



Routing

Complete Course on Computer Networks - Part I

Computer Networks

Supernetting OR Aggregation

Sum
add
sum
All the Net's
, 8/12

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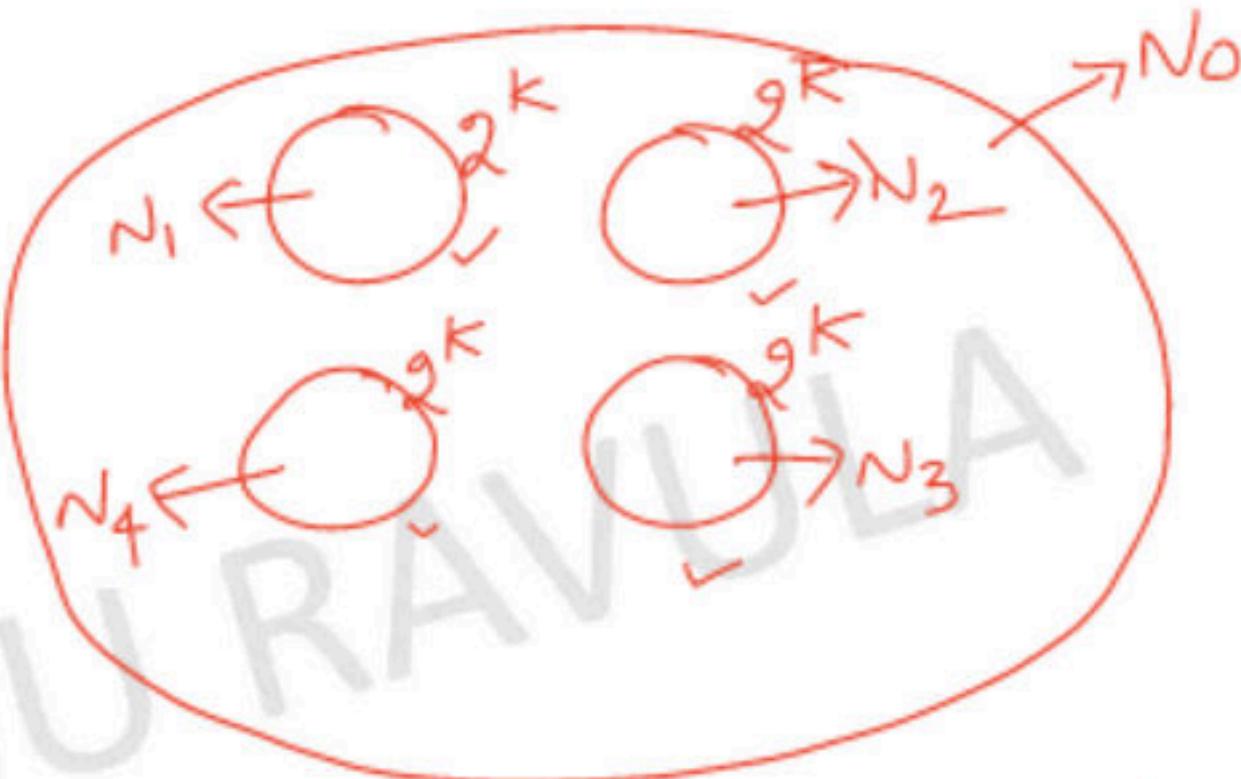
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In subnetting, a single network is divided into multiple smaller subnetworks.

In Supernetting/Aggregation, multiple networks are combined into a bigger network termed as a Super network or Supernet.

Rules for Aggregation :

1. All the Networks should be contiguous. ✓
 2. The block size of every networks should be equal and must be in form of 2^n .
 3. First Network id should be exactly divisible by whole size of supernet.



$$4 \times 2^k = 2^{k+2}$$

(0-127)
(128)

$$4 \times 2^k = 2^{k+2}$$

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200.1.0.0/24 A



200.1.0.0 ✓

200.1.0.1

2⁸

200.1.0.255

$$2^8 + 2^8 + 2^8 + 2^8 = 2^{10} \checkmark$$

200.1.1.0/24 B



200.1.1.0

200.1.1.1

2⁸

200.1.1.255

200.1.2.0/24 C

200.1.2.0

2⁸

200.1.2.255

200.1.0.0/2¹⁰ ✓

$$2^{10} \Rightarrow H^D = 10 \Rightarrow N^D = 2^2$$

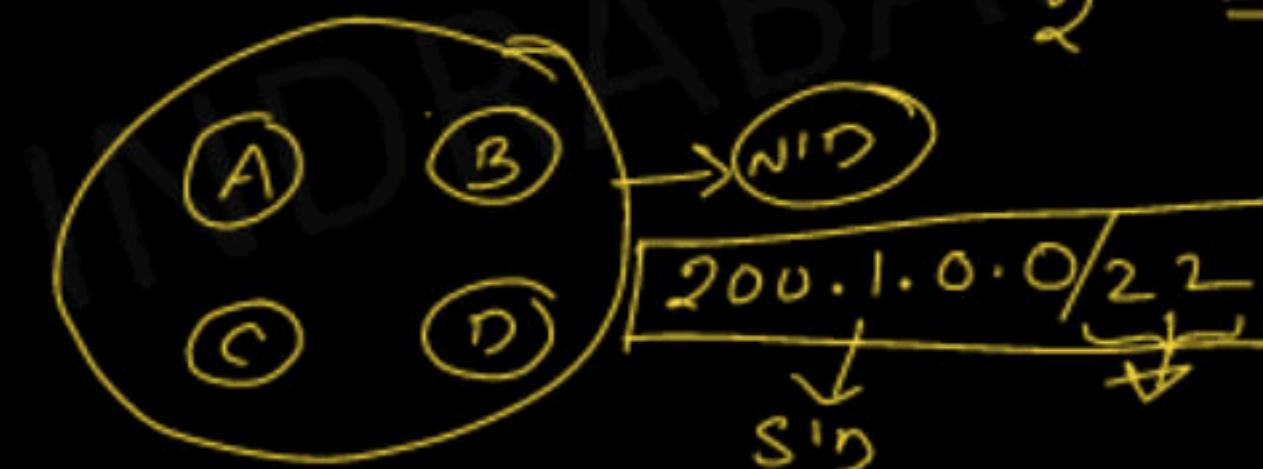
200.1.3.0/24 D

1

2⁸

200.1.3.255

2 ✓



Points to be checked before aggregation :

- 1. All the Networks should be contiguous.
- 2. The block size of every networks should be equal and must be in form of 2^n .
- 3. First Network id should be exactly divisible by whole size of supernet.

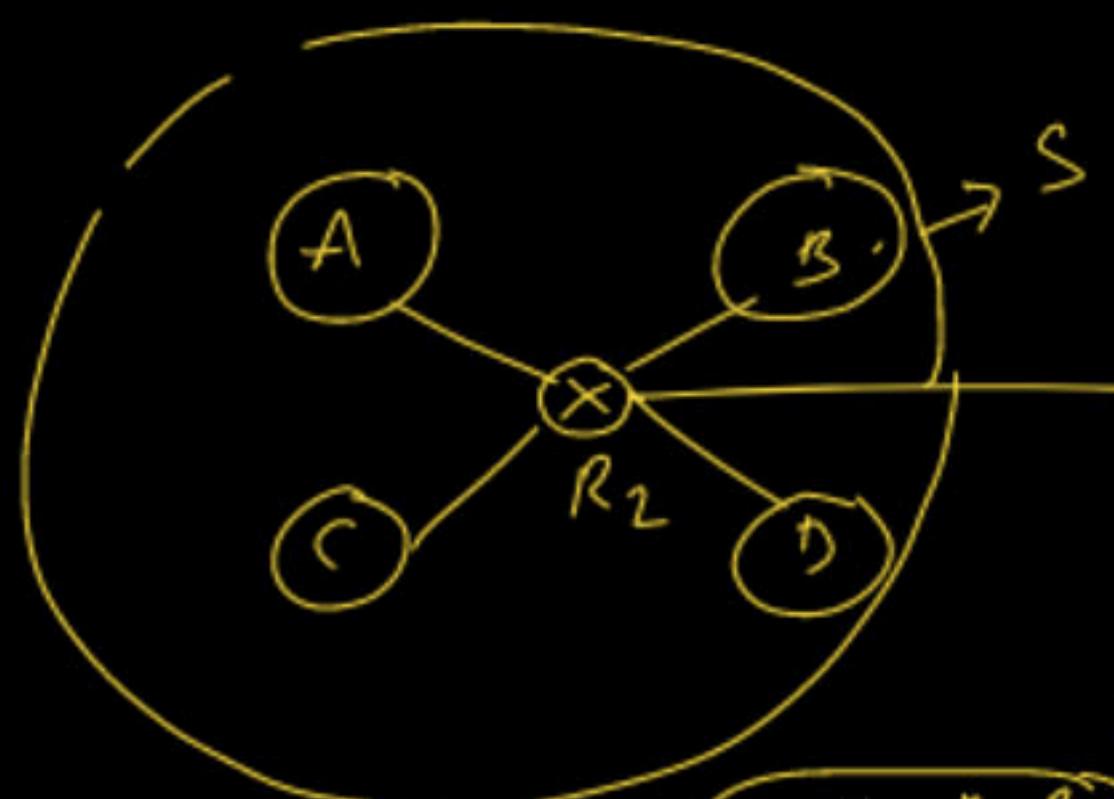
Example:

200.1.0.0 / 24
200.1.1.0 / 24
200.1.2.0 / 24
200.1.3.0 / 24

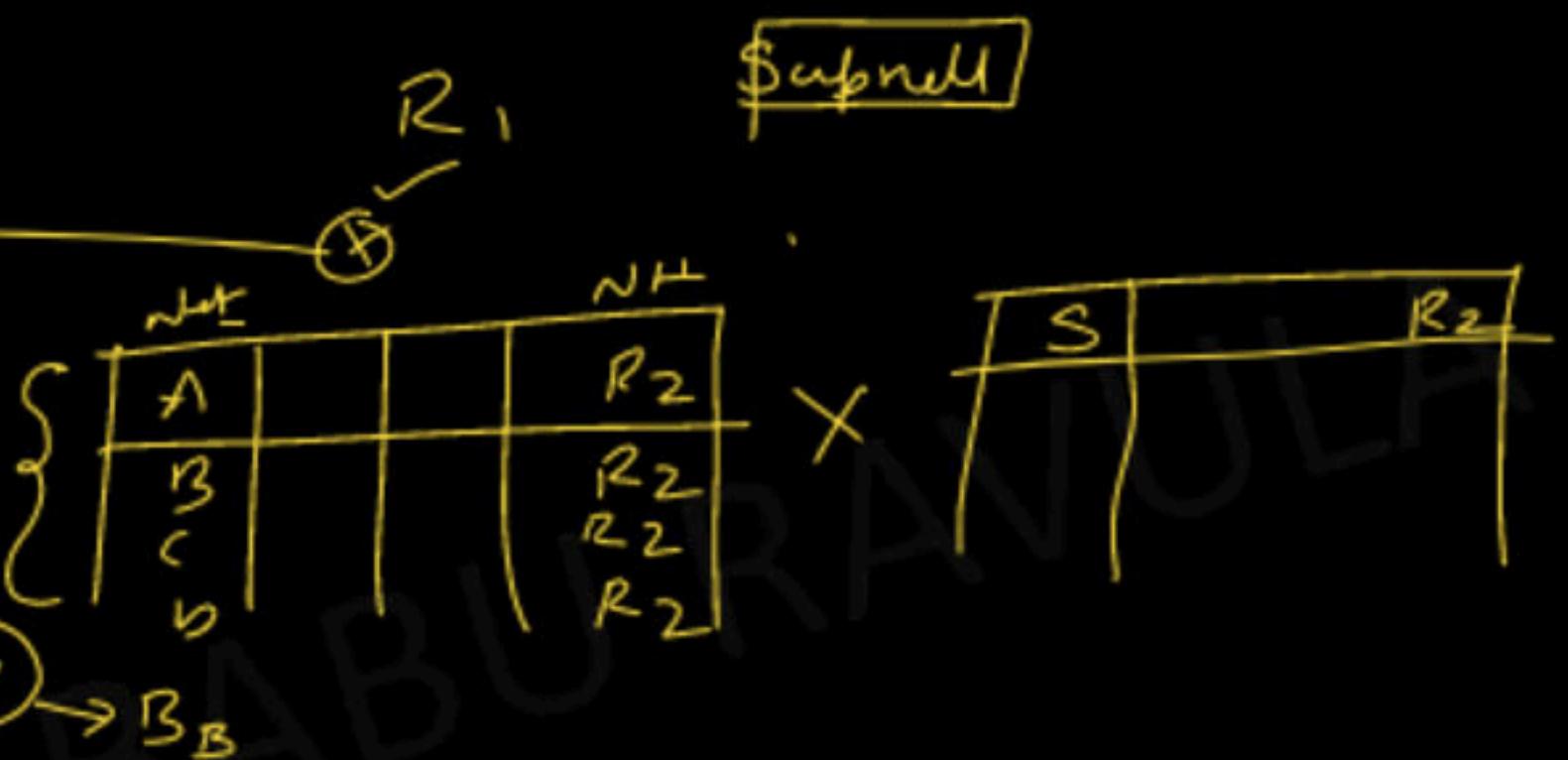
Supernet

Total size of the supernet = $4 \times 2^8 = 2^{10}$
Dividing the First Network id with 2^{10}
Has 0 in last 10 bits. Therefore Divisible.

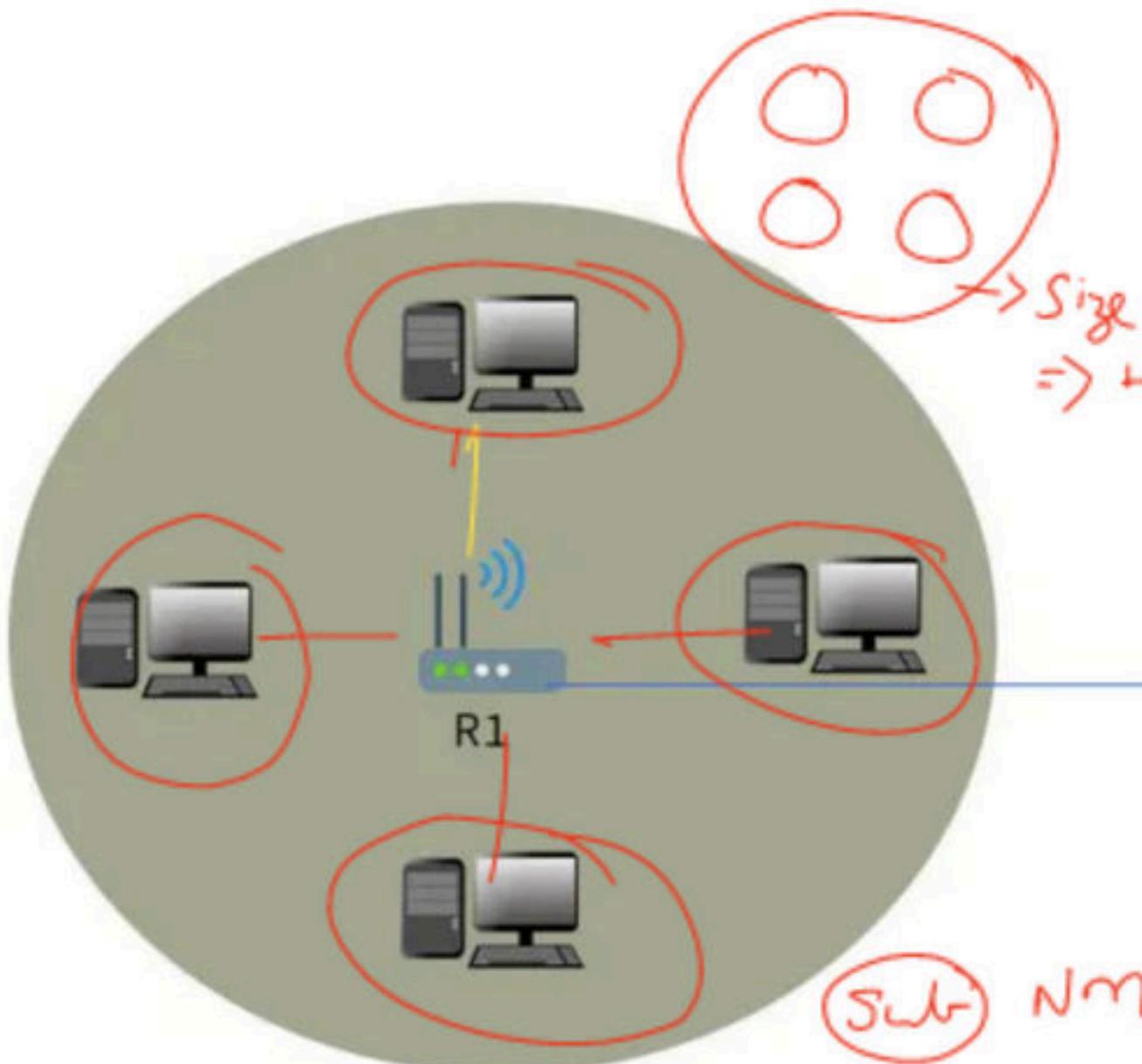
All are satisfied, hence we can move forward with aggregation.



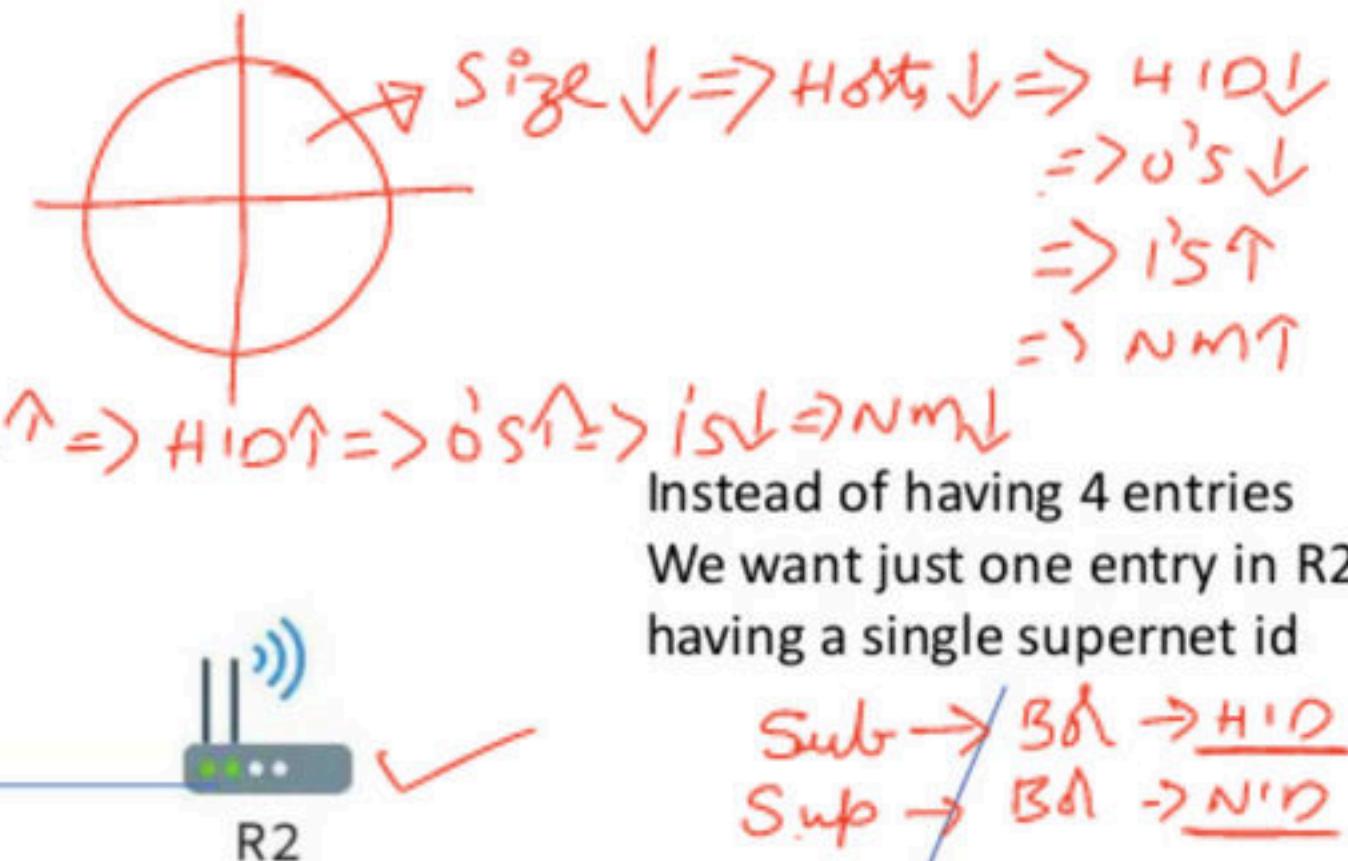
$B_1, B_2, B_3, B_4 \rightarrow B_B$



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a



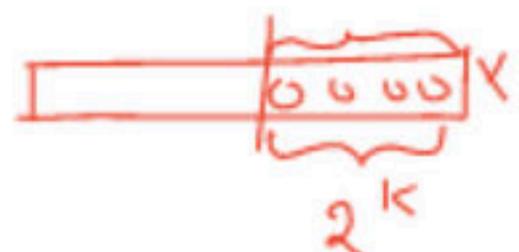
ROUTING TABLE AT R2

NETWORK ID	SUBNET MASK	INTERFACE
✓ 200.1.0.0	255.255.255.0	a
✓ 200.1.1.0	255.255.255.0	a
✓ 200.1.2.0	255.255.255.0	a
✓ 200.1.3.0	255.255.255.0	a

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Finding the Supernet mask:



$$\textcircled{1} \text{ Sm} \rightarrow \text{size} - \textcircled{k} \rightarrow \text{32} - \textcircled{k}$$

It is 32 bit number

In Supernetting, the Number of 1's represent the Fixed part
And Number of 0's represent the Variable part

200.1.00000000.00000000	{	⊕
200.1.00000001.00000000		
200.1.00000010.00000000		
200.1.00000011.00000000		

Fixed Variable
1's ✓ 0's ✓

Replacing the fixed part with 1's and variable with 0's
We get the supernet mask,

255.255.252.0

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Finding the Supernet mask:

It is 32 bit number

In Supernetting, the Number of 1's represent the Fixed part
And Number of 0's represent the Variable part

200.1.00000000.00000000	
200.1.00000001.00000000	
200.1.00000010.00000000	
200.1.00000011.00000000	

Fixed Variable

Replacing the fixed part with 1's and variable with 0's
We get the supernet mask,

255.255.252.0

SHORTCUT TO FIND THE SUPERNET ID AND SUPERNET MASK

If the network id's follow the Rules then,
The first IP address is always the Supernet id.

Add the network size of all the networks given
The total denotes the host if part of the subnet mask .

From the example:

$$\text{Network size of all} = 2^8 + 2^8 + 2^8 + 2^8 = 2^{10}$$

Therefore the subnet mask contains
10 bits in host id part.

And the network id part will contain 22 bits.

That is what is the subnet mask

10. 0. 0. 0 / 16
10. 1. 0. 0 / 16
10. 2. 0. 0 / 16
10. 3. 0. 0 / 16

①

$$2^{16} \times 4 = 2^{18} \Rightarrow 10 \cdot 0 \cdot 18 \Rightarrow \frac{10}{19}$$

10. 0. 0. 0 / 14

255. 252. 0. 0

Sub $\rightarrow 2^k$

2
4
8
16

①
②
③

✓
150. 0. 0. 0 / 24
150. 0. 1. 0 / 24
 $\rightarrow 150. 0. 2. 0 / 23$

2
24
24

150. 0. 0. 0 / 23
150. 0. 2. 0 / 23

150. 0. 0. 0 / 22

①

②

③

$$2^9 \times 2 - 2^{10} = 10 \Rightarrow NID = 22$$

150. 0. 0000000
23

NOT

$$\begin{array}{r} 0\ 0\ 0\ 0\ 0\ 0\ 0 \\ 0\ 1\ 1\ 1\ 1\ 1\ 1 \\ \hline 0\ 0\ 0\ 0\ 0\ 0 \end{array} - 150. 0. 0. 0$$

$$- 150. 0. 0. 255$$

$$- 150. 0. 1. 0$$

$$- 150. 0. 1. 255$$

100. 1. 2. 3 / 24 X

100. 1. 3. 4 / 24

100. 1. 4. 5 / 24

100. 1. 5. 5 / 24

100. 1. 2. 0 - 100. 1. 2. 255

100. 1. 3. 0 - 100. 1. 3. 255

100. 1. 4. 0 - 100. 1. 4. 255

100. 1. 5. 0 - 100. 1. 5. 255

X Con ①

Sum X

$$② \rightarrow 2^8 \times 4 = 2^{10}$$

$$③ \quad 100. 1. 0000000 | 0. 00000000$$

$$\begin{array}{r} 8-9 \\ \hline [8 \text{ am} - 9 \text{ am}] \\ \downarrow \\ [\text{Special}] \end{array}$$

OS → Monday → 8:00 am Not divisible

8th → Reddy
↳ [6 pm - 9 pm] ✓

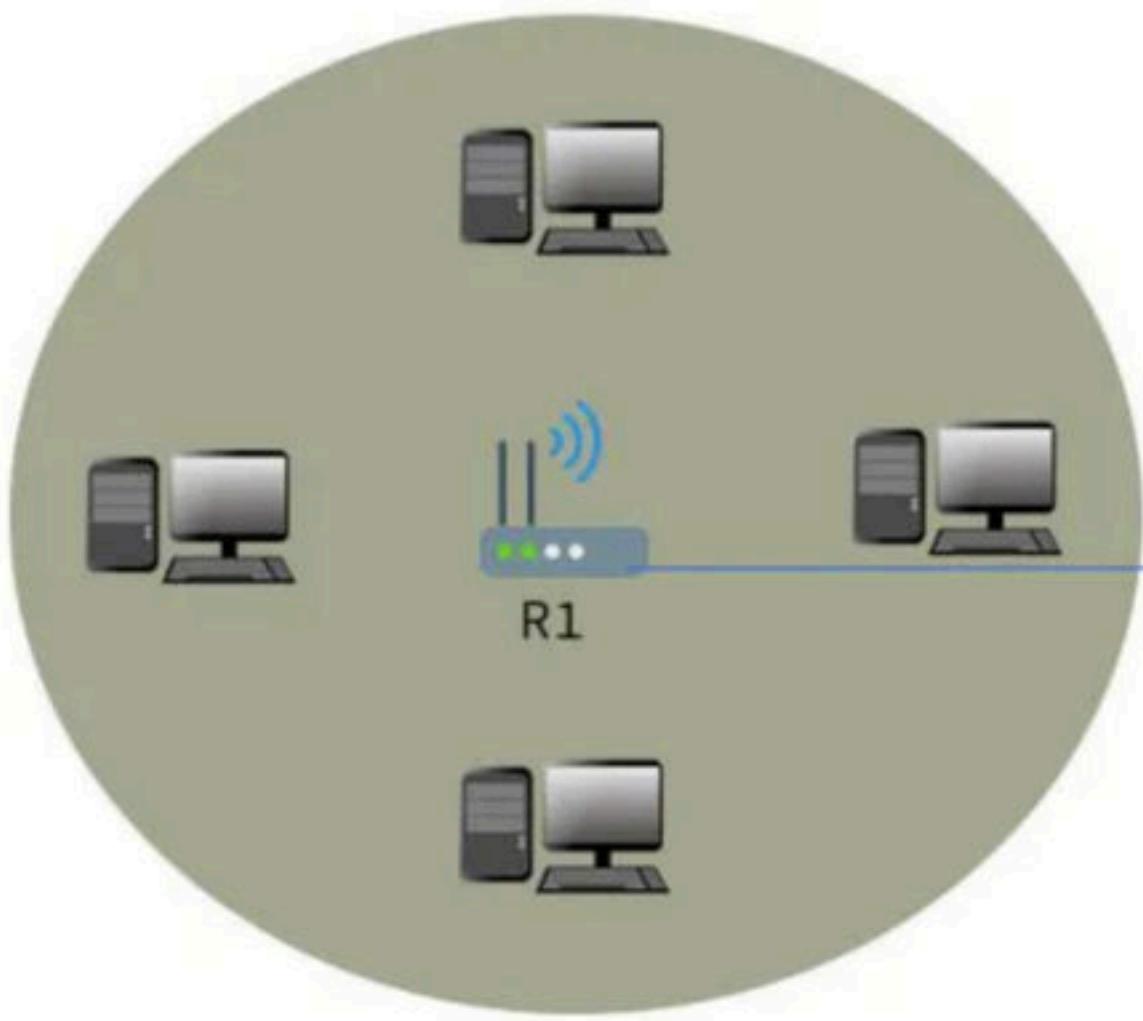
Fri
Mon
Tue
Wed
Thu
Fri

7-8
8-9

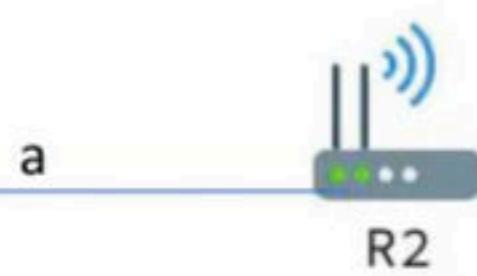
CNV

OS X

12 →
Reddy



Revised Routing table



ROUTING TABLE AT R2

NETWORK ID	SUBNET MASK	INTERFACE
200.1.0.0	255.255.252.0	a

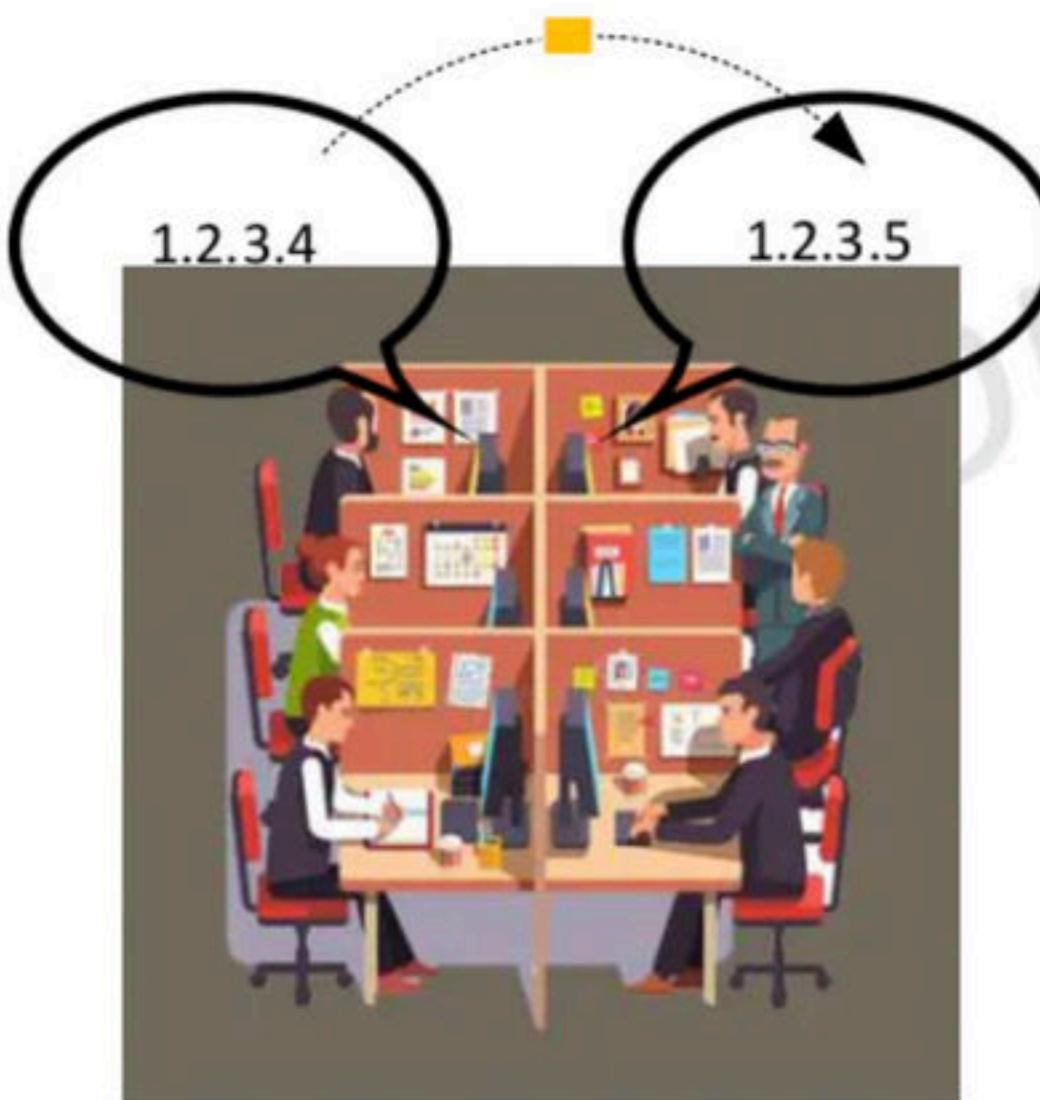
Note : In case of R1, we need all the 4 entries

Computer Networks

Private IP addresses

Imagine there is a software company, in which there are 6 PCs and the company has 2 criteria:

- 1.) No internet access / No communication with the outside world
- 2.) All the employees can communicate between each other



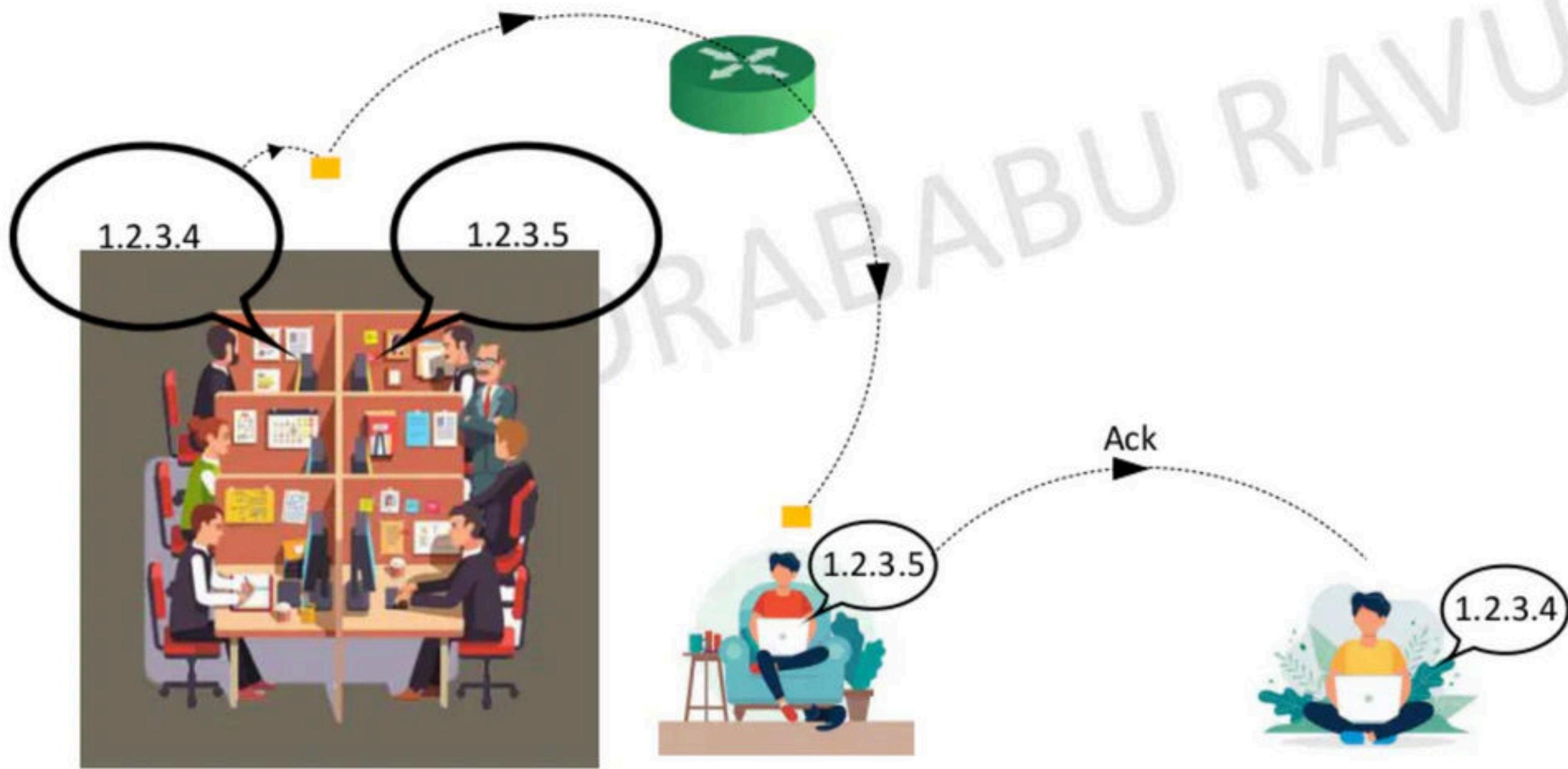
For this you can set a TCP/IP network and
Assign any IP address to the hosts

This allocation remains safe only till the packet is
sent within the network

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Suppose internet was accessed and the packet sent from 1.2.3.4 To 1.2.3.5 escaped onto the internet



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IANA has come to a solution to the problem and introduced **Private IP address**

So if one wishes to use Ips only within the Private Network, Private IPs should be assigned and not the Public IPs

**PRIVATE IP
RANGE**

10.0.0.0 to 10.255.255.255

172.16.0.0 to 172.31.255.255

192.168.0.0 to 192.168.255.255

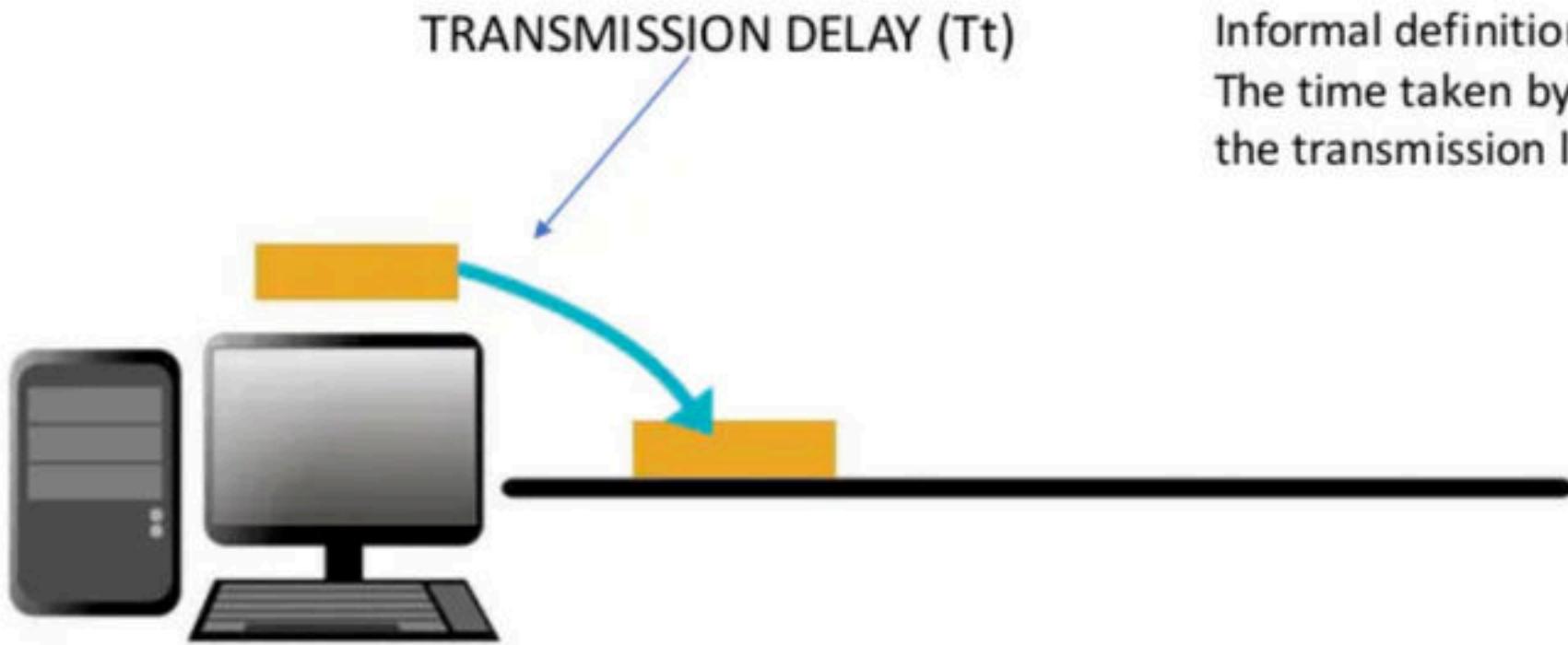
So, due to this what happens is even if the packet goes outside the private network the router discards it because It was send from a Private IP.

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Computer Networks

Delays in Computer Networks

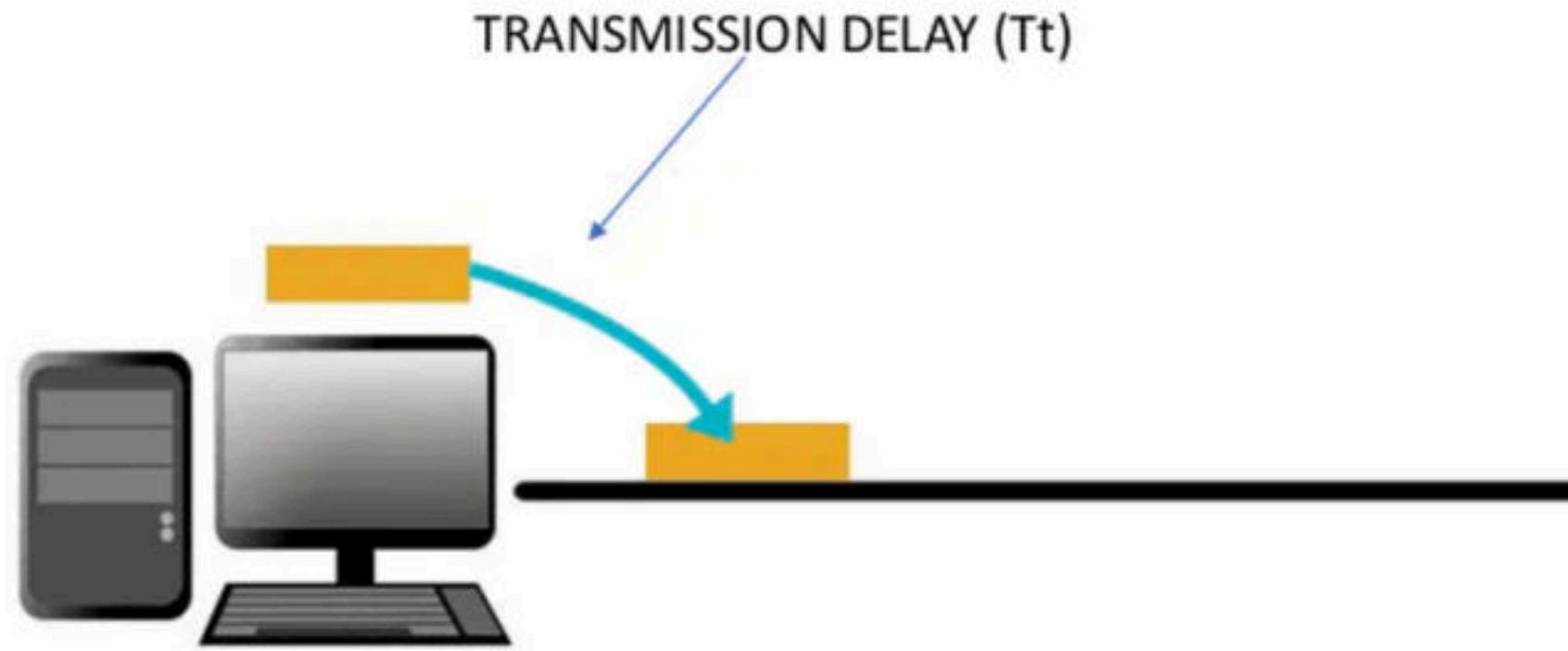


Informal definition:

The time taken by the host to put the data packet into the transmission link is called Transmission Delay

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If Bandwidth is 1 bps
And data to be sent is 10 bits
The T_t would be 10 sec

So, in general we can say that,
 $T_t = \frac{\text{Length of data (bits)}}{\text{Bandwidth(bps)}} = \frac{L}{B} \text{ sec}$

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Consider these 2 examples

Example 1 : If $L = 1000$ bits and $BW = 1$ Kbps

Then

$$T_t = \frac{L}{B} = \frac{1000}{1000} = 1 \text{ sec}$$

Example 2 : If $L = 1$ KB and $BW = 1$ Kbps

Then

$$T_t = \frac{L}{B} = \frac{1024}{1000} = 1.024 \text{ sec}$$

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REMEMBER

Consider these 2 examples

Example 1 : If $L = 1000$ bits and $BW = 1$ Kbps

Then

$$T_t = \frac{L}{B} = \frac{1000}{1000} = 1 \text{ sec}$$

Example 2 : If $L = 1$ KB and $BW = 1$ Kbps

Then

$$T_t = \frac{L}{B} = \frac{1024}{1000} = 1.024 \text{ sec}$$

Whenever data has **K**,
 $K = 1024$

Whenever data has **M**,
 $M = 1024 \times 1024$

Whenever data has **G**,
 $G = 1024 \times 1024 \times 1024$

Whenever Bandwidth has **K**,
 $K = 1000 = 10^3$

Whenever Bandwidth has **M**,
 $M = 10^6$

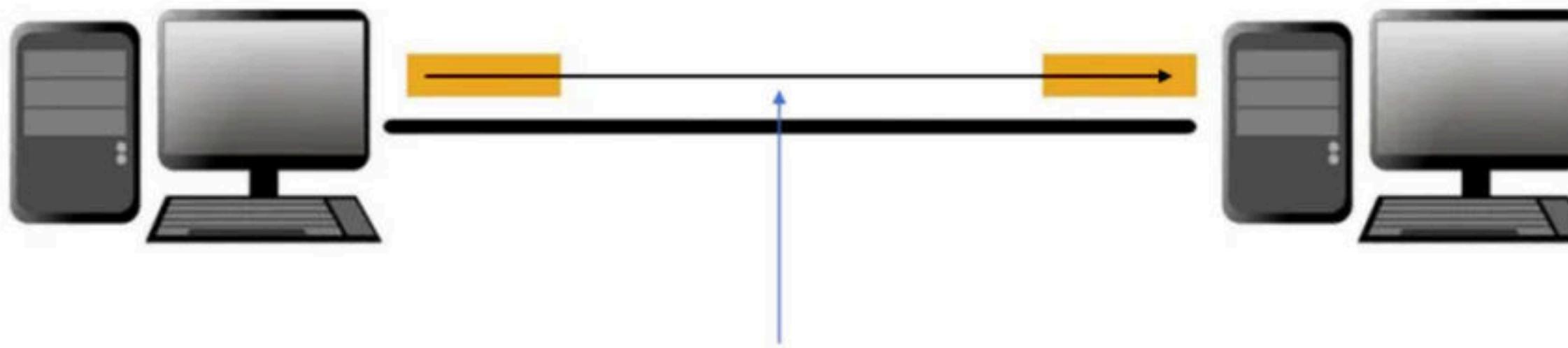
Whenever Bandwidth has **G**,
 $G = 10^9$

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SENDER

RECEIVER



PROPAGATION DELAY (T_p)

Time taken for one bit to travel from sender to receiver end of the link is called as propagation delay.

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$$T_p = \frac{\text{distance of the link (d)}}{\text{Velocity(v)}} \text{ seconds}$$

Generally the link nowadays is optical fibre and
We know that the speed at which the light travels
is 3×10^8 m/s.

In optical fibre the light travels with 70% of the original speed of light(3×10^8 m/s)
 $\Rightarrow v = 0.7 \times 3 \times 10^8 \text{ m/s} = \underline{2.1 \times 10^8 \text{ m/s}}$



Generally the velocity will be given in the question but, in questions where velocity is not given, we need to take it as 2.1×10^8 m/s

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Example: $d = 2.1 \text{ km}$ and $v = 2.1 \times 10^8 \text{ m/s}$

$$T_p = \frac{\text{distance of the link } (d)}{\text{Velocity} (v)}$$

$$\begin{aligned} T_p &= \frac{2.1}{2.1 \times 10^8} \\ &= \frac{2.1 \times 1000}{2.1 \times 10^8} \\ T_p &= 10^{-5} \text{ sec} \end{aligned}$$



Converting 10^{-5} sec to μsec

We know that μ is 10^{-6}

Step 1 : Divide and multiply by 10^{-6}

$$10^{-5} \times \frac{10^{-6}}{10^{-6}}$$

Step 2 : Combine

$$10^{-5} \times \frac{10^{-6}}{10^{-6}} = 1 \times 10^{-6}$$

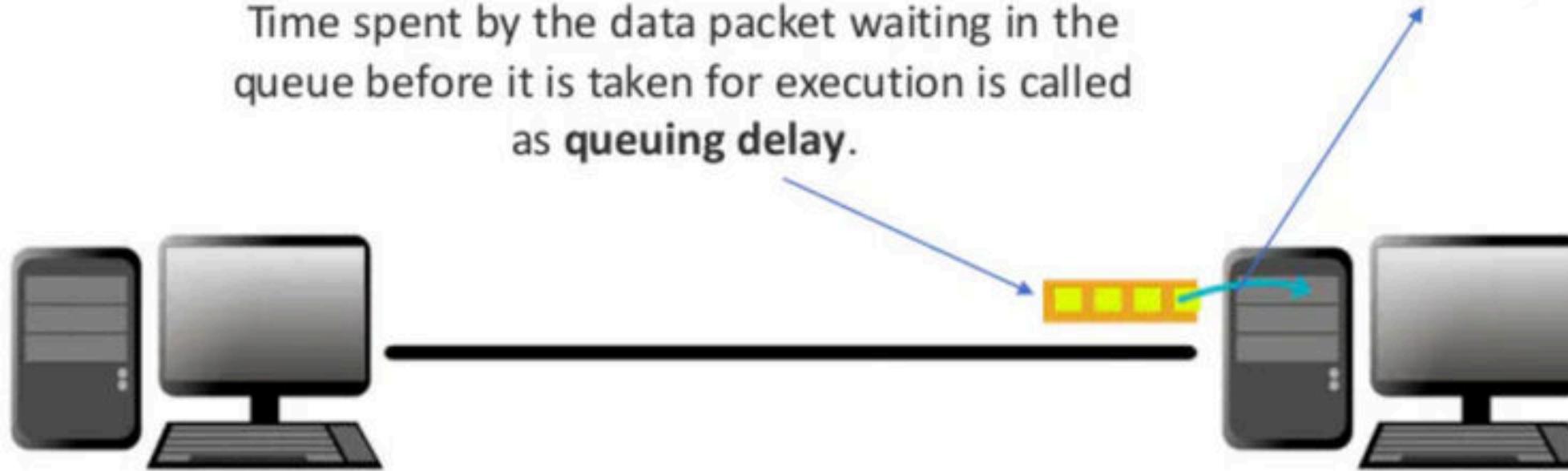
$$= 1 \mu\text{sec}$$

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Time taken by the processor to process the data packet is called as **processing delay**

Time spent by the data packet waiting in the queue before it is taken for execution is called as **queuing delay**.

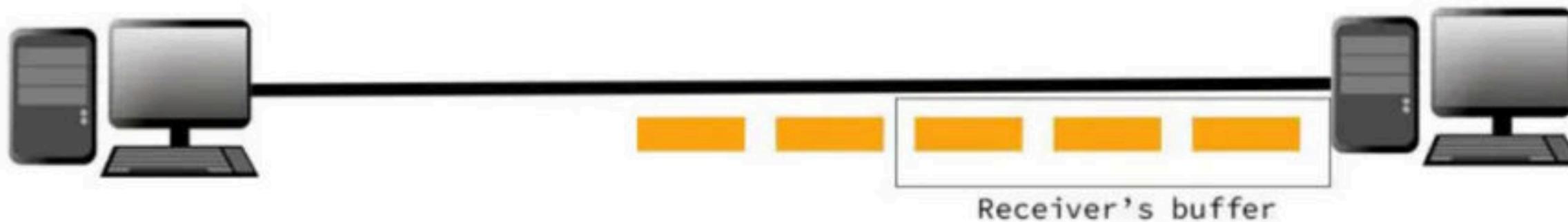


NOTE : THESE TWO DELAYS DEPEND UPON THE TYPE OF PROCESSOR USED AND CANNOT BE EVALUATED AND THEREFORE ARE CONSIDERED AS ZERO IN ALMOST ALL NUMERICALS

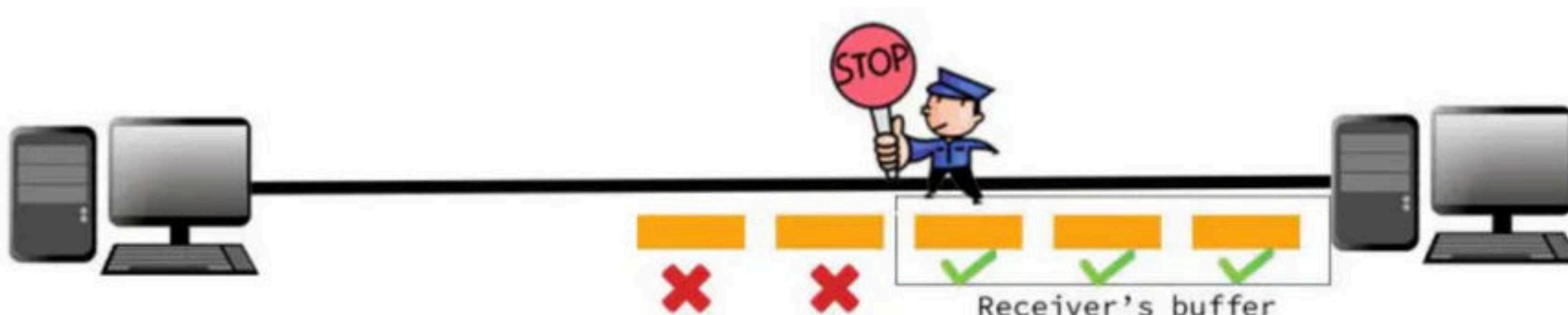
Computer Networks

Flow Control Methods- Stop and Wait

WHY FLOW CONTROL IS REQUIRED?



WHY FLOW CONTROL IS REQUIRED?



Buffer size of receiver was 3, so other 2 packets got discarded
Therefore, The sender must send the packets in the rate at which
the receiver can receive it.
Here is where **Flow control** comes in picture.

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Tt



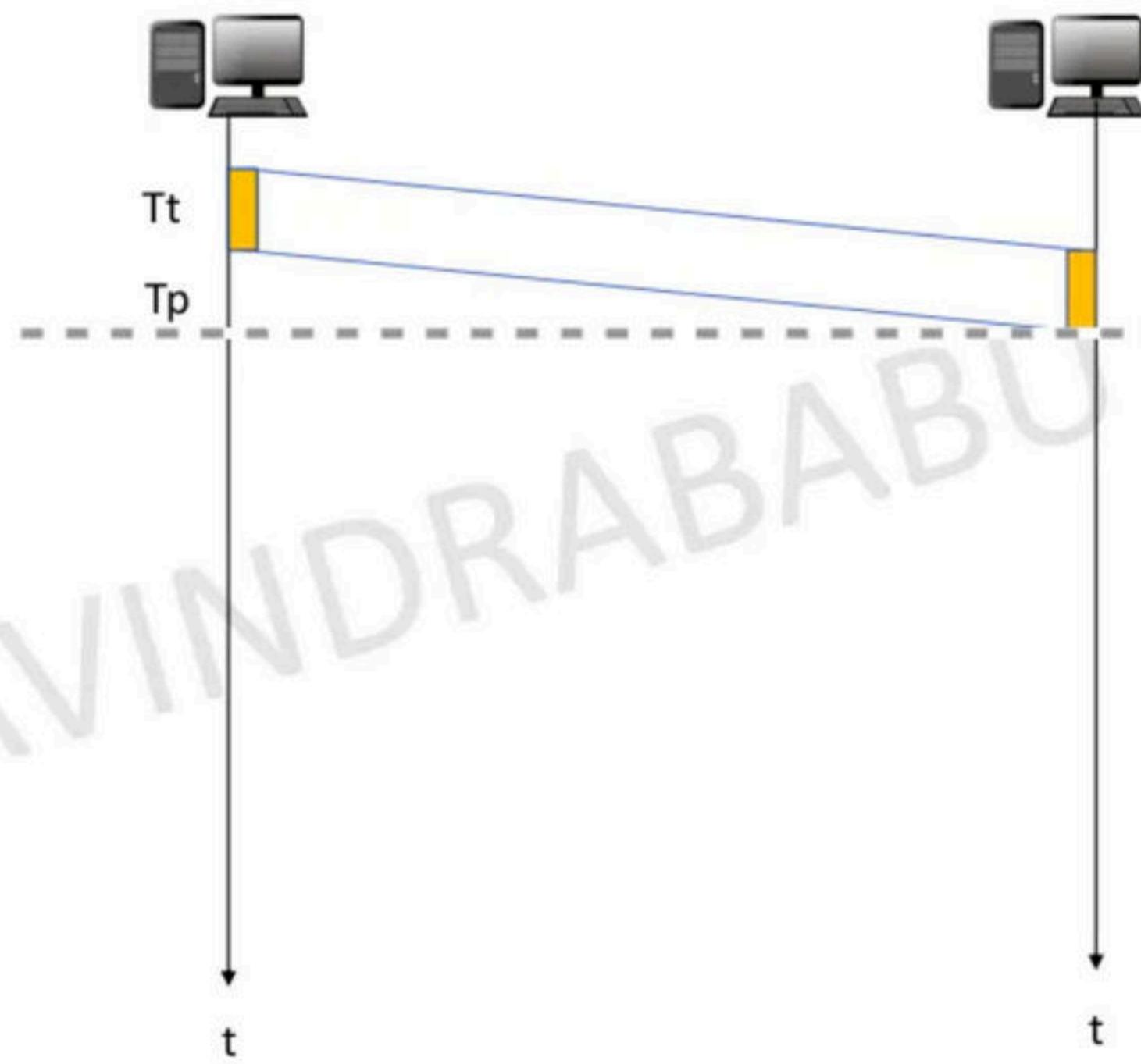
t



t

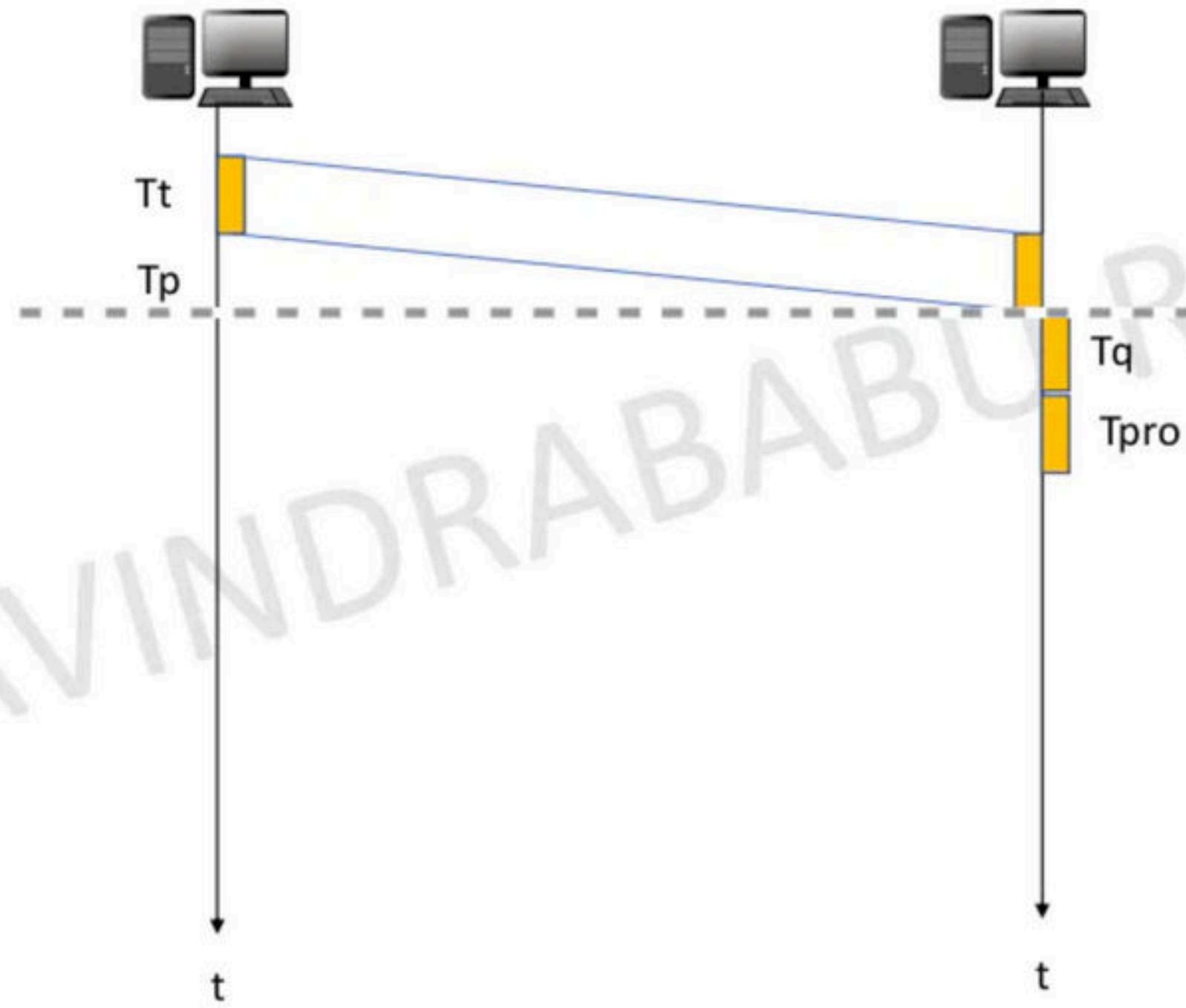
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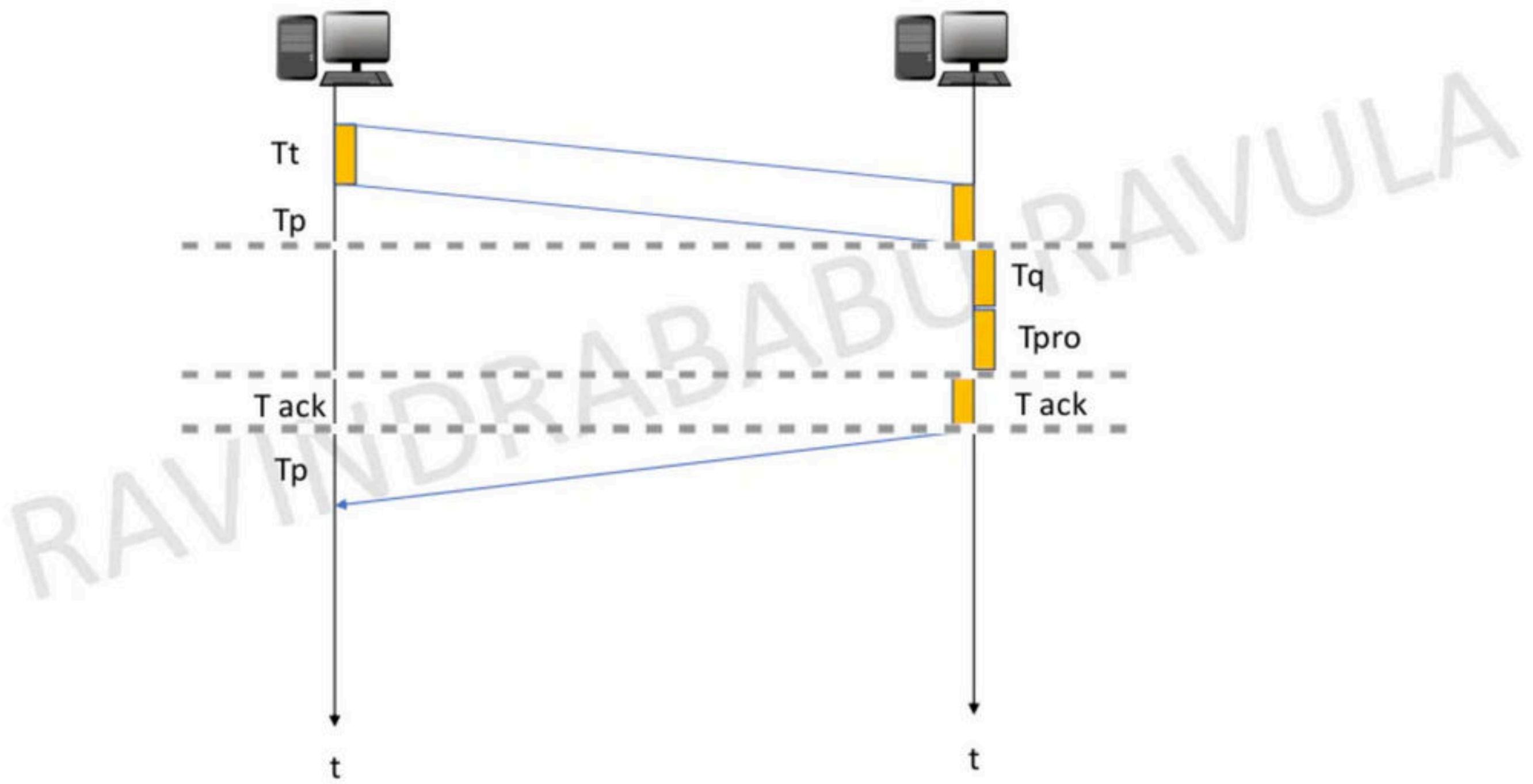
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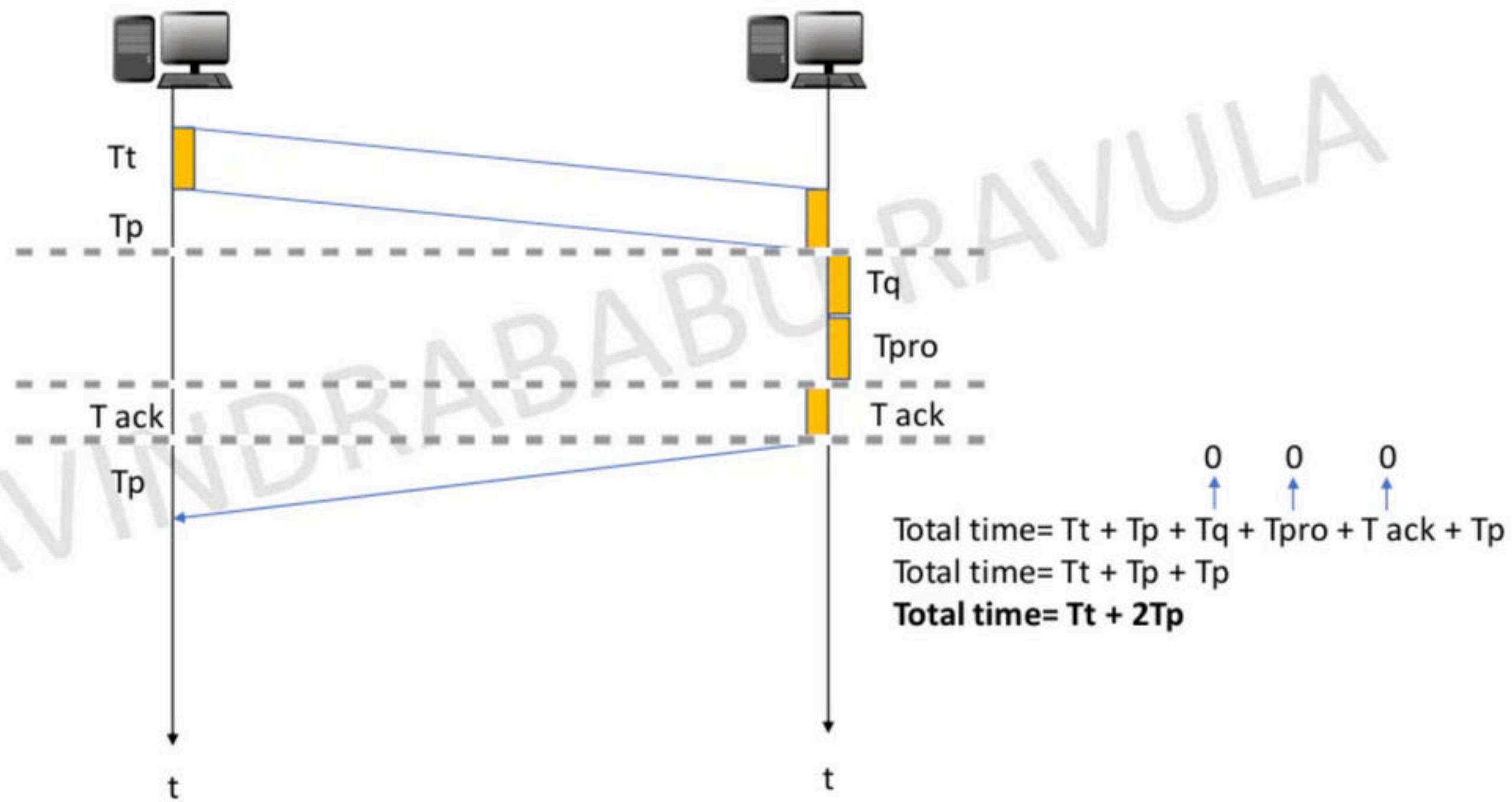
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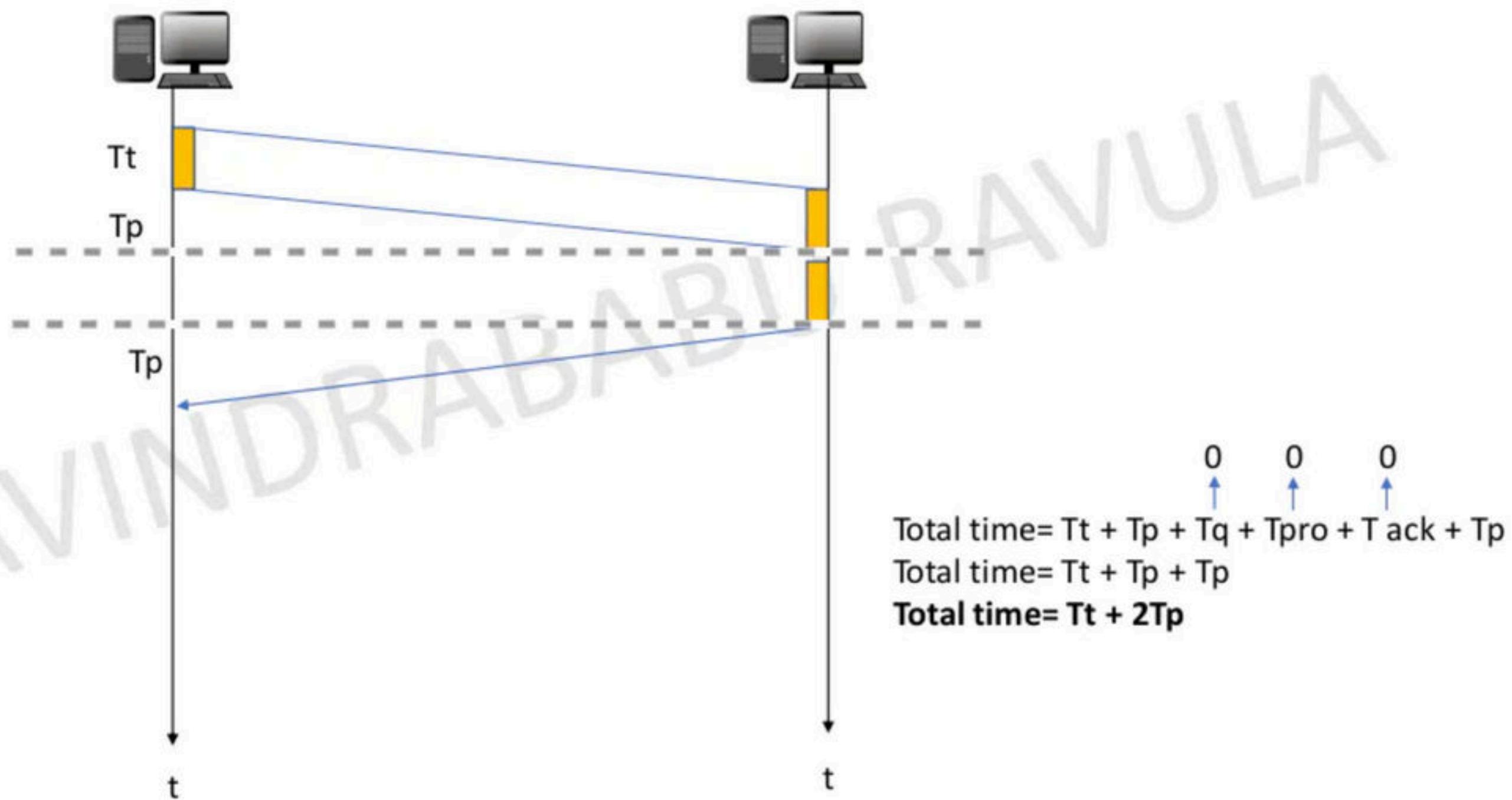
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EFFICIENCY

Efficiency(η) = Useful time
Total cycle time

$$\eta = \frac{Tt}{Tt + 2Tp}$$

$$\eta = \frac{1}{1 + \frac{2Tp}{Tt}} \quad a = \frac{Tp}{Tt}$$

$$\eta = \frac{1}{1 + 2a}$$

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THROUGHPUT

Effective bandwidth

Or

$$\text{Throughput} = \frac{L}{T_t + 2T_p}$$

Or

$$\begin{aligned}\text{Bandwidth utilization} &= \frac{L/B}{T_t + 2T_p} \times B \\ &= \frac{T_t}{T_t + 2T_p} \times B \\ &= \eta \times B\end{aligned}$$

$$\boxed{\text{Throughput} = \text{Efficiency} (\eta) \times \text{Bandwidth}(B)}$$

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REVISION OF THE FORMULAE



REMEMBER

Whenever data has **K**,
 $K = 1024$

Whenever data has **M**,
 $M = 1024 \times 1024$

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Whenever Bandwidth has **K**,
 $K = 1000 = 10^3$

Whenever Bandwidth has **M**,
 $M = 10^6$

Whenever Bandwidth has **G**,
 $G = 10^9$

$$1.) \quad T_t = \frac{\text{Length of data (bits)}}{\text{Bandwidth(bps)}} = \frac{L}{B}$$

$$2.) \quad T_p = \frac{\text{distance of the link (d)}}{\text{Velocity(v)}}$$

$$3.) \quad \eta = \frac{1}{1 + 2a}$$

$a = \frac{T_p}{T_t}$

$$4.) \quad \text{Throughput} = \text{Efficiency} (\eta) \times \text{Bandwidth}(B)$$

$$5.) \quad \text{Round Trip Time (RTT)} = 2 \times T_p$$

STOP AND WAIT

Problems on Stop and wait

1.) $T_t = 1\text{ms}$ $T_p = 1\text{ms}$

$$\eta = \frac{1}{1 + 2a} = \frac{1}{3} = 0.33 \text{ or } 30\%$$

2.) $T_t = 2\text{ms}$ $T_p = 1\text{ms}$

$$\eta = \frac{1}{1 + 2a} = \frac{1}{2} = 0.5 \text{ or } 50\%$$

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Problems on Stop and wait

1.) $T_t = 1\text{ms}$ $T_p = 1\text{ms}$

$$\eta = \frac{1}{1 + 2a} = \frac{1}{3} = 0.33 \text{ or } 30\%$$

2.) $T_t = 2\text{ms}$ $T_p = 1\text{ms}$

$$\eta = \frac{1}{1 + 2a} = \frac{1}{2} = 0.5 \text{ or } 50\%$$

So, if we want the efficiency to be atleast 50 % then,

$$\eta \geq 0.5$$

$$\frac{T_t}{T_t + 2T_p} \geq \frac{1}{2}$$

$$2T_t \geq T_t + 2T_p$$

$$T_t \geq 2T_p$$

Or we can say that,

$$\frac{L}{B} \geq 2T_p$$

$$L \geq 2T_p * B$$

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Question:

Given, bandwidth = 4 Mbps, T_p = 1ms, What is the length of the packet so as to achieve at least 50% efficiency?

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Question:

Given, bandwidth = 4 Mbps, T_p = 1ms, What is the length of the packet so as to achieve at least 50% efficiency?

$$L \geq 2T_p * B$$

$$L \geq 2 \cdot 10^{-3} \cdot 4 \cdot 10^6$$

$$L \geq 8 \cdot 10^3 \text{ bits}$$

Therefore, Length of packet must be at least 8000 bits so as to achieve at least 50 % efficiency.

SOMETHINGS THAT CAN BE SAID ABOUT EFFICIENCY

$$\eta = \frac{1}{1 + \frac{2Tp}{Tt}}$$

$$\eta = \frac{1}{1 + \frac{2(d/v)}{(L/B)}}$$

As we can see that,

$$\begin{array}{l} d \uparrow \\ L \uparrow \end{array} \quad \begin{array}{l} \eta \downarrow \\ \eta \uparrow \end{array}$$

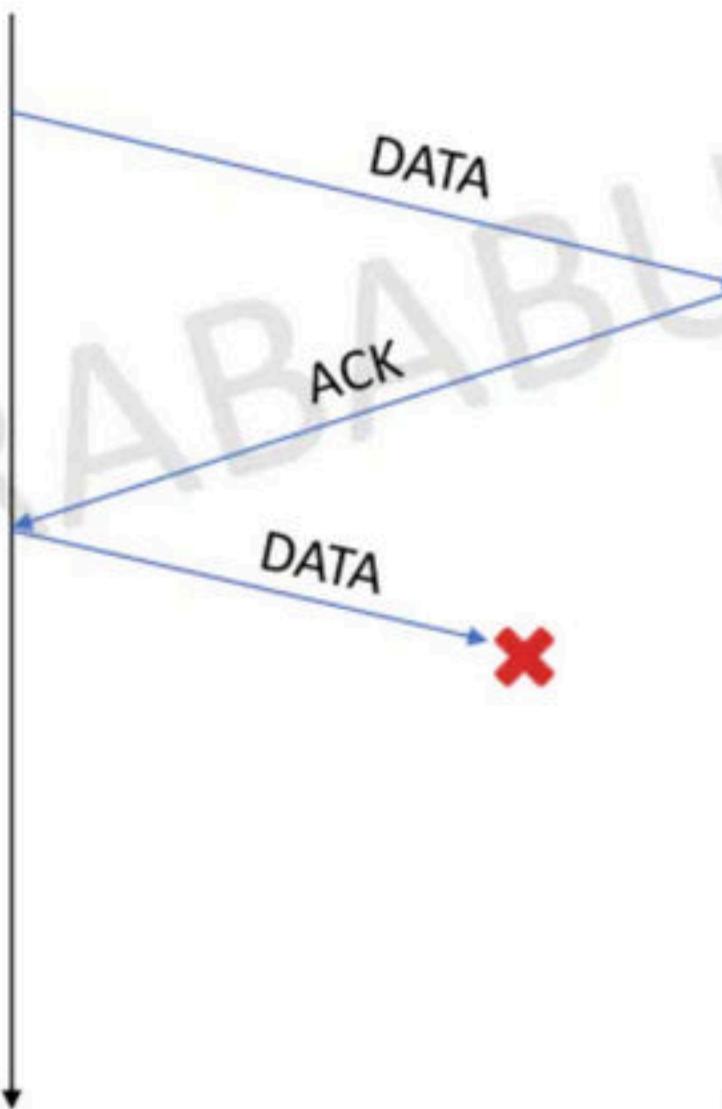
So, Stop and Wait is good for LANs
Good for big packets

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PROBLEMS WITH STOP AND WAIT

PROBLEM 1: Data packet lost



SENDER THINKS THAT
RECEIVER IS BUSY

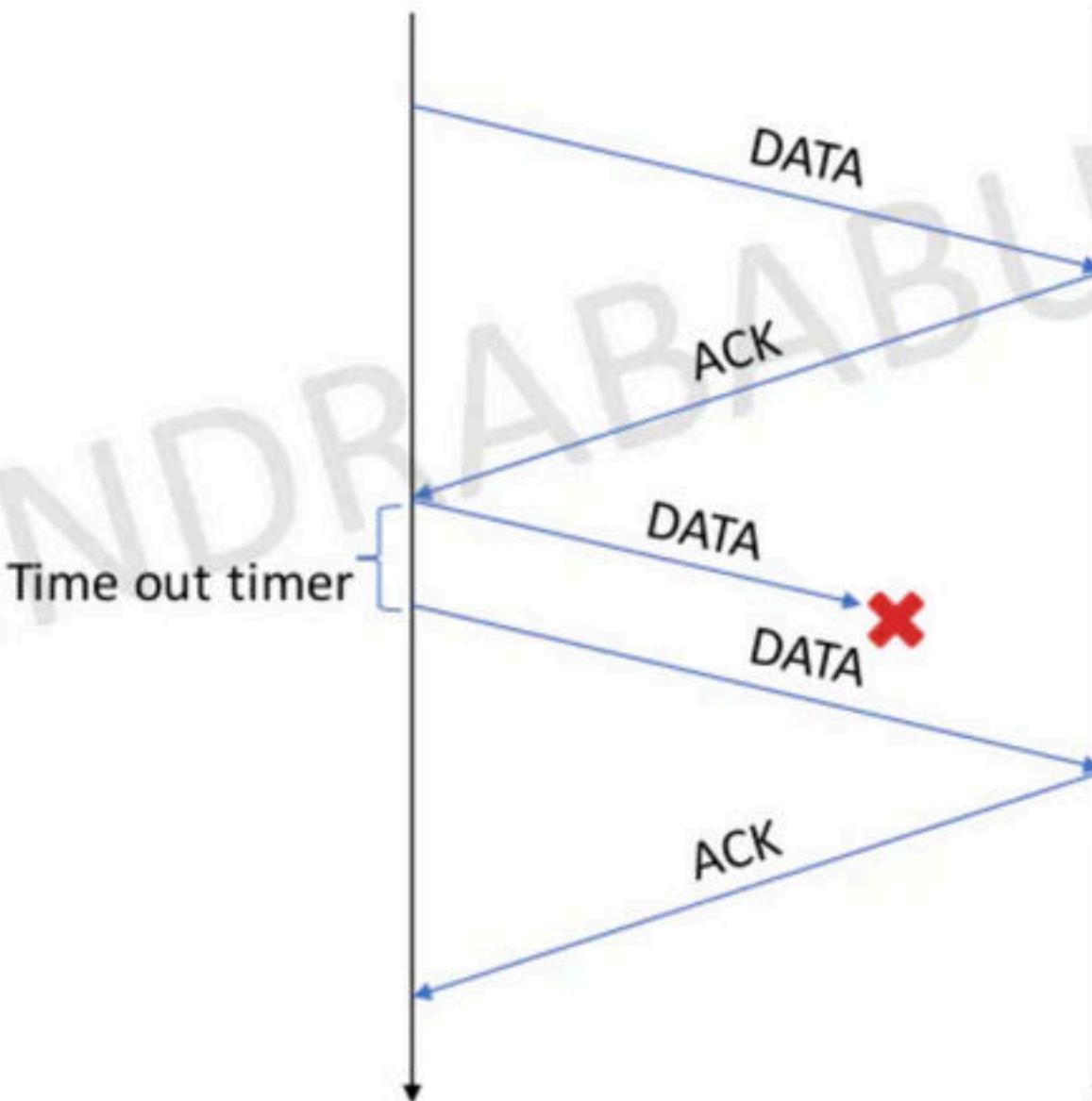
RECEIVER THINKS SENDER DID
NOT SEND THE DATA

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PROBLEMS WITH STOP AND WAIT

PROBLEM 1: Data packet lost



SOLUTION

So, to solve this issue the sender
Waits for time known as **Time out Timer**
And resends the packet.

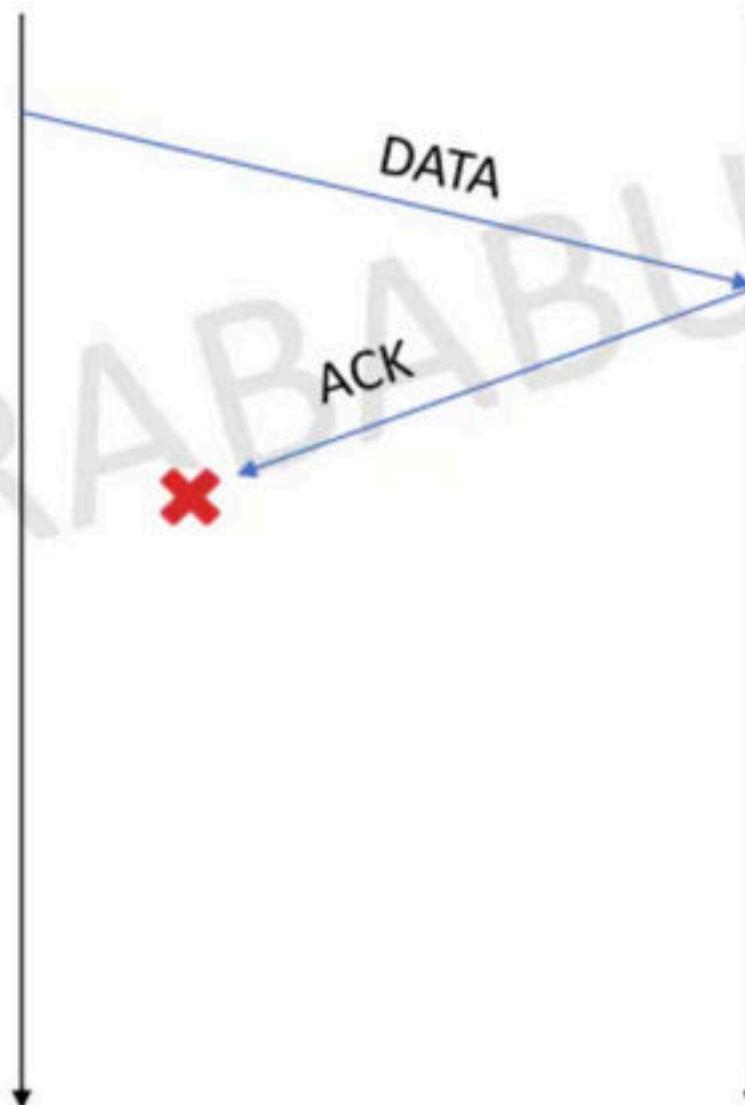
This is stop and wait + timeout timer
Which is known as "**Stop and wait ARQ**"
ARQ stands for Automatic Repeat Request

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PROBLEMS WITH STOP AND WAIT

PROBLEM 2: Acknowledgement lost



SENDER THINKS THAT
RECEIVER HAS NOT RECEIVED THE PACKET

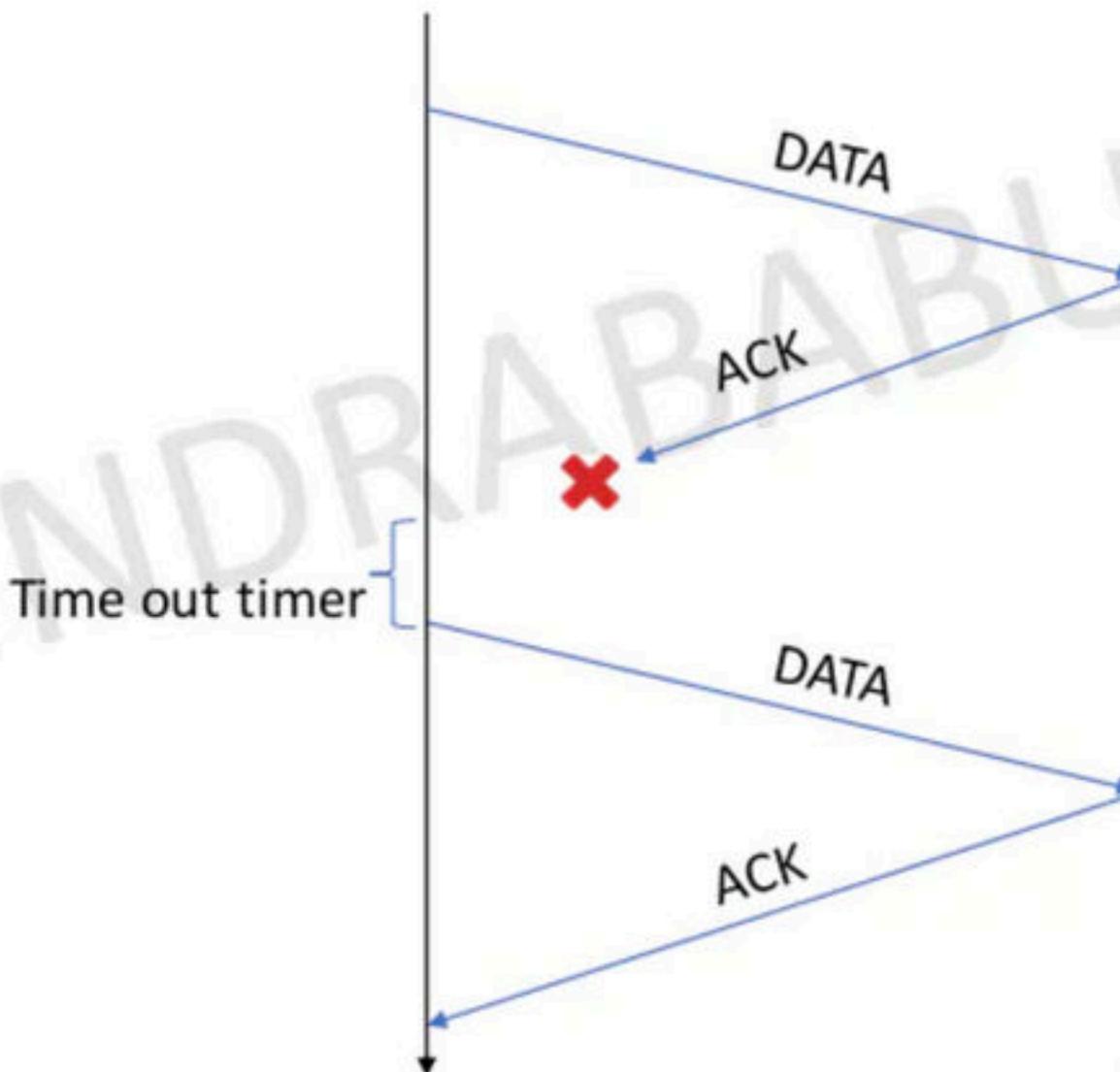
RECEIVER THINKS SENDER HAS RECEIVED ACK

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PROBLEMS WITH STOP AND WAIT

PROBLEM 2: Acknowledgement lost



SENDER WAITS FOR TIMEOUT TIMER
AND RESENDS THE PACKET

RECEIVER THINKS SENDER HAS SENT
NEW DATA PACKET.

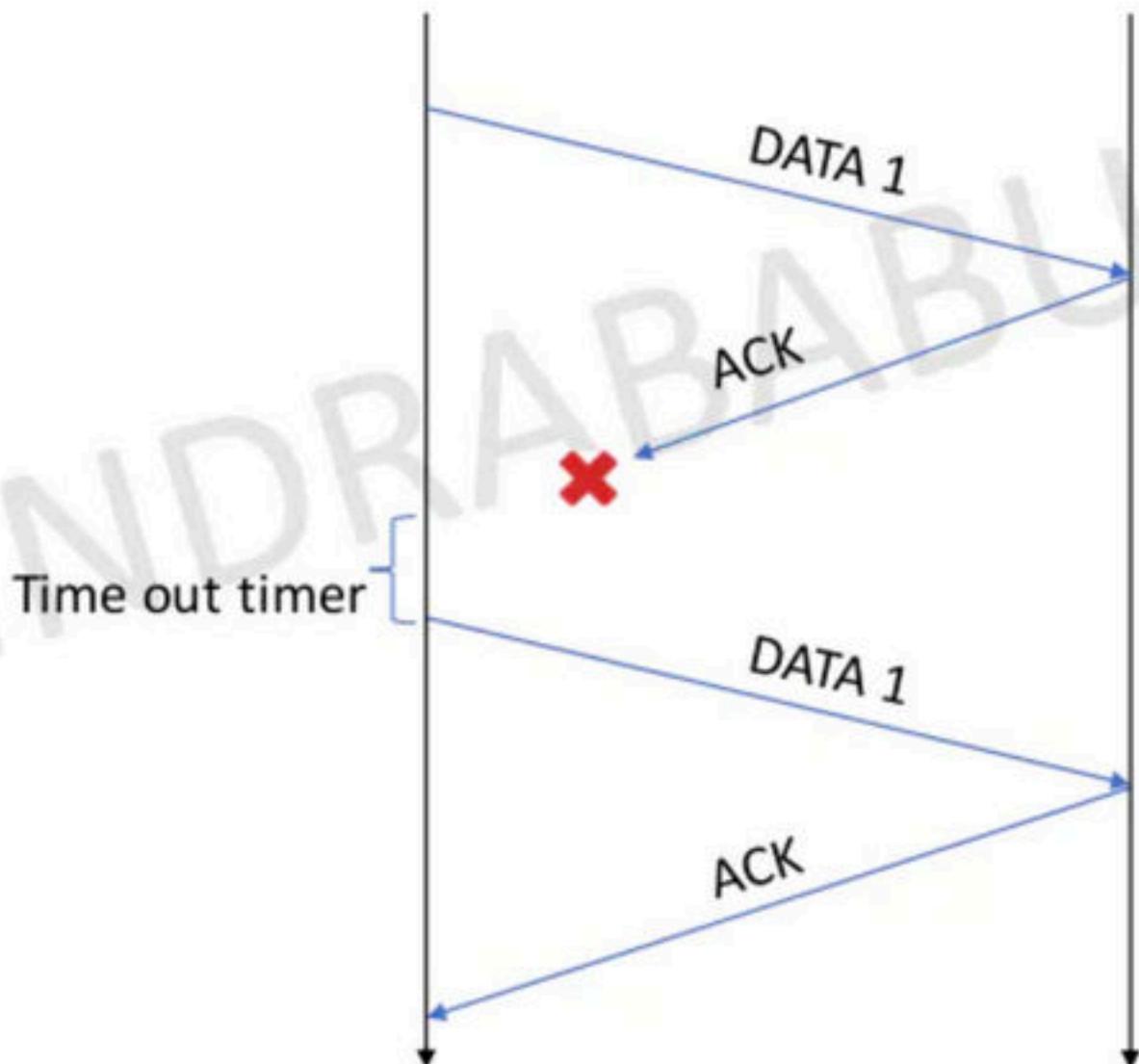
THIS IS DUPLICATE PACKET PROBLEM

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PROBLEMS WITH STOP AND WAIT

PROBLEM 2: Acknowledgement lost



SOLUTION :

SENDER SENDS DATA PACKET WITH
SEQUENCE NUMBERS

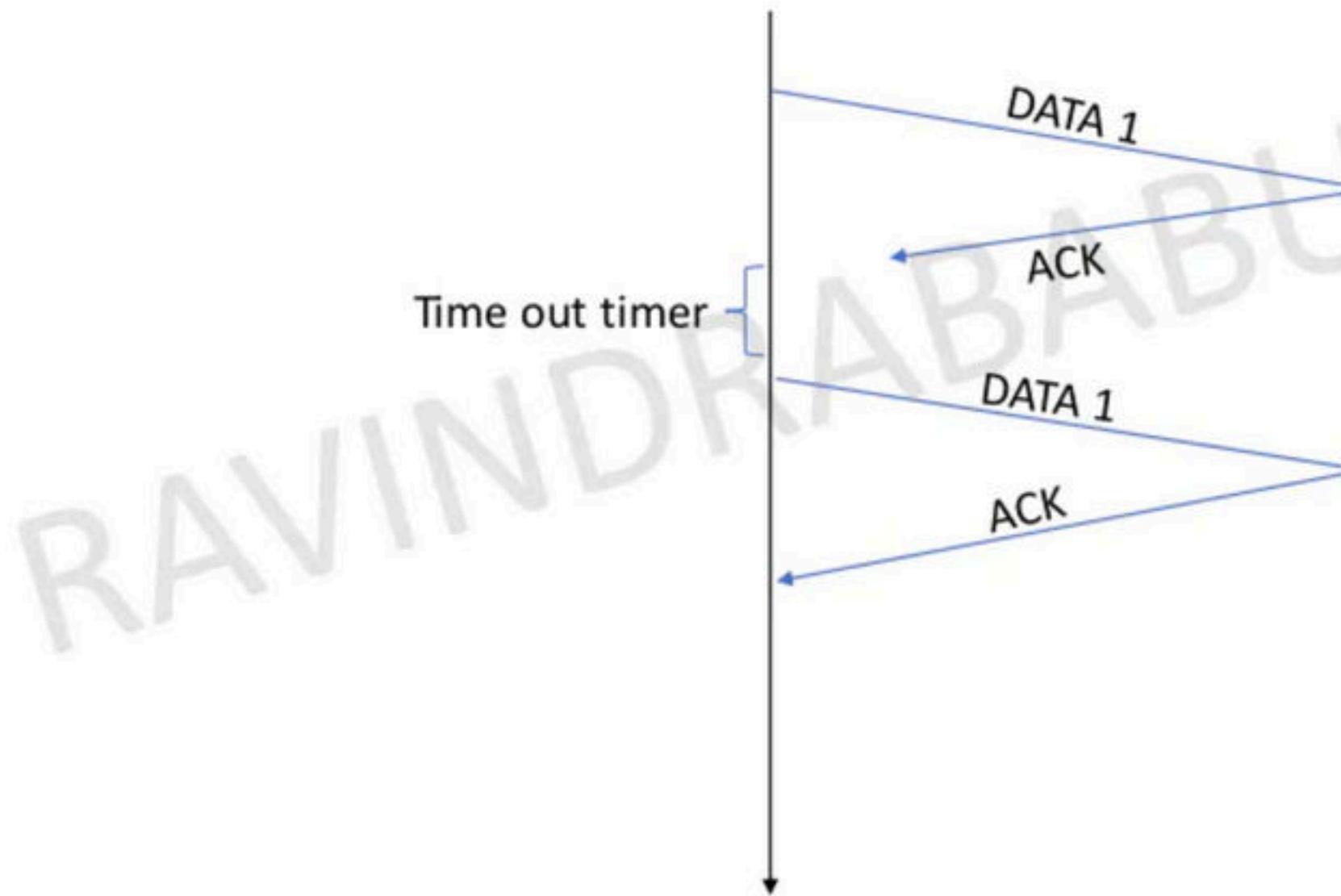
STOP AND WAIT + TO TIMER + SEQ NUMBER

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PROBLEMS WITH STOP AND WAIT

PROBLEM 3: Acknowledgement Delayed



ACKNOWLEDGEMENT IS DELAYED FOR DATA 1 AND THE PACKET IS RESENT BY THE SENDER BY WAITING FOR TO TIMER

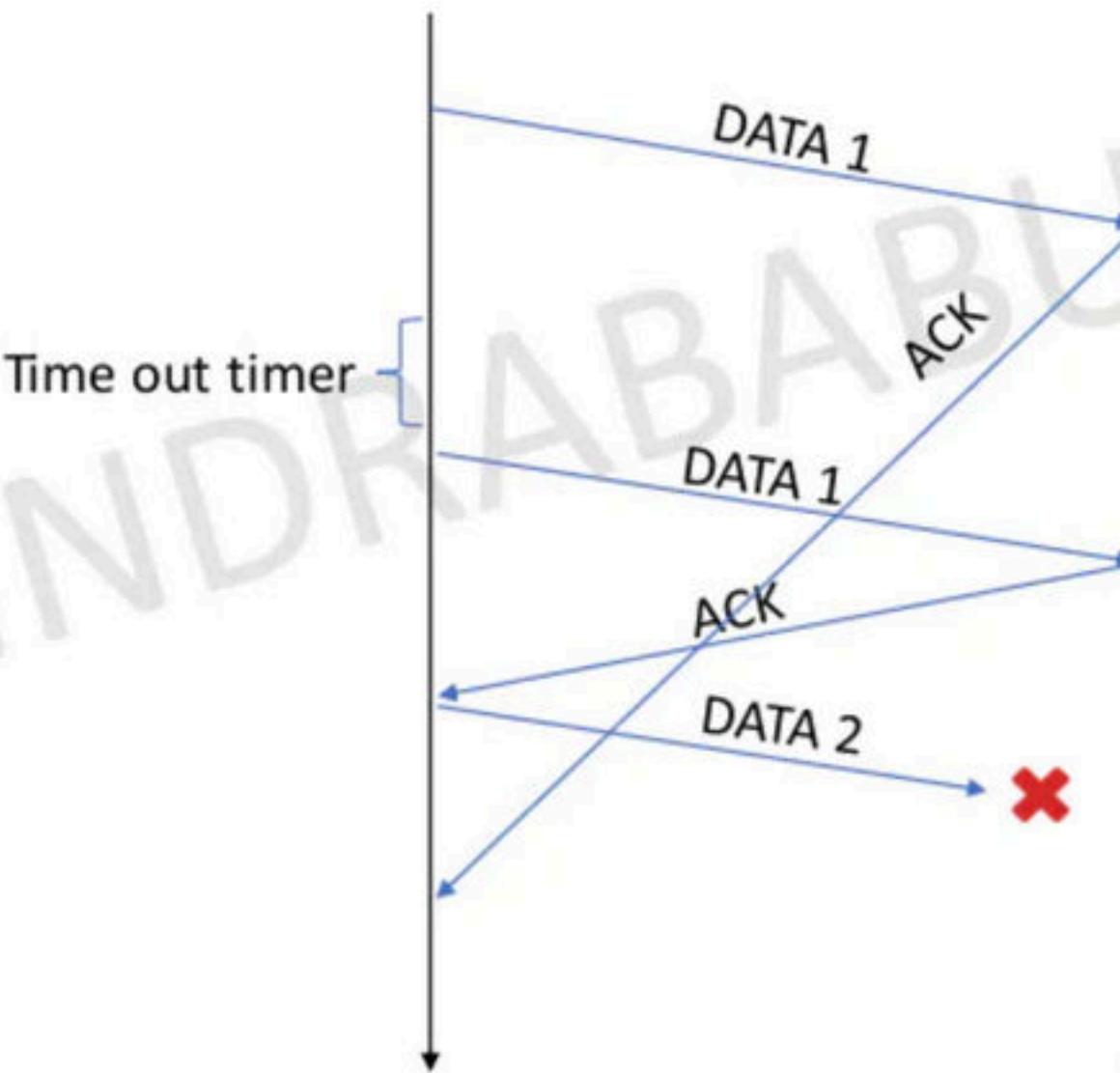
RECEIVER SENDS THE ACK FOR THE RESENT DATA 1 PACKET

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PROBLEMS WITH STOP AND WAIT

PROBLEM 3: Acknowledgement Delayed



NOW, IMAGINE DATA 2 PACKET IS SENT AND GETS LOST.

AND THE DELAYED ACK IS RECEIVED NOW

DUE TO THIS WHAT HAPPENS IS,
SENDER THINKS THIS IS AN ACK FOR DATA 2
BUT THE RECEIVER NEVER RECEIVED DATA 2
PACKET !

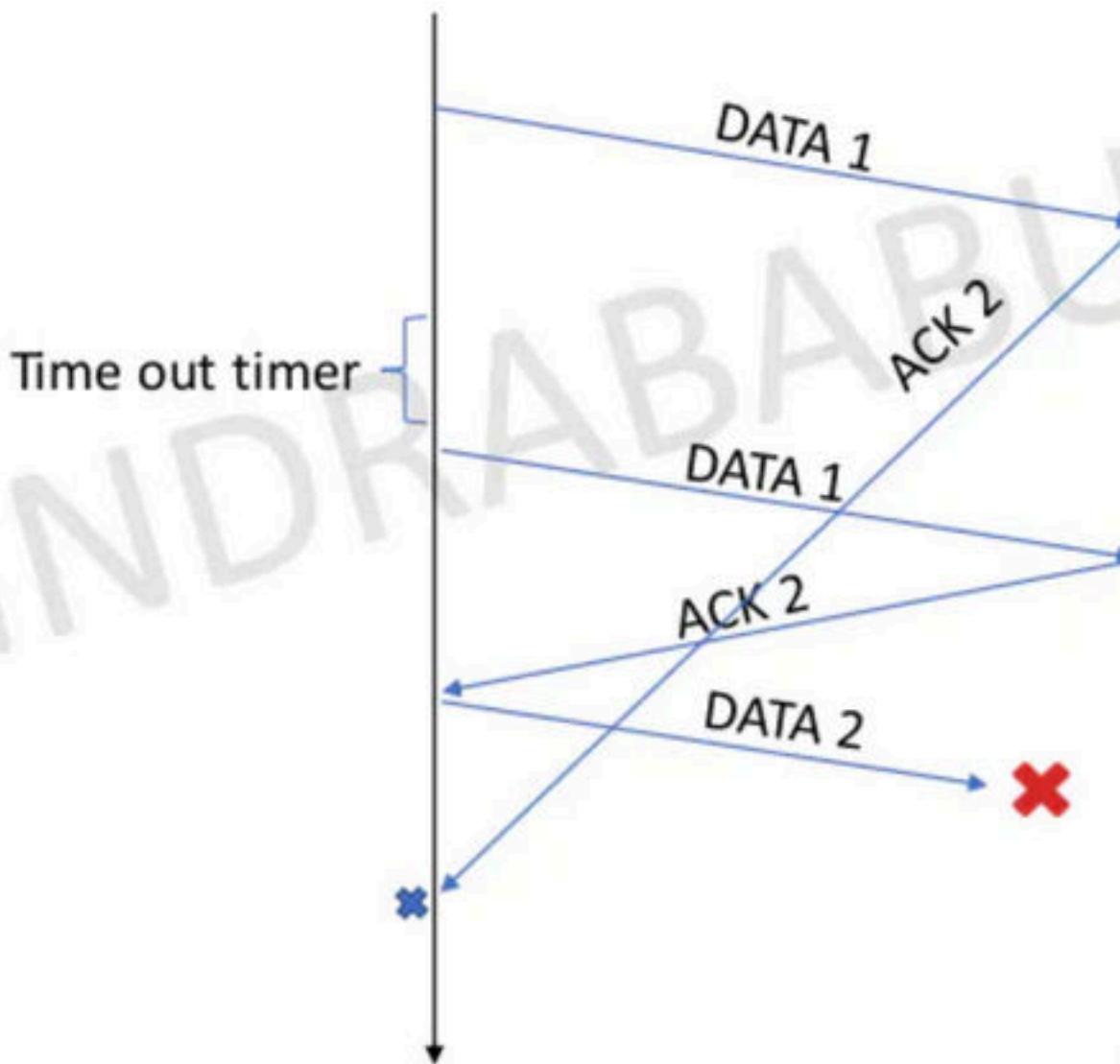
THIS IS **MISSING PACKET PROBLEM**

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PROBLEMS WITH STOP AND WAIT

PROBLEM 3: Acknowledgement Delayed



SOLUTION:

ACK NUMBER WILL BE SENT BY RECEIVER

ACK NUMBER = SEQUENCE NO + 1

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QUESTION : Suppose sender wants to send 10 packets to receiver and every 4th packet is lost

How many packets will be sent in total?

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SOLUTION:

Packets to be sent : 1 2 3 4 5 6 7 8 9 10

As per the given scenario : 1 2 3 4 4 5 6 7 7 8 9 10 10

Total transmissions = 13

Question:

Suppose while sending packets to destination there is error probability of 0.2 .

If we are sending 400 packets over this channel. How many Packets would be sent?

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packets sent would be :

$$400 + 400(0.2) + 80(0.2) \dots$$

If we are sending n packets with p error probability, then,

packets sent would be,

$$= (n + np + np^2 \dots)$$

$$= n(1 + p + p^2 + \dots)$$

$$= n(1/(1-p))$$