Open system Interconnection (OSI)

DataLink Layer & Binary Exponential BackOff Algorithm

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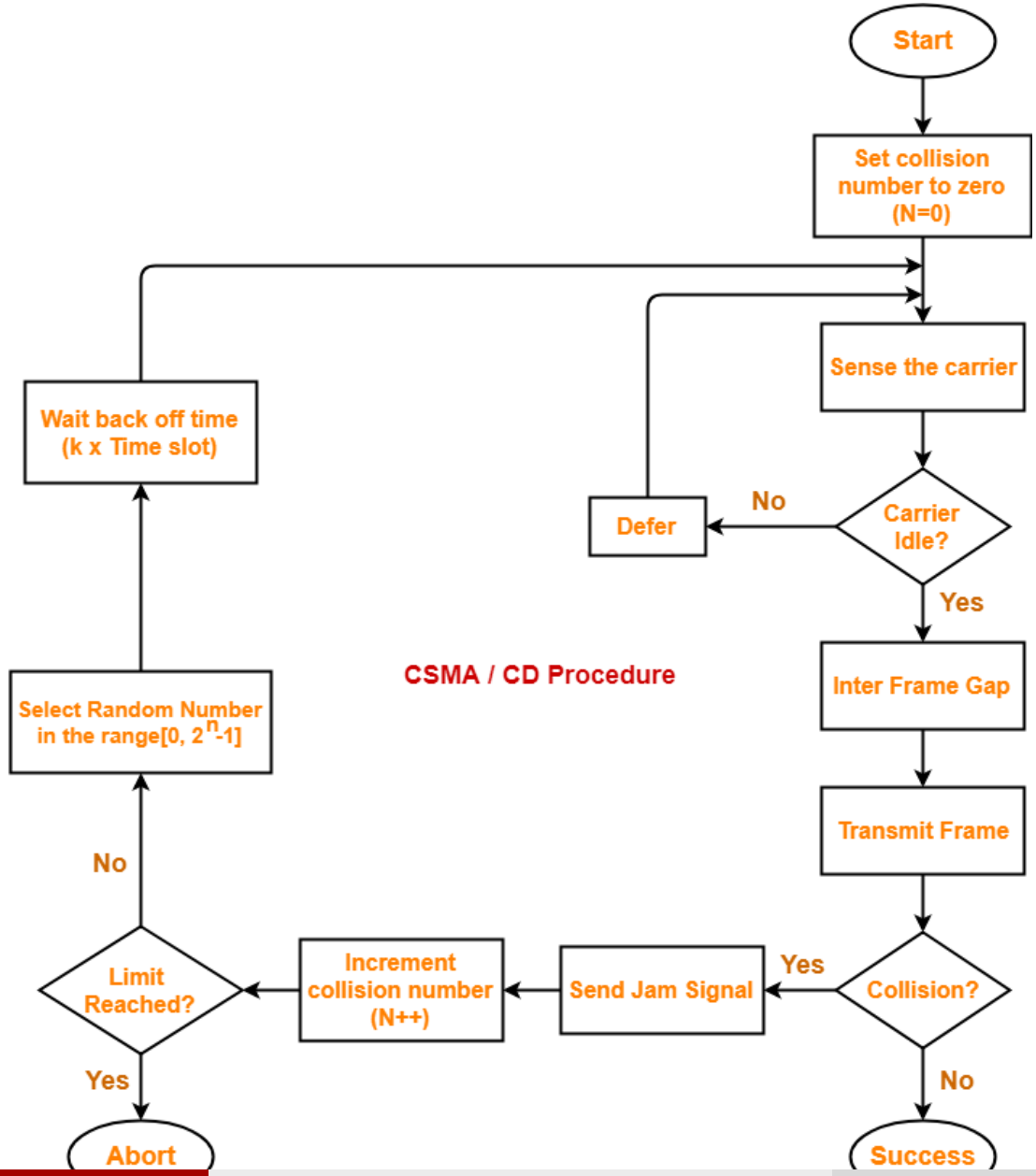
CSMA/CD

- We have discussed-
  - CSMA / CD stands for Carrier Sense Multiple Access / Collision Detection.
  - It allows the stations to sense the carrier and transmit data if the carrier is free.
- The following CSMA / CD flowchart shows the CSMA / CD procedure-

Binary Exponential BackOff Algorithm

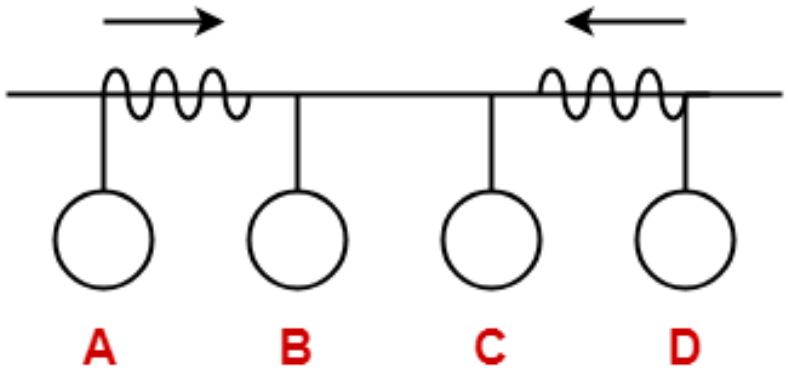


Binary Exponential BackOff Algorithm

- **Back Off Time: In CSMA / CD protocol**
  - After the occurrence of collision, station waits for some random back off time and then retransmits.
  - This waiting time for which the station waits before retransmitting the data is called as back off time.
  - Back Off Algorithm is used for calculating the back off time.
- **Back Off Algorithm: After undergoing the collision**
  - Transmitting station chooses a random number in the range [0, 2^n-1] if the packet is undergoing collision for the nth time.
  - If station chooses a number k, then-
    Back off time = k x Time slot
    where value of one time slot = 1 RTT

Example

- Consider the following scenario where stations A and D start transmitting their data simultaneously-



- For simplicity,
  We consider the value of time slot = 1 unit.
- Thus, back off time = K units.

Scene-01:

- For 1st Data Packet Of Both Stations-
  - Both the stations start transmitting their 1st data packet simultaneously.
  - This leads to a collision.
  - Clearly, the collision on both the packets is occurring for the 1st time.
  - So, collision number for the 1st data packet of both the stations = 1.
- **At Station A: After detecting the collision-**
  - Station A randomly chooses a number in the range $[0, 2^1\text{-}1] = [0,1]$.
  - If station A chooses the number K_A, then back off time = K_A units.
- **At Station D: After detecting the collision**
  - Station A randomly chooses a number in the range $[0, 2^1\text{-}1] = [0,1]$.
  - If station A chooses the number K_D, then back off time = K_D units.

Following 4 cases are possible

K_A	K_D	Remarks
0	0	• In this case, both the stations start retransmitting their data immediately. • This case leads to a collision again.
0	1	• In this case, station A starts retransmitting its data immediately while station D waits for 1 unit of time. • This case leads to A successfully retransmitting its data after the 1^{st} collision.
1	0	• In this case, station A waits for 1 unit of time while station D starts retransmitting its data immediately. • This case leads to D successfully retransmitting its data after the 1^{st} collision.
1	1	• In this case, both the stations wait for 1 unit of time and then starts retransmitting their data simultaneously. • This case leads to a collision again.

- From here,
  - Probability of station A to successfully retransmit its data after the 1st collision $= 1 / 4$
  - Probability of station D to successfully retransmit its data after the 1st collision $= 1 / 4$
  - Probability of occurrence of collision again after the 1st collision $= 2 / 4 = 1 / 2$
- Now,
  - Consider case-02 occurs.
  - This causes station A to successfully retransmit its 1st packet after the 1st collision.

Scene-02

- **For 2nd Data Packet Of Station A And 1st Data Packet Of Station D**
  - Consider after some time,
  - Station A starts transmitting its 2nd data packet and station D starts retransmitting its 1st data packet simultaneously. This leads to a collision.
- **At Station A-**
  - The 2nd data packet of station A undergoes collision for the 1st time.
  - So, collision number for the 2nd data packet of station A = 1.
  - Now, station A randomly chooses a number in the range [0, 21-1] = [0,1].
  - If station A chooses the number KA, then back off time = KA units.

- **At Station D-**
  - The 1st data packet of station D undergoes collision for the 2nd time.
  - So, collision number for the 1st data packet of station D = 2.
  - Now, station D randomly chooses a number in the range [0, 22-1] = [0,3].
  - If station D chooses the number KD, then back off time = KD units.
- Following 8 cases are possible

K_A	K_D	Remarks
0	0	• In this case, both the stations start retransmitting their data immediately. • This case leads to a collision again.
0	1	• In this case, station A starts retransmitting its data immediately while station D waits for 1 unit of time. • This case leads to A successfully retransmitting its data after the 2^{nd} collision.
0	2	• In this case, station A starts retransmitting its data immediately while station D waits for 2 unit of time. • This case leads to A successfully retransmitting its data after the 2^{nd} collision.

0	3	• In this case, station A starts retransmitting its data immediately while station D waits for 3 unit of time. • This case leads to A successfully retransmitting its data after the 2^{nd} collision.
1	0	• In this case, station A waits for 1 unit of time while station D starts retransmitting its data immediately. • This case leads to D successfully retransmitting its data after the 2^{nd} collision.
1	1	• In this case, both the stations wait for 1 unit of time and then starts retransmitting their data simultaneously. • This case leads to a collision again.
1	2	• In this case, station A waits for 1 unit of time while station D waits for 2 unit of time. • This case leads to A successfully retransmitting its data after the 2^{nd} collision.
1	3	• In this case, station A waits for 1 unit of time while station D waits for 3 unit of time. • This case leads to A successfully retransmitting its data after the 2^{nd} collision.

- From here,
  - Probability of station A to successfully retransmit its data after the 2nd collision = 5 / 8
  - Probability of station D to successfully retransmit its data after the 2nd collision = 1 / 8
  - Probability of occurrence of collision again after the 2nd collision = 2 / 8 = 1 / 4
- Now,
  - Consider case-03 occurs.
  - This causes station A to successfully retransmit its 2nd packet after the 2nd collision.

Scene-03

- For 3rd Data Packet Of Station A And 1st Data Packet Of Station D
  - Consider after some time,
  - Station A starts transmitting its 3rd data packet and station D starts retransmitting its 1st data packet simultaneously.
  - This leads to a collision.
- **At Station A-**
  - The 3rd data packet of station A undergoes collision for the 1st time.
  - So, collision number for the 3rd data packet of station A = 1.
  - Now, station A randomly chooses a number in the range $[0, 2^1\text{-}1] = [0,1]$.
  - If station A chooses the number K_A, then back off time = K_A unit.

- **At Station D-**
  - The 1st data packet of station D undergoes collision for the 3rd time.
  - So, collision number for the 1st data packet of station D = 3.
  - Now, station D randomly chooses a number in the range $[0, 2^3\text{-}1] = [0,7]$.
  - If station D chooses the number K_D, then back off time = K_D unit.
- Following 16 cases are possible-

K_A	K_D	Remarks
0	0	• In this case, both the stations start retransmitting their data immediately. • This case leads to a collision again.
0	1	• In this case, station A starts retransmitting its data immediately while station D waits for 1 unit of time. • This case leads to A successfully retransmitting its data after the 3rd collision.
0	2	• In this case, station A starts retransmitting its data immediately while station D waits for 2 unit of time. • This case leads to A successfully retransmitting its data after the 3rd collision.

0	3	• In this case, station A starts retransmitting its data immediately while station D waits for 3 unit of time. • This case leads to A successfully retransmitting its data after the 3rd collision.
0	4	• In this case, station A starts retransmitting its data immediately while station D waits for 4 unit of time. • This case leads to A successfully retransmitting its data after the 3rd collision.
0	5	• In this case, station A starts retransmitting its data immediately while station D waits for 5 unit of time. • This case leads to A successfully retransmitting its data after the 3rd collision.
0	6	• In this case, station A starts retransmitting its data immediately while station D waits for 6 unit of time. • This case leads to A successfully retransmitting its data after the 3rd collision.

0	7	• In this case, station A starts retransmitting its data immediately while station D waits for 7 unit of time. • This case leads to A successfully retransmitting its data after the 3^{rd} collision.
1	0	• In this case, station A waits for 1 unit of time while station D starts retransmitting its data immediately. • This case leads to D successfully retransmitting its data after the 3^{rd} collision.
1	1	• In this case, both the stations wait for 1 unit of time and then starts retransmitting their data simultaneously. • This case leads to a collision again.
1	2	• In this case, station A waits for 1 unit of time while station D waits for 2 unit of time. • This case leads to A successfully retransmitting its data after the 3^{rd} collision.

1	3	• In this case, station A waits for 1 unit of time while station D waits for 3 unit of time. • This case leads to A successfully retransmitting its data after the 3rd collision.
1	4	• In this case, station A waits for 1 unit of time while station D waits for 4 unit of time. • This case leads to A successfully retransmitting its data after the 3rd collision.
1	5	• In this case, station A waits for 1 unit of time while station D waits for 5 unit of time. • This case leads to A successfully retransmitting its data after the 3rd collision.
1	6	• In this case, station A waits for 1 unit of time while station D waits for 6 unit of time. • This case leads to A successfully retransmitting its data after the 3rd collision.

1	3	• In this case, station A waits for 1 unit of time while station D waits for 3 unit of time. • This case leads to A successfully retransmitting its data after the 3rd collision.
1	4	• In this case, station A waits for 1 unit of time while station D waits for 4 unit of time. • This case leads to A successfully retransmitting its data after the 3rd collision.
1	5	• In this case, station A waits for 1 unit of time while station D waits for 5 unit of time. • This case leads to A successfully retransmitting its data after the 3rd collision.
1	6	• In this case, station A waits for 1 unit of time while station D waits for 6 unit of time. • This case leads to A successfully retransmitting its data after the 3rd collision.

1	7	• In this case, station A waits for 1 unit of time while station D waits for 7 unit of time. • This case leads to A successfully retransmitting its data after the 3rd collision.

- From here,
  - Probability of station A to successfully retransmit its data after the 3rd collision = 13 / 16
  - Probability of station D to successfully retransmit its data after the 3rd collision = 1 / 16
  - Probability of occurrence of collision again after the 3rd collision = 1 / 16
- In the similar manner, the procedure continues.

Important Notes:

- **Note-1: With each successive collision-**
  - Back off time increases exponentially.
  - Collision probability decreases exponentially.
- **Note-02:Back Off Algorithm is also known as Binary Exponential Back Off Algorithm because-**
  - It works for only two stations.
  - The back off time increases exponentially. Collision probability decreases exponentially.
- **Note-03:**
  - One disadvantage of Back Off Algorithm is that it shows capture effect.
  - It means if a particular station wins the collision one time, then its probability of winning the successive collisions increases exponentially.

Thank You