

EITF25 – Internet: Technology and Applications

Data Link Layer

-2-

Network Access

2013, Lecture 03

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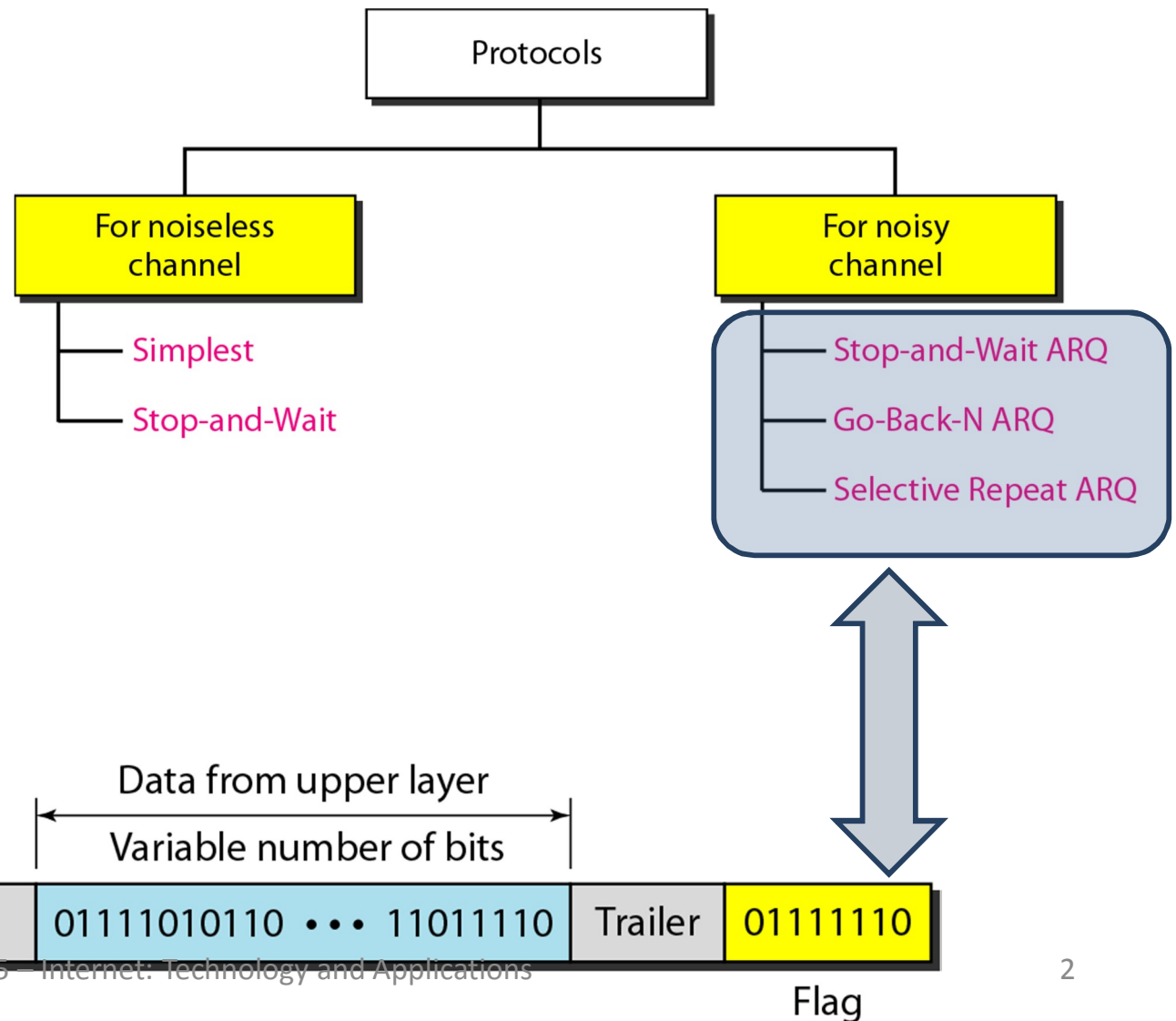
Underlying LAN or WAN
technology



Previously on EITF25

Logical Link Control Sublayer

- Flow control
 - Send data
 - Wait for ACK
- Error control
 - Detect error
 - Retransmit
- Framing

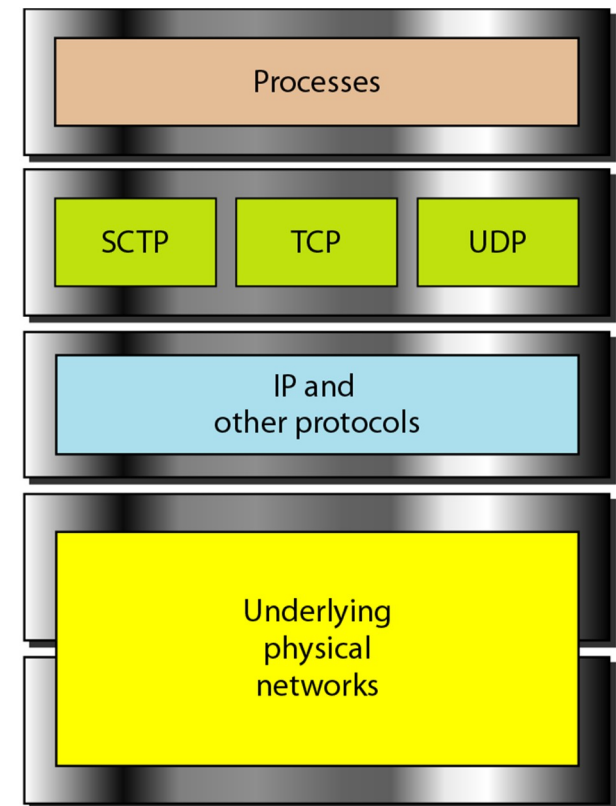


Internet: Data Link Layer

(2)

Medium Access Control Sublayer

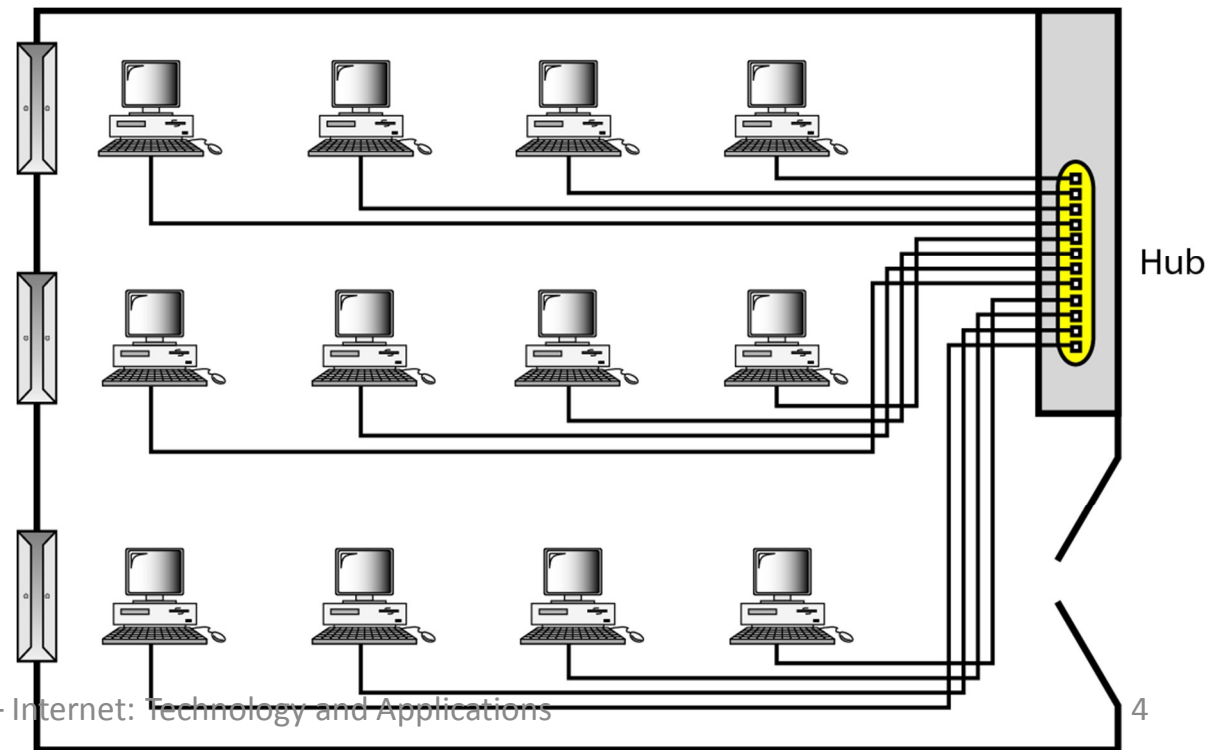
- Access methods
[Forouzan ed.5 ch.12.1-2]
- Ethernet
[Forouzan ed.5 ch.13.1-5]
- Wireless local area networks
[Forouzan ed.5 ch.15.1-2]



**[Kihl & Andersson: 5.1-6]*

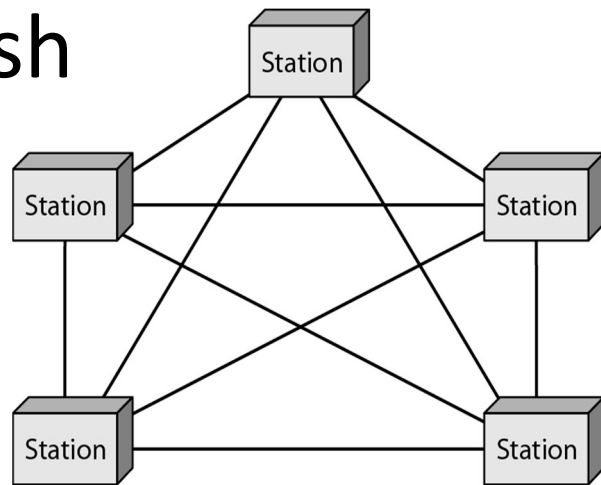
Local Area Networks (LAN)

- Typically limited in size
- Traditionally "shared-medium"
- Designed for private areas
 - Offices
 - Campuses
 - Homes

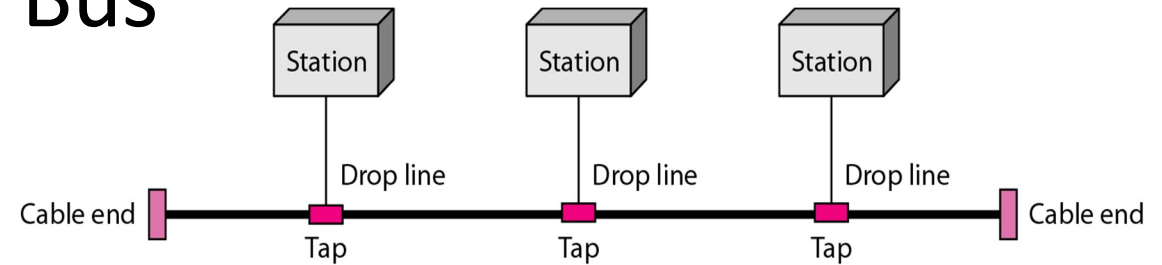


Conventional LAN topologies

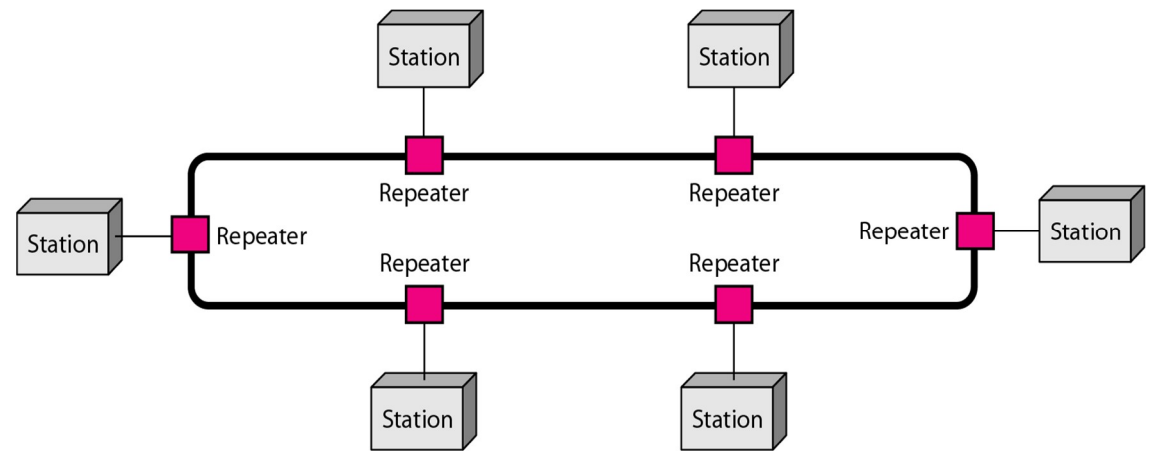
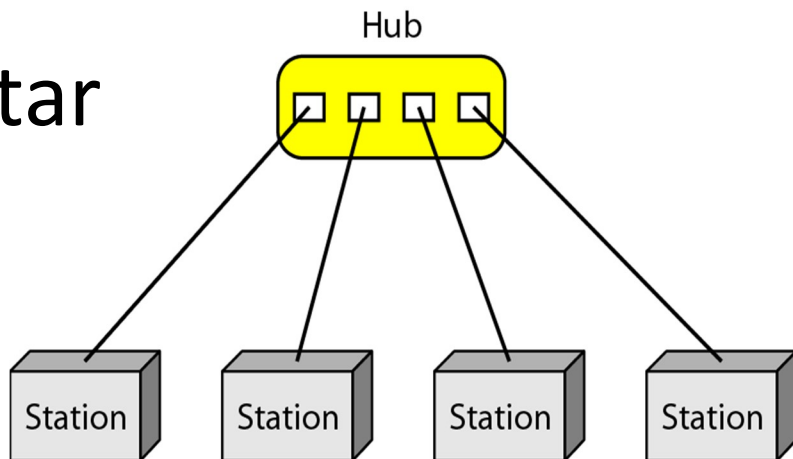
Mesh



Bus

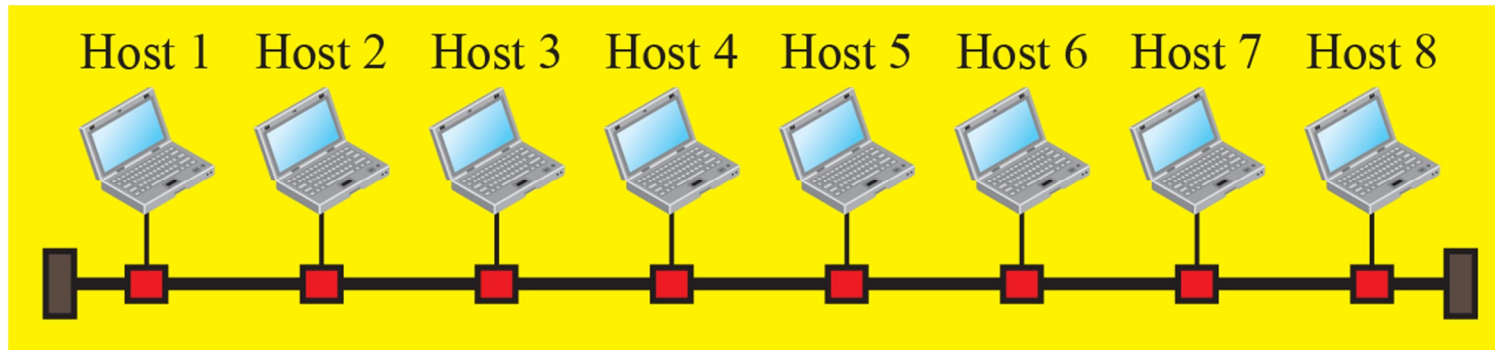


Star



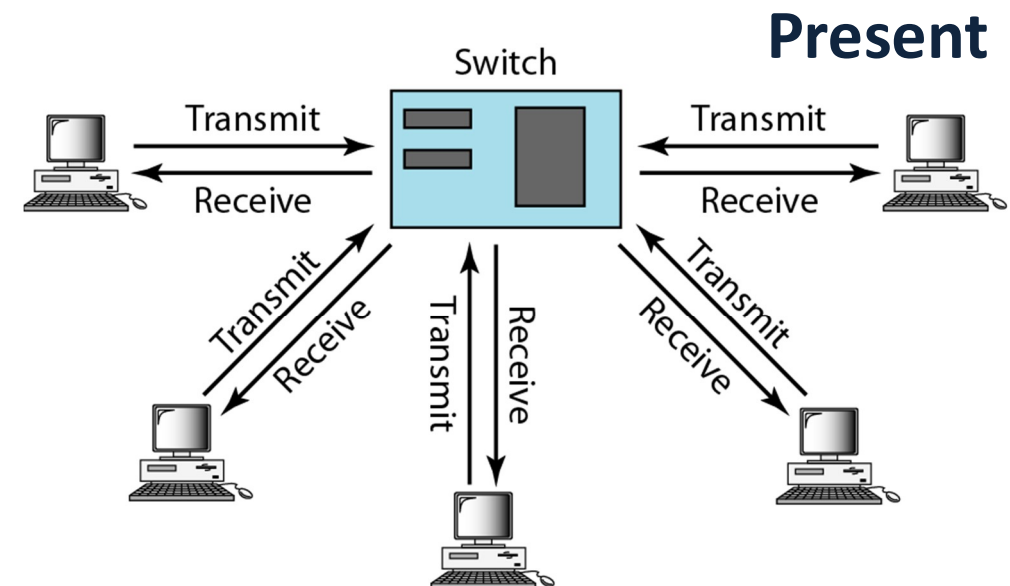
Ring

Concept of shared medium



Past

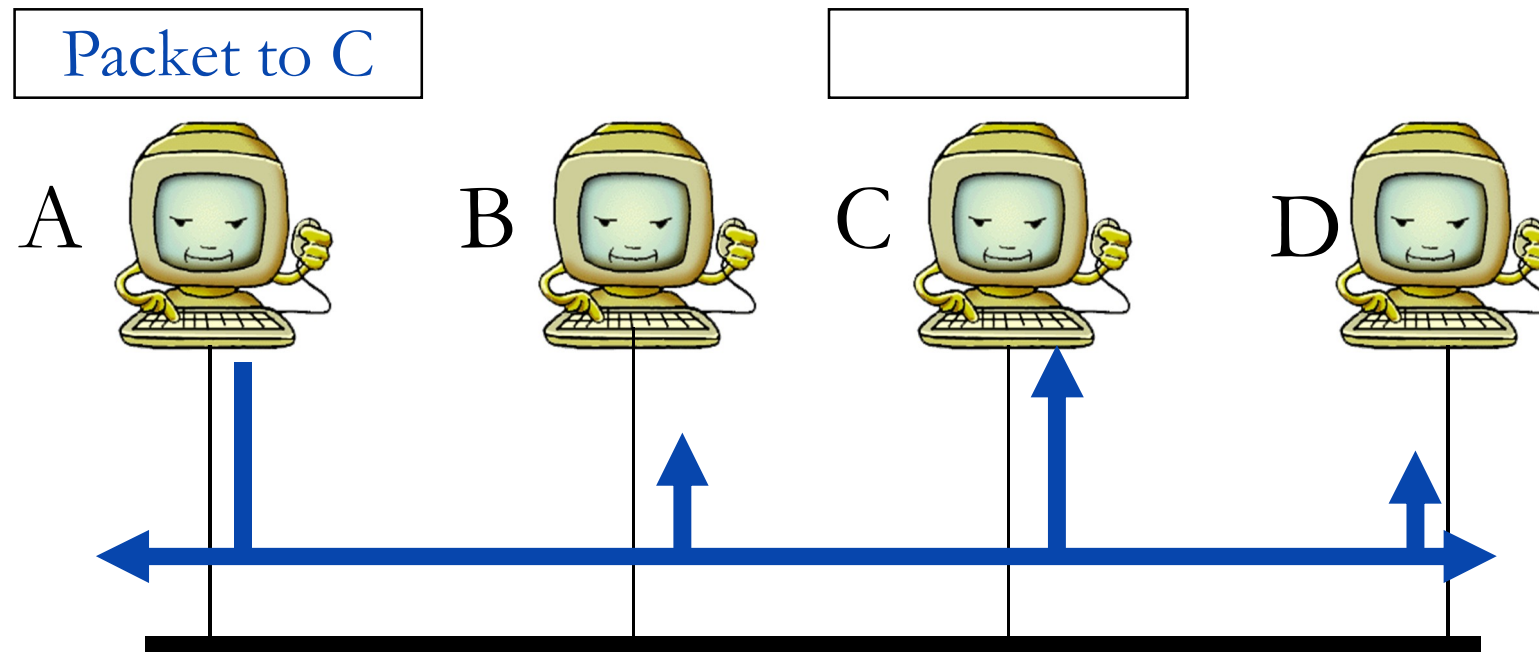
- Not for wired media any longer
- Wireless LAN (WLAN) share wireless medium.



Shared medium characteristics

- Broadcast
 - All data reaches all stations
- Attenuation
 - The network has a limited size.
- Extending the link
 - Repeaters amplify signal on link

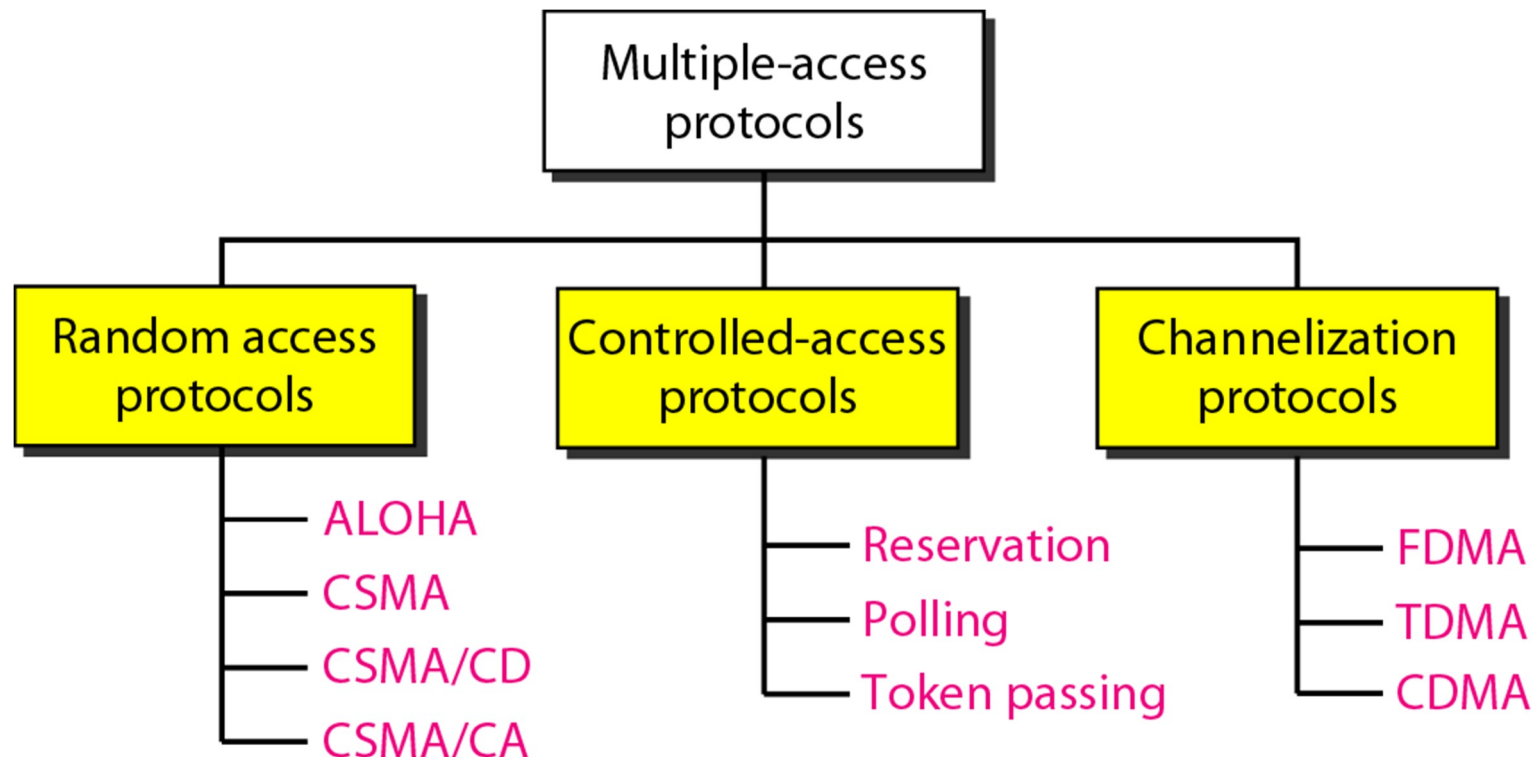
Data transfer on a shared medium



The computer with the right destination address copies the packet and delivers it to the application.

Medium Access Control (MAC)

- Set of rules for sending (and receiving) data in a multiple access network

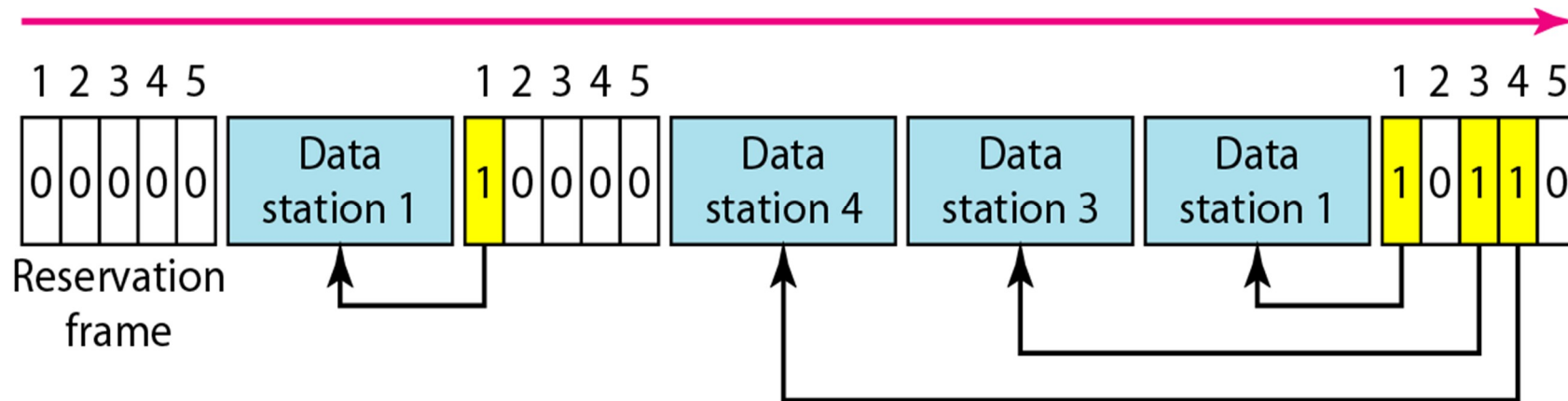


Controlled access protocols

- Stations consult one another to find which station has the right to send.
- A station cannot send unless it has been authorized by other stations.
- Used in different parts of the mobile networks.

Controlled access: Reservation

- Time is divided into intervals.
- A reservation frame precedes the data frames.
- Stations need to make a reservation before sending data.

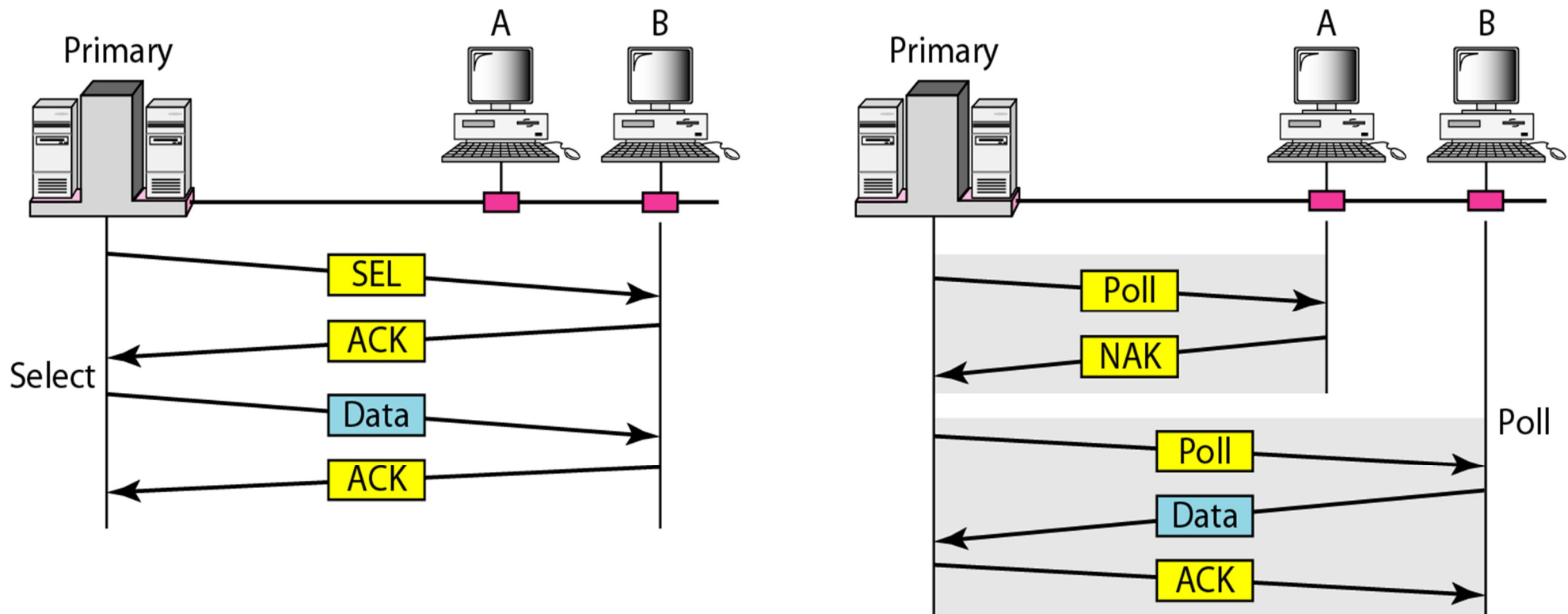


Controlled access: Polling

- One Primary Station (Master)
- Others are Secondary Stations (Slaves)
- Master controls the link.
- Slaves follow instructions.
- All data exchange is through the master.

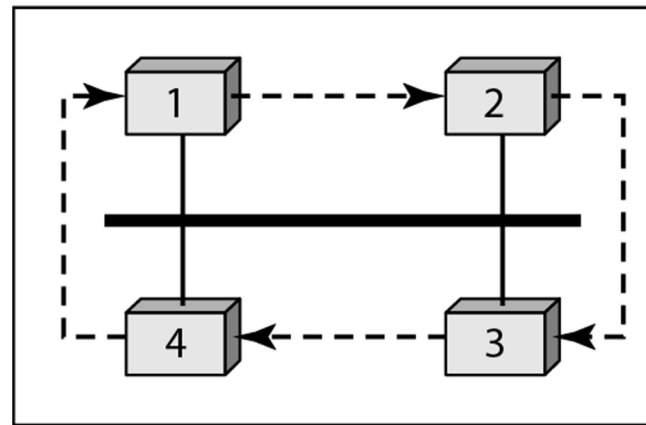
Poll and Select functions

- If the primary station has anything to send, it uses a Select function. If it wants to receive data it uses a Poll function.

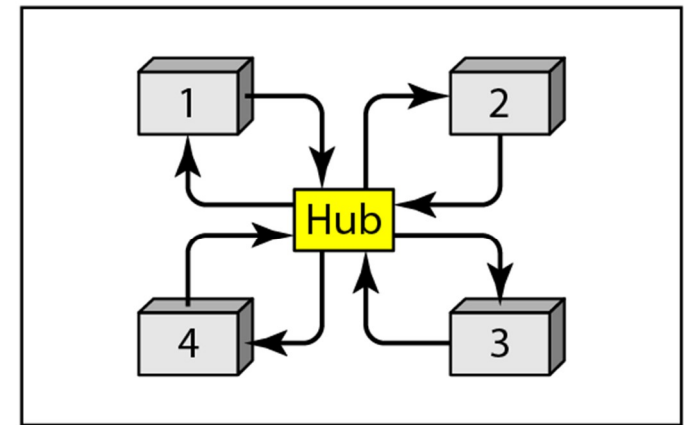


Controlled access: Token Passing

- Stations organized in a logical ring



c. Bus ring



d. Star ring

- Token

- A special packet circulating through the ring
- Only a station holding the token can use the link.
- A station can only possess the token for a certain time, then it must release and pass the token on.

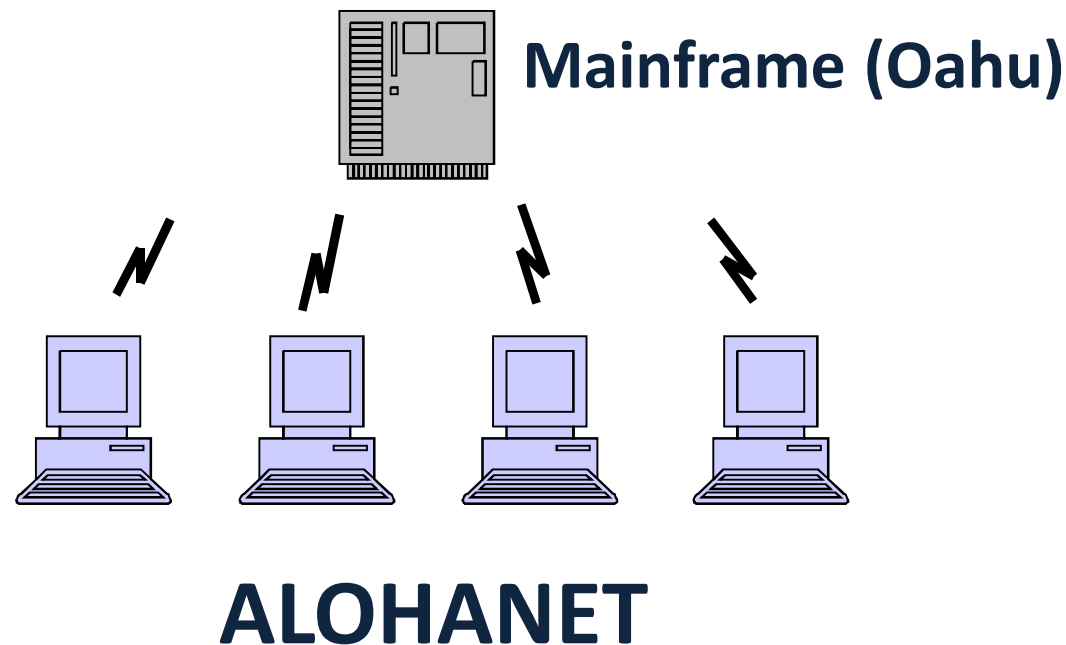
Random access protocols

- No station superior to another
- No station in control of another
- A station with data to send uses a procedure to decide whether or not to send



Random access: ALOHA

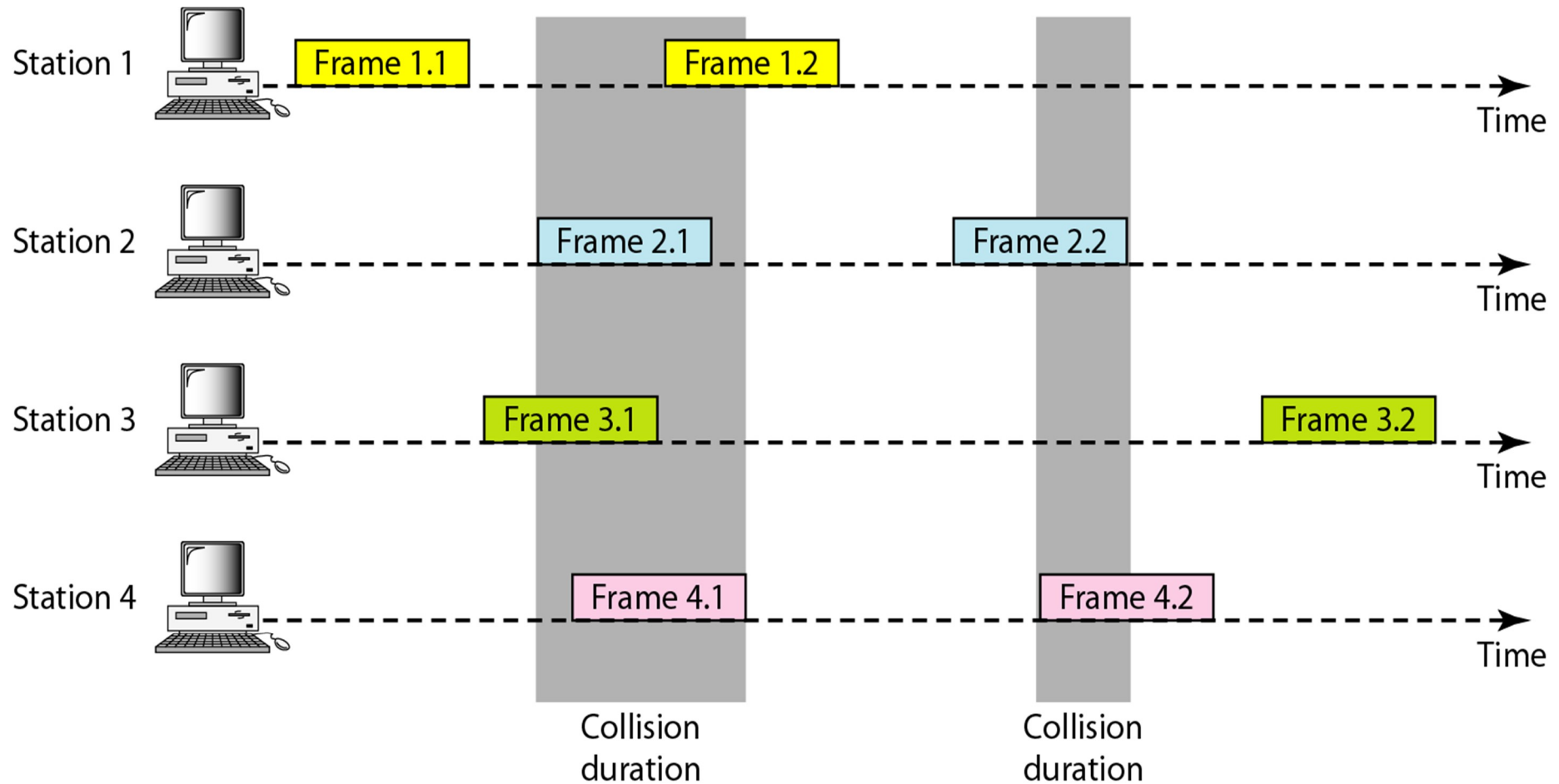
- Multiple-access method of ALOHANET
 - One of the first WLAN in the world
 - Developed by the University of Hawaii (1970)



Pure ALOHA

- Stations share one frequency band
- Mainframe sends data on another frequency (broadcast channel)
- A station sends a frame whenever it has a frame to send.
- If the station receives an ACK from the mainframe on the broadcast channel, the transmission is successful.
- If not, the frame needs to be retransmitted.

Pure ALOHA: Frames



Pure ALOHA: Resend strategy

- After a collision
 - Wait a random time and resend (backoff time T_B)
 - After K_{max} attempts give up and try later (abort)

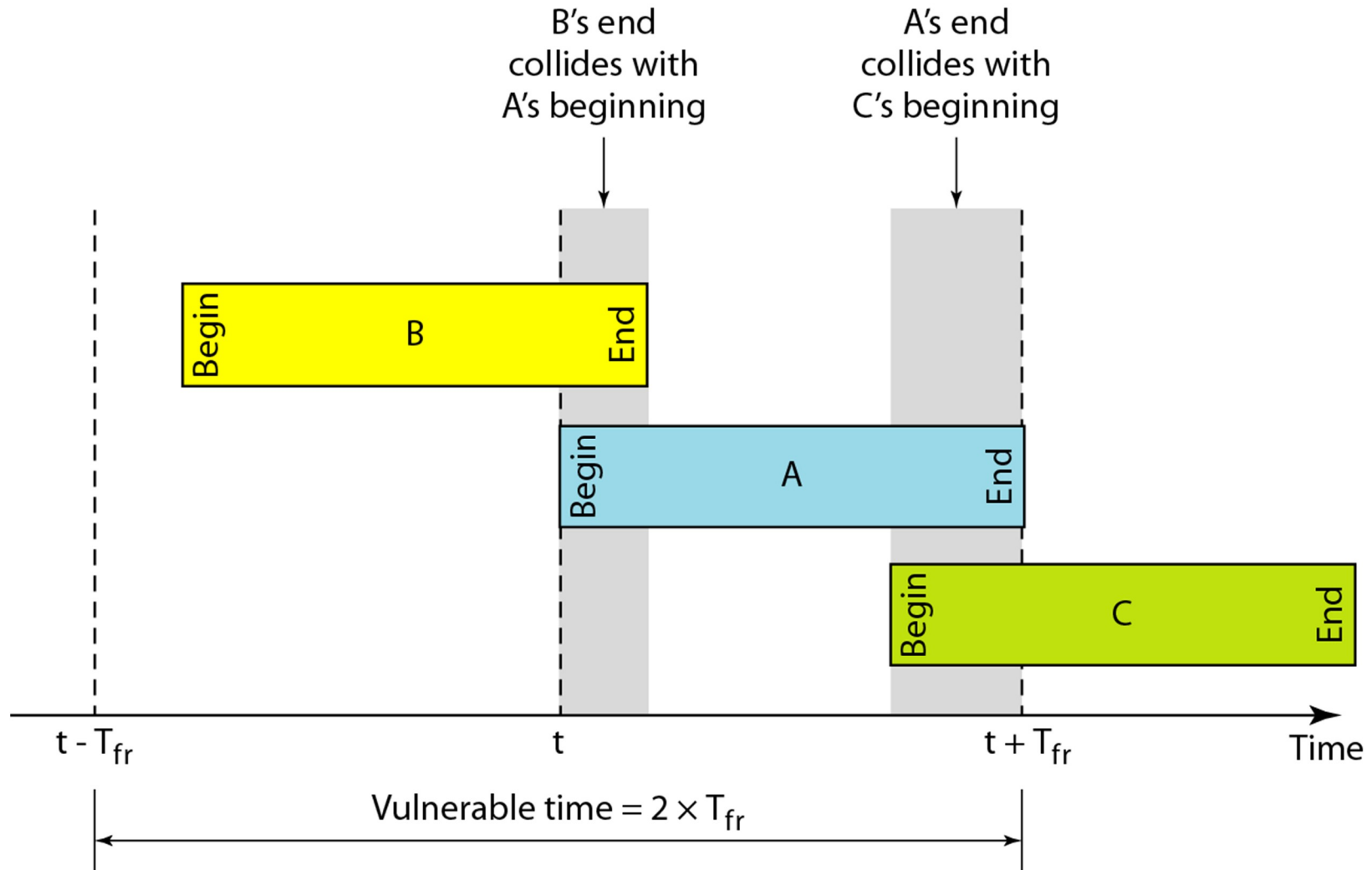
T_B

Example: In **binary exponential backoff** the backoff time is chosen to be

$$T_B \sim \mathcal{U}\left(0, (2^k - 1)T_f\right)$$

where k is the attempt number.

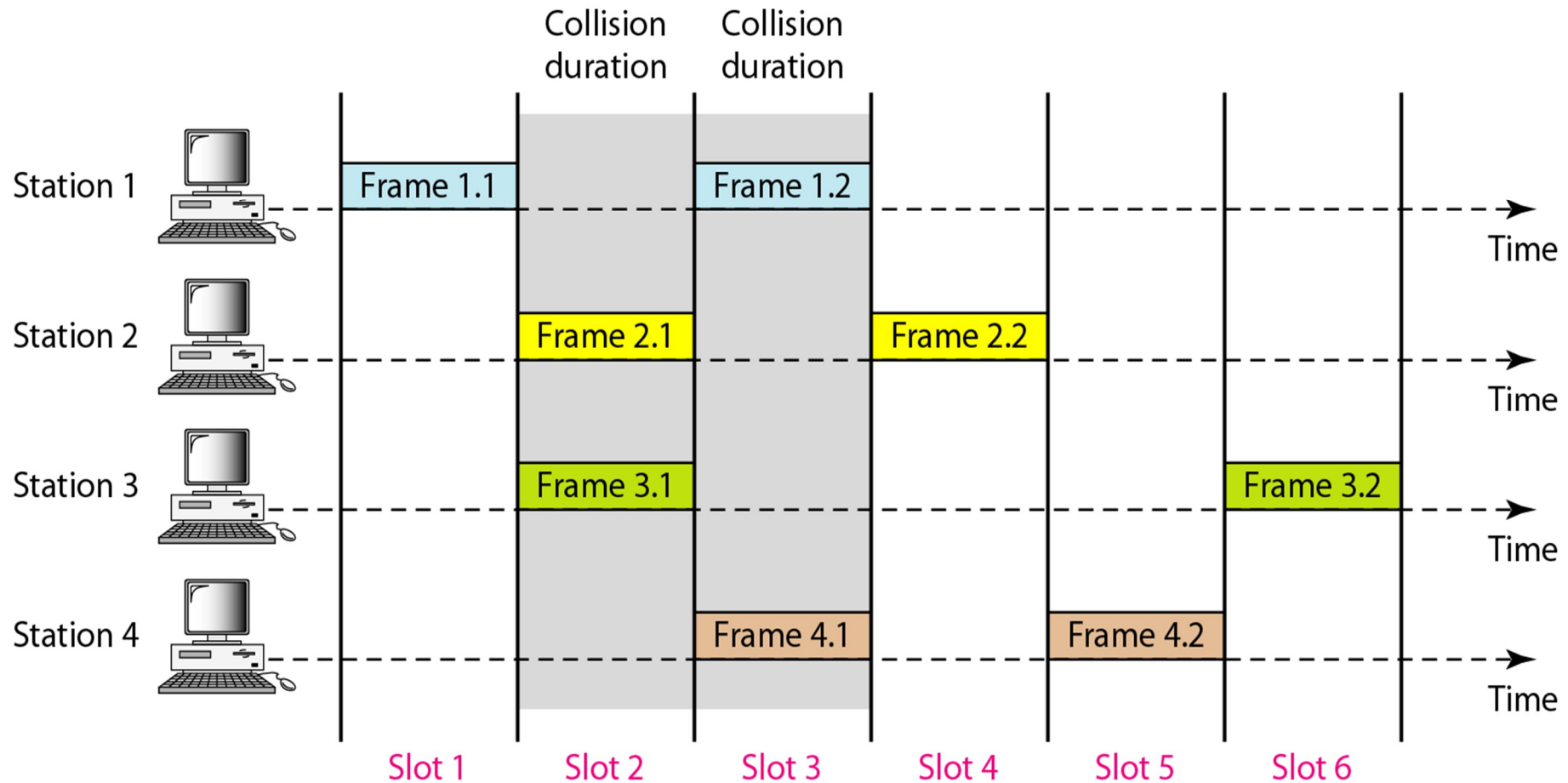
Pure ALOHA: Collisions



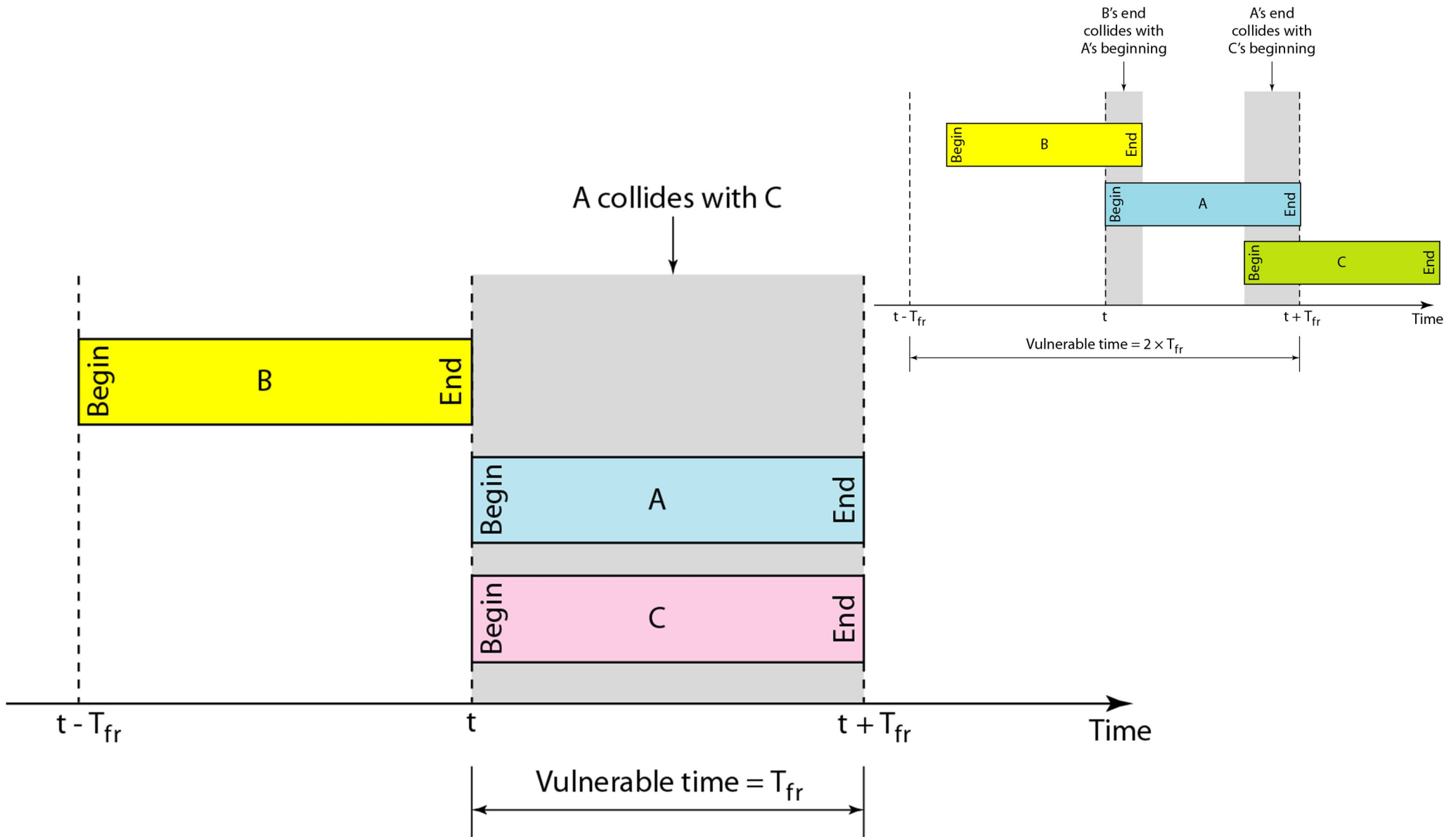
Slotted ALOHA

- Time divided into slots
- Each slot contains one frame in time
- A station can only send at the beginning of a slot.

Slotted ALOHA: Frames



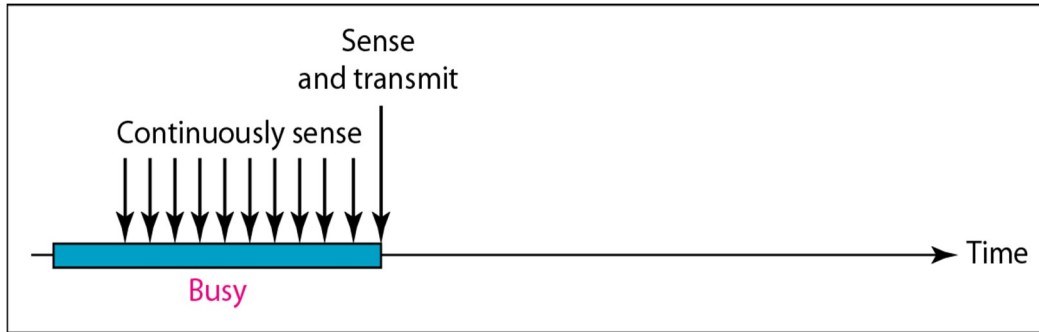
Slotted ALOHA: Collisions



Carrier Sense Multiple Access (CSMA)

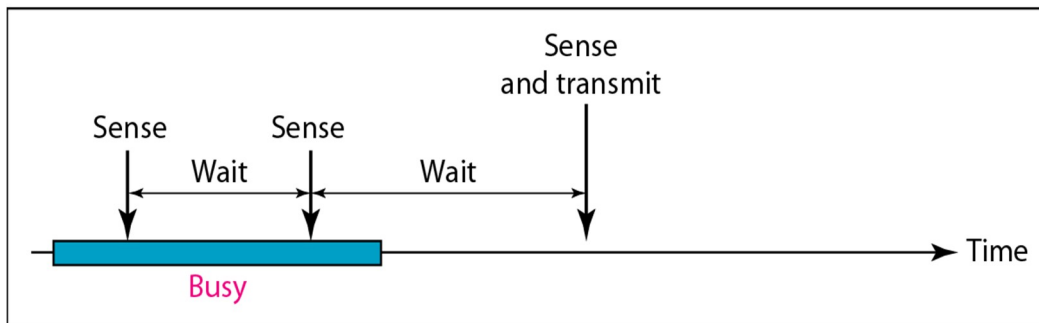
- Listen to (sense) medium before sending
- If medium occupied (busy), wait
 - 1-persistent
 - Non-persistent
 - P-persistent

Persistence methods



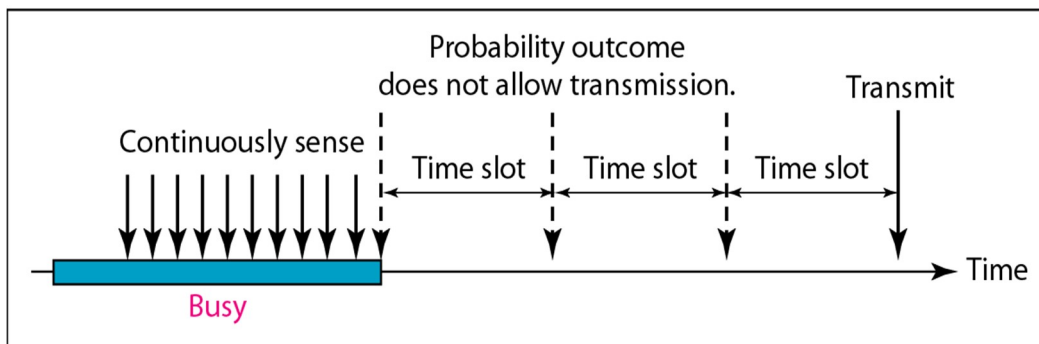
a. 1-persistent

Keep sensing and send as soon as channel idle



b. Nonpersistent

Wait random, sense again, send if idle

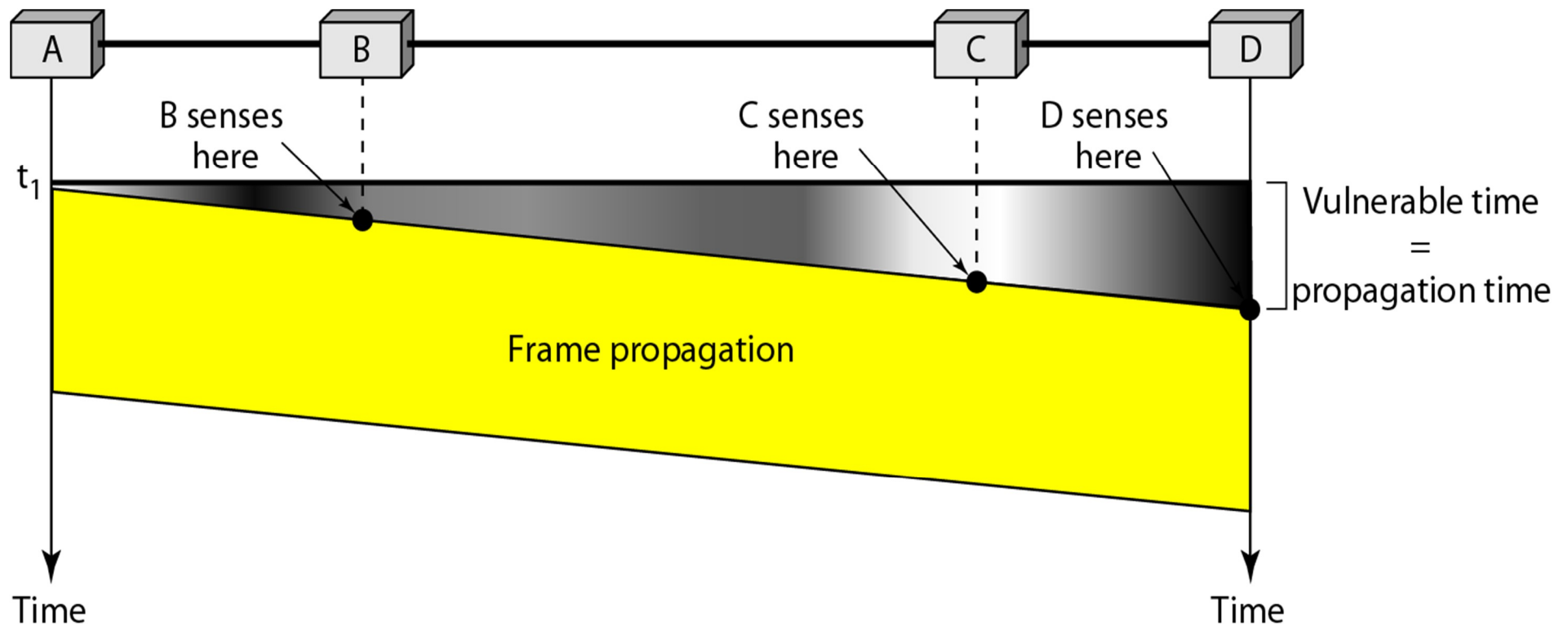


c. p-persistent

Transmit with probability p , sense with $1-p$, wait if busy

CSMA: Vulnerable time

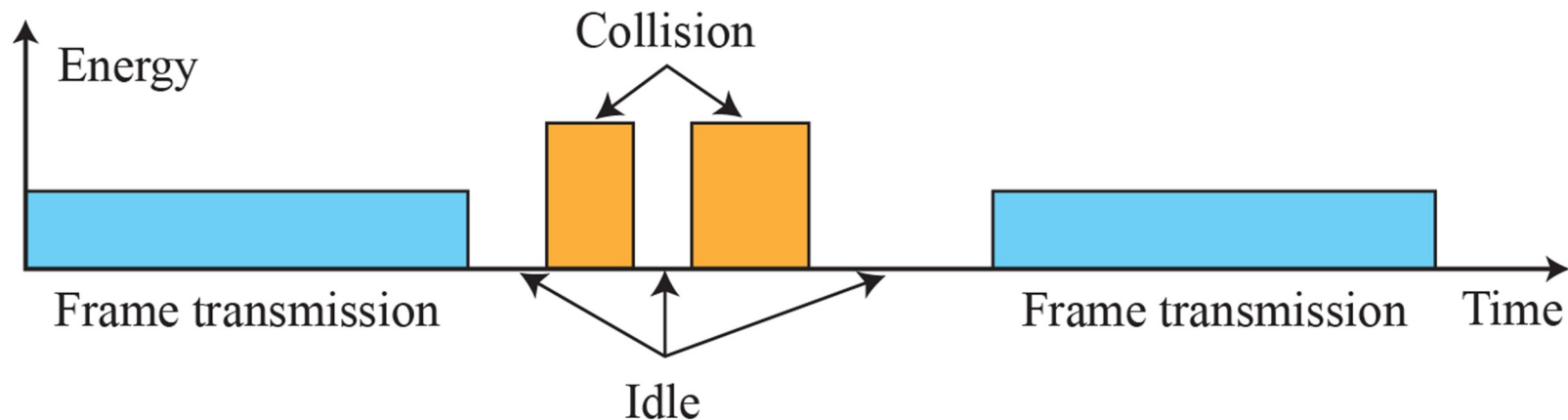
- Propagation time



- Collisions?

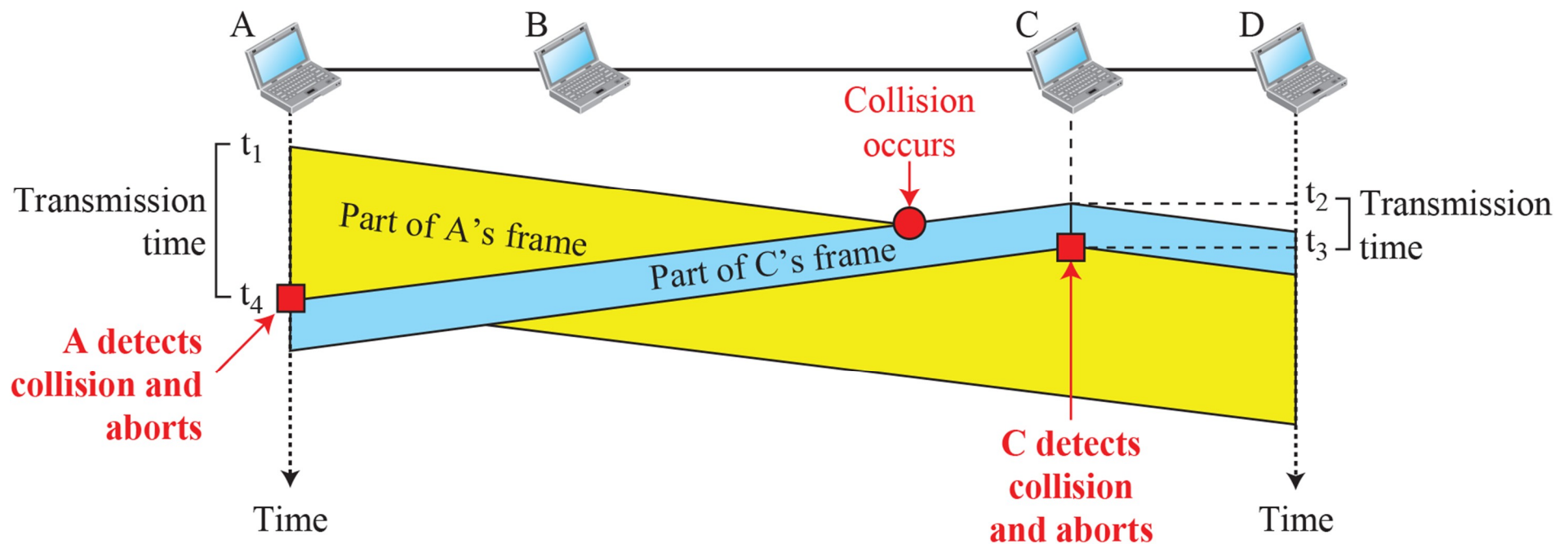
CSMA with Collision Detection (CSMA/CD)

- CSMA has no collision procedure
- CSMA/CD developed to handle collisions



CSMA/CD: Collision detection

- Monitors medium after sending a frame
- Abort transmission and send a jamming signal if collision detected



CSMA/CD: Minimum frame size

- Sending station must be able to detect a collision *before* transmitting the frame's last bit
- Frame transmission time must be at least two times maximum propagation time
- Colliding signal can propagate to sending station before the last bit is transmitted.

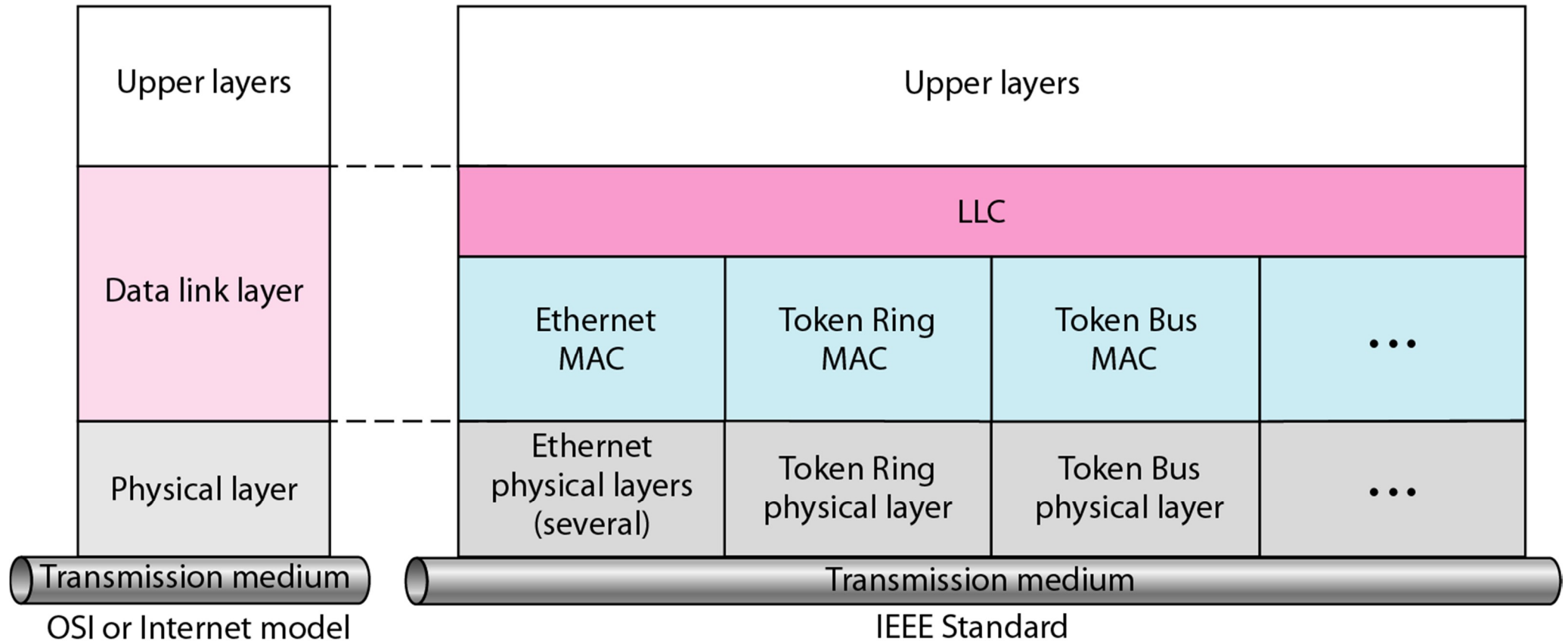
See you in 15' :)



- After the break
 - Ethernet
 - MAC addresses
 - Wireless LAN

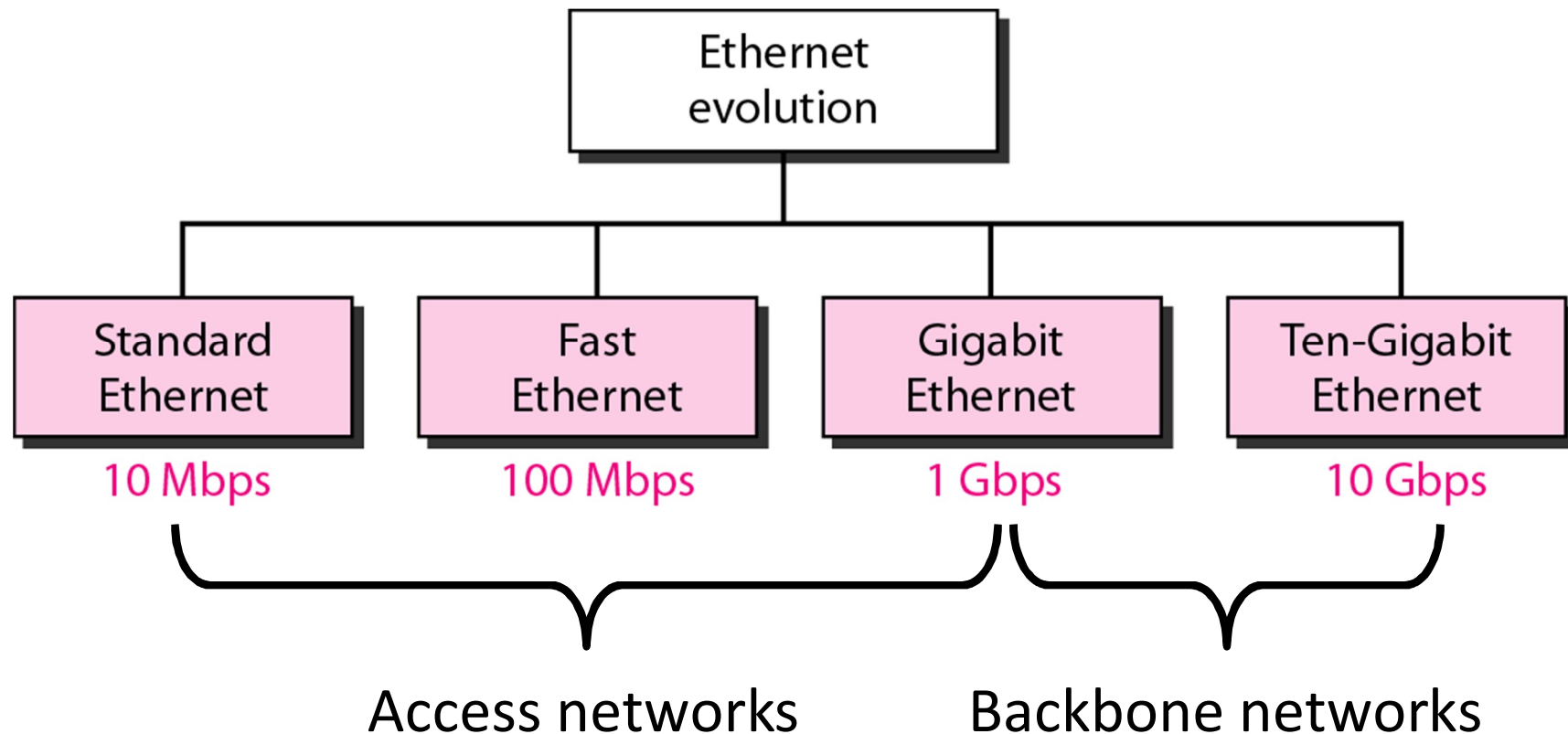
IEEE's LAN standards (Project 802)

LLC: Logical link control
MAC: Media access control



IEEE 802.3: Ethernet

- Created 1976 by Xerox
- Evolved through new versions

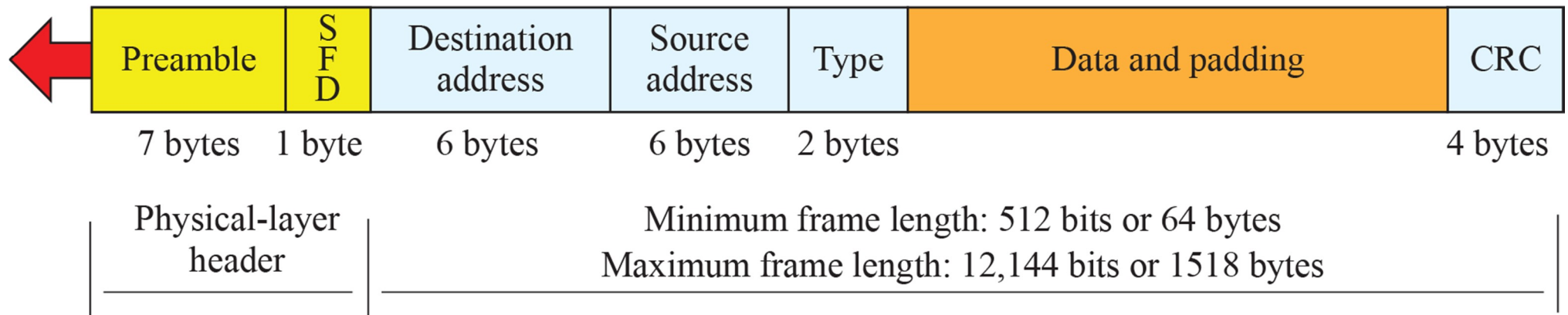
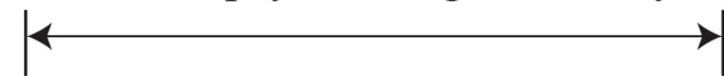


Ethernet frame structure

Preamble: 56 bits of alternating 1s and 0s

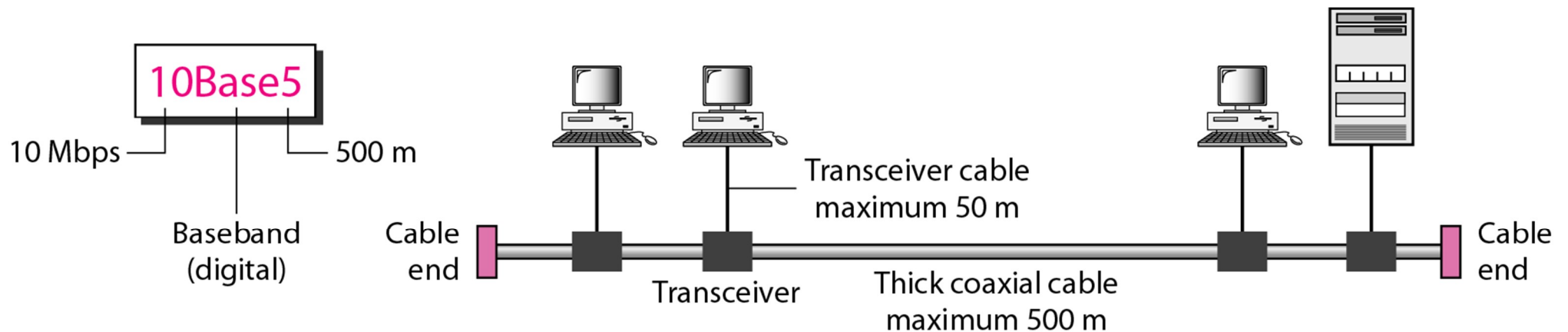
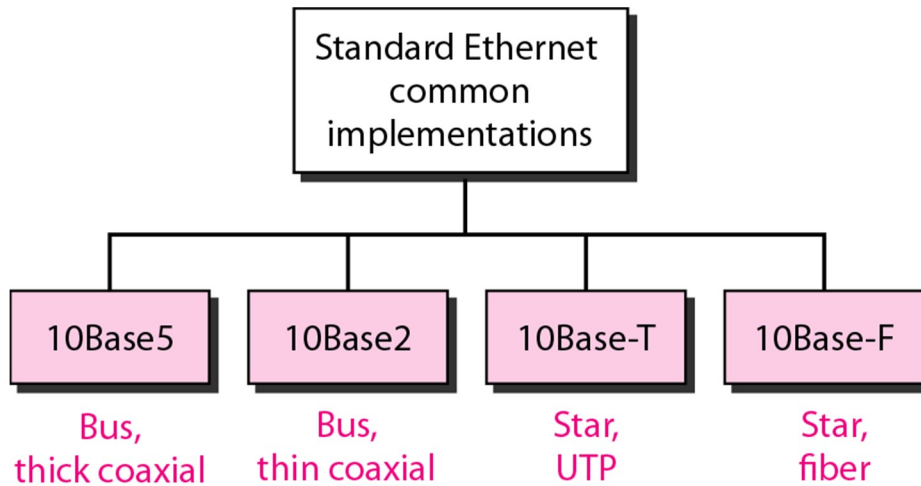
SFD: Start frame delimiter, flag (10101011)

Minimum payload length: 46 bytes
Maximum payload length: 1500 bytes



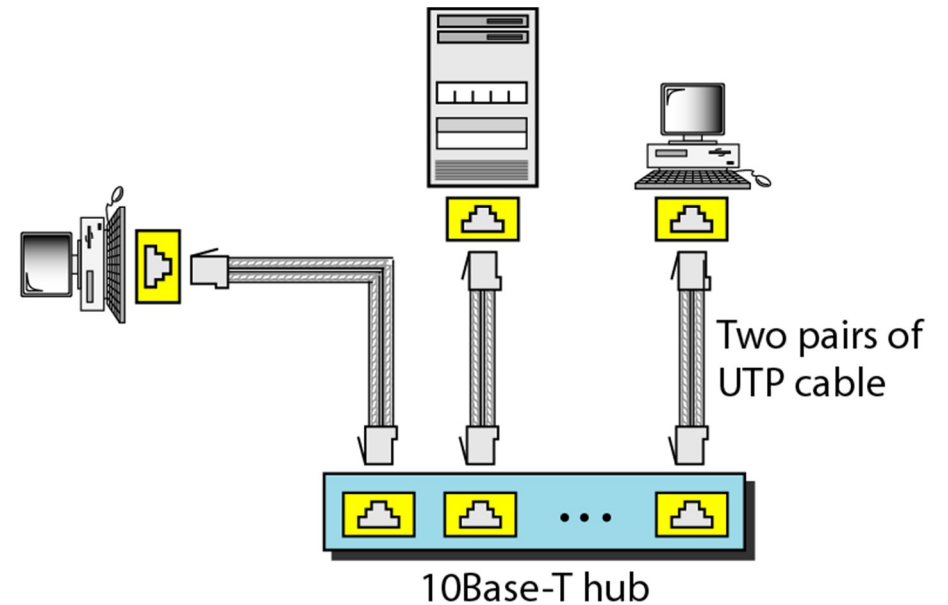
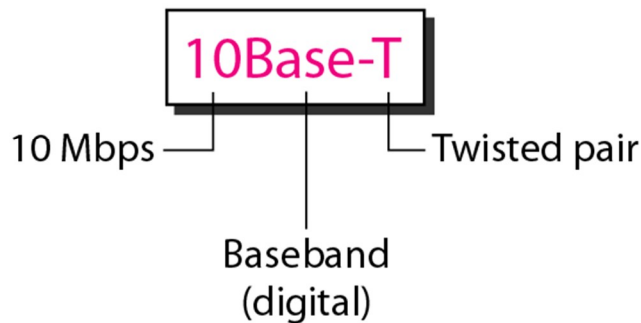
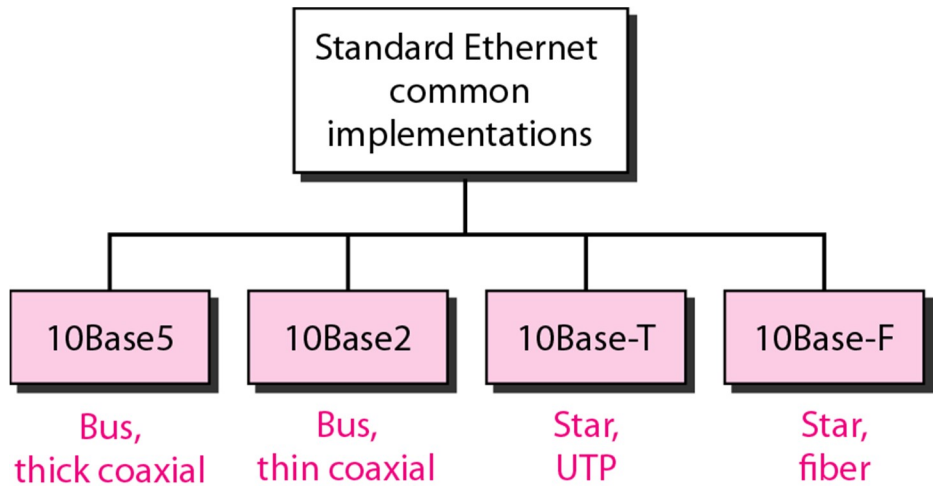
Standard Ethernet implementations

CSMA/CD



Standard Ethernet implementations

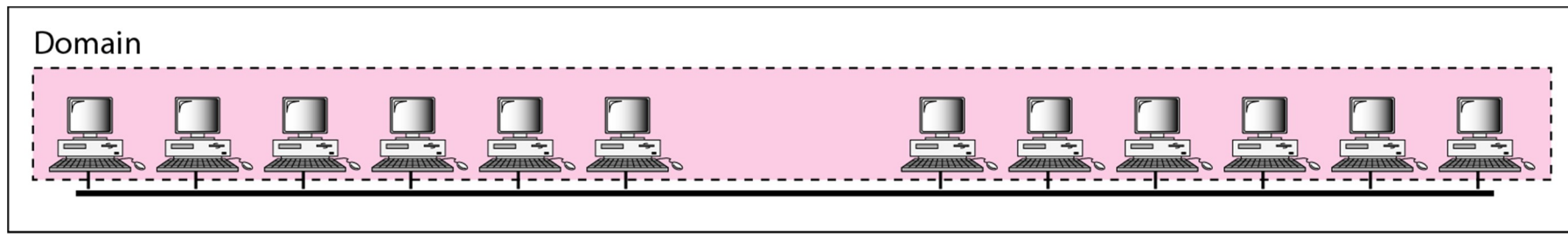
CSMA/CD



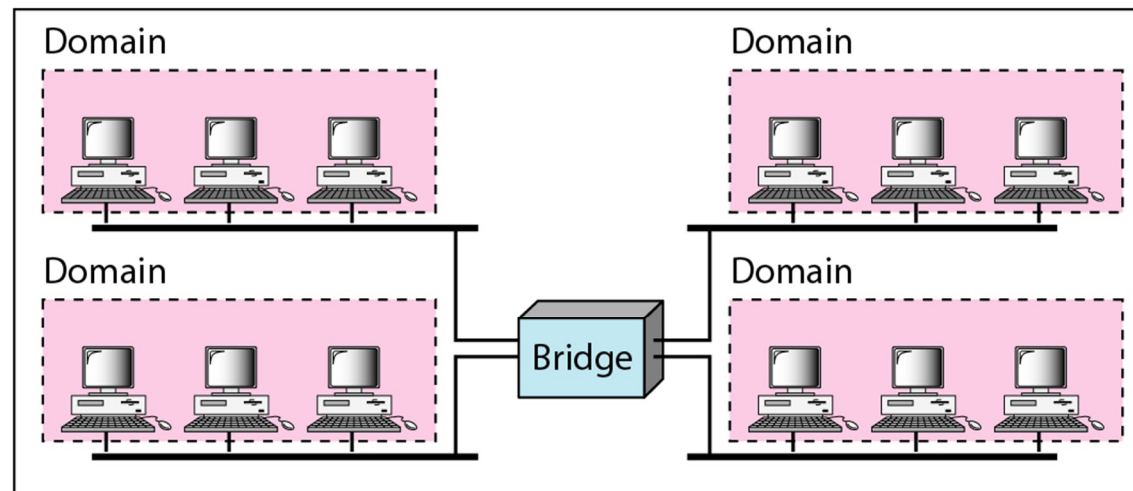
Evolution of Ethernet

CSMA/CD

- Collision domains



a. Without bridging



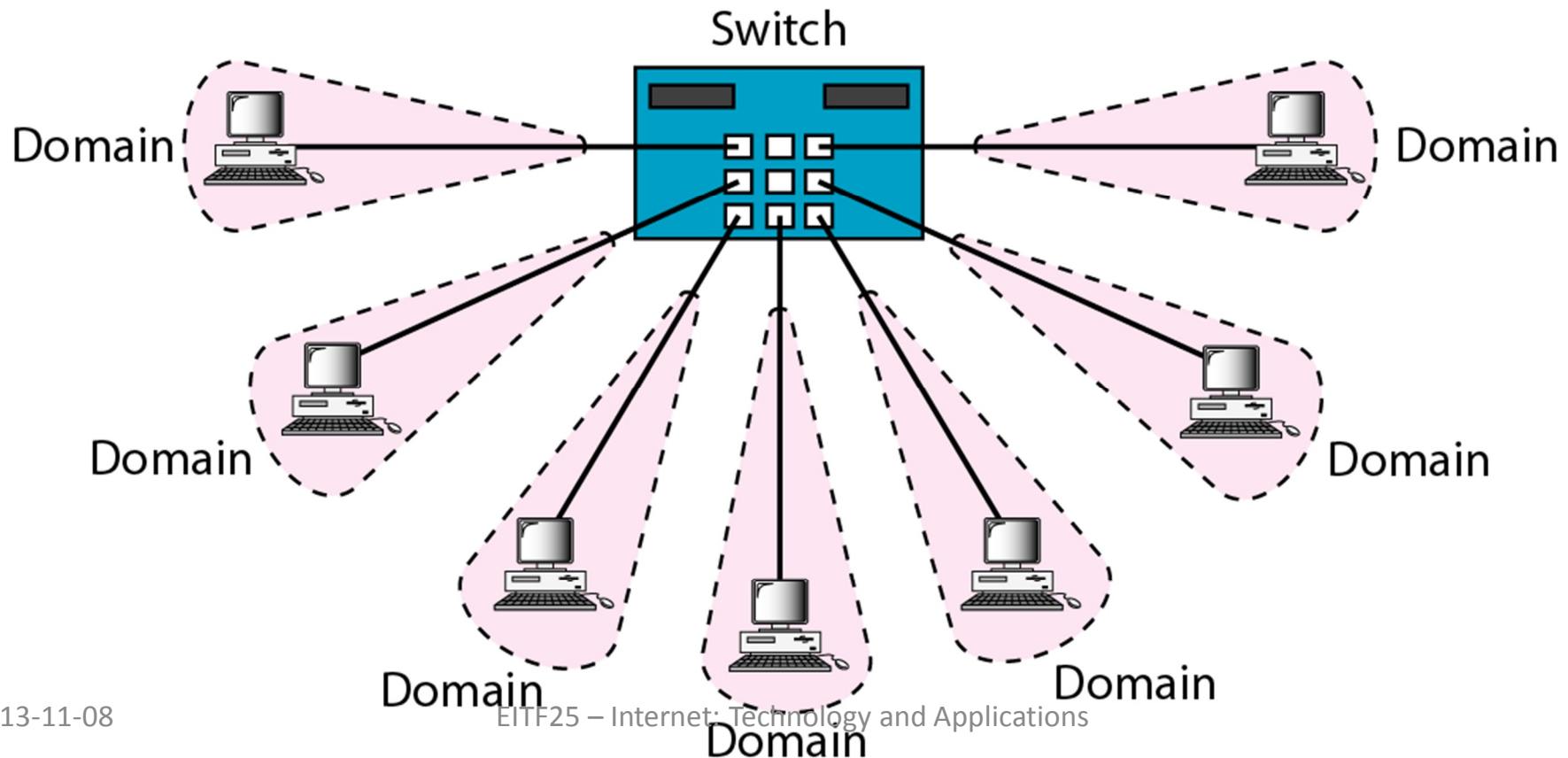
b. With bridging

Switched Ethernet

Switching table

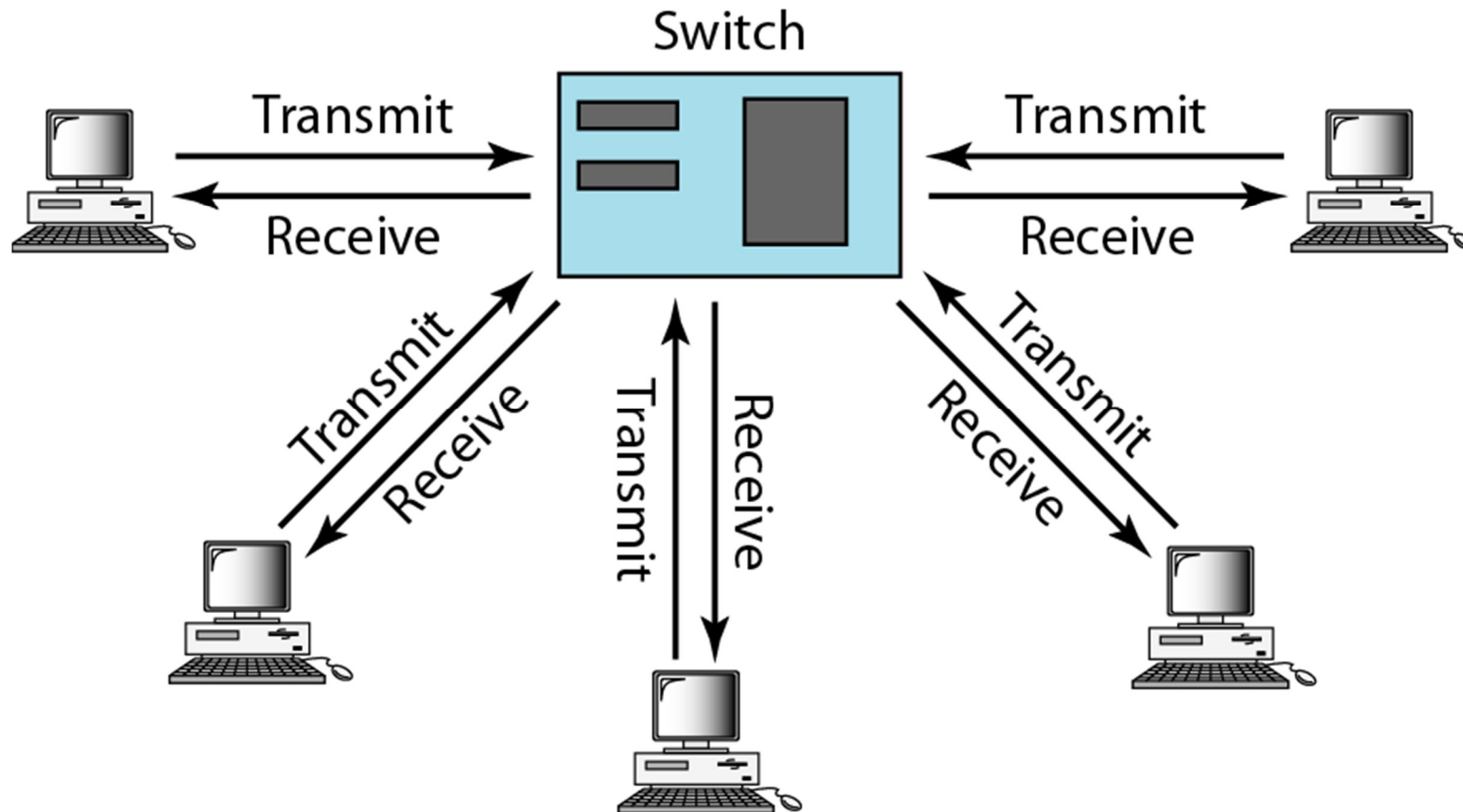
Address	Port
71:2B:13:45:61:41	1
71:2B:13:45:61:42	2
64:2B:13:45:61:12	3
64:2B:13:45:61:13	4

CSMA/CD



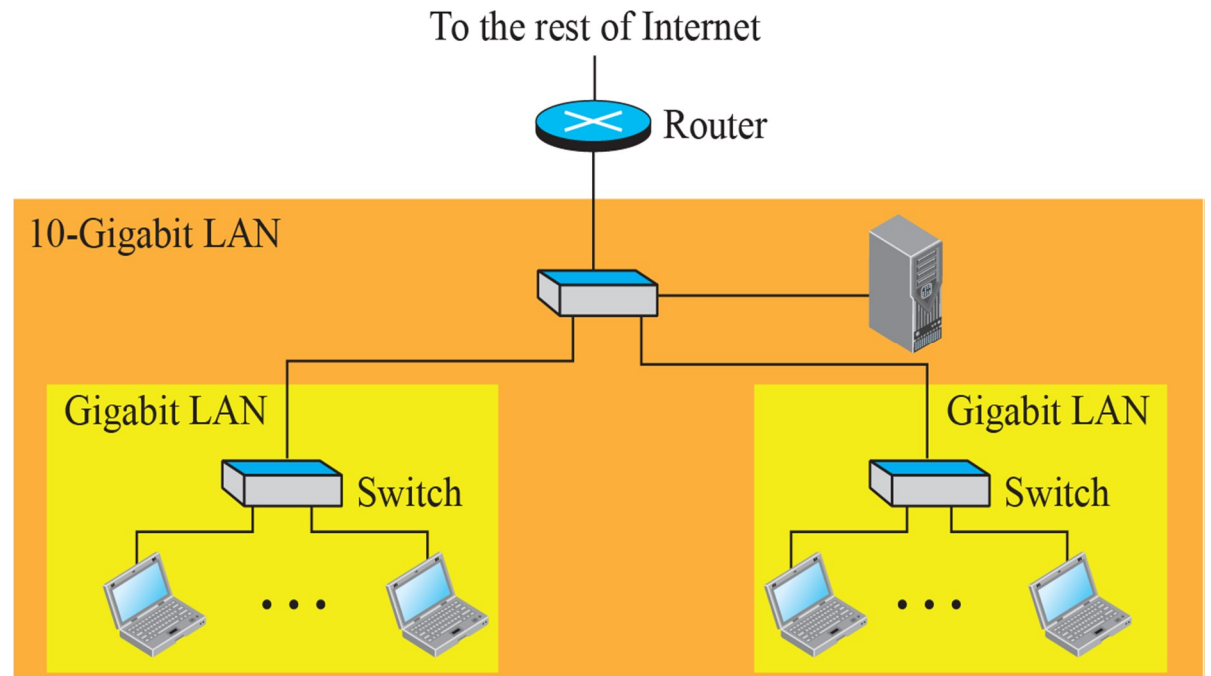
Full-duplex switched Ethernet

CSMA/CD



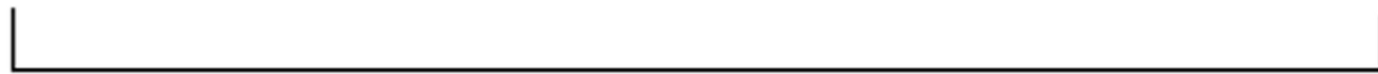
Even more Ethernet evolution

- Fast
 - 100 Mbps
- Gigabit
 - 1 000 Mbps
- 10-Gigabit
 - Metropolitan
- More and better wires (UTP or optic fibre)
- More advanced encoding (FEC)



Ethernet MAC address

06 : 01 : 02 : 01 : 2C : 4B



6 bytes = 12 hex digits = 48 bits

- `ipconfig /all`

Network addresses

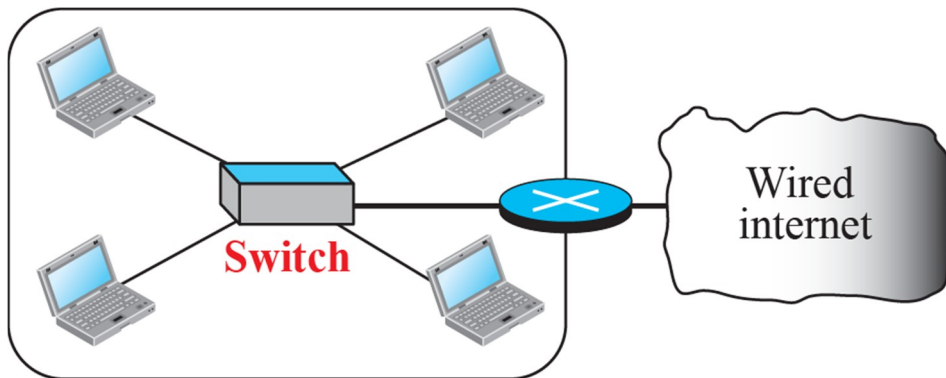
- In a network, all stations need an address so that the data can reach the right destination.
- All computers connected to a standard LAN have a unique physical address.

Unicast and broadcast addresses

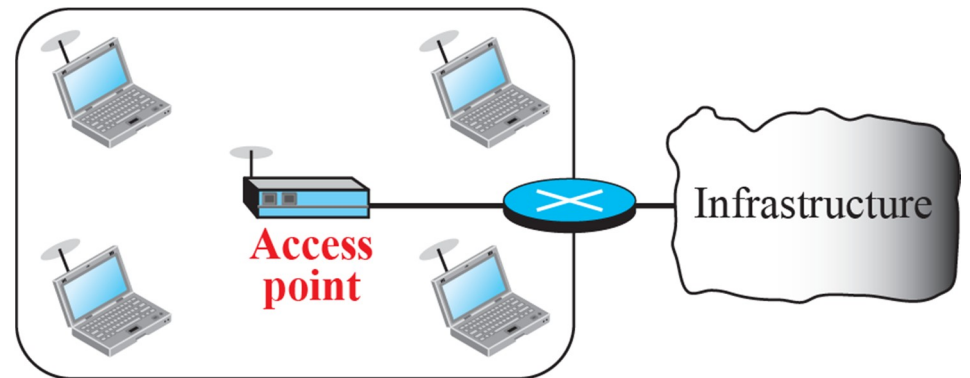
- Data transfer usually performed in ***unicast***
 - One source and one destination
- Some messages sent in ***broadcast***
 - One source to all hosts in the network
- In 802-networks, the broadcast address is defined as all 1:s.

Wireless LAN

- Popularity of Internet ↑
- Popularity of mobility ↑



Wired LAN

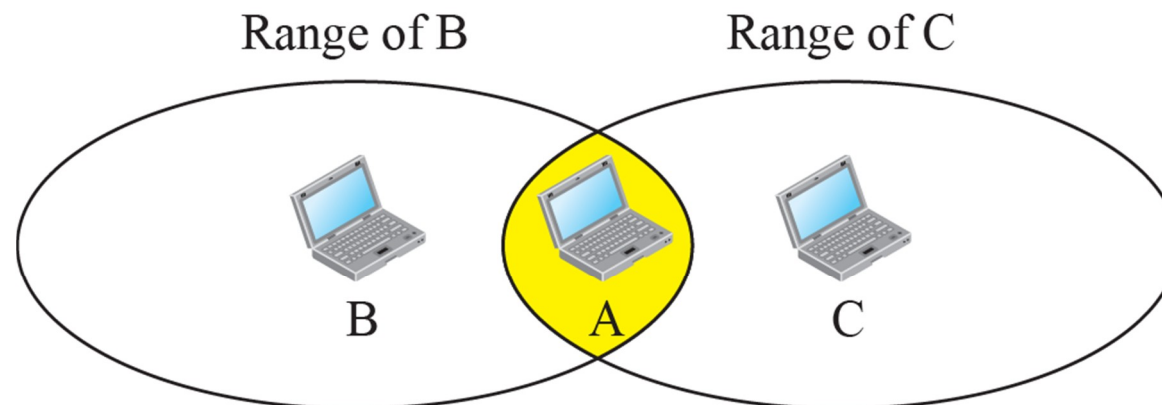


Infrastructure network

- **Basically: A change in medium**
- **Media access technology becomes important**

Hidden terminal problem

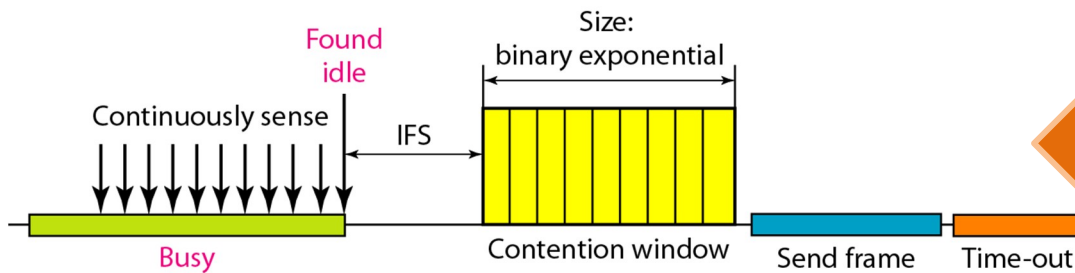
- Infamous in wireless networks
- Prevents collision detection



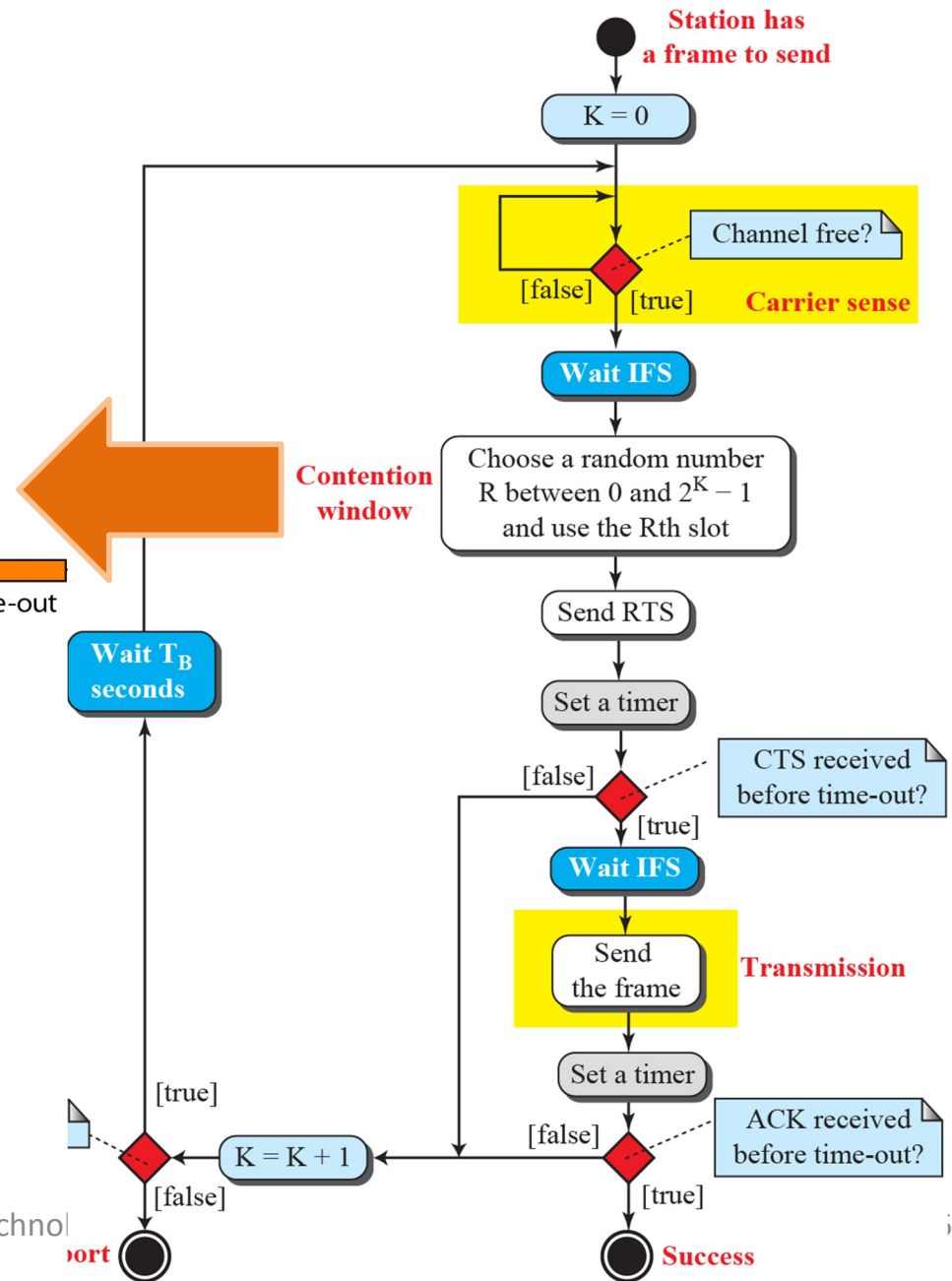
a. Stations B and C are not in each other's range.

CSMA with Collision Avoidance (CSMA/CA)

- Invented for wireless

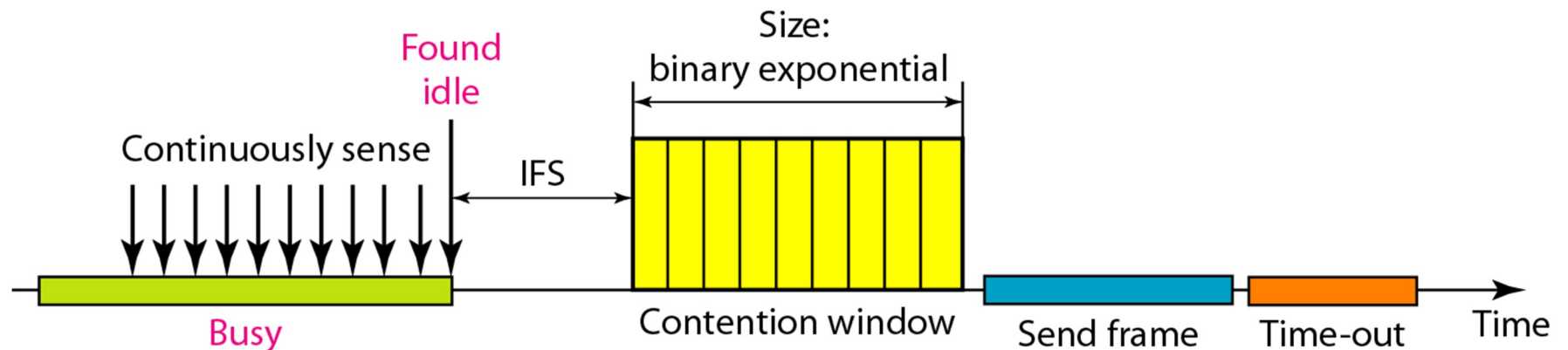


- Interframe space
- Contention window
- RTS/CTS/ACK



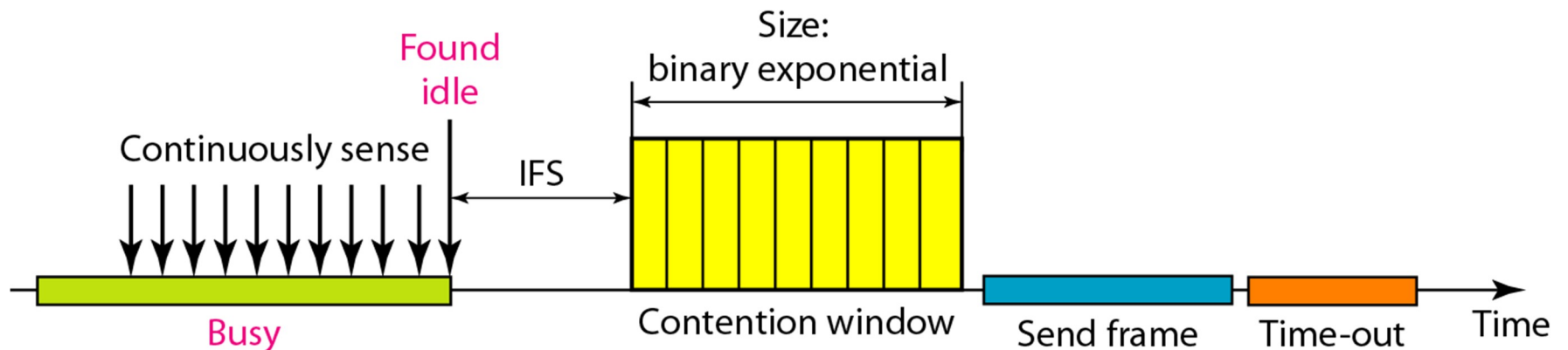
Interframe space

- Do not send immediately when medium idle
- Wait a period of time (interframe space, IFS)
 - A distant station may have already started transmitting
- If, after IFS time, channel still idle, send



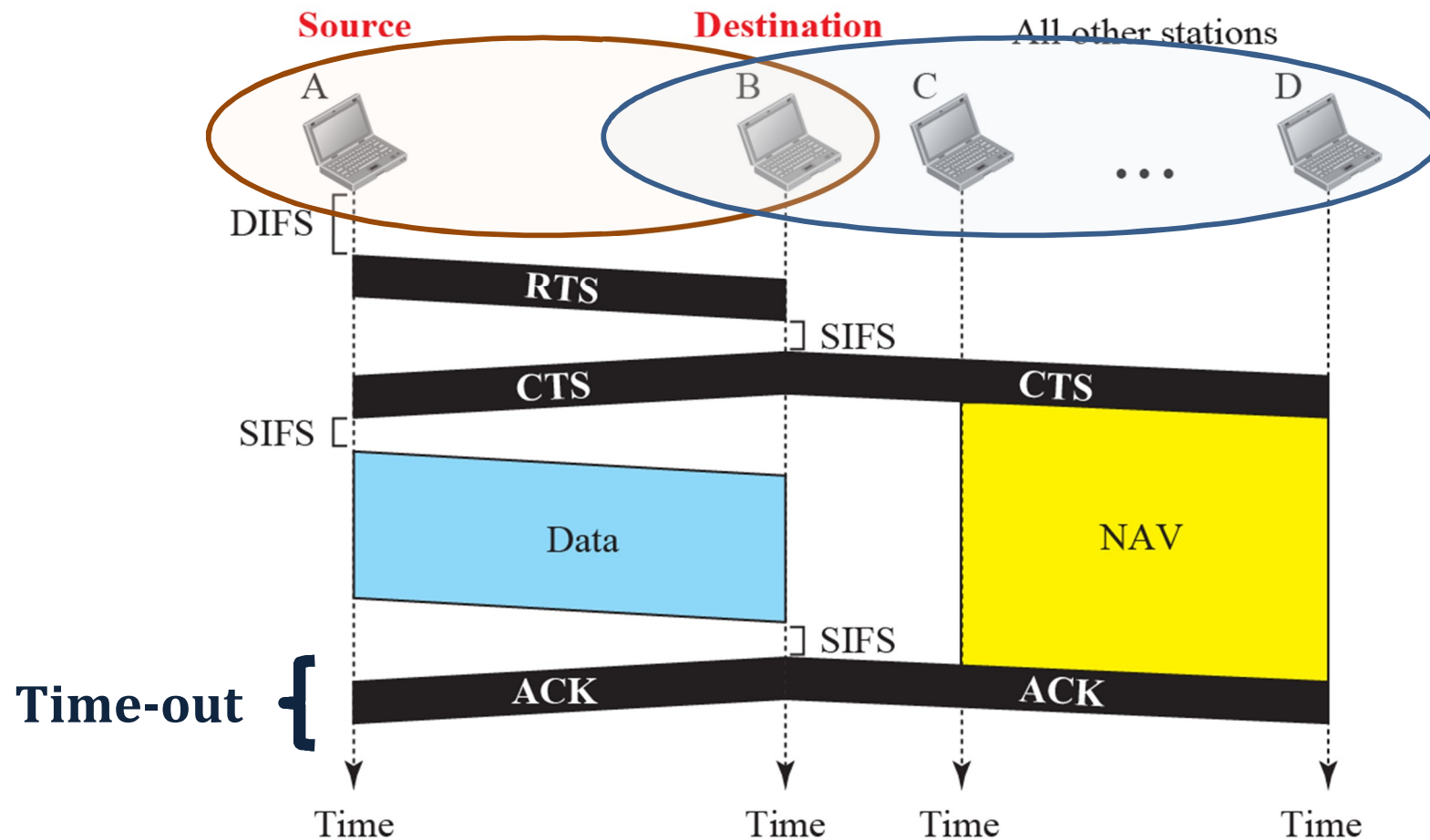
Contention window

- Amount of time divided into slots
- Pick a random number of slots as waiting time
- During waiting time, if channel becomes busy, defer transmission and restart timer when channel idle again



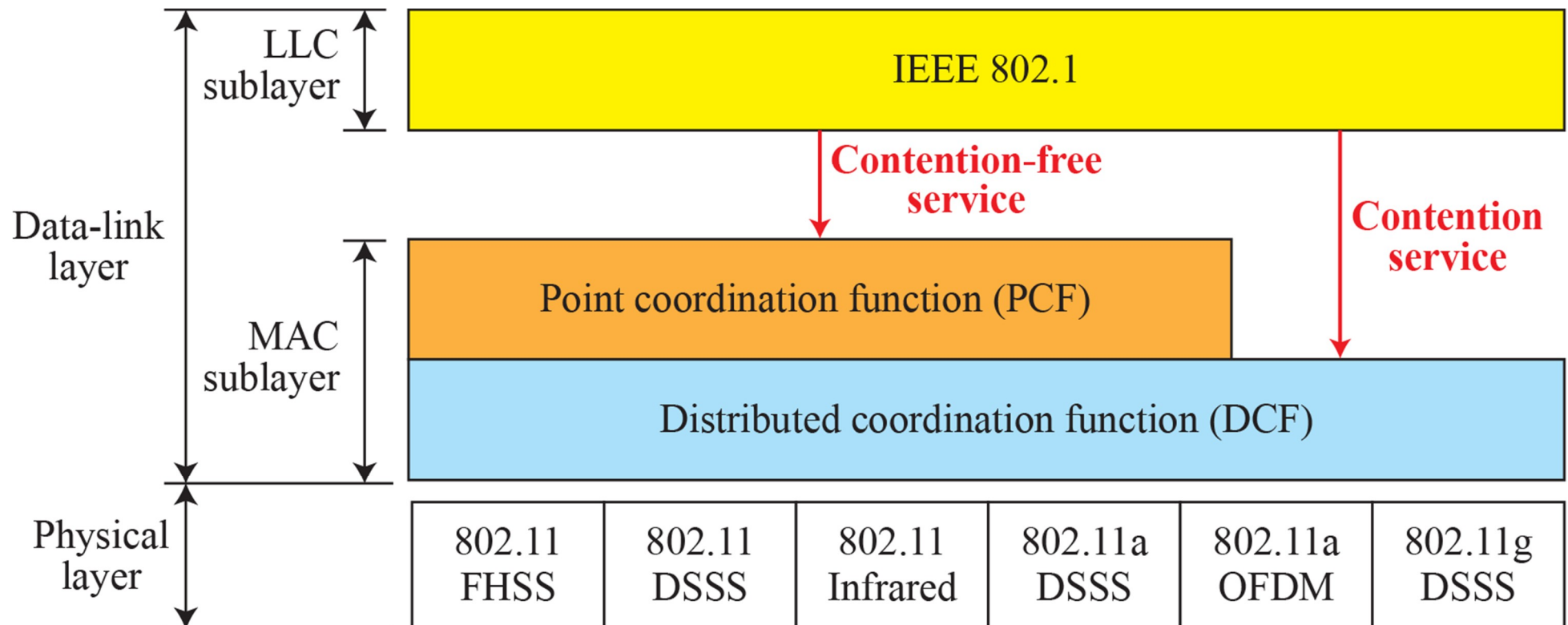
RTS/CTS/ACK

- Solution to hidden terminal problem



IEEE 802.11 project

- IEEE WLAN standard



Summary: Data Link Layer (2)

Medium Access Control Sublayer

- Access methods
 - Slotted ALOHA, CSMA/CD
- Ethernet
 - Evolution of local area networks
- Wireless LAN
 - Hidden terminal problem
 - CSMA/CA