Data Communications and Networking Fourth Edition

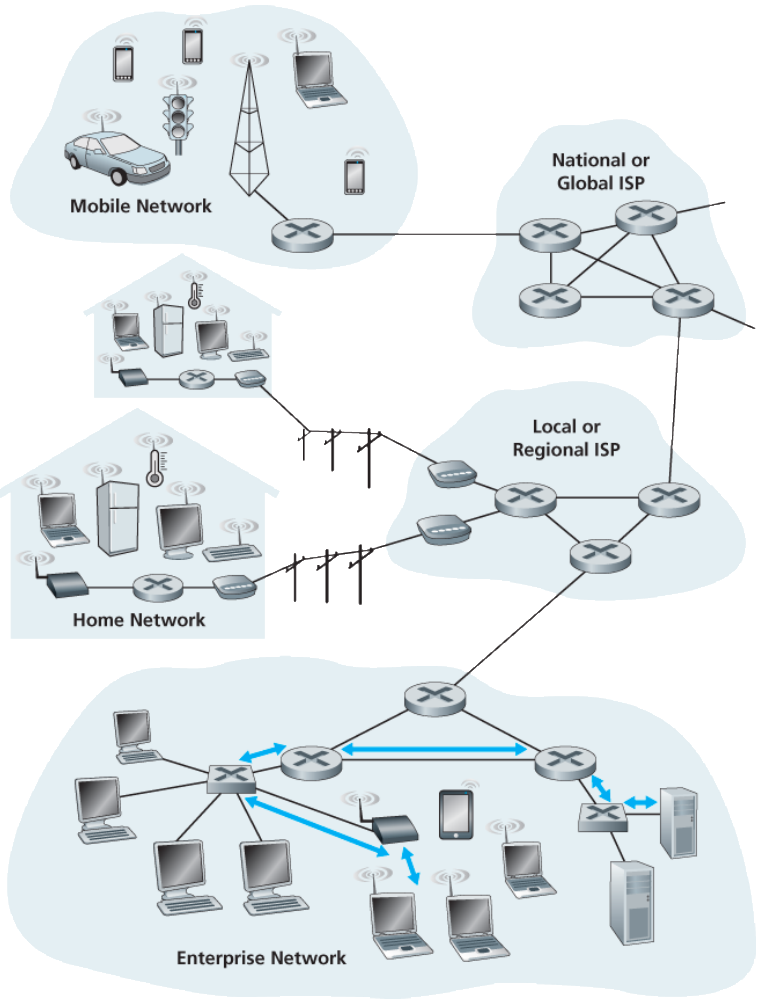
Forouzan

Chapter 12

Multiple Access

Link Layer Terminology

- ***Nodes :*** ***hosts and routers***
- ***Links:***
  - ***wired links***
  - ***wireless links***
- ***Frame :*** ***layer-2 packet***



data-link layer **has the responsibility of transferring datagram from one node to** ***physically adjacent*** **node over a link**

Link Layer and LANs

- Link layer services:
  - Error detection
    - errors caused by signal attenuation, noise.
    - receiver detects presence of errors ➡ signals sender for retransmission or drops frame
  - Error correction
    - receiver identifies *and corrects* bit error(s) without resorting to retransmission
  - Flow control
    - pacing between adjacent sending and receiving nodes
  - Framing - link layer addressing
  - Sharing a **broadcast/multipoint** link : **Multiple access**

Figure 12.1 *Data link layer divided into two functionality-oriented sublayers*

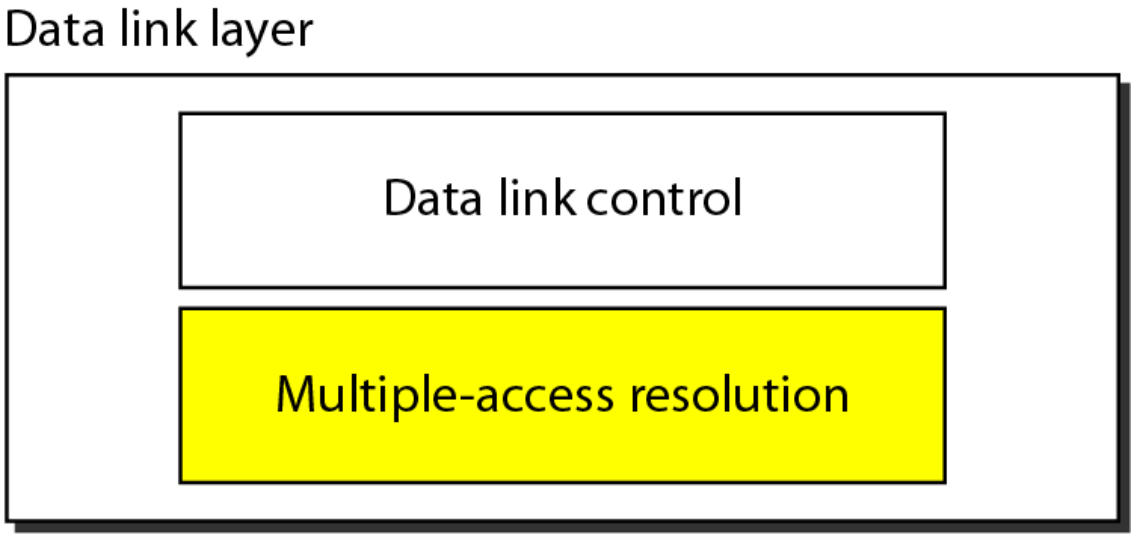
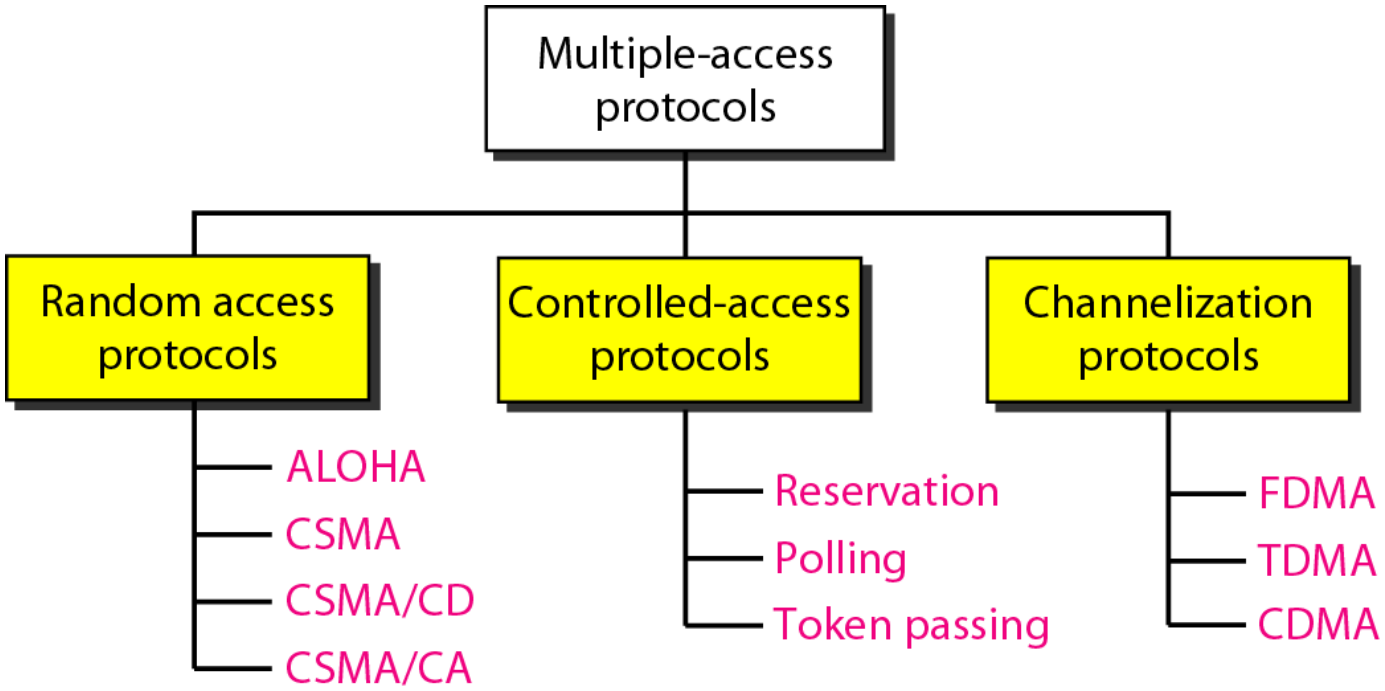


Figure 12.2 *Taxonomy of multiple-access protocols discussed in this chapter*



12-1 RANDOM ACCESS

In random access or contention methods, no station is superior to another station and none is assigned the control over another. No station permits, or does not permit, another station to send. At each instance, a station that has data to send uses a procedure defined by the protocol to make a decision on whether or not to send.

Topics discussed in this section:

ALOHA
Carrier Sense Multiple Access
Carrier Sense Multiple Access with Collision Detection
Carrier Sense Multiple Access with Collision Avoidance

12-1-1 ALOHA

- The earliest random access method
- Was developed at the **University of Hawaii**
- Has two variants:
  - **Pure ALOHA**
  - **Slotted ALOHA**

PURE ALOHA

- The original ALOHA protocol
- Each station sends a frame whenever it has a frame to send
- Since there is only one channel to share, there is the possibility of **collision** between frames from different stations

Figure 12.3 *Frames in a pure ALOHA network*

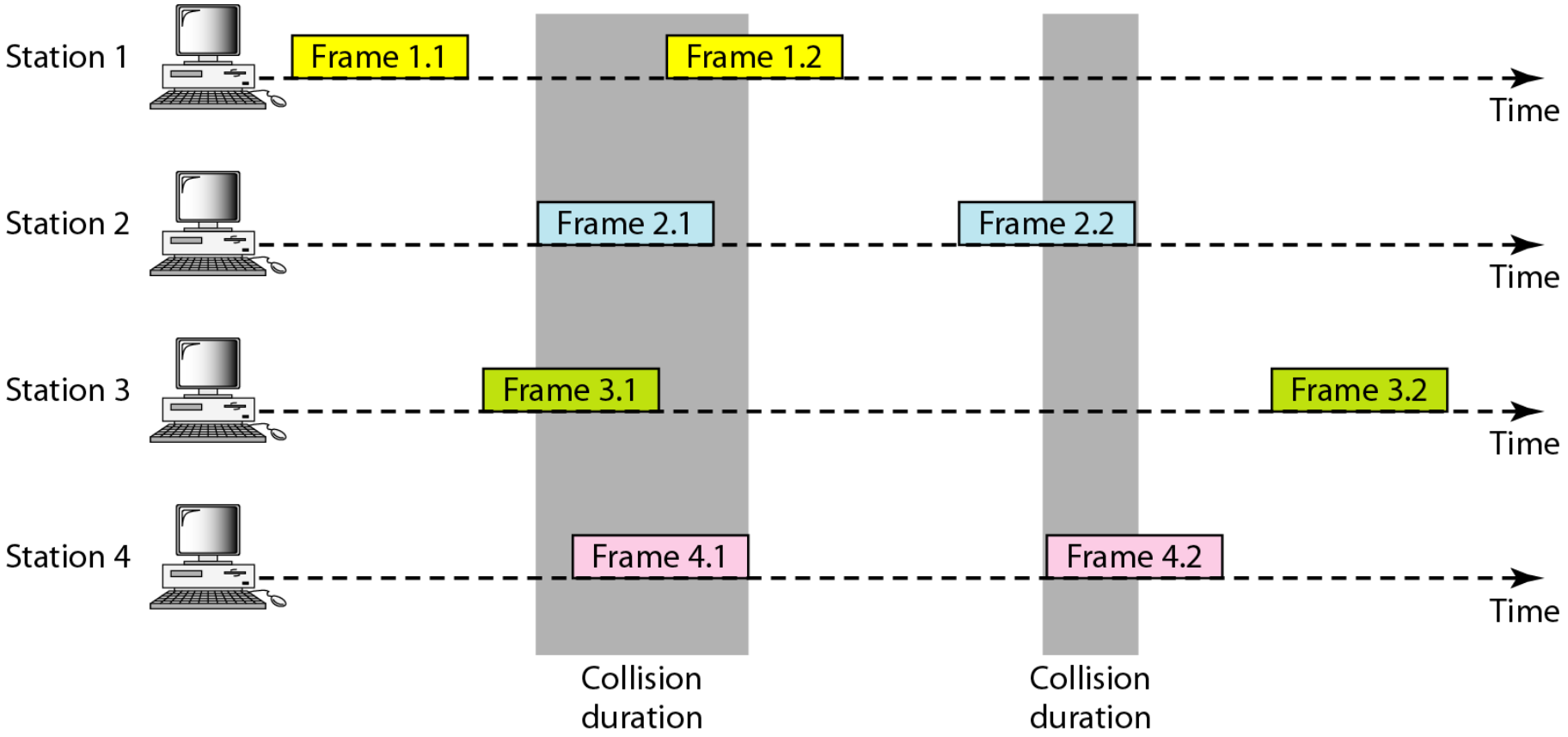


Figure 12.4 *Procedure for pure ALOHA protocol*

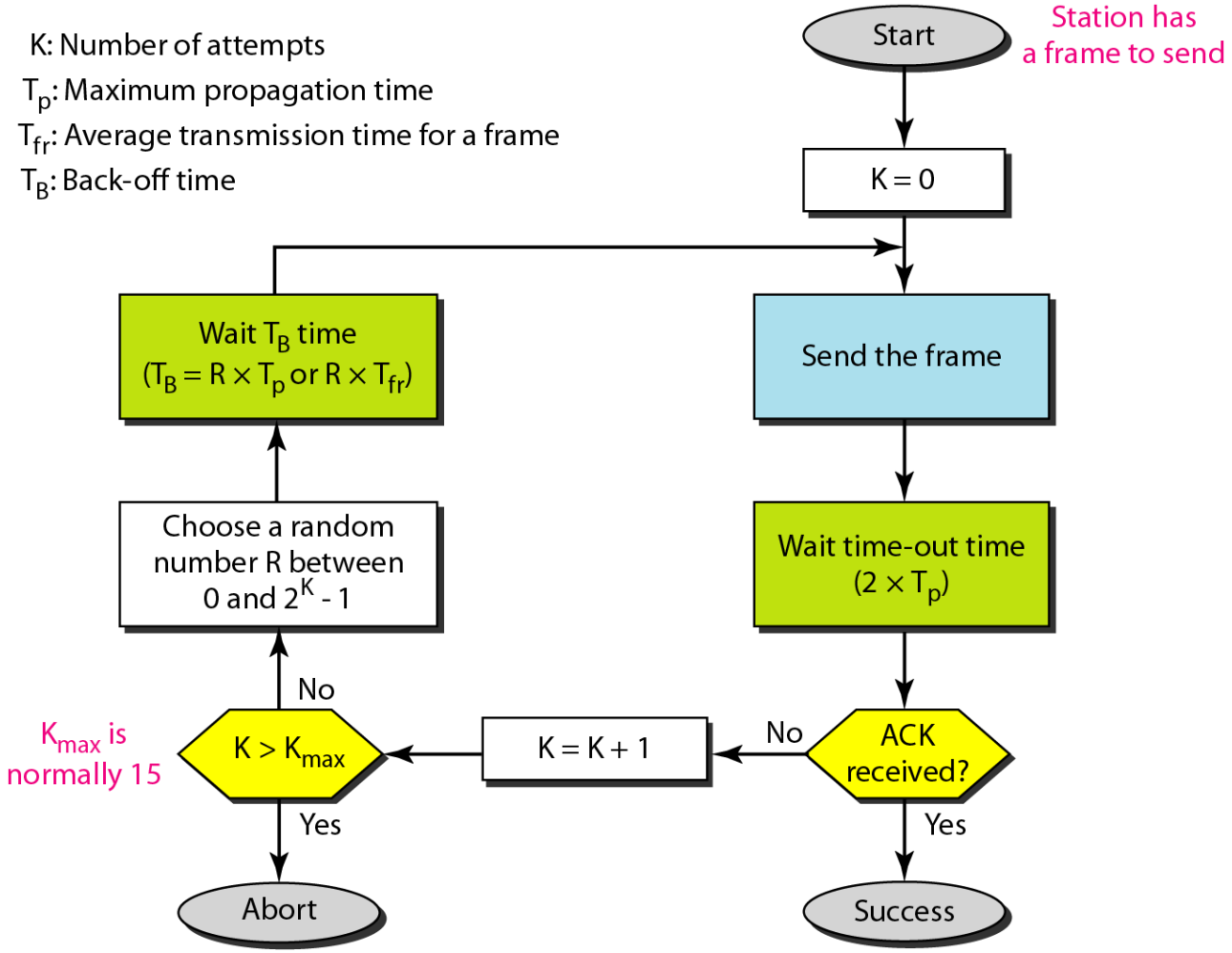
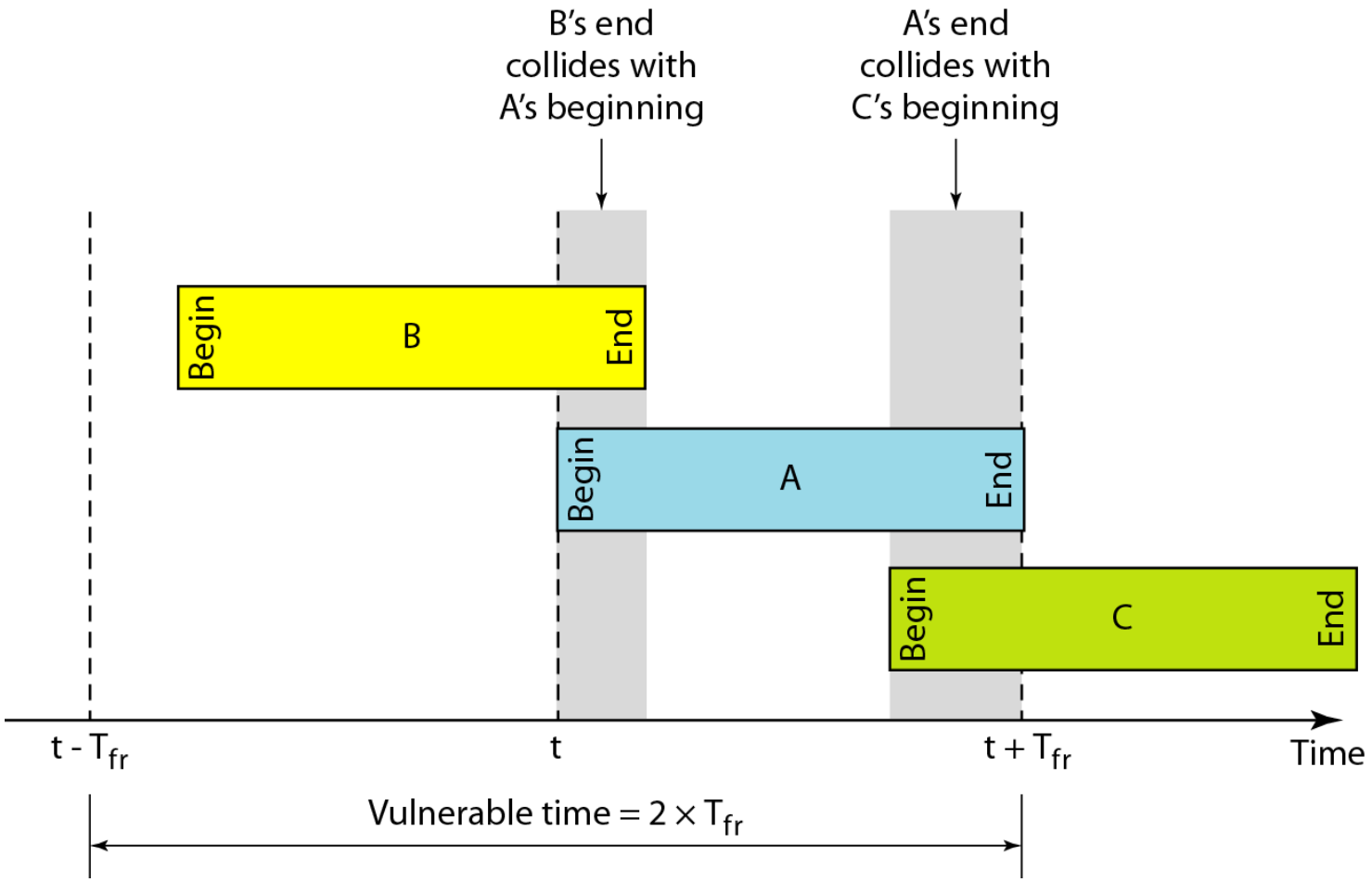


Figure 12.5 *Vulnerable time for pure ALOHA protocol*



Example 12.2

A pure ALOHA network transmits 200-bit frames on a shared channel of 200 kbps. What is the requirement to make this frame collision-free?

Solution

Average frame transmission time T_{fr} is 200 bits/200 kbps or 1 ms. The vulnerable time is $2 \cdot 1$ ms = 2 ms. This means no station should send later than 1 ms before this station starts transmission and no station should start sending during the period (1 ms) that this station is sending.

SLOTTED ALOHA

- In slotted ALOHA the time is divided into slots of T_{fr} seconds
- Stations can send frames **only at the beginning of the time slot**
- Improves the efficiency of pure ALOHA

Figure 12.6 *Frames in a slotted ALOHA network*

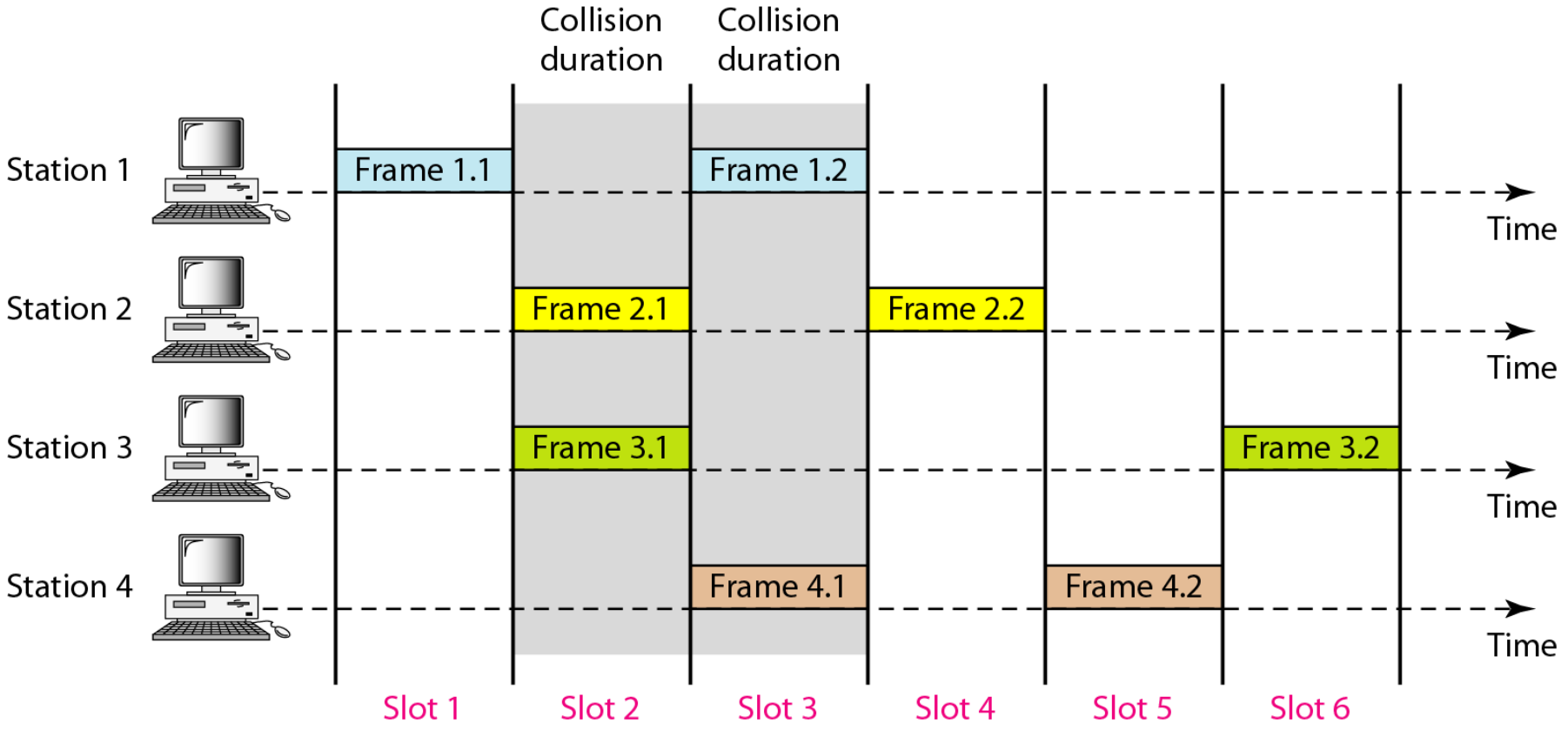
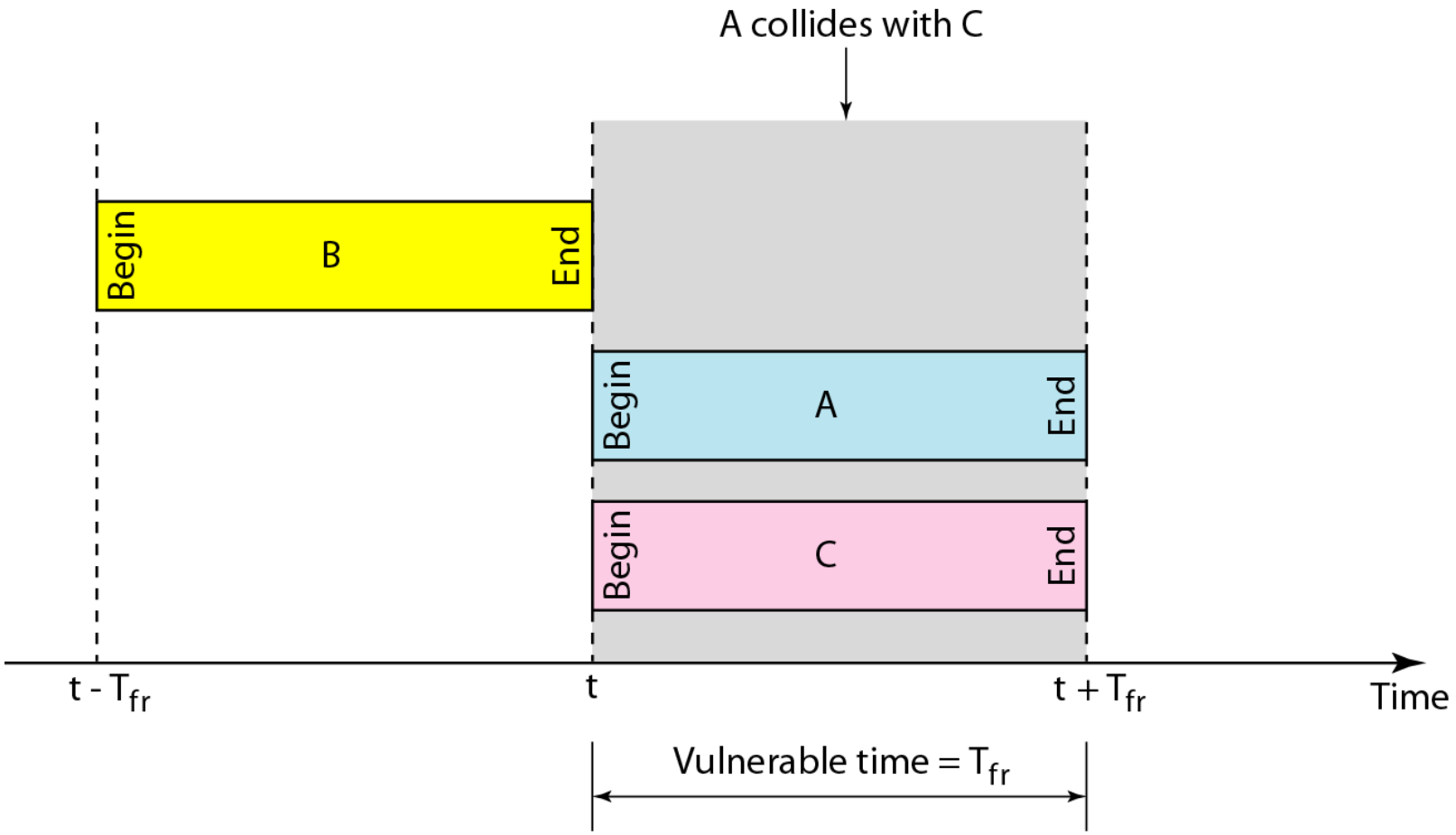


Figure 12.7 *Vulnerable time for slotted ALOHA protocol*



12-1-2 CSMA

- **Carrier Sense Multiple Access**
- Senses the medium before sending frame
- Reduce the possibility of collision, but it cannot eliminate it due to **propagation delay**

Figure 12.8 *Space/time model of a collision in CSMA*

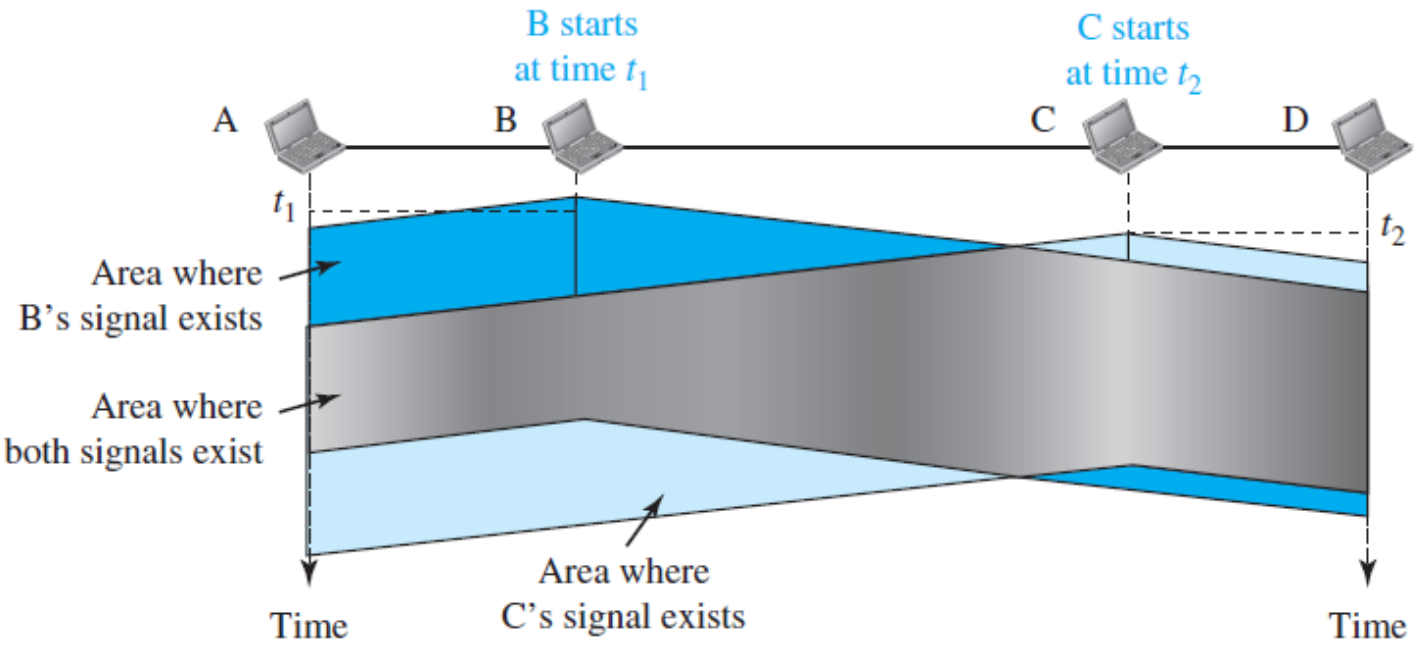


Figure 12.9 *Vulnerable time in CSMA*

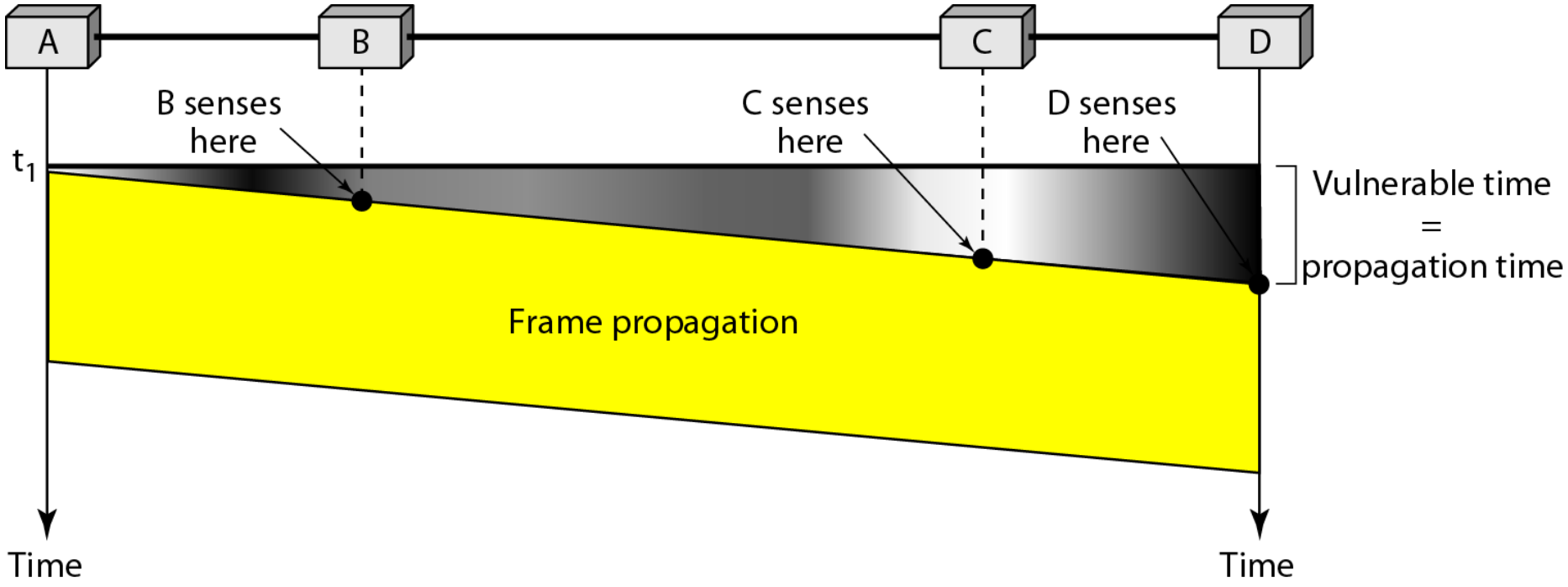
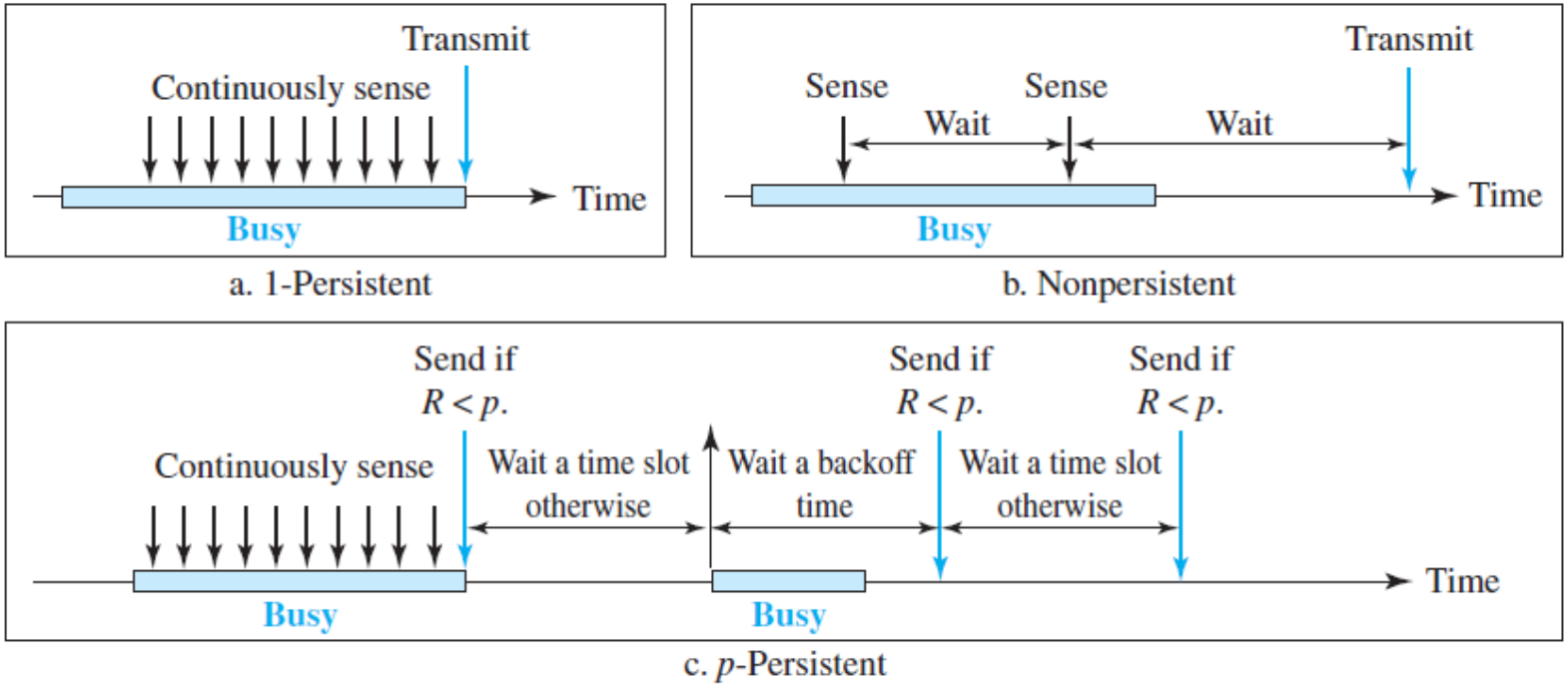


Figure 12.10 *Behavior of three persistence methods of CSMA*



12-1-3 CSMA/CD

- **Carrier Sense Multiple Access with Collision Detection**
- The CSMA method does not specify the procedure following a collision
- CSMA/CD augments the algorithm to handle the collision
- The medium is monitored continuously by each station
- If there is a collision,
  - **Immediately aborts transmission**
  - **The frame is sent again**

Figure 12.12 *Collision of the first bit in CSMA/CD*

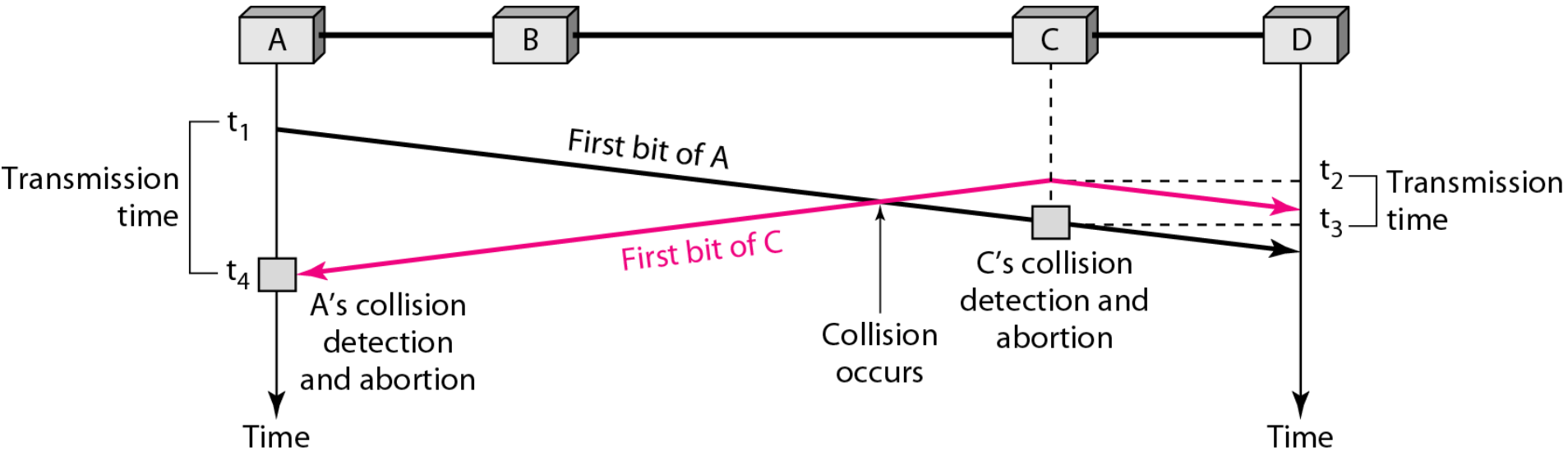
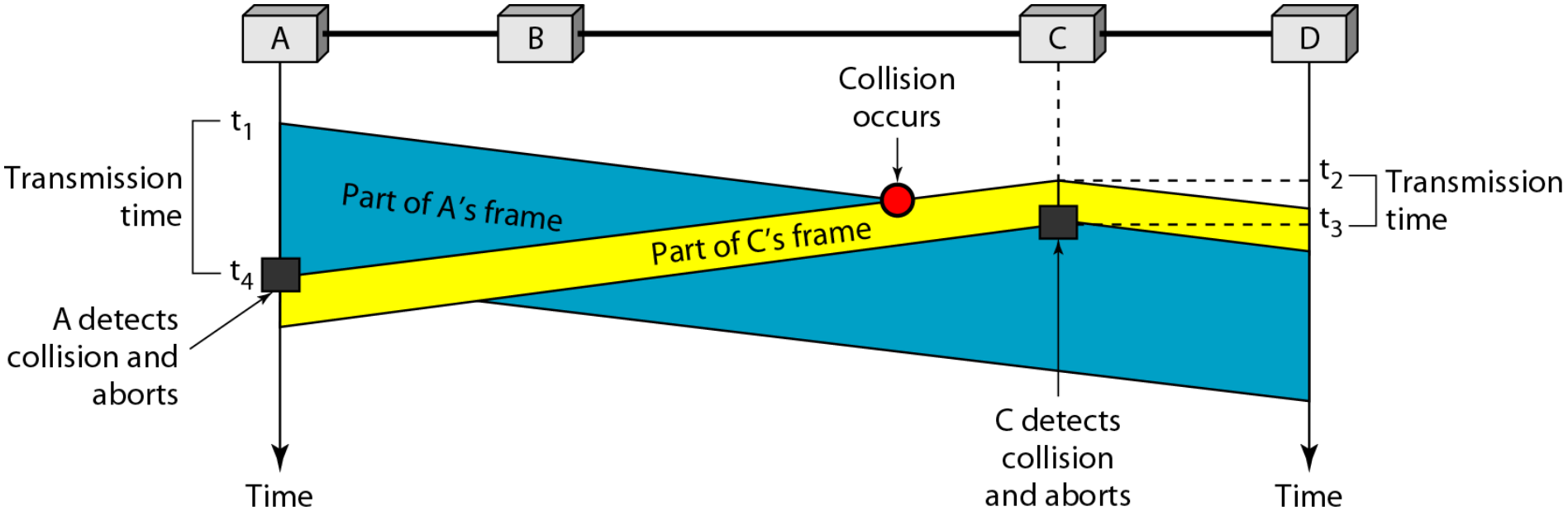


Figure 12.13 *Collision and abortion in CSMA/CD*



Minimum Frame Size

The frame transmission time T_{fr} must be at least two times the maximum propagation time T_p

Example 12.5

A network using CSMA/CD has a bandwidth of 10 Mbps. If the maximum propagation time (including the delays in the devices and ignoring the time needed to send a jamming signal, as we see later) is 25.6 μs, what is the minimum size of the frame?

Solution

The frame transmission time is $T_{fr} = 2 \times T_p = 51.2$ μs. This means, in the worst case, a station needs to transmit for a period of 51.2 μs to detect the collision. The minimum size of the frame is 10 Mbps × 51.2 μs = 512 bits or 64 bytes. This is actually the minimum size of the frame for Standard Ethernet.

Figure 12.14 *Flow diagram for the CSMA/CD*

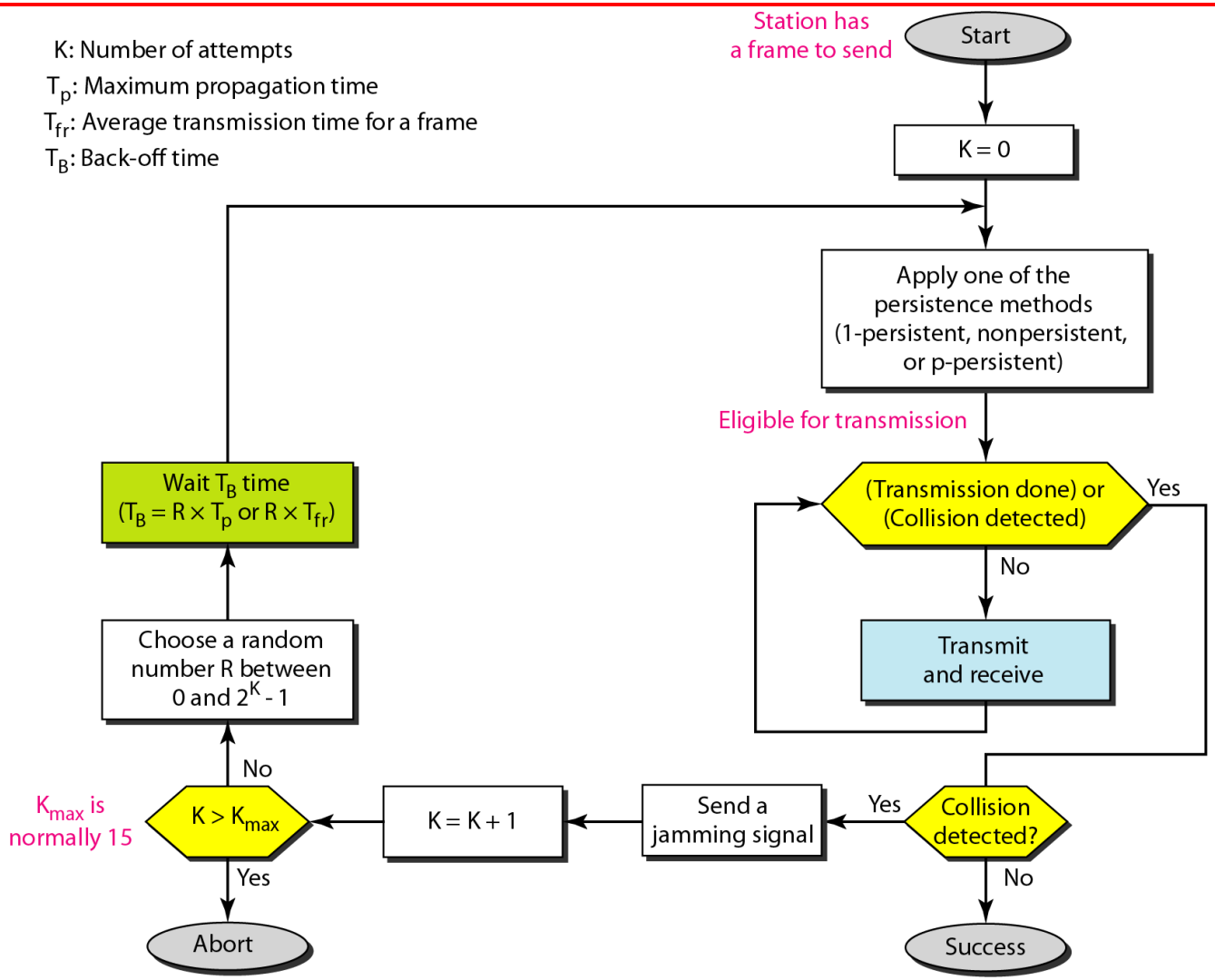
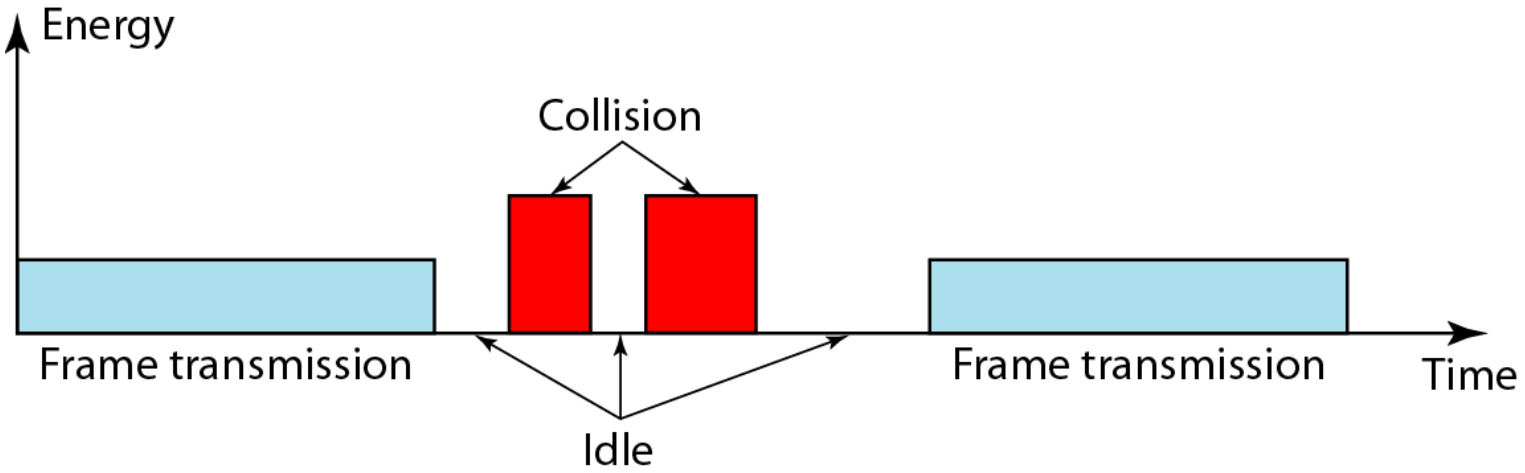


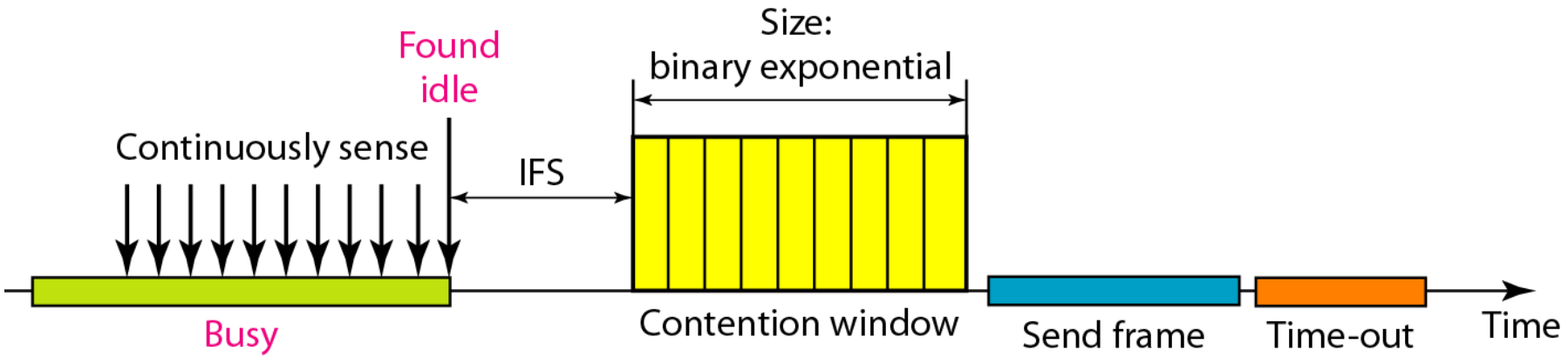
Figure 12.15 *Energy level during transmission, idleness, or collision*



12-1-4 CSMA/CA

- **Carrier Sense Multiple Access with Collision Avoidance**
- Collisions are avoided using three strategies:
  - **The interframe space (IFS)**
  - **The contention window**
  - **Acknowledgment**

Figure 12.16 *Timing in CSMA/CA*



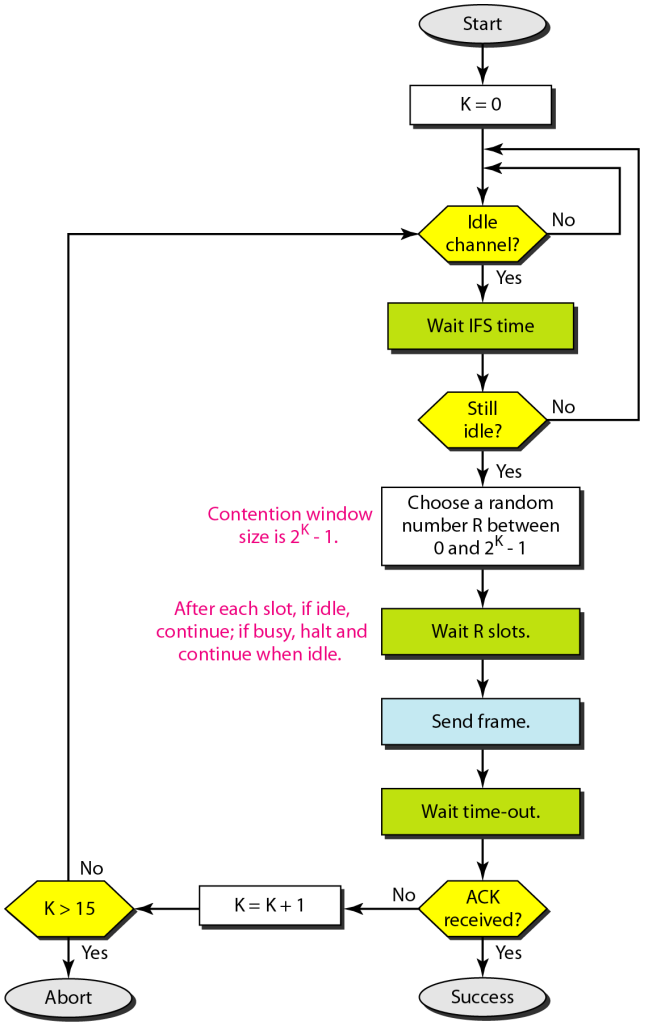
Note

In CSMA/CA, the IFS can also be used to define the priority of a station or a frame.

Note

In CSMA/CA, if the station finds the channel busy, it does not restart the timer of the contention window; it stops the timer and restarts it when the channel becomes idle.

Figure 12.17 *Flow diagram for CSMA/CA*

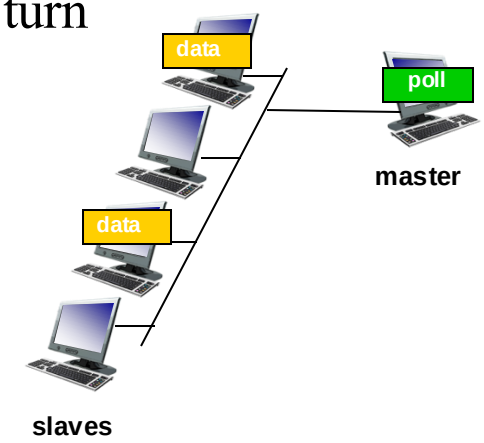


12-2 CONTROLLED ACCESS

In controlled access methods, the 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.

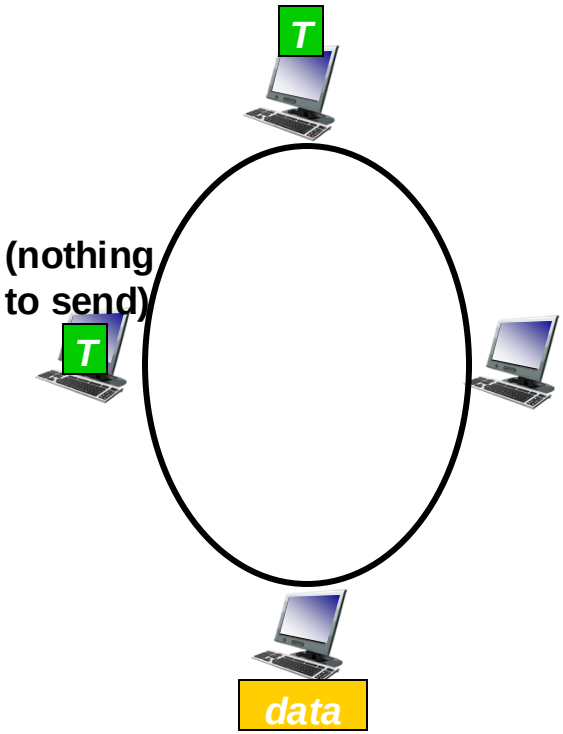
CONTROLLED ACCESS METHODS

- **Reservation:**
  - Time is divided into intervals
  - A station needs to make a reservation before sending data
- **Polling:**
  - One device is designated as a primary station (**master**) and the other devices are secondary stations (**slave**)
  - Master node "invites" slave nodes to transmit in turn
  - Typically used with "dumb" slave devices
  - **Concerns:**
    - polling overhead
    - latency
    - single point of failure (master)



CONTROLLED ACCESS METHODS

- **Token Passing:**
  - Token message (a special packet)
  - The stations in a network are organized in a logical ring
  - Control token passed from one node to next sequentially
  - The possession of the token gives the station the right to access the channel and send its data
  - **Concerns:**
    - token overhead
    - latency
    - single point of failure (token)



12-3 CHANNELIZATION

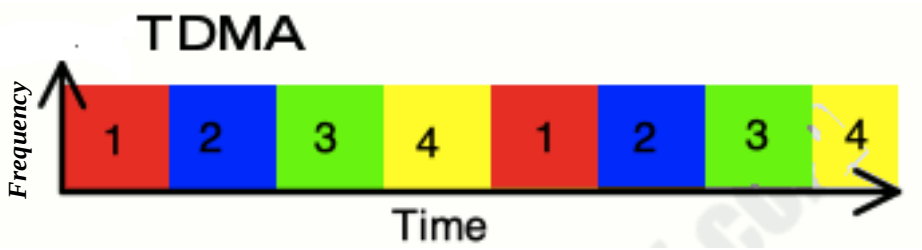
Channelization *(or channel partition, as it is sometimes called) is a multiple-access method in which the available bandwidth of a link is shared in time, frequency, or through code, among different stations.*

Topics discussed in this section:

TDMA (Time Division Multiple Access)
FDMA (Frequency Division Multiple Access)
CDMA (Code Division Multiple Access)

TDMA:Time Division Multiple Access

- TDMA divides divides the time frames into time slots.
- Each slot is assigned to one of the nodes.
- Slots sizes are usually the same as the packet (frame) size of node.



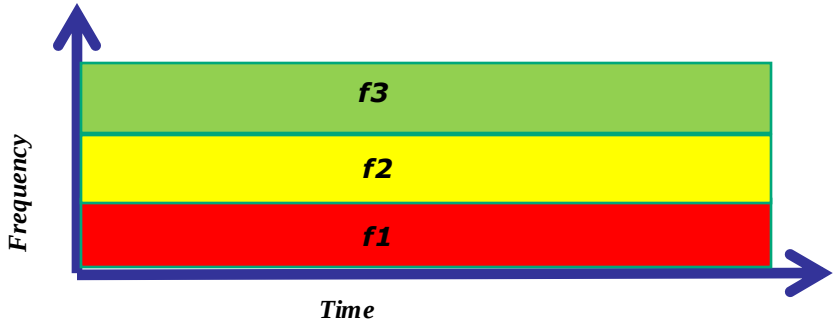
- ***Advantages***
  - ***Eliminates collision***
  - ***Each node gets dedicated R/N bps during frame time.***

FDMA: Frequency Division Multiple Access

- *channel spectrum divided into frequency bands*
- *each station assigned fixed frequency band*

Disadvantage

- *unused transmission time in frequency bands go idle*
  - *example: only band 1 have packet to send, frequency bands 2 & 3 remains idle*
- *Limited bandwidth of R/N for each node*

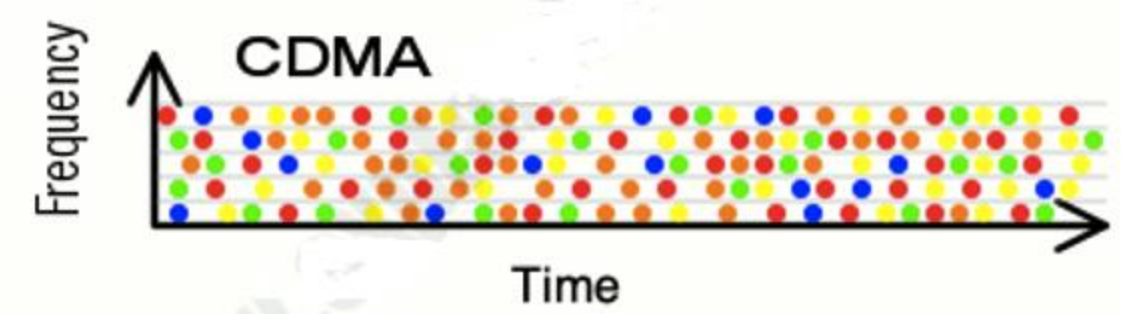


CDMA: Code Division Multiple Access

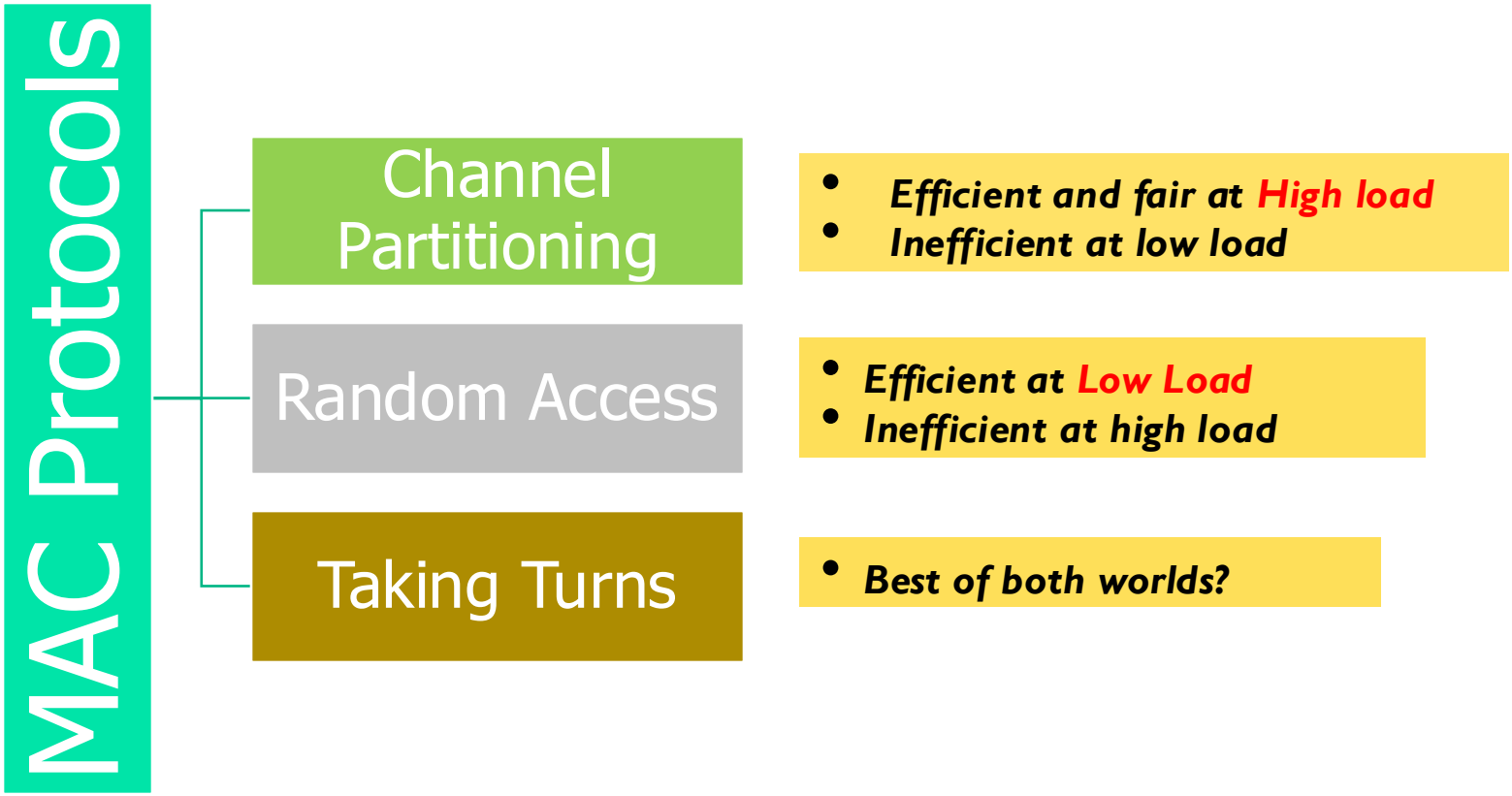
- Assigns a different code to each node.
- Each node then uses its unique code to encode the data bits it sends.

Disadvantage

- ***Total frequency band is used inefficiently.***



MAC protocols



Summary of MAC protocols

- *channel partitioning,* by time, frequency or code
  - Time Division, Frequency Division
- *random access* (dynamic),
  - ALOHA, S-ALOHA, CSMA, CSMA/CD
  - carrier sensing: easy in some technologies (wire), hard in others (wireless)
  - CSMA/CD used in Ethernet
  - CSMA/CA used in 802.11
- *taking turns*
  - polling from central site, token passing
  - Bluetooth, FDDI, token ring

THE END!