CN (IT-3001)

Networking Devices, Switching

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Content

- Networking Devices
  - Hub, switches, routers, gateway, etc.
- Different Switching techniques:
  1. Circuit Switching
  2. Message Switching
  3. Packet Switching
     - Virtual Circuit Switching
     - Datagram switching

Types of connecting devices in a network

- Basically, we have five connecting devices: **Repeater, Hubs**, **Switch, Routers, Bridges,** and **Gateways.**

Repeater/Hub

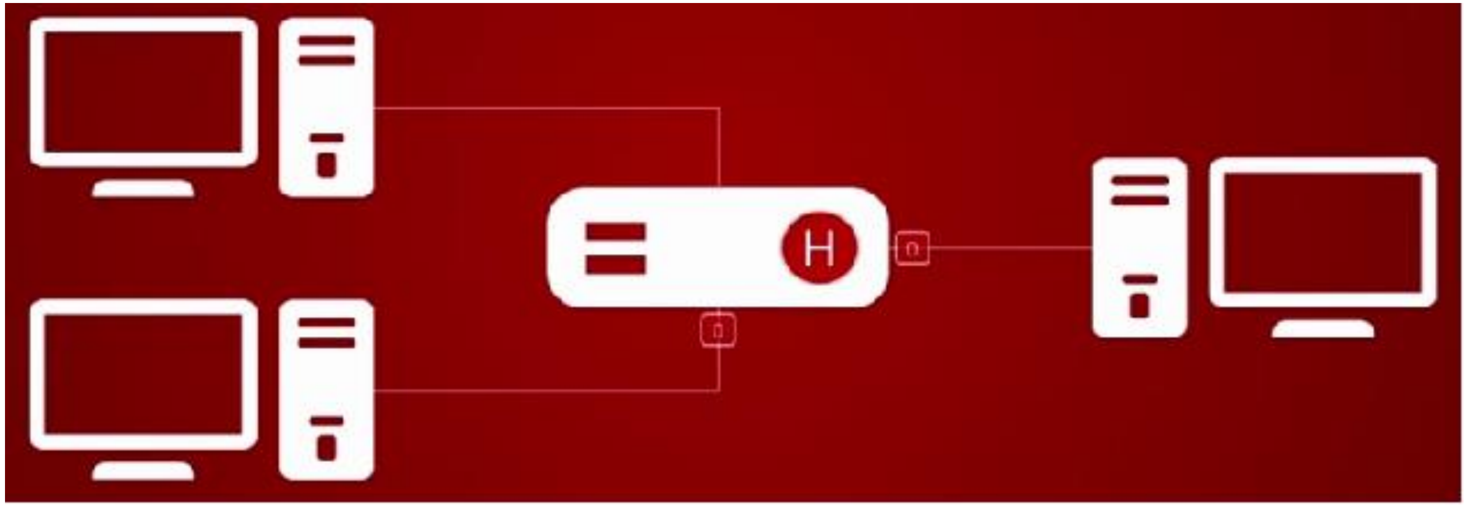


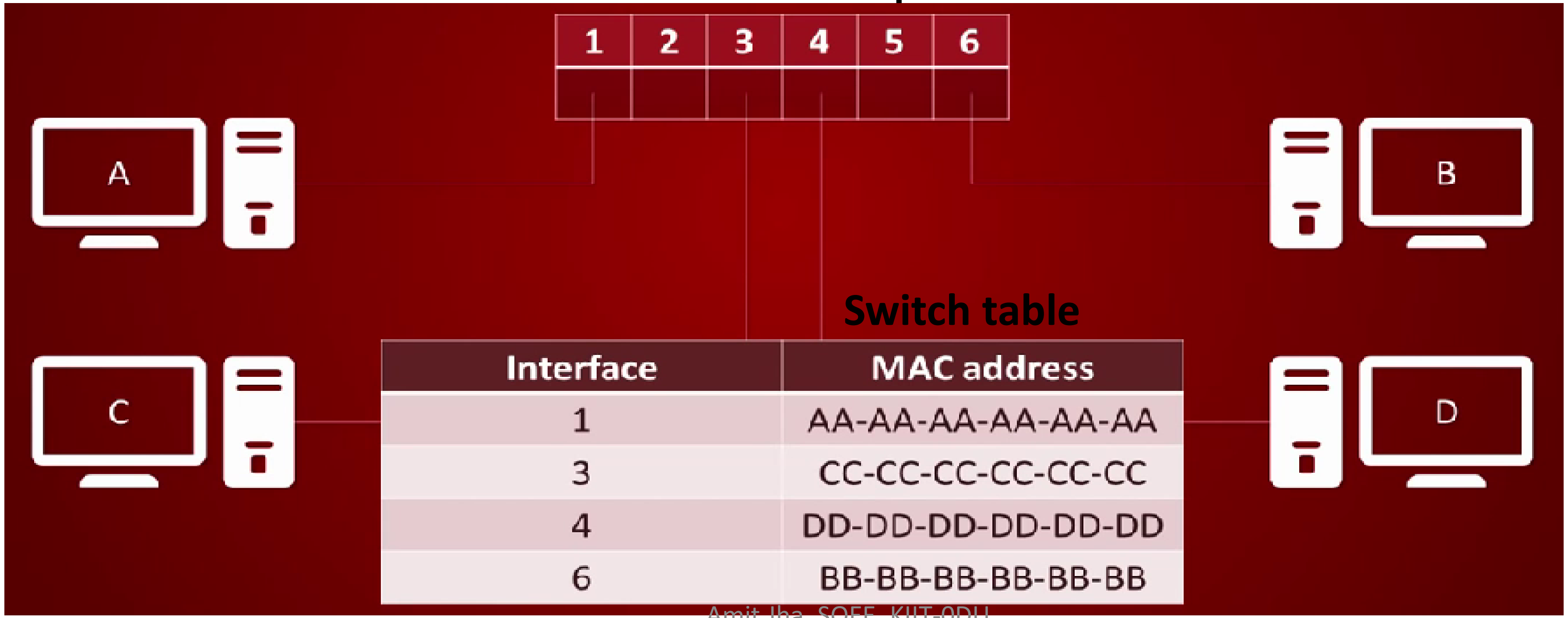
Fig. Network with a hub

How a repeater/hub behaves

- It does not know anything about the packets(from network layer) i.e., to whom does it belong to.
- It sends packets to each device connected to it.
- It is the simplest and cheapest way to create a network.
- But it generates **lots of unnecessary traffic.**
- Thus, wastage in Bandwidth.
- Security is an issue.

Switch/Bridge

- It is smarter brother of hub.
- It sends packets to the exact destination without spanning the entire network.
- Each device has NIC card with a unique MAC address.



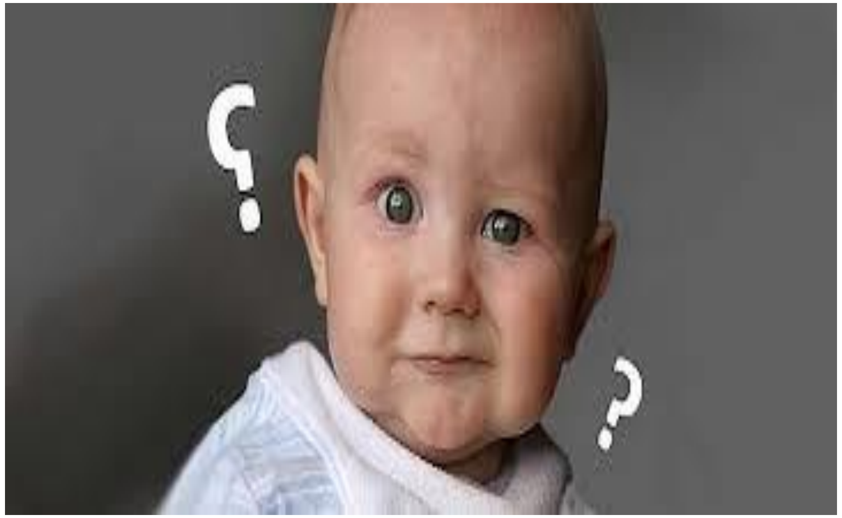
Interface	MAC address
1	AA-AA-AA-AA-AA-AA
3	CC-CC-CC-CC-CC-CC
4	DD-DD-DD-DD-DD-DD
6	BB-BB-BB-BB-BB-BB

Fig. Network with a switch

How a Switch behaves?

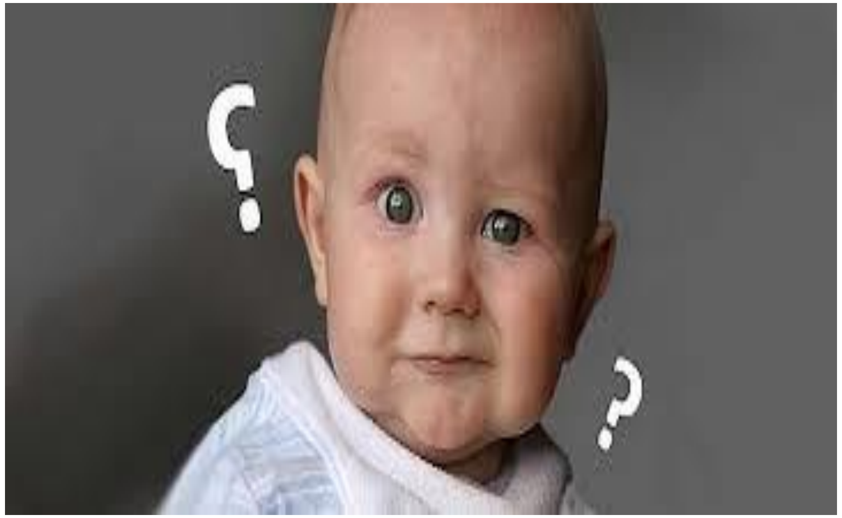
- Every device has a unique MAC address printed on NIC card.
- Every packet is sent to the specific destination only.
- Thus, No flooding of packets.
- No traffic (B.W) problem.
- Not only the Ethernet connections but also Wi-Fi uses it.

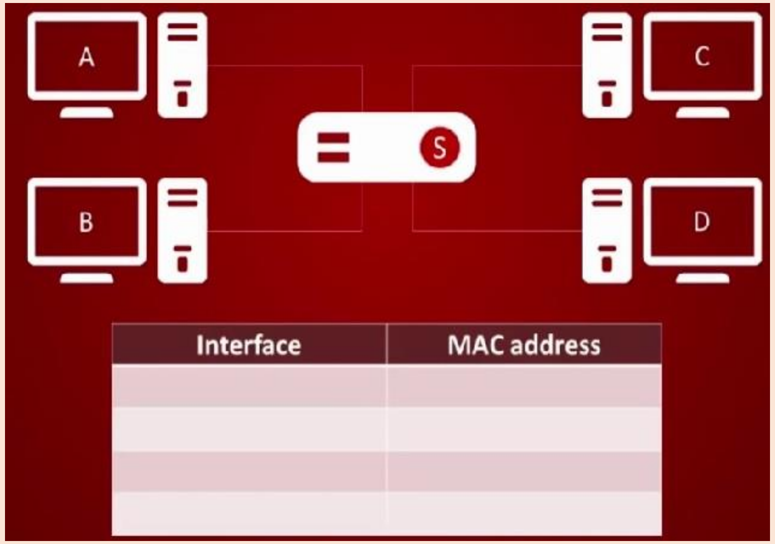
- ***How does a switch know the MAC address of every devices?***



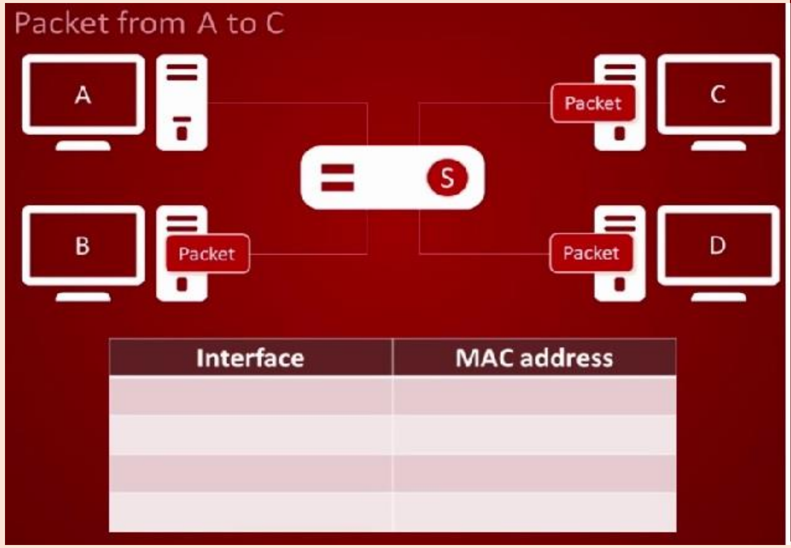
- ***How does a switch know the MAC address of every devices?***

Ans: *The switch table.*

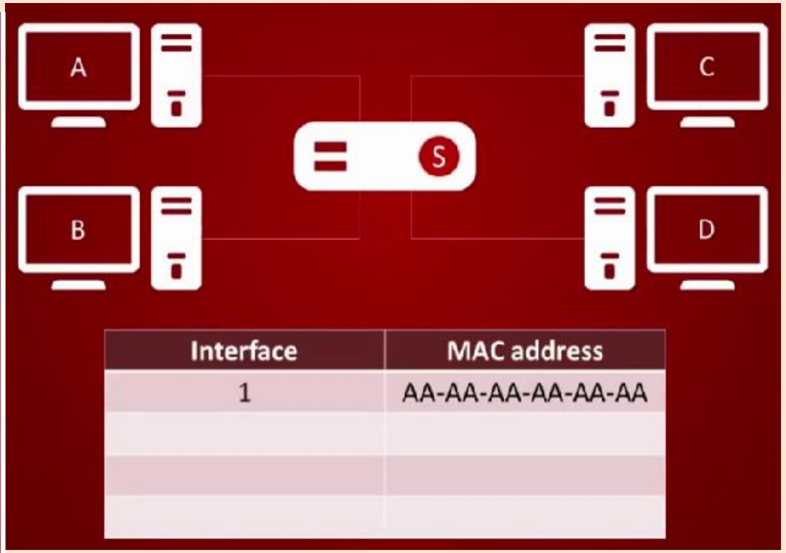




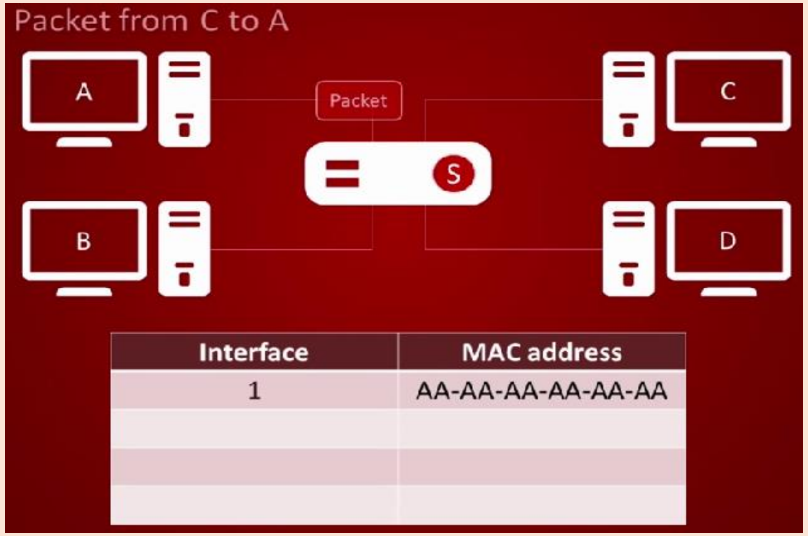
Step 1: Initially switch is empty



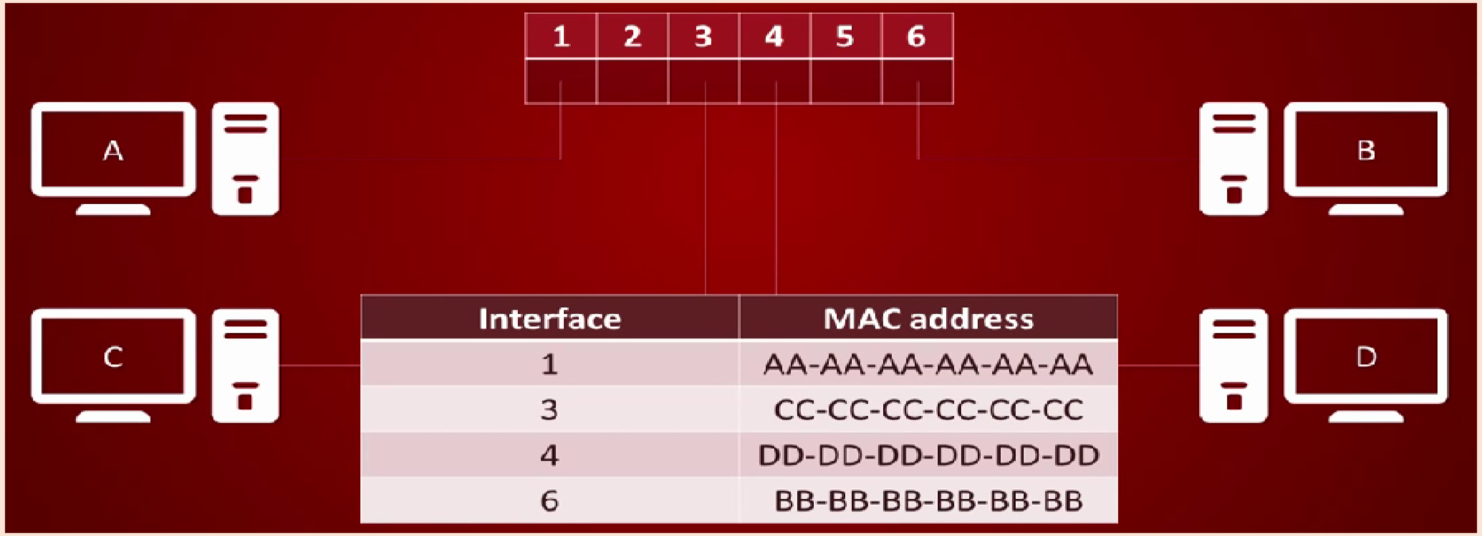
Step 2: Flooding of packets



Step 3: Previously used MAC address is now known



Step 4: No flooding



Step 5: Finally, the switch table is created with the same process

Router

- It is the glue that ties networks together.
- Hubs and switches are the devices use to create networks.
- But if we want to send packets between those networks then routers come into the picture.
- We need routers to send packets from our laptop to search engine server over the Internet.
- Once, we send packets to our ISP, routers make sure that packets is passed on from network to network to reach search engine server.
- We can use routers at home as well.
- Some other functions of a router includes
  - Performing network address translation
  - Assigning IP address to hosts using DHCP
  - Broadcasting a WiFi signal (i.e., acts as an access point for WiFi)

How does a router behaves?

Fig. Why do we need routers?

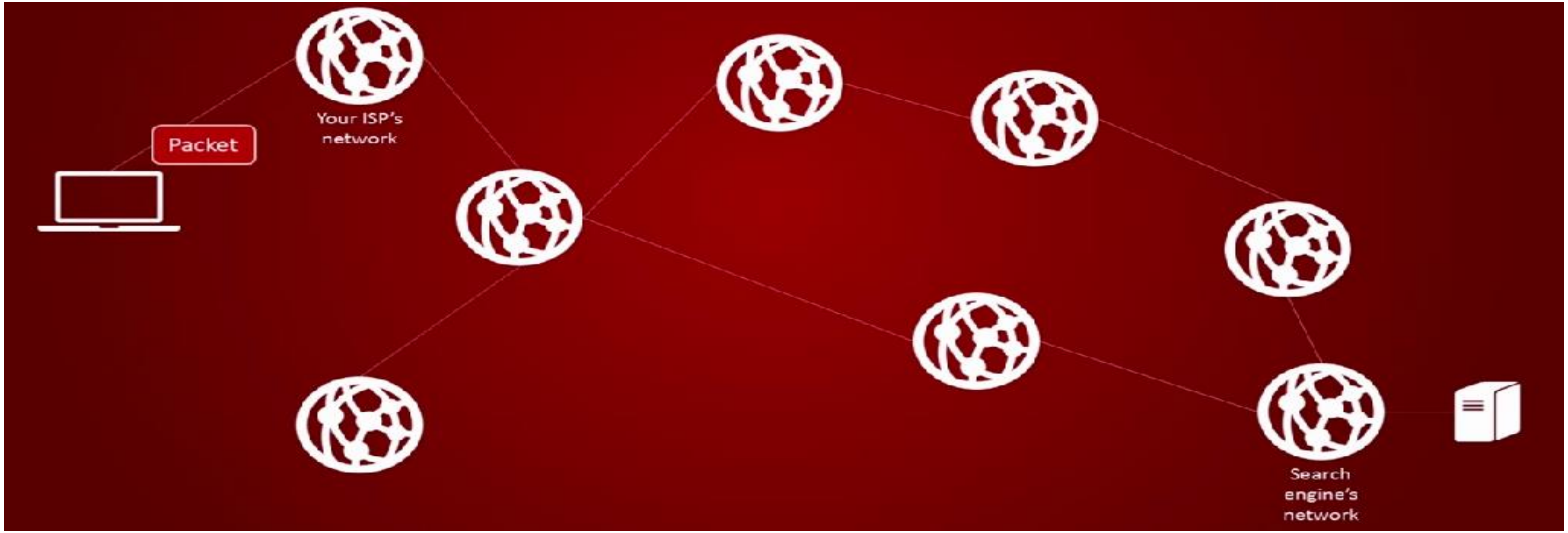


Fig. Routers on the Internet

Can we use any connecting devices at any layer?

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No…

Use of different connecting devices in a network

Application Layer	Gateway	Application Layer
Presentation Layer		Presentation Layer
Session Layer		Session Layer
Transport Layer		Transport Layer
Network Layer	Router	Network Layer
Data Link Layer	Switch/Bridge	Data Link Layer
Physical Layer	Repeater/Hub	Physical Layer

DNS: Domain Name System
www.chillmaro.com

Socket Address
IP+Port Number
(4 or 16) + 2 Bytes

IP address 10.0.73.23
(4 or 16 Bytes)

MAC address
00-01-42-13-24-AB
(6 Bytes)

Raw data
0011010101...

What should you buy?

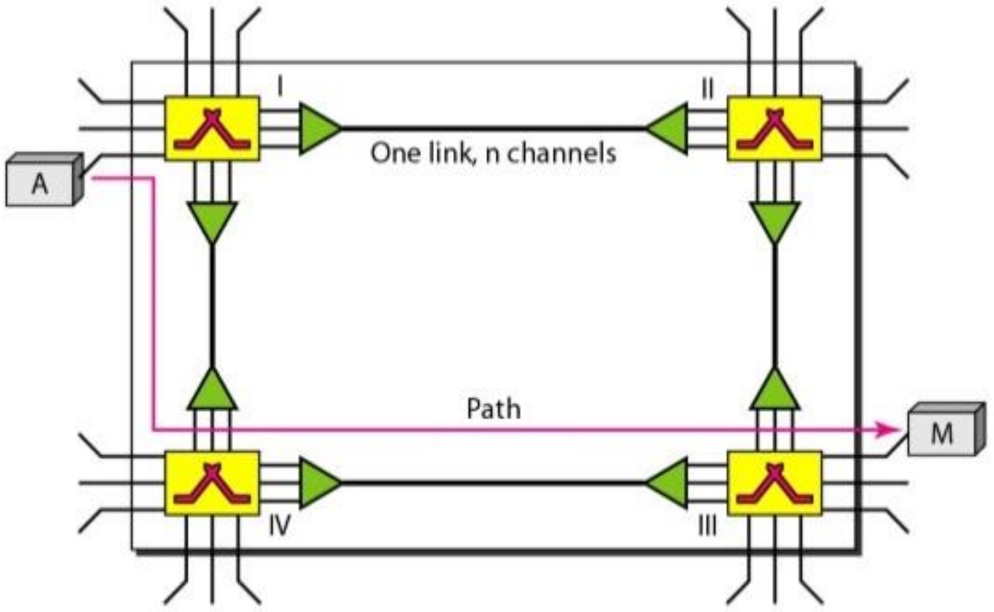
- Don’t buy a hub because
  - They are bandwidth wasters.
  - Switches are not expensive than hub. So buy a switch instead of a hub,
- Switch
  - is cheaper than a router.
  - We can still connect the switch to a router
  - Quicker than routers for internal communications
  - Many routers have the Ethernet switch built in
- Router
  - It connects a network with the other networks.

Switching

- Traditionally, three methods of switching have been important: ***circuit switching***, ***message switching***, and ***packet switching***.
- The first and last are commonly used today, the middle one has been phased out in general communications but still has networking applications.
- We can then divide today's networks into three broad categories: ***circuit-switched networks***, ***message-switched networks***, and ***packet-switched networks***.
- Packet-switched networks can further be divided into two subcategories datagram networks and virtual-circuit networks.

Circuit-Switched Networks

A trivial circuit-switched network



- It is made of a set of switches conn-ected by physical links, in which each link is divided into *n* channels.
- In the **circuit-switched network,** there are 4 switches and 4 links.
- Each link is divided into *n (n=3, here)* channels by using FDM or TDM.
- In circuit switching, the resources need to be reserved during the setup phase; the resources remain dedicated for the entire duration of data transfer until the teardown phase.

Circuit switching: Key points

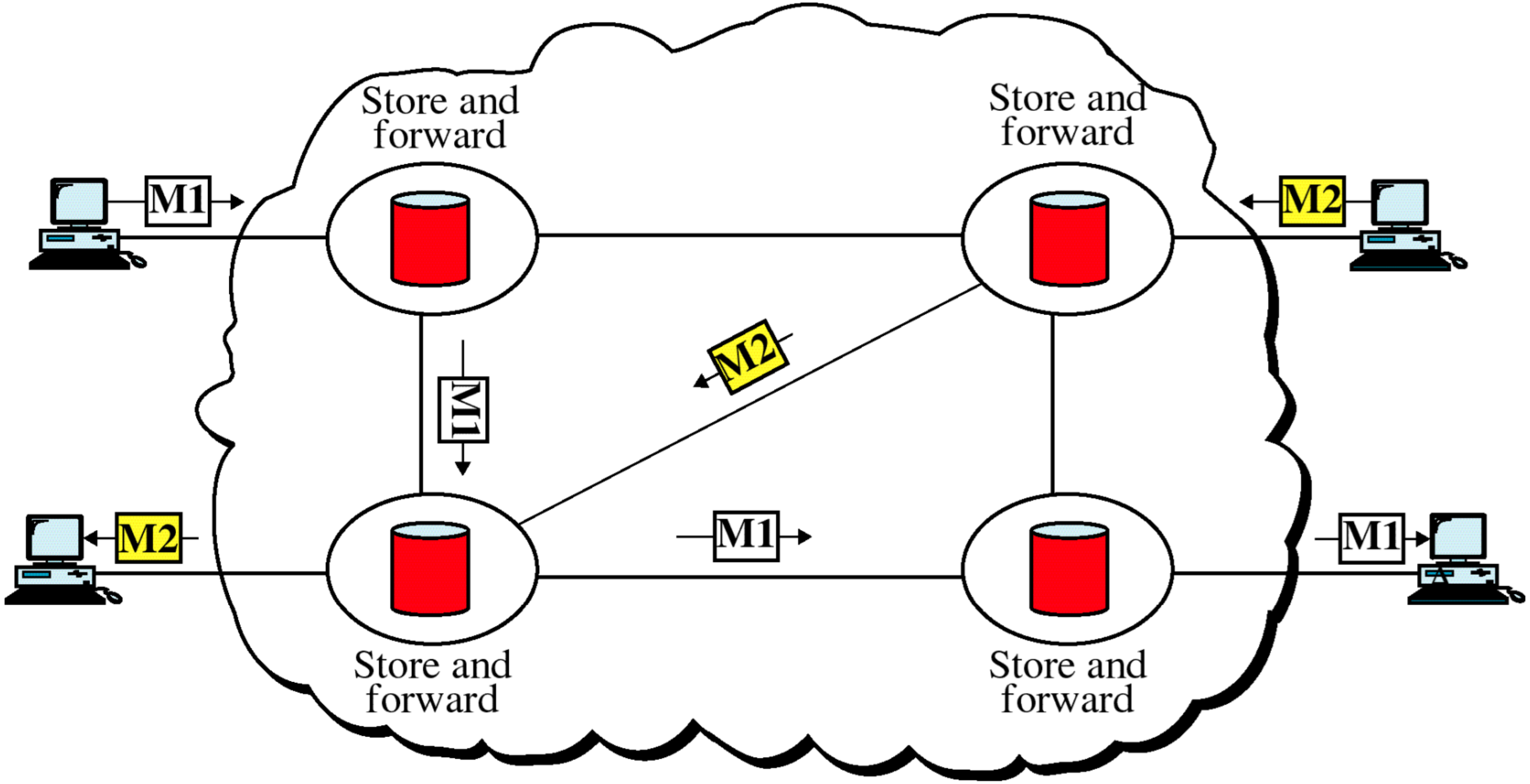
- ***Circuit switching*** is a technique that directly connects the sender and the receiver in an unbroken path.
- Telephone switching equipment, for example, establishes a path that connects the caller's telephone to the receiver's telephone by making a physical connection.
- With this type of switching technique, once a connection is established, a dedicated path exists between both ends until the connection is terminated.
- Three phases in circuit switching are Establish, Transfer, Disconnect.
- Routing decisions must be made when the circuit is first established, but there are no decisions made after that time.
- Ex: It is used in telephone networks.

- ***Advantages:*** The communication channel (once established) is dedicated.
- ***Disadvantages:***
  - Possible long wait to establish a connection, during which no data can be transmitted.
  - More expensive than any other switching techniques, because a dedicated path is required for each connection.
  - Inefficient use of the communication channel, because the channel is not used when the connected systems are not using it.

Message Switching

- With message switching there is no need to establish a dedicated path between two stations.
- When a station sends a message, the destination address is appended to the message.
- The message is then transmitted through the network, in its entirety, from node to node.
- Each node receives the entire message, stores it in its entirety on disk, and then transmits the message to the next node.
- This type of network is called a store-and-forward network.

A Message Switched Network



Message Switching: Key points

- A message-switching node is typically a general-purpose computer.
- The device needs sufficient secondary-storage capacity to store the incoming messages, which could be long.
- A time delay is introduced using this type of scheme due to store-and-forward time, plus the time required to find the next node in the transmission path.
- Example application: Although, we do not see its application at lower layer, it is still used in some applications like electronic mail (e-mail).

- ***Advantages:***

- Channel efficiency can be greater compared to circuit-switched systems, because more devices are sharing the channel.
- Traffic congestion can be reduced, because messages may be temporarily stored in route.
- Message priorities can be established due to store-and-forward technique.

- ***Disadvantages:***

- Message switching is not compatible with interactive applications.
- Store-and-forward devices are expensive, because they must have large disks to hold potentially long messages.

Q.) Which are the factors on which we need to work on?

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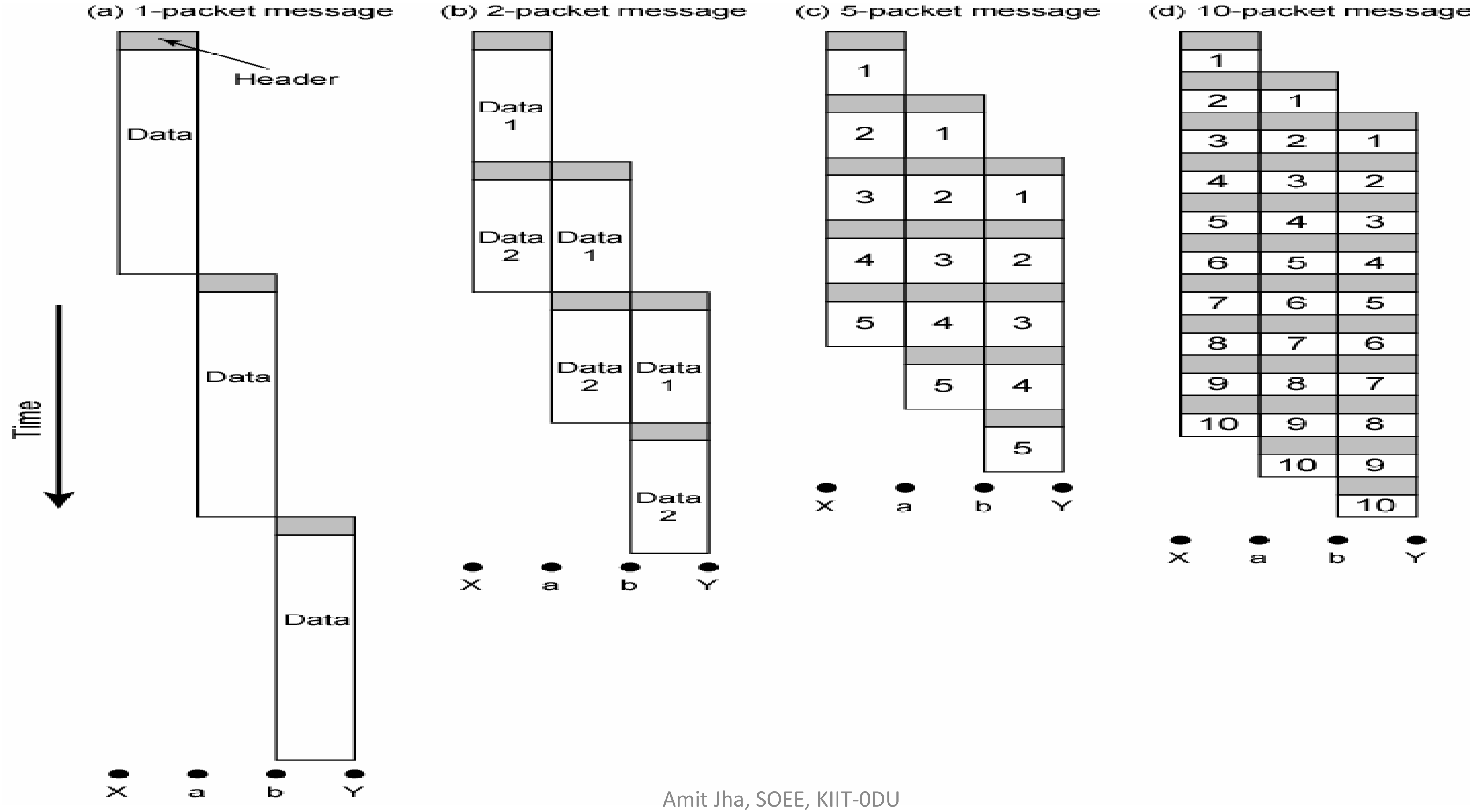
Ans)

- The first and foremost, we don’t want dedicated channels.
- It will be better to divide message into **packets** bcz
  - Long message has more chances to **incur error** than short packets.
  - Long message is not suitable for interactive application because it causes very **long waiting delay** on other messages.
  - Moreover, the delay for one message is generally longer than the **total delay of packets** the message is divided into.

Confused ????????????????????

Packet Size and its importance



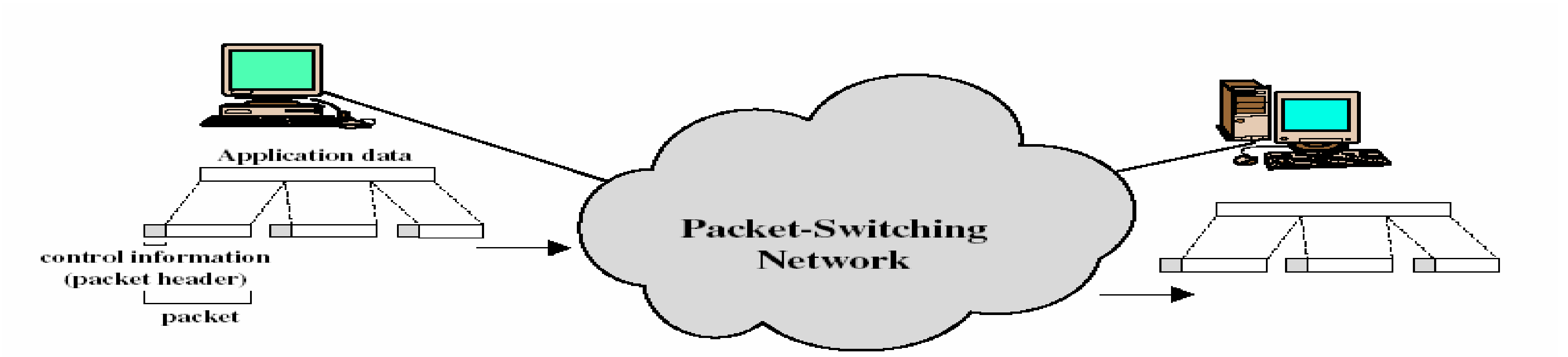
Packet Switching

- ***Packet switching*** can be seen as a solution that tries to combine the advantages of message and circuit switching and to minimize the disadvantages of both.
- There are two methods of packet switching: **Datagram** and **virtual circuit.**
- In both packet switching methods, a message is broken into small parts(fixed or variable), called packets.
- Each packet is tagged with appropriate source and destination addresses.
- Since packets have a strictly defined maximum length, they can be stored in main memory instead of disk, therefore access delay and cost are minimized.
- Also the transmission speeds, between nodes, are optimized.
- With current technology, packets are generally accepted onto the network on a first-come, first-served basis. If the network becomes overloaded, packets are delayed or discarded (``dropped'').

Packet Switching: Key points

- In a packet switched, message needs to be divided into packets of fixed or variable size.
- The size of the packet is determined by the network and the governing protocol.
- Resources are allocated on demand on a first-come, first-served basis.
- Packet switching is further classified as:
    - Datagram Switching and
    - Virtual Circuit Switching

Using Packet Switching: A Quick Look



packet header contains routing information

Intermediate nodes(routers) store the packet, decide the route, and forward the packet: processing delay

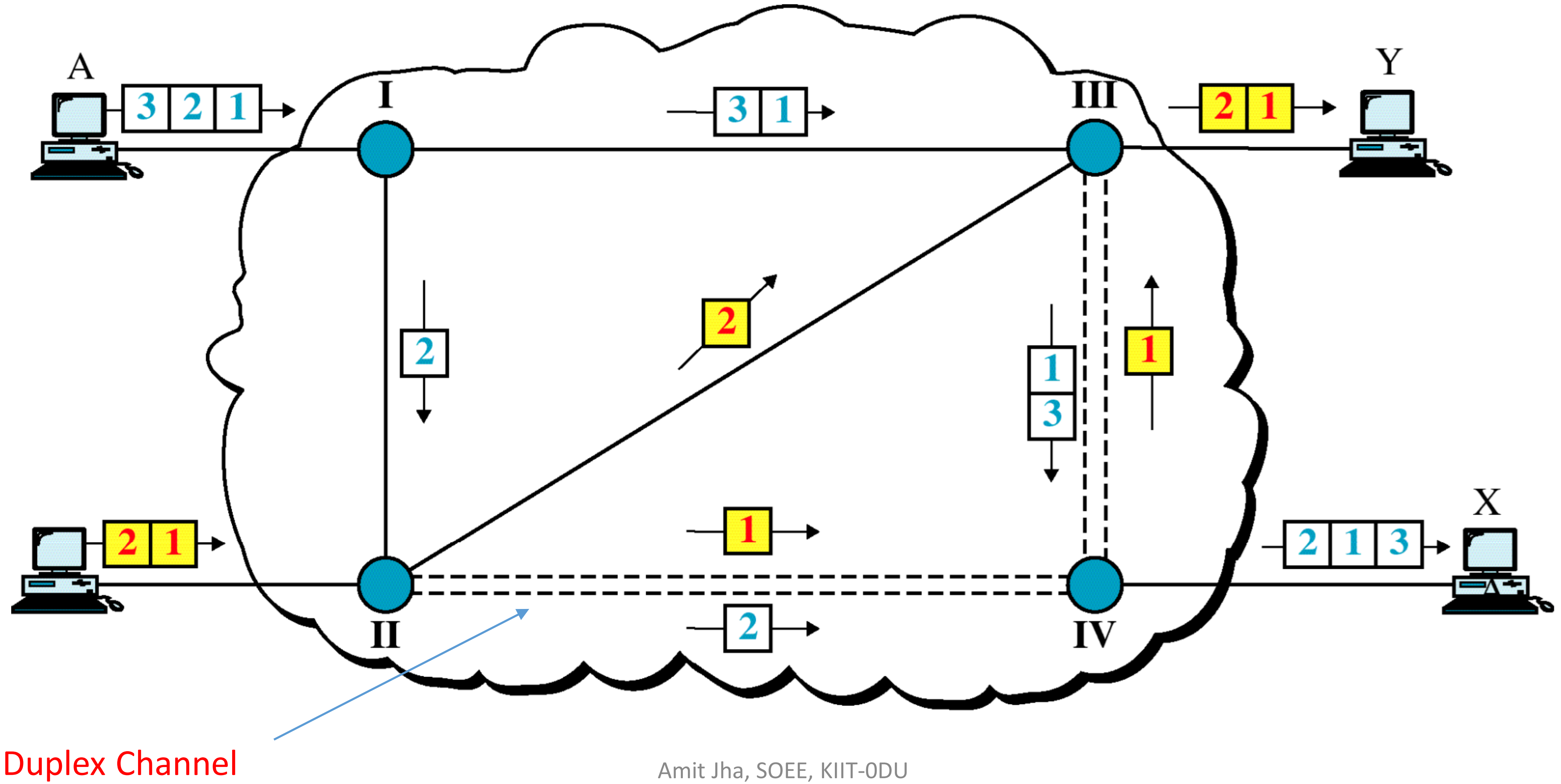
Packet Switching Implementation

- Station breaks long message into packets
- Packets sent one at a time to the network
- Packets are handled in two different approaches
  - Datagram Service (Connection less)
  - Virtual circuit (Connection oriented)

Packet Switching: Datagram Service

- In a datagram network, each packet is treated independently of all others, even if they belong to the same message.
- It is generally done at network layer.
- For each packet, each node makes its own decision as to how to forward it so that it eventually reaches its destination.
- Different packets may take different paths to reach to the same destination.
- Thus, reordering may required but at the destination only.
- It is possible for a packet to be destroyed if one of the nodes on its way is crashed momentarily. Thus all its queued packets may be lost.
- It is called ***connection less*** bcz setup or teardown phases are not required

A datagram network with four switches(routers)



Datagram Switching: Key points

- Each packet contains a full destination address.
- Packets can take **any practical route**.
- Each packet is treated independently.
- Packets may arrive **out of order** (so receiver may require re-ordering)
- Packets may go mission (end node handles recovery of missing packets)
- *It is best effort network.*
- Store and forward operation required at each node for each packet
- Connection less protocol: Ethernet, IP, UDP
- Ex: Internet using IP, voice and video communication and notifying message to alert a user that he/she has received a new e-mail(using UDP)

Q) If there are no setup or teardown phases, how are the packets routed to their destination in a datagram network?

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Ans: In this type of network, each switch has a **routing table** based on destination address. The routing tables are dynamic and updated periodically.

Packet Switching: Virtual-Circuit

- In this, a pre-planned route is established before any data packets are sent.
- A **logical(virtual)** connection is established when
  - A sender sends a “call request packet” to the receiver.
  - The receiver sends back an acknowledgement packet “call accepted packet” to the sender the receiver agrees on conversational parameters.

- The conversational parameter can be maximum packet size, path to be taken, and other variables necessary to establish and maintain the conversation.

- In virtual circuit, the route between stations does not mean that this is a dedicated path, as in circuit switching.

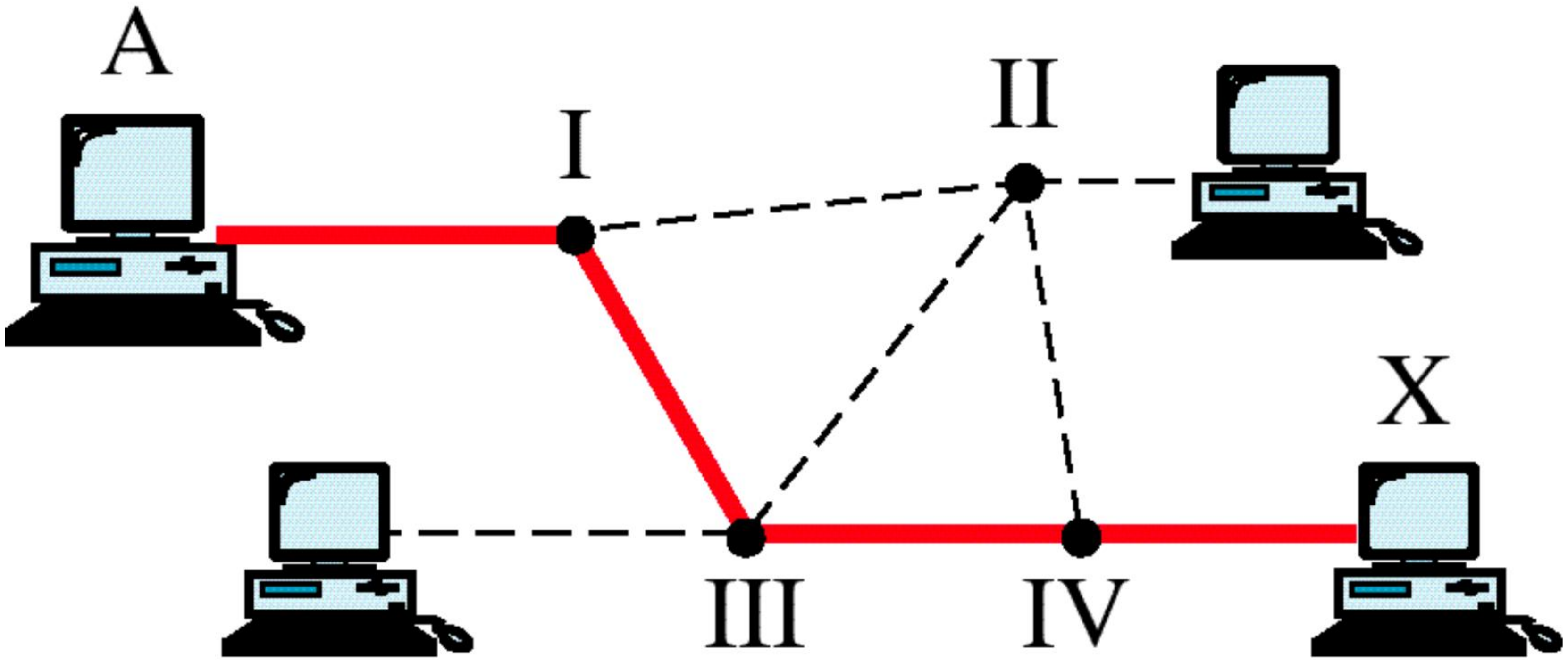
- In virtual circuit approach, routing decision is not made every time for all packets.

Routing decision is made only once for all packets using that virtual circuit.

Packets transfer involves basically three steps:

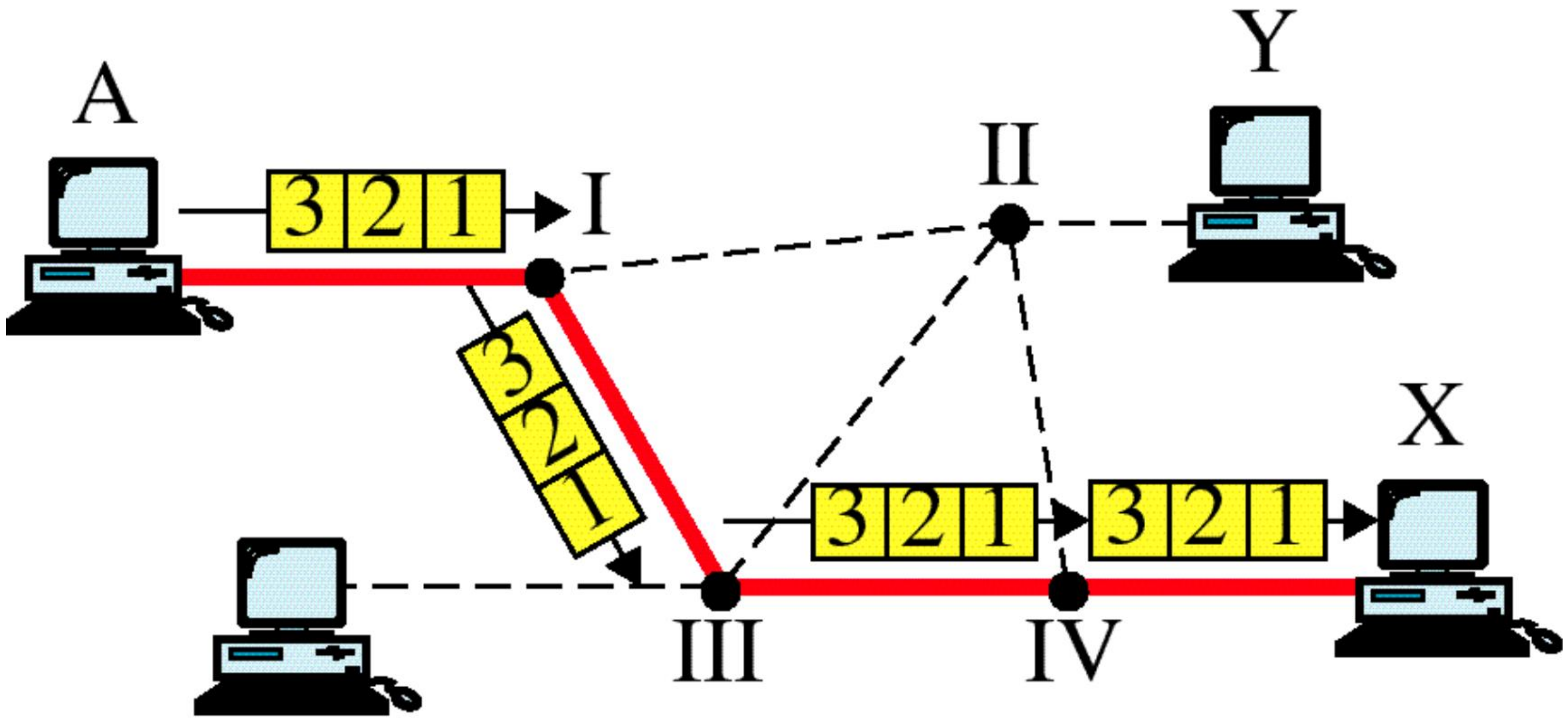
- Connection establishment
- Data transfer
- Connection release

Step 1 of VC: Connection establishment



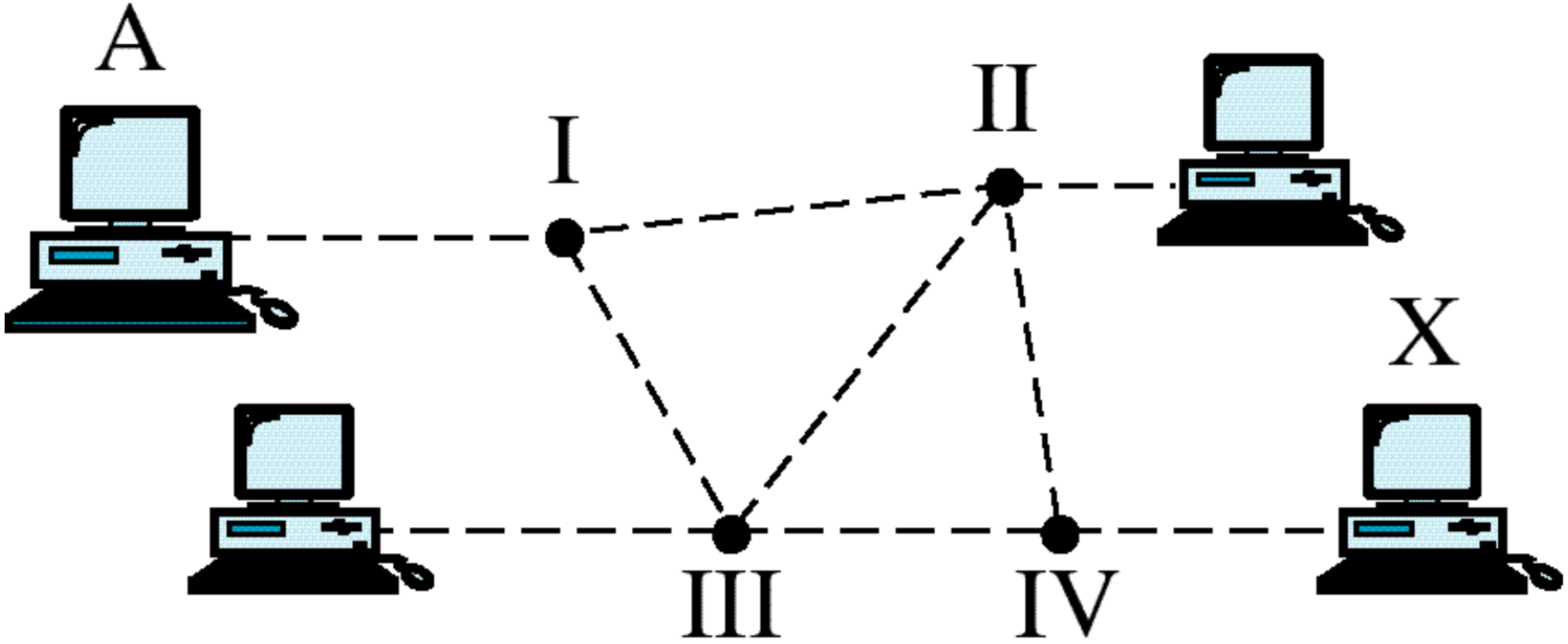
Connection establishment

Step 2 of VC: Data Transfer



Data transfer

Step 3 of VC: Connection Release



Connection release

Virtual-Circuit: Key Points

- A packet is still buffered at each node and queued for output over line
- VC's offer guarantee that
  - The packets sent arrive in order at the destinations
  - No duplication of the packets or omission
  - No error
- **Routing decision is made only once** for all packets using that virtual circuit.
- Packets are forwarded more quickly as no routing decision to make every time.

• Intermediate nodes need to do store and forward in both the cases.

- **Advantages of Packet Switching**
  - **Line efficiency**: maximize link efficiency by making optimal use of link bandwidth
  - **Robust** against link and node failure
  - Data rate conversion: Nodes buffer the data if required to equalize rates
  - Packets are accepted even when network is busy
  - Priority **c**an be used
  - Cost effective
- **Disadvantages of Packet Switching**
  - Protocols for packet switching are typically **more complex**
  - Packet switched system **still can’t deliver the same quality** as delivered by circuit switched system.
  - If packet is lost, sender needs to retransmit the data.
  - It can add some initial cost in implementation.

A comparison of circuit switched and packet switched(connection less) system

Item	Circuit-switched	Packet-switched
Call setup	Required	Not needed
Dedicated physical path	Yes	No
Each packet follows the same route	Yes	No
Packets arrive in order	Yes	No
Is a switch crash fatal	Yes	No
Bandwidth available	Fixed	Dynamic
When can congestion occur	At setup time	On every packet
Potentially wasted bandwidth	Yes	No
Store-and-forward transmission	No	Yes
Transparency	Yes	No
Charging	Per minute	Per packet

Circuit Switching	Virtual Circuit Packet Switching
Dedicated path is established before communication	No dedicated path
Message is sent as it is	Message is broken into small parts called ***Packets***
No Store-and-forward transmission	store-and-forward transmission
Processing delay is incurred at each node During call setup; but it is incurred during call accept signal as connection already has been setup	Processing delay is incurred during call setup; also during call accept because of store and forward technique
Constant data rate	Constant data rate is not guaranteed because of store-and-forward of packets at all nodes
Money is charged as per minute	Money is charged as per packets
No overhead bits after call setup	Overhead is present in each packet

Performance Metrics for Packet Switched Network

- We are going to see only two performance metrics used to analyse the performance of a packet switched networks.
    1. Throughput
    2. Latency

1. **Throughput:** The throughput is a measure of how fast we can actually send data through a network.

Can we say that bandwidth in bits per second and throughput are same?

No, they are not same even they sound like.

- A link may have a bandwidth of *B* bps, but we can only send *T* bps through this link with *T* always less than *B*. In other words, the bandwidth is a potential measurement of a link; the throughput is an actual measurement of how fast we can send data.

Confused ?

- For example, we may have a link with a bandwidth of 1 Mbps, but the devices connected to the end of the link may handle only 200 kbps. This means that we cannot send more than 200 kbps through this link.
- Imagine a highway designed to transmit 1000 cars per minute from one point to another. However, if there is congestion on the road, this figure may be reduced to 100 cars per minute. The bandwidth is 1000 cars per minute; the throughput is 100 cars per minute.

- **Ex.** A network with bandwidth of 10 Mbps can pass only an average of 12,000 frames per minute with each frame carrying an average of 10,000 bits. What is the throughput of this network?

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- **Sol:** Throughput= (12000*10000)/60= 2Mbps

Observation: The throughput is almost one-fifth of the bandwidth in this case.

2. Latency (Delay)

- The latency or delay defines how long it takes for an entire message to completely arrive at the destination from the time the first bit is sent out from the source.
- Latency is made up of four components: *propagation time*, *transmission time*, *queuing time* and *processing delay*.

so,

Latency = propagation time + transmission time + queuing time + processing delay

1) Propagation Time: Propagation time measures the time required for a bit to travel from the source to the destination.

Propagation Time = Distance/ Velocity

2) Transmission Time: This is the time required to send a complete message.

Transmission Time = Message size/ Bandwidth

3) Queuing Time: the time needed for each intermediate or end device to hold the message before it can be processed.

The queuing time is not a fixed factor; it changes with the load imposed on the network.

4) Processing time: Time required to process the message like error detection, acknowledgement, correction, etc).

Practice Session to Chapter-01

Ex 1: What are the propagation time and the transmission time for a 2.5 Kbyte message (an e-mail) if the bandwidth of the network is 1 Gbps? Assume that the distance between the sender and the receiver is 12,000 km and that light travels at 2.4 x 10^8 *mls.*

Practice Session to Chapter-01

Ex 2: A device is sending out the data at the rate of 1000 bps.

a. *How long does it take to send out 10 bits?*

b. *How long does it take to send out a character (8 bits)?*

c. *How long does it take to send a file of 100,000 characters?*

Practice Session to Chapter-01

Ex 3: A device is sending out the data at the rate of 1000 bps.

a. *How long does it take to send out 10 bits?*
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c. *How long does it take to send a file of 100,000 characters?*

Practice Session to Chapter-01

Ex 4: A file contains 2 million bytes. How long does it take to download this file using a 56 Kbps channel (dial-up modem)?

Practice Session to Chapter-01

Ex 5: What is the transmission time of a packet sent by a station if the length of the packet is 1 million bytes and bandwidth of the channel is 200 Kbps.

Practice Session to Chapter-01

Ex 6: What is the length of a bit in a channel if the propagation speed in the medium is 2×10^8m/s and the channel bandwidth is

a. *1 Mbps ?*
b. *10 Mbps ?*

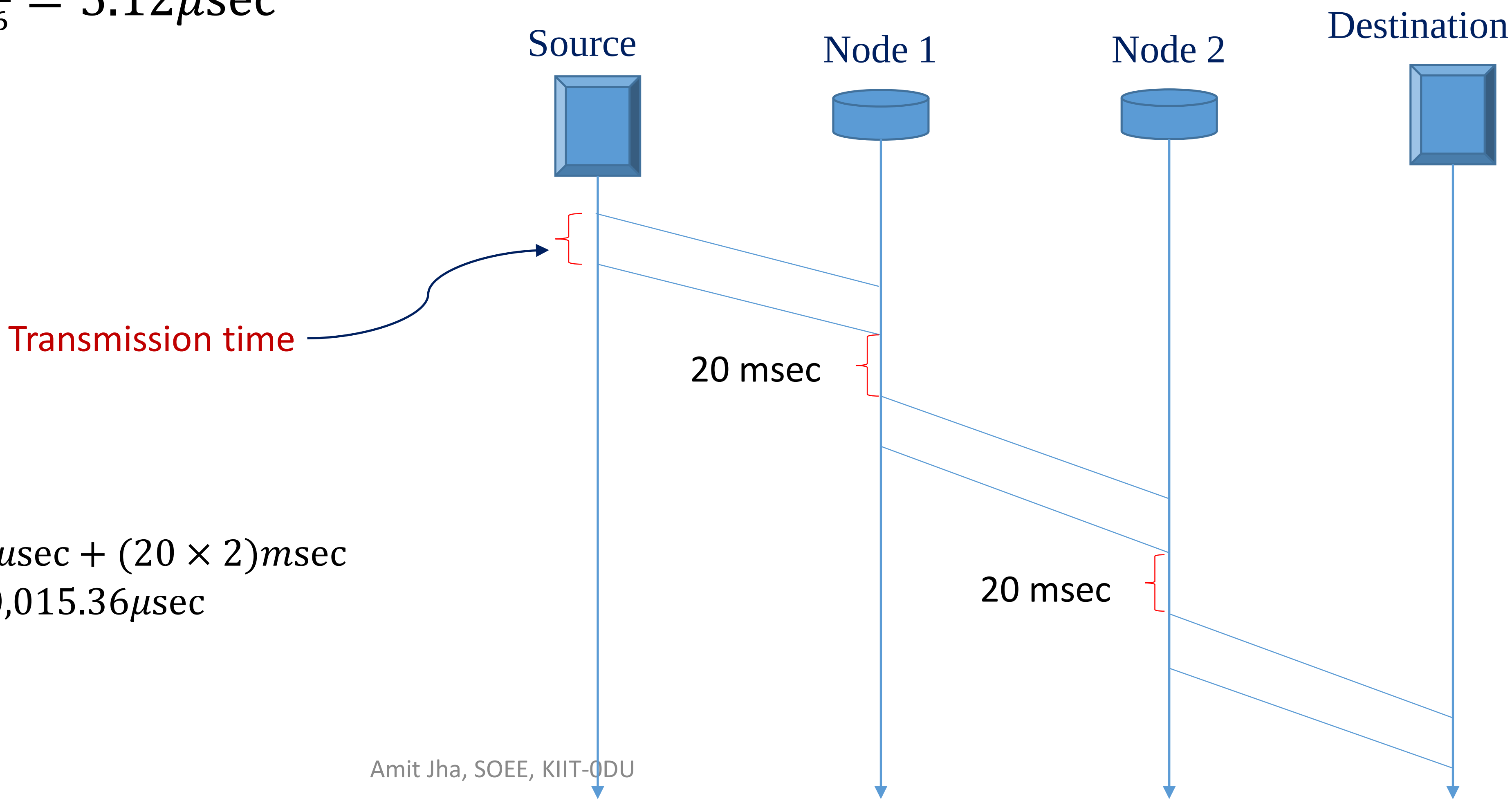
Practice Session to Chapter-01

Ex 7: Consider a packet switched network. A 64 bytes Packet is sent over a 100 Mbps link. There are two intermediate nodes and the waiting time at each node is 20 msec. Calculate the total time required by the packets to reach the destination.

Solution to Ex.7:

Propagation delay is not given, so assume it as negligible.

Transmission Time = $\dfrac{64\times8}{100\times10^6} = 5.12\mu sec$



So, total time required is

$$T = 3 \times 5.12\mu sec + (20 \times 2)msec$$
$$= 40{,}015.36\mu sec$$