GLA UNIVERSITY

COMPUTER NETWORK

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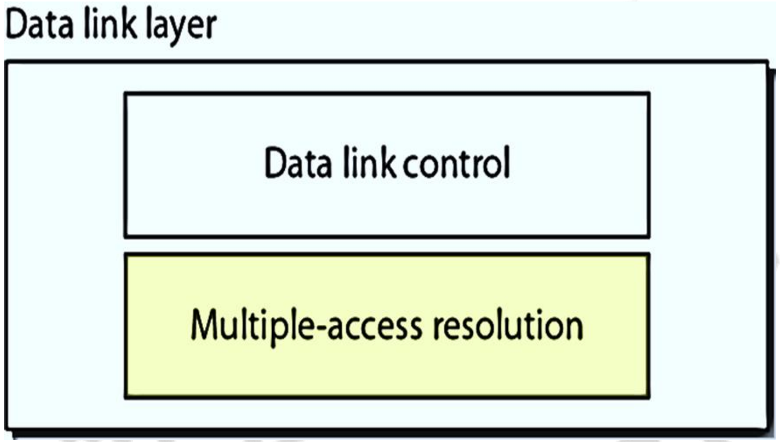
MULTIPLE ACCESS

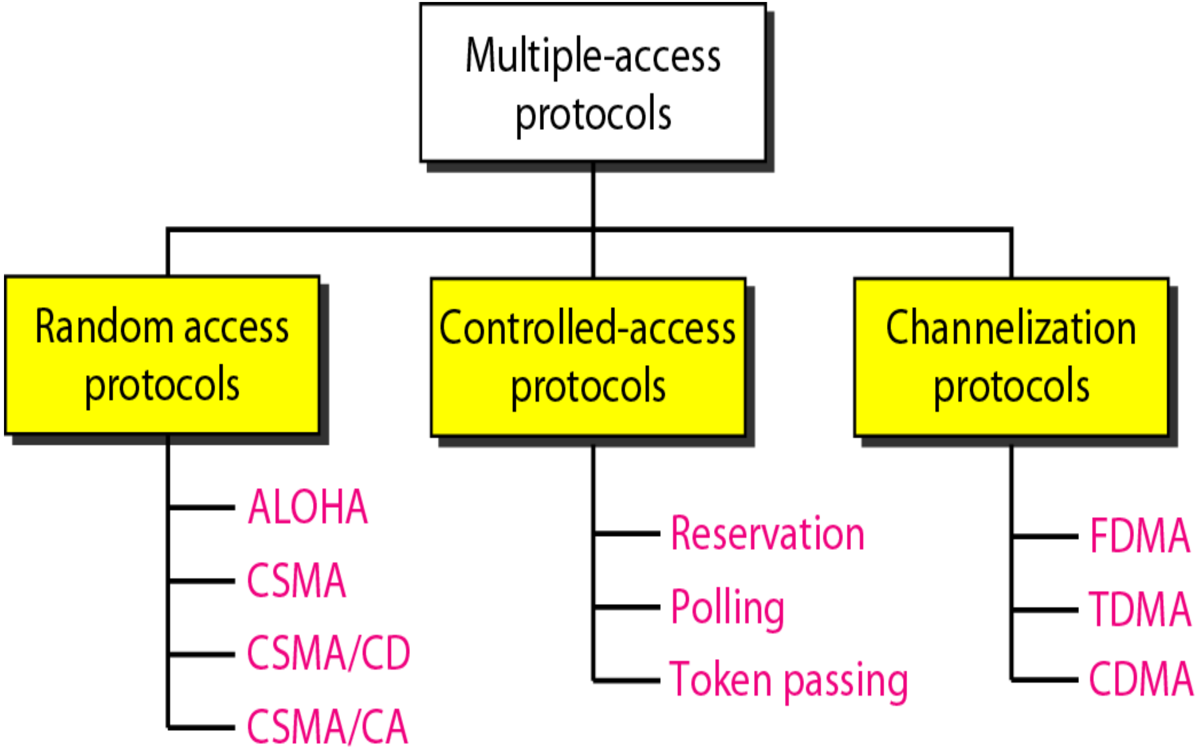
Multiple Access

- Data link layer divided into two functionality-oriented sublayers



- The upper sublayer is responsible for data link control, and the lower sublayer is responsible for resolving access to the shared media
- If the channel is dedicated, we do not need the lower sublayer

Multiple Access



Multiple Access →Random Access

- In random access methods, no station is superior to another station and none is assigned the control over another
- 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

Multiple Access →Random Access →Aloha

- There are two different versions of Aloha
  - Pure Aloha
  - Slotted Aloha

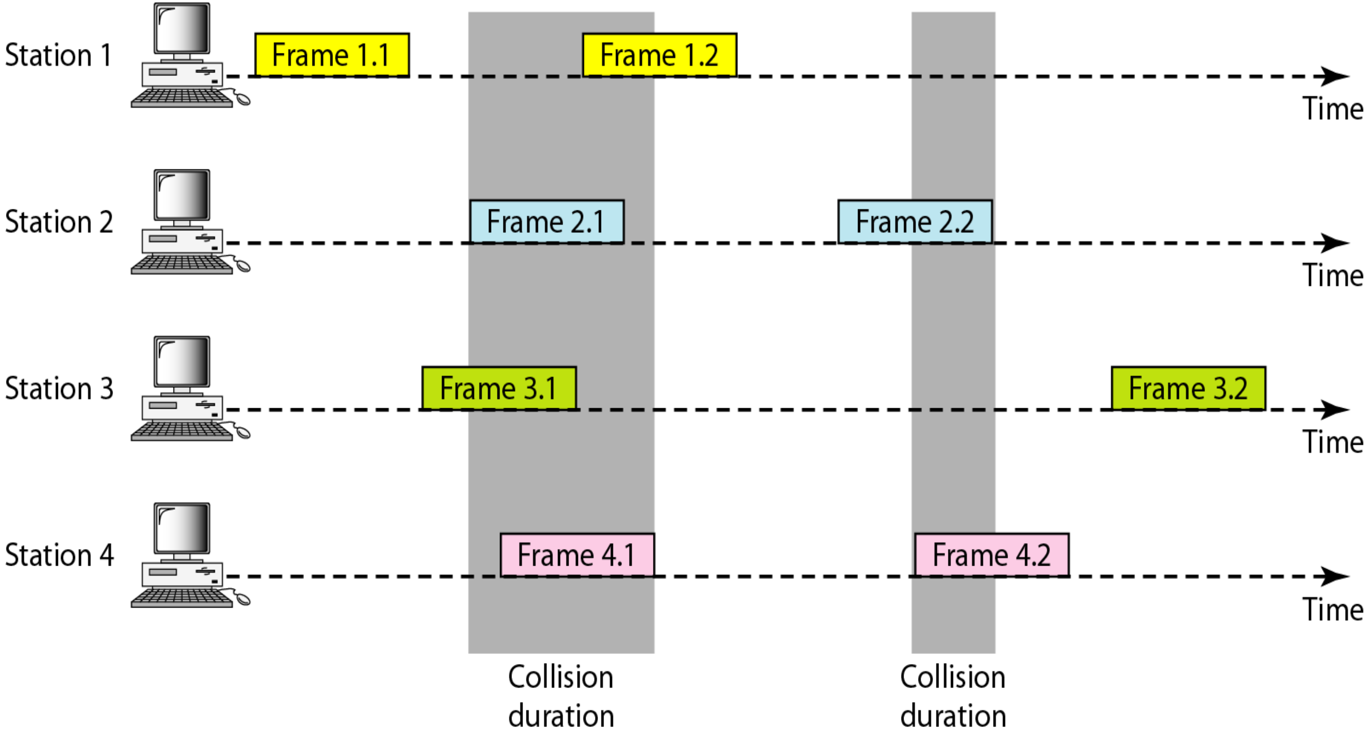
Multiple Access →Random Access →Aloha →Pure Aloha

- It allows the stations to transmit data at any time whenever they want
- After transmitting the data packet, station waits for some time
- The following two cases are possible
  - Case 01: Transmitting station receives an acknowledgement
    - Assumption: the transmission is successful
  - Case 02: Transmitting station does not receive any acknowledgement within specified time
    - Assumption: the transmission is unsuccessful

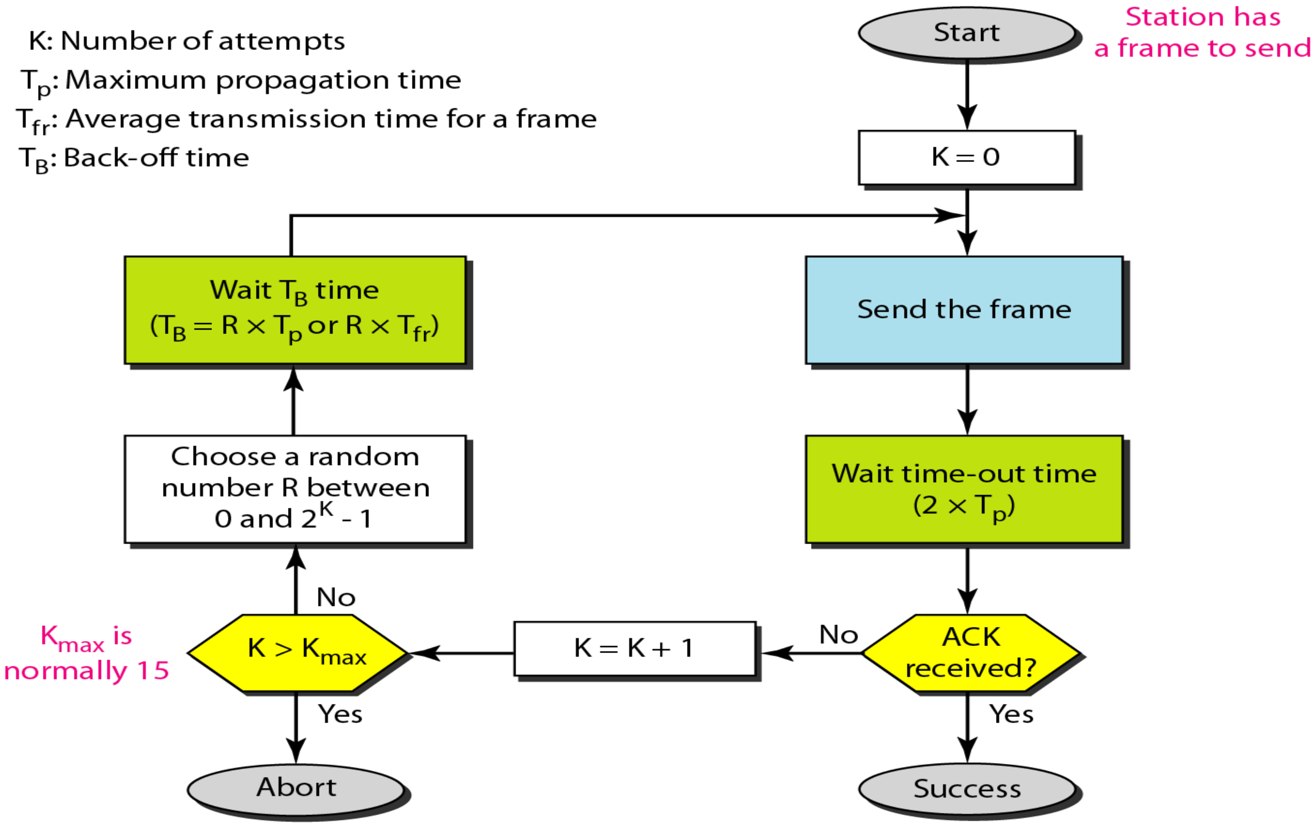
Multiple Access →Random Access →Aloha →Pure Aloha

- Frame time
  - The time required to send a frame is called frame time
- Vulnerable time
  - It is the time during which no transmission should be done to avoid any collision
  - In case of Pure Aloha vulnerable time is 2T

Multiple Access →Random Access →Aloha →Pure Aloha



Multiple Access →Random Access →Aloha →Pure Aloha



Multiple Access →Random Access →Aloha →Pure Aloha

- Eg:
  - The stations on a wireless ALOHA network are a maximum of 600 km apart. If we assume that signals propagate at 3×10^8 m/s, we find
- Solution

$$T_p = (600 \times 10^3) / (3 \times 10^8) = 2 \text{ ms}$$

- Now we can find the value of T_B for different values of k
  - For k = 1, the range is {0, 1}. The station needs to generate a random number with a value of 0 or 1.
  - This means that T_B is either 0 ms (0×2) or 2 ms (1×2), based on the outcome of the random variable

Multiple Access →Random Access →Aloha →Pure Aloha

- The throughput for pure ALOHA is

$$S = G * e^{-2G}$$

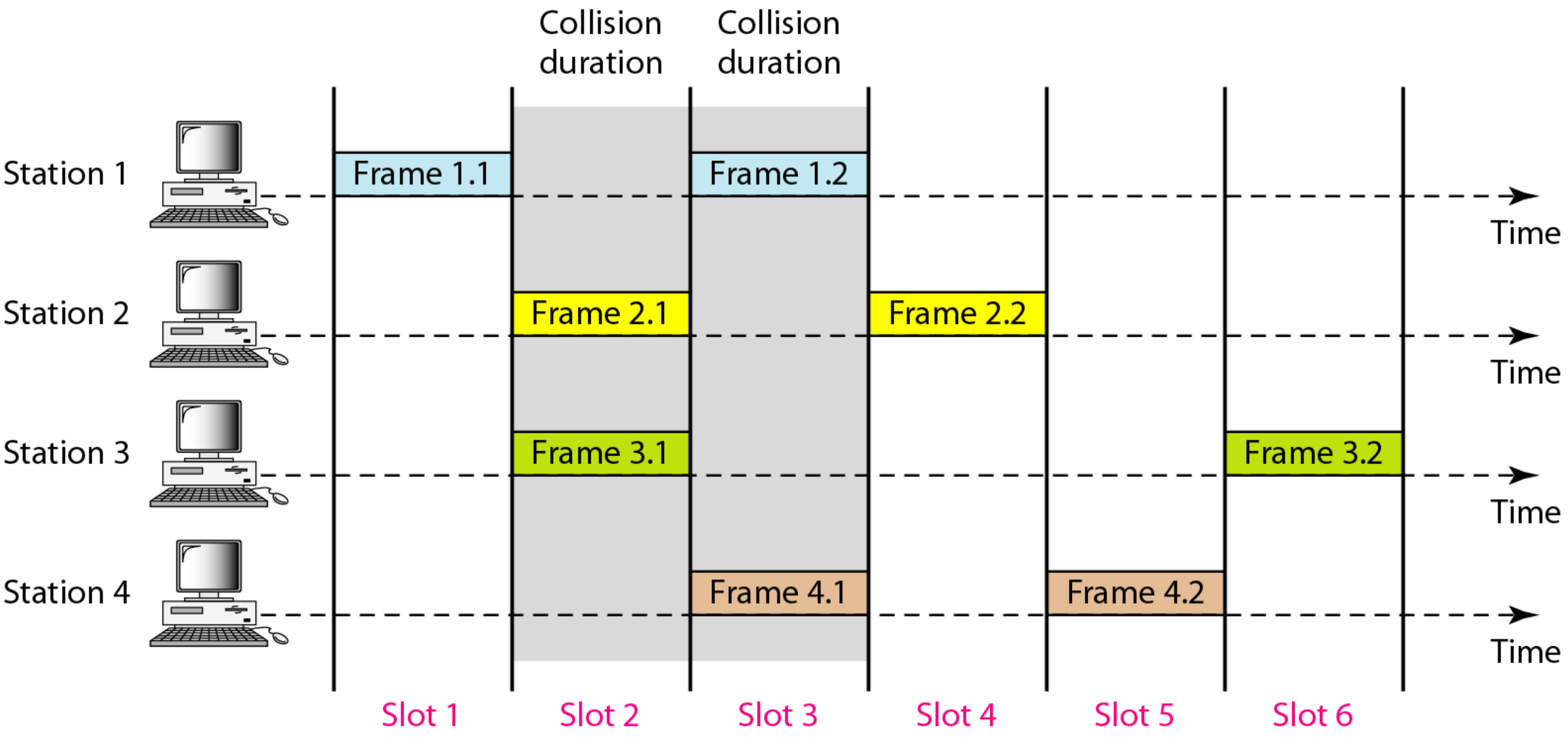
where,

G is load

Multiple Access →Random Access →Aloha →Slotted Aloha

- Slotted Aloha divides the time of shared channel into discrete intervals called as time slots
- Any station can transmit its data in any time slot
- The only condition is that station must start its transmission from the beginning of the time slot
- If the beginning of the slot is missed, then station has to wait until the beginning of the next time slot
- A collision may occur if two or more stations try to transmit data at the beginning of the same time slot
- However, the vulnerable time is now reduced to half, i.e. equals to T_f

Multiple Access →Random Access →Aloha →Slotted Aloha



Multiple Access →Random Access →Aloha →Slotted Aloha

- The throughput for slotted ALOHA is

$$S = G * e^{-G}$$

where,

G is load

Multiple Access →Random Access →Aloha

- Eg:
  - 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

$$T_{fr} = 200 \text{ bits}/200 \text{ kbps}$$
$$= 1 \text{ ms}$$

- Vulnerable time

$$= 2 * T_{fr}$$
$$= 2 \times 1$$
$$= 2 \text{ ms}$$

Multiple Access →Random Access →Aloha

- Eg:
  - A pure ALOHA network transmits 200-bit frames on a shared channel of 200 kbps. What is the throughput if the system (all stations together) produces 1000 frames per second

Solution

$$T_{fr} = 200 \text{ bit}/200 \text{ kbps}$$
$$= 1 \text{ ms}$$

- If the system creates 1000 frames per second, i.e. 1 frame per millisecond, then load = 1

$$\text{Throughput (S)} = G * e^{-2G}$$
$$S = 0.135\ (13.5\ \%)$$
$$\text{Overall throughput} = 1000 * 0.135$$
$$= 135 \text{ frames}$$

- Only 135 frames out of 1000 will probably survive

Multiple Access →Random Access →Aloha

- Eg:
  - A pure ALOHA network transmits 200-bit frames on a shared channel of 200 kbps. What is the throughput if the system (all stations together) produces 500 frames per second

Solution

$$T_{fr} = 200 \text{ bit}/200 \text{ kbps}$$
$$= 1 \text{ ms}$$

- If the system creates 500 frames per second, i.e. 1/2 frame per millisecond, then load = 1/2

$$\text{Throughput (S)} = G * e^{-2G}$$
$$S = 0.184\ (18.4\ \%)$$
$$\text{Overall throughput} = 500 * 0.184$$
$$= 92 \text{ frames}$$

- Only 92 frames out of 500 will probably survive

Multiple Access →Random Access →Aloha

- Eg:
  - A slotted ALOHA network transmits 200-bit frames using a shared channel with a 200-kbps bandwidth. Find the throughput if the system (all stations together) produces 1000 frames per second

Solution

$$T_{fr} = 200 \text{ bit}/200 \text{ kbps}$$
$$= 1 \text{ ms}$$

- If the system creates 1000 frames per second, i.e. 1 frame per millisecond, then load = 1

$$\text{Throughput (S)} = G * e^{-G}$$
$$S = 0.368 \ (36.8\ \%)$$
$$\text{Overall throughput} = 1000 * 0.368$$
$$= 368 \text{ frames}$$

- Only 368 frames out of 1000 will probably survive

Multiple Access →Random Access →Aloha

- Eg:
  - A slotted ALOHA network transmits 200-bit frames using a shared channel with a 200-kbps bandwidth. Find the throughput if the system (all stations together) produces 500 frames per second

Solution

$$T_{fr} = 200 \text{ bit}/200 \text{ kbps}$$
$$= 1 \text{ ms}$$

- If the system creates 500 frames per second, i.e. 1/2 frame per millisecond, then load = 1/2

$$\text{Throughput (S)} = G * e^{-G}$$
$$S = 0.303 \ (30.3\ \%)$$
$$\text{Overall throughput} = 500 * 0.303$$
$$= 151 \text{ frames}$$

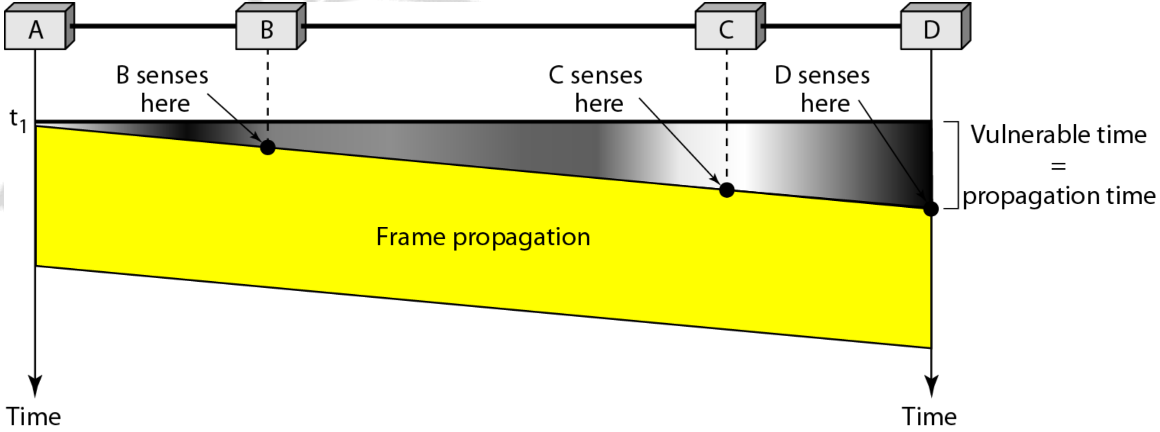
- Only 151 frames out of 500 will probably survive

Multiple Access →Random Access →CSMA

- This method was developed to decrease the chances of collisions when two or more stations start sending their data
- CSMA requires that each station first check the state of the medium before sending
- CSMA is based on the principle “sense before transmit”
- CSMA can reduce the possibility of collision, but it cannot eliminate it
- CSMA stands for Carrier Sense Multiple Access

Multiple Access →Random Access →CSMA

- Vulnerable Time
  - The vulnerable time for CSMA is the propagation time T_p
  - When a station sends a frame, and any other station tries to send a frame during this time, a collision will result

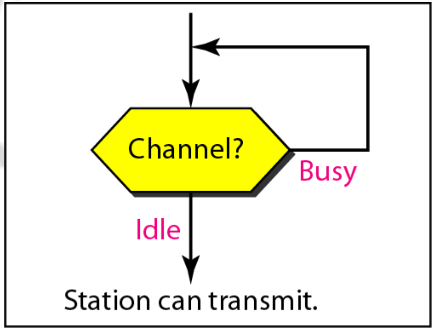


Multiple Access →Random Access →CSMA

- There are three types
  - 1-Persistent CSMA
  - Non-Persistent CSMA
  - P-Persistent CSMA

Multiple Access →Random Access →CSMA→1 persistent

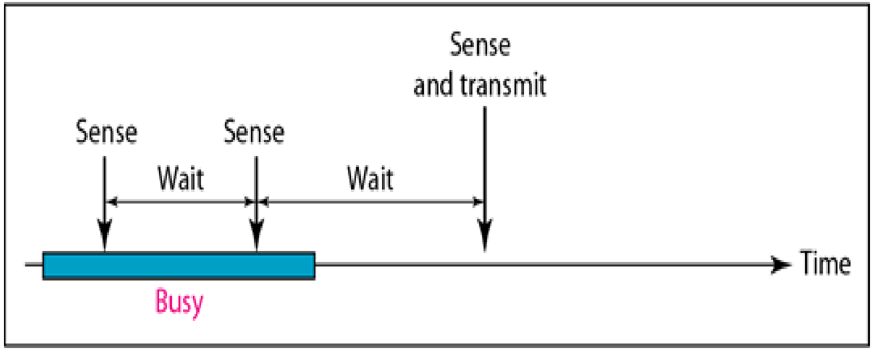
- If a station wants to transmit data, it continuously senses the channel to check whether the channel is idle or busy
- If the channel is busy, the station waits until it becomes idle
- When the station detects an idle-channel, it immediately transmits the frame with probability 1
- Hence it is called 1-persistent CSMA



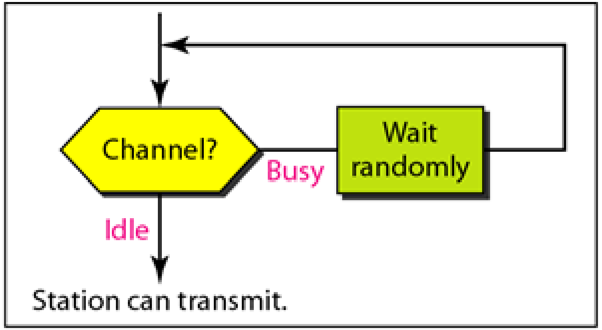
a. 1-persistent

Multiple Access →Random Access →CSMA→Non persistent

- 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



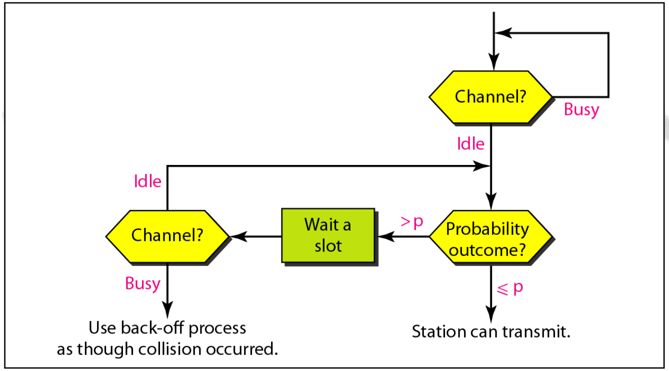
b. Nonpersistent



b. Nonpersistent

Multiple Access →Random Access →CSMA→p persistent

- The p-persistent approach combines the advantages of the other two strategies
- It reduces the chance of collision and improves efficiency
- In this method, if the station finds the line idle, it follows these steps:
  - With probability p, the station sends its frame
  - The station waits for the beginning of the next time slot and checks the line again
  - If the line is idle, it goes to step 1
  - If the line is busy, it acts as though a collision has occurred and uses the back off procedure



c. p-persistent

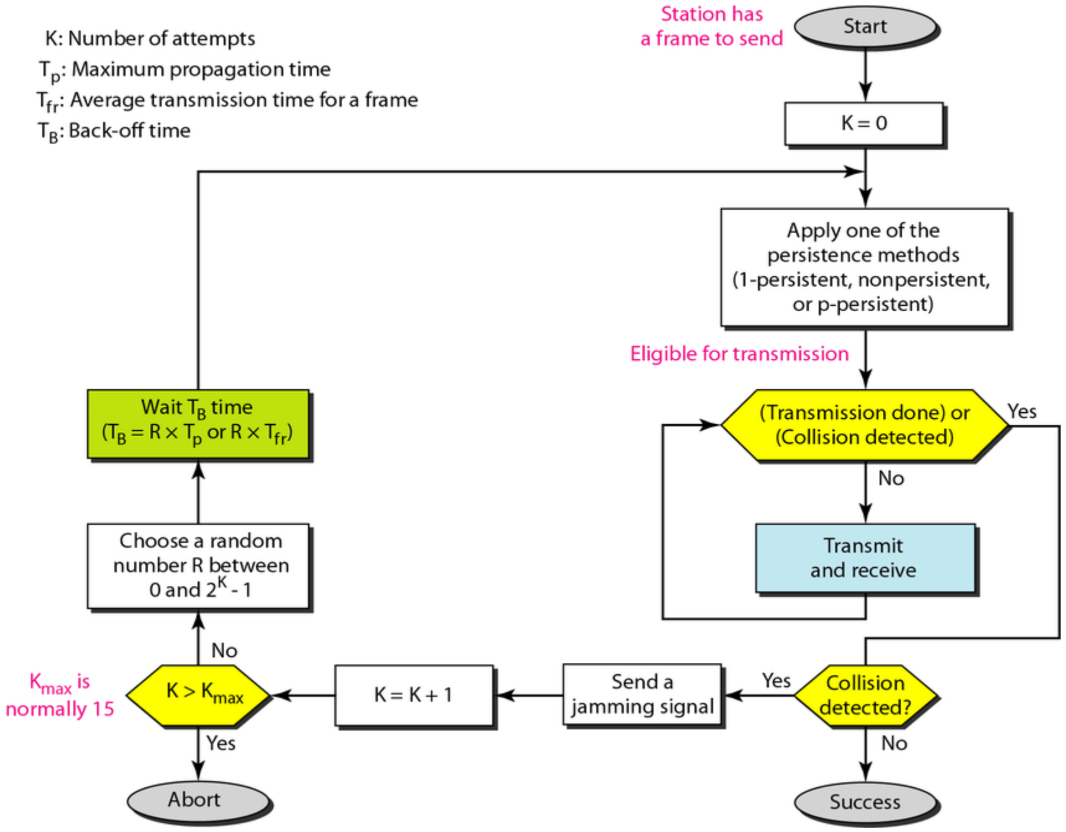
Multiple Access →Random Access →CSMA/CD

- CSMA/CD (Carrier Sense Multiple Access/ Collision Detection) is a media-access control method
- CSMA/CD is one such technique where different stations agree on some terms and collision detection measures
- This protocol decides which station will transmit so that data reaches the destination without corruption

Multiple Access →Random Access →CSMA/CD

- Step 1:
  - Check if the sender is ready for transmitting data packets
- Step 2:
  - Sender has to keep on checking if the transmission link is idle
  - Sender sends dummy data on the link. If it does not receive any collision signal, this means the link is idle, it sends the data otherwise not
- Step 3:
  - Sender transmits its data on the link., CSMA/CD does not use ‘acknowledgement’ system. It checks for the collision signals. During transmission, if collision signal is received, transmission is stopped. The station then transmits a jam signal onto the link and waits for random time interval before it resends the frame. After some random time, it again attempts to transfer the data and repeats above process.
- Step 4:
  - If no collision was detected in propagation, the sender completes its frame transmission

Multiple Access →Random Access →CSMA/CD



Multiple Access →Random Access →CSMA/CD

- How a station knows if its data collides?
  - Consider the situation for two stations, A and B
  - Propagation Time: T_p = 1 hr
  - At time t = 0, A transmits its data
  - At t = 30 mins.: Collision occurs
  - After collision occurs, a collision signal is generated and sent to both A & B to inform the stations about collision. Since the collision happened midway, the collision signal also takes 30 minutes to reach A & B
  - Therefore, t = 1 hr: A & B receive collision signals. This collision signal is received by all the stations on that link

Multiple Access →Random Access →CSMA/CD

- How a station knows if its data collides?
  - Consider another situation for two stations, A and B
  - At time t = 0, A transmits its data
  - At t = 59:59 mins: Collision occurs
  - This collision occurs just before the data reaches B. Now the collision signal takes 59:59 minutes again to reach A. Hence, A receives the collision information approximately after 2 hours, that is, after 2 * Tp
  - This is the maximum collision time that a system can take to detect if the collision was of its own data
  - Length of the packet = 2 * T_p * Bandwidth of the link

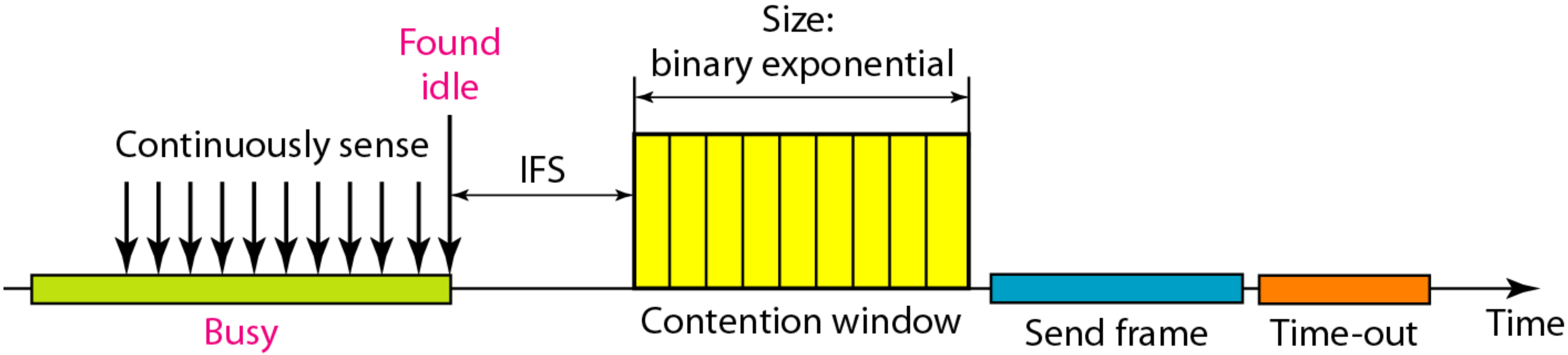
Multiple Access →Random Access →CSMA/CA

- Carrier Sense Multiple Access with Collision Avoidance (CSMA/CA)
- In contrast to CSMA/CD that deals with collisions after their occurrence, CSMA/CA prevents collisions prior to their occurrence
- The basic idea behind CSMA/CA is that the station should be able to receive while transmitting, to detect a collision from different stations
- In wired networks, if a collision has occurred then the energy of received signal almost doubles and the station can sense the possibility of collision
- In case of wireless networks, most of the energy is used for transmission and the energy of received signal increases by only 5 – 10 % if a collision occurs. It can't be used by the station to sense collision. Therefore CSMA/CA has been specially designed for wireless networks

Multiple Access →Random Access →CSMA/CA

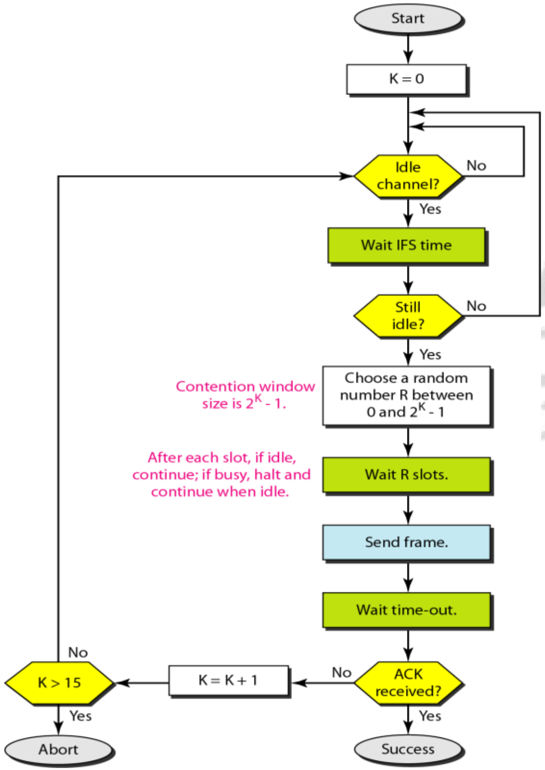
- These are three types of strategies:
  - Inter Frame Space (IFS):
    - The concept of an IFS allows wireless systems to implement a simple priority system. Systems with high priority data have shorter IFS times, so whenever the medium is clear they will be the first to send
  - Contention Window:
    - It is the amount of time divided into slots. A station which is ready to send frames chooses random number of slots as wait time
  - Acknowledgements:
    - The positive acknowledgements and time-out timer can guarantee a successful transmission of the frame

CSMA/CA



Size:
binary exponential
Found
idle
Continuously sense
IFS
Busy
Contention window
Send frame
Time-out
Time

CSMA/CA



Channel idle? Don't transmit yet!
Wait IFS time

Still idle after IFS? Don't transmit yet!
Now in Contention Window.
Choose random number and wait that many slots

CSMA/CA

- Algorithm for CSMA/CA
  - When a frame is ready, the transmitting station checks whether the channel is idle or busy
  - If the channel is busy, the station waits until the channel becomes idle
  - If the channel is idle, the station waits for an Inter-frame gap (IFG) amount of time and then sends the frame
  - After sending the frame, it sets a timer
  - The station then waits for acknowledgement from the receiver. If it receives the acknowledgement before expiry of timer, it marks a successful transmission
  - Otherwise, it waits for a back-off time period and restarts the algorithm

CSMA/CD - CA

- Eg:
  - 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,) is 25.6 μs, what is the minimum size of the frame?

Solution

$$\text{size of frame} = 2 * \text{propagation delay} * \text{bandwidth}$$

$$= 2 * (25.6 * 10^{-6}) * 10 * 10^{6}$$

$$= 512 \text{ bits or } 64 \text{ bytes}$$

CSMA/CD - CA

- Eg:
  - In a CSMA/CD, network running at 1 Gbps over 1 km cable with no repeaters, the signal speed in the cable is 200000 km/sec. What is minimum frame size?

Solution

Propagation delay (T_p) = Distance/Propagation speed

$= 1$ km / (200000 km/sec)

$= 0.5 * 10^{-5}$ sec

$= 5 * 10^{-6}$ sec

Frame size = 2 * Propagation delay * Bandwidth

$= 2 * 5 * 10^{-6} * 10^{9}$

= 10000 bits`

CSMA/CD - CA

- Eg:
  - A 2 km long broadcast LAN has 10^7 bps bandwidth and uses CSMA / CD. The signal travels along the wire at 2×10^8 m/sec. What is the minimum packet size that can be used on this network?

Solution

$$\text{Propagation delay } (T_p) = \text{Distance/Propagation speed}$$
$$= 2 \text{ km} / (2 * 10^8 \text{ m/sec})$$
$$= 10^{-5} \text{ sec}$$
$$\text{Frame size} = 2 * \text{Propagation delay} * \text{Bandwidth}$$
$$= 2 * 10^{-5} * 10^7$$
$$= 200 \text{ bits}$$

CSMA/CD - CA

- Eg:
  - A and B are the only two stations on Ethernet. Each has a steady queue of frames to send. Both A and B attempts to transmit a frame, collide and A wins first back off race. At the end of this successful transmission by A, both A and B attempt to transmit and collide. The probability that A wins the second back off race is ___ ?

CSMA/CD - CA

Solution

In 1st Transmission Attempt:

- Both the stations A and B attempts to transmit a frame
- collision occurs
- Back Off Algorithm runs
- Station A wins and successfully transmits its 1st data packet

In 2nd Transmission Attempt:

- Station A attempts to transmit its 2nd data packet
- Station B attempts to retransmit its 1st data packet
- collision occurs

CSMA/CD - CA

Solution

Now, We have to find the probability of station A to transmit its 2nd data packet successfully after 2nd collision

After the 2nd collision,

At Station A:

2^{nd} data packet of station A undergoes collision for the 1st time

So, collision number for the 2^{nd} data packet of station A = 1

Now, station A randomly chooses a number from the range $[0, 2^1-1] = [0, 1]$

Then, station A waits for back off time and then attempts to retransmit its data packet

At Station B:

1^{st} data packet of station B undergoes collision for the 2nd time

So, collision number for the 1st data packet of station B = 2

Now, station B randomly chooses a number from the range $[0, 2^2-1] = [0, 3]$

Then, station B waits for back off time and then attempts to retransmit its data packet

CSMA/CD - CA

Solution

Following 8 cases are possible

From here,

Probability of A winning the 2nd back off race

= 5/8

= 0.625

Station A	Station B	Remark
0	0	Collision
0	1	A wins
0	2	A wins
0	3	A wins
1	0	B wins
1	1	Collision
1	2	A wins
1	3	A wins