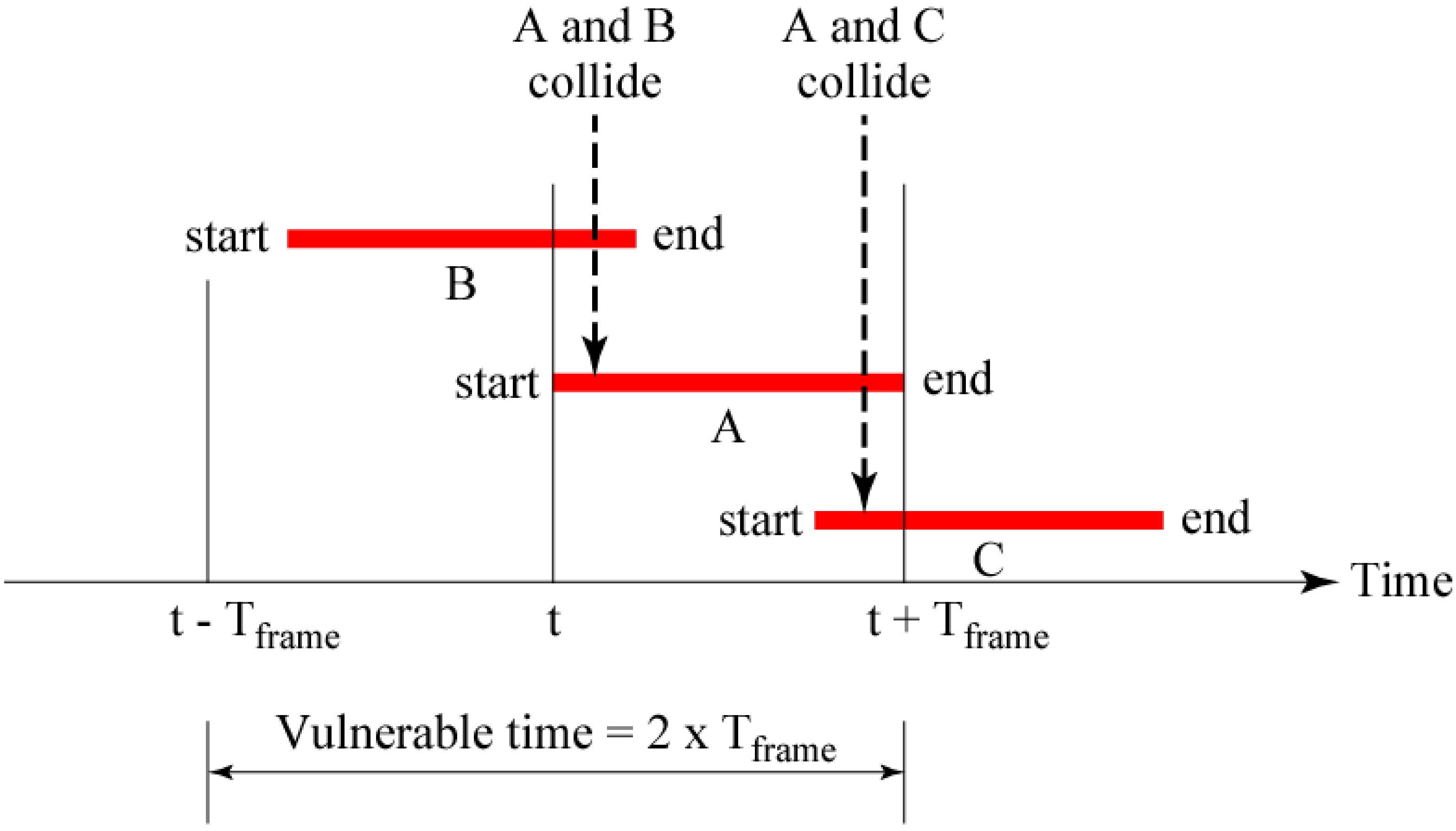
Random Access

- In random access or contention methods, no station is superior to another
- A station can transmit when it desires
  - Following the predefined procedure
- What does the name implies?
- There may be collision
- What should a MAC protocol do?

ALOHA

- developed for packet radio nets
- when station has frame, it sends
- then listens for a bit over max round trip time
  - if receive ACK then fine
  - if not, retransmit
  - if no ACK after repeated transmissions, give up
- uses a frame check sequence (as in HDLC)
- 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%

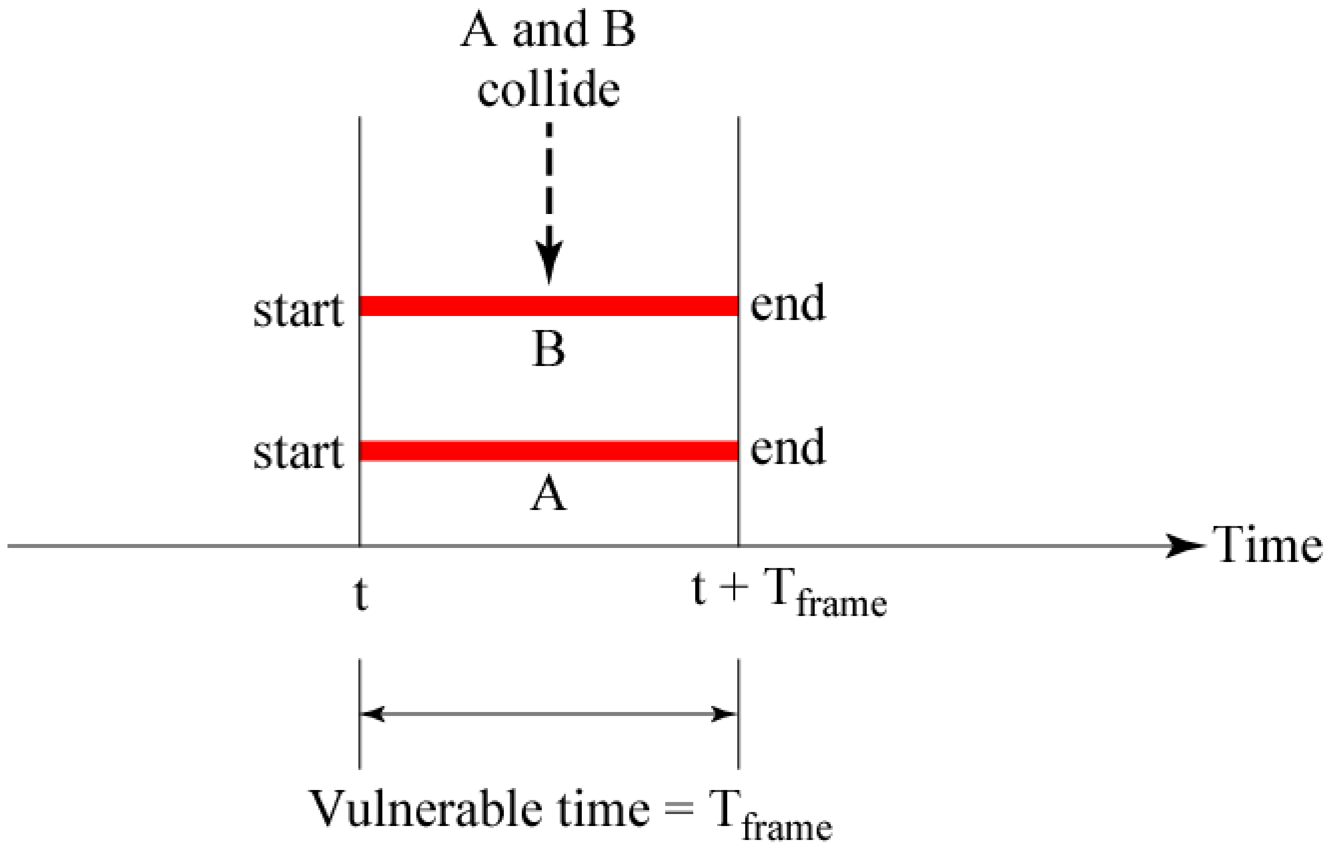
Vulnerable Time for Pure ALOHA Protocol



Slotted ALOHA

- time on channel based on 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%
- both have poor utilization
- fail to use fact that propagation time is much less than frame transmission time

Vulnerable Time for Slotted ALOHA Protocol



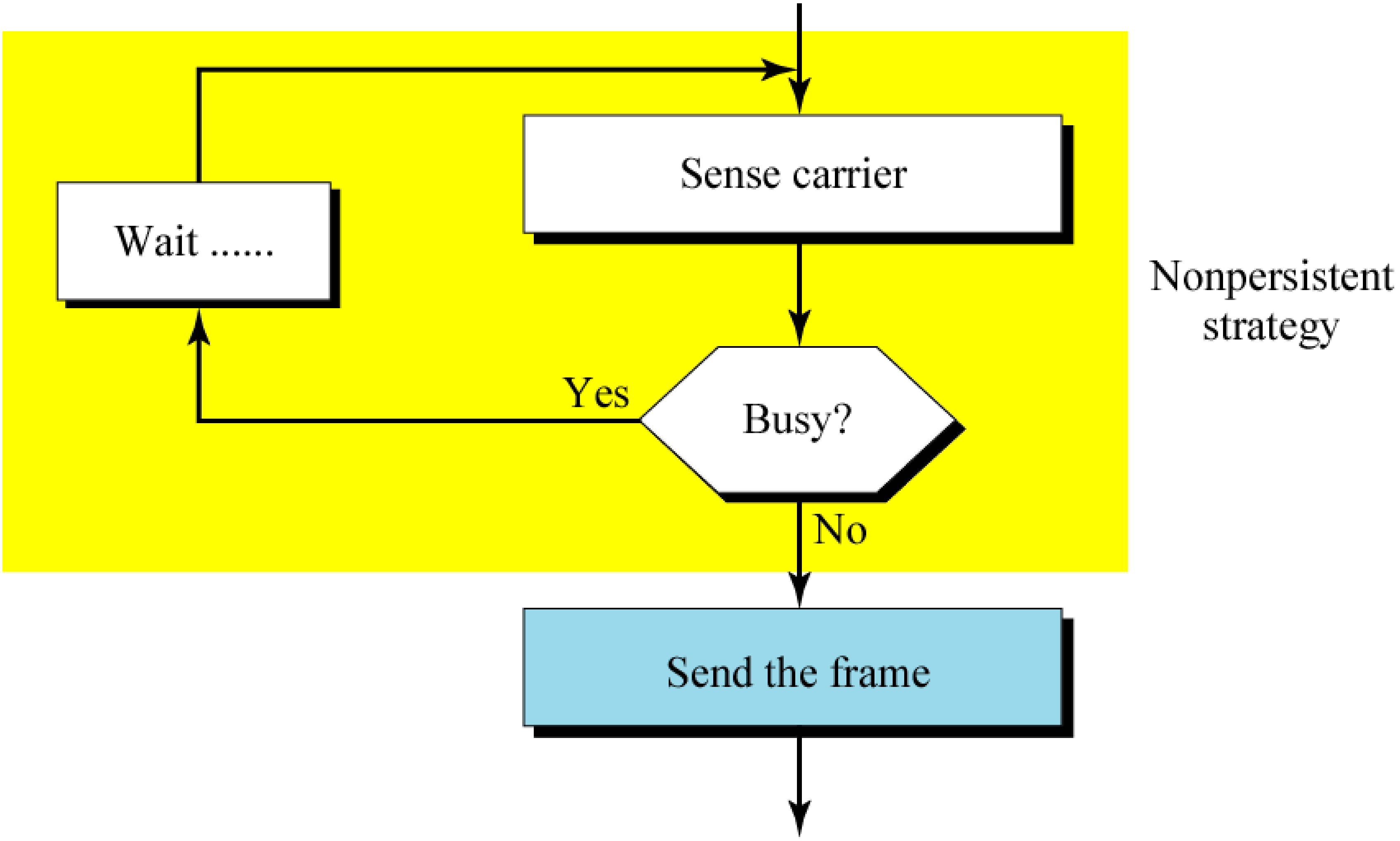
CSMA

- stations soon know transmission has started
- so first listen for clear medium (carrier sense)
- if medium idle, transmit
- if two stations start at the same instant, collision
  - wait reasonable time
  - if no ACK then retransmit
  - collisions occur occur at leading edge of frame
- max utilization depends on propagation time (medium length) and frame length

Nonpersistent CSMA

- Nonpersistent CSMA rules:
  1. if medium idle, transmit
  2. if medium busy, wait amount of time drawn from probability distribution (retransmission delay) & retry
- random delays reduces probability of collisions
- capacity is wasted because medium will remain idle following end of transmission
- nonpersistent stations are deferential

Nonpersistent Method



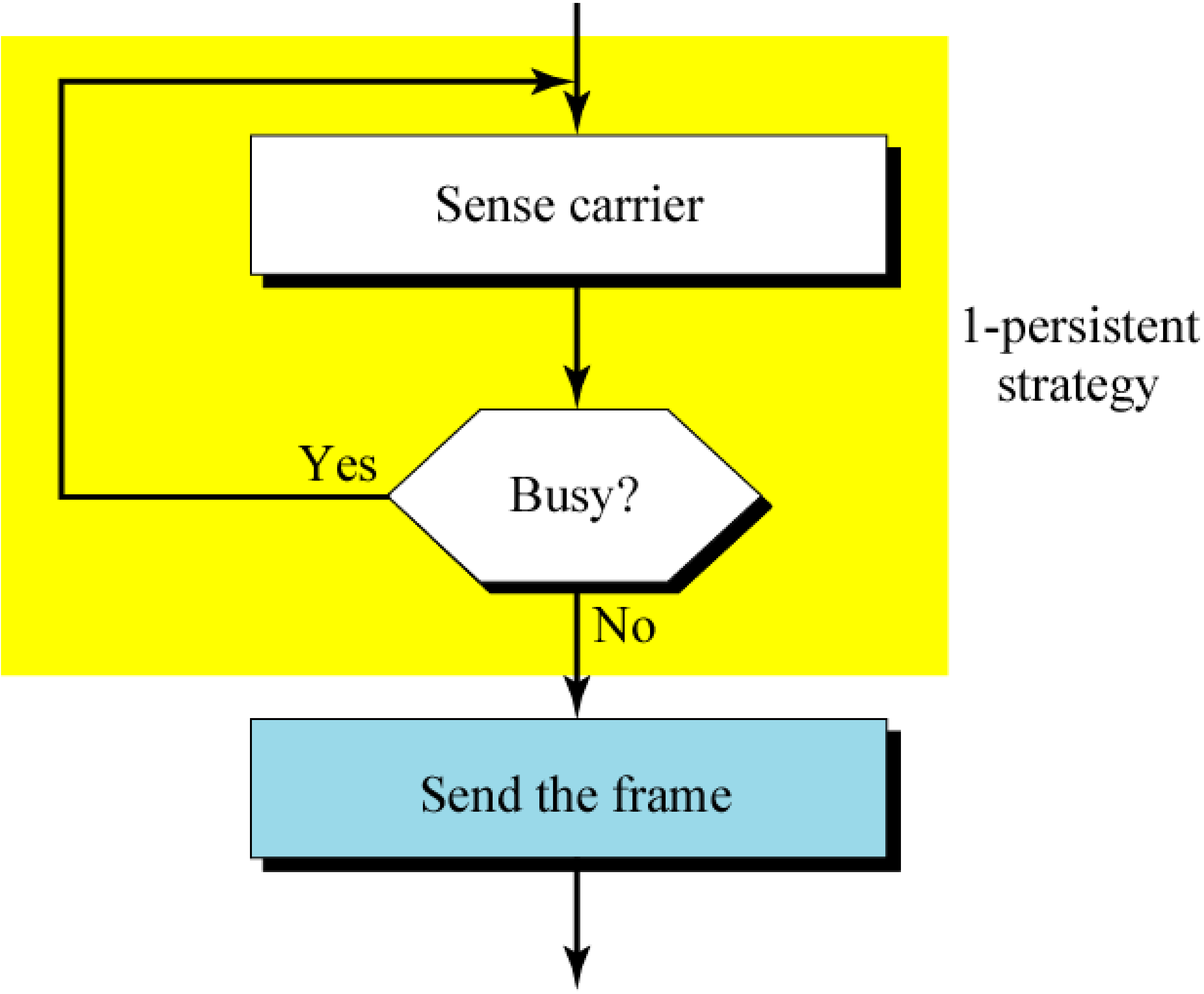
1-persistent CSMA

- 1-persistent CSMA avoids idle channel time
- 1-persistent CSMA rules:

1. if medium idle, transmit;
2. if medium busy, listen until idle; then transmit immediately

- 1-persistent stations are selfish
- if two or more stations waiting, a collision is guaranteed

1-Persistent Approach



P-persistent CSMA

- a compromise to try and reduce collisions and idle time
- p-persistent CSMA rules:
  1. if medium idle, transmit with probability p, and delay one time unit with probability (1–p)
  2. if medium busy, listen until idle and repeat step 1
  3. if transmission is delayed one time unit, repeat step 1
- issue of choosing effective value of p to avoid instability under heavy load

Value of p?

- have n stations waiting to send
- at end of tx, expected no of stations is np
  - if np>1 on average there will be a collision
- repeated tx attempts mean collisions likely
- eventually when all stations trying to send have continuous collisions hence zero throughput
- thus want np<1 for expected peaks of n
  - if heavy load expected, p small
  - but smaller p means stations wait longer

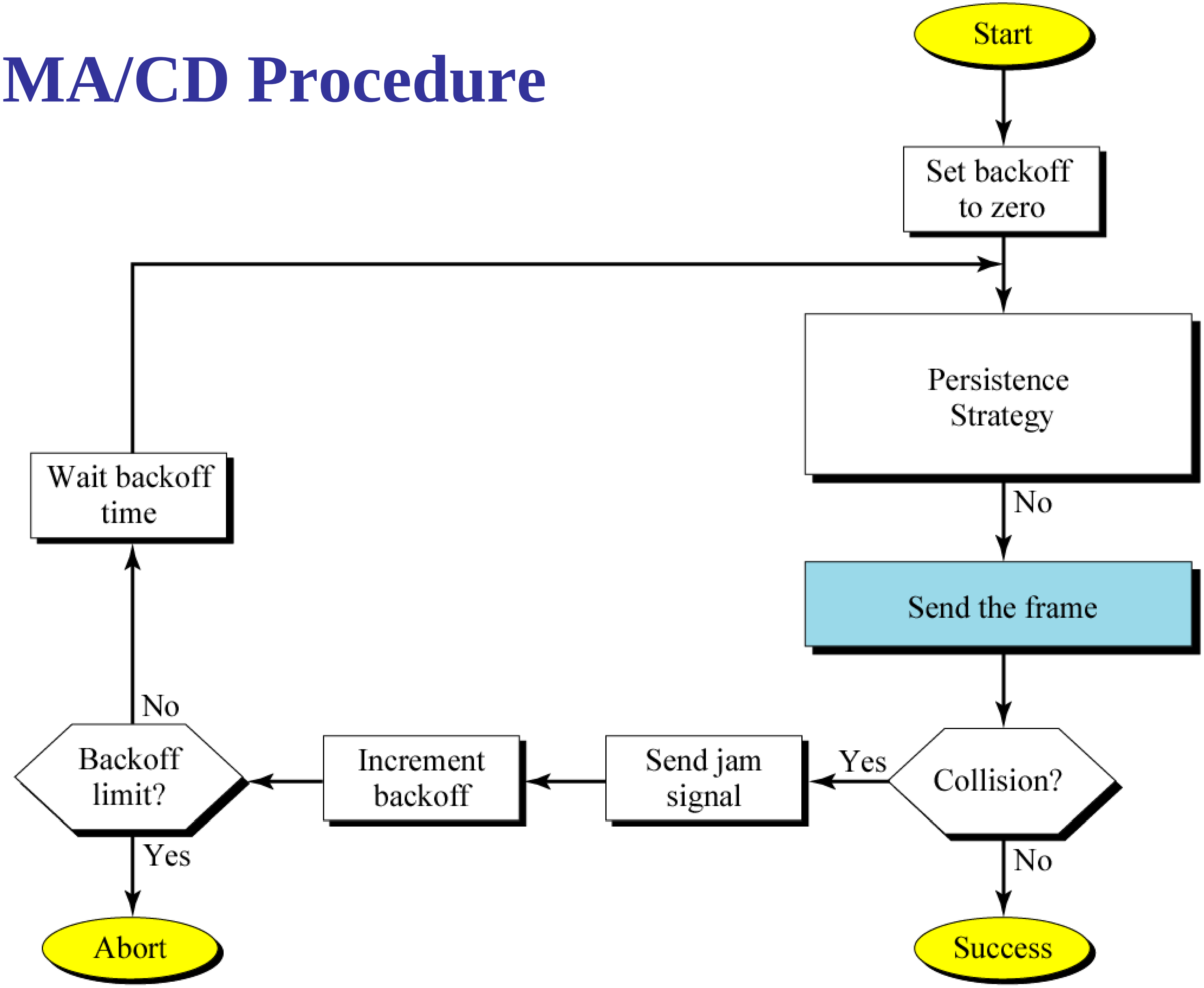
Ethernet (CSMA/CD)

- most widely used LAN standard
- developed by
  - Xerox - original Ethernet
  - IEEE 802.3
- Carrier Sense Multiple Access with Collision Detection (CSMA/CD)
  - random / contention access to media

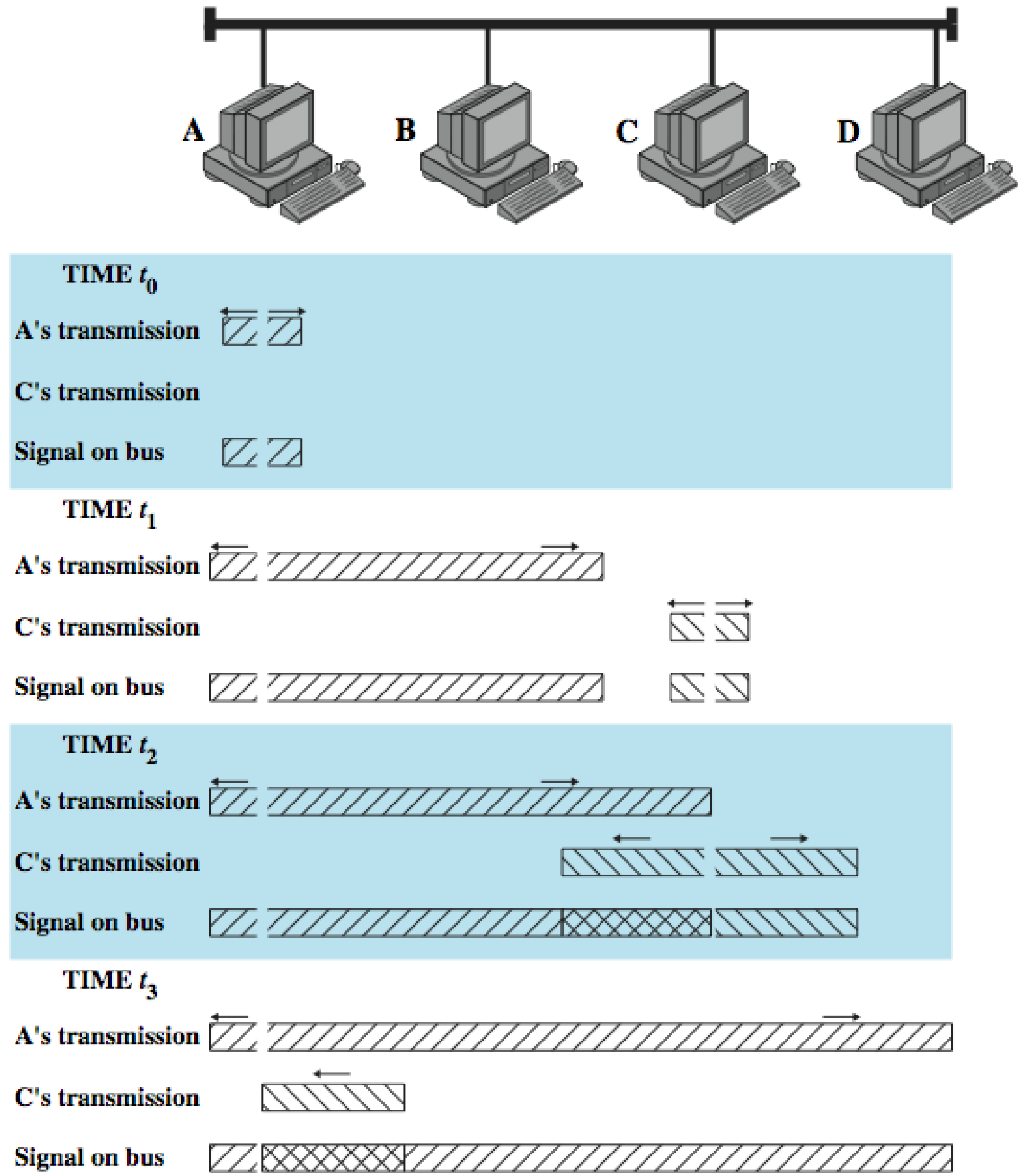
CSMA/CD Description

- with CSMA, collision occupies medium for duration of transmission
- better if stations listen whilst transmitting
- CSMA/CD rules:
  1. if medium idle, transmit
  2. if busy, listen for idle, then transmit
  3. if collision detected, jam and then cease transmission
  4. after jam, wait random time then retry

CSMA/CD Procedure



CSMA/CD Operation



Which Persistence Algorithm?

- IEEE 802.3 uses 1-persistent
- both nonpersistent and p-persistent have performance problems
- 1-persistent seems more unstable than p-persistent
  - because of greed of the stations
  - but wasted time due to collisions is short
  - with random backoff unlikely to collide on next attempt to send

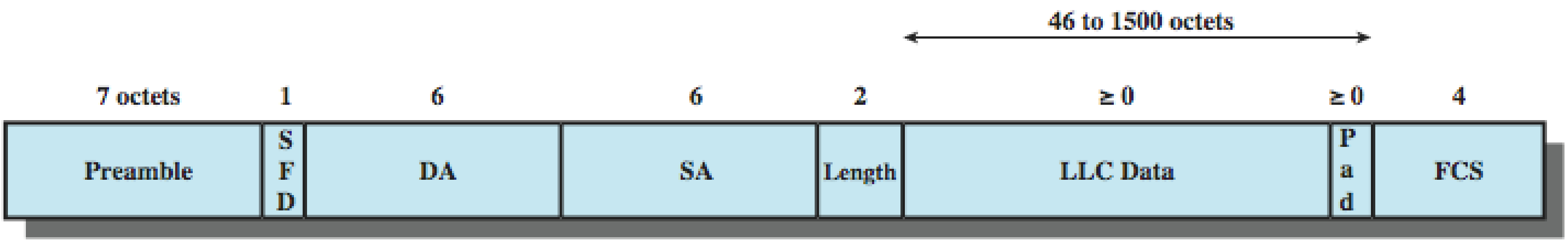
Binary Exponential Backoff

- for backoff stability, IEEE 802.3 and Ethernet both use binary exponential backoff
- backoff-time=r $\times$ slot-time
  - n: no. of experienced successive collisions
  - k: backoff factor = min (n, 10)
  - r: a random integer between 0 and 2^k-1
- stations repeatedly resend when collide
  - on first 10 attempts, mean random delay doubled
  - value then remains same for 6 further attempts
  - after 16 unsuccessful attempts, station gives up and reports error

Collision Detection

- on baseband bus
  - collision produces higher signal voltage
  - collision detected if cable signal greater than single station signal
  - signal is attenuated over distance
  - limit to 500m (10Base5) or 200m (10Base2)
- on twisted pair (star-topology)
  - activity on more than one port is collision
  - use 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)

	10BASE5	10BASE2	10BASE-T	10BASE-FP
Transmission medium	Coaxial cable (50 ohm)	Coaxial cable (50 ohm)	Unshielded twisted pair	850-nm optical fiber pair
Signaling technique	Baseband (Manchester)	Baseband (Manchester)	Baseband (Manchester)	Manchester/on-off
Topology	Bus	Bus	Star	Star
Maximum segment length (m)	500	185	100	500
Nodes per segment	100	30	—	33
Cable diameter (mm)	10	5	0.4 to 0.6	62.5/125 µm

Ethernet Address in Hexadecimal Notation

07-01-02-01-2C-4B

Globally and Locally Unique Addresses

- Global unique address
  - The first 3 bytes are the vendor block code
  - The second 3 bytes are the vendor specific identifier
- Locally unique address
  - The addresses of two NICs may be purchased from different vendors, the administrator should ensure the uniqueness

Modifications of Fast-Ethernet

- For a given minimum-length frame, the extent of a network scales inversely with data rate.
- For 100 Mbps Fast Ethernet, a choice had to be made to do one or more of the following:
  - Increase the minimum frame length so that large networks (with multiple repeaters) could be supported.
  - Leave the minimum frame as is, and decrease the extent of the network accordingly.
  - Change the CSMA/CD algorithm to avoid the conflict

Modifications of Fast-Ethernet

- Fast Ethernet uses
  - The same 512-bit minimum frame.
  - Decrease the network extent to the order of 200m, using twisted-pair cabling. No change to the CSMA/CD algorithm.

100Mbps Fast Ethernet

	100BASE-TX		100BASE-FX	100BASE-T4
Transmission medium	2 pair, STP	2 pair, Category 5 UTP	2 optical fibers	4 pair, Category 3, 4, or 5 UTP
Signaling technique	MLT-3	MLT-3	4B5B, NRZI	8B6T, NRZ
Data rate	100 Mbps	100 Mbps	100 Mbps	100 Mbps
Maximum segment length	100 m	100 m	100 m	100 m
Network span	200 m	200 m	400 m	200 m

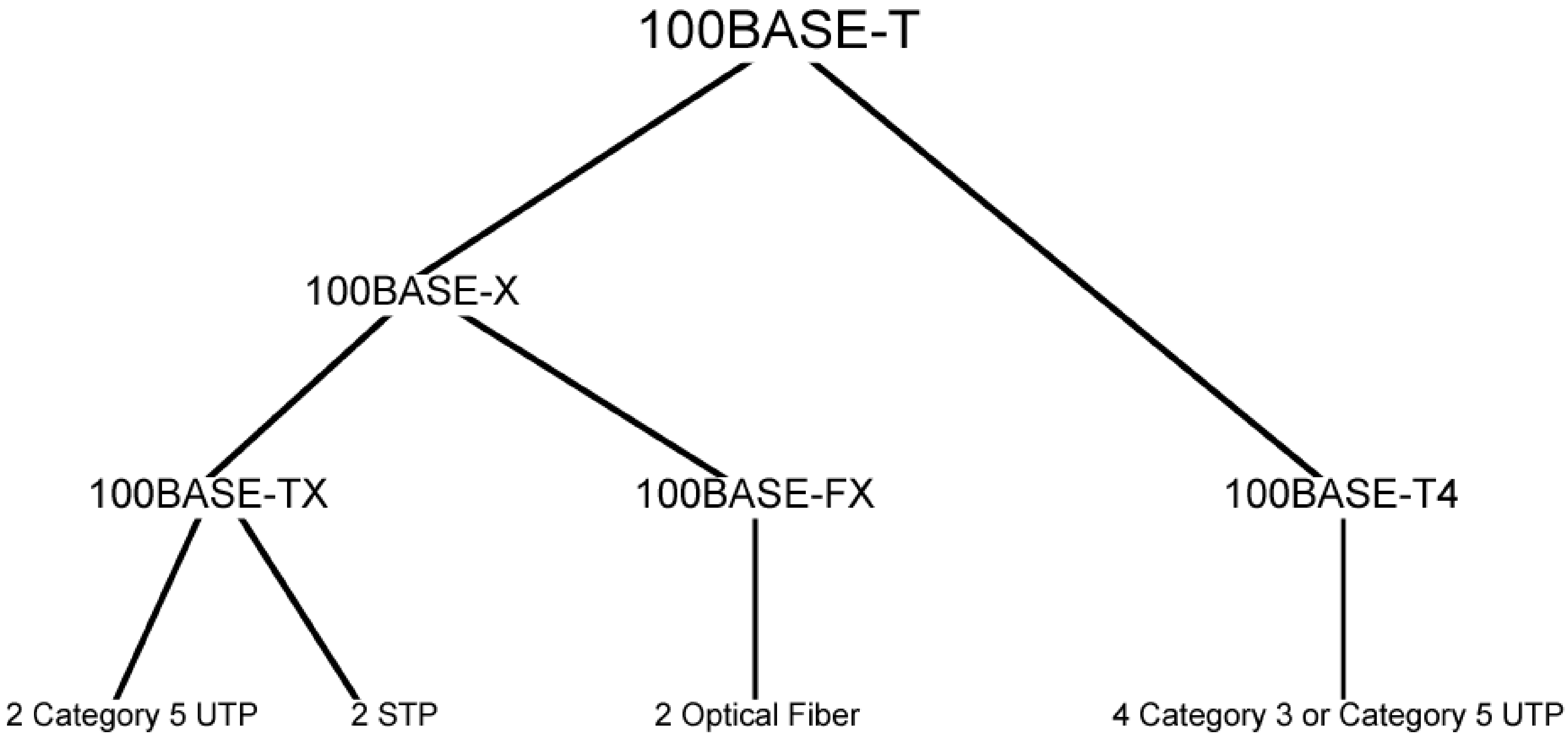
100BASE-X

- uses a unidirectional data rate 100 Mbps over single twisted pair or optical fiber link
- encoding scheme same as FDDI
  - 4B/5B-NRZI
- two physical medium specifications
  - 100BASE-TX
    - uses two pairs of twisted-pair cable for tx & rx
    - STP and Category 5 UTP allowed
    - MTL-3 signaling scheme is used
  - 100BASE-FX
    - uses two optical fiber cables for tx & rx
    - convert 4B/5B-NRZI code group into optical signals

100BASE-T4

- 100-Mbps over lower-quality Cat 3 UTP
  - takes advantage of large installed base
  - does not transmit continuous signal between packets
  - useful in battery-powered applications
- can not get 100 Mbps on single twisted pair
  - so data stream split into three separate streams
  - four twisted pairs used
  - data transmitted and received using three pairs
  - two pairs configured for bidirectional transmission
- use ternary signaling scheme (8B6T)

100BASE-T Options



Full Duplex Operation

- traditional Ethernet half duplex
- using full-duplex, station can transmit and receive simultaneously
- 100-Mbps Ethernet in full-duplex mode, giving a theoretical transfer rate of 200 Mbps
- stations must have full-duplex adapter cards
- and must use switching hub
  - each station constitutes separate collision domain
  - CSMA/CD algorithm no longer needed
  - 802.3 MAC frame format used

Mixed Configurations

- Fast Ethernet supports mixture of existing 10-Mbps LANs and newer 100-Mbps LANs
- supporting older and newer technologies
  - e.g. 100-Mbps backbone LAN supports 10-Mbps hubs
    - stations attach to 10-Mbps hubs using 10BASE-T
    - hubs connected to switching hubs using 100BASE-T
    - high-capacity workstations and servers attach directly to 10/100 switches
    - switches connected to 100-Mbps hubs use 100-Mbps links
    - 100-Mbps hubs provide building backbone
    - connected to router providing connection to WAN

Modifications of Gigabit Ethernet

- Fast Ethernet uses
  - The same 512-bit minimum frame.
  - Decrease the network extent to the order of 200m, using twisted-pair cabling. No change to the CSMA/CD algorithm.
- For Gigabit Ethernet, network extent is only about 20m !!, if the same approach is used.

Solutions for Gigabit Ethernet

- Keep the 512-bit minimum frame.
- Modify the MAC algorithm (Carrier Extension) to artificially extend the frame as seen on the physical channel so that a short frame appears longer.
  - This supports the same wiring closet topology (100m) without increasing the minimum length of the data portion of the frame.
- Provide an optional performance enhancement for senders of short frames (frame bursting).

Carrier Extended Frame Format

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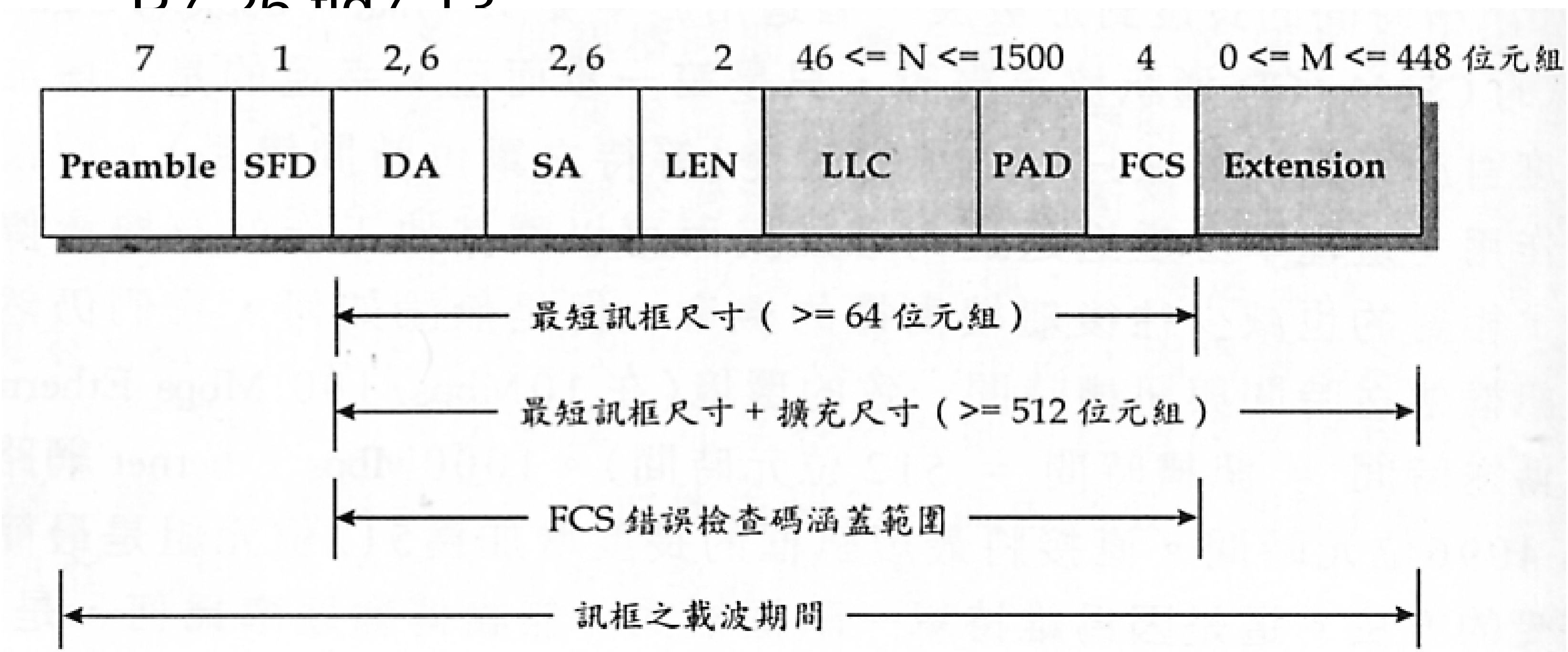
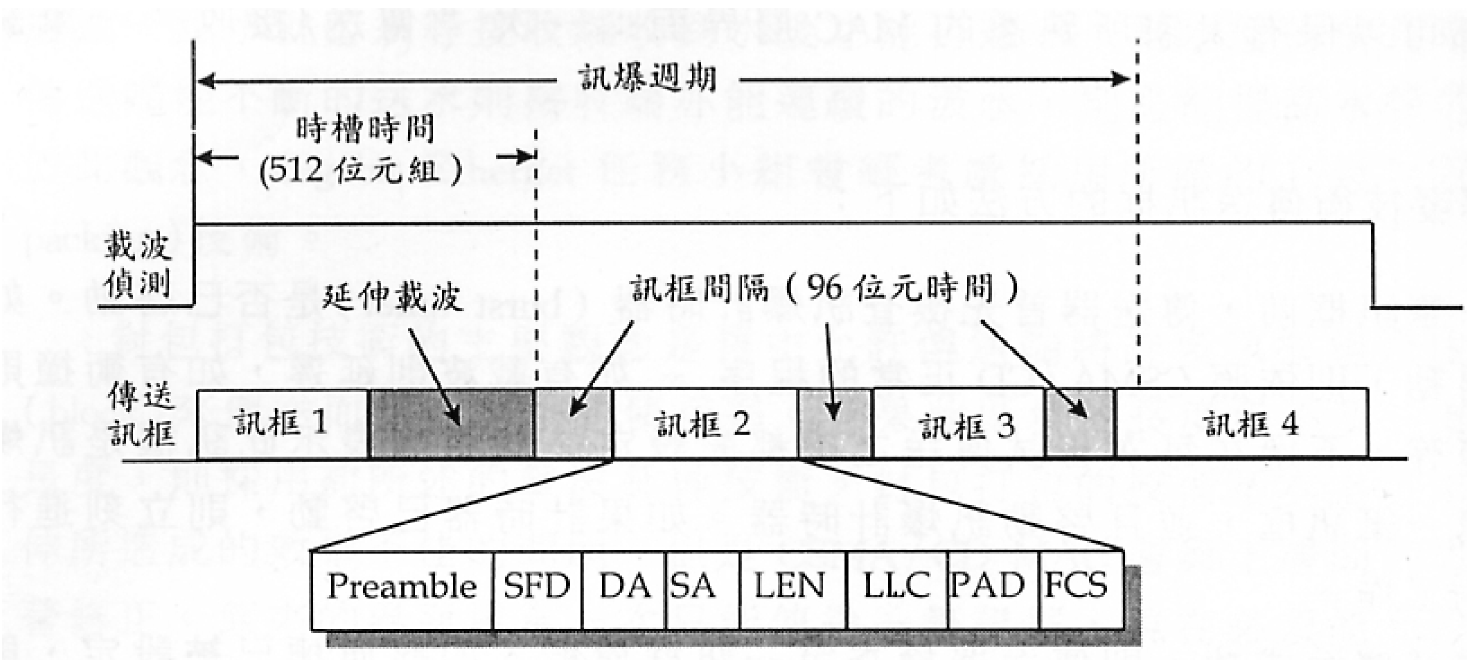
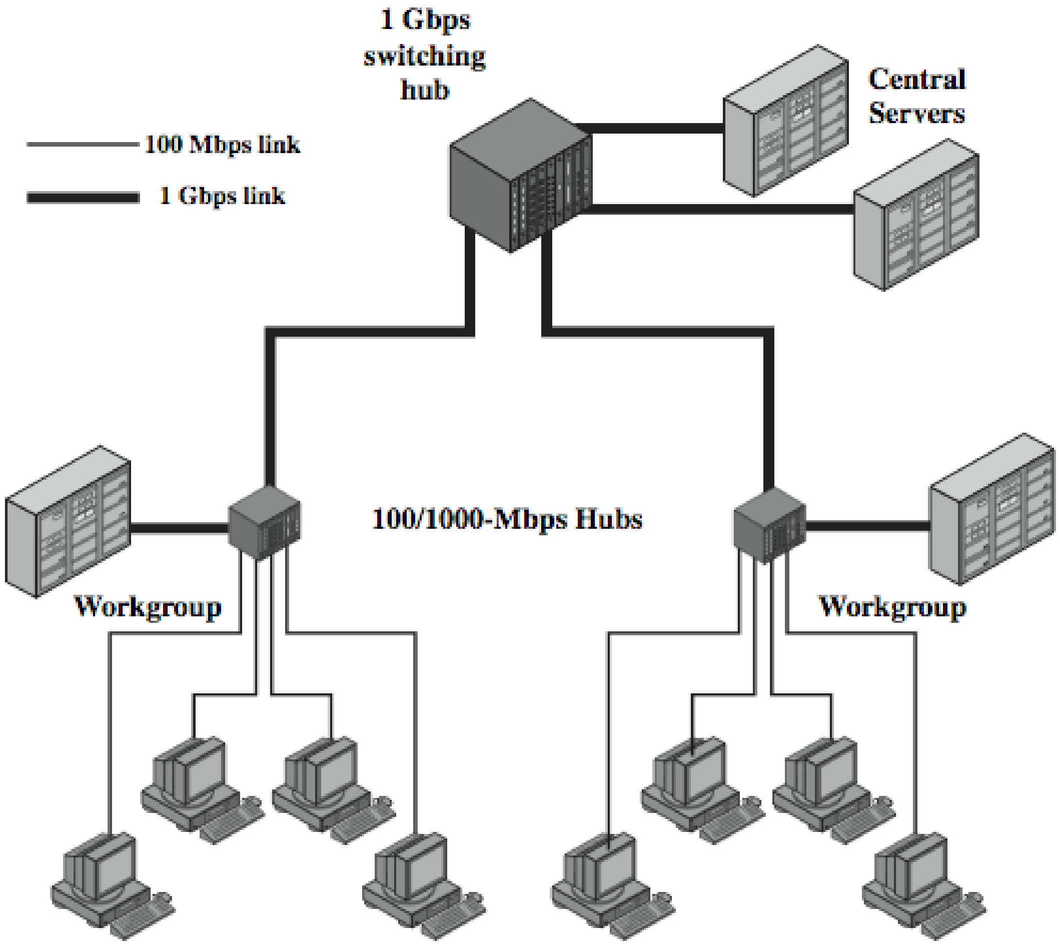


Frame Bursting



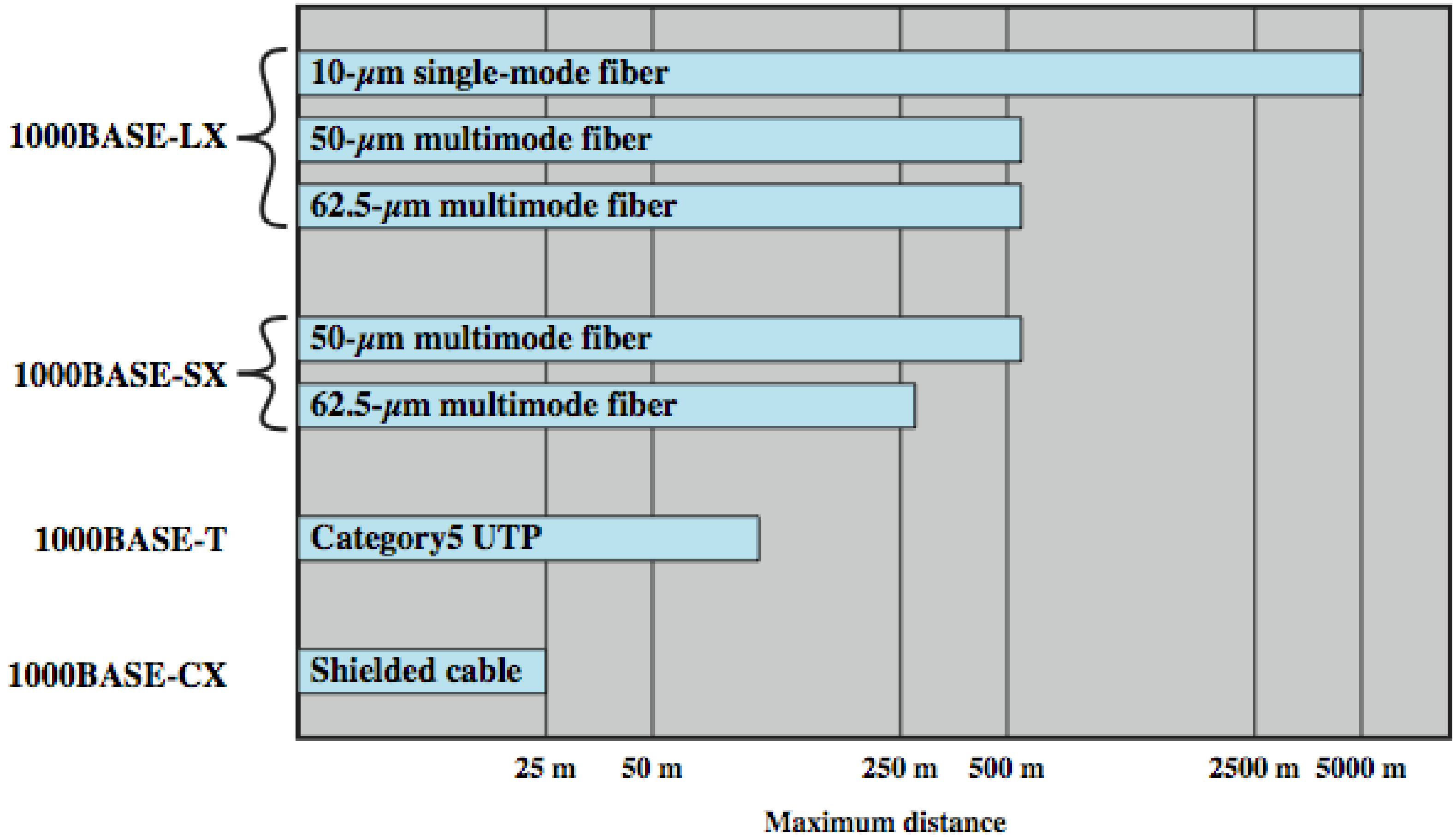
Gigabit Ethernet Configuration



Gigabit Ethernet - Differences

- carrier extension
  - at least 4096 bit-times long (512 for 10/100)
- frame bursting
- not needed if using a switched hub to provide dedicated media access

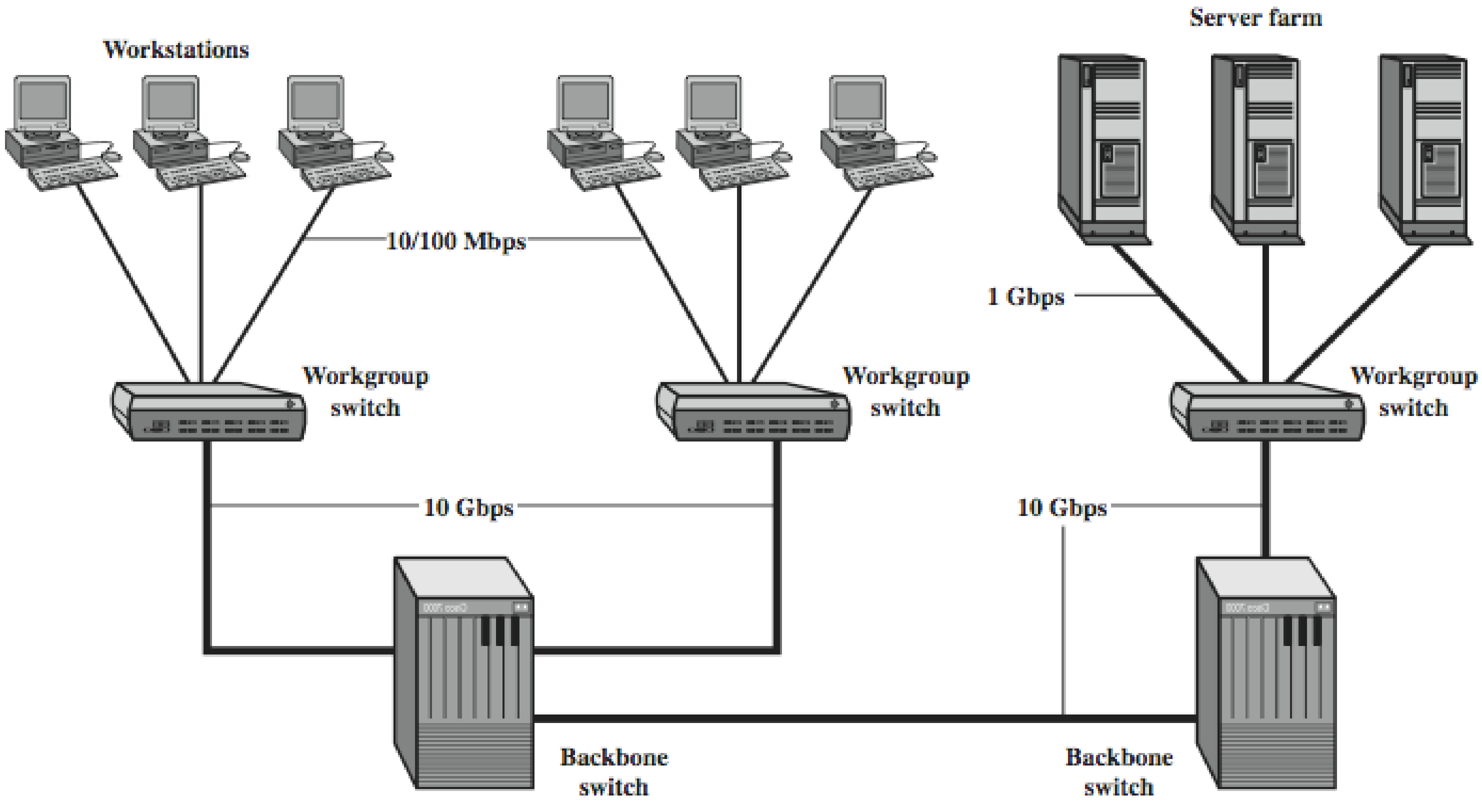
Gigabit Ethernet – Physical



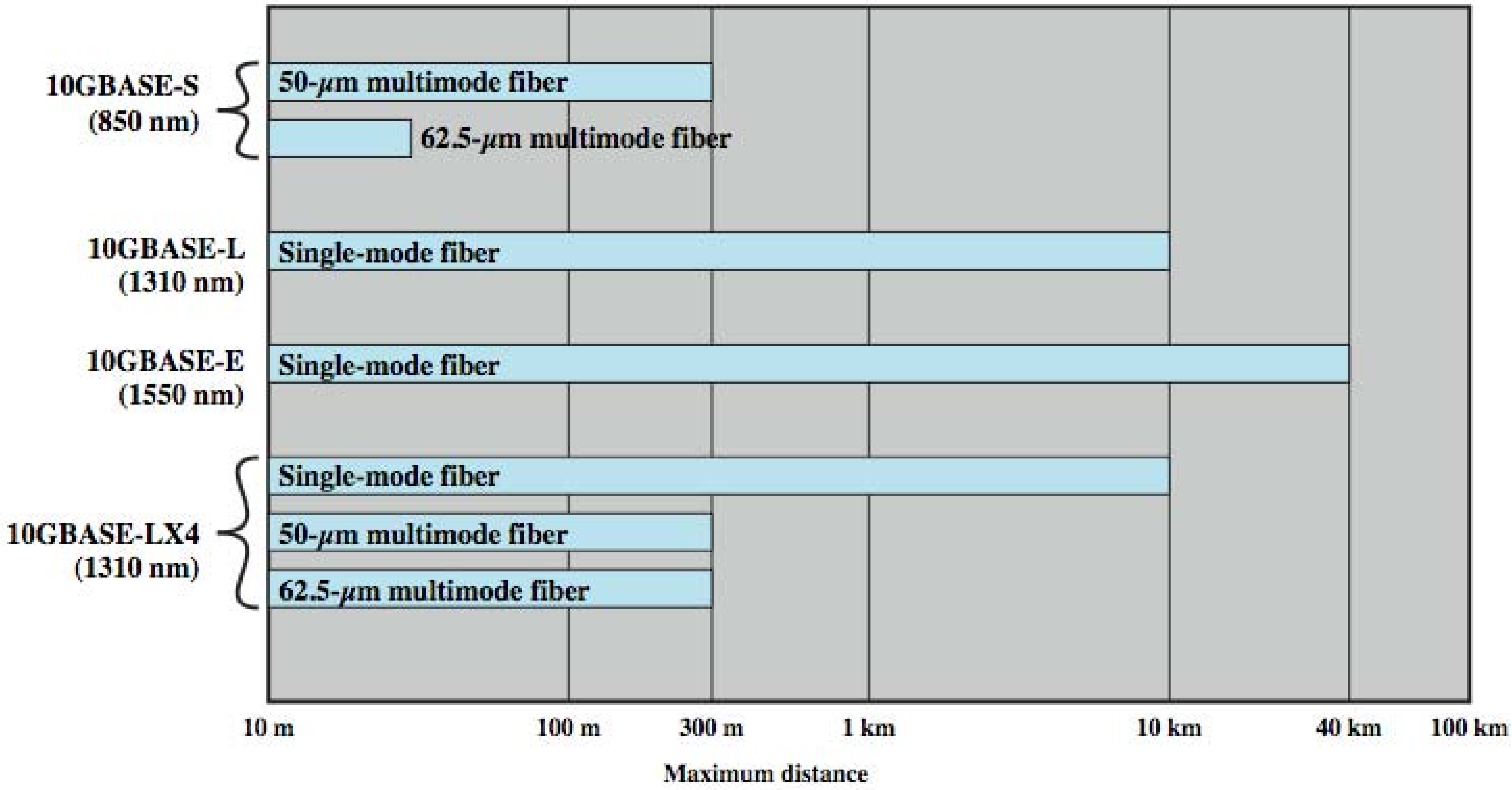
10Gbps Ethernet

- growing interest in 10Gbps Ethernet
  - for high-speed backbone use
  - with future wider deployment
- alternative to ATM and other WAN technologies
- uniform technology for LAN, MAN, or WAN
- advantages of 10Gbps Ethernet
  - no expensive, bandwidth-consuming conversion between Ethernet packets and ATM cells
  - IP and Ethernet together offers QoS and traffic policing approach ATM
  - have a variety of standard optical interfaces

10Gbps Ethernet Configurations



10Gbps Ethernet Options



Summary

- High speed LANs emergence
- Ethernet technologies
  - CSMA & CSMA/CD media access
  - 10Mbps ethernet
  - 100Mbps ethernet
  - 1Gbps ethernet
  - 10Gbps ethernet