IEEE 802.3 MAC: Ethernet

MAC Protocol:

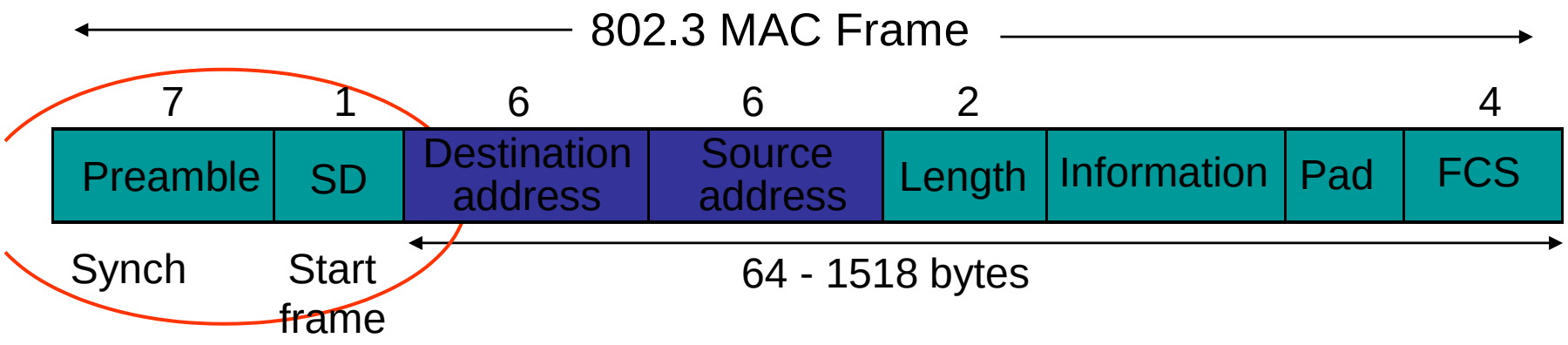
- CSMA/CD
- *Slot Time* is the critical system parameter
  - upper bound on time to detect collision
  - upper bound on time to acquire channel
  - upper bound on length of frame segment generated by collision
  - quantum for retransmission scheduling
  - max{round-trip propagation, MAC jam time}
- Truncated binary exponential backoff
  - for retransmission n: $0 < r < 2^k$, where k=min(n,10)
  - Give up after 16 retransmissions

IEEE 802.3 Original Parameters

- Transmission Rate: 10 Mbps
- Min Frame: 512 bits = 64 bytes
- Slot time: 512 bits/10 Mbps = 51.2 μsec
  - 51.2 μsec x $2x10^5$ km/sec =10.24 km, 1 way
  - 5.12 km round trip distance
- Max Length: 2500 meters + 4 repeaters

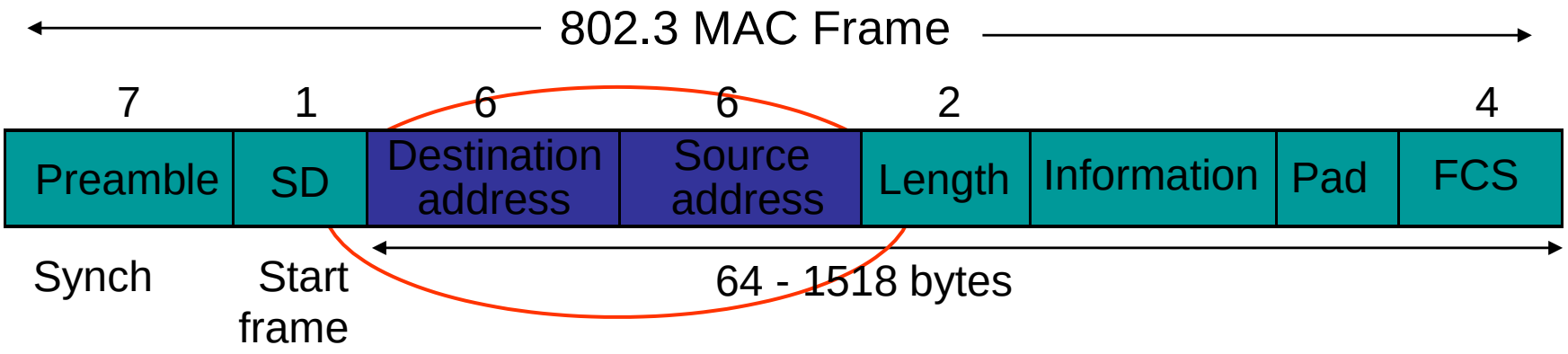
- *Each x10 increase in bit rate, must be accompanied by x10 decrease in distance*

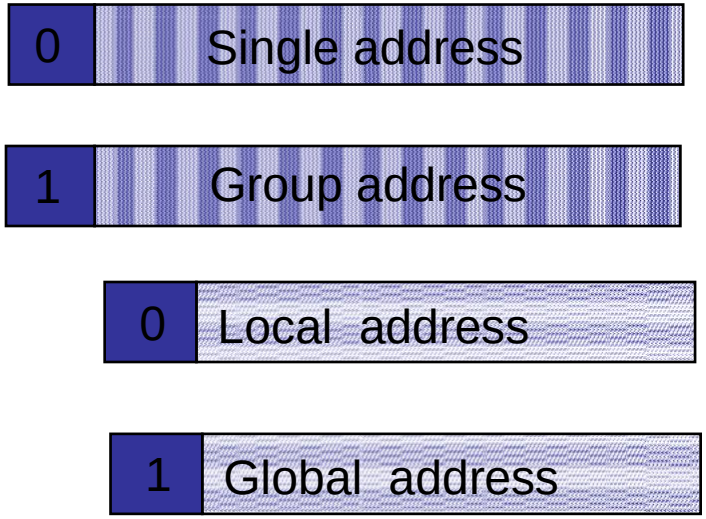
IEEE 802.3 MAC Frame



- Every frame transmission begins “from scratch”
- Preamble helps receivers synchronize their clocks to transmitter clock
- 7 bytes of 10101010 generate a square wave
- Start frame byte changes to 10101011
- Receivers look for change in 10 pattern

IEEE 802.3 MAC Frame



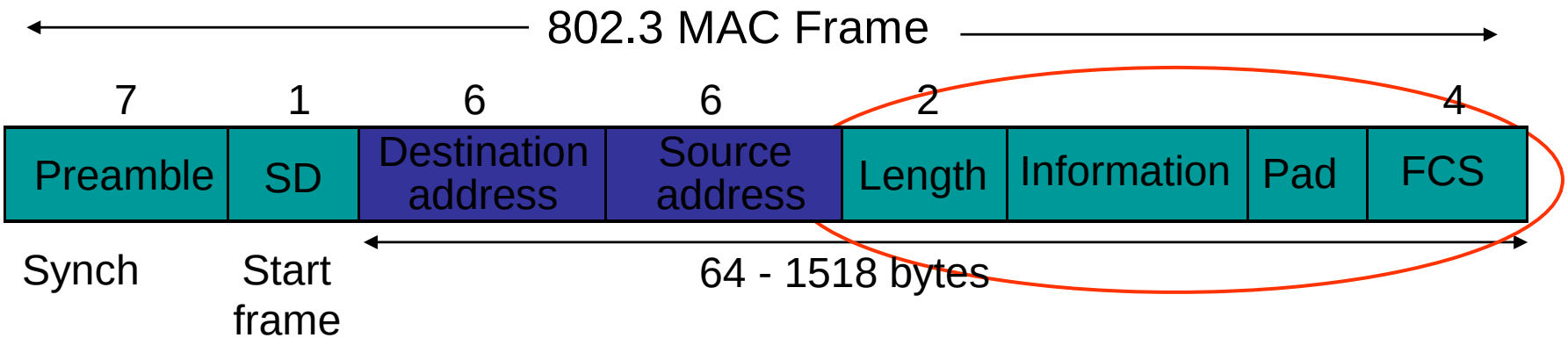


- Destination address
  - single address
  - group address
  - broadcast = 111...111

  Addresses
  - local or global

  Global addresses
  - first 24 bits assigned to manufacturer;
  - next 24 bits assigned by manufacturer
  - Cisco 00-00-0C
  - 3COM 02-60-8C

IEEE 802.3 MAC Frame



- Length: # bytes in information field
  - Max frame 1518 bytes, excluding preamble & SD
  - Max information 1500 bytes: 05DC
- Pad: ensures min frame of 64 bytes
- FCS: CCITT-32 CRC, covers addresses, length, information, pad fields
  - NIC discards frames with improper lengths or failed CRC

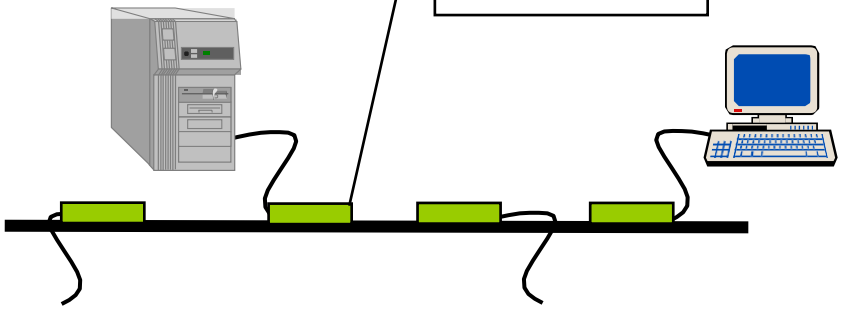
IEEE 802.3 Physical Layer

Table 6.2 IEEE 802.3 10 Mbps medium alternatives

	10base5	10base2	10baseT	10baseFX
Medium	Thick coax	Thin coax	Twisted pair	Optical fiber
Max. Segment Length	500 m	200 m	100 m	2 km
Topology	Bus	Bus	Star	Point-to-point link

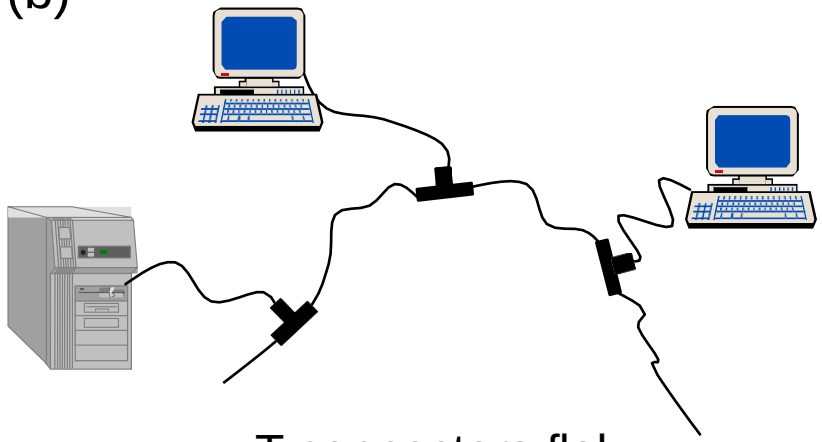
Hubs & Switches!

(a)



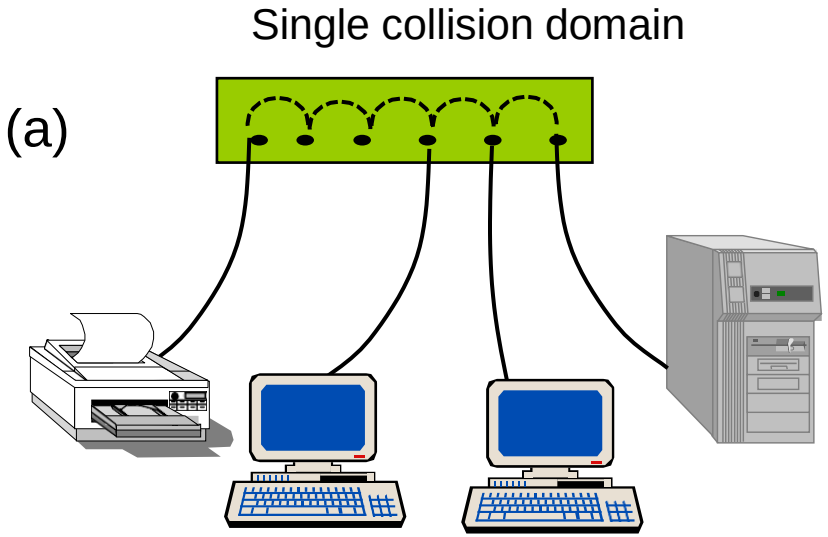
Thick Coax: Stiff, hard to work with

(b)

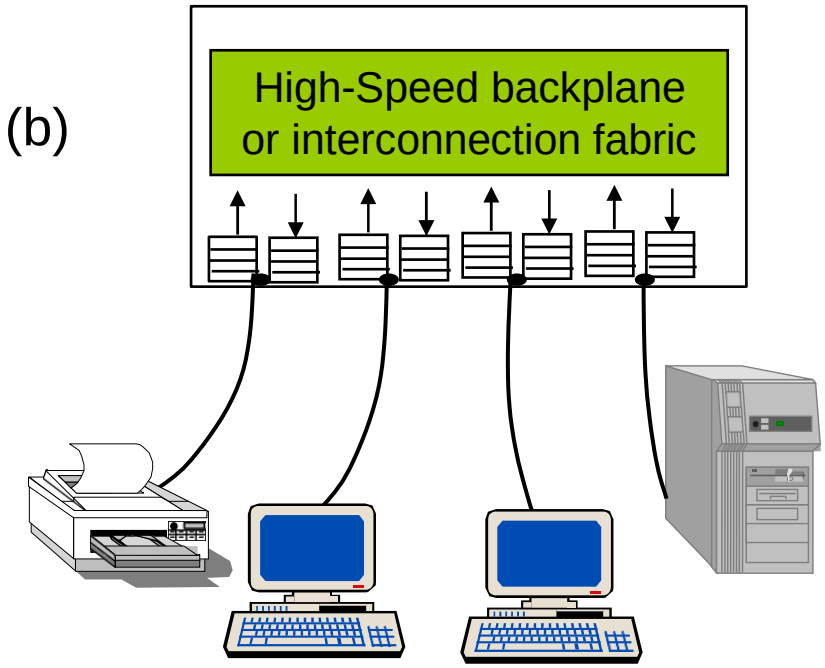


T connectors flaky

Ethernet Hubs & Switches

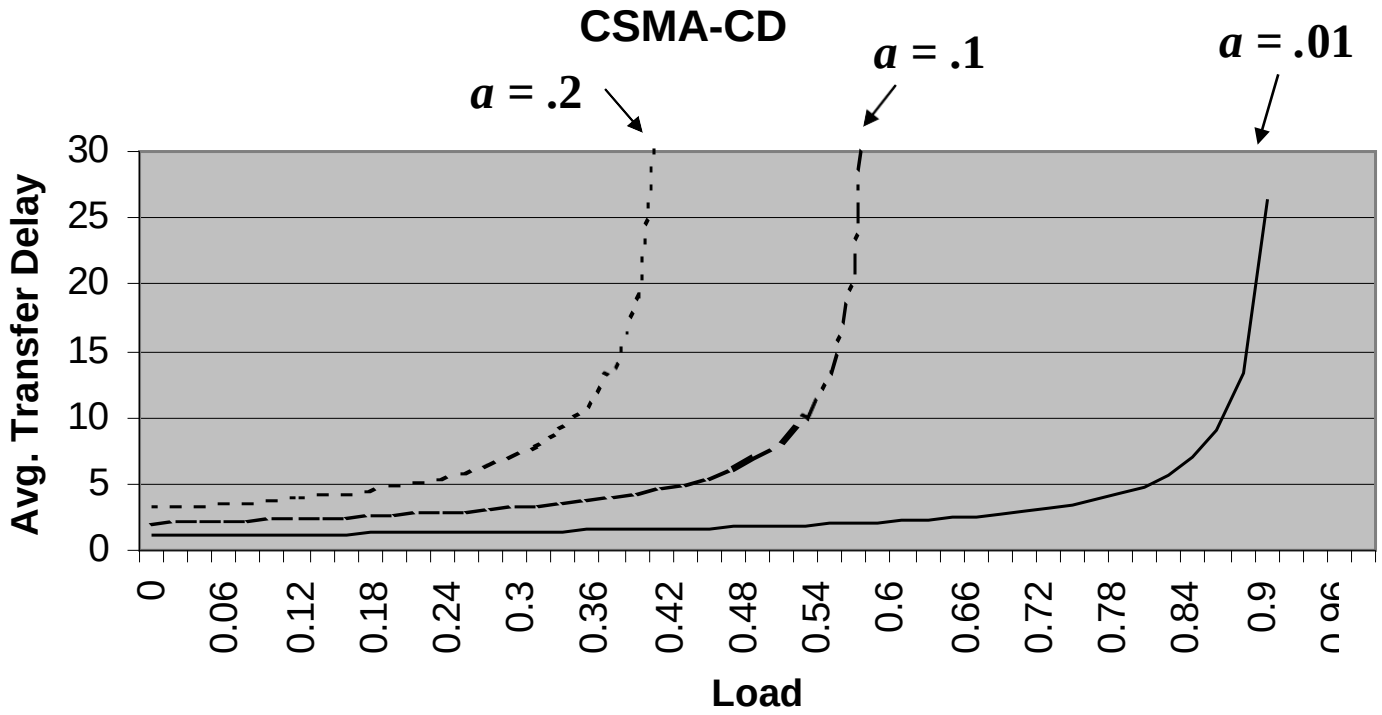


Twisted Pair Cheap
Easy to work with
Reliable
Star-topology CSMA-CD



Twisted Pair Cheap
Bridging increases scalability
Separate collision domains
Full duplex operation

Ethernet Scalability



- CSMA-CD maximum throughput depends on normalized delay-bandwidth product $a=t_{prop}/X$
- x10 increase in bit rate = x10 decrease in X
- To keep a constant need to either: decrease t_{prop}

(distance) by x10; or increase frame length x10

Fast Ethernet

Table 6.4 IEEE 802.3 100 Mbps Ethernet medium alternatives

	100baseT4	100baseT	100baseFX
Medium	Twisted pair category 3 UTP 4 pairs	Twisted pair category 5 UTP two pairs	Optical fiber multimode Two strands
Max. Segment Length	100 m	100 m	2 km
Topology	Star	Star	Star

To preserve compatibility with 10 Mbps Ethernet:

- Same frame format, same interfaces, same protocols
- Hub topology only with twisted pair & fiber
- Bus topology & coaxial cable abandoned
- Category 3 twisted pair (ordinary telephone grade) requires 4 pairs
- Category 5 twisted pair requires 2 pairs (most popular)
- Most prevalent LAN today

Gigabit Ethernet

Table 6.3 IEEE 802.3 1 Gbps Fast Ethernet medium alternatives

	1000baseSX	1000baseLX	1000baseCX	1000baseT
Medium	Optical fiber multimode Two strands	Optical fiber single mode Two strands	Shielded copper cable	Twisted pair category 5 UTP
Max. Segment Length	550 m	5 km	25 m	100 m
Topology	Star	Star	Star	Star

- Slot time increased to *512 bytes*
- Small frames need to be extended to 512 B
- Frame bursting to allow stations to transmit burst of short frames
- Frame structure preserved but CSMA-CD essentially abandoned
- Extensive deployment in backbone of enterprise data networks and in server farms

10 Gigabit Ethernet

Table 6.5 IEEE 802.3 10 Gbps Ethernet medium alternatives

	10GbaseSR	10GBaseLR	10GbaseEW	10GbaseLX4
Medium	Two optical fibers Multimode at 850 nm 64B66B code	Two optical fibers Single-mode at 1310 nm 64B66B	Two optical fibers Single-mode at 1550 nm SONET compatibility	Two optical fibers multimode/single-mode with four wavelengths at 1310 nm band 8B10B code
Max. Segment Length	300 m	10 km	40 km	300 m – 10 km

- Frame structure preserved
- CSMA-CD protocol officially abandoned
- LAN PHY for local network applications
- WAN PHY for wide area interconnection using SONET OC-192c
- Extensive deployment in metro networks anticipated

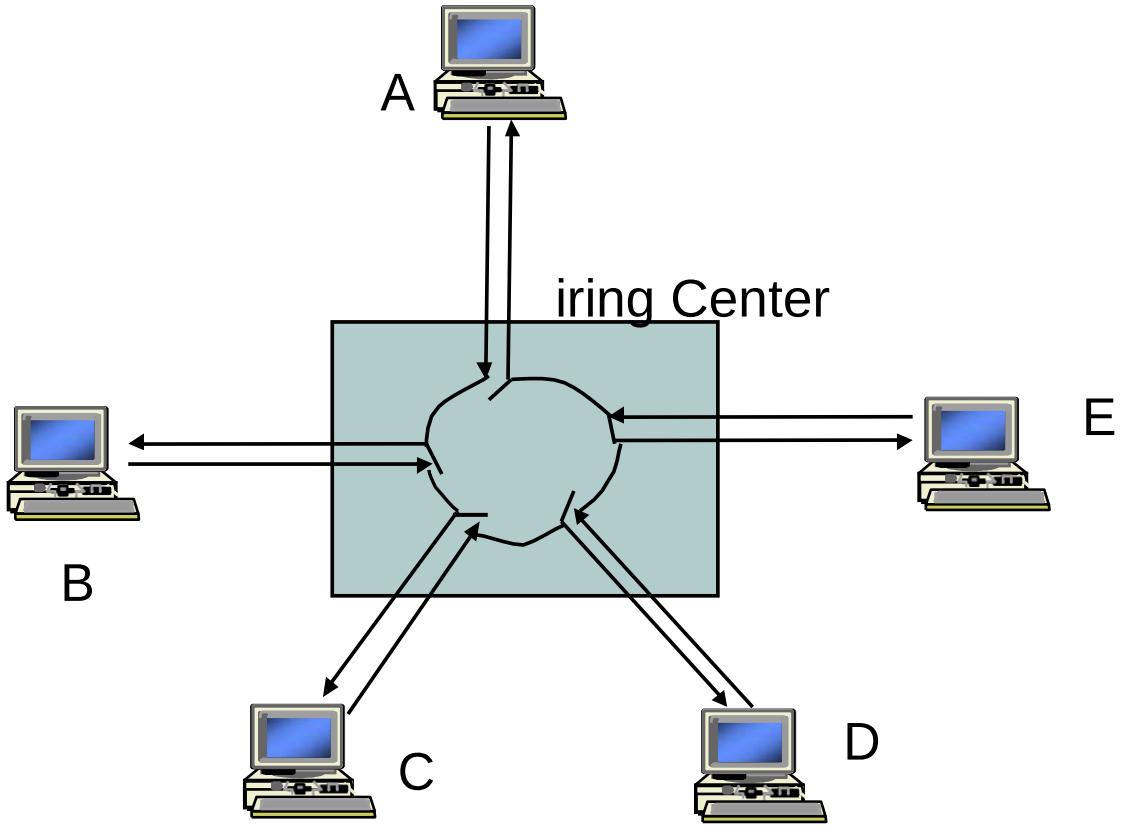
Token Ring

IEEE 802.5 Ring LAN

- Unidirectional ring network
- 4 Mbps and 16 Mbps on twisted pair
  - Differential Manchester line coding
- Token passing protocol provides access
  - ✓ Fairness
  - ✓ Access priorities
  - ⌑ Breaks in ring bring entire network down
- Reliability by using star topology

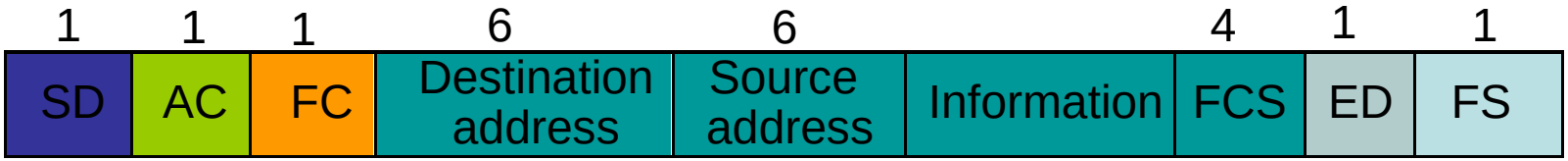
Star Topology Ring LAN

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



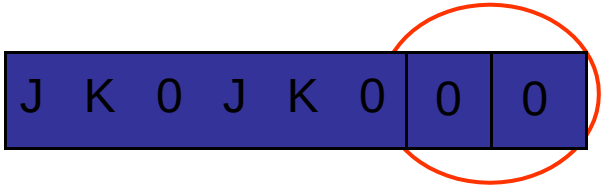
Token Frame Format

Data frame format



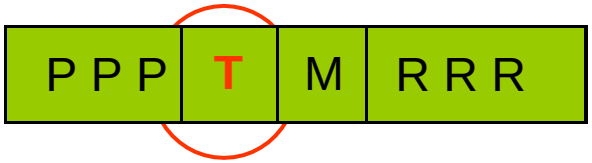
Token frame format

Starting delimiter



J, K nondata 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

References:

Data Communications and Networking By Behrouz A.Forouzan