③

CSMA/CD (CSMA with Collision Detection)

- In CSMA schemes, collisions involve entire frame transmissions
- The amount of the wasted bandwidth can be reduced by aborting the transmission as soon as a collision is detected
  - If a collision is detected during the transmission, the station
    - aborts the transmission
    - sends a short jamming signal to ensure that other stations know that a collision has occurred, and
    - use a backoff algorithm to schedule a future re-sensing time

IEEE 802.3 MAC Protocol

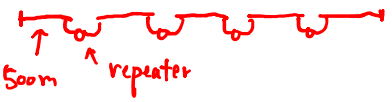
- 1-persistent CSMA/CD

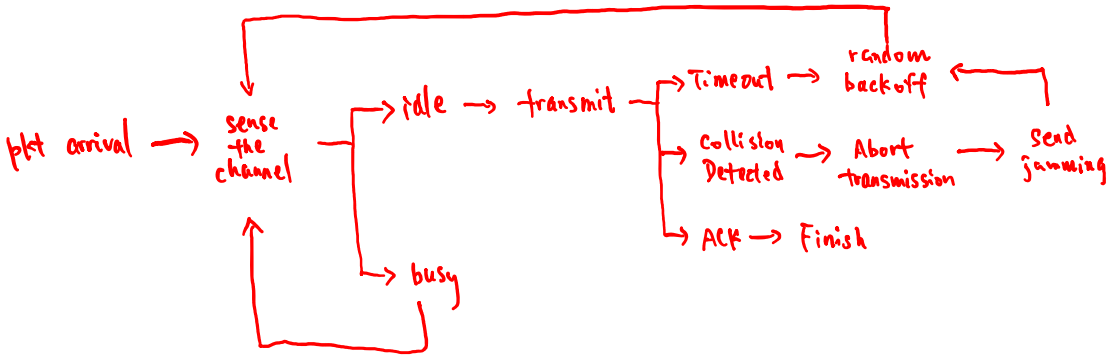
(modern Ethernet) bus topology

10 Base 5

10 Mbps

500m : max length of a bus segment





① random backoff

② How to detect collision?

③ why jamming?

IEEE 802.3 MAC Protocol

(Contention)

- Collision resolution: Truncated Binary Exponential Backoff
  - If a station has experienced the n^{th} collision in a row for a frame, it selects an integer value (K) at random from {0, 1, … …, 2^m-1} where m = min(n, 10) and waits for K mini-slots (each mini-slot = $2t_{prop}$) before sensing again
  - Up to 16 re-transmission attempts will be allowed, after which the system gives up

failure

choose K from $\{0, 1, \cdots, 2^m - 1\}$

where $m = \min(n, 10)$

wait for K mini-slots

$2 t_{prop}$

IEEE 802.3 MAC Protocol

- Collision resolution: Truncated Binary Exponential Backoff
  - The increasing range of selection for backoff after each collision is intended to increase the likelihood that re-transmission will succeed.

Eg. 2 stations (A,B) have pkt arrival at the same time

1st round of attempt : $Pr(\text{collision}) = 1$

2nd round : $n = 1$, $m = 1$, $k \in \{0, 1\}$

	k value	
A	0	1
B	0	1

$Pr(\text{collision}) = \frac{2}{2 \times 2} = 50\%$

3rd round : $n = 2$, $m = 2$, $k \in \{0, 1, 2, 3\}$

$Pr(\text{collision}) = \frac{4}{4 \times 4} = 25\%$

IEEE 802.3 MAC Protocol

- Collision Detection

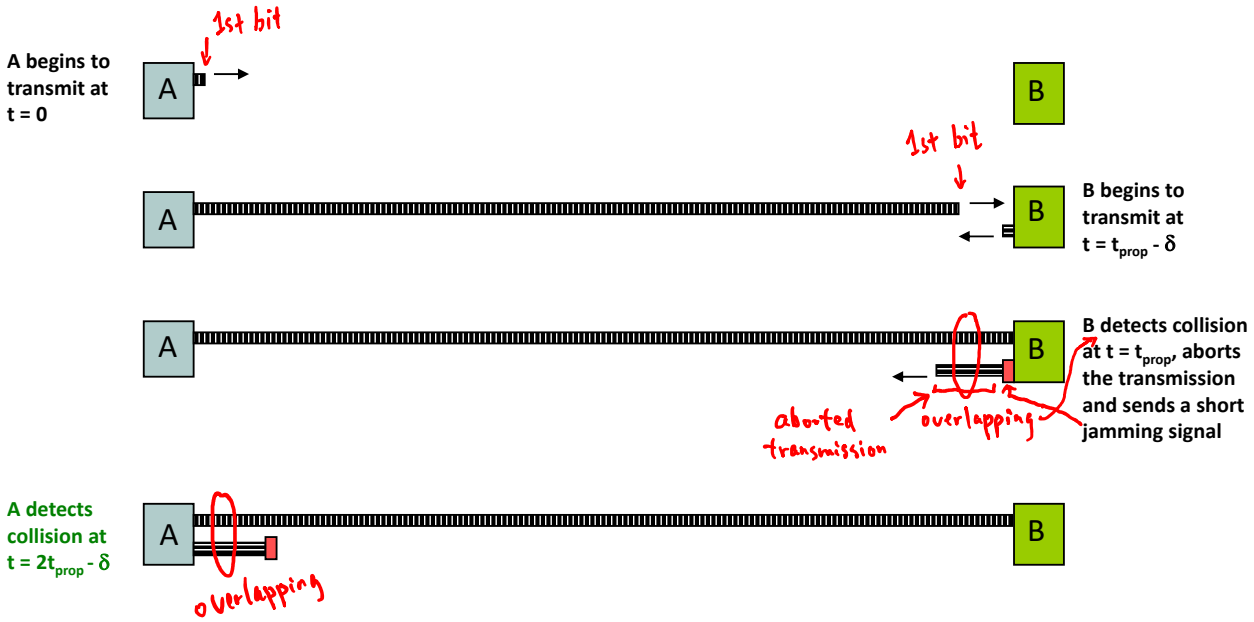
Goal: detect whether a station's own on-going transmission collides with other stations' transmissions

How: based on "abnormal voltage level" on the medium

↑ caused by overlapping signals

- own signal → min frame size: $2t_{prop} * R$
- other signal(s) → jamming signal to follow aborted transmission (48 bits in IEEE 802.3)

CSMA/CD Reaction Time



- It takes A up to $2t_{prop}$ time to find out whether it has captured the channel successfully

Minimum Frame Size in IEEE 802.3 Ethernet

$(2t_{prop}) * R \leq$ min frame size

R ↑ data rate

duration of time to keep transmitting

10 Base 5

$$t_{prop} = \frac{500\,m * 5}{2 * 10^8\ m/s} + 3\,\mu s * 4$$

($2 * 10^8$ m/s: speed of signal prop; $3\,\mu s * 4$: processing delay at repeater)

$= 24.5\,\mu s$

min frame size $= (2t_{prop}) * R$

$= 49\,\mu s * 10\,Mbps = 490$ bits

⇓

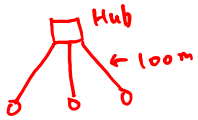
512 bits = 64 bytes

100 Mbps Ethernet :

R

bus → star

500 m → 100 m segment



$$t_{prop} = \frac{100 * 2}{2 * 10^8} + 1\,\mu s$$

$= 2\,\mu s$

$(2t_{prop}) * R = 400$ bits $\leq$ 512 bits

1 Gbps Ethernet

R

min frame size = 512 bytes

= 4096 bits

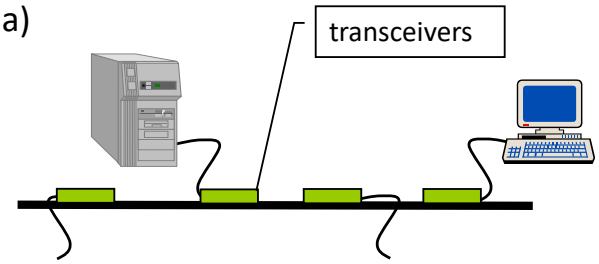
$(2t_{prop}) * R = 4000$ bits

Ethernet Physical Layers

Hubs & Switches

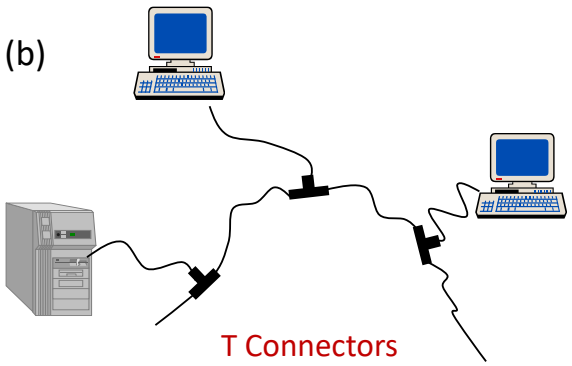
	10base5	10base2	10baseT	100baseT
Medium	thick coax	thin coax	twisted pair	CAT5
Max Segment Length	500 m	200 m	100 m	100 m
Topology	bus	bus	star	star

(a)



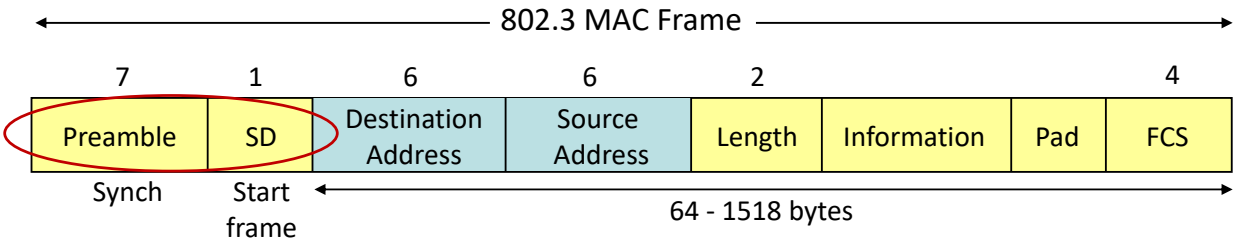
Thick Coax: stiff, hard to work with

(b)

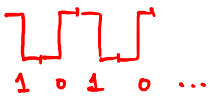


T Connectors

IEEE 802.3 MAC Frame



- Preamble helps receiver synchronize its clock to transmitter clock
  - 7 bytes of 10101010 generate a square wave



- Start frame byte changes to "10101011"

- Receiver looks for change in "10" pattern