Computer Networks

8/1/24.

Largest CN → Internet.

Applications :-

1. Gather latest information about sports, politics, entertainments

2. Play Games

3. Spotify, - - -> Songs

4. Social Media.

5. Banking

6. Online Shopping.

7. Online class

8. Video Conferencing.

9) Watching movies.

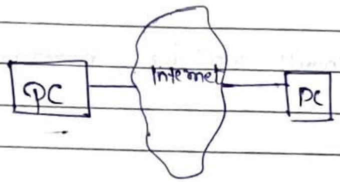
10) Ticket bookings.

⋮

∞

Devices connected to Internet :

(1) Mobile (2) PC/ laptop (3) TV (4) Watches (5) CCTV (IOT devices) 6) Router



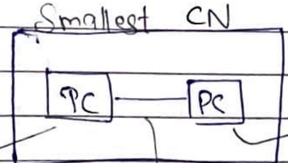
→ Communication.

↳ to share information.

↳ Data in particular format agreed on by both parties.

Ex: If one says twenty → secs / hair / Rupees — ? } it can be any thing

Smallest CN



Sender/ transmitter

→ destination/Receiver

↳ interconnection.

↳ can be wired or wireless.

Communication is necessary.

This wired or wireless connᶜ is also called a communication Link or Transmission medium

CN is Interconnection of devices to communicate data.

→ Roles of sender and receiver can changed

↳ Roles reversal.

→ Wireless transmission — Access Point (Router).

10/1/24

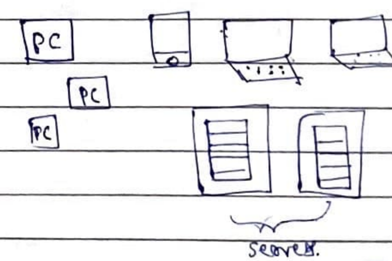
Internet - network of networks.

Server – a powerful computing machine which serves and responds to user request

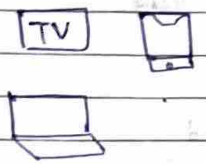
University network :

End devices – devices which are connected to the network (internet)

→ PCs, mobiles, laptops, university servers



Home :



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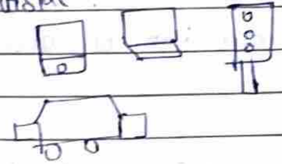
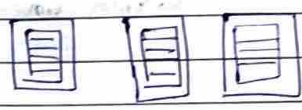


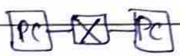
→ Datacenters :



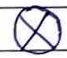
↳ These servers are also network edge.

Network edge : End devices forms a network edge.

→ Two PCs can't directly be connected, we require "switches" in between

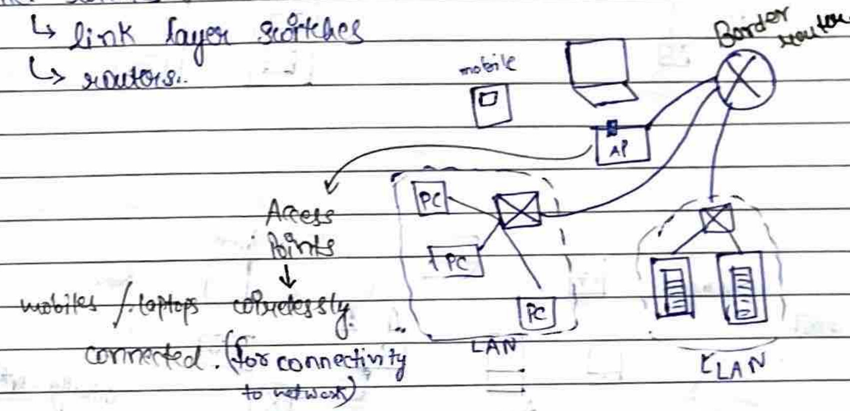


Google search :
switches (cisco)
cisco router
Google data center.

Switch :  Router :  : connects devices together.

Network : consists of - end devices
- Packet switches

Packet switches
↳ link layer switches
↳ routers.

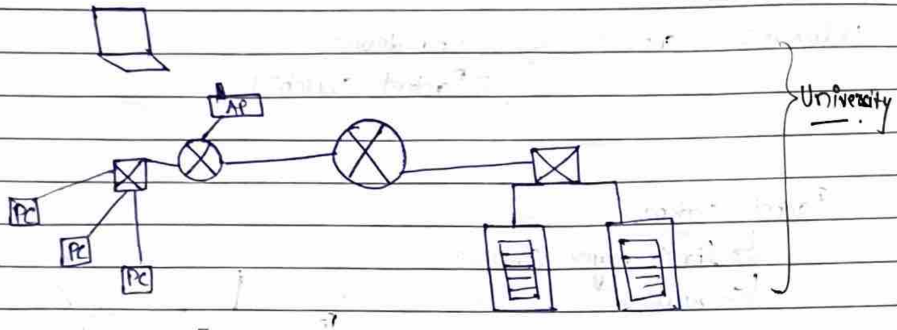


→ We have multiple switches, not all the devices are connected to a single switch

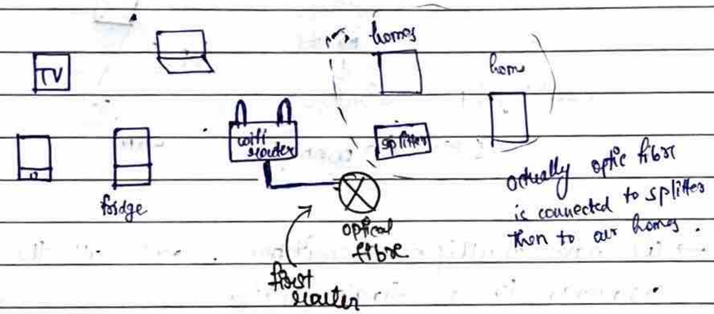
Local Area Network (LAN) :
↳ connection between devices is limited only to a few meters.

Border router :

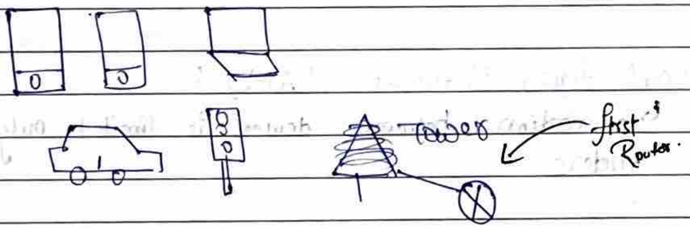
There can be single or many routers.
There will be generally single border router.



Home:



Outside:

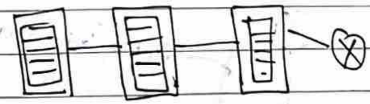


WAN: Wide Area Network: The connection b/w devices upto a few kms.

Access network: how are these devices connected to first router (set of devices & links thats connected to " ")

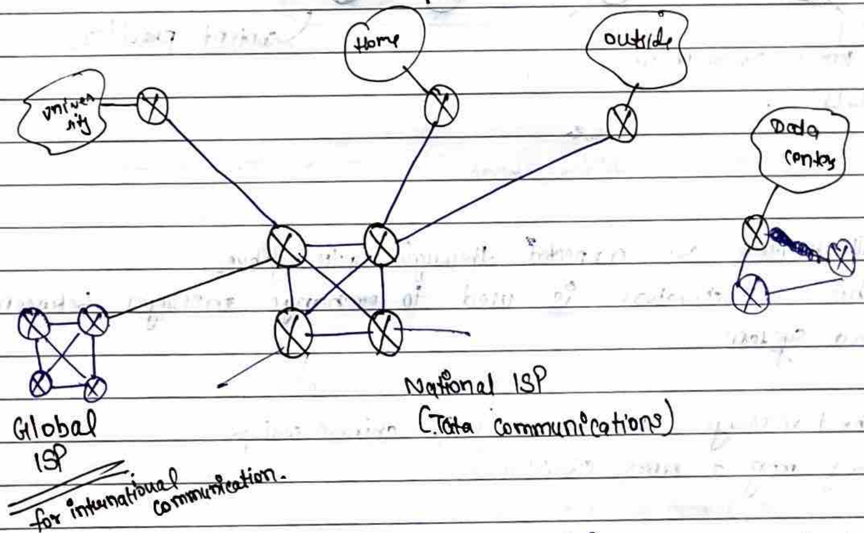
→ E.g., those wires in university, ⊠, ⊗ ...etc.

Data centers: content providers.



Internet Service Providers: (ISP):

Local or regional ISPs:
↳ all the first router of a LAN



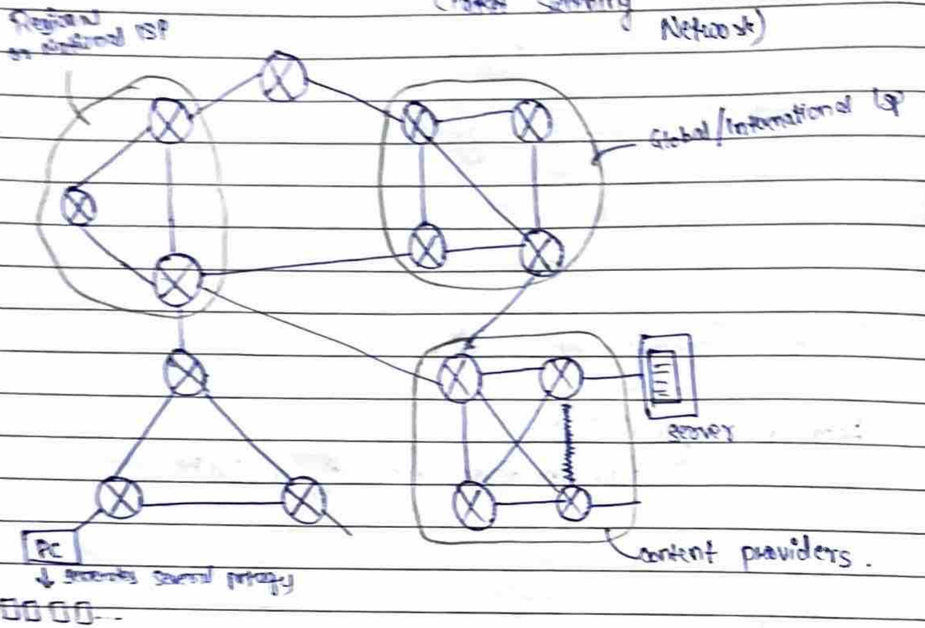
→ Airtel, Reliance jio, ... are Local ISPs.

→ The path taken from one place to another via National ISP is called route.

⇒ Internet v/s internet.

5/1/24

(Packet Switching Network)



→ All routers are connected through optic fibres.
→ This infrastructure is used to exchange messages between end system

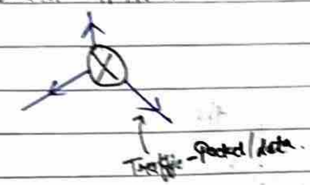
→ Short message - less error } Ex. chinese whisper.
Long msg - More errors

Similarity : In network system : long msg or huge files is divided in small chunks called $\boxed{\text{Packets}}$

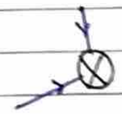
"Packet switching"

→ Packets - sent to server & server responds to it.

Out bound link :



Inbound link :



* Traffic can go & come in a router — System is so called Duplex communication
↓
packets

→ Router does a processing to check where that packet is to be sent.

→ Router generates address to decide which one would be next router.

→ Every switch is storing the packet & then forwarding to next router.

This is called Store & Forwarding

→ This packet is be some no. of bits, let it be l bits. One by one each bit is ~~travel~~ sent. Router can't be ~~compute~~ processed until all the bits are reached to router.

→ Every Router contains ~~Forward~~ Forwarding tables
↳ Protocols are maintained in this table.

→ helps to decide which outbound link to choose for a router.

(~~Book~~ by Forozen) → CN

Delays : are held at each router

⇒

⊛ Delays :

Transmission delay (d_{trans}) :

has nothing to do with the length of the cable / link

The time it ~~takes~~ takes to put (each bit of packet) entire packet on the transmission link.

- Defined in bits/sec = R = Transmission Rate (Xmission rate)
  L = ~~bat~~ length of bits or no. of bits.   X : Trans

$$\boxed{d_{trans} = \frac{L}{R}}$$

→ Bucket − hole − Trans. delay is time taken for bucket to get empty through hole

o → more delay

◯ − less delay

Q) Packet length = 16000 bits
Link transmission Rate = 100 Mbps. (Mega bits per sec)
Find transmission delay :

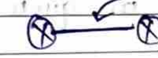
Mbps : v/s
MBps

$$d_{trans} = \frac{16000}{100 \times 10^{6}} = \frac{160}{100 \times 10^{4}} \quad 1.6 \times 10^{-4}$$

$$= \underline{0.16\ ms}$$

Propogation
⊛ ~~Transmission~~ delay :

→ "Each bit" travels though this entire link



This delay Propogation Delay $\boxed{(d_{prop}) = \frac{d}{S}}$ d → dist. S → speed

[↳ It depends on how fast bit can cover
& " " distance bit has to cover.]

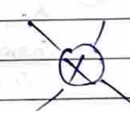
there could be diff. types of cable, depending upon that speed of propogation can vary.

Optic Cable − 3×10^{8} (Speed of cable)

$[2.3 \times 10^{8} - 3 \times 10^{8}]$.

⊛ Processing delay ($d_{processing}$).

↳ Router's processing delay.



delay → konsi link se data lena hai ye decide karne me jo delay aya woh

#Processing delay in router is generally constant.

→ Packets arrived are stored in queue (FIFO)

↳ Queueing delay (d_{queue}).

17/1/24

Q) How long does it take a packet of length 1000 bytes to propagate over a link of distance 2500 km? Propagation speed = 2.5×10^8 m/s. Transmission rate = 2 mbits ps

→ $L = 1000$ bytes
$= 8000$ bits

$d = 2500$ km

$S = 2.5\times10^8$ m/s

$R = 2$ mbps $= 2\times10^6$ bits/s.

$$= \frac{L}{R} + \frac{d}{s} = \frac{8000}{2\times10^6} + \frac{2500\times10^3}{2.5\times10^8}$$

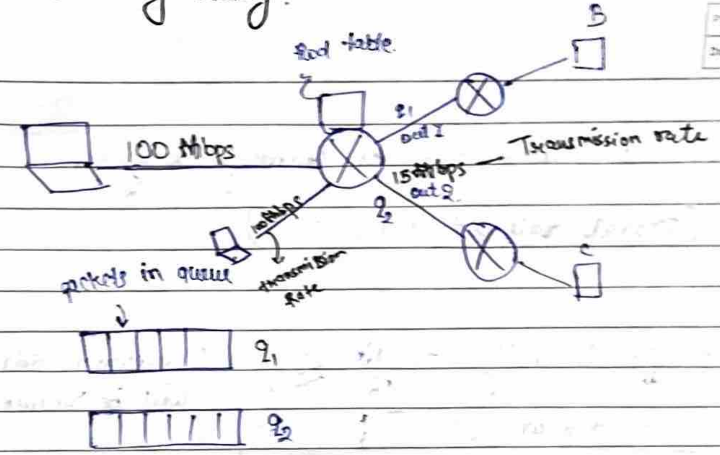
$$= 400\times10^{-5} + 1000\times10^{-5}$$

$$= 1400\times10^{-5}$$

Total delay $= 14$ ms.

Propagation delay $= \frac{d}{S} = \frac{2500\times10^3}{2.5\times10^8} = 10$ m/s.

⊛ Queueing delay.



Delay that a packet is having for being in a queue associated with the outbound link is called Queueing delay.

It does not depends just on R, it also depends on arriving rate

100 Mbps → ⊗ → 15 Mbps ⟹ queueing delay occurs

15 Mbps or 15 Mbps → ⊗ → 100 Mbps or 15 Mbps ⟹ NO queueing delay.

→ Let 'a' be the arrival rate packets/sec., L bits

→ bit arrival rate $= aL$ b/s
bit transmission rate : R b/s

$$\boxed{\text{Traffic Intensity} = \frac{\text{bits arriving rate}}{\text{bit transmission rate}}} = \frac{aL}{R}$$

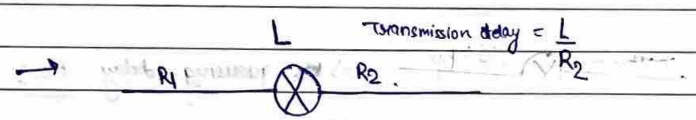
M T W T F S S
Page No.:
Date:

* if $\frac{aL}{R} > 1$: There will be queuing delay.
(arrival rate > transmis^n rate)

⇒ ~~tran~~ traffic intensity (I) ⇒ $\frac{aL}{R} \le 1$: Queueing delays will be reduced.

How are packets arriving?

- Periodically → Periodic traffic
- Bursts → Bursty traffic. ⇒ more queueing delays generally
  - Say 10 pkts are coming every 10 sec.

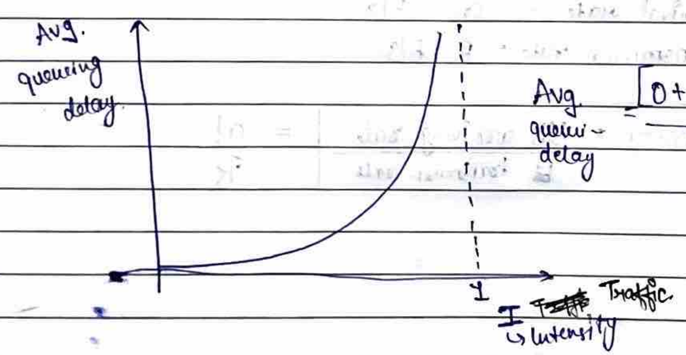
→ 

Transmission delay = $\frac{L}{R_2}$

Ⓧ ⇒ $\frac{L}{R}$ N (no of packets) → Queueing delay for 1st packet = 0

2nd " = L/R.

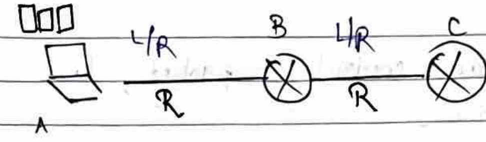
N^{th} packet = $(N-1)\frac{L}{R}$



Avg. queuing delay = $\frac{[0+1+2+\dots(N-1)]\frac{L}{R}}{N}$

→

M T W T F S S
Page No.:
Date:

Q) 

Note: R has nothing to cable or length of cable.

L → length of packets (bits)
R : bps

How much time will it take to reach all the three packets.
→ Assume prop delay is negligible

time to reach C for each packet A → C : $\frac{L}{R} + \frac{L}{R} = \underbrace{\frac{2L}{R}}_{\text{for 1 packet \& 2 links}}$ } considering no que delay, no prop delay

☆ { for each packets n links = $\frac{nL}{R}$ }

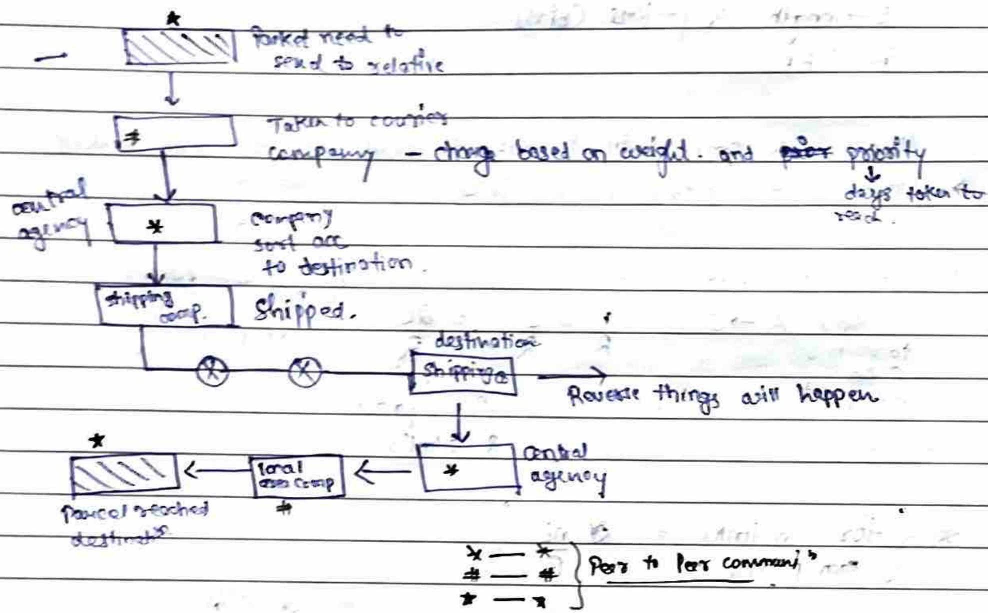
Total time for all packets = $\frac{4L}{R}$. (when 1st is at C, 2nd is at B at 2L/R; at $\frac{3L}{R}$: 2nd is at C & 3rd at B)

↓

★ $\boxed{\text{for } n \text{ packets (Total time)} = \frac{(n+1)L}{R}}$

23/1/24.

→ Emails, web-browsing, congestion control, packet loss, packet error, forwarding tables.



⊛ Protocol Layering :

The changes made a one layer other layers wont be affected. All the layers are independent of each other.

→ There is peer to peer communication at each level.

→ Peer at Senders end understands the peer at receiver's end & vice-versa.

TCP/IP stack

Layers : all are different protocols

Layer	
Application	Software
Transport	Software
Network	some like same s/w
Data Link	implemented in hardware
Physical	implemented in hardware

↳ called network stack, or TCP/IP stack.

This is a part of software in O.S.

⇒ Laptops can connect through wifi, Ethernet, Bluetooth, & zigbee
Network Interface cards
Also called Network Adaptors.

→ Network Interface cards – implemented by (or in) last two layers.

→ TCP/IP stack

→ All starts @ Application protocol : this layer generates & sends messages & received a receiving end. → Present at sender as well as receiver end.

for sending a file – FTP (File transfer protocol)

sending a message/mail – SMTP

accessing webpage – HTTP

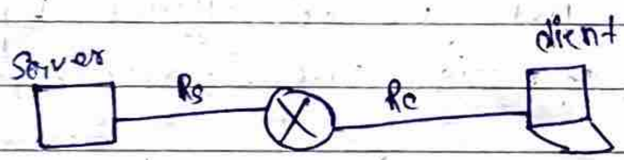
⇒ DNS (Domain name server)

22/1/24

⊛ Throughput: (τ)

Rate at which bits are being received at destination.

→ (bits/s)

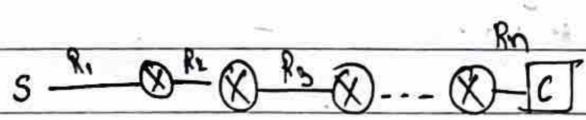


→ if $R_s < R_c$ ⇒ Since packets are coming to client not greater than R_s, so here throughput is R_s bits/s.

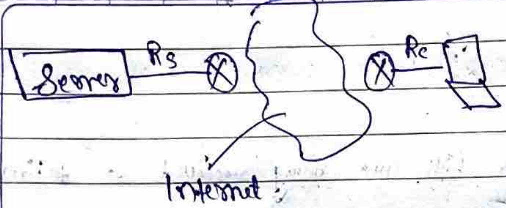
→ if $R_c < R_s$: throughput = R_c bps

$$\boxed{\tau = \min(R_s, R_c)}$$

\# Min is called ~~bottom~~ bottle-neck link



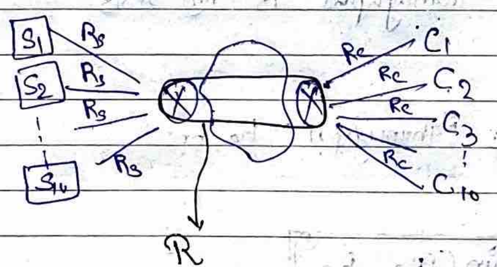
$$\boxed{\tau = \min(R_1, R_2, \dots R_n)}$$



Consider only traffic is file we want.

Our download speed is not affected by Internet as internet's transmission rate is very high

so $\hookrightarrow$ $T = \min(R_s, R_c)$



R → common link shared by all 10 on internet

Say: R_s = 1 Mbps.

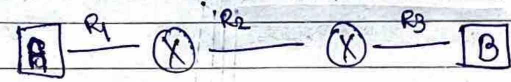
R = 5 Mbps ← each user takes 0.5 Mbps = 500 kbps

R_c = 500 kbps. → so it now becomes limiting factor,

Here, ~~bottl~~ bottle neck link.

→ if R is say 100 times or more larger than R_s, R_c, then there would have been no issue with it. ← like 100 Gbps..etc.

Q) Suppose host A wants to send a large file to Host B, path from A to B has 3 links of rate $R_1 = 500$ kbps, $R_2 = 2$ Mbps, $R_3 = 1$ Mbps.



Assuming no traffic: $T = 500$ kbps.

→ File size = 4 million bytes; How much time does it take to transfer it from A to B

$$size = 4 \times 10^5 \times 8$$

$$time = \frac{4 \times 8 \times 10^{8}}{500 \times 10^{3}}$$

= 64 sec

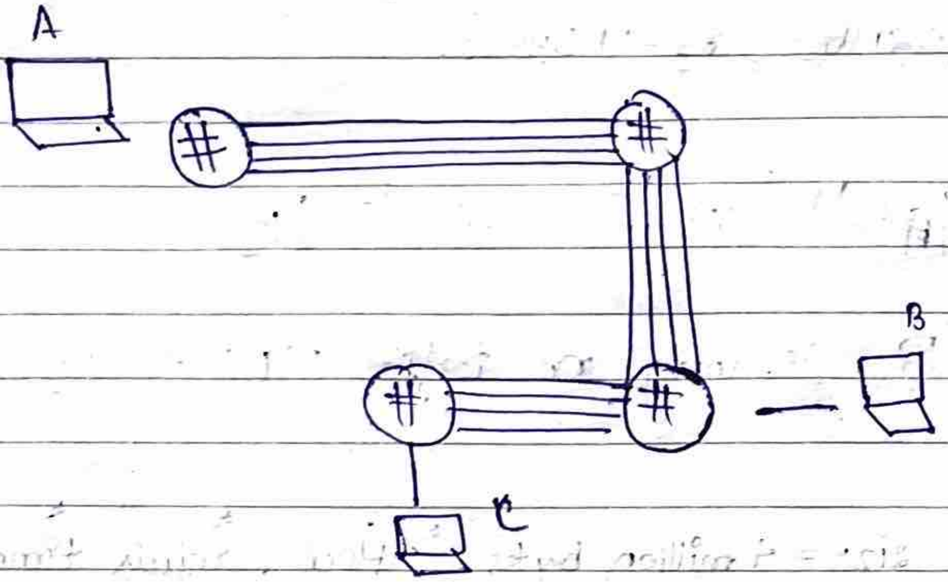
(X) → Packet Switches.

(#) → Circuit switches

PAGE NO. 2
DATE: / /

Read abt it — Book

Circuit Switched Network :



→ Packet switches have reservation for resources.

→ first reservation is made & buffer queue is made

disadv. {
1) Resources will be reserved for all time.
2) No of user are limited.
}

Virtual circuits : All times ckts are not reserved for VIP traffic

[1st Unit : Kurose & Ross] ✓ — Unsolved examples (class)
[Forouzan : 5th ed.]

23/1/24.

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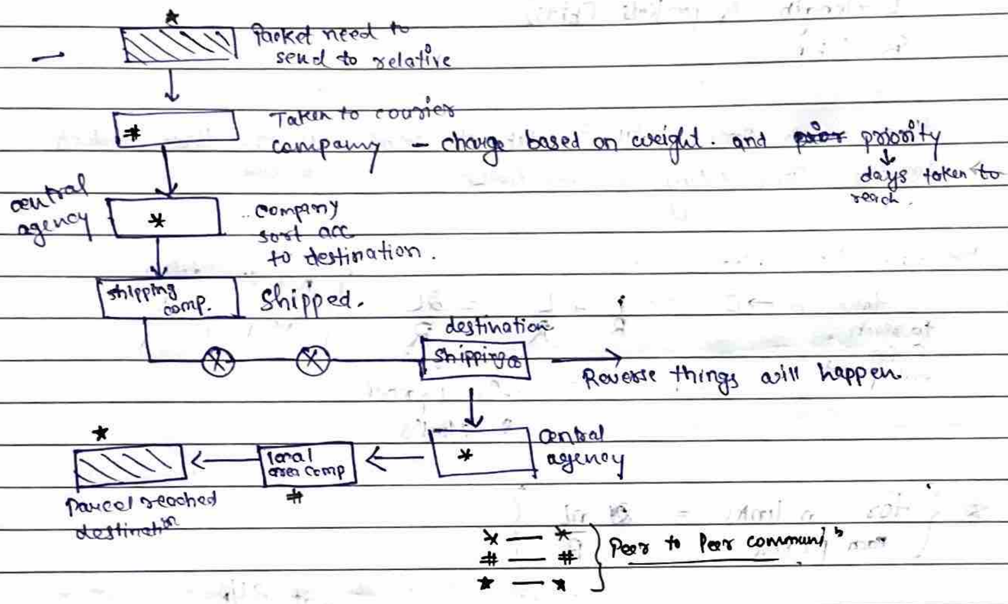

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Network } some h/w some s/w

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M T W T F S S
Page No.:
Date:

Transport layer:

⇒ Application layer transfers ~~...~~ messaging data to Transport layer

⇒ Transfer → Lossy : connection less service
→ Lossless : Connection oriented service

⇒ TCP - Transmission Control Protocol - Provides lossless service
UDP - User Datagram protocol - Provides lossy service
↳ few packets gets loss not many

UDP used [Say few bits lost for ~~videos~~ videos there won't be ~~to~~ much issue.

TCP used [But if same happens to mail/message info gets lost

→ Here there are multiple protocol here taking care of errors & losses

Network layer:
↳ ~~...~~ Entire path of how packet travels from src - desti^n is decided by this layer

→ Protocol used : IP (Internet Protocol).

M T W T F S S
Page No.:
Date:

Data Link:
↳ Packets to router

→ Also handles errors & losses.

→ 3 data links - Based on frequency (Wifi, Ether, BT)

→ 3 Physical links

→ Radio frequency : 88 to 108 MHz reserved

→ Freq of BT, Wifi ? ⇒

Internet v/s internet
↓
If network is using "IP", it becomes Internet.

↳ network of networks.
↳ we were studying till now