Propagation Vs Transmission

Propagation	**Transmission**
How long it takes *one* bit to *travel* from one end of the medium to the other or time it takes the signal to travel from source to destination	How long it takes to get *all* the bits *into* the medium in the first place or time it takes the sender to transmit all bits of the packet
It is proportional to the length of the medium (length/speed or distance/speed)	It is ----- packet length/data rate
Propagate means to move something in a medium.....	Transmit means to send something.......
Therefore, propagation delay is the time taken by an object to pass through a medium	Whereas transmission delay is the time taken to transfer something
It depends on the distance between source and receiver and also the medium through which it is travelling	It depends on the length of object which is to be transmitted and the rate at which the object is transmitted

Propagation Vs Transmission

Packet transmission time: Example

Consider a 100 Mbit/s Ethernet, and the maximum packet size of 1520 bytes

Maximum packet transmission time= 1520*8 bit / (100 000 000 bit/s) =----- µs

Packet propagation time: Example

Consider wireless communication with maximum distance of 100 meter between sender and receiver

Maximum link propagation delay ≈ 100 m / (300 000 000 m/s) = ---- µs

EXAMPLE: A 1000 byte packet is sent from your home to a server. It is first sent over a 10 Mbps wireless link. Once it has been received completely, it is then sent over a 100 Mbps ISP link. The propagation delay of the wireless link is 500 nanoseconds and the propagation delay of the ISP link is 10ms. *How long does it take (in milliseconds) for the packet to reach the server?*

Medium Access Control (Sub-Layer)

Multiple-access problem: when a channel is shared among many nodes, the problem arises to when each node should access the channel

Protocols used to determine who goes next on a multi-access channel belong to MAC layer

MAC allows several stations connected to the transmission medium to transmit over it and to share its capacity

MAC Protocols

MAC is important in LANs, particularly critical to the performance of wireless LANs as wireless is naturally an open, shared, and broadcast medium/channel

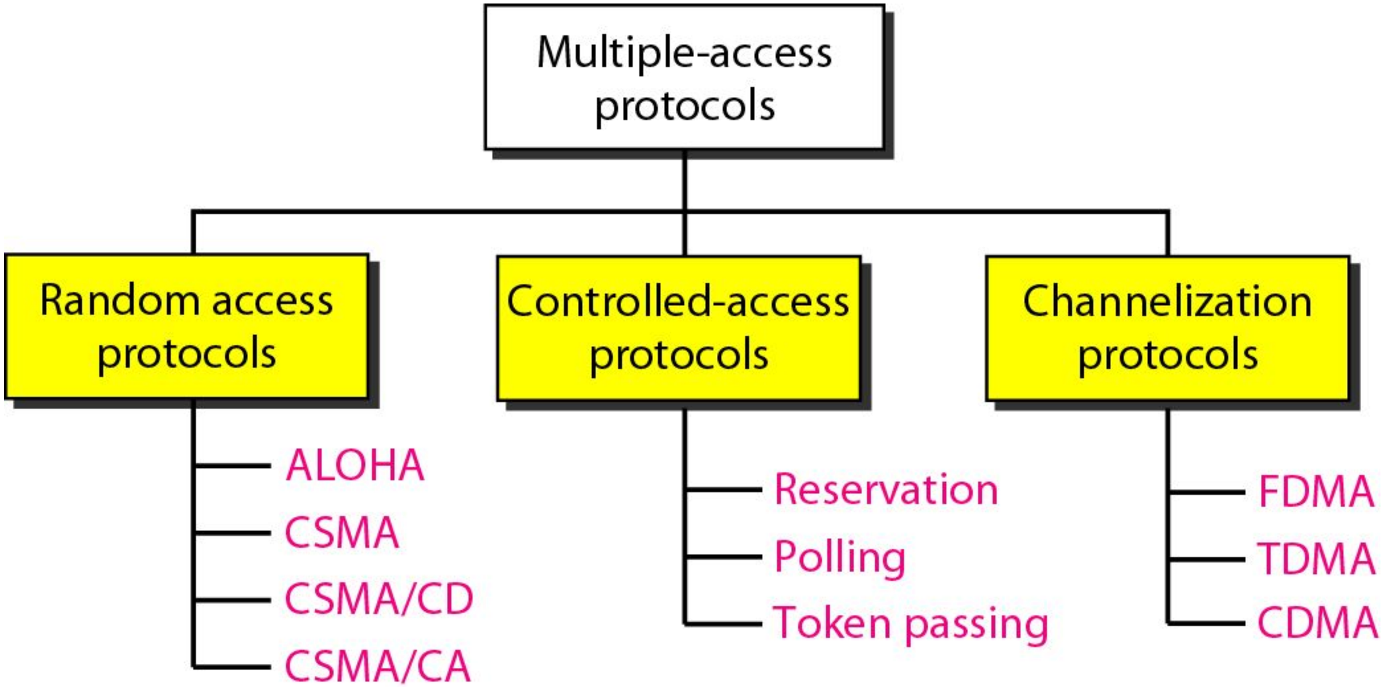
- A *MAC protocol is used* ***to resolve potential contention*** and ***collision*** when using the communication medium
- MAC protocols define rules to force distributed nodes to access wireless medium in an orderly and efficient manner

Distributed system is the key matter which makes this issue hard as there is no one in-charge in the system

Ingredients of MAC Protocols

- Carrier sense (CS)
- Hardware capable of sensing whether transmission taking place in vicinity
- Acknowledgments
  - When collision detection not possible, link-layer mechanism for identifying failed transmissions
- Backoff mechanism
  - Method for estimating contention and deferring transmissions
- Collision detection (CD)
  - Hardware capable of detecting collisions
- Collision avoidance (CA)
  - Protocol for avoiding collisions

Taxonomy of multiple-access protocols



Random multiple access protocols

- In random access or contention methods,
  - No station is superior to another station and
  - No station 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
  - A station can transmit
    - When it desires
    - Provided it obeys the mechanism defined by the protocol
      - Such as verification of state of medium

Random multiple access protocols

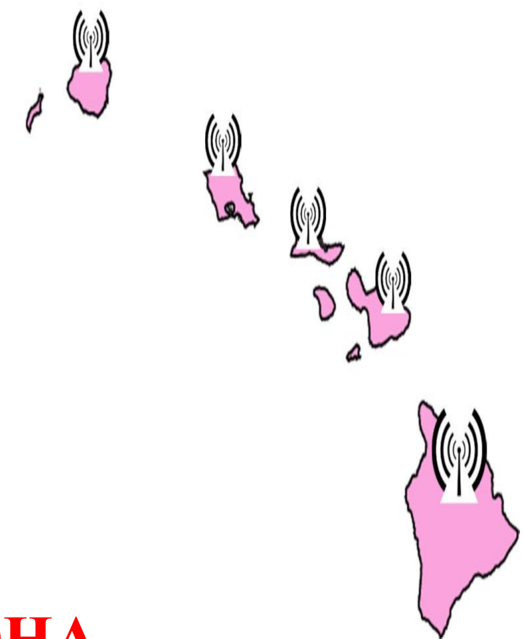
- Stations transmit without any schedule
- Methods are called *random access* because
  - transmission is random among the stations
- Also called *contention methods*
  - Stations have competition to access the common medium that can lead to conflicts
  - no rules specify which station should transmit next
- *Access collision*
  - If more than one stations try to send
    - Frames can be either destroyed or modified

Random multiple access protocols

- To avoid access collision or resolve when it happens, a node follows a procedure that tackles the following:
  - When to access the medium
  - What to do if medium busy
  - How to determine the transmission failure or success
  - What to do in the situation of collision

ALOHA Network

(Areal LOcations of Hazardous Atmospheres)



- Norm Abramson devised a new protocol at the University of Hawaii for multiple access
  - When should nodes send?
- computer network connecting the Hawaiian islands in the late 1960s with wireless links

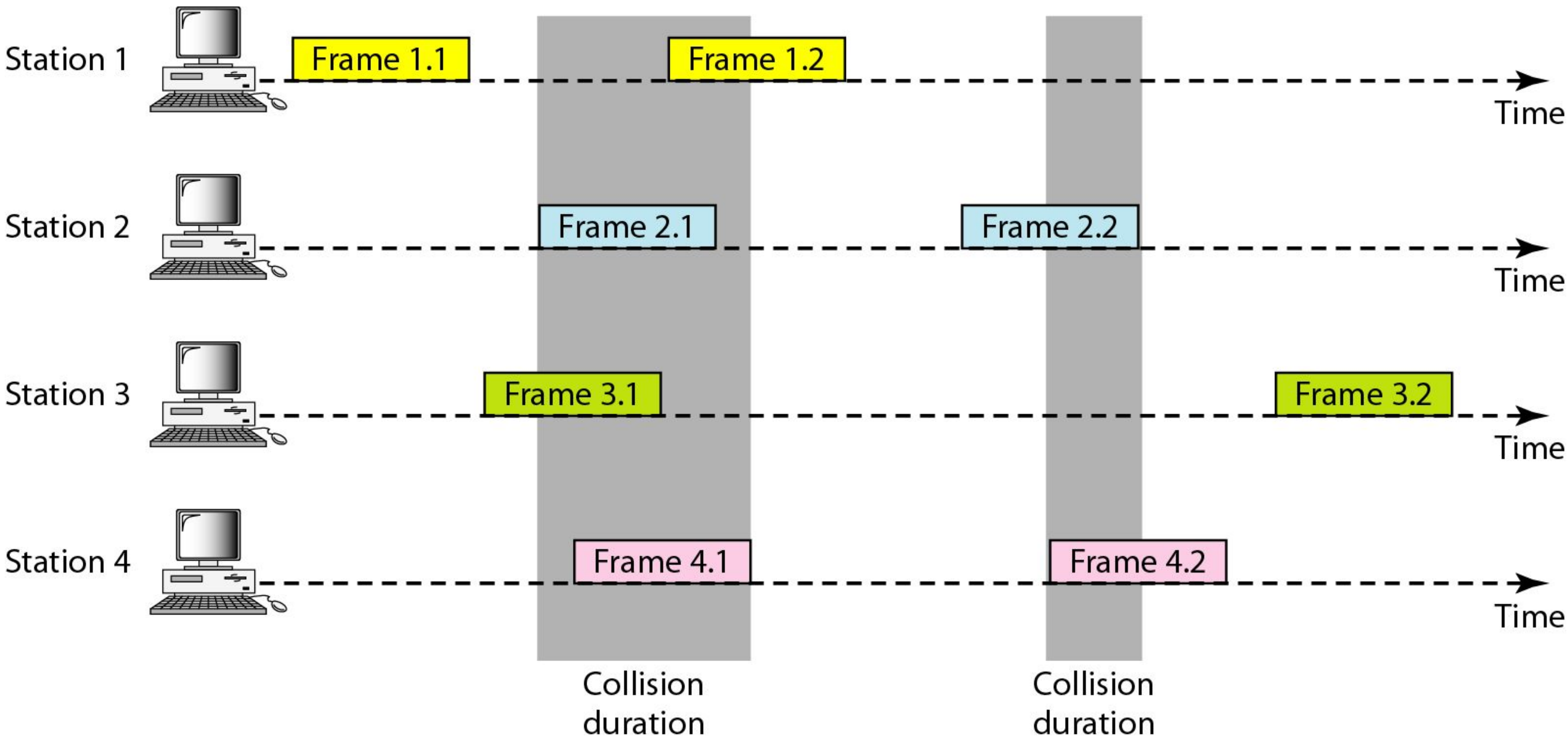
Use of very simple procedure: **Multiple access**

All random access methods evolved from ALOHA

Principal of pure ALOHA:

- If you have data to send, send the data
- If the message collides with another transmission (no ACK received), sender waits random time before trying again (resend)

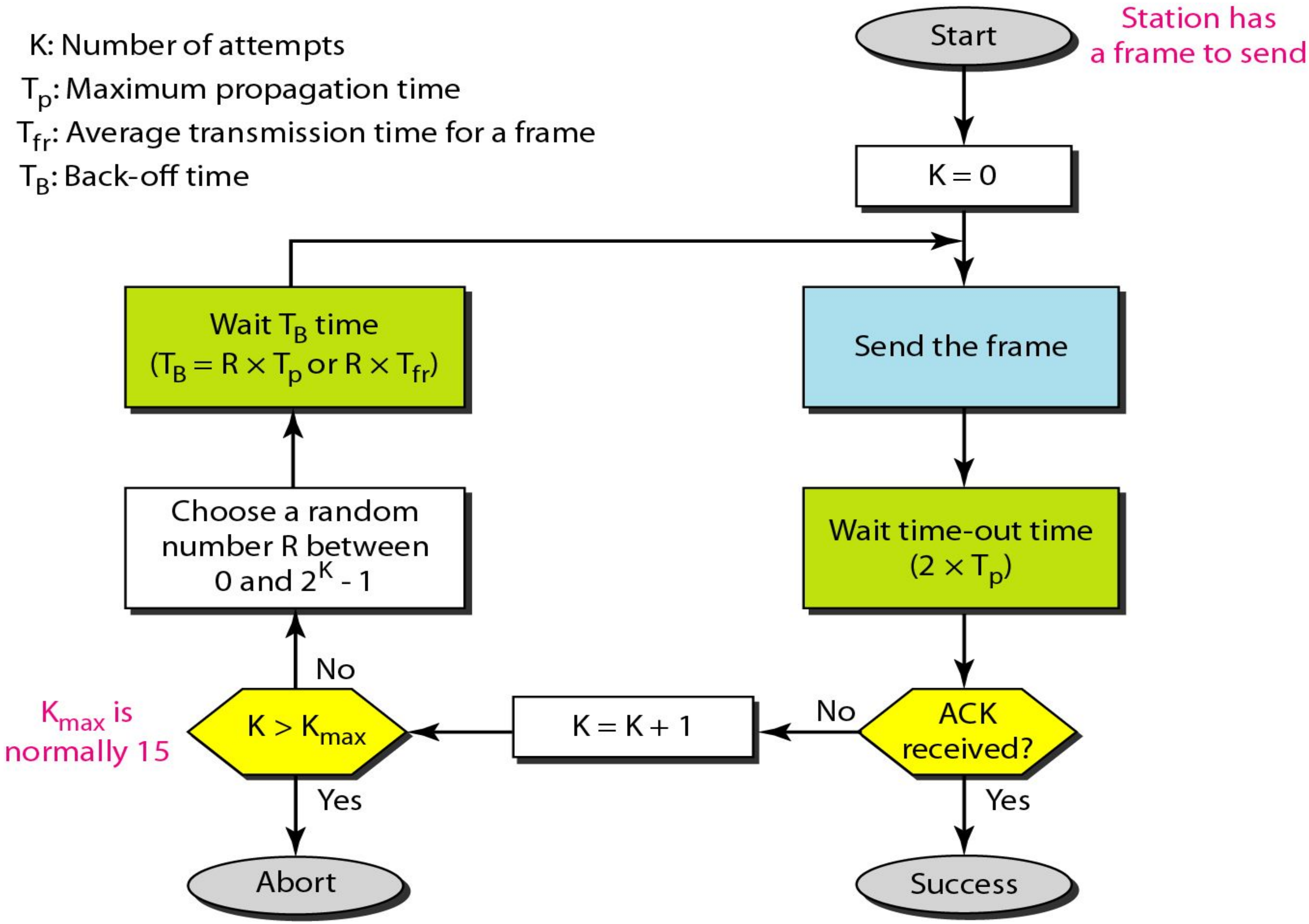
Frames in a pure ALOHA network:
4 stations each with 2 frames contending with one another for access to the shared channel



Pure ALOHA

- Even if one bit of a frame coexists on the channel with one bit from another frame: **There is a collision**
- Resend the frames that have been destroyed during transmission
- **It relies on ACKs from receiver**
  - If no ACK received after a **time-out period**, then assumes that frame has been destroyed and resend the frame
- If all collided stations retransmit after time out: **Frame may collide again**
- Pure ALOHA dictates that each station waits a random amount of time (**back-off time:T_B**) before resending its frame
  - The randomness helps in avoiding more collisions
- To **prevent congestion** of the channel with retransmitted frames
  - a station must give up after a maximum number of retransmission attempts K_{max} and try later

Procedure for pure ALOHA protocol



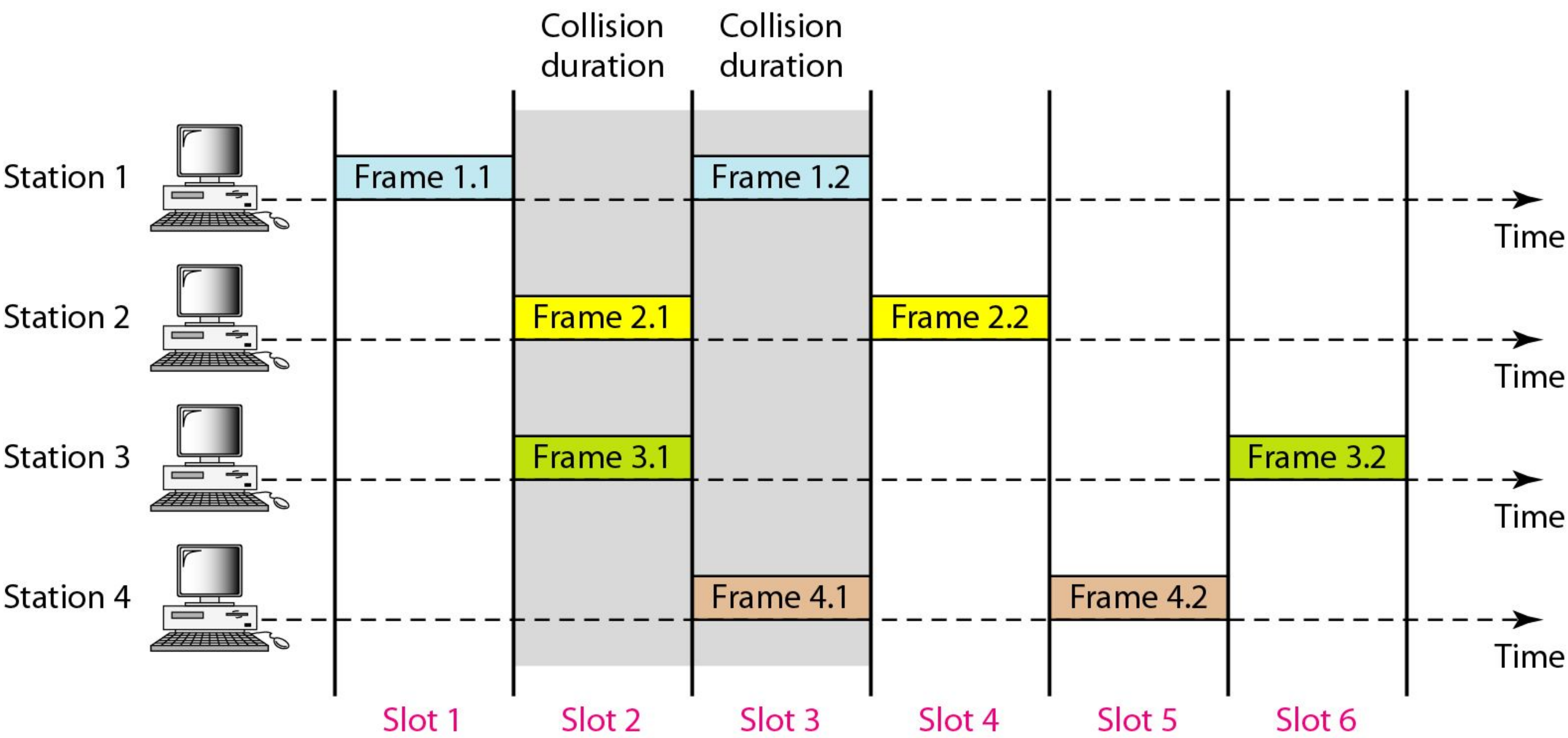
Pure ALOHA Example

- On a wireless ALOHA network
  - stations are maximum 300 Km apart
  - Assume that signals propagate at 3×10^8 m/s
  - *Maximum propagation time= Tp = ?*
  - *Backoff time = T_B = ? If K = 1, 2,3*
- What will be the maximum propagation time and backoff time if stations are 900 Km apart

Slotted ALOHA

- Slotted ALOHA was invented to improve the efficiency of pure ALOHA
- In slotted ALOHA, time is divided into **slots** of $\mathbf{T_{fr}}$ **seconds** (average transmission time for a frame) and force the station to send only at the beginning of the time slot
  - A station must wait until the beginning of the next time slot
    - If it misses to transmit at the start of a time slot
- Possibility of collision
  - If two stations try to send at the start of the same time slot

Frames in a slotted ALOHA network



CSMA (Carrier Sense Multiple Access)

- CSMA protocol was developed to minimize the chances of collision, so as to improve the performance
- Improves ALOHA by listening for activity before we send (**carrier sense**)
- Protocols in which station listen for a carrier (such as an electrical bus, or a band of the electromagnetic spectrum) and act accordingly are called **carrier sense protocols**
- Collision chances can be reduced to great extent
  - if a station senses the channel before trying to use it
- So CSMA is based on the principal of sense before transmit
  - If channel sensed idle, transmit entire frame
  - If channel sensed busy, defer transmission
  - **Human analogy: don’t interrupt others**

CSMA

- CSMA cannot eliminate the possibility of collision completely
  - it can only reduce the chances of collision
- Collision is possible if two nodes send instantaneously (simply)
- BUT a collision is still possible even if they send at slightly different times
  - it takes time for frames to propagate along the medium
- **The propagation delay is the major concern for the chances of collision**

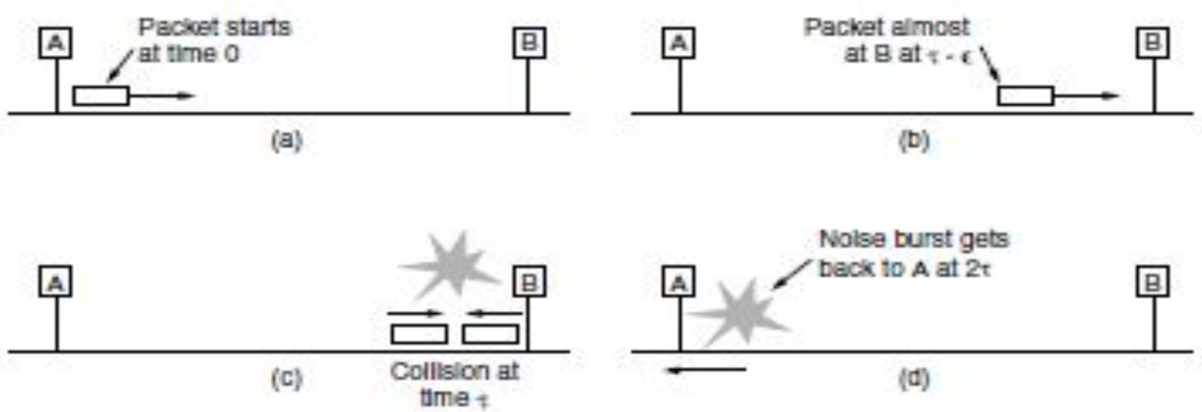


Figure 4-15. Collision detection can take as long as 2τ.

CSMA

- Let s*tation A senses the medium at* t_1 *and finds it idle,*
  - *so it sends a frame*
- *At time* t_2 $(t_2 > t_1)$‘*station B senses the medium and finds it idle*
  - *because, at this time, the first* bits from station A have not reached station B
  - So, B also sends a frame
- The two signals collide and both frames are destroyed
- **CSMA Access Modes**
  - **1-persistent CSMA**
  - **Non-persistent CSMA**
  - **P-persistent CSMA**

1-Persistent CSMA

- station that wants to transmit data, continuously senses the channel to check whether it is idle or busy
- If the channel is busy
  - the station continues sensing until it becomes idle
- When an idle channel is detected
  - The station immediately transmits the frame with probability 1 (**so called1-persistent CSMA**)
- It has the highest chance of collision
  - two or more stations may find channel to be idle at the same time and transmit their frames
  - When the collision occurs, the stations wait a random amount of time and start all over again
- This mode is used in CSMA/CD

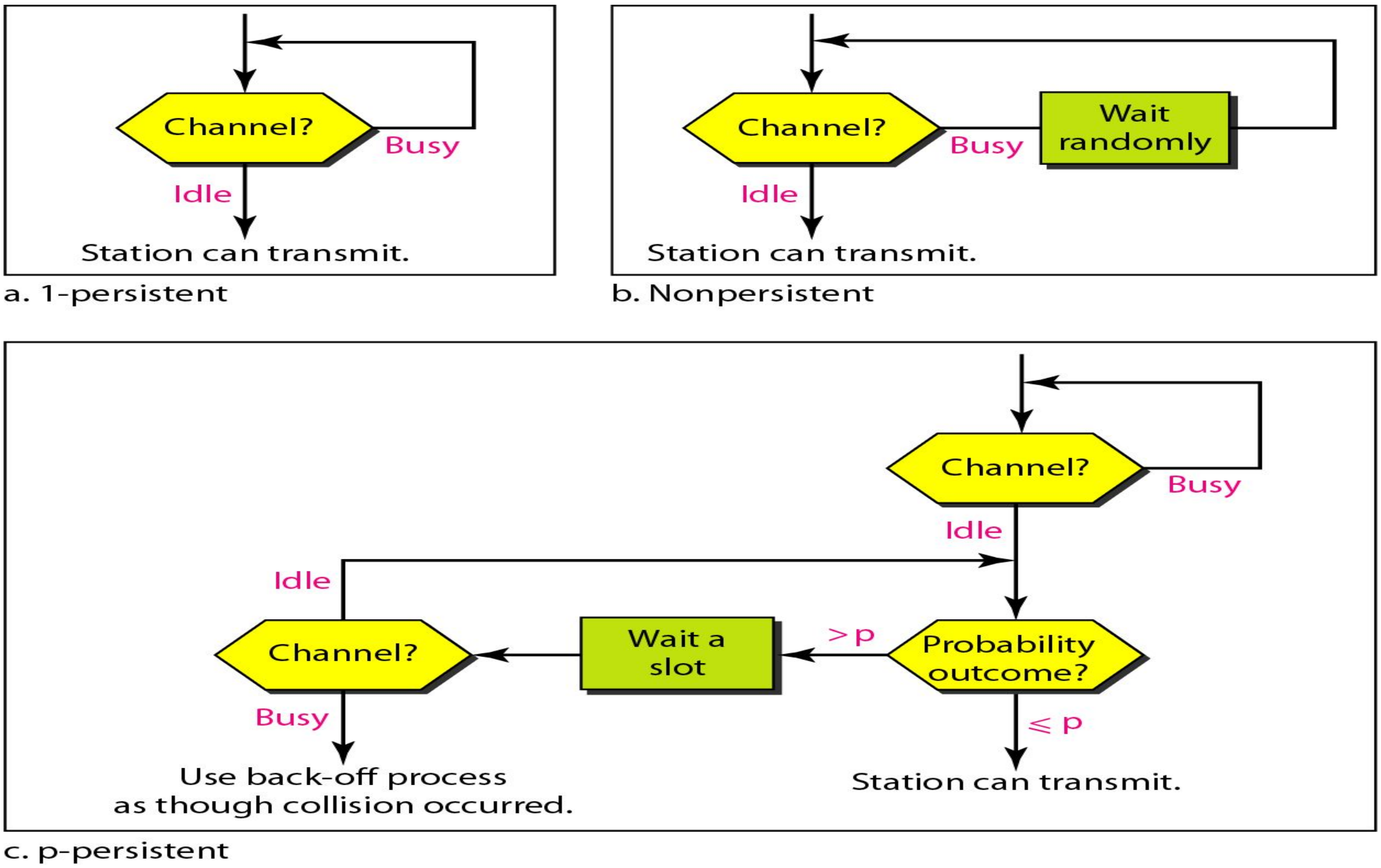
Non-Persistent CSMA

- A station that has a frame to send senses the channel
  - If the channel is idle,
    - it sends immediately
  - If the channel is busy,
    - it waits a random amount of time, and
    - then senses the channel again
  - In non-persistent CSMA the station does not continuously sense the channel for the purpose of capturing it when it detects the end of precious transmission

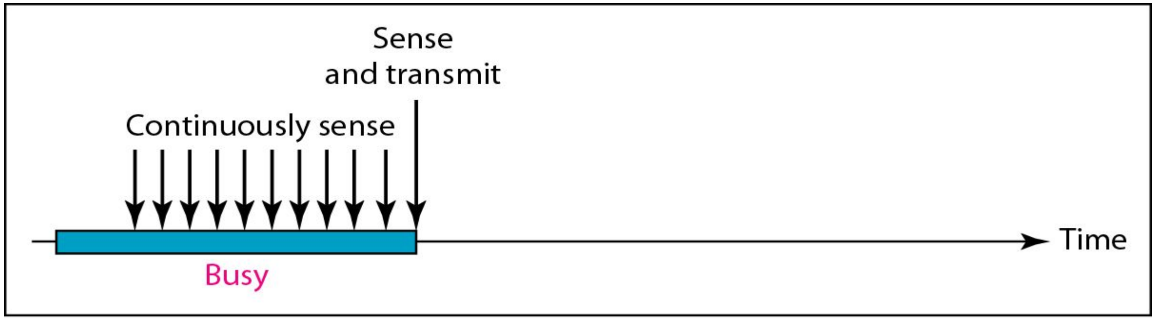
P-Persistent CSMA

- This method is used when channel has time slots such that the time slot duration is equal to or greater than the maximum propagation delay time
- Whenever a station becomes ready to send, it senses the channel
  - If channel is busy, station waits until next slot
  - If the channel is idle, it transmits with a probability p
  - With the probability q=1-p, the station then waits for the beginning of the next time slot
  - If the next slot is also idle, it either transmits or wait again with probabilities p and q respectively
  - This process is repeated till either frame has been transmitted or another station has begun transmitting
  - In case of the transmission by another station, the station act as though a collision has occurred and it waits a random amount of time and starts again
- This mode is used in CSMA/CA
- **Advantage:** it reduce collision chances and improve the efficiency of the network

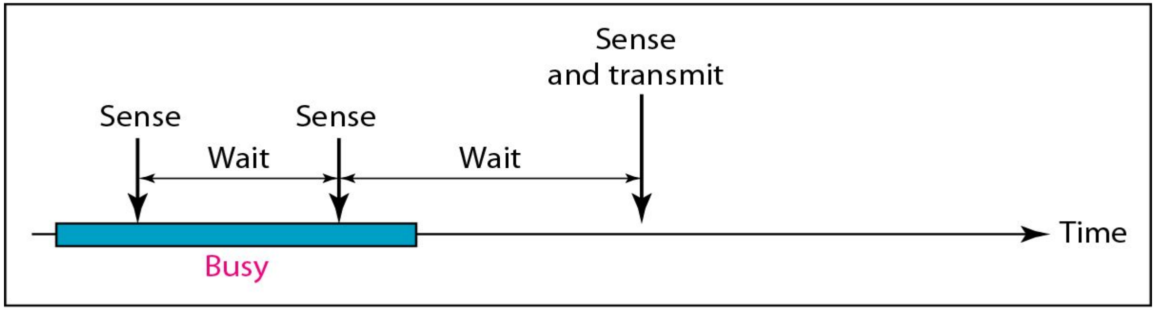
Flow diagram for three persistence methods



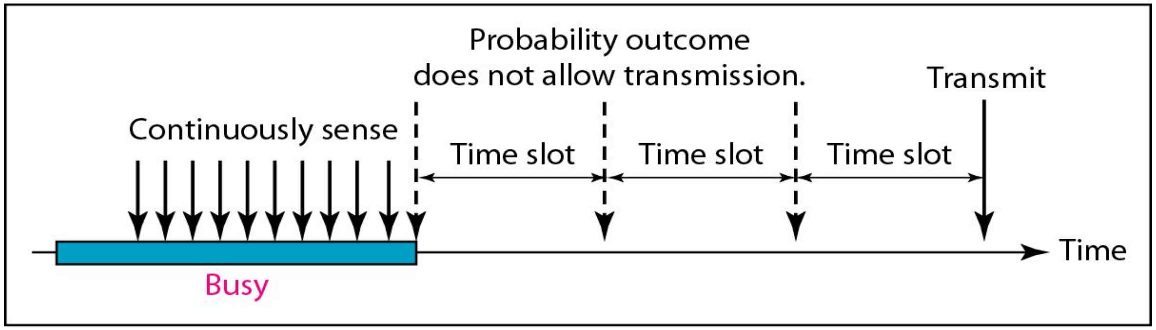
Behavior of three persistence methods



a. 1-persistent



b. Nonpersistent



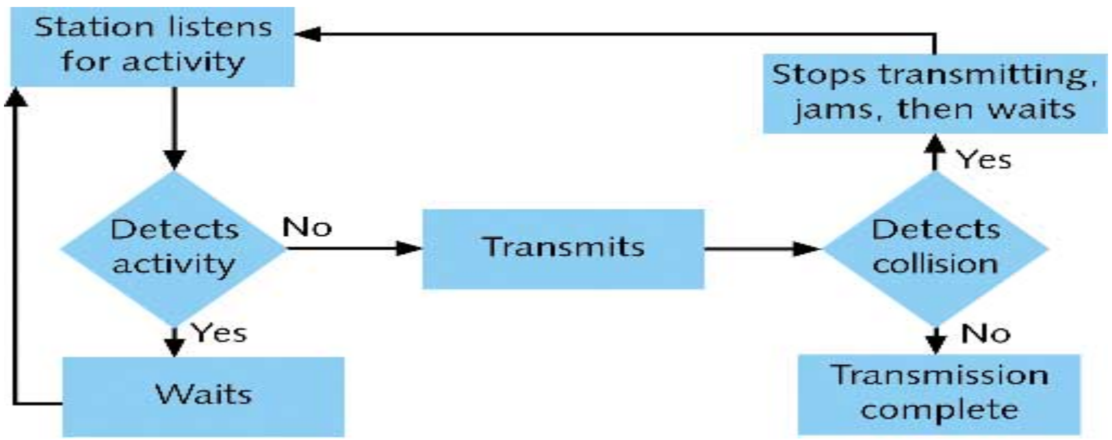
c. p-persistent

- CSMA does not specify any procedure after collision
- CSMA/CD enhances the algorithm to handle the collision

CSMA/CD (carrier sense multiple access/ collision detection)

- Persistent and non-persistent CSMA protocols are definitely an improvement over ALOHA because they ensure that no station begins to transmit while the channel is busy
- However, if two stations sense the channel to be idle and begin transmitting simultaneously, their signals will still collide.
- Another improvement (on top of ALOHA) is for the stations to quickly detect the collision and abruptly stop transmitting, (rather than finishing them).This scheme saves time and bandwidth

CSMA/CD

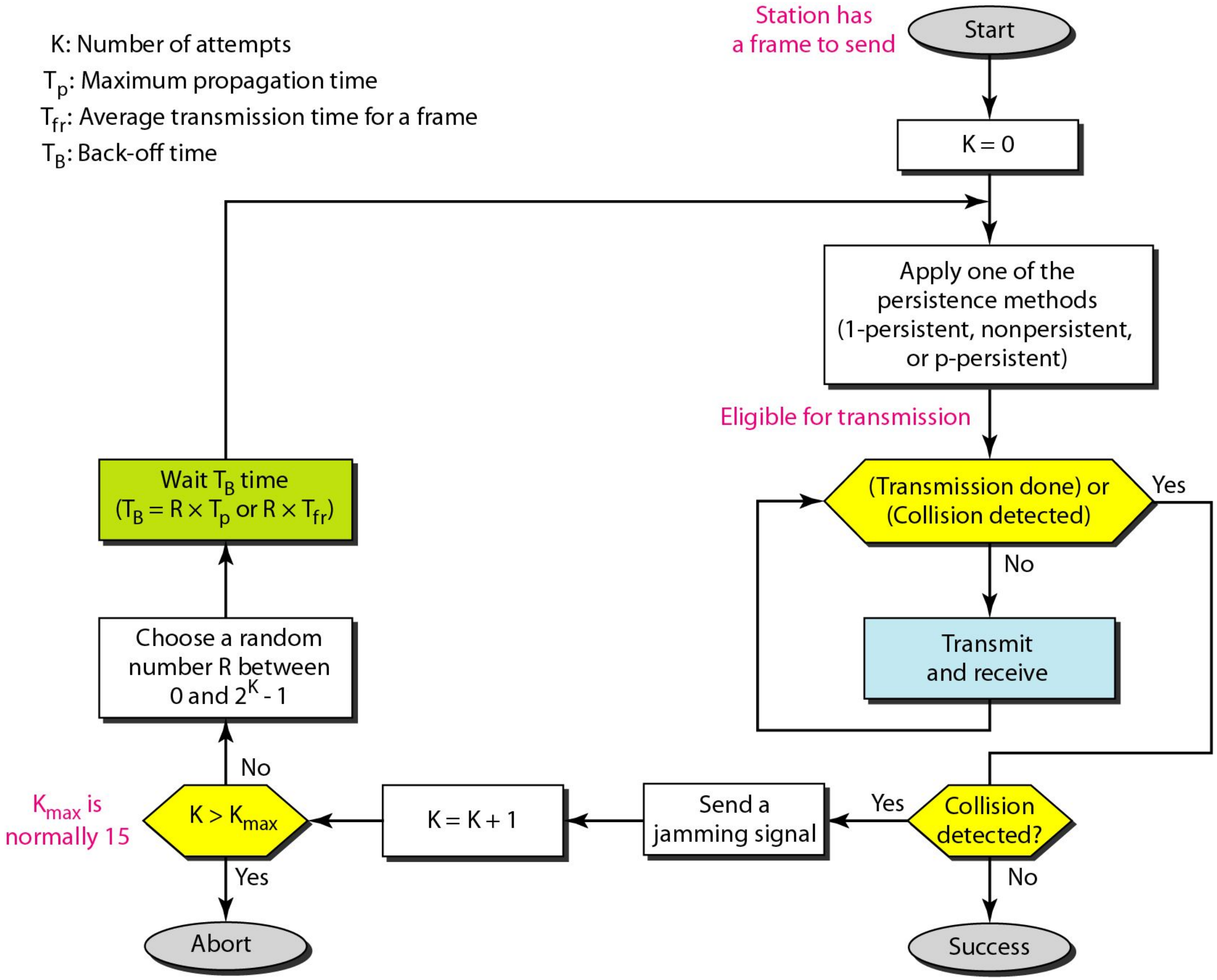


- When a sender detects a collision, it sends a “jam signal”.
    - ❖Make sure that all nodes are aware of the collision
    - ❖Length of the jam signal is 32 bit times
- In CSMA/CD, stations abort their transmission when they detect a collision e.g., Ethernet, IEEE802.3
- It is not applicable to wireless systems

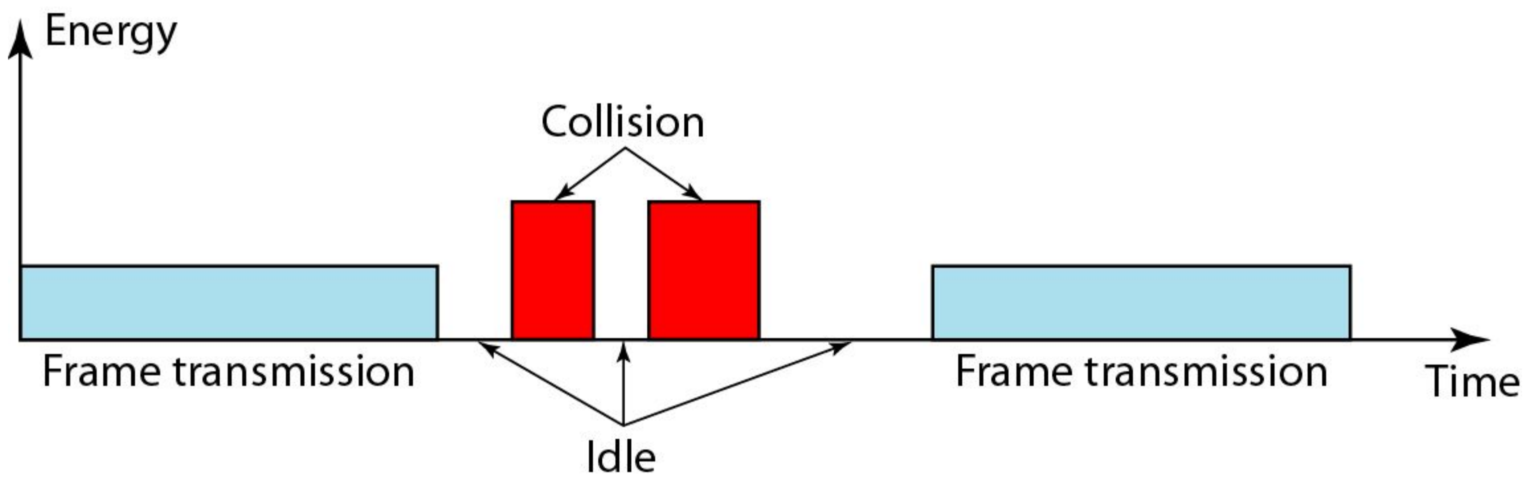
CSMA/CD: Procedure

1. Node has a frame to transmit
2. Sense the medium
   I. If busy (not idle): wait until becomes free
   II. If idle: transmit
3. After transmission, check weather collision has occurred
   I. If collision has detected
      a) Send a jam signal
      b) Increment retransmission counter
      c) Check maximum number of retransmission attempts. If yes, abort transmission
      d) Based on number of collisions, calculate random backoff time and wait that time
      e) Repeat from step 2 again
   II. If no collision detected, transmission is successful
4. Retransmission counters are reset and end frame transmission

Flow diagram for the CSMA/CD



Energy level during transmission, idleness, or collision



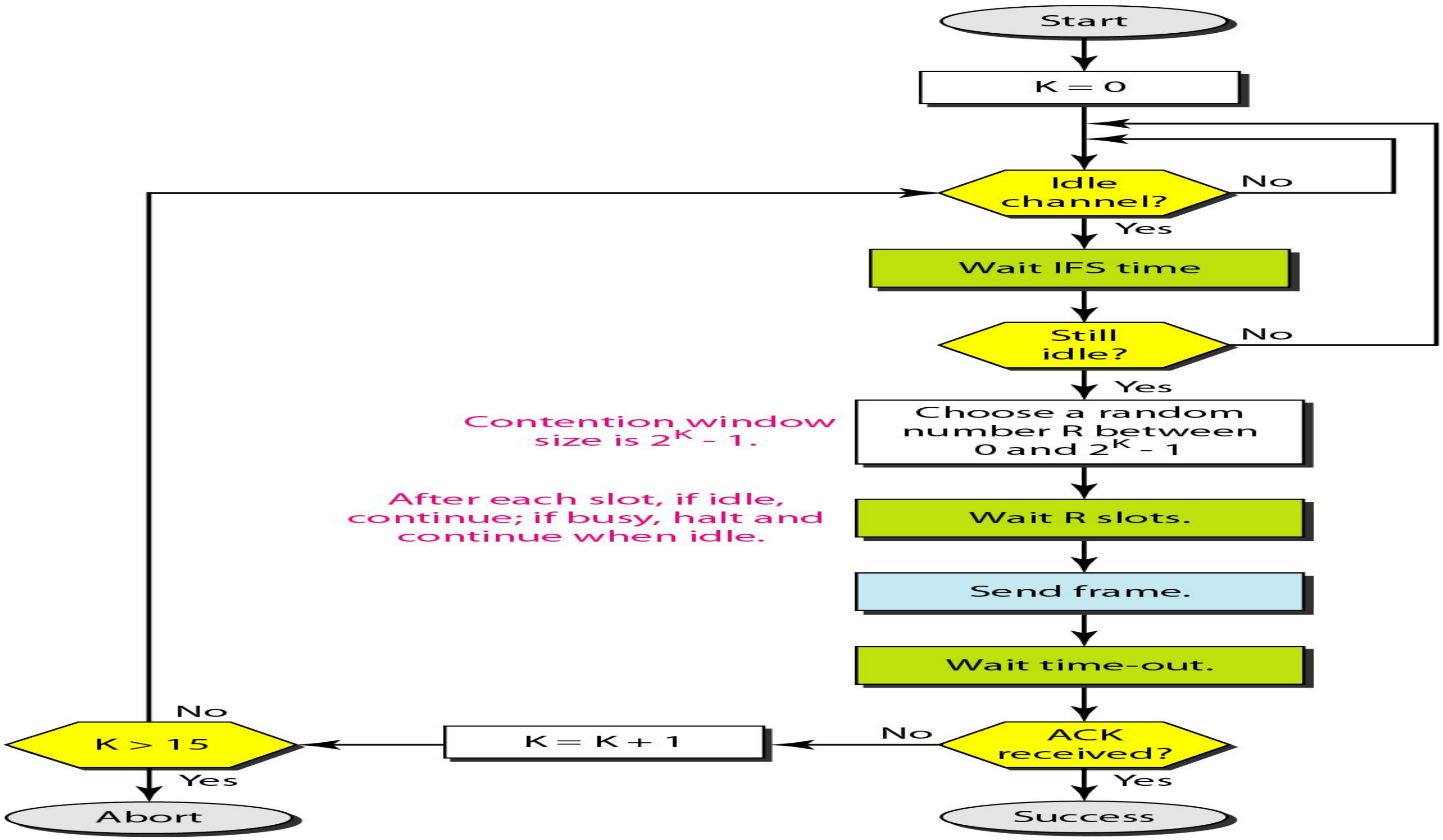
- level of energy in a channel can have three values
  - Zero: the channel is idle
  - Normal: The station has successfully captured the channel and is sending its frame
  - Abnormal: there is a collision and the level of the energy is twice the normal level
- station that has a frame to send or is sending a frame needs to monitor the energy level to determine if the channel is idle, busy, or in collision mode

Collision detection: If the signal, the sender reads back, is different from the signal it is putting out, it knows that a collision is occurring

- In fact, a received signal must not be tiny compared to the transmitted signal
- In *CSMA/CD : a station needs to be able to receive while* transmitting to detect a collision
- When there is **no collision**, the station receives **one signal**: its own signal
- When there is **a collision**, the station receives **two signals**: its own signal and the signal transmitted by a second station
- To distinguish between these two cases, the received signals in these two cases must be significantly different

- In a wired network, the received signal has almost the same energy as the sent signal because
- So in a collision, the detected energy almost doubles
- Popular CSMA scheme and its variant CSMA/CD developed for wired networks
  - Can not be used directly in wireless networks

CSMA/Collision Avoidance



Timing in CSMA/CA