EITF25 Internet--Techniques and Applications

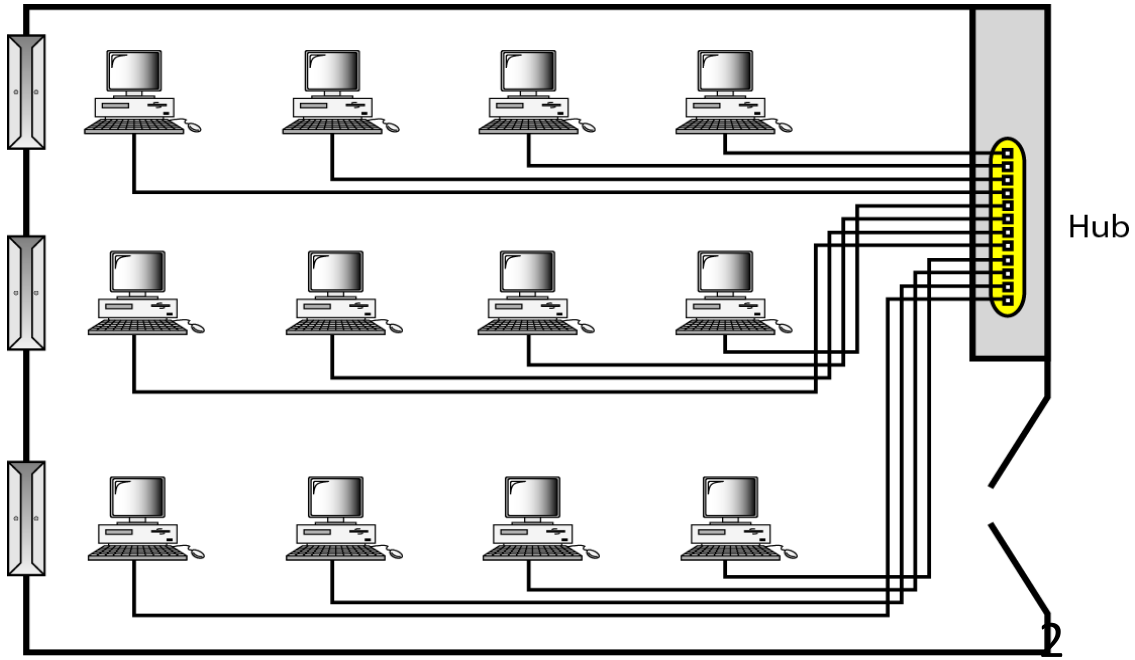
Stefan Höst

L5 Data link (part 2)

LUND UNIVERSITY

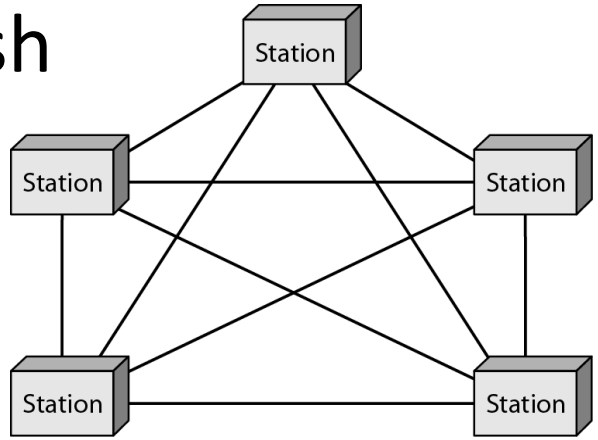
Local Area Networks (LAN)

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

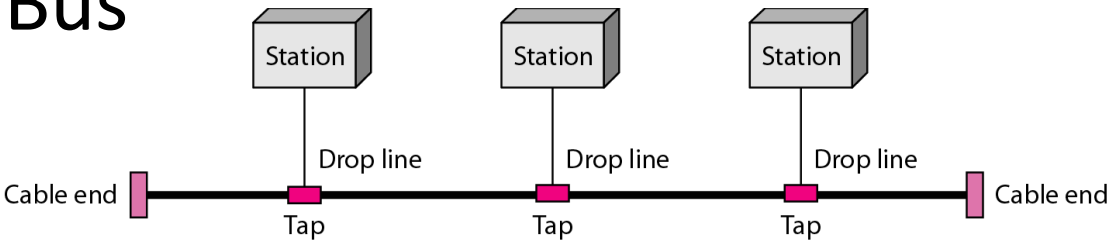


Conventional LAN topologies

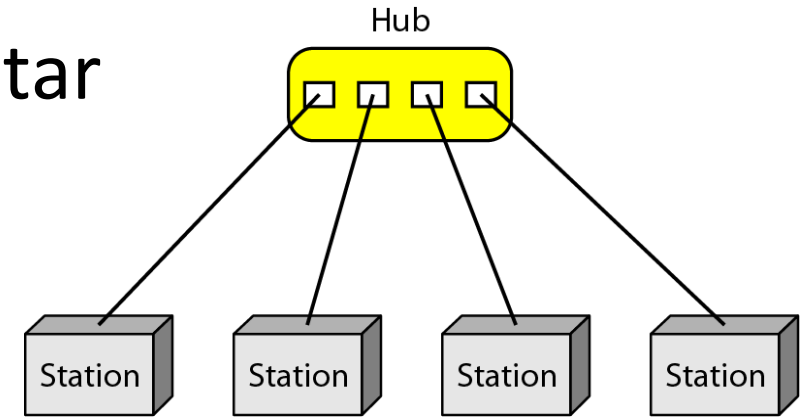
Mesh



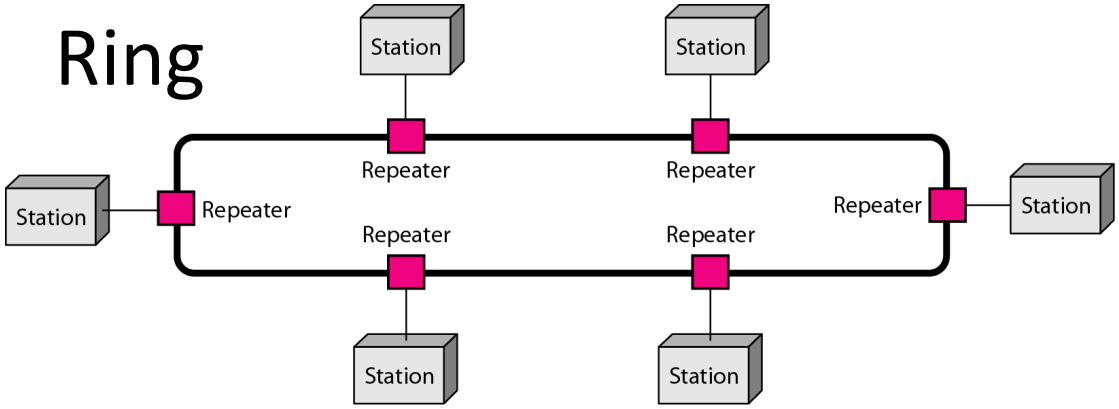
Bus



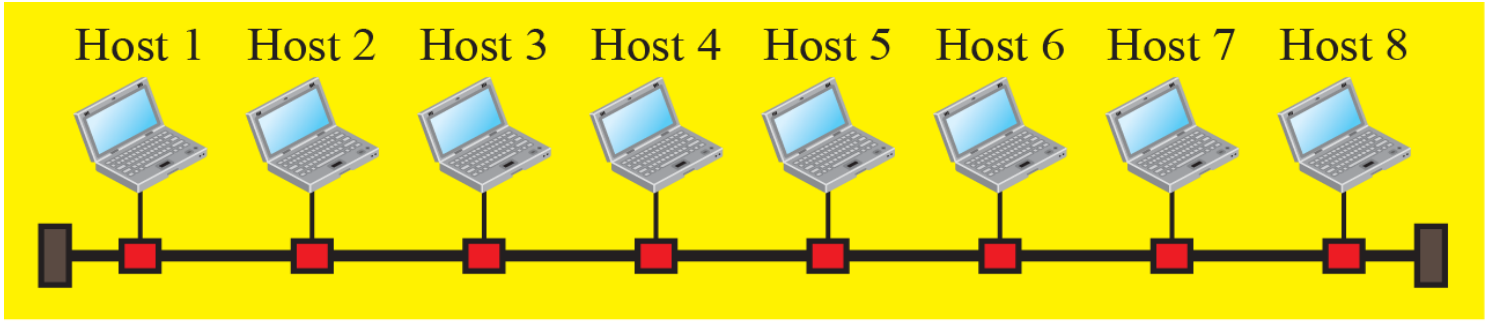
Star



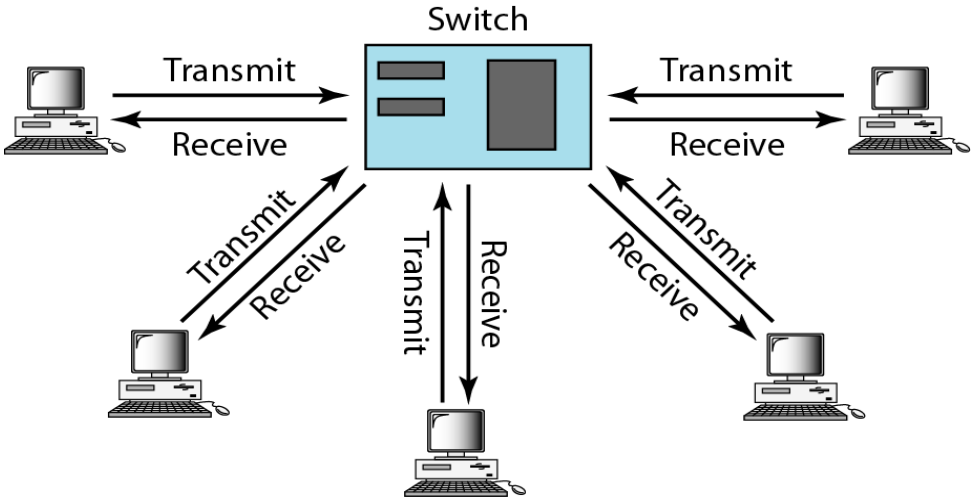
Ring



Concept of shared medium



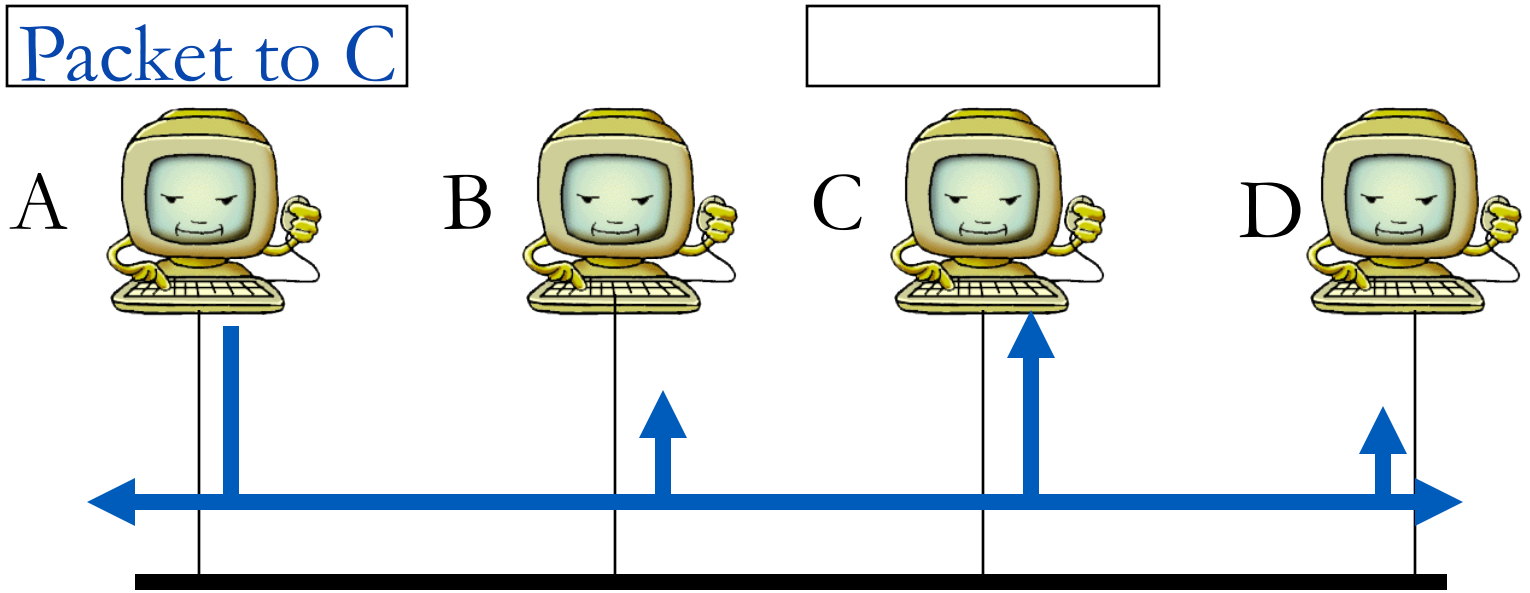
- Not for wired media any longer
- Wireless LAN (WLAN) share wireless medium.



Shared medium characteristics

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

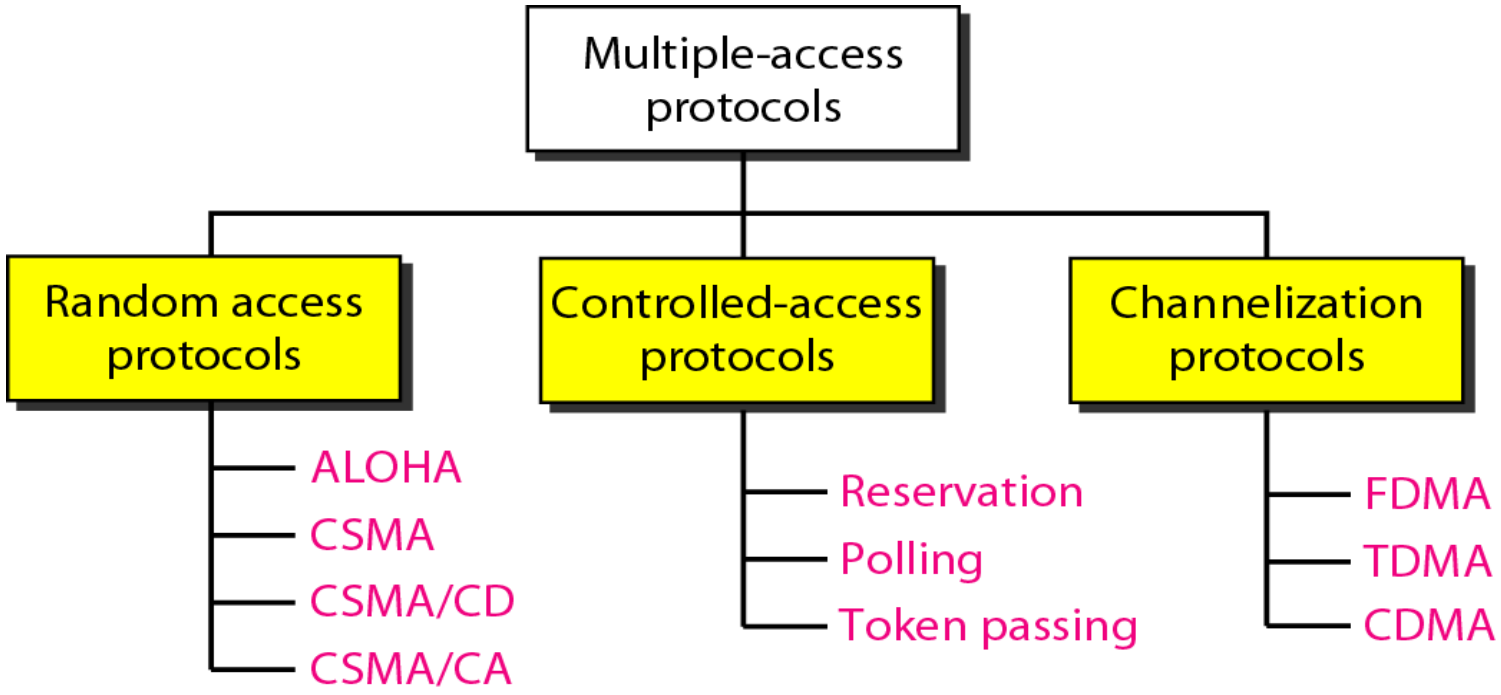
Data transfer on a shared medium



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



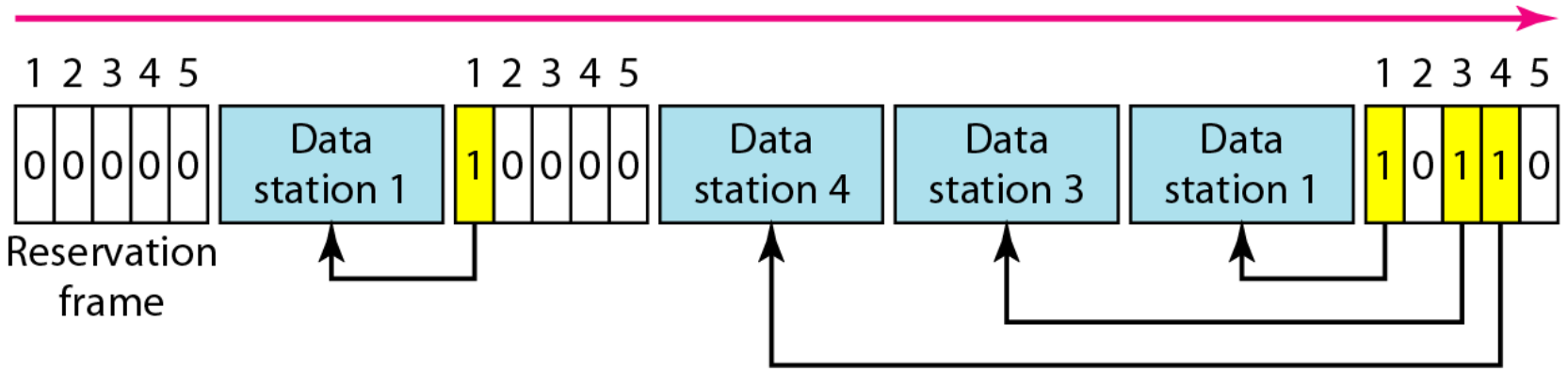
Controlled access protocols

- 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.



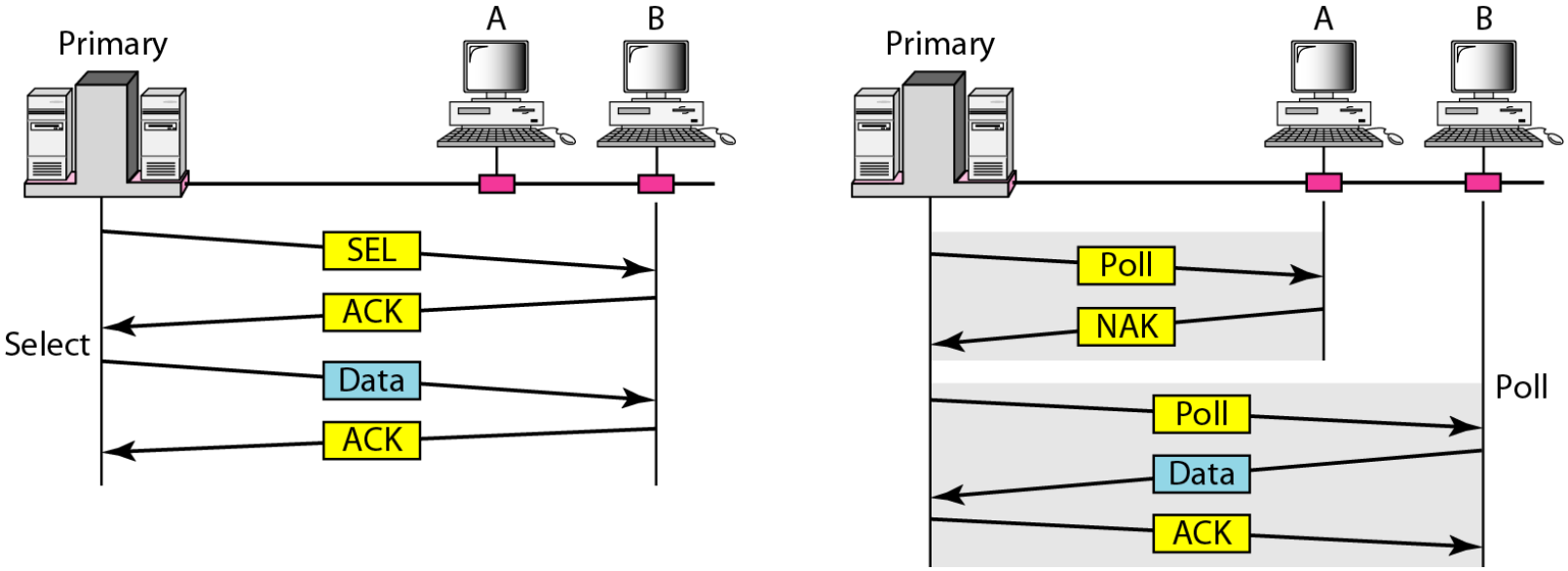
Controlled access: Polling

- One Primary Station (Master)
- Others are Secondary Stations (Slaves)

- Master controls the link.
- Slaves follow instructions.
- All data exchange is through the master.

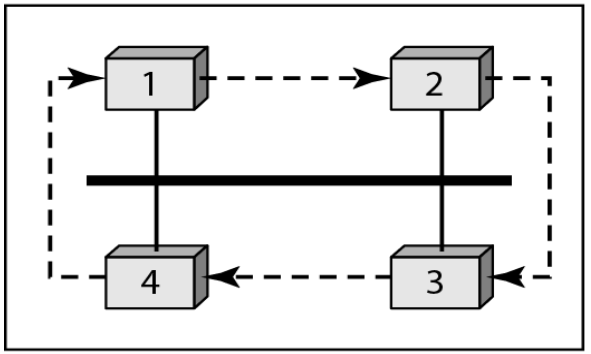
Poll and Select functions

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

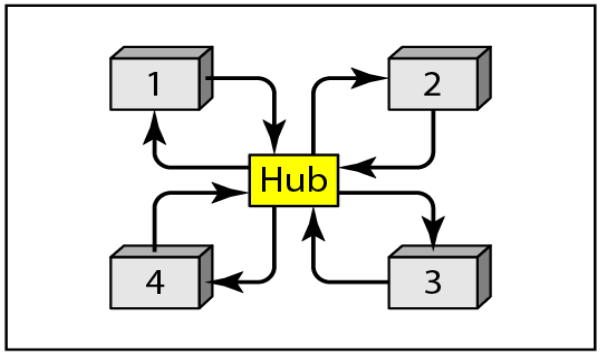


Controlled access: Token Passing

- Stations organized in a logical ring



c. Bus ring



d. Star ring

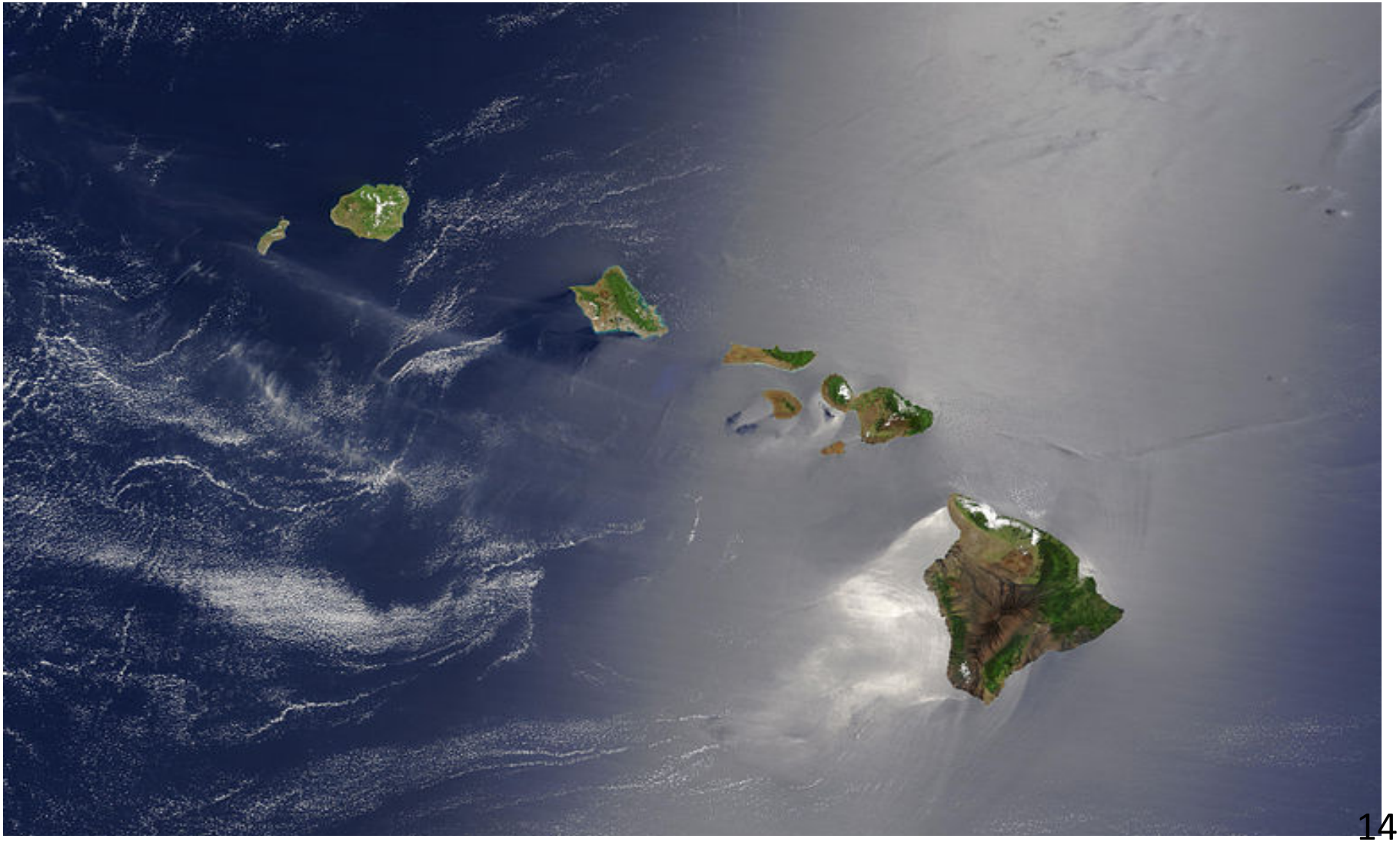
- Token
  - A special packet circulating through the ring
  - Only a station holding the token can use the link.
  - A station can only possess the token for a certain time, then it must release and pass the token on.

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

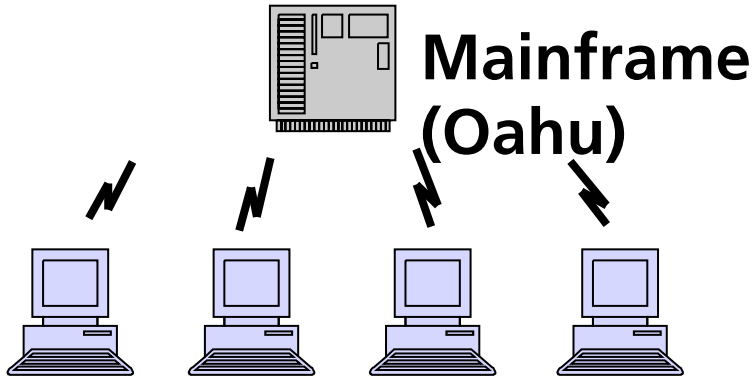
Hawaii



Random access: ALOHA

Multiple-access method of ALOHANET

- One of the first WLAN in the world
- Devloped by the University of Hawaii (1970)

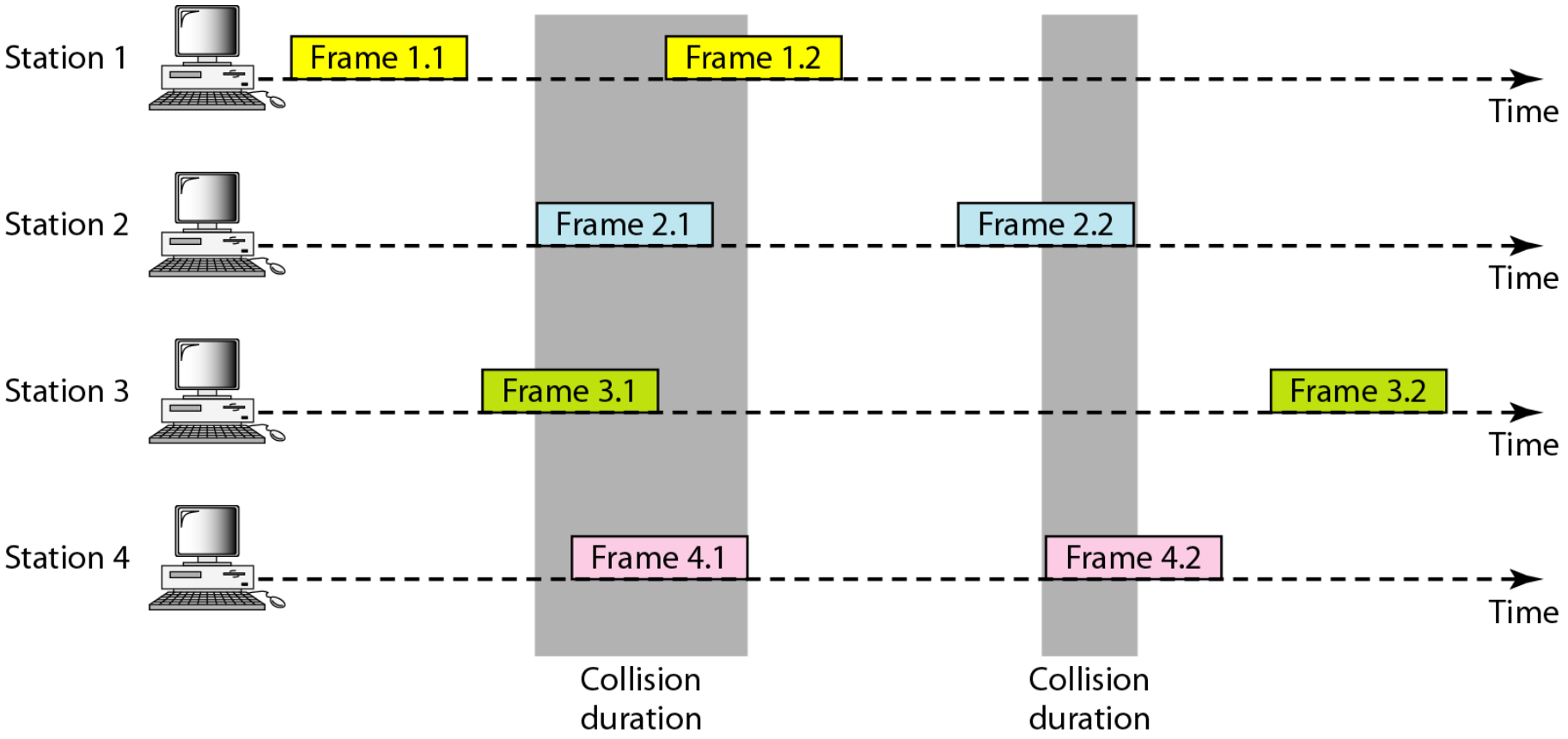


ALOHANET

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

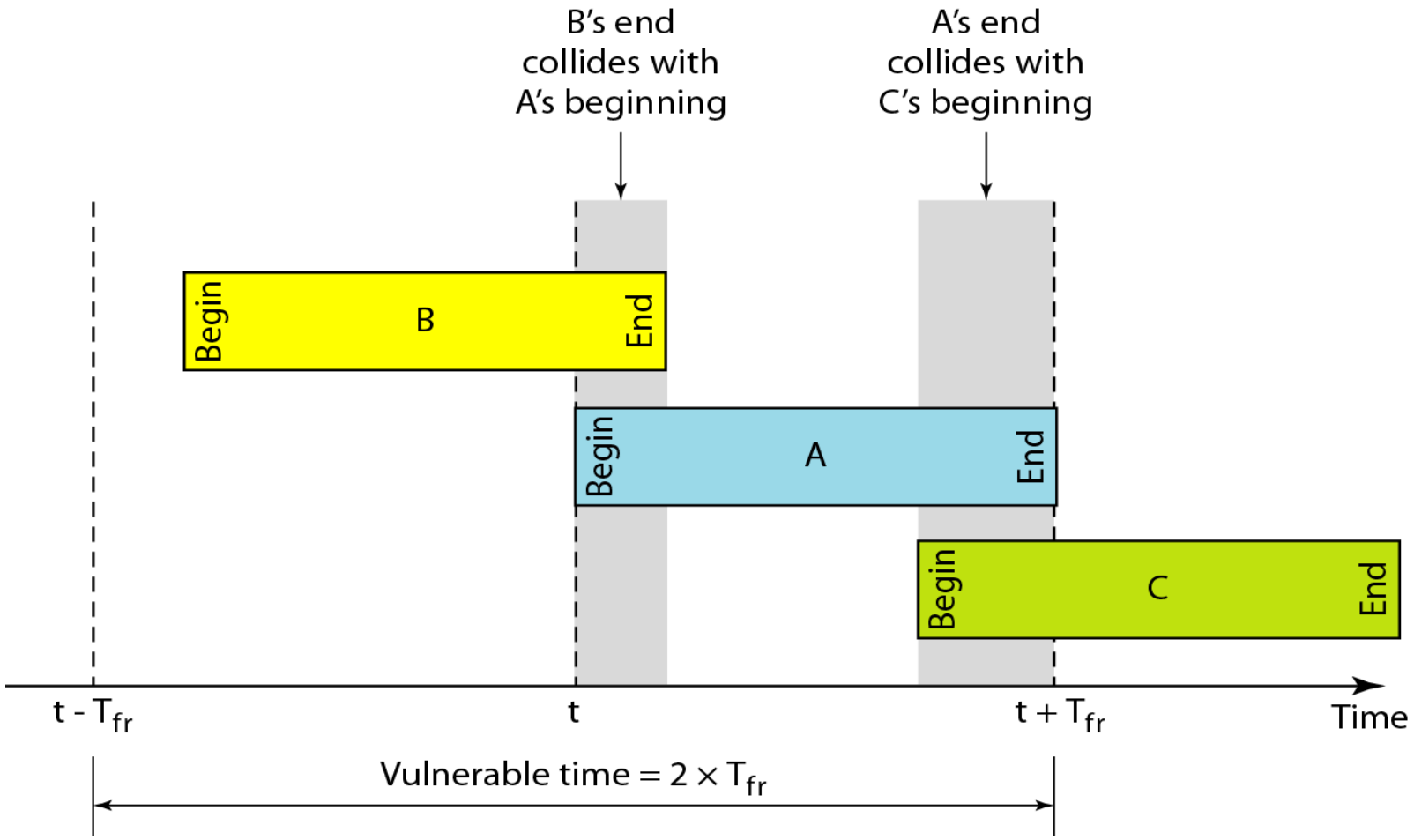
- Wait a random time and resend (backoff time T_B)
- After K_{max} attempts give up and try later (abort)

Example: In binary exponential backoff the backoff time T_B is

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

where *k* is the attempt number.

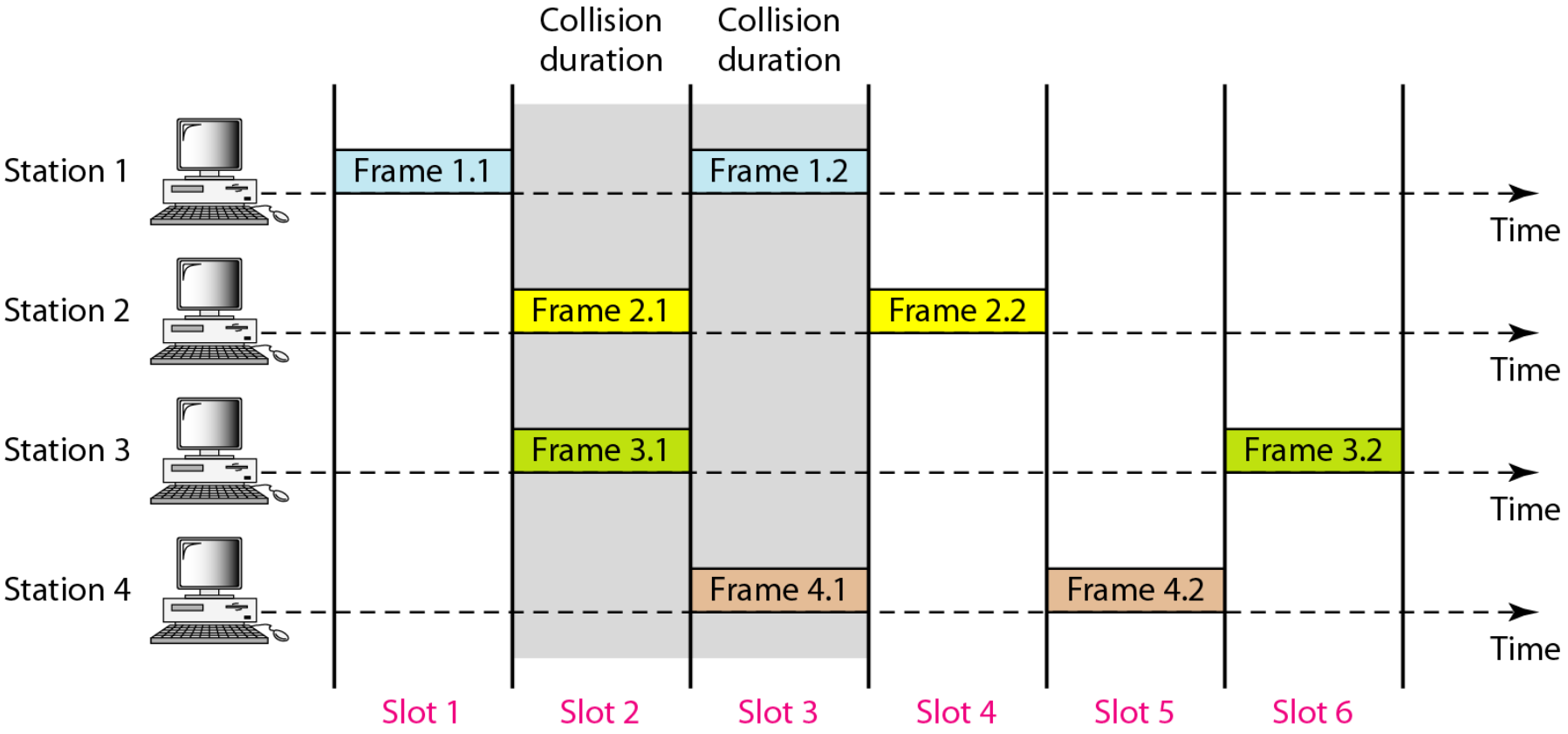
Pure ALOHA: Collisions



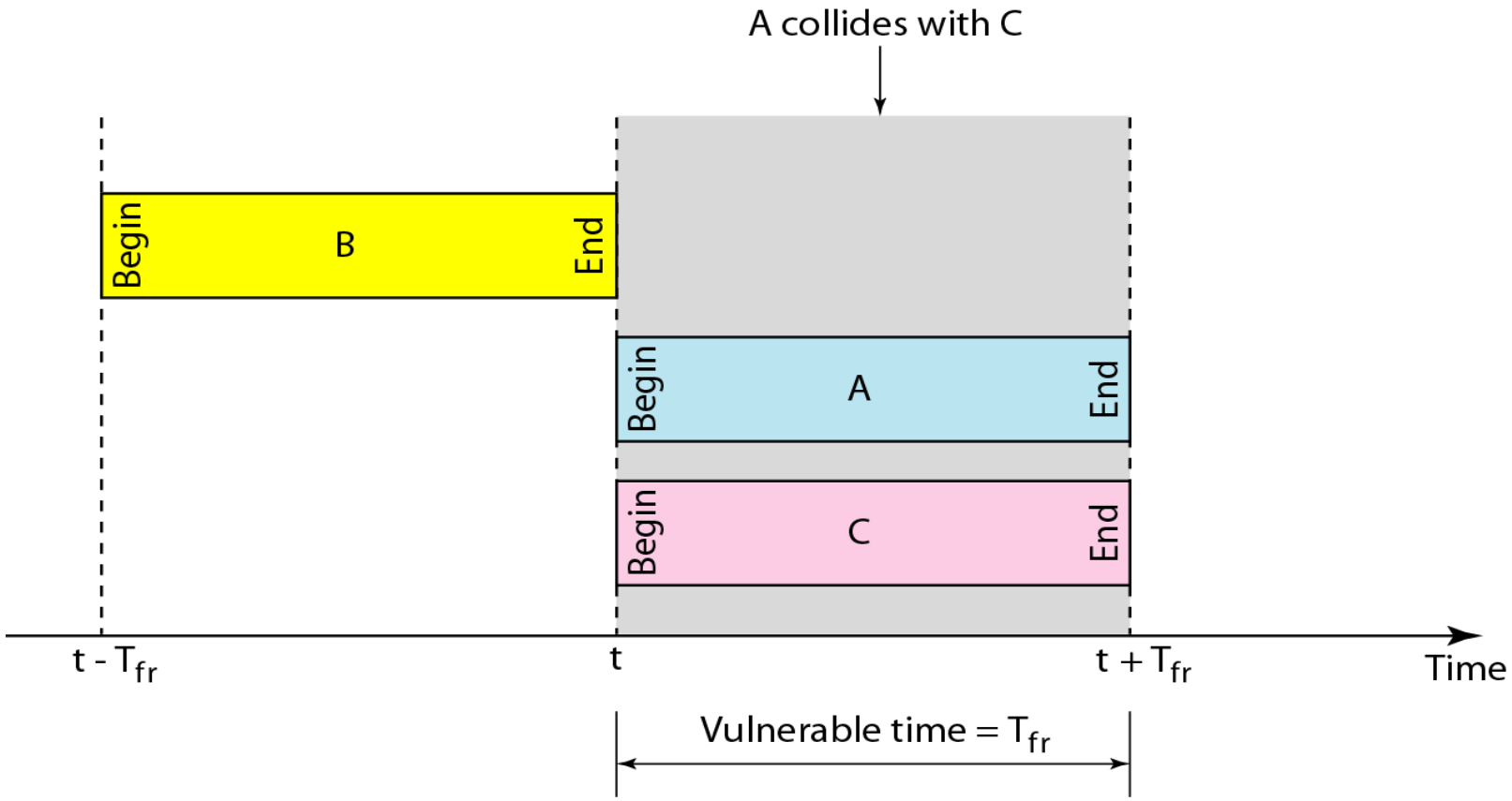
Slotted ALOHA

- 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: Colllisions



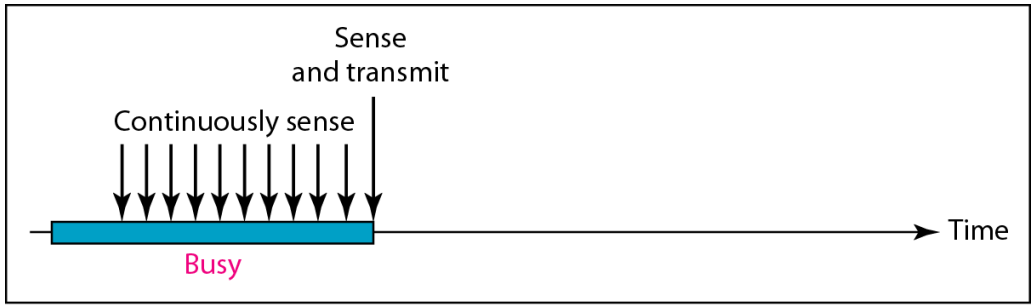
Throughput

- For Aloha the maximum utilization of the shared medium is
  - Slotted Aloha: 36.8%
  - Pure Aloha: 18.4%

Carrier Sense Multiple Access (CSMA)

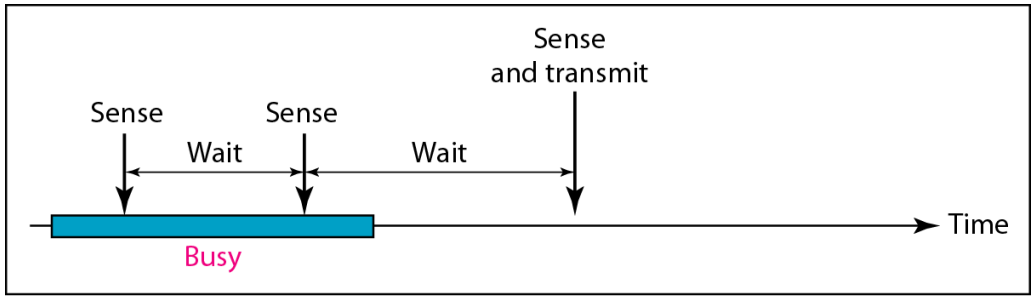
- Listen to (sense) medium before sending
- If medium occupied (busy), wait
  - 1-persistent
  - Non-persistent
  - P-persistent

Persistence methods



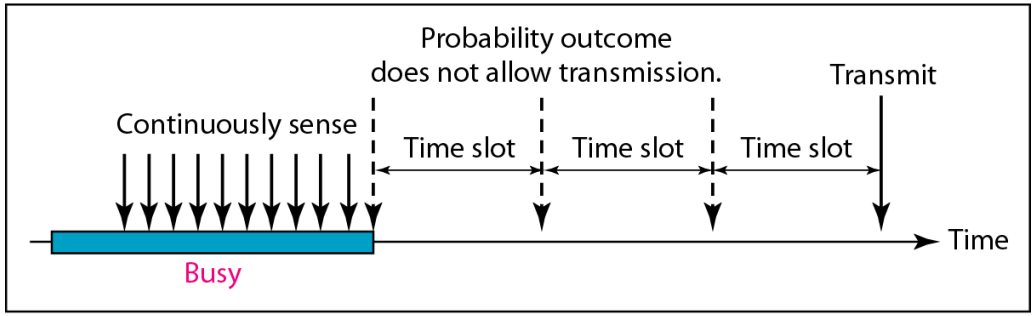
a. 1-persistent

Keep sensing and send as soon as channel idle



b. Nonpersistent

Wait random, sense again, send if idle

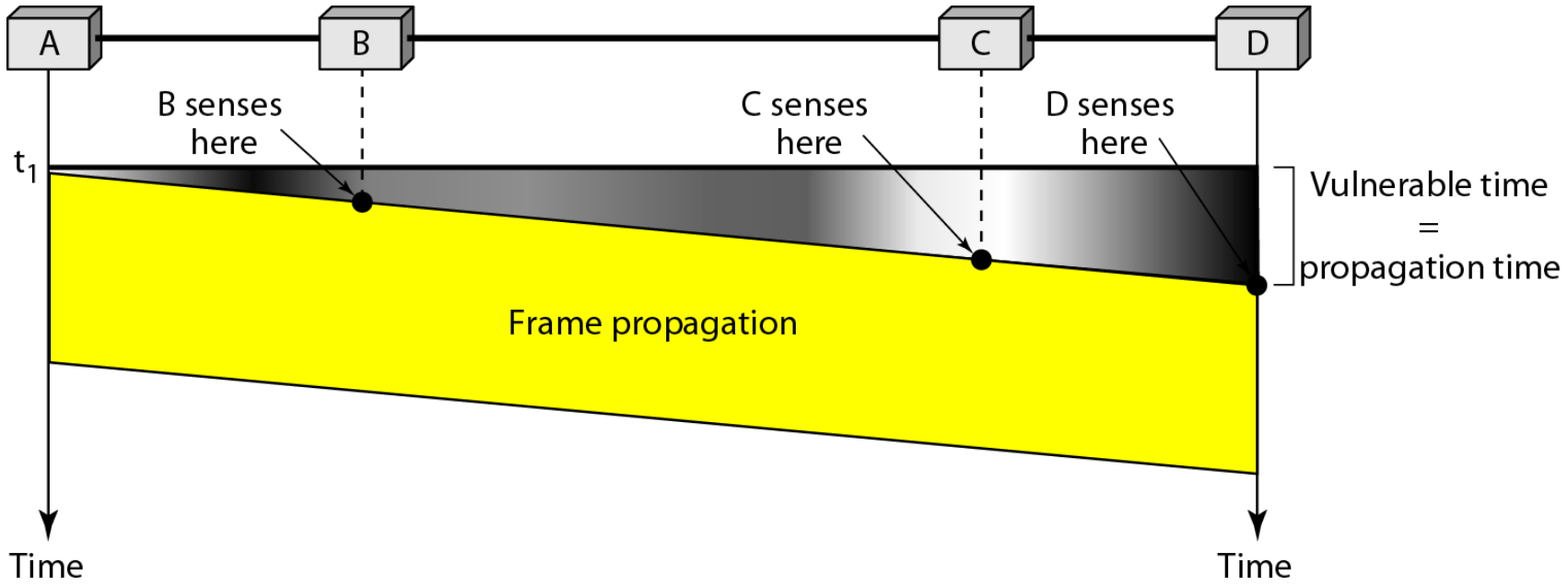


c. p-persistent

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

CSMA: Vulnerable time

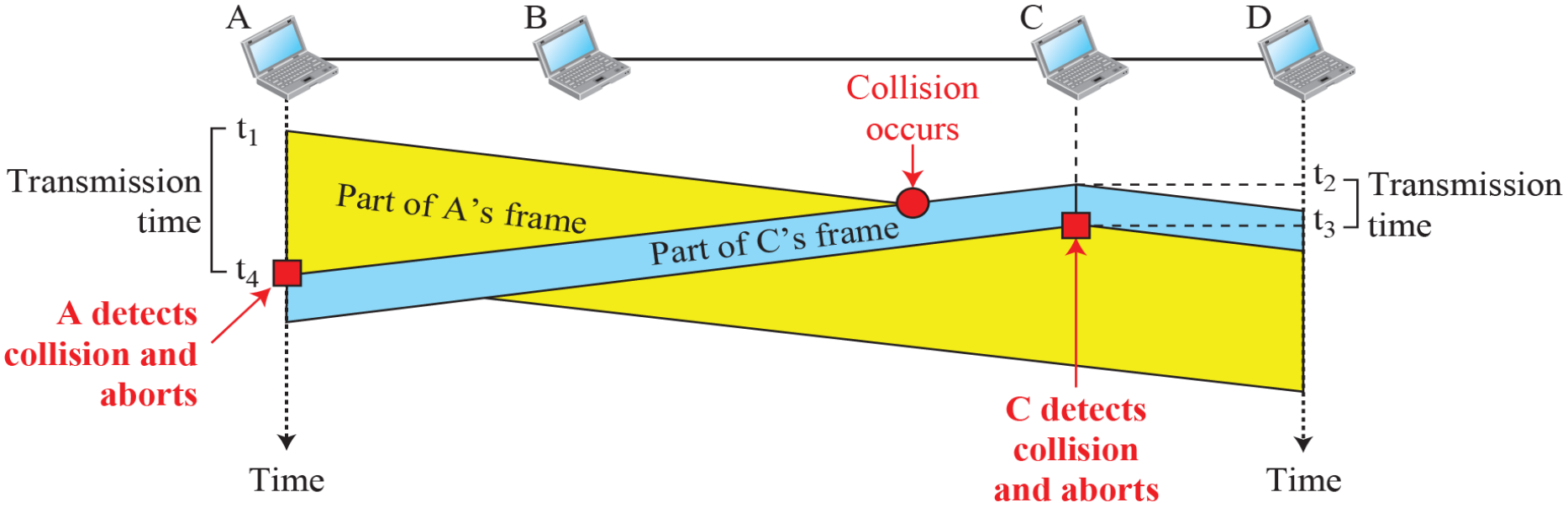
- Propagation time



- CSMA has no collision procedure

CSMA/CD: Collision detection

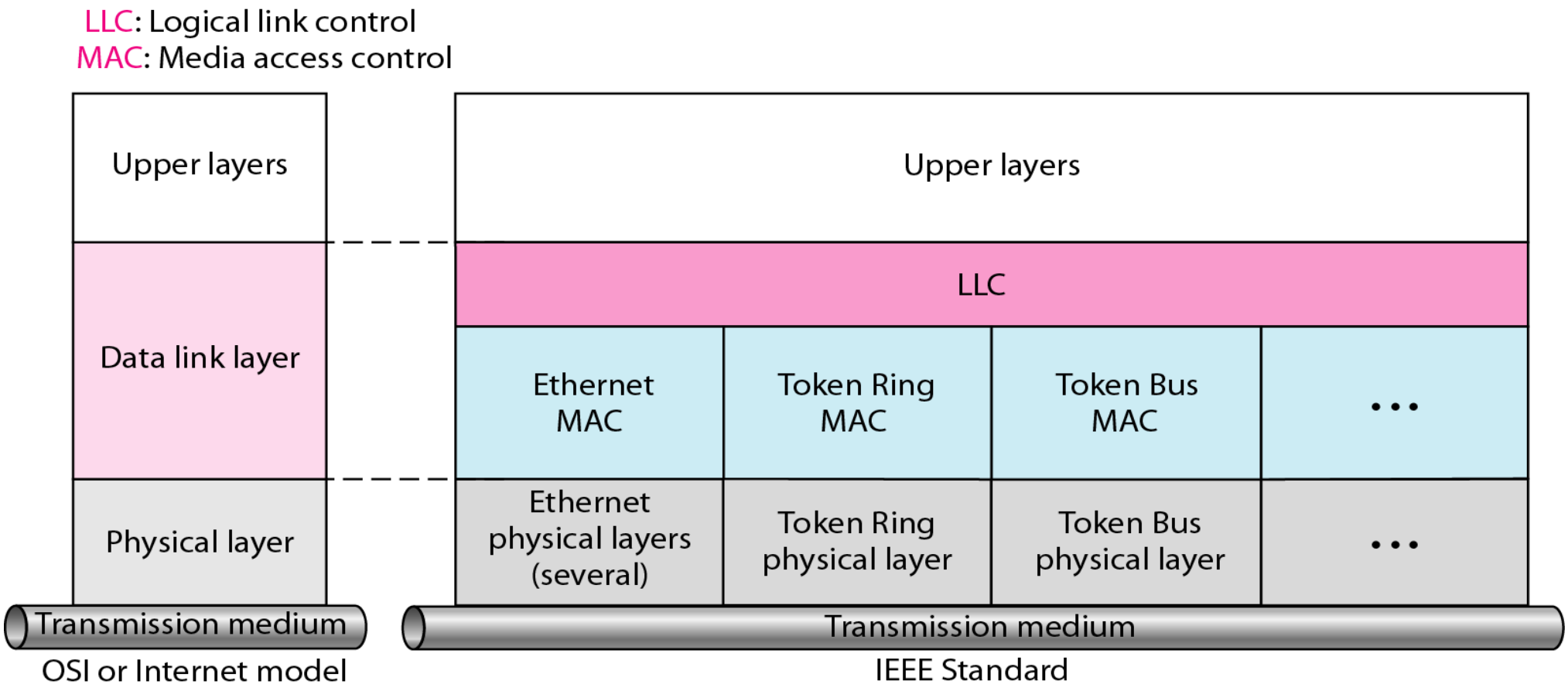
- Monitors medium after sending a frame
- Abort transmission and send a jamming signal if collision detected



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.

IEEE's LAN standards (Project 802)



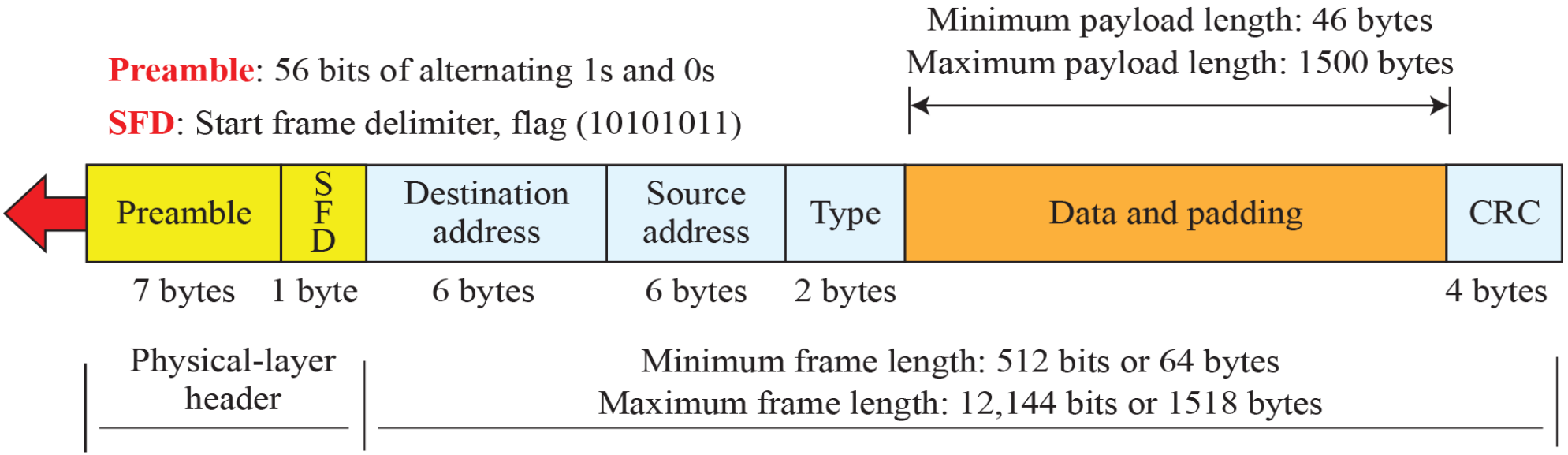
IEEE 802.3: Ethernet

- Created 1976 by Xerox, from 1983 in IEEE
- Evolved through new versions
  - 10 Mbps (Standard ethernet)
  - 100 Mbps (Fast ethernet)
  - 1 Gbps (Gibabit ethernet)
  - 10 Gbps (10-Gigabit ethernet)
  - 100 Gbps (100-Gigabit ethernet)
  - (400 Gbps expected in 2017)

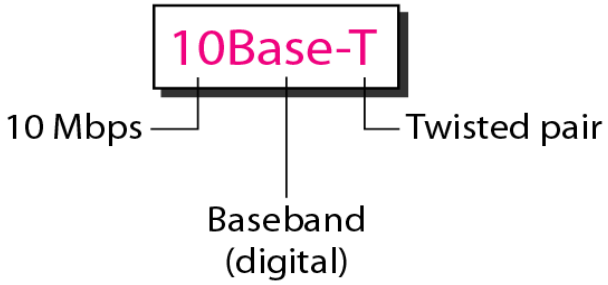
Access/home networks

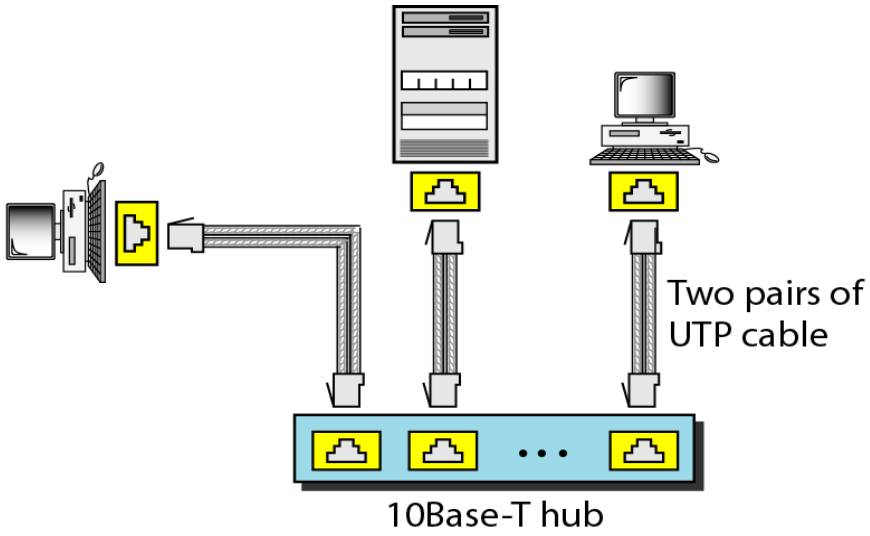
Backbone networks

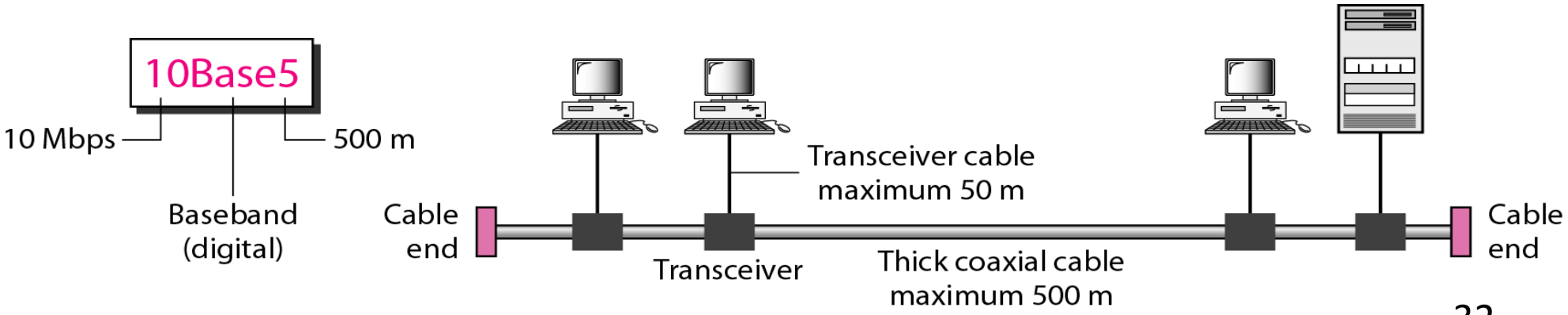
Ethernet frame structure



Standard Ethernet implementations

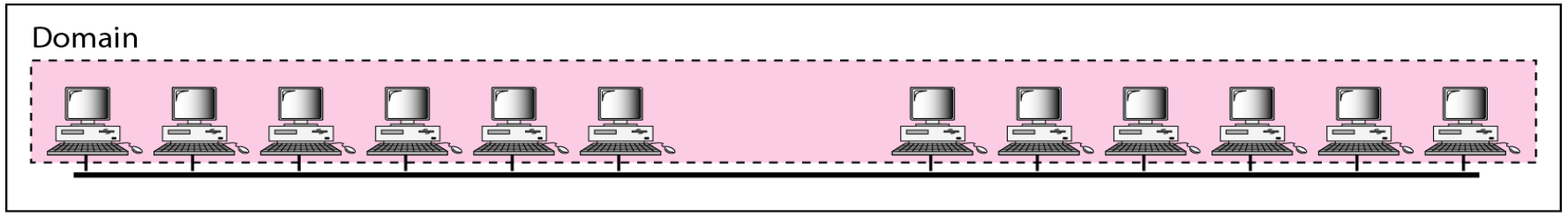




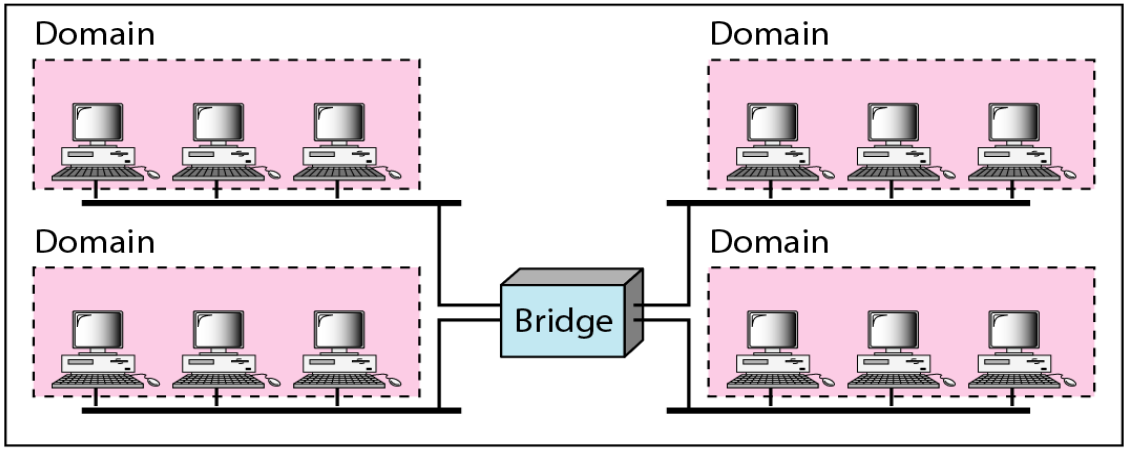


Evolution of Ethernet

- Collision domains



a. Without bridging

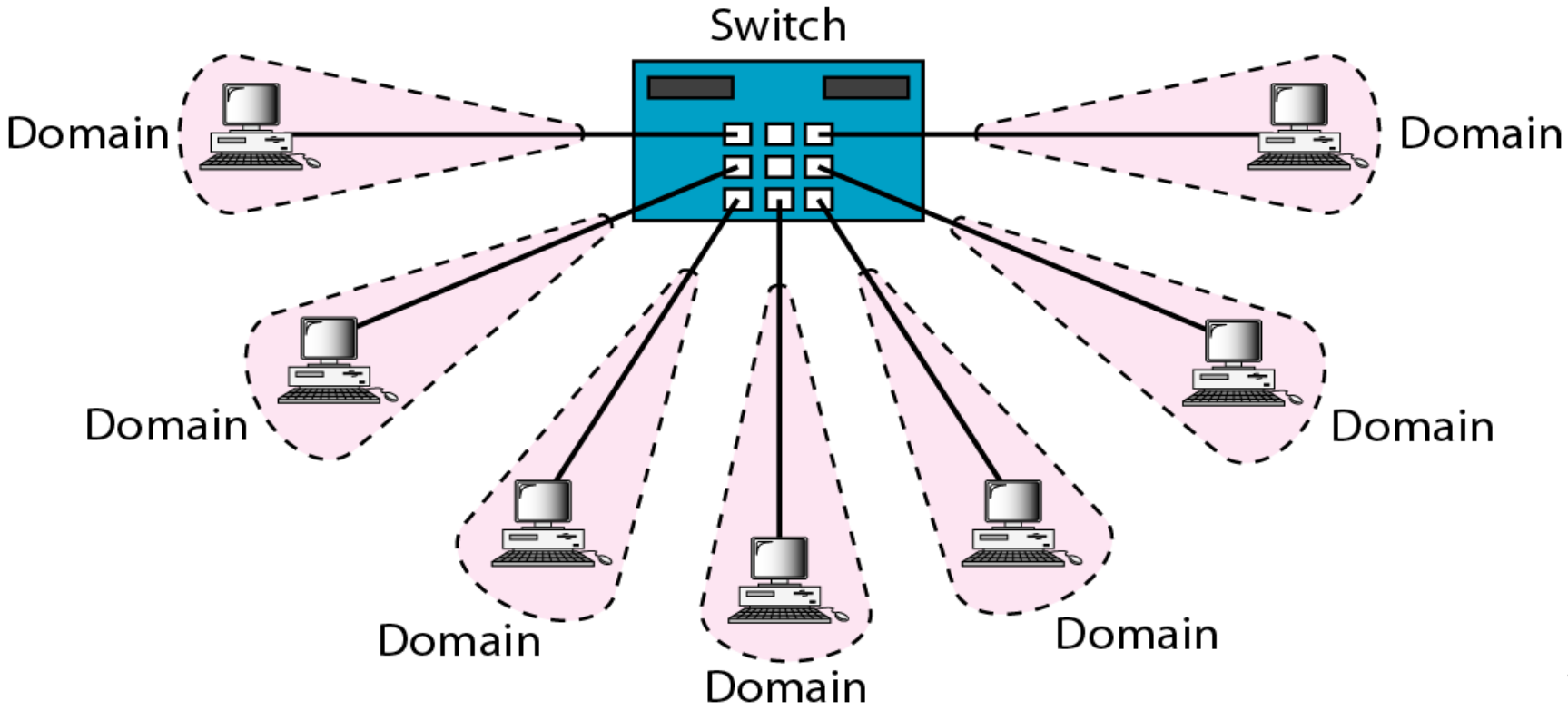


b. With bridging

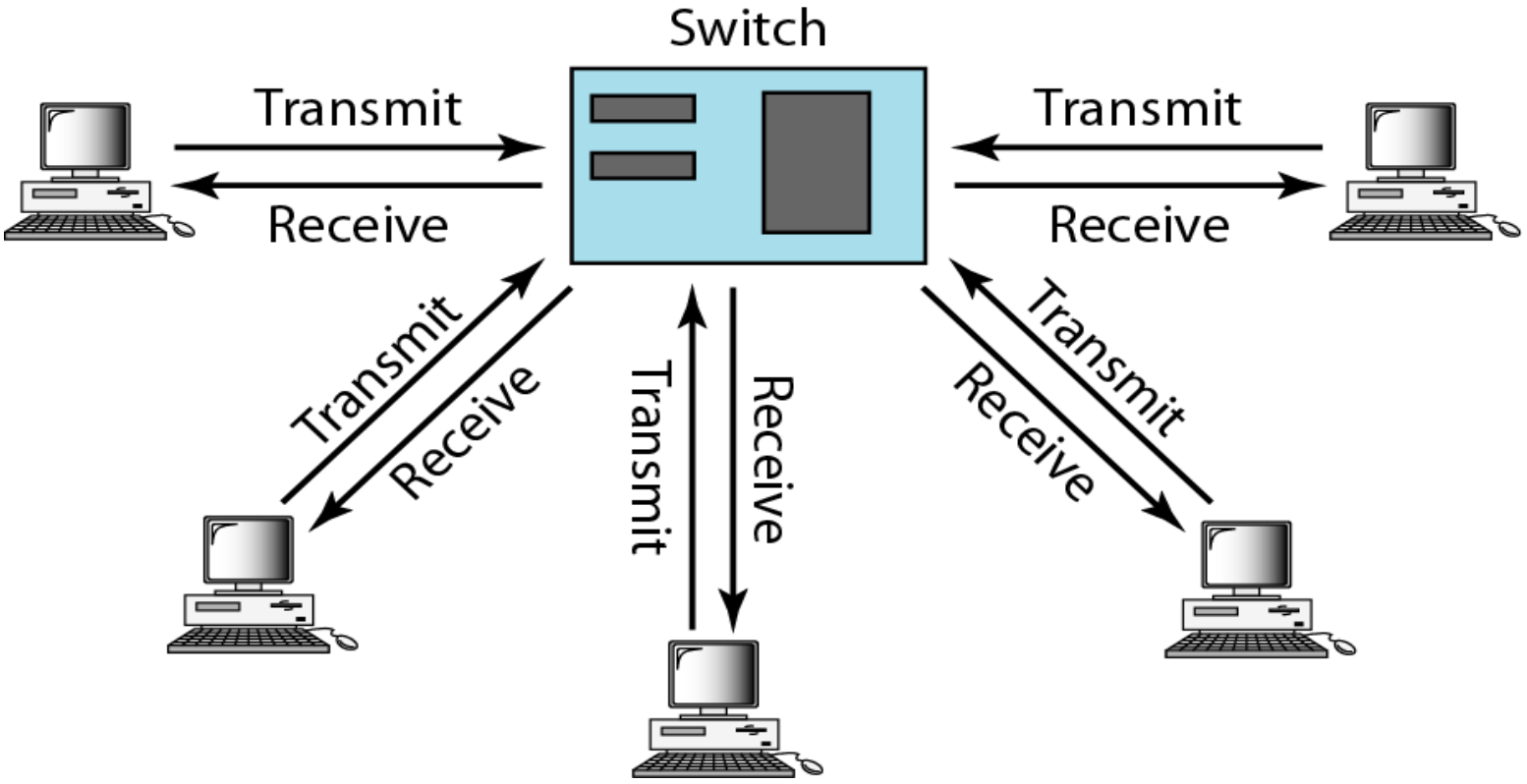
Switched Ethernet

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



Full-duplex switched Ethernet



Ethernet MAC address

- ipconfig /all (Windows)
- ifconfig (Unix)

Network addresses

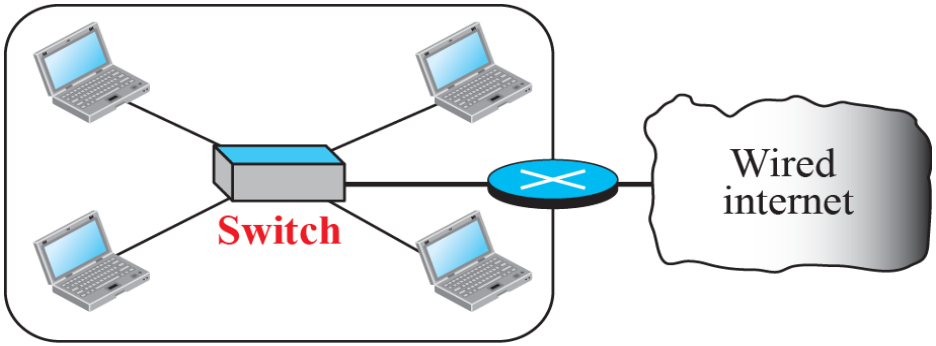
- In a network, all stations need an address so that the data can reach the right destination.
- All computers connected to a standard LAN have a unique physical address.

Unicast and broadcast addresses

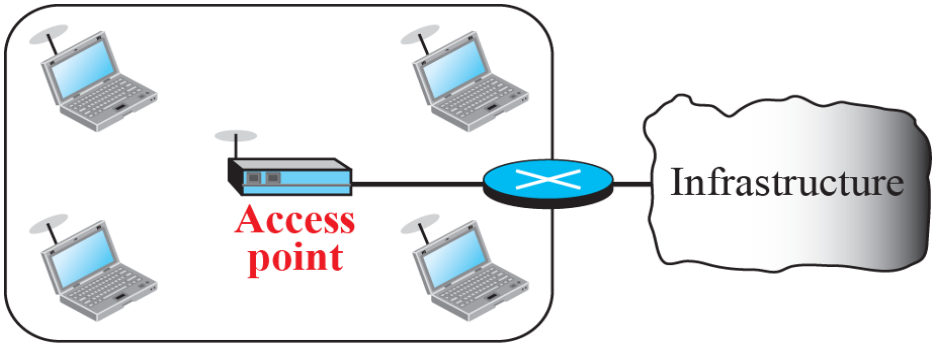
- Data transfer usually peformed in ***unicast***
  - One source and one destination
- Some messages sent in ***broadcast***
  - One source to all hosts in the network
- In 802-networks, the broadcast address is defined as all 1:s.

Wireless LAN

- Popularity of Internet ↑
- Popularity of mobility ↑



Wired LAN

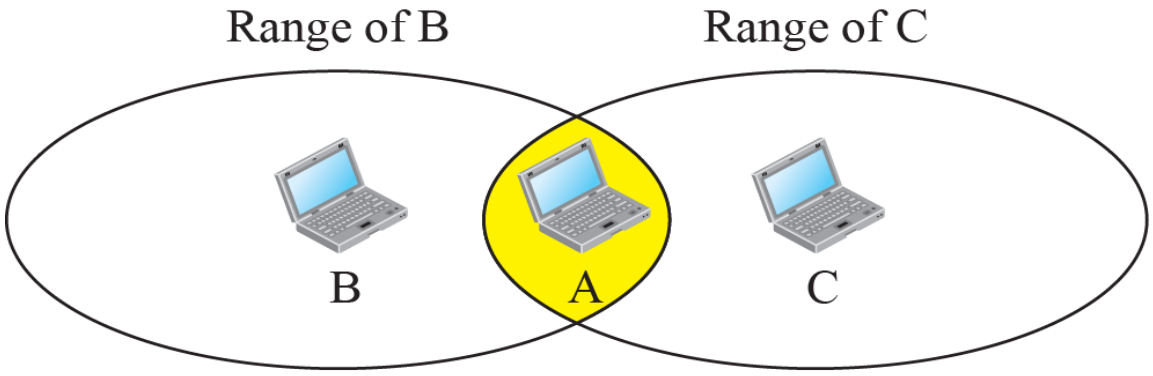


Infrastructure network

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

Hidden terminal problem

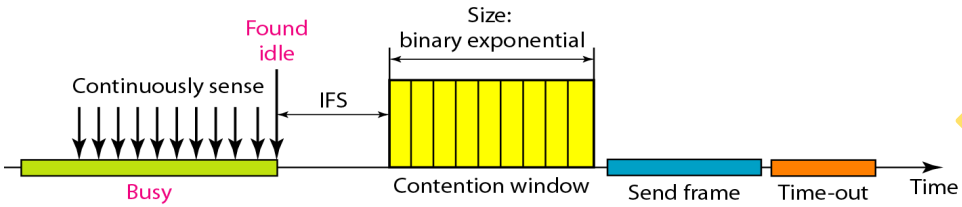
- Infamous in wireless networks
- Prevents collision detection

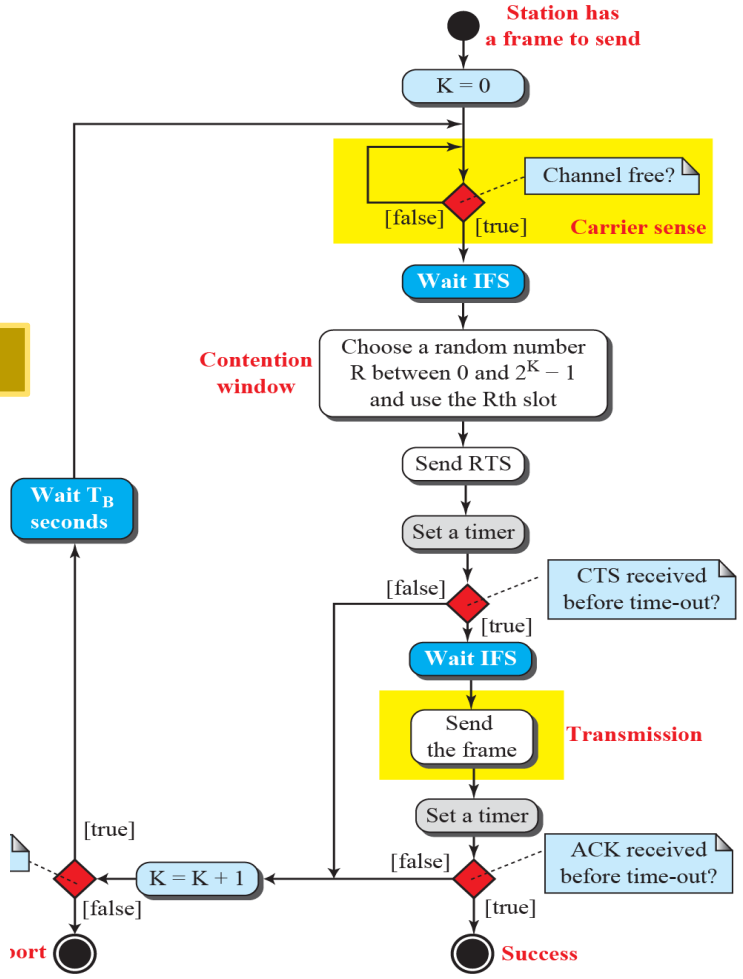


a. Stations B and C are not in each other's range.

CSMA with Collision Avoidance (CSMA/CA)

- Invented for wireless

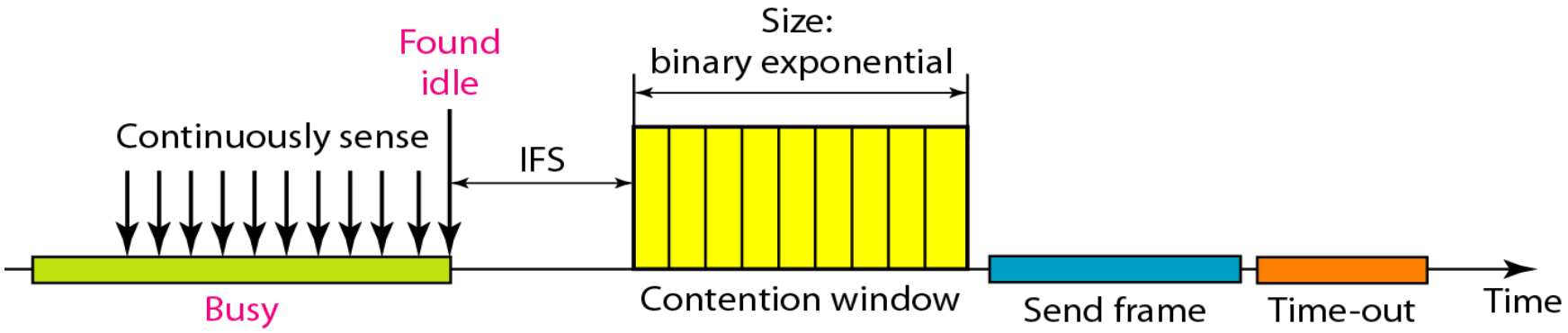




- Interframe space
- Contention window
- RTS/CTS/ACK

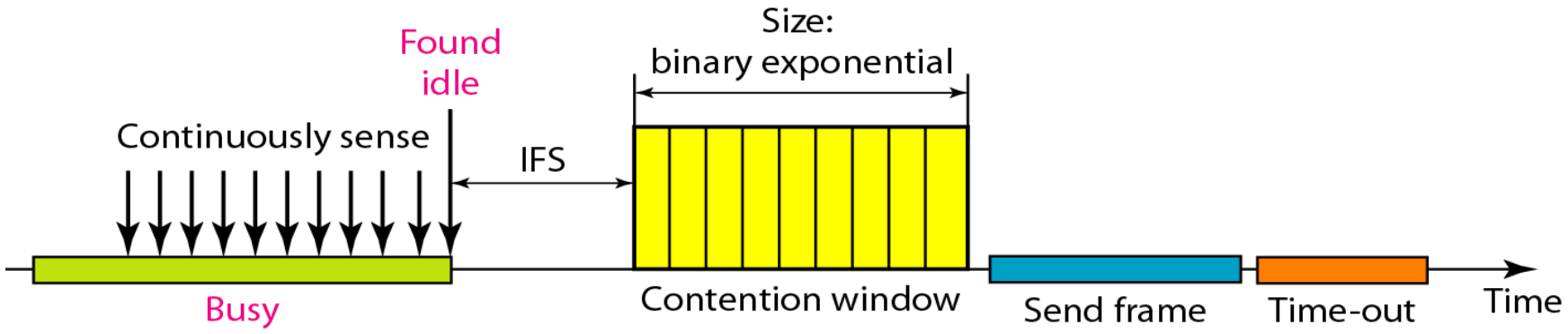
Interframe space

- 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