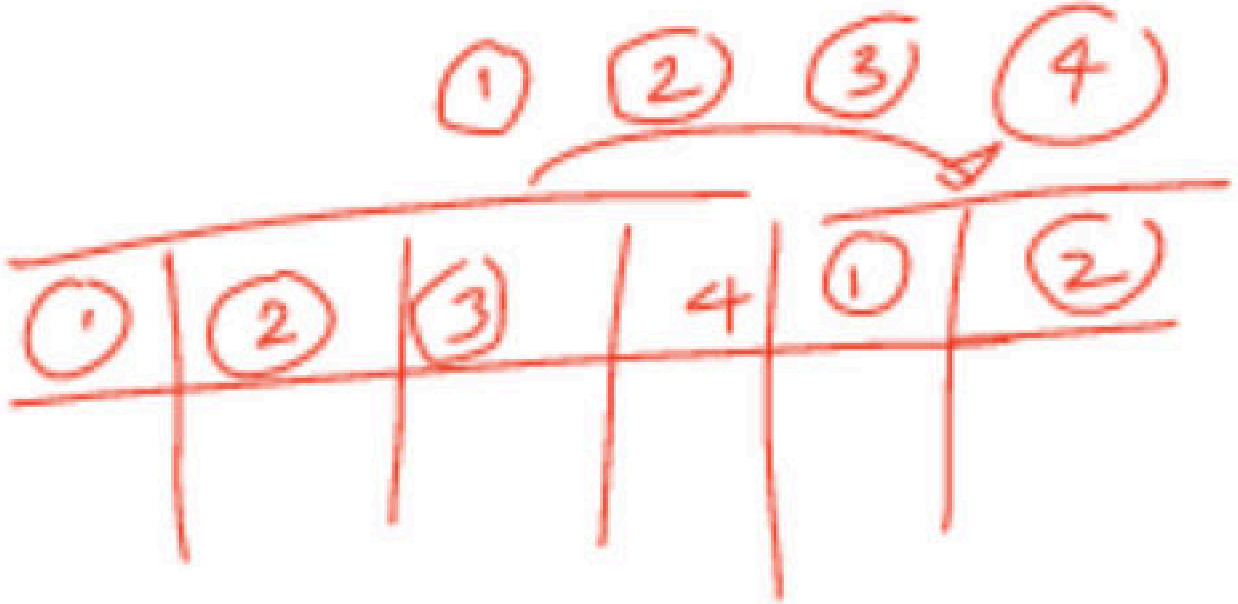
TCP/IP Problems

Complete Course on Computer Networks - Part I

Ravindrababu RAVULA • Lesson 22 • Feb 10, 2021

Access Control Methods



1.)Time Division Multiplexing-

In Time Division Multiplexing (TDM),

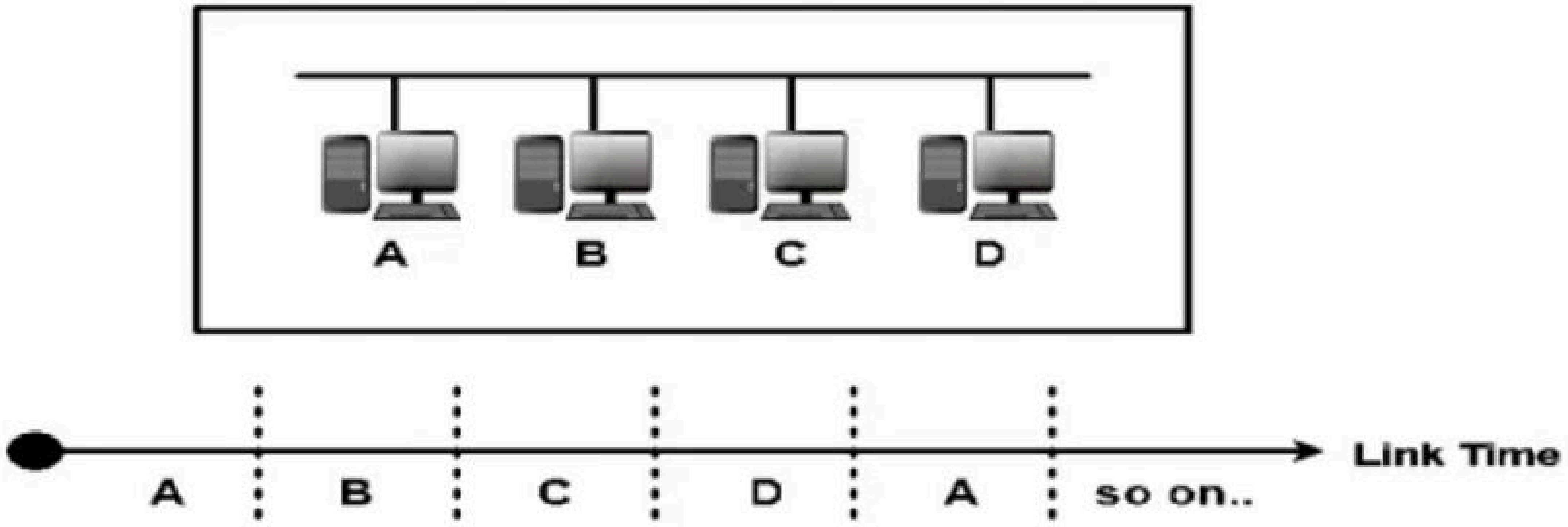
- Time of the link is divided into fixed size intervals called as **time slots** or **time slices**.
- Time slots are allocated to the stations in **Round Robin** manner.
- Each station transmit its data during the time slot allocated to it.
- In case, station does not have any data to send, its time slot goes waste. dis

Simple. No coll.

many station × data

90% → data

10% → data



Time Division Multiplexing

Slide - 1 minute

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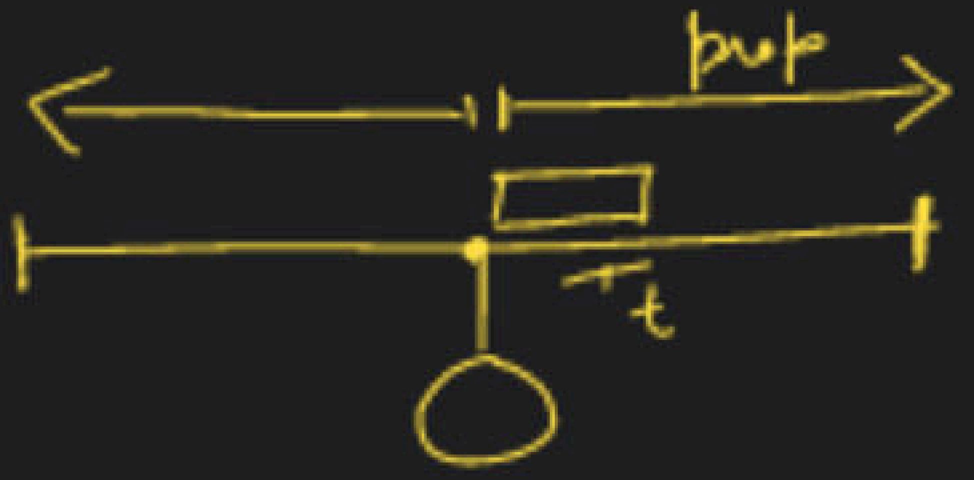
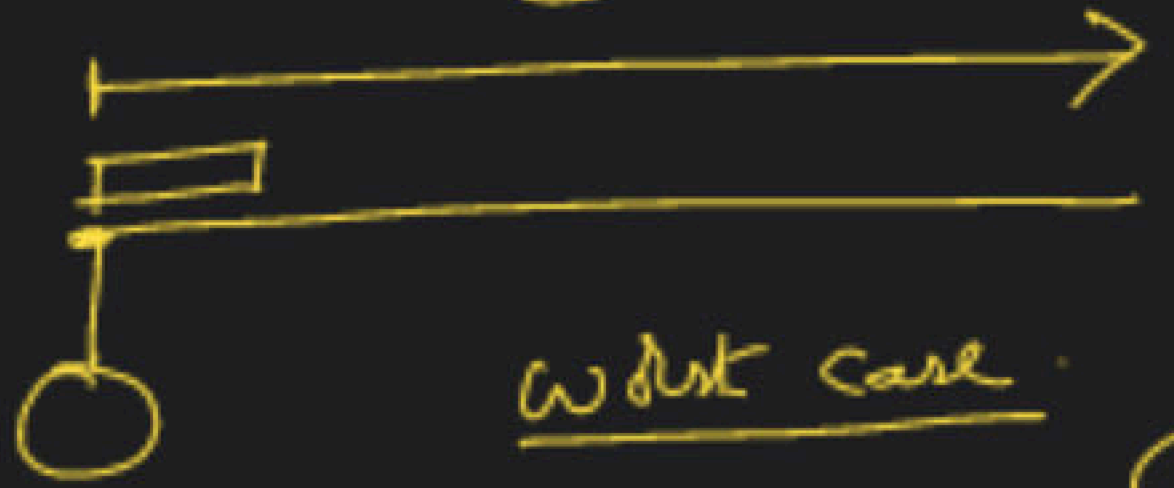




Worst case

1KB

4KB

① → Dont have data.

static

fixed

$T_{slot} = T_t + T_p$

→ Trans the data

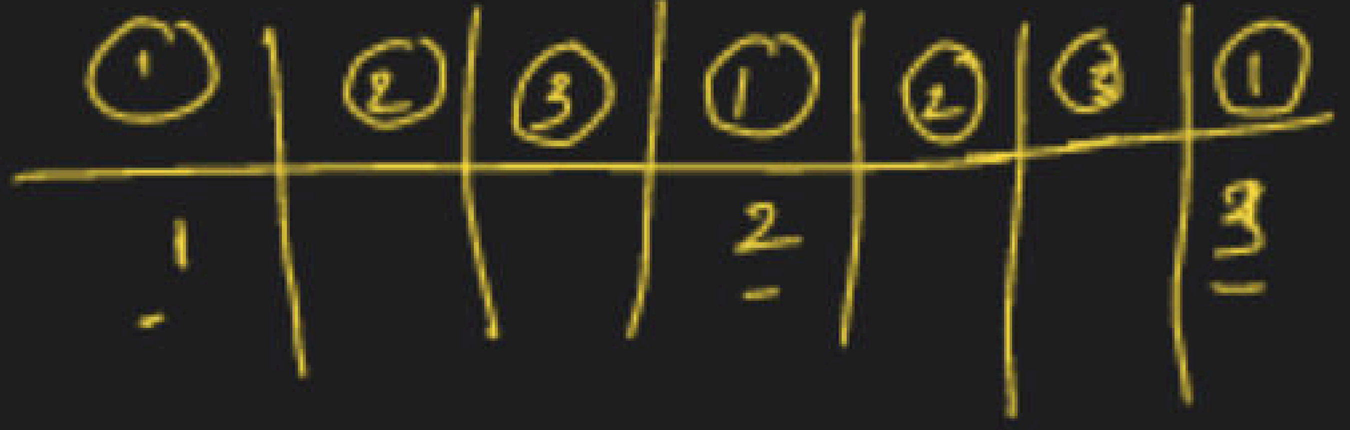
Assume → Same amount

64KB → divide 16 packets

max → NA

64KB

4KB



Size Of Time Slots-

The size of each time slot is kept such that each station gets sufficient time for the following tasks-

- To put its data packet on to the transmission link
- Last bit of the packet is able to get out of the transmission link

$$\text{Size of each time slot} = T_t + T_p$$

$T_t + T_p$

NOTE-

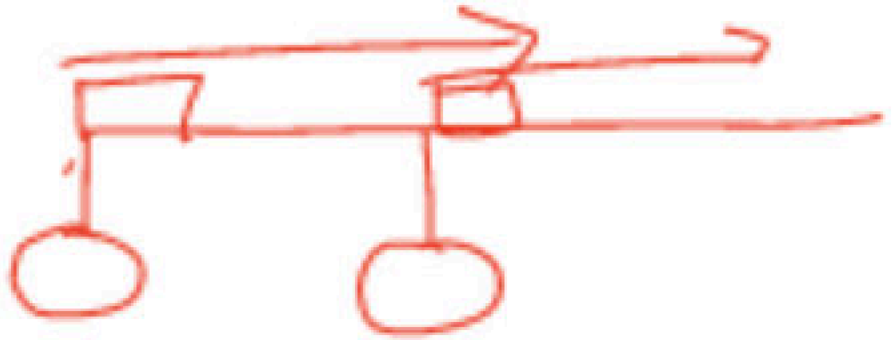
To keep the size of time slots constant,

- We have assumed that all the stations want to send the packets of same size.
- This keeps T_t constant for all the stations.
- We have considered the worst case when both the stations are present at the two extreme ends.
- This ensures T_p will be maximum and all the stations will get sufficient time to propagate their data.

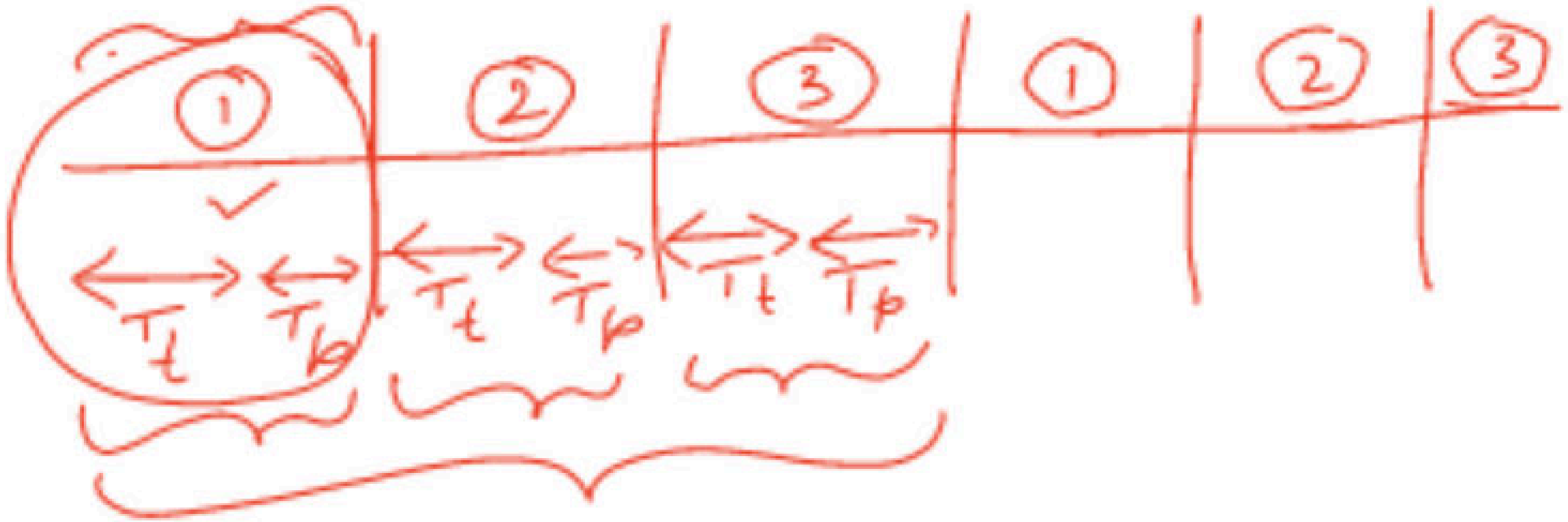
× brac

email, math, movie.

T_p.



$$T_t = \frac{L_{max}}{B} \quad T_p = \frac{d_{max}}{V}$$



Efficiency-

Efficiency (η) = Useful Time / Total Time

- Useful time = Transmission delay of data packet = T_t
- Useless time = Propagation delay of data packet = T_p

flow
acc

$$\text{Efficiency } (\eta) = \frac{T_t}{T_t + T_p}$$

OR

$$\text{Efficiency } (\eta) = \frac{1}{1 + a} \quad \text{where } a = \frac{T_p}{T_t}$$

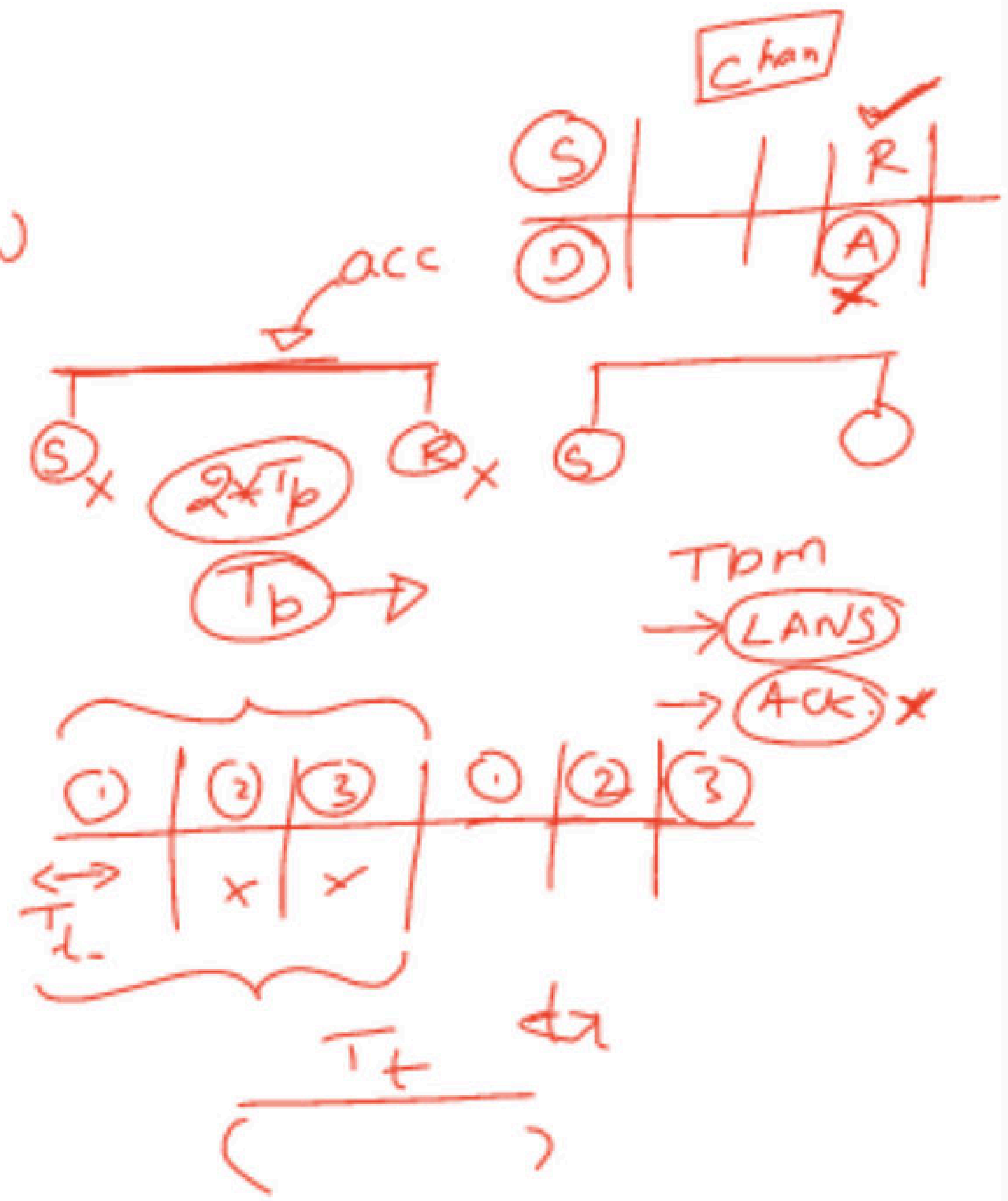
Important Formulas-

- Size of each time slot in Time Division Multiplexing = $T_t + T_p$
- Efficiency (η) = 1 / (1+a) where a = T_p / T_t
- Effective Bandwidth / Bandwidth Utilization / Throughput = Efficiency(η) x Bandwidth
- Maximum Available Effective Bandwidth = Total number of stations x Bandwidth requirement of 1 station

$\eta * BW$

Disadvantage-

- If any station does not have the data to send during its time slot, then its time slot goes waste.
- This reduces the efficiency.
- This time slot could have been allotted to some other station willing to send data.



Problem-

If transmission delay and propagation delay of a packet in Time Division Multiplexing is 1 msec each at 4 Mbps bandwidth, then-

1. Find the efficiency.
2. Find the effective bandwidth.
3. How many maximum stations can be connected to the network if each station requires 2 Kbps bandwidth?

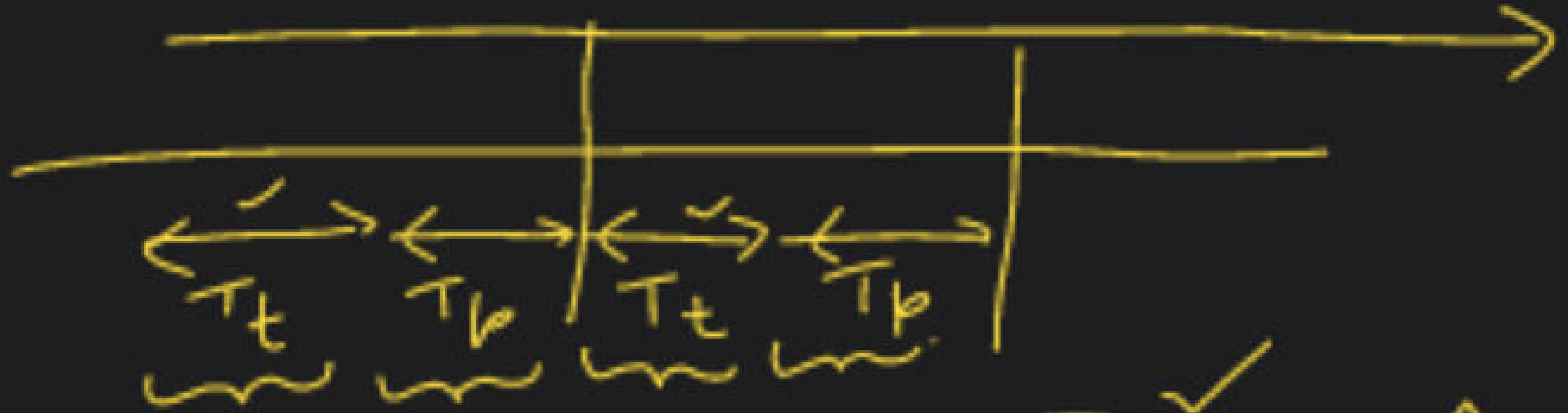
Solution-

Given-

- Transmission delay (T_t) = 1msec
- Propagation delay (T_p) = 1msec
- Bandwidth = 4 Mbps

$T_t = T_p = 1ms \Rightarrow a = \frac{T_p}{T_t} = 1 \Rightarrow \eta = \frac{1}{1+a} = \frac{1}{1+1} = 50\%$

$Th = \eta * BW = \frac{1}{2} * 4\ mbps \Rightarrow 2\ mbps$



$2mbps = N * 2kbps$

$2 \times 10^6 = N \times 2 \times 10^3$

$\Rightarrow \boxed{N = 1000}$

For a TDM Network,

$$\text{Efficiency } (\eta) = 1 / 1+a \text{ where } a = T_p / T_t$$

Calculating Value Of ‘a’-

$a = T_p / T_t$
a = 1 msec / 1 msec
a = 1

Calculating Efficiency-

Efficiency (η)
= 1 / (1+a)
= 1 / (1 + 1)
= 1 / 2
= 0.5
= 50%

$$\text{Effective Bandwidth} = \text{Efficiency } (\eta) \times \text{Bandwidth}$$
$$= 0.5 \times 4 \text{ Mbps}$$
$$= 2 \text{ Mbps}$$

Maximum Effective Bandwidth=Total number of stations x Bandwidth requirement of 1 station

Let the total number of stations that can be connected be N.
Then, we have-

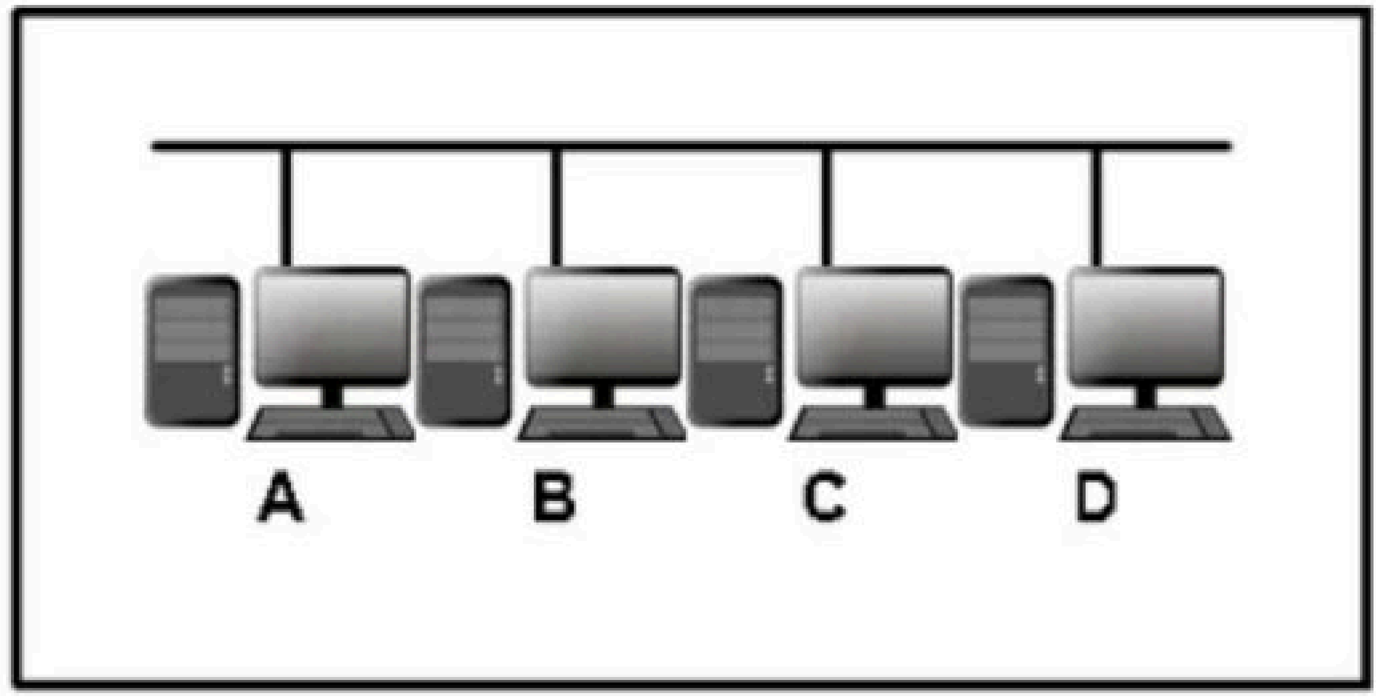
$$2 \text{ Mbps} = N \times 2 \text{ Kbps}$$
$$N = 1000$$

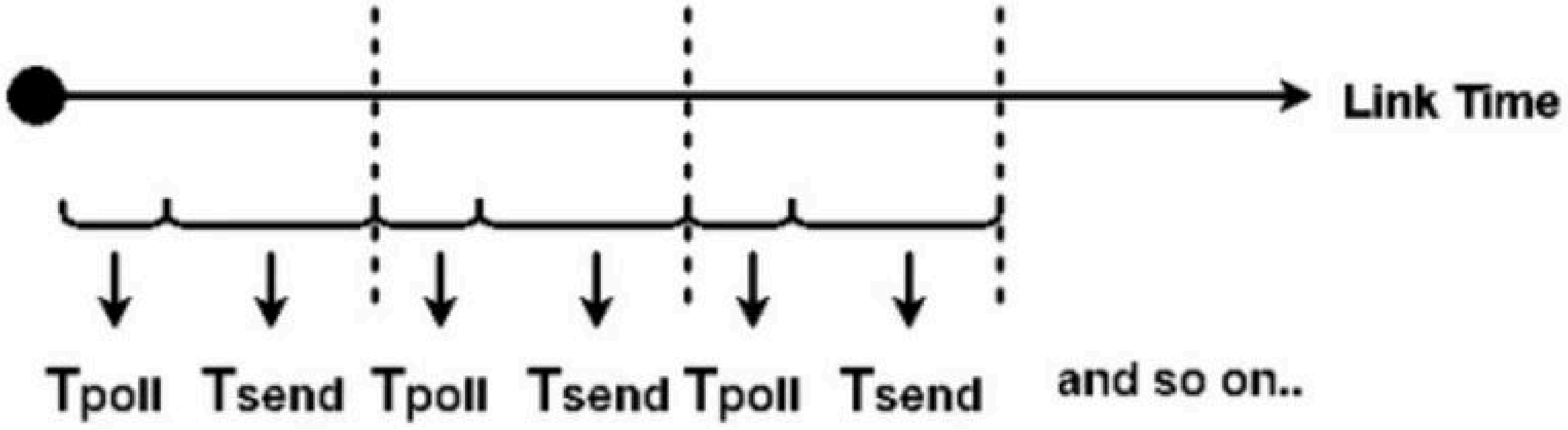
Thus, maximum 1000 stations can be connected.

2.)Polling-

In this access control method,

- A polling is conducted in which all the stations willing to send data participates.
- The polling algorithm chooses one of the stations to send the data.
- The chosen station sends the data to the destination.
- After the chosen station has sent the data, the cycle repeats.





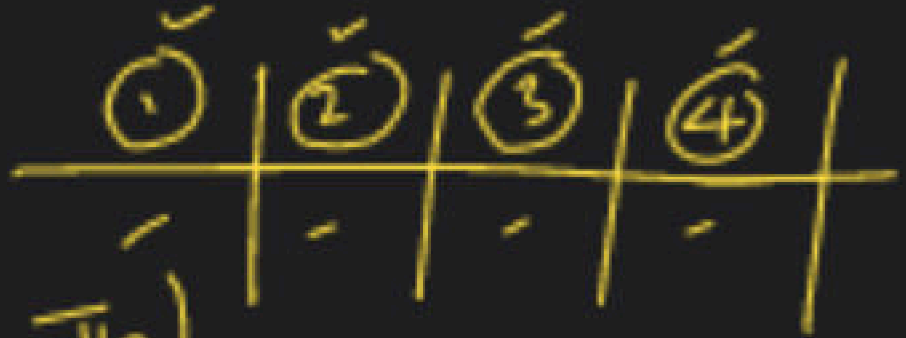
Polling Access Control Method

Here-

- T_{poll} = Time taken for polling
- T_{send} = Time taken for sending the data = Transmission delay + Propagation delay = $T_t + T_p$

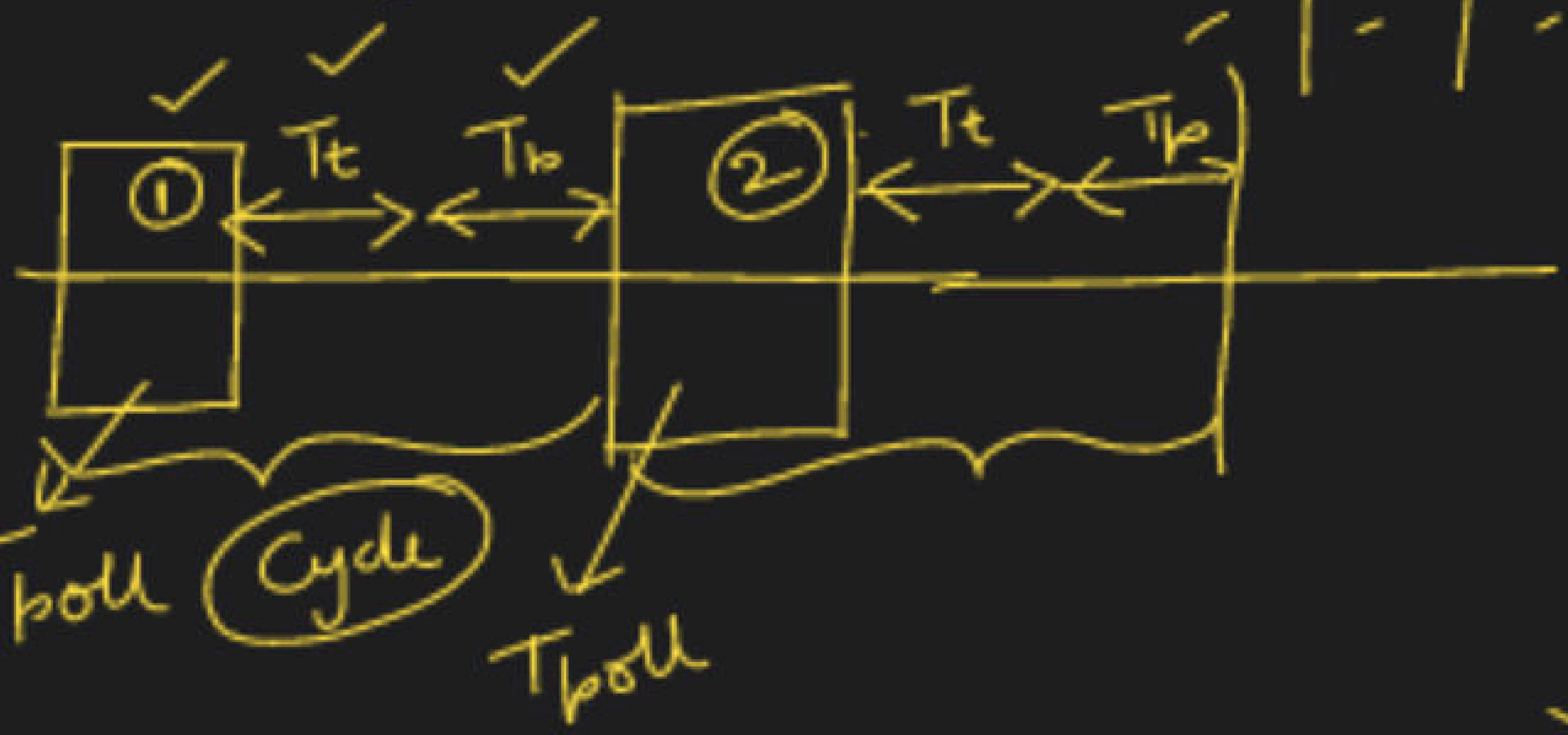
Polling:

TDM



90%

→ waste

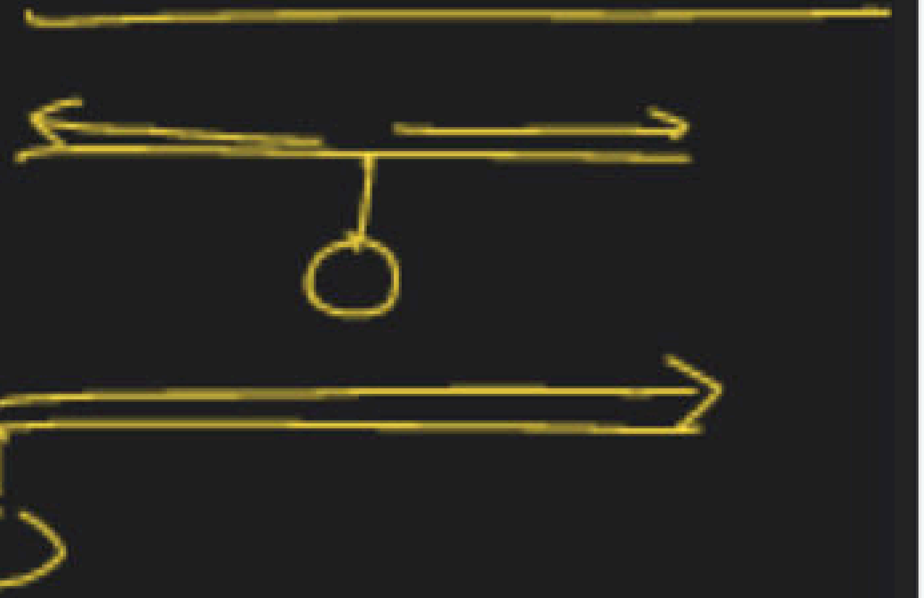


$$T_t = \frac{L}{B}$$

$$T_p = \frac{d_{max}}{V} = \frac{L_{max}}{B}$$

$$\eta = \frac{T_t}{T_t + T_p + T_{poll}}$$

$$\frac{1}{1+a}$$



Efficiency-

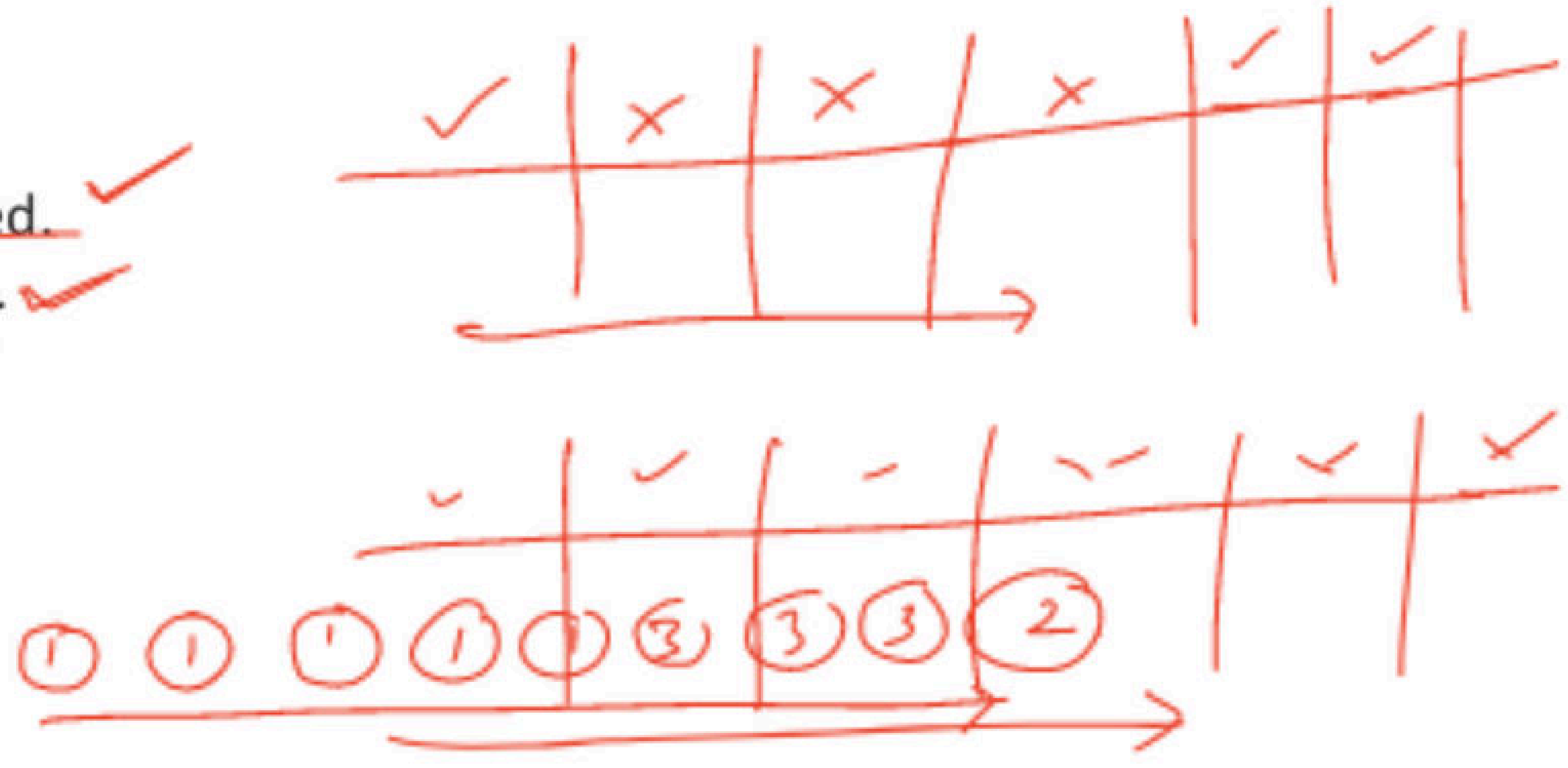
Efficiency (η) = Useful Time / Total Time

- Useful time = Transmission delay of data packet = T_t
- Useless time = Time wasted during polling + Propagation delay of data packet = $T_{poll} + T_p$

$$\boxed{\text{Efficiency } (\eta) = \frac{T_t}{T_{poll} + T_t + T_p}}$$

Advantages-

- Unlike in Time Division Multiplexing, no slot is ever wasted.
- It leads to maximum efficiency and bandwidth utilization.



Disadvantages-

- Time is wasted during polling.
- Link sharing is not fair since each station has the equal probability of winning in each round.
- Few stations might starve for sending the data.

Important Formulas-

- Efficiency (η) = $T_t / (T_{poll} + T_t + T_p)$
- Effective Bandwidth / Bandwidth Utilization / Throughput = Efficiency(η) x Bandwidth
- Maximum Available Effective Bandwidth = Total number of stations x Bandwidth requirement of 1 station

3.) CSMA / CD

CSMA / CD stands for Carrier Sense Multiple Access / Collision Detection.

This access control method works as follows-

Step-01: Sensing the Carrier-

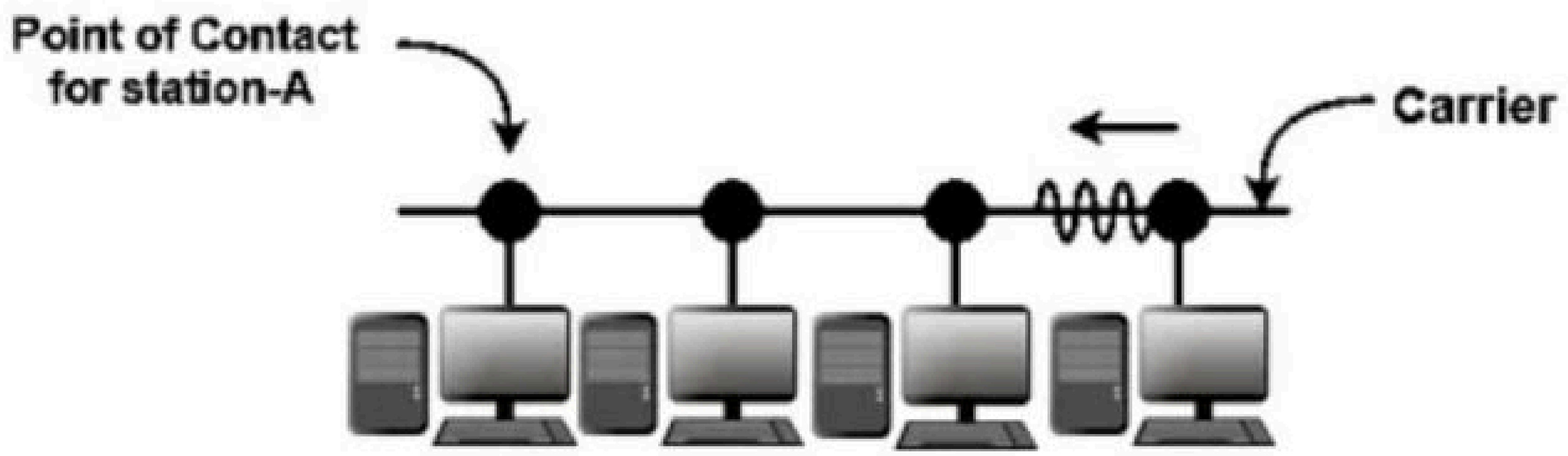
- Any station willing to transmit the data senses the carrier.
- If it finds the carrier free, it starts transmitting its data packet otherwise not.

How?

- Each station can sense the carrier only at its point of contact with the carrier.
- It is not possible for any station to sense the entire carrier.
- Thus, there is a huge possibility that a station might sense the carrier free even when it is actually not.

Example-

Consider the following scenario-



(Bus Topology)

At the current instance,
- If station A senses the carrier at its point of contact, then it will find the carrier free.
- But the carrier is actually not free because station D is already transmitting its data.
- If station A starts transmitting its data now, then it might lead to a collision with the data transmitted by station D.

Step-02: Detecting the Collision-

In CSMA / CD,

- It is the responsibility of the transmitting station to detect the collision.
- For detecting the collision, CSMA / CD implements the following condition.
- This condition is followed by each station-

Transmission delay >= 2 x Propagation delay

Meaning-

According to this condition,

- Each station must transmit the data packet of size whose transmission delay is at least twice its propagation delay.
- If the size of data packet is smaller, then collision detection would not be possible.

Length Of Data Packet-

We know-

- Transmission delay = Length of data packet (L) / Bandwidth (B)
- Propagation delay = Distance between the two stations (D) / Propagation speed (V)

Substituting values in the above condition, we get-

$$L / B >= 2 \times D / V$$

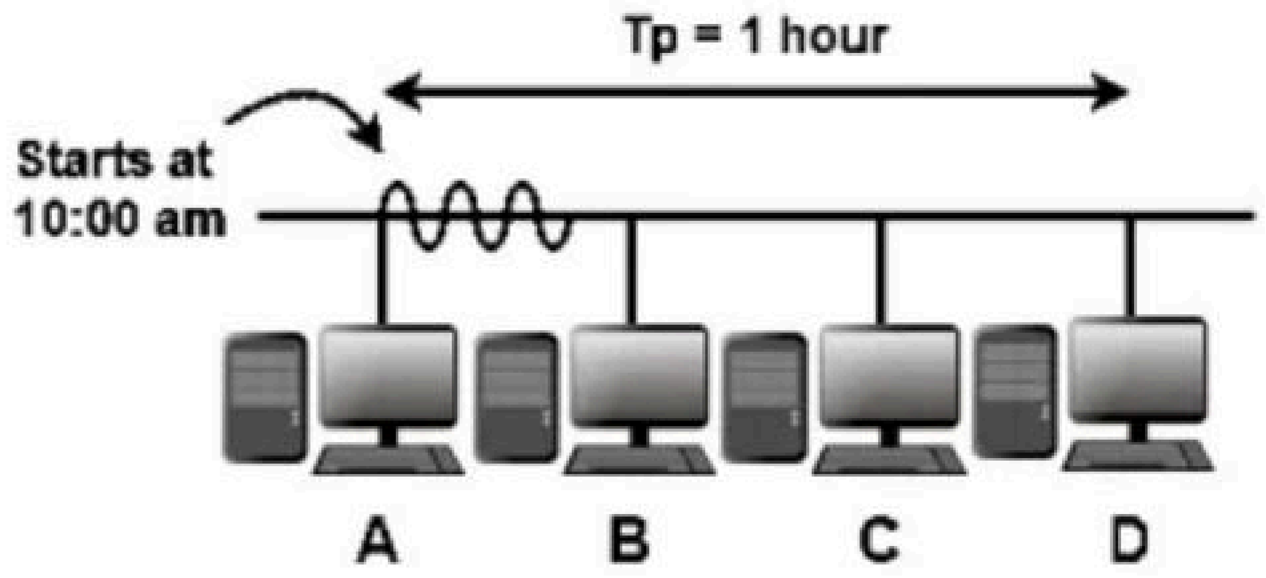
Thus,

$$L >= 2 \times B \times D / V$$

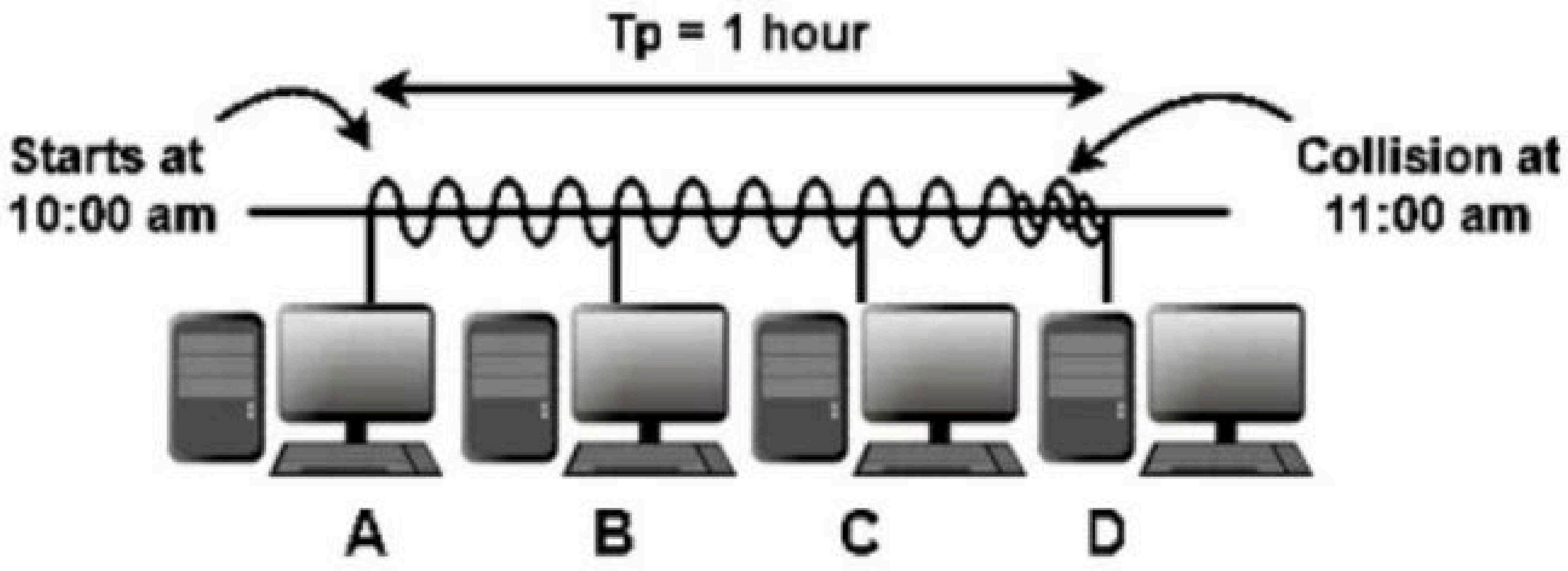
Understanding the Condition To Detect Collision With Example

- Consider at time 10:00 am, station A senses the carrier.
- It finds the carrier free and starts transmitting its data packet to station D.
- Let the propagation delay be 1 hour.

(We are considering station D for the worst case)



- Let us consider the scenario at time 10:59:59:59 when the packet is about to reach the station D.
- At this time, station D senses the carrier.
- It finds the carrier free and starts transmitting its data packet.
- Now, as soon as station D starts transmitting its data packet, a collision occurs with the data packet of station A at time 11:00 am.



- After collision occurs, the collided signal starts travelling in the backward direction.
- The collided signal takes 1 hour to reach the station A after the collision has occurred.
- For station A to detect the collided signal, it must be still transmitting the data.
- So, transmission delay of station A must be >= 1 hour + 1 hour >= 2 hours to detect the collision.
- That is why, for detecting the collision, condition is $T_t >= 2T_p$.

Two cases are possible-

Case-01:

If no collided signal comes back during the transmission,
- It indicates that no collision has occurred.
- The data packet is transmitted successfully.

Case-02:

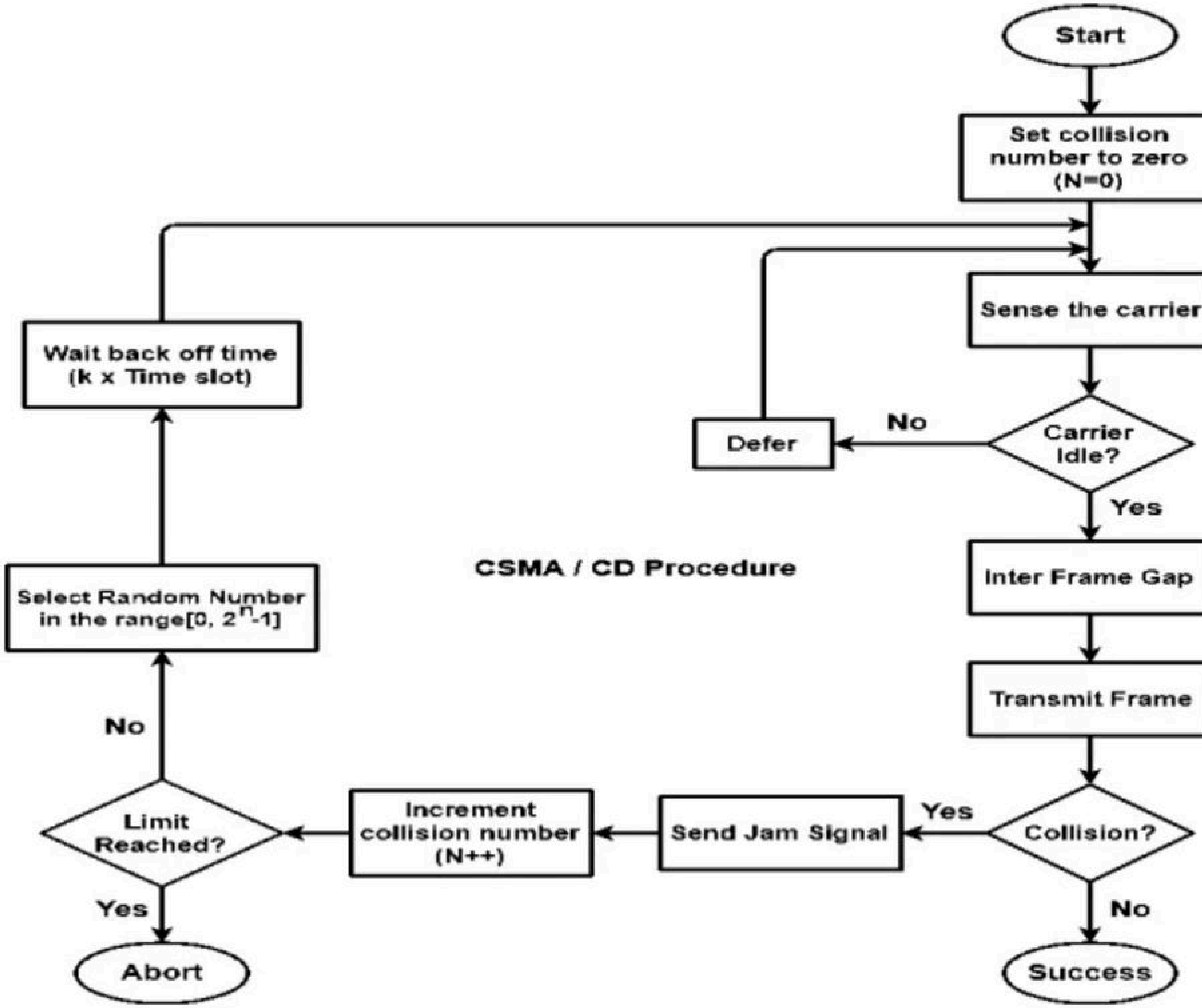
If the collided signal comes back during the transmission,
- It indicates that the collision has occurred.
- The data packet is not transmitted successfully.
- Step-03 is followed.

Step-03: Releasing Jam Signal-

- Jam signal is a 48 bit signal.
- It is released by the transmitting stations as soon as they detect a collision.
- It alerts the other stations not to transmit their data immediately after the collision.
- Otherwise, there is a possibility of collision again with the same data packet.
- Ethernet sends the jam signal at a frequency other than the frequency of data signals.
- This ensures that jam signal does not collide with the data signals undergone collision.

Step-04: Waiting For Back Off Time-

- After the collision, the transmitting station waits for some random amount of time called as **back off time**.
- After back off time, it tries transmitting the data packet again.
- If again the collision occurs, then station again waits for some random back off time and then tries again.
- The station keeps trying until the back off time reaches its limit.
- After the limit is reached, station aborts the transmission.
- Back off time is calculated using **Back Off Algorithm**.


Start
Set collision number to zero (N=0)
Sense the carrier
Carrier Idle?
No
Defer
Yes
Inter Frame Gap
Transmit Frame
Collision?
Yes
No
Success
Send Jam Signal
Increment collision number (N++)
Limit Reached?
Yes
Abort
No
Select Random Number in the range[0, 2^n-1]
Wait back off time (k x Time slot)
CSMA / CD Procedure

Efficiency (η) = Useful Time / Total Time

Before a successful transmission,
- There may occur many number of collisions.
- $2 \times T_p$ time is wasted during each collision.

Thus,
- Useful time = Transmission delay of data packet = T_t
- Useless time = Time wasted during collisions + Propagation delay of data packet = $c \times 2 \times T_p + T_p$
- Here, c = Number of contention slots / collision slots.

$$\boxed{\textbf{Efficiency } (\eta) = \frac{T_t}{c \times 2 \times T_p + T_t + T_p}}$$

Here,
- c is a variable.
- This is because number of collisions that might occur before a successful transmission are variable.

Probabilistic Analysis shows-

Average number of collisions before a successful transmission = e

$$\text{Efficiency } (\eta) = \frac{T_t}{e \times 2 \times T_p + T_t + T_p}$$

OR

$$\text{Efficiency } (\eta) = \frac{T_t}{T_t + 6.44 \times T_p}$$

OR

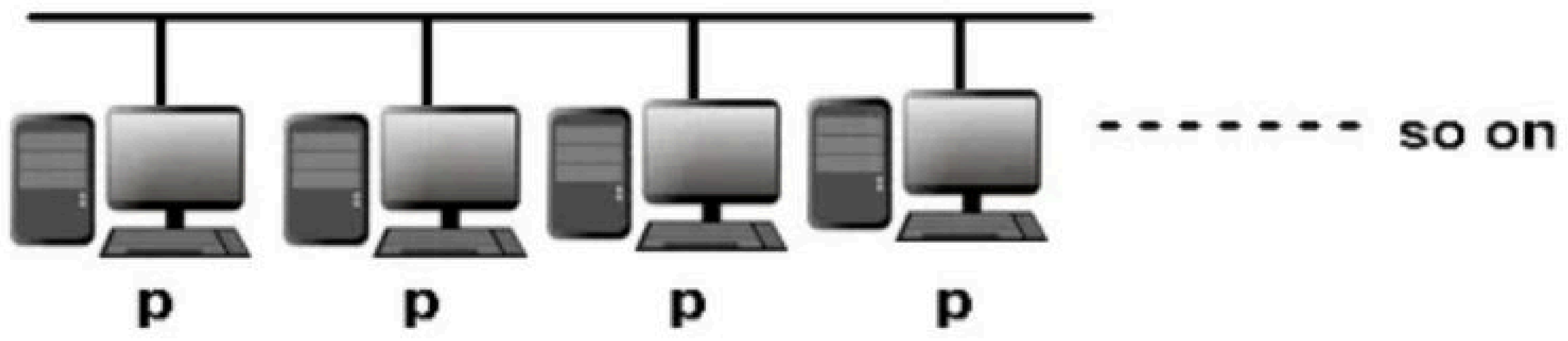
$$\text{Efficiency } (\eta) = \frac{1}{1 + 6.44 \times a} \text{, where } a = T_p / T_t$$

Probabilistic Analysis-

Let us perform the probabilistic analysis to find the average number of collisions before a successful transmission.

Consider-

- Number of stations connected to a CSMA / CD network = n
- Probability of each station to transmit the data = p



Transmission will be successful only when-

- One station transmits the data
- Other (n-1) stations do not transmit the data.

Thus, Probability of successful transmission is given by-

$$P_{\text{successful transmission}} = {}^{n}C_{1} \times p \times (1-p)^{n-1}$$

Now, let us find the maximum value of $P_{\text{successful transmission}}$.
For maximum value, we put-

$$\boxed{\frac{dP_{\text{successful transmission}}}{dp} = 0}$$

On solving,

At $p = 1/n$, we get the maximum value of $P_{\text{successful transmission}}$

Thus,
$(P_{\text{successful transmission}})_{max}$
$= {}^nC_1 \times 1/n \times (1 - 1/n)^{n-1}$
$= n \times 1/n \times (1 - 1/n)^{n-1}$
$= (1 - 1/n)^{n-1}$

$(P_{\text{successful transmission}})_{max} = (1 - 1/n)^{n-1}$

If there are sufficiently large number of stations i.e. $n \to \infty$, then we have-

$$\lim_{n\to\infty} \left(P_{\text{successful transmission}} \right)_{max} = \lim_{n\to\infty} \left(1 - \frac{1}{n}\right)^{n-1}$$

$$= \frac{1}{e}$$

Number of times a station must try before successfully transmitting the data packet
$= 1 / P_{max}$ (Using Poisson's distribution)
$= 1 / (1/e)$
$= e$

Average number of collisions that might occur before a successful transmission = e

Important Notes-

Note-01:

- CSMA / CD is used in wired LANs.
- CSMA / CD is standardized in IEEE 802.3

Note-02:

- CSMA / CD only minimizes the recovery time.
- It does not take any steps to prevent the collision until it has taken place.

Important Formulas-

- Condition to detect collision: Transmission delay >= 2 x Propagation delay
- Minimum length of data packets in CSMA / CD = 2 x Bandwidth x Distance / Speed
- Efficiency of CSMA / CD = 1 / (1 + 6.44 x a) where $a = T_p / T_t$
- Probability of successful transmission = ${}^{n}C_1 \times p \times (1-p)^{n-1}$
- Average number of collisions before a successful transmission = e

Back off algorithm for CSMA/CD

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-

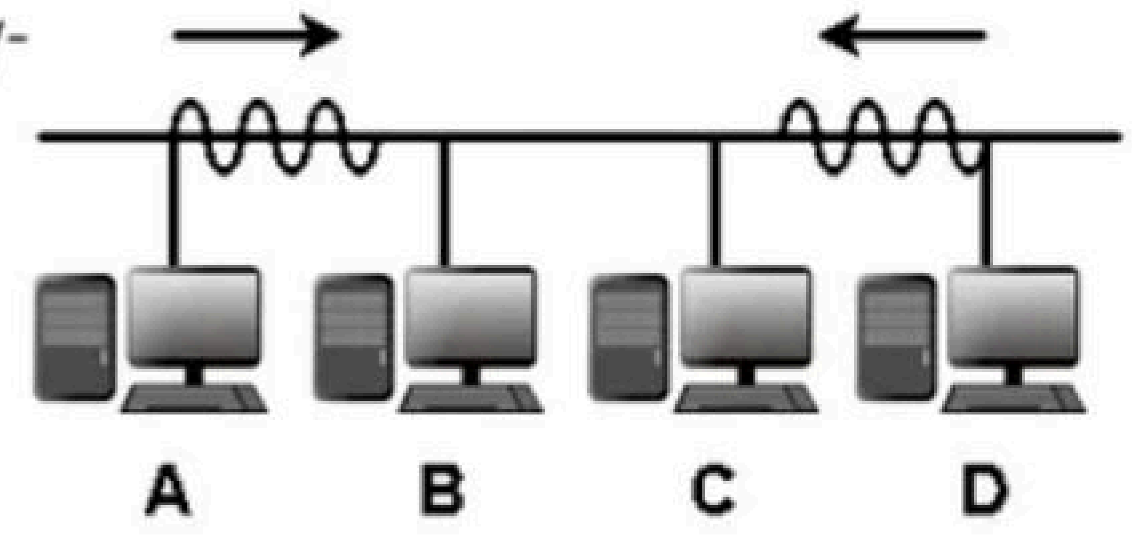
After undergoing the collision,

- Transmitting station chooses a random number in the range $[0, 2^n-1]$ if the packet is undergoing collision for the n^{th} time.
- If station chooses a number k, then-

Back off time = k x Time slot

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 $[0, 2^1-1]$ = $[0,1]$.

•If station A chooses the number K_A, then back off time = K_A units.

At Station D-

After detecting the collision,

•Station D randomly chooses a number in the range $[0, 2^1-1]$ = $[0,1]$.

•If station D chooses the number K_D, then back off time = K_D units.

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 1^{st} collision = 1 / 4
- Probability of station D to successfully retransmit its data after the 1^{st} collision = 1 / 4
- Probability of occurrence of collision again after the 1^{st} collision = 2 / 4 = 1 / 2

Now,
- Consider case-02 occurs.
- This causes station A to successfully retransmit its 1^{st} packet after the 1^{st} 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 2^{nd} data packet and station D starts retransmitting its 1^{st} 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 $[0, 2^1-1] = [0,1]$.
- If station A chooses the number K_A, then back off time = K_A 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 $[0, 2^2-1] = [0,3]$.
- If station D chooses the number K_D, then back off time = K_D units.

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 2nd 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 2nd 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 2nd 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 2nd 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 2nd 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 2nd collision.

From here,

- Probability of station A to successfully retransmit its data after the 2^{nd} collision = 5 / 8
- Probability of station D to successfully retransmit its data after the 2^{nd} collision = 1 / 8
- Probability of occurrence of collision again after the 2^{nd} collision = 2 / 8 = 1 / 4

Now,

- Consider case-03 occurs.
- This causes station A to successfully retransmit its 2^{nd} packet after the 2^{nd} 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 $[0, 2^1-1] = [0,1]$.
•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 $[0, 2^3-1] = [0,7]$.
•If station D chooses the number K_D, then back off time = K_D unit.

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 3rd 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 3rd 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 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.

Before discussing Token Passing, let us discuss few important concepts required for the discussion.

Time Conversions-

In token passing,

- Time may be expressed in seconds, bits or meters.
- To convert the time from one unit to another, we use the following conversion chart-