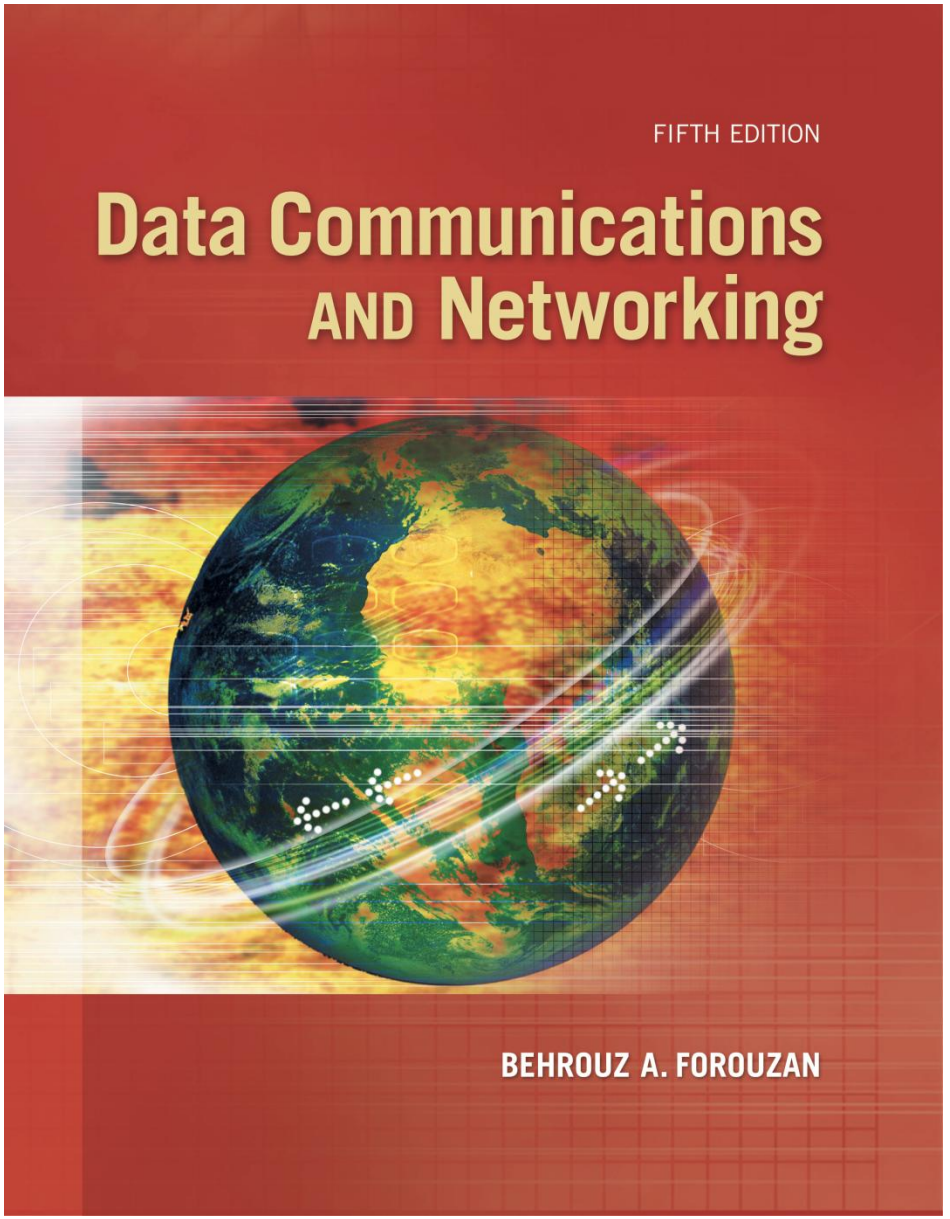
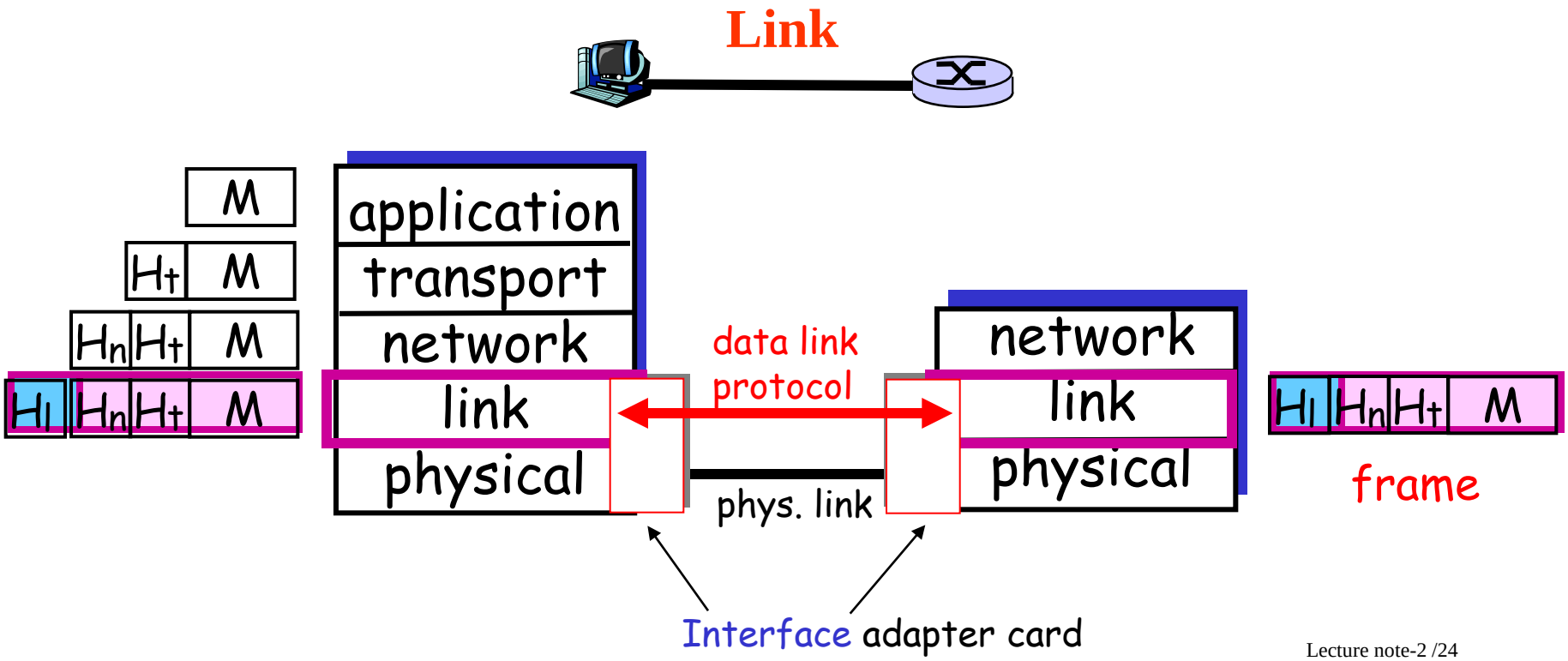
Chapter 12

Media Access Control (MAC)

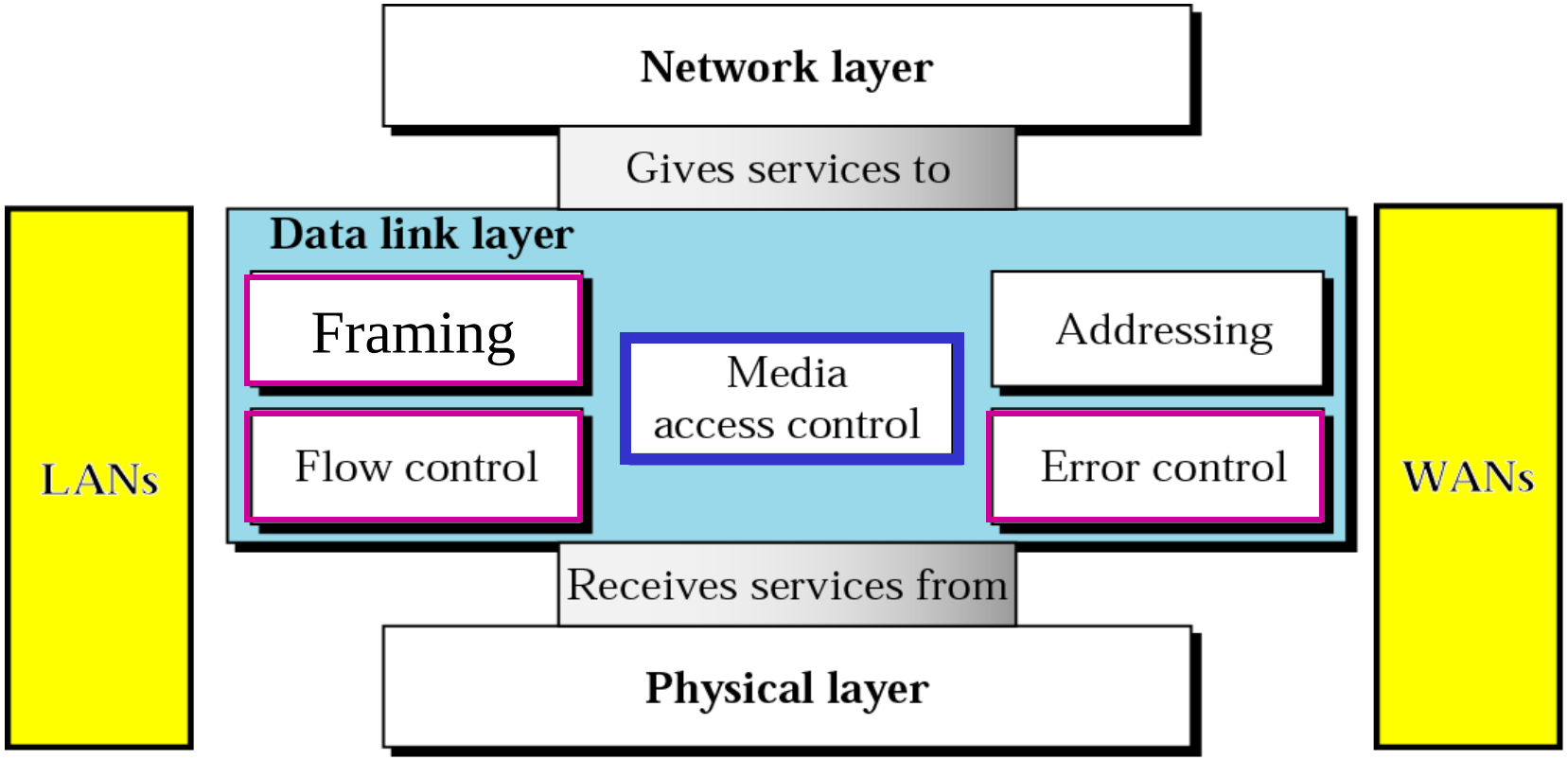


Review of Link Layer: setting the context

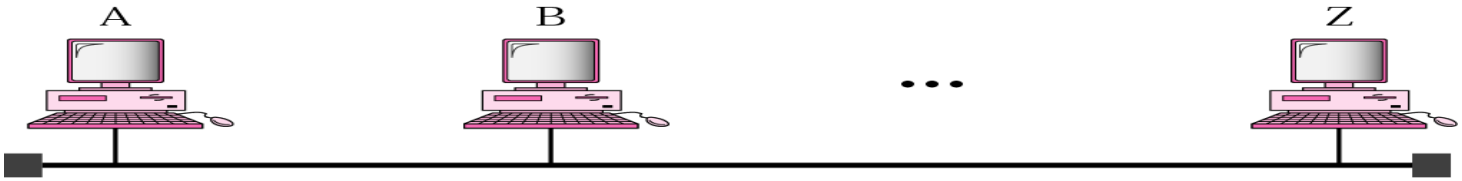
- two *physically connected* devices:
  - host-router, router-router, host-host
- unit of data: *frame*



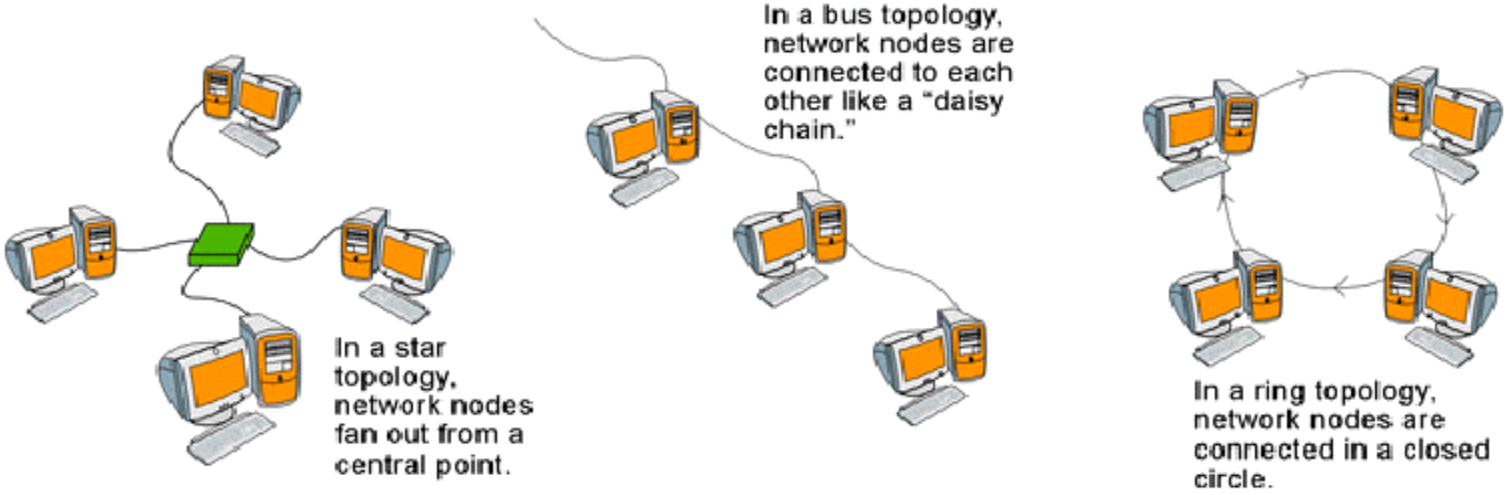
Review of of the data-link layer



Media Access TOPOLOGIES



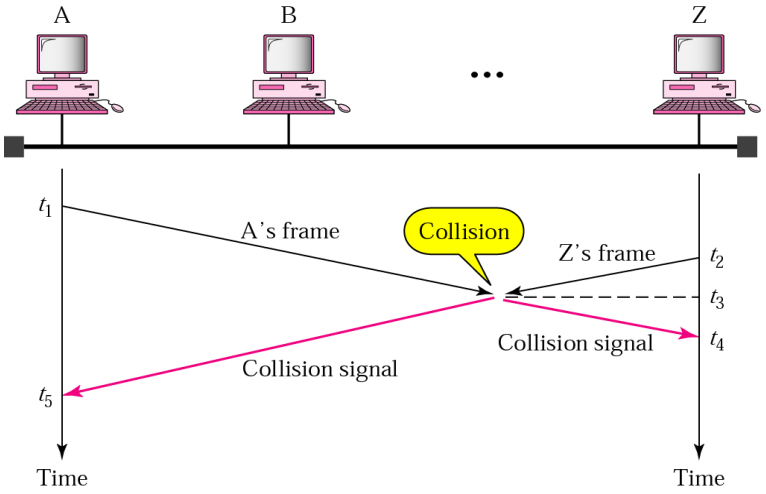
Point-to-multipoint protocol (**shared physical media)**



- **Physical Topology vs. Logical Topology**

Problem of Media ACCESS

- **Each station has the right to the medium without being controlled by any other station.**



- **Problem=Collision**
  - **Confliction caused by multiple stations that try to send data on medium simultaneously**
  - **Frames will be either destroyed or modified**

collision=the event that occurs when two or more transmitters send at the same time on a shared channel; data will be destroyed.

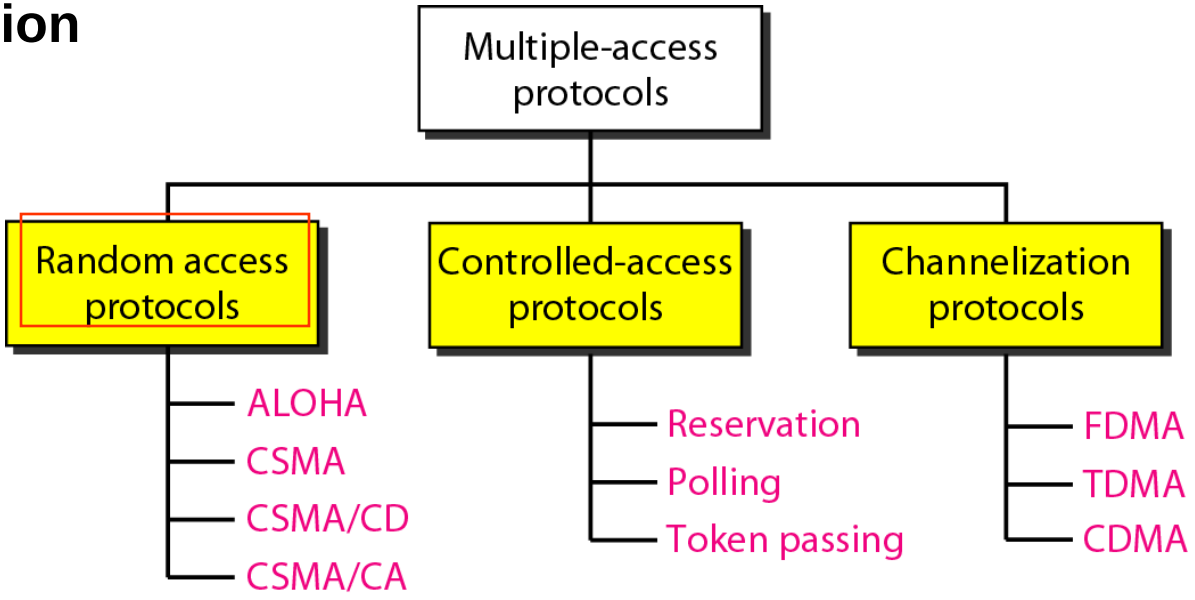
Goals of Multiple Access Control Protocols

MAC Protocols arbitrate access to a common shared channel among a population of users

1. *Fair among users*
2. *High efficiency*
3. *Low delay*
4. *Fault tolerant*

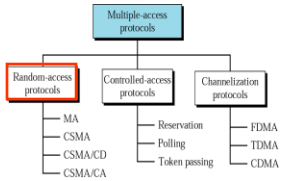
Today Topic: Multiple[Media] Access

- **Multiple Access Methods**
  - **Random Access**
  - **Controlled Access**
  - **Channelization**



- **Example = The Ethernet**

Multiple ACCESS METHODS

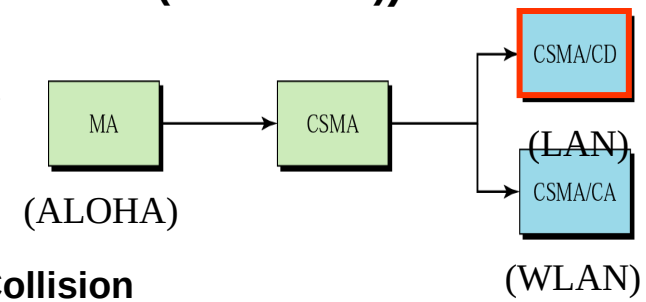


- **Access Method - allows LAN users to transmit data and controls access the shared physical media. Different types of access methods exist including:**
  1) **Random Access - Multiple Access (next slide)**
  2) **Controlled Access -Central Control (not used often)**
  3) **Channelization protocol: Multiplexing (Broadband)**

  ❖ **Switching (becoming cheaper & more popular) –Ch.16.2**
  - Creates full duplex path between sender and receiver

Examples of MAC Protocol category

- **Multiple Access Method Types (cont.)**
  - **1) Random Access - Multiple Access (Contention (Baseband))**
    1. Random Access (not used often) ***
    2. CSMA - Carrier Sense Multiple Access ***
       1. **Carrier sense for Collision**
    3. **CSMA/CD (Ethernet)**
       1. **Carrier sense + collision Detection for Collision**

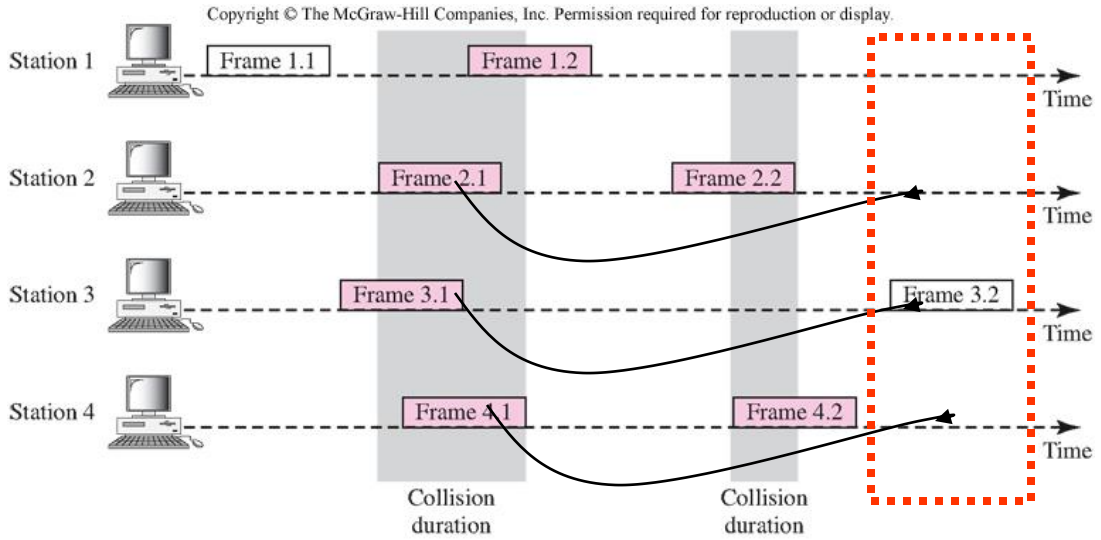


  - **2) Controlled Access -Central Control (not used often)**
    1) type of polling & selecting
    2) **Token Passing (Token Ring)**
  - **3) Channelization protocol: Multiplexing (Broadband)**
    - Frequency Division
    - Time Division

***** Requires acknowledgement from receiver**

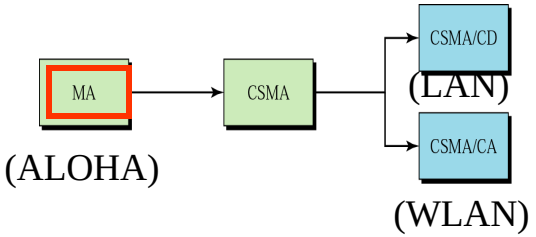
ALGORITHM OF pure ALOHA PROTOCOL

- **Procedure [Send –Ack relationship without No control]**

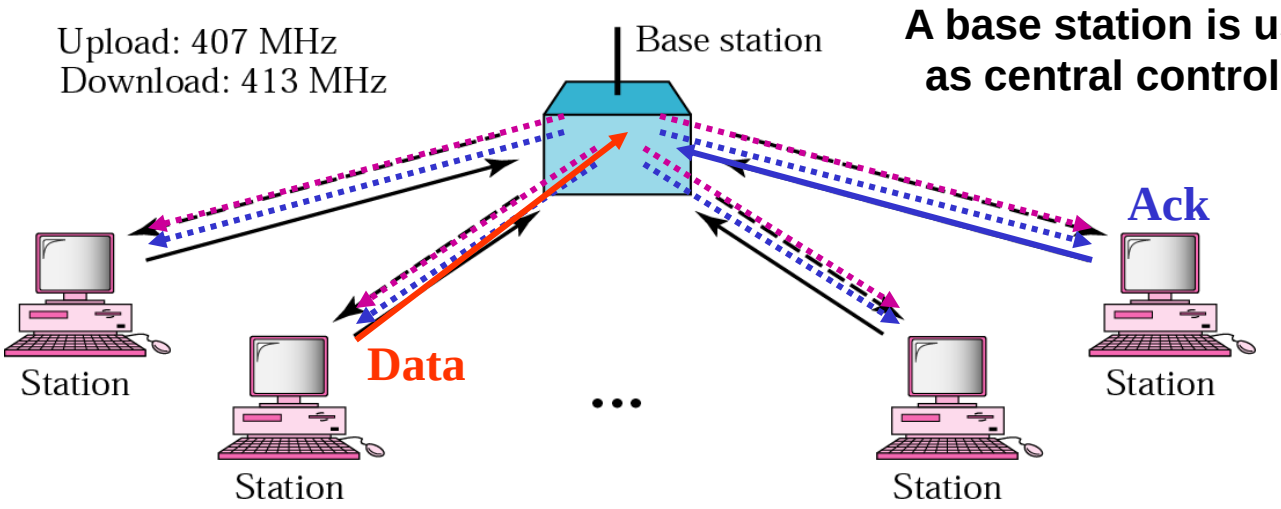


- **Problem=Repeated Collisions**
  - **Confliction caused by the previous collision to repeat data sending on medium simultaneously**
  - **Frames will be either destroyed or modified, once again**
- **Solution: Binary Exponential Back-off**

1. ALOHA NETWORK

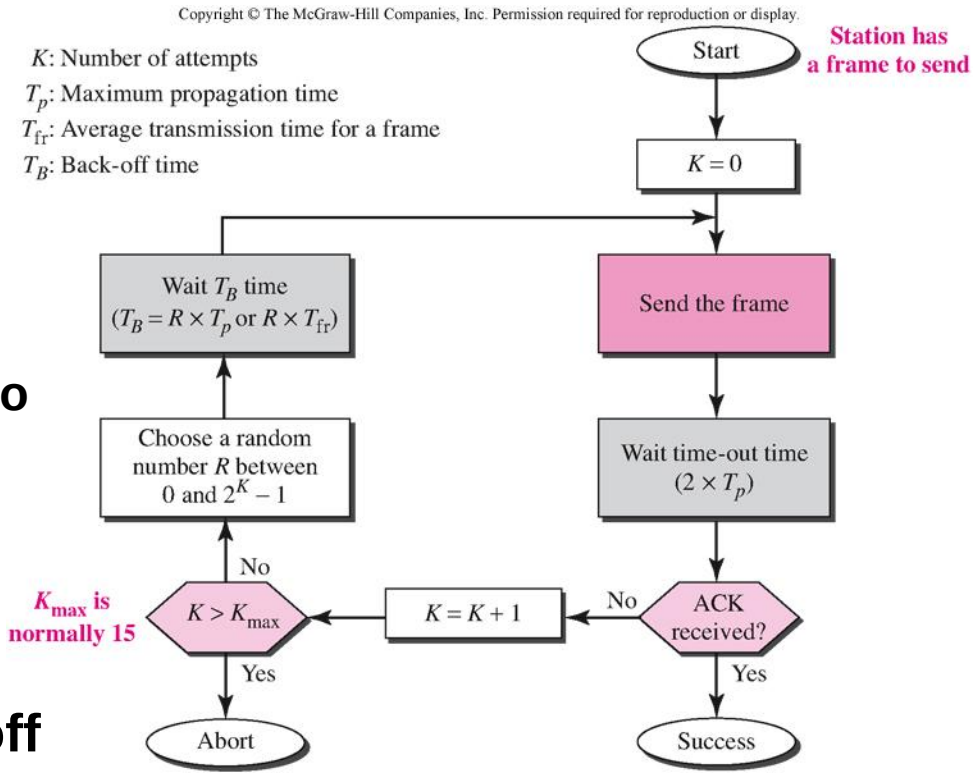


- **Multiple access (MA) + Binary Back-off:**
  - **Multiple access:** any station sends a frame when it has a frame to send
  - **Acknowledgement:** after sending the frame, the station waits for an acknowledgement.
  - If it does not receive an acknowledgement during the allotted time, it assumes that the frame is lost and tries to send after a random amount of time



PROCEDURE OF ALOHA PROTOCOL

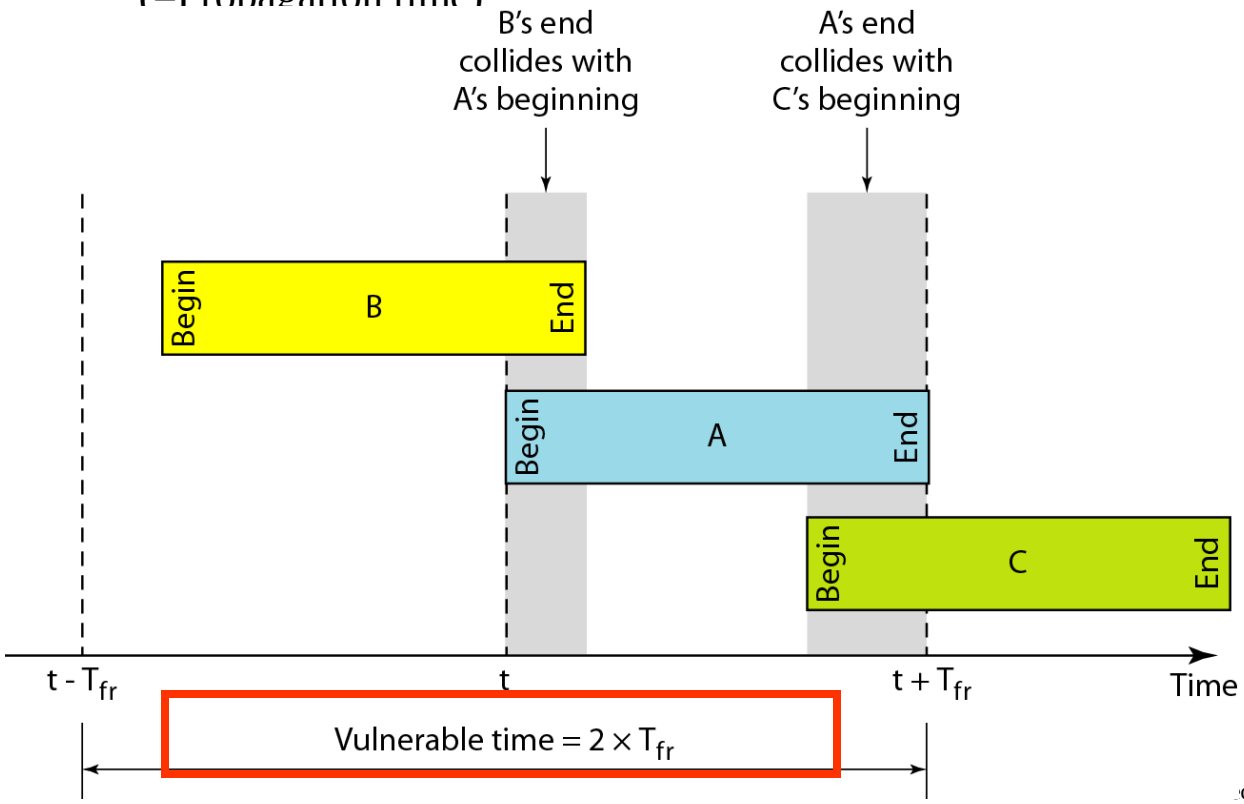
- **Relay Acknowledgement**
  - **Send –Ack relationship**
  - **No control**
- **Problem=Repeated Collision**
  - **Confliction caused by multiple stations that try to send data on medium simultaneously**
  - **Frames will be either destroyed or modified**
- **Binary Exponential Back-off**
  - **T_B=R×T_P**
  - **R= Random (0, 2^K-1)**



Problem of OF ALOHA PROTOCOL

- **The throughput of ALOHA Protocol is $S = G \times e^{-2G}$**
- **The maximum throughput S_{max} =0.184 when (G=1/2) due the vulnerable time =2T × fr (See Example 12.2)**

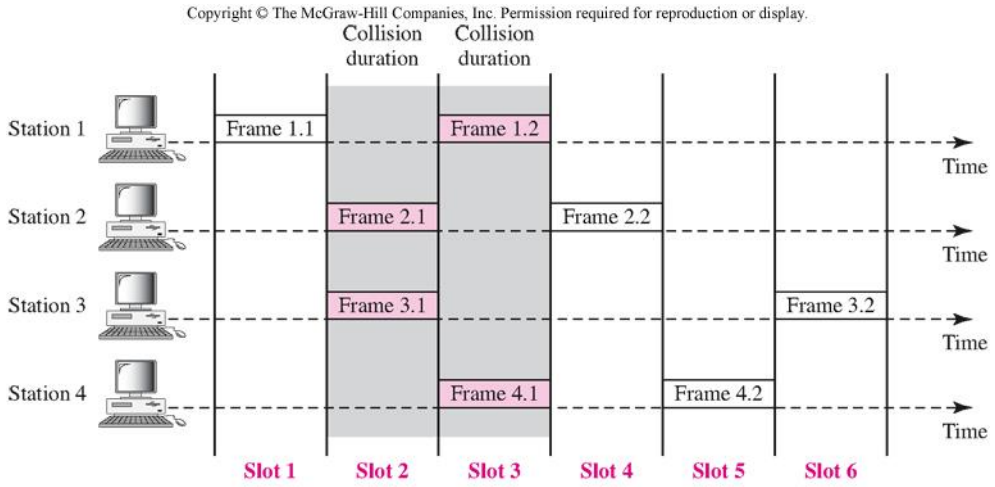
(=Propagation time)



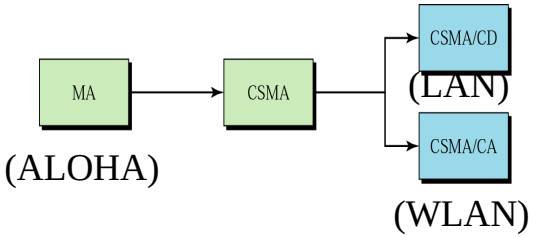
Slotted ALOHA PROTOCOL

- **The throughput of ALOHA Protocol is $S = G \times e^{-G}$**
- **The maximum throughput S_{max} =0.368 when (G=1) due the vulnerable time =T × fr (See Example 12.2)**

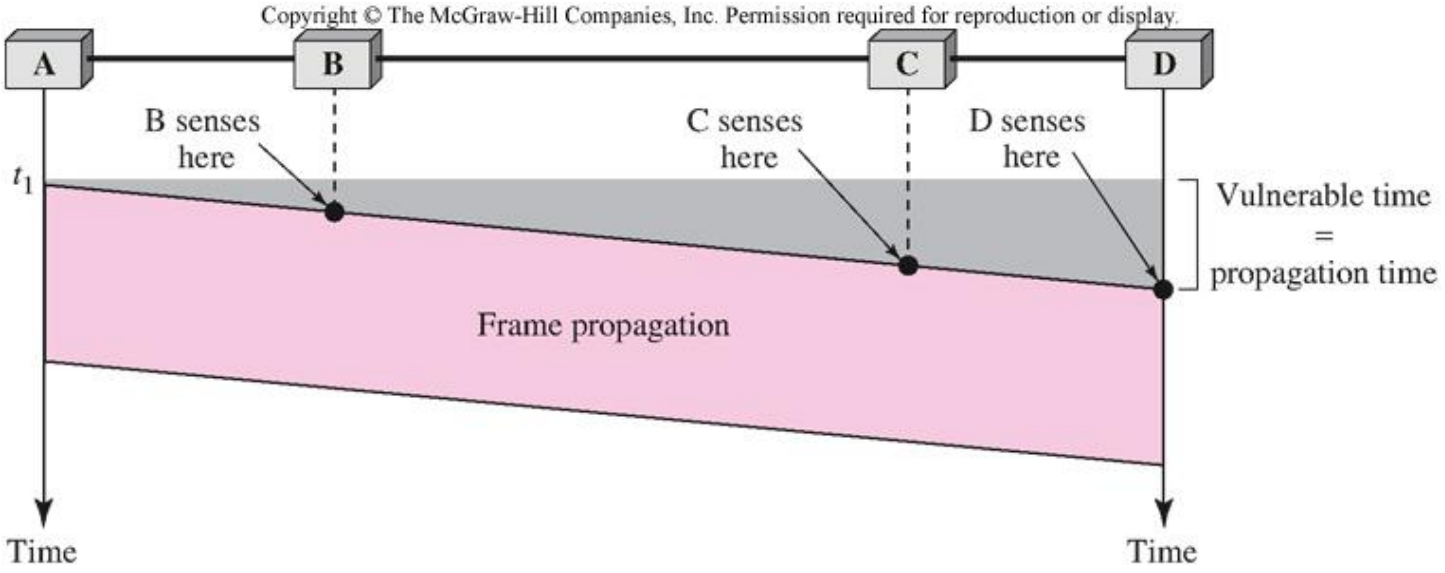
(=Propagation time)



2. Carrier sense multiple access

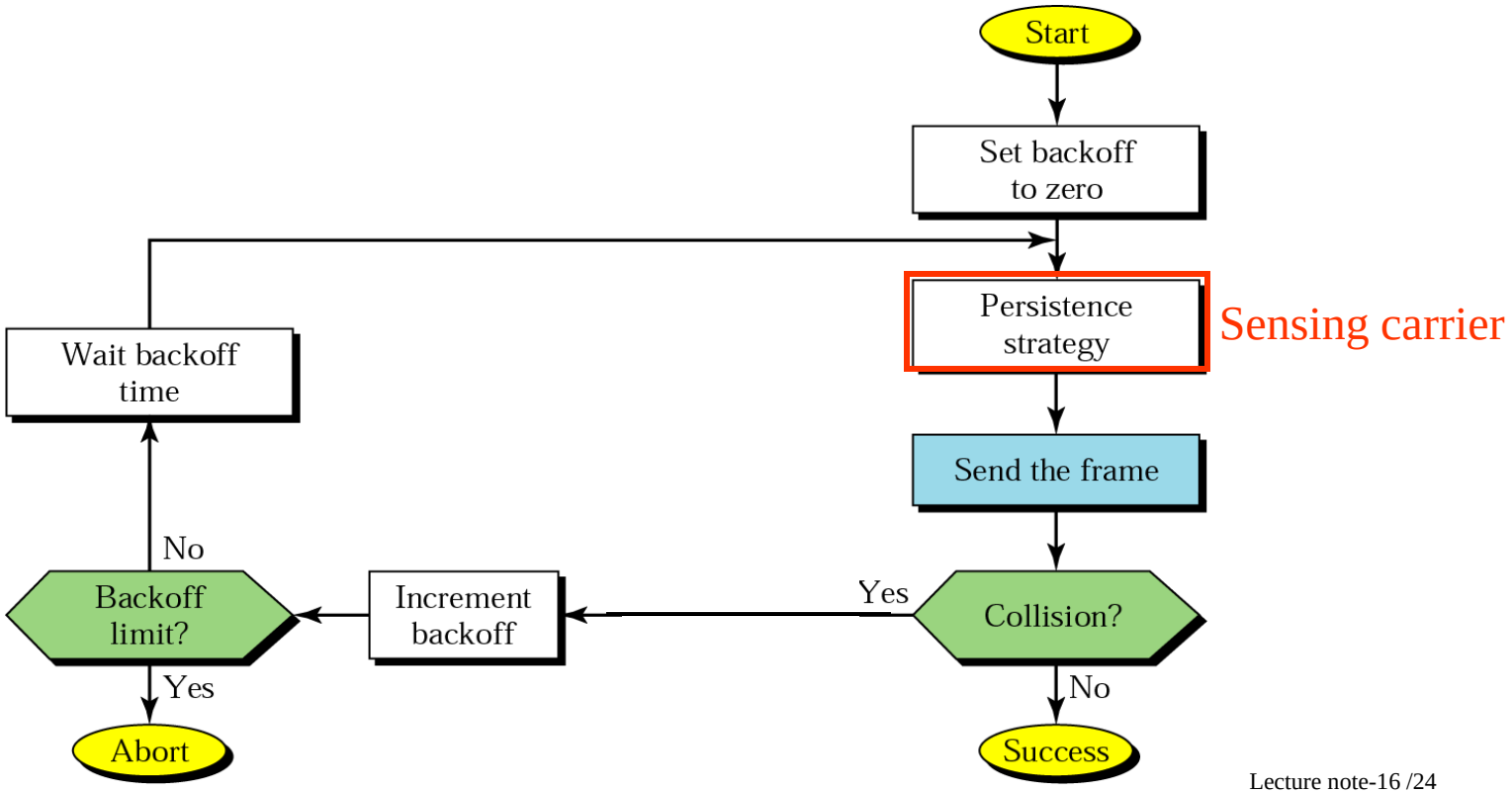


- **Reduce COLLISION – Carrier sense**
  - **Each station first listen to the medium, before sending**
  - **Reduce the possibility of collision but can not eliminate it: what if multiple stations detected that the medium is idle and then send data at the same time?**



PROCEDURE OF CSMA PROTOCOL

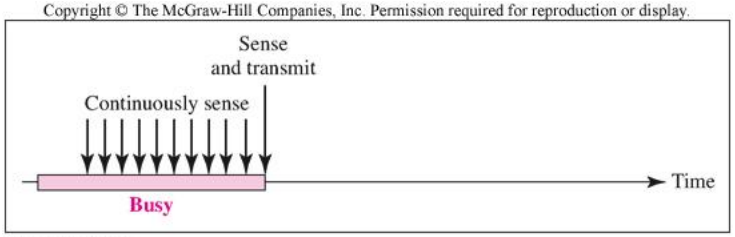
- **Each station first listen to the medium, before sending**
- **If collision, run Binary Exponential Back-off**



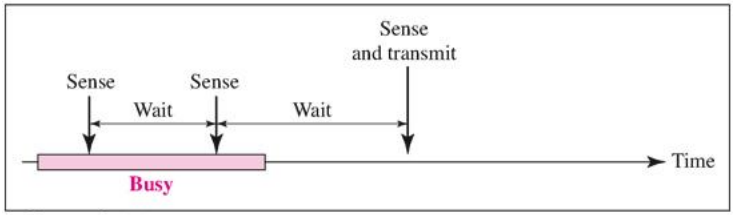
PERSISTENCE STRATEGY

Def=strategy when a station senses a busy medium

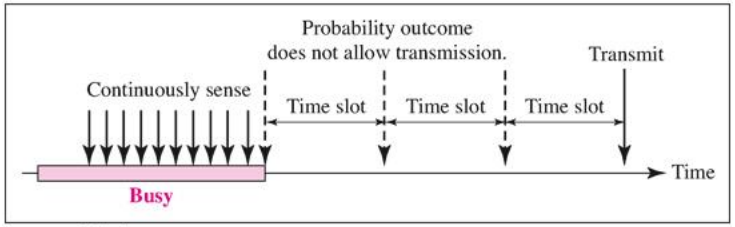
- **None persistent strategy**
  - **If line is idle, the station sends immediately. If the line is not idle, the station waits a random period of time and then sense the line again.**
- **Persistent strategy**
  - ***1* persistent method: if the stations finds the line idle, it sends its frame immediately (with a probability of 1).**
  - ***P* persistent method: if the line is idle, the station may or may not send, it sends with probability *p* and refrains from sending with probability *1-p*.**



a. 1-persistent



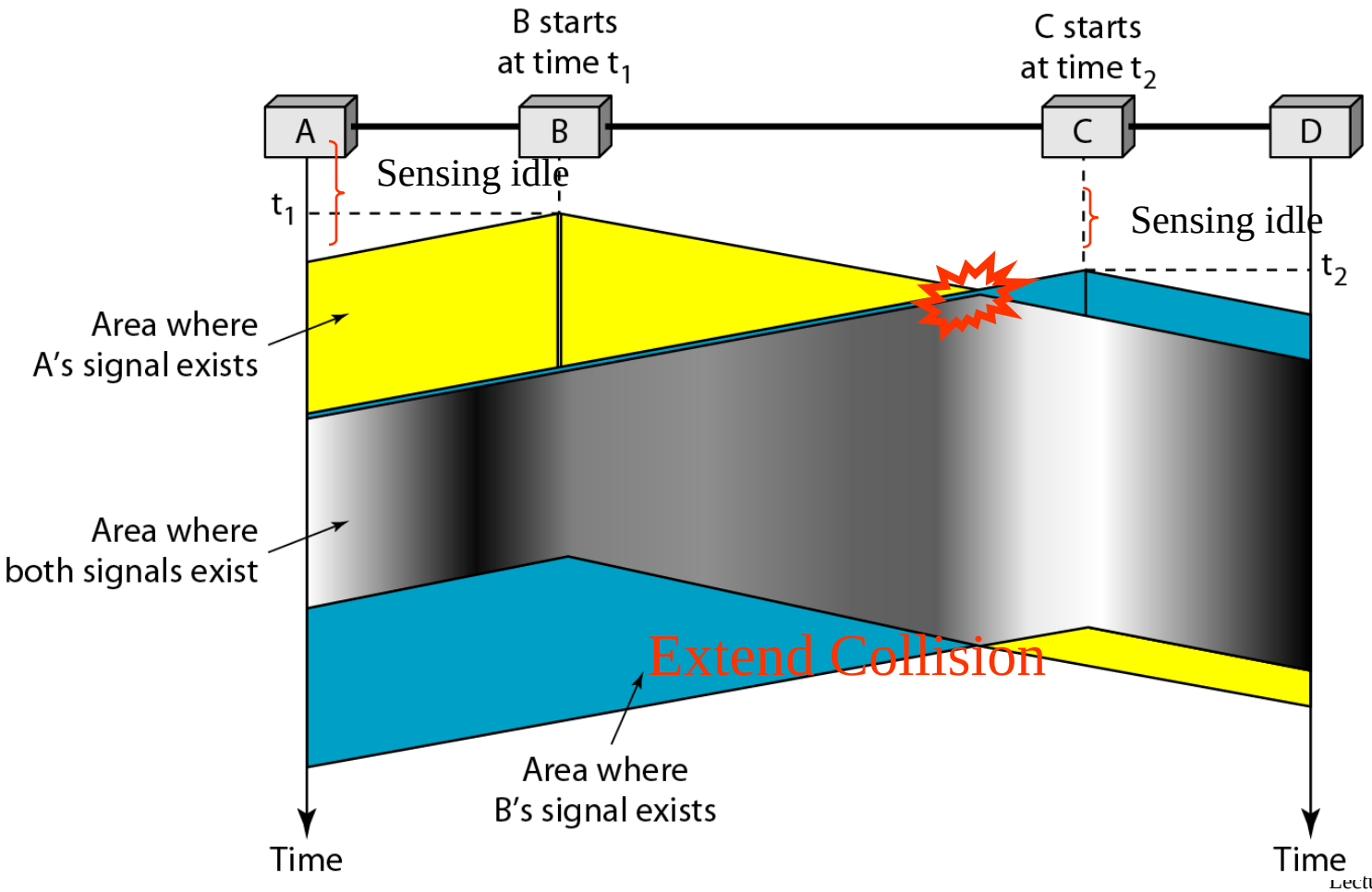
b. Nonpersistent



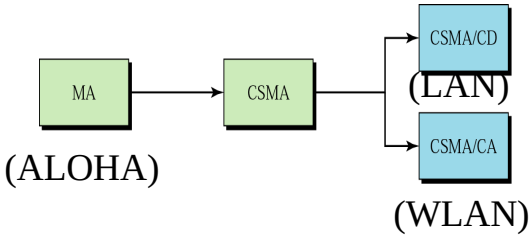
c. *p*-persistent

Problem of OF CSMA PROTOCOL

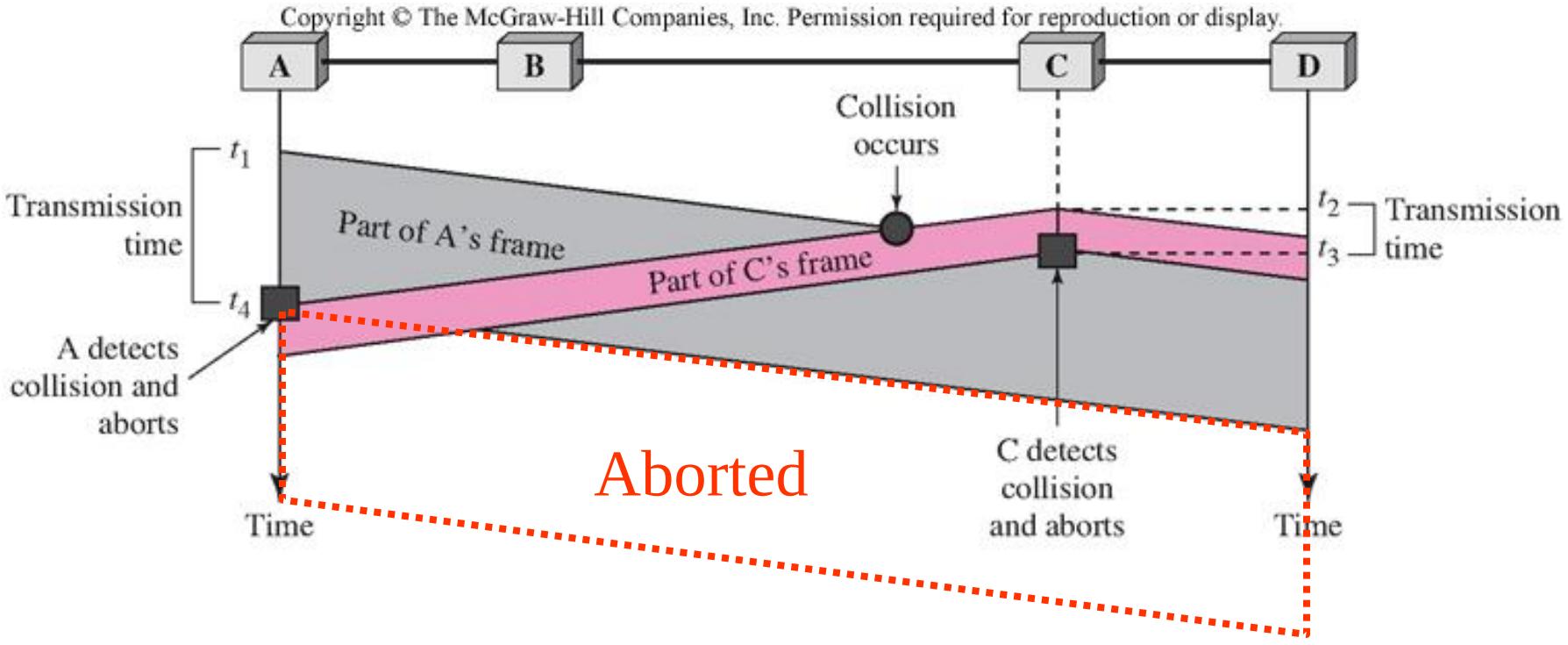
- **Unable to escape from Collision Prolong**



3. CSMA/CD

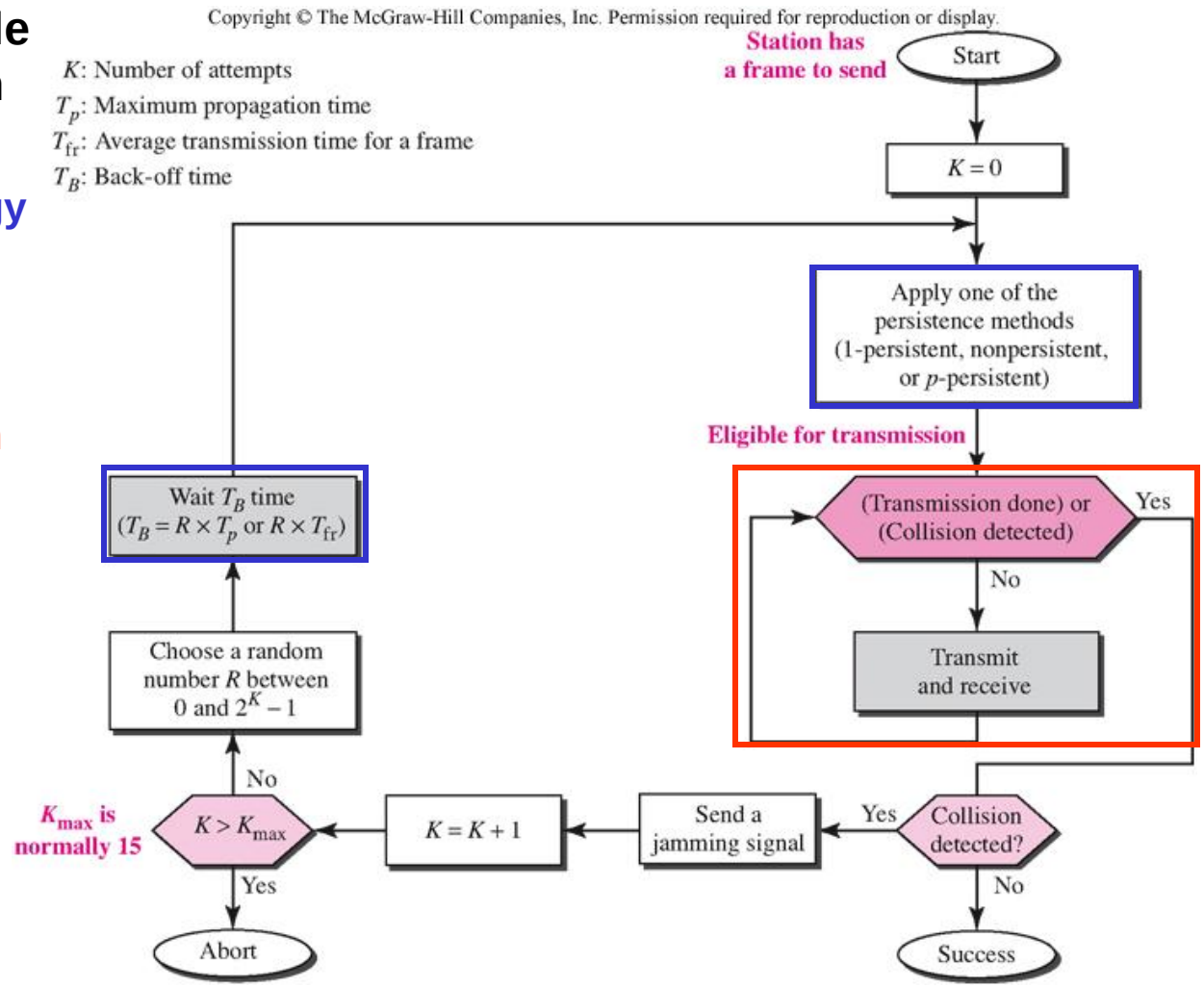


- **Carrier sense multiple access with collision detection**
  - **Carrier Sense for Collision avoidance**
  - **Collision detection for abort sending**



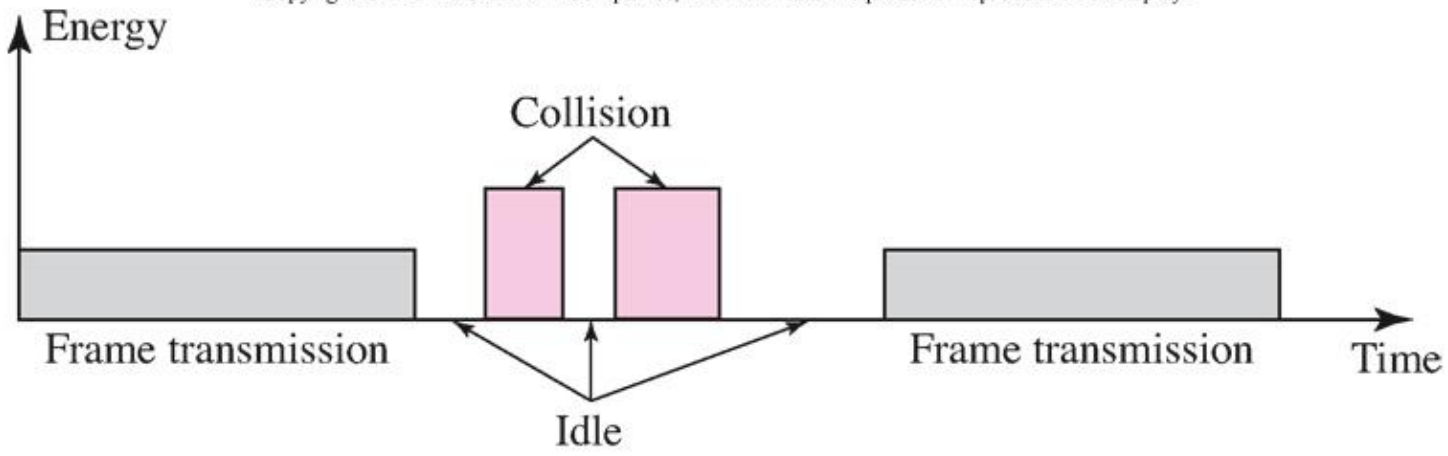
Procedure of CSMA/CD

- **Carrier sense multiple access with collision detection**
  - **Persistence strategy for Carrier Sensing**
  - **Binary Back-off algorithm**
  - **Stop sending when Collision detection**

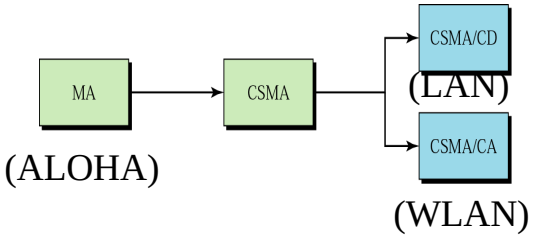


Collision Detection in CSMA/CD

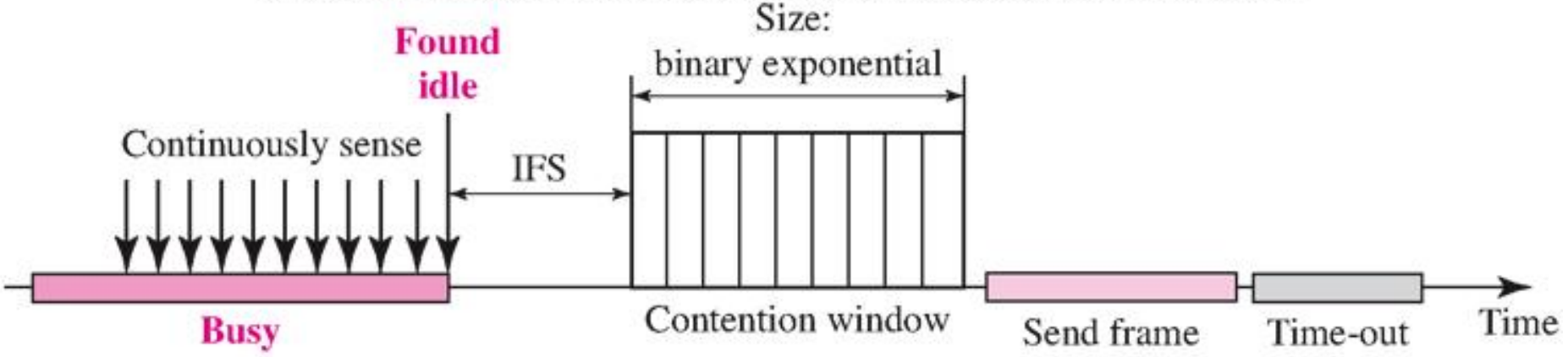
- **collision detection with Energy level**



4. CSMA-CA

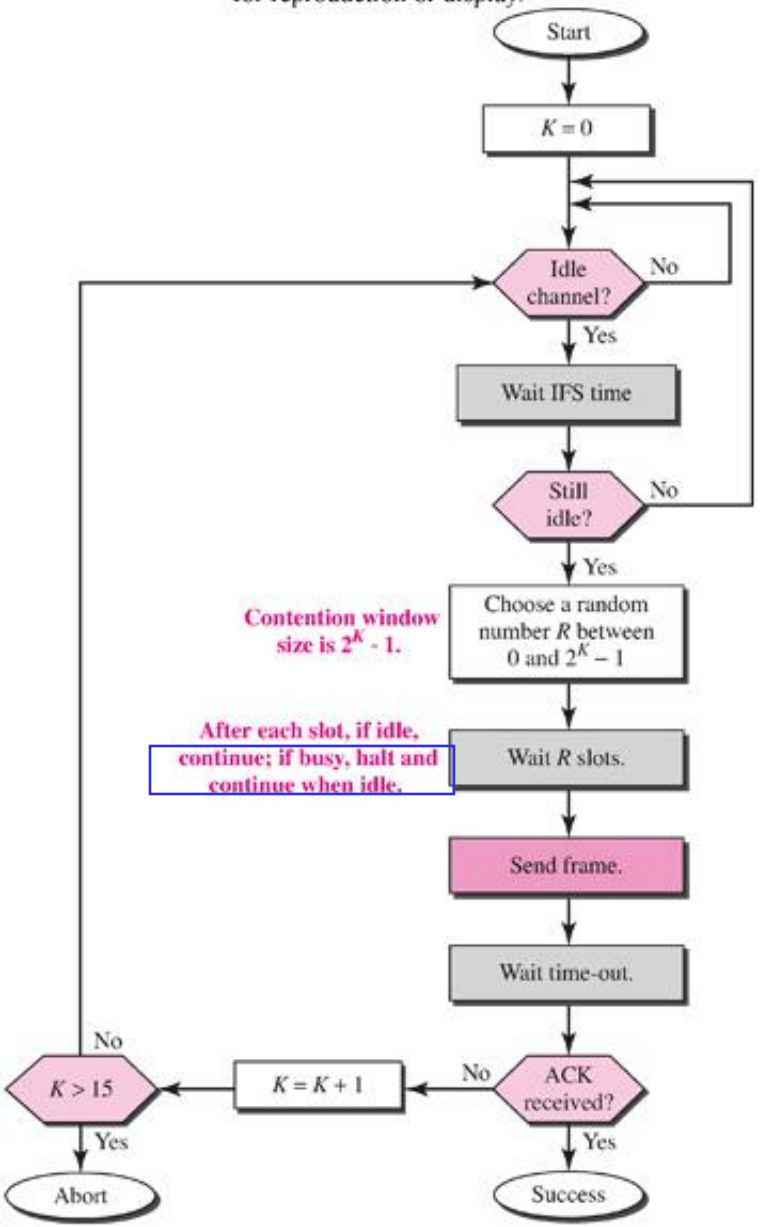


- **CSMA with Collision Avoidance**
  - **by deferring transmission (IFG: inter-frame gap) even if the channel is found idle. (due to the consecutive transmission)**
  - **By waiting a random number of slots according to the binary exponential back-off strategy (similar to the p-persistent)**

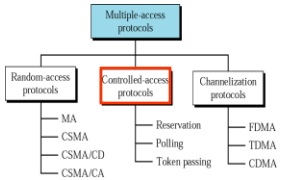


Procedure of CSMA/CA

- **Carrier sense multiple access with collision avoidance**
  - **Carrier Sense**
  - **Collision detection**
  - **Collision avoidance**



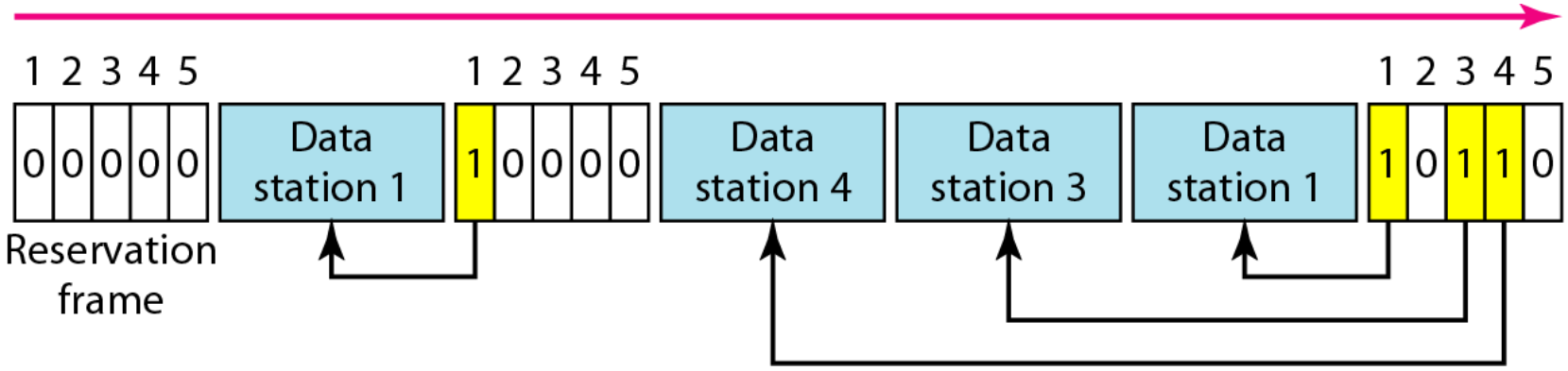
CONTROL ACCESS



1. **Reservation**
2. **Polling**
3. **Token passing**

RESERVATION ACCESS METHOD

- **A station that needs to make a reservation before sending data**
- **A reservation frame precedes the data frames sent in a each time interval, which consists of minislot. Each of the slot is assigned to a station in the system.**



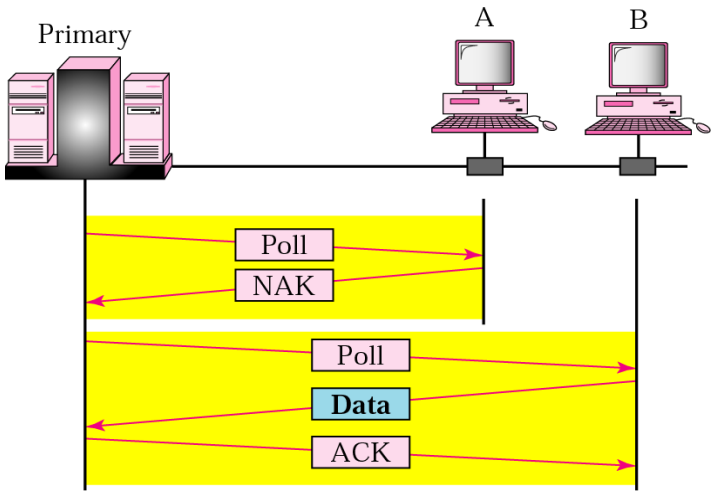
POLLING AND SELECTING

- **Polling and Selecting works with topologies in which one device is designed as a primary station and the other devices are secondary stations.**
- **Primary station controls the link. All data exchanges must be made through the primary device even when the ultimate destination is a second device.**

  - **Polling: the primary is ready to receive data**
  - **Selecting: the primary device has something to send**

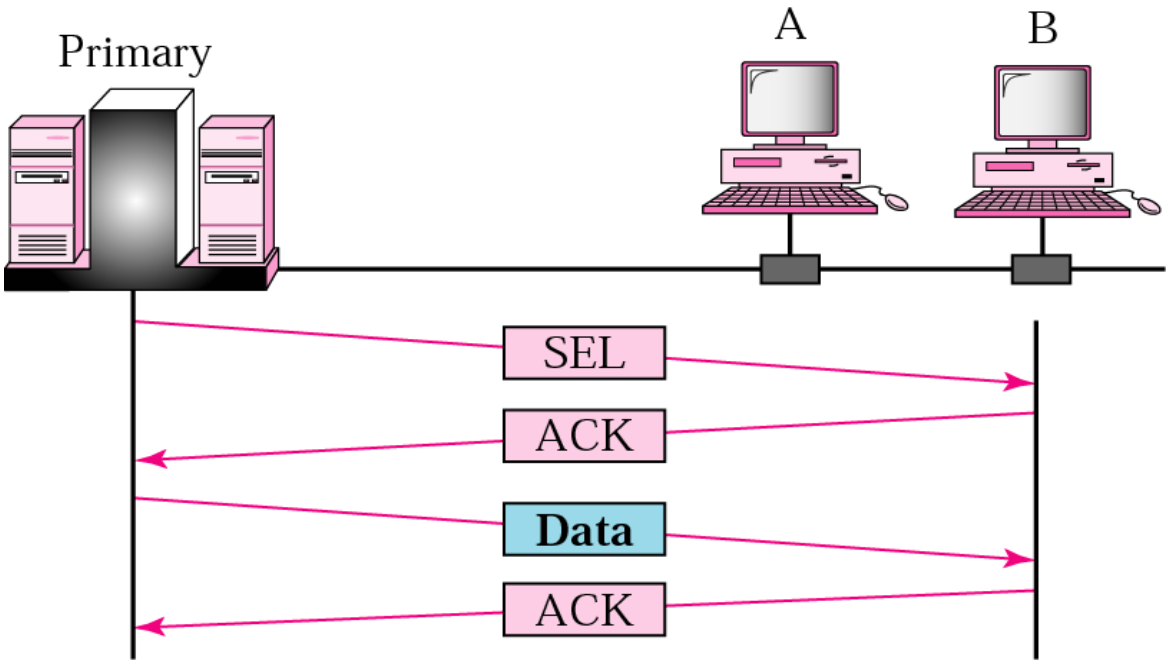
POLLING

- **Used by the primary divide to solicit transmissions from the secondary device**
- **When the primary is ready to receive data, it must ask(poll) each device in turn if it has anything to send**
- **If a station got polling message and does not have data to send, it sends back response with negative (NAK) frame and the primary station sends polling message to the next station**
- **If a station has data to send, it returns the positive (data frame) and primary returns a acknowledgement (ACK frame) to verify its receipt.**



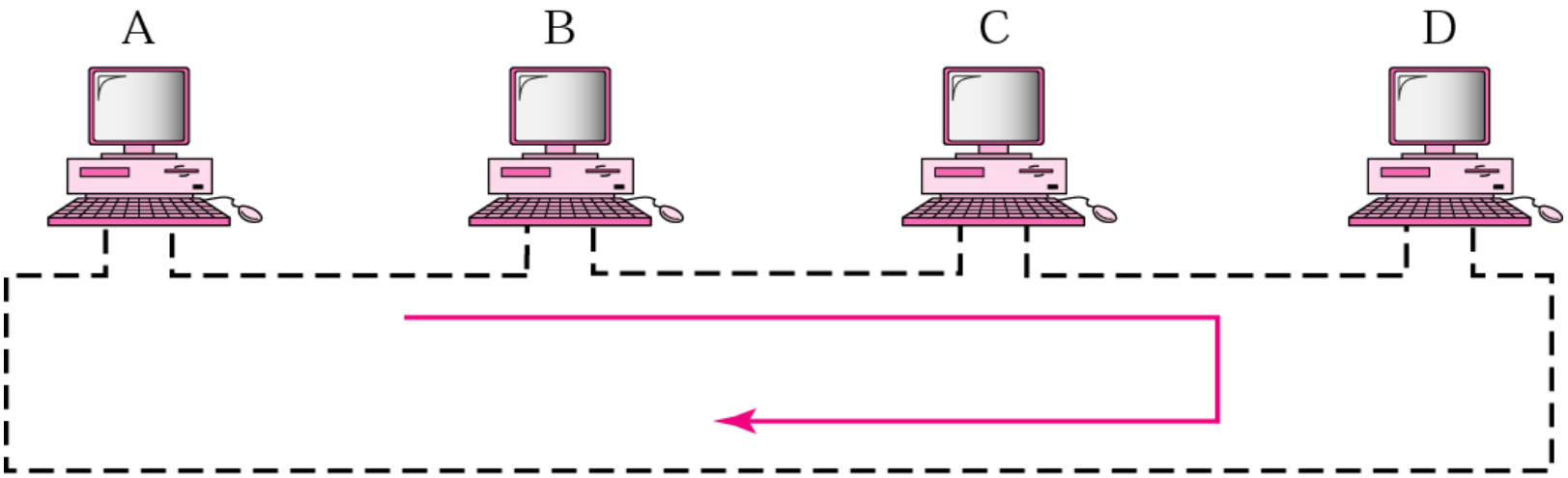
SELECTING

- **In select mode, when a primary device has something to send, it sends a select (SEL) frame to check if the secondary is ready to receive the data.**

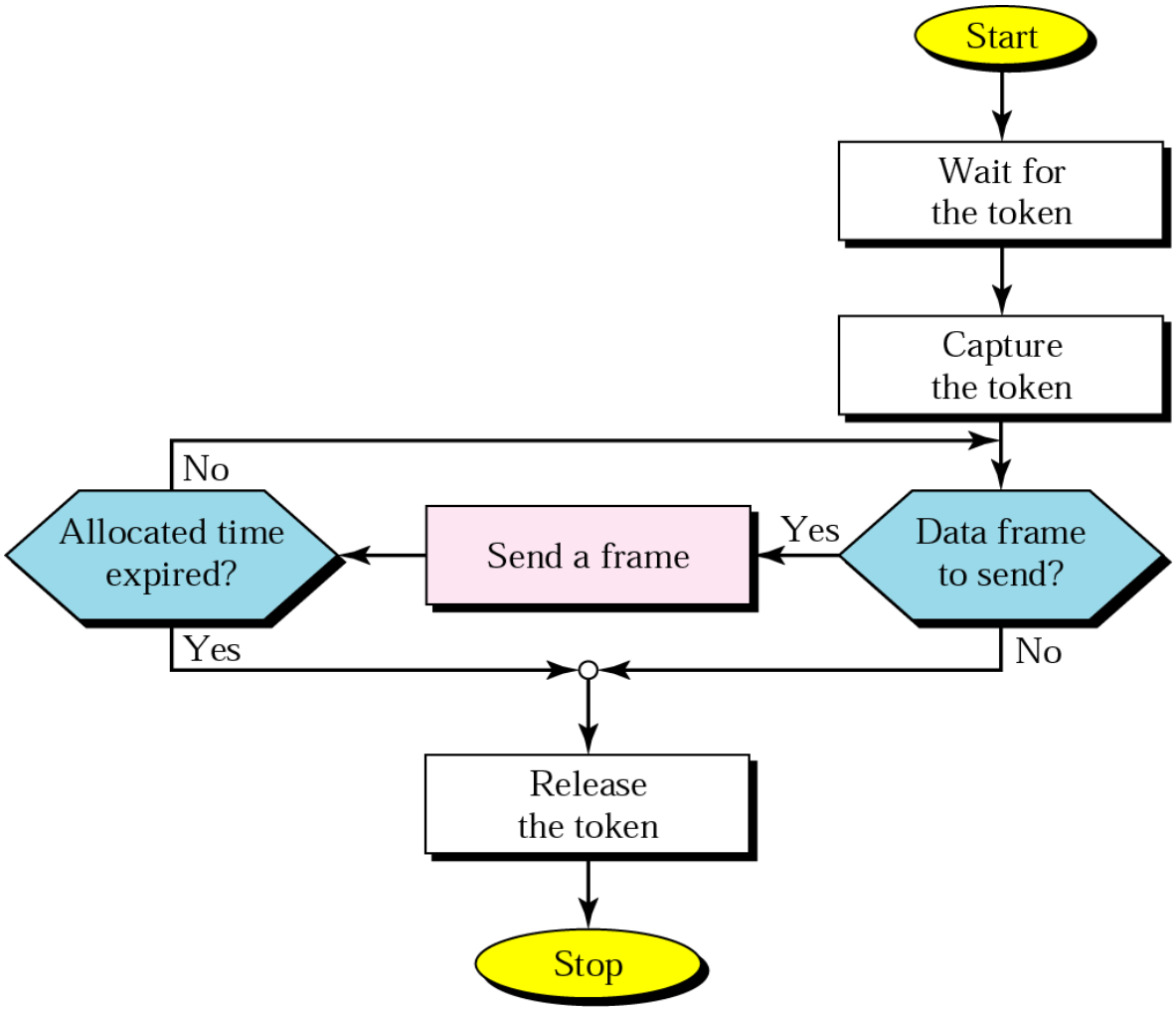


TOKEN PASSING

- **Stations are arranged around a ring, each station has a predecessor and a successor.**
- **Data comes from the predecessor and going to the successor.**
- **A station is authorized to send data when it receives a special frame called a token**
  - **If the station does not have data to send, it passes the token to its successor station.**
  - **If the station has data to send, it sends the frames and finally release the token to be used by the successor station.**



TOKEN PASSING PROCEDURE



12-3 CHANNELIZATION

Channelization is a multiple-access method in which the available bandwidth of a link is shared in time, frequency, or through code, between different stations. In this section, we discuss three channelization protocols.

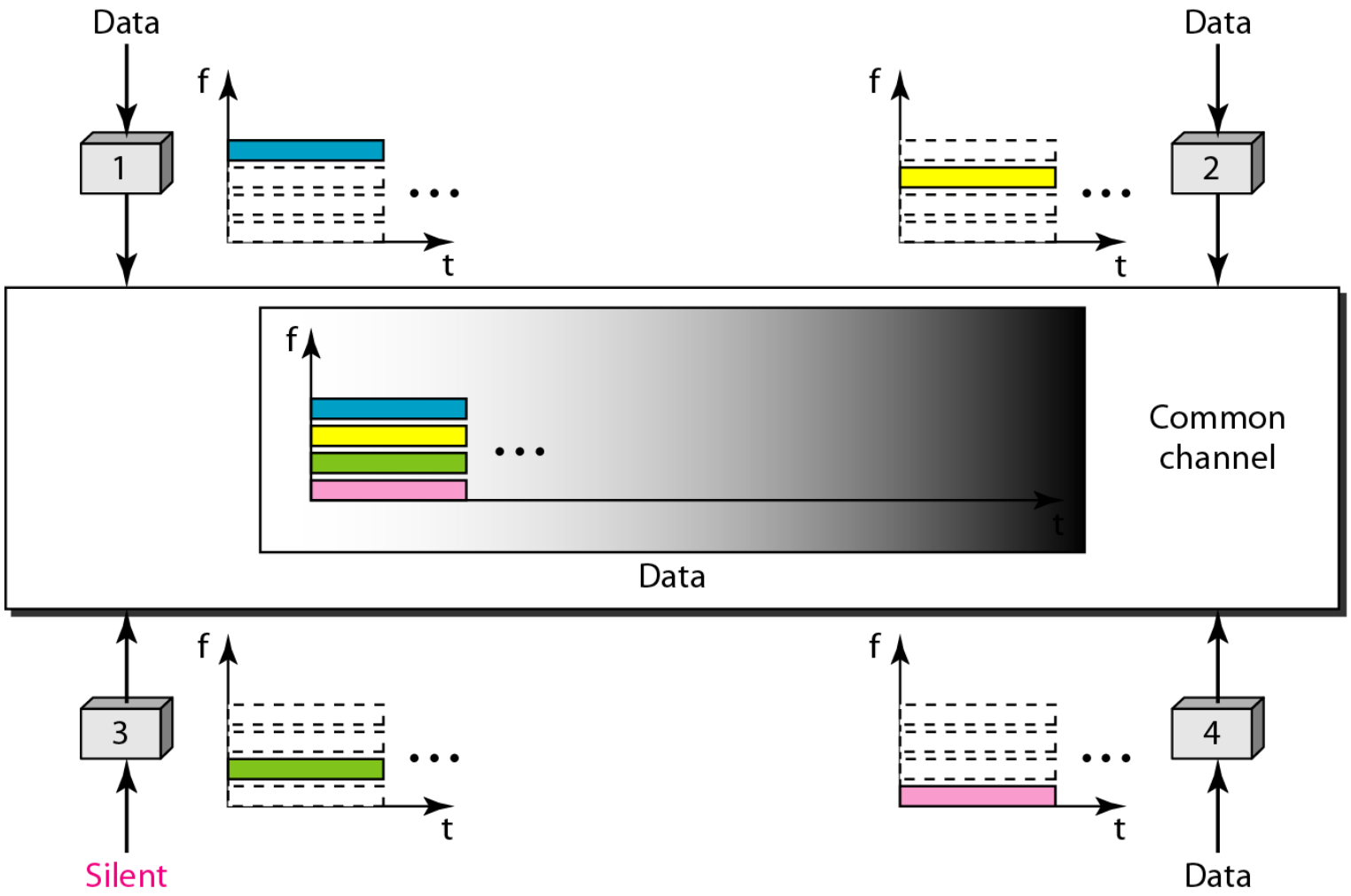
Topics discussed in this section:

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

Note

We see the application of all these methods in Chapter 16 when we discuss cellular phone systems.

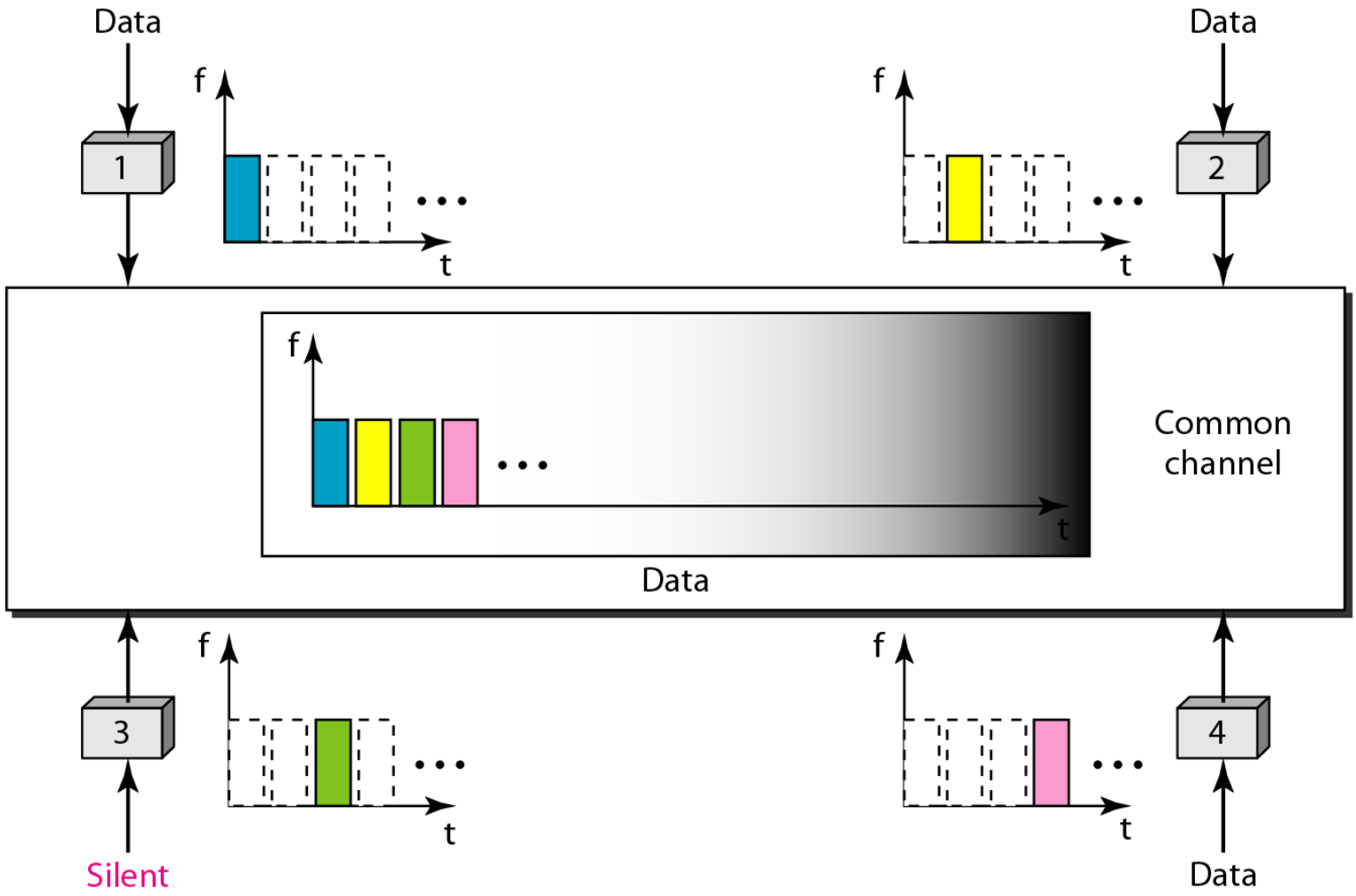
Figure 12.21 Frequency-division multiple access (FDMA)



Note

In FDMA, the available bandwidth of the common channel is divided into bands that are separated by guard bands.

Figure 12.22 Time-division multiple access (TDMA)



Note

In TDMA, the bandwidth is just one channel that is timeshared between different stations.

Note

In CDMA, one channel carries all transmissions simultaneously.

Figure 12.23 Simple idea of communication with code

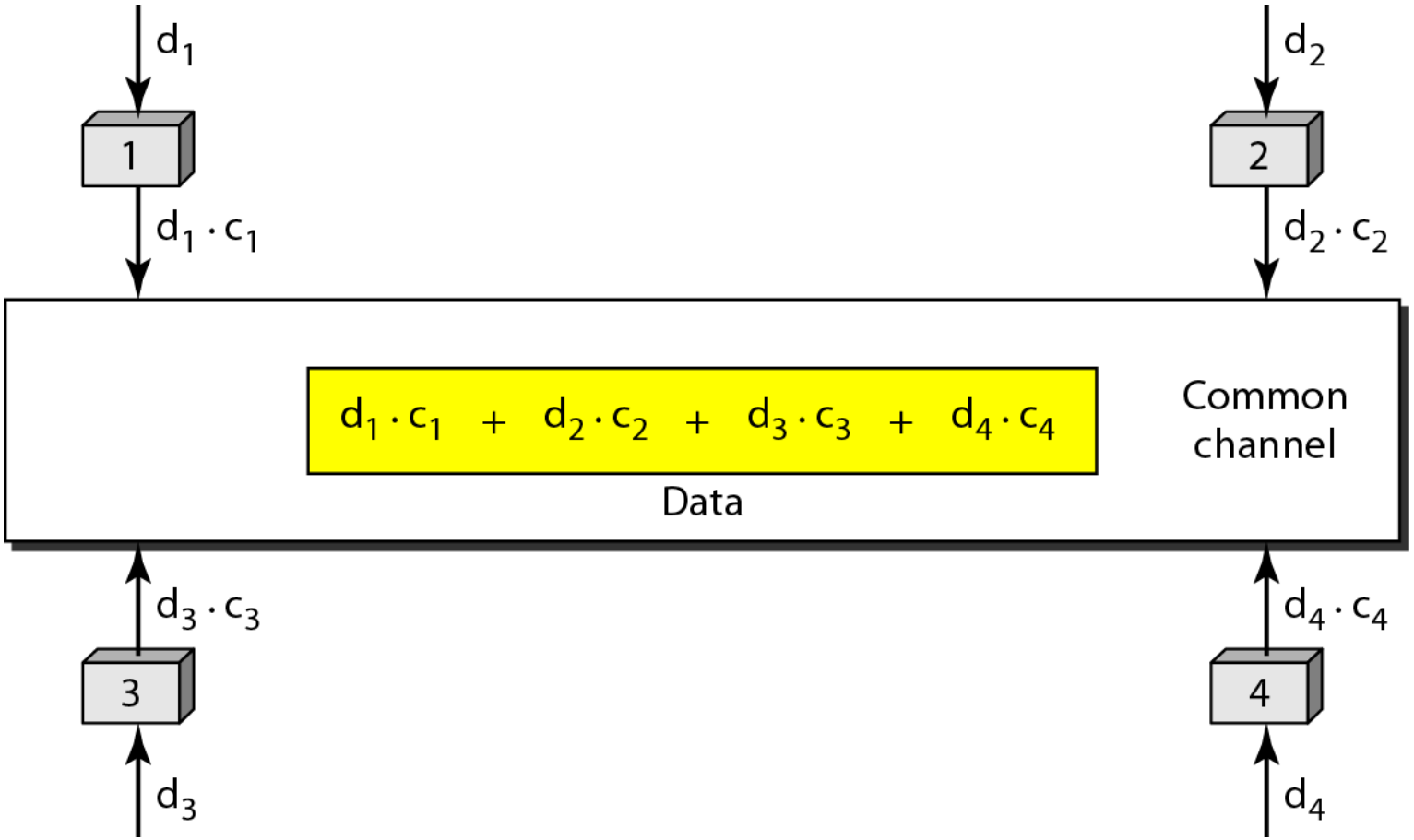


Figure 12.24 Chip sequences

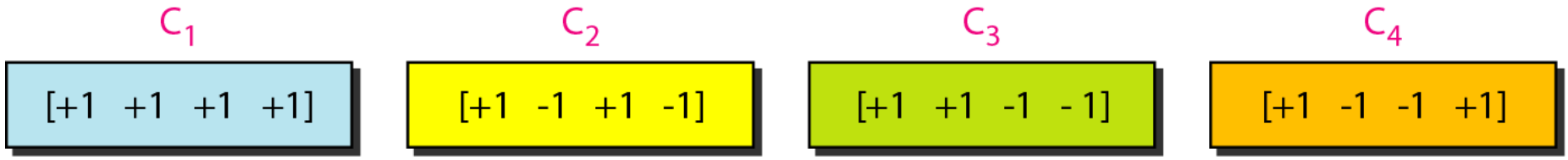


Figure 12.25 Data representation in CDMA

Figure 12.26 Sharing channel in CDMA

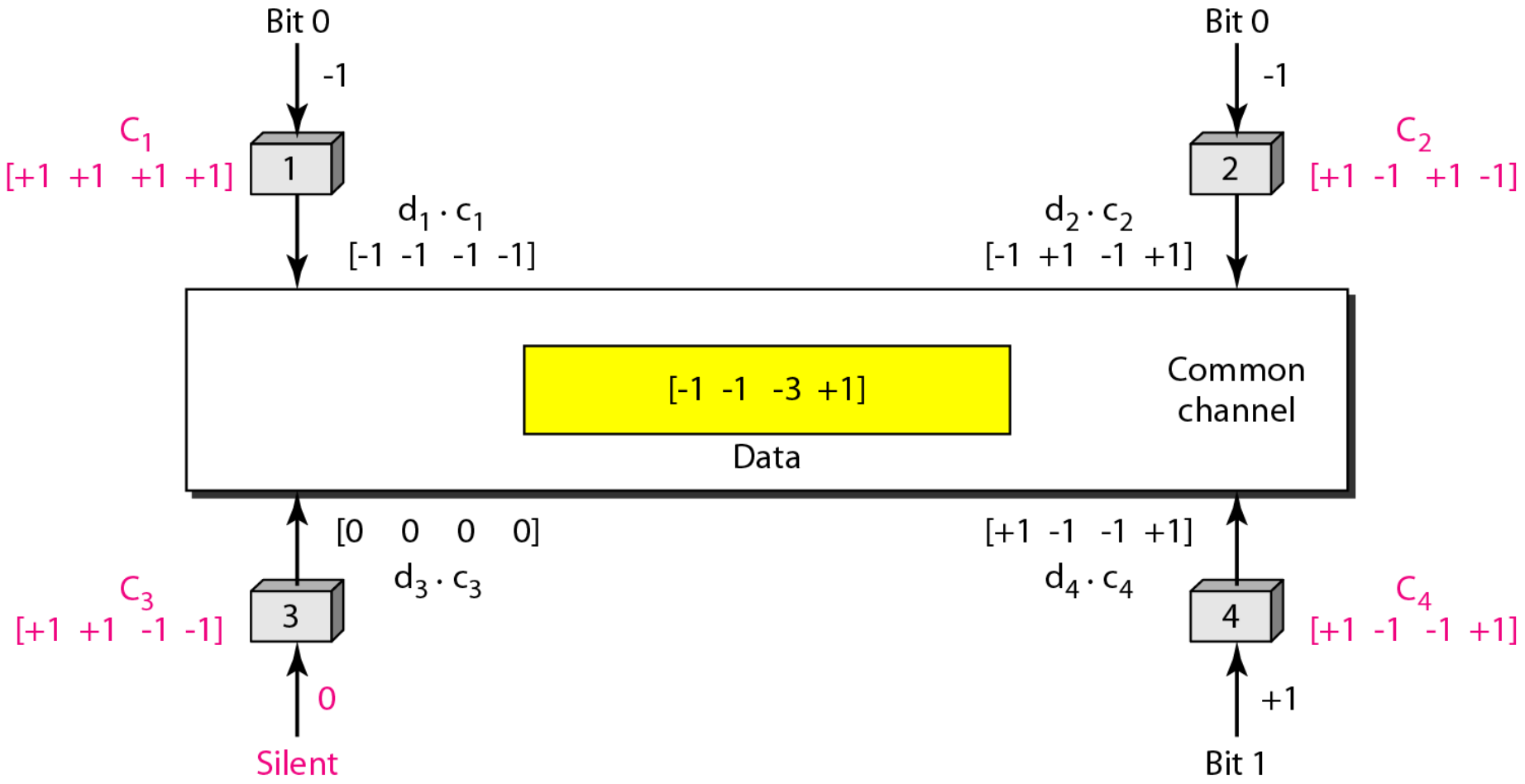


Figure 12.27 Digital signal created by four stations in CDMA

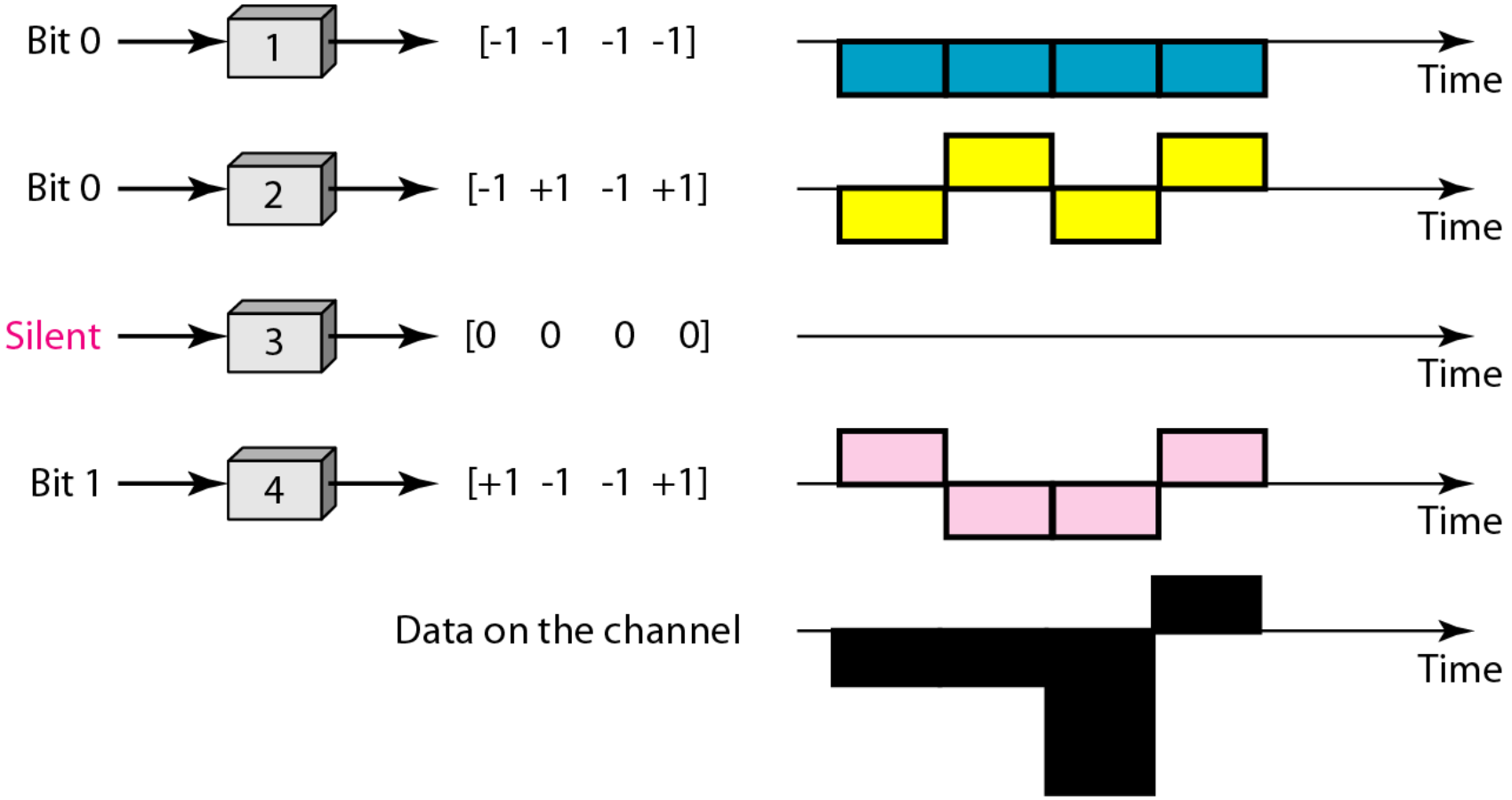


Figure 12.28 Decoding of the composite signal for one in CDMA

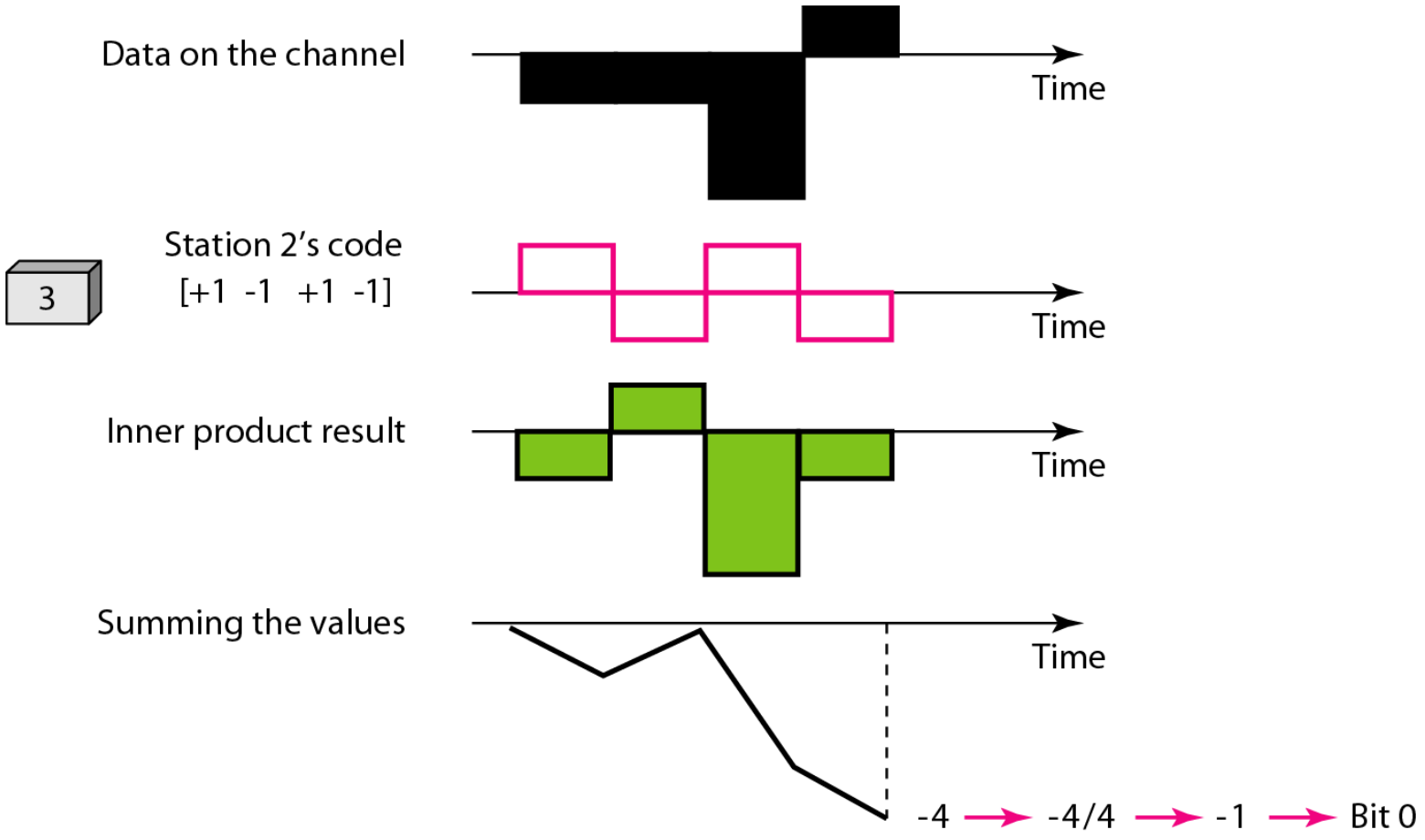
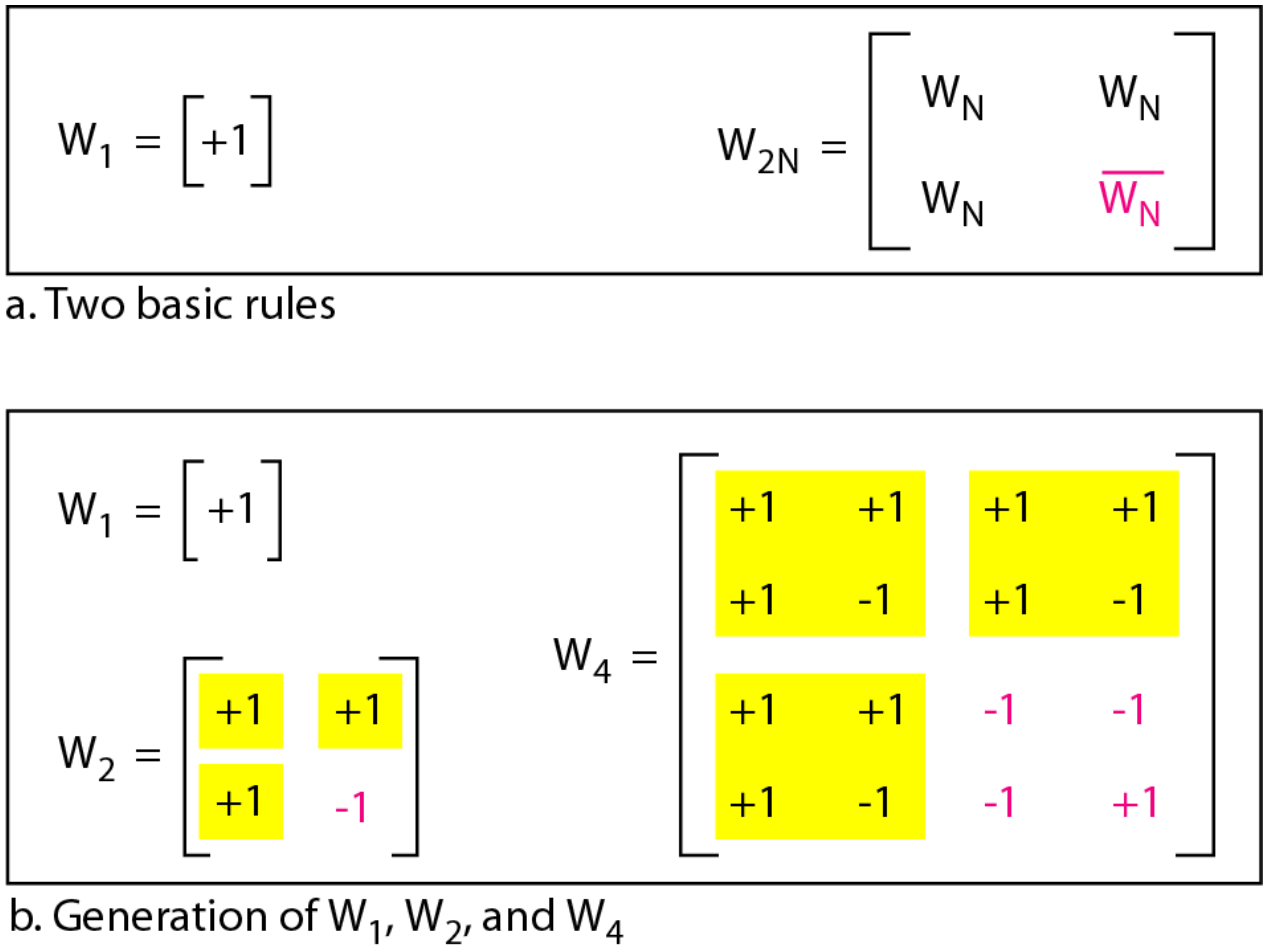


Figure 12.29 General rule and examples of creating Walsh tables



supplementary

Pure Aloha (cont.)

P(success by given node) = P(node transmits) ·

P(no other node transmits in $[p_0\text{-}1,p_0]$ ·

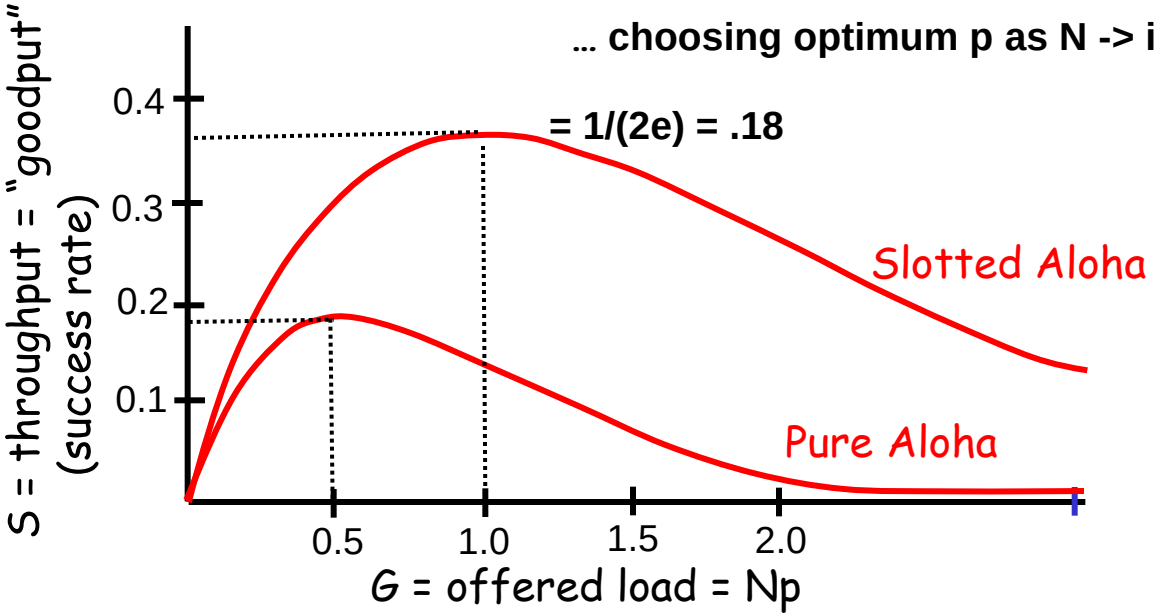
P(no other node transmits in $[p_0\text{-}1,p_0]$

= p · (1-p) · (1-p)

P(success by any of N nodes) = N p · (1-p) · (1-p)

… choosing optimum p as N -> infty …

= 1/(2e) = .18



protocol constrains effective channel throughput!

Slotted Aloha efficiency

Q: what is max fraction slots successful?

A: Suppose N stations have packets to send

- **each transmits in slot with probability *p***
- **prob. successful transmission *S* is:**

by single node: $S = p(1-p)^{(N-1)}$

by any of N nodes

***S* = Prob (only one transmits)**

$= N p (1-p)^{(N-1)}$

… choosing optimum p as n -> infty ...

$= 1/e = .37$ *as N -> infty*

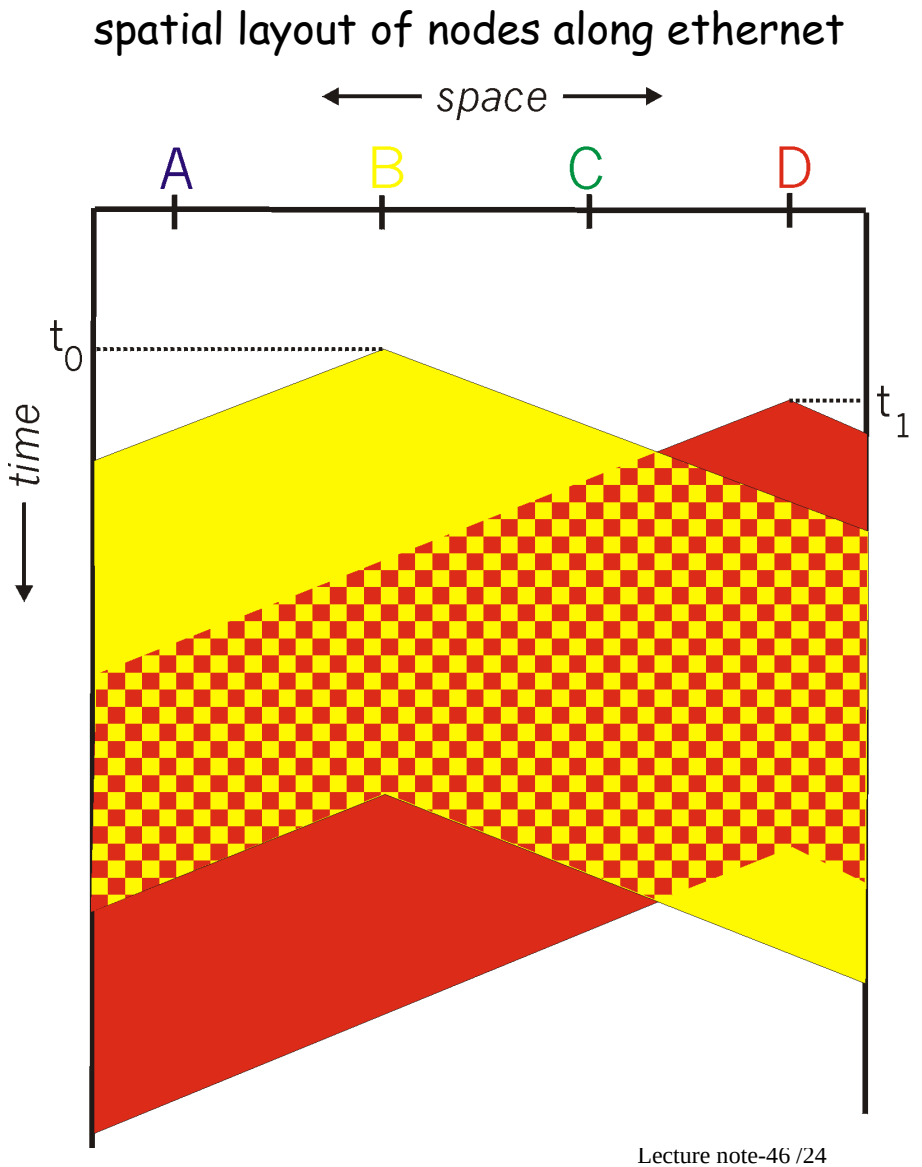
At best: channel use for useful transmissions 37% of time!

CSMA collisions

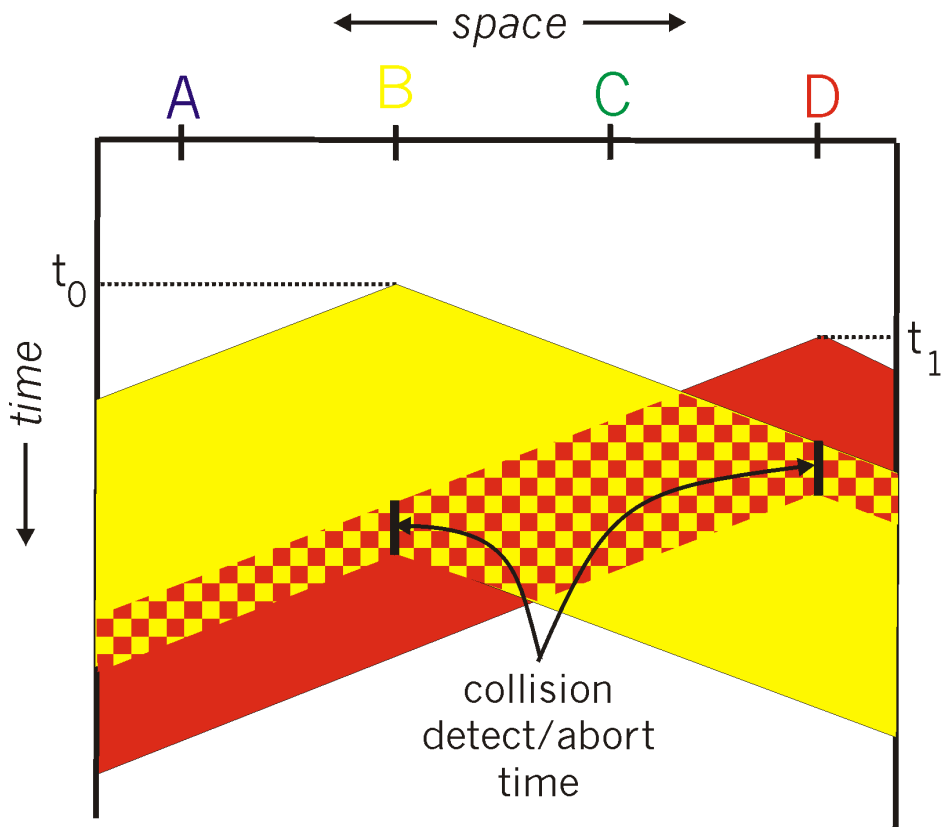
collisions *can* occur:
propagation delay means two nodes may not year hear each other's transmission

collision:
entire packet transmission time wasted

note:
role of distance and propagation delay in determining collision prob.



CSMA/CD collision detection



What we do at next = ETHERNET

- Device must conform to the Ethernet protocols
  - No network control concept
- Baseband
  - Half duplex with CSMA/CD hub
  - Full duplex with LAN switch
- Up to 100 Mb/sec using coax, twisted pair or fiber
  - 10 Base-T or 10 Base-F
  - 100 Base-T (Fast Ethernet)
- Up to 10 km length
- Broadcast capacity
- Low cost