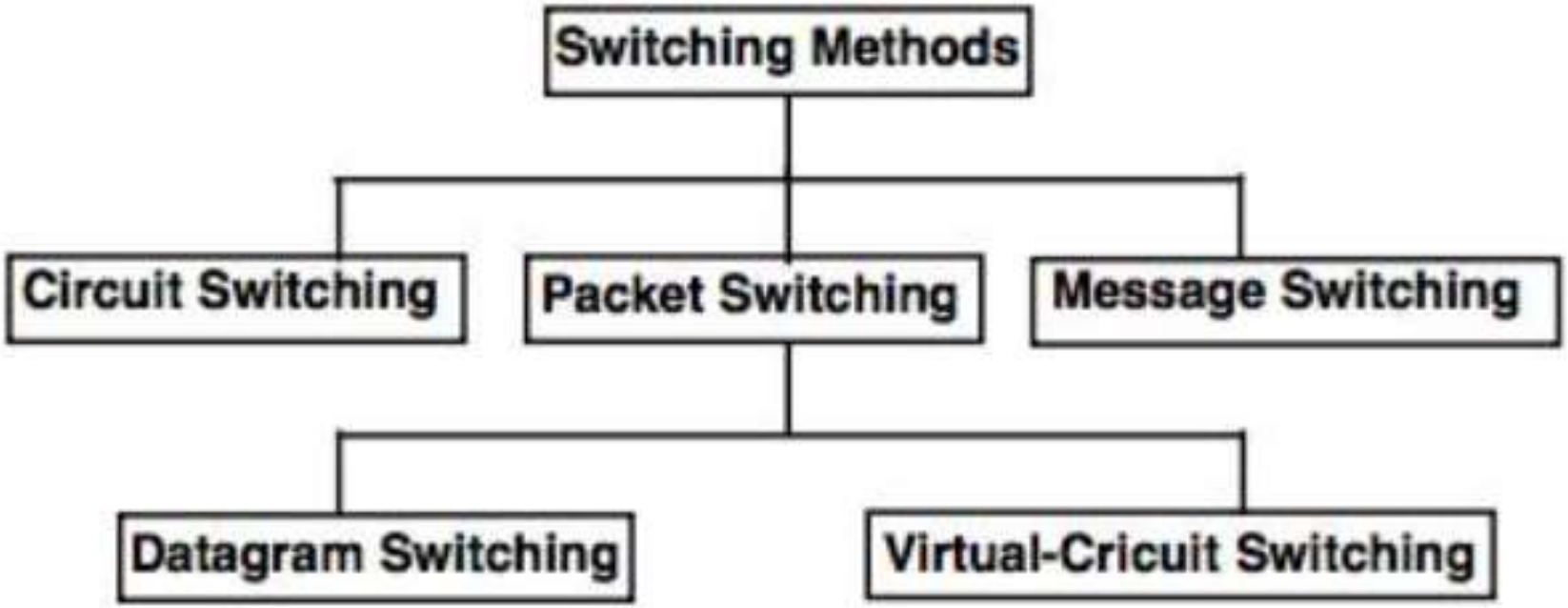
Switching Techniques

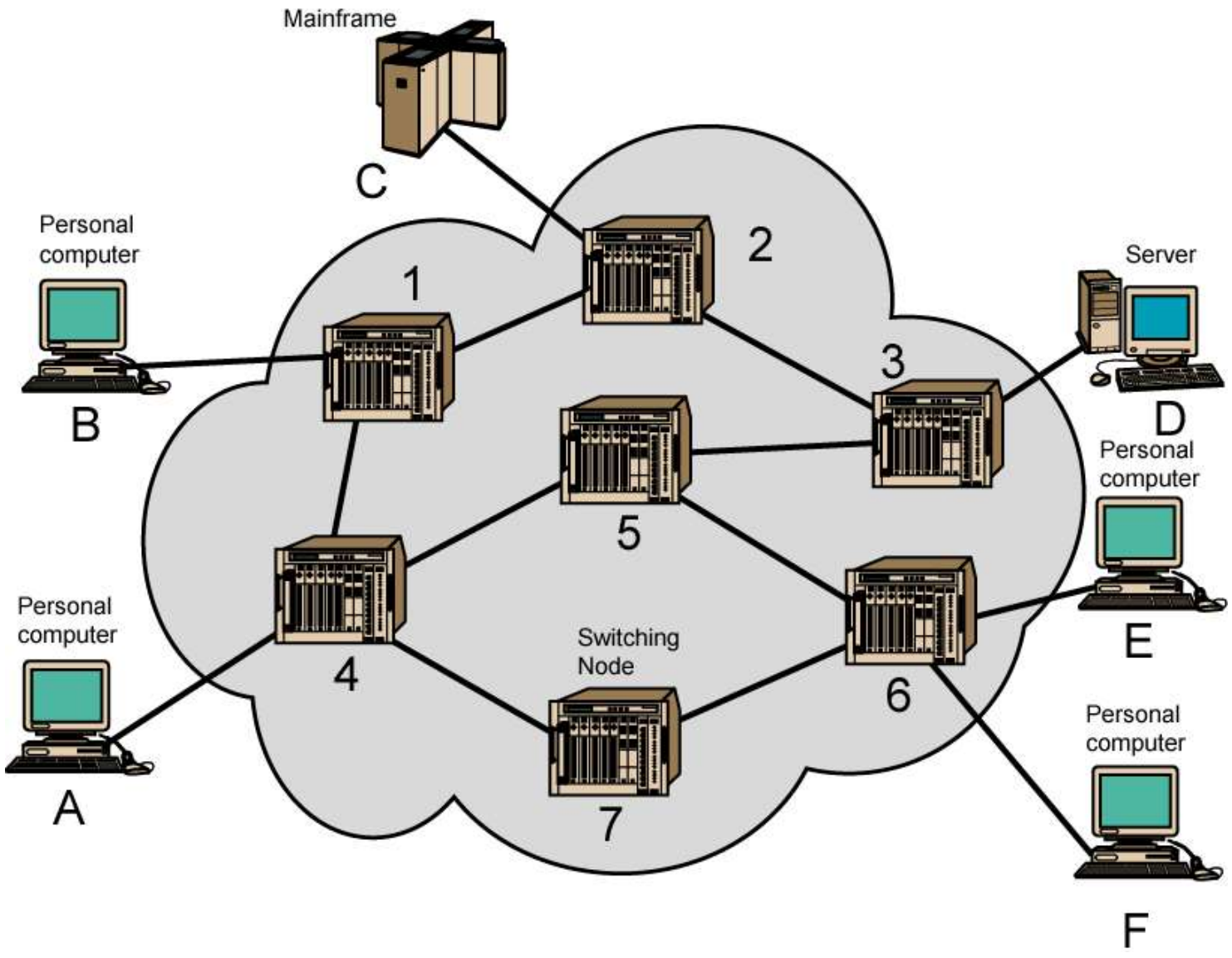
- In large networks there might be multiple paths linking sender and receiver.
- Information may be switched as it travels through various communication channels.
- There are three typical switching techniques available for digital traffic.

  - Circuit Switching
  - Message Switching
  - Packet Switching


Switching Methods
Circuit Switching
Packet Switching
Message Switching
Datagram Switching
Virtual-Cricuit Switching

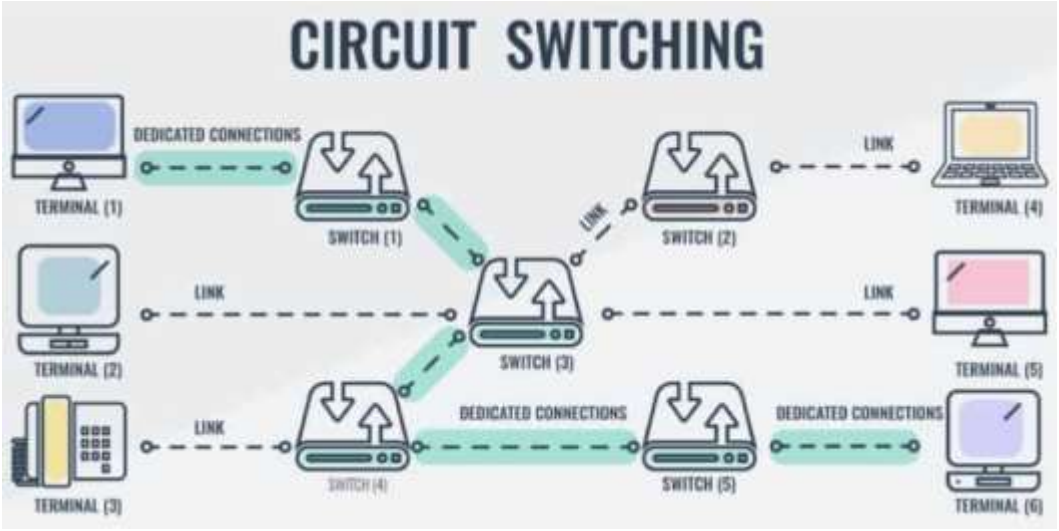
Circuit Switching

- **Circuit switching** is a technique that directly connects the sender and the receiver in an unbroken path.
- Telephone switching equipment,
  - **For example,**
  - **E**stablishes 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.
- **Routing decisions** must be made
  - When the circuit is first established,
  - But there are no decisions made after that time.


Mainframe
C
Personal computer
B
1
2
3
Server
D
Personal computer
E
5
4
Switching Node
6
Personal computer
A
7
Personal computer
F

Circuit Switching

- **Circuit switching** in a network operates almost the same way as the telephone system works.
- A complete end-to-end path must exist before communication can take place.
- The computer initiating the data transfer must ask for a connection to the destination.
- Once the connection has been initiated and completed to the destination device,
- The destination device must acknowledge that it is ready and willing to carry on a transfer.
- **Bandwidth- shared ()**

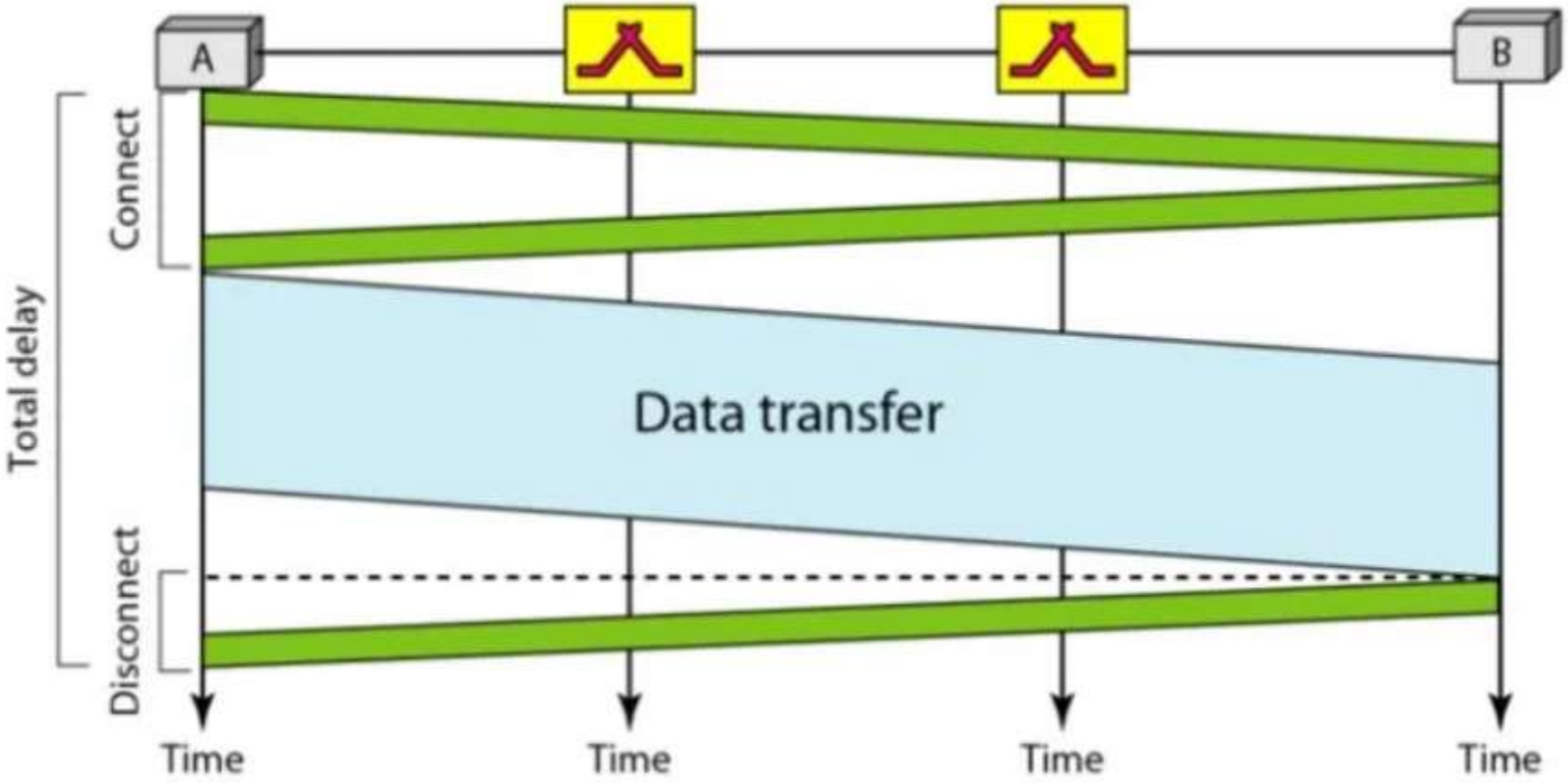


Circuit Switching

- Circuit switching:
  - There is a dedicated communication path between two stations (end-to-end)
  - The path is a connected sequence of links between network nodes.
  - On each physical link, a logical channel is dedicated to the connection.

- Communication via circuit switching has three phases:
  - Circuit establishment (link by link)
    - Routing & resource allocation (FDM or TDM)
  - Data transfer
  - Circuit disconnect
    - Deallocate the dedicated resources

- The switches must know
  - how to find the route to the destination and
  - how to allocate bandwidth (channel) to establish a connection.



- ***Propagation delay:*** *The time it takes a signal to propagate from one node to the next.This time is generally negligible. The speed of electromagnetic signals through a wire medium, for example, is typically*
  - ***Transmission time:*** *The time it takes for a transmitter to send out a block of data. For example, it takes 1 s to transmit a 10,000-bit block of data onto a 10kbps line.*
  - ***Node delay:*** *The time it takes for a node to perform the necessary processing as it switches data.*

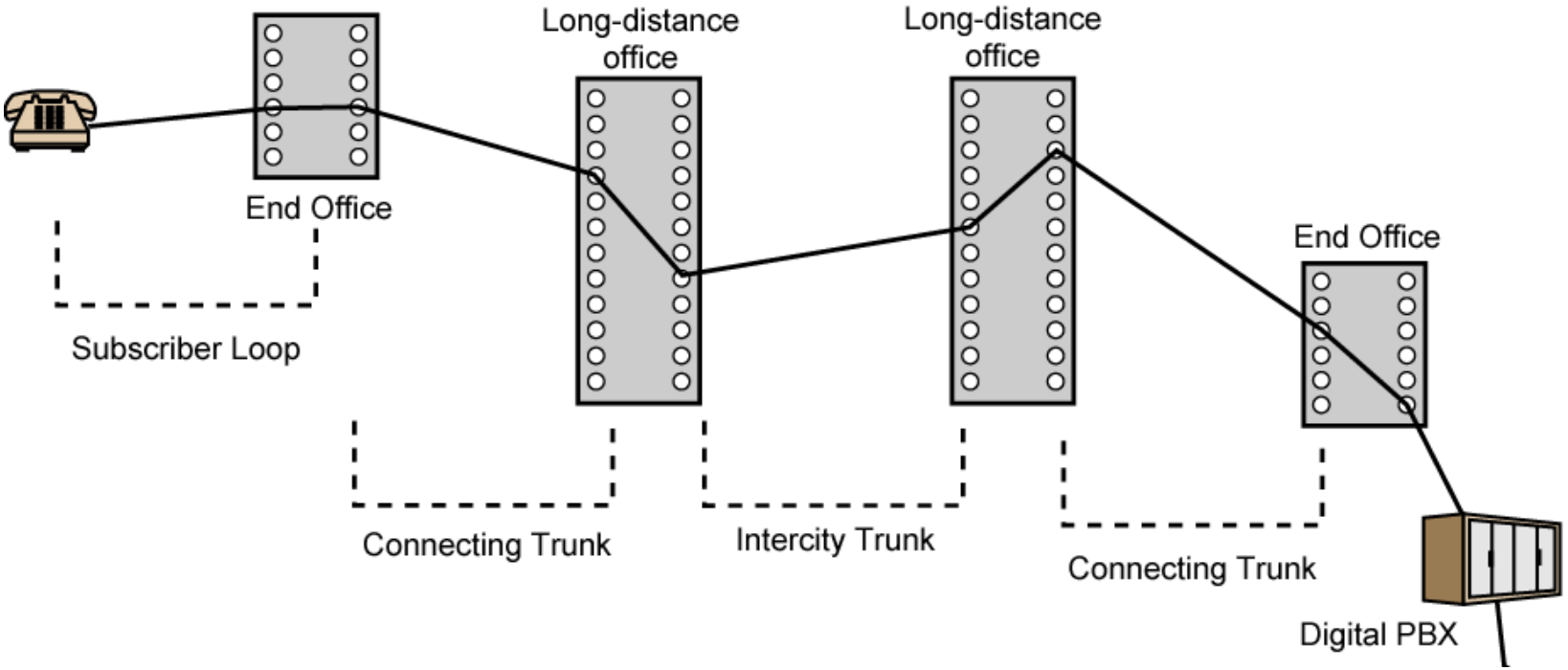
Circuit Switching Properties

- Inefficiency
  - Channel capacity is dedicated for the whole duration of a connection
  - **If no data,** capacity is wasted

- Delay
  - **Long initial delay:** circuit establishment takes time
  - **Low data delay:** after the circuit establishment,
  - information is transmitted at a fixed data rate with no delay other than the propagation delay.
  - The delay at each node is negligible.

- Developed for voice traffic (public telephone network) but can also applied to data traffic.
  - For voice connections, the resulting circuit will enjoy a high percentage of utilization because most of the time one party or the other is talking.
  - But how about data connections?

Public Circuit Switched Network



Subscribers: the devices that attach to the network.

Subscriber loop: the link between the subscriber and the network.

Exchanges: the switching centers in the network.

End office: the switching center that directly supports subscribers.

Trunks: the branches between exchanges. They carry multiple voice-frequency circuits using either FDM or synchronous TDM.

Circuit switching

Advantages:

- The communication channel (once established) is dedicated.

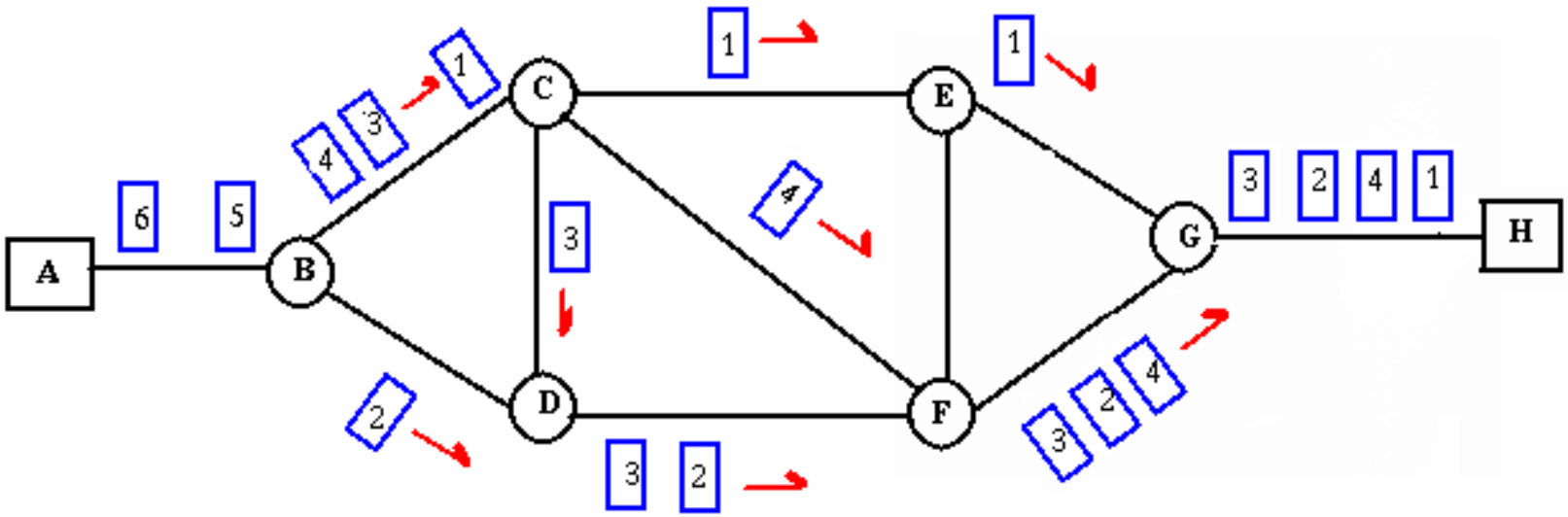
Disadvantages:

- Possible long wait to establish a connection, (10 seconds, more on long- distance or international calls.) 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.

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.



Packet Switching

Packet Switching

- In both packet switching methods,
  - a message is broken into small parts, 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 size

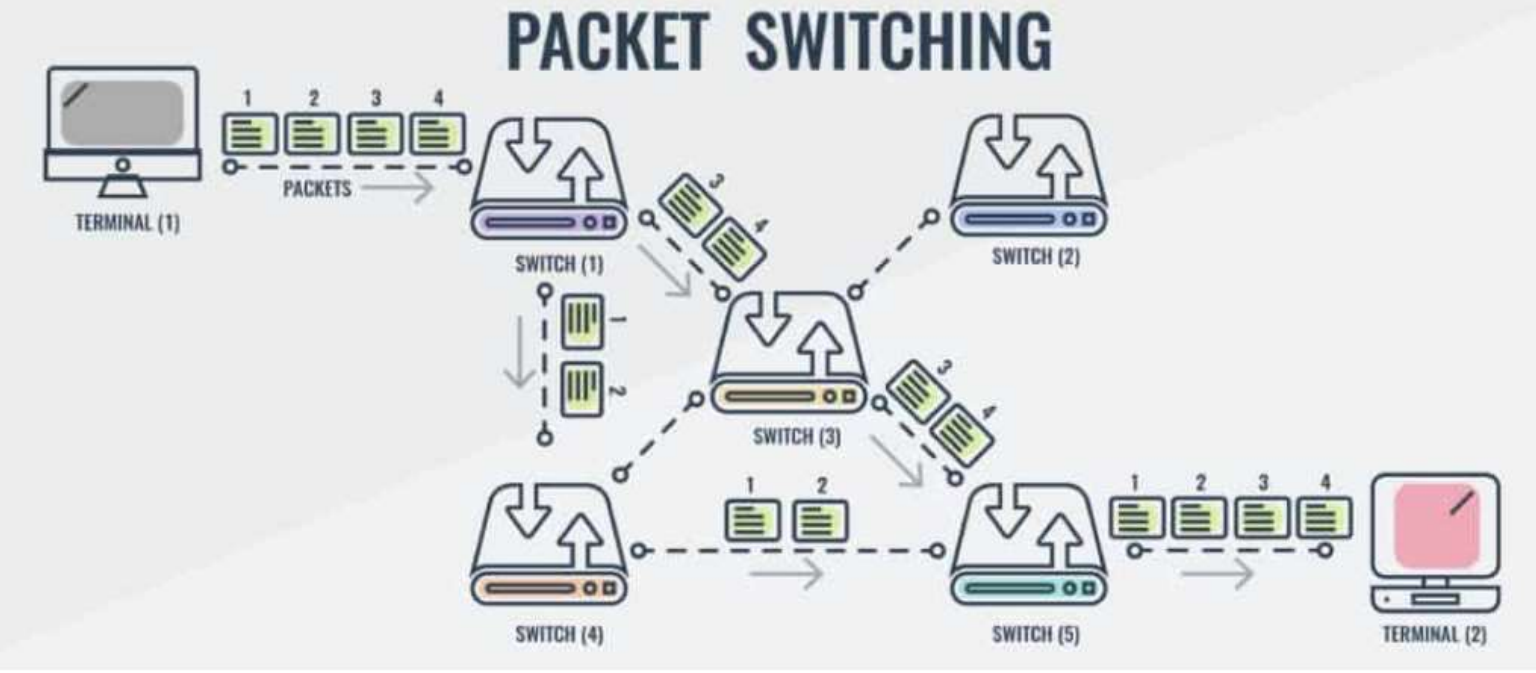
- The size of the packet can vary from 180 bits,
- the size for the Datakit® virtual circuit switch designed by Bell Labs for communications and business applications;
- to 1,024 or 2,048 bits for the 1PSS® switch, also designed by Bell Labs for public data networking;
- to 53 bytes for ATM switching, such as Lucent Technologies' packet switches.

Packet switching

- In packet switching,
  - the analog signal from your phone is converted into a digital data stream.
  -
- That series of digital bits is then divided into **relatively tiny clusters of bits, called packets.**
- Each packet has at its **beginning the digital address**
  - -- a long number -- to which it is being sent.
- The system blasts out all those tiny packets, as fast as it can, and
- They travel across the nation's digital backbone systems to their destination:

Packet switching

- They do not necessarily travel together;
- they do not travel sequentially.
- They don't even all travel via the same route.
- But eventually they arrive at the right point
  - -- that digital address added to the front of each string of digital data and
  - **at their destination** are reassembled into the correct order, then **converted to analog form**



Packet Switching: Datagram

- Datagram packet switching is similar to message switching in that each packet is a self-contained unit with **complete addressing information attached.**

- It allows packets to take a variety of possible paths through the network.
- each with the **same destination address,**
  - do not follow the same route, and
  - they may arrive out of sequence at the exit point node (or the destination).

- Reordering is done at the destination point based on the sequence number of the packets.

- 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.

Packet Switching:Virtual Circuit

- In the virtual circuit approach,
  - a preplanned route is established before any data packets are sent.
- A logical connection is established when
  - a sender send a **"call request packet"** to the receiver and
  - the receiver **send back an acknowledge packet** "call accepted packet"
  - to the sender
    - if the receiver agrees on conversational parameters.
- The conversational parameters can be
  - **maximum packet sizes, path to be taken**, and
  - other variables necessary to establish and
  - maintain the conversation.
- **Virtual circuits** imply
  - acknowledgements,
  - flow control, and error control,
- so **virtual circuits** are reliable.
- That is, they have the capability
  - to inform upper-protocol layers if a transmission problem occurs.

Packet Switching:Virtual Circuit

- In virtual circuit,
  - the route between stations does not mean that this is a dedicated path, **as in circuit switching.**
- **A packet is still buffered at each node** and queued for output over a line.

- The difference between virtual circuit and datagram approaches:
  - With virtual circuit,
    - the node does not need to make a routing decision for each packet.
    - It is made only once for all packets using that virtual circuit.

Packet Switching: Virtual Circuit

VC's offer guarantees that

- the packets sent arrive in the order sent
- with no duplicates or omissions
- with no errors (with high probability)

regardless of how they are implemented internally.

Advantages of packet switching

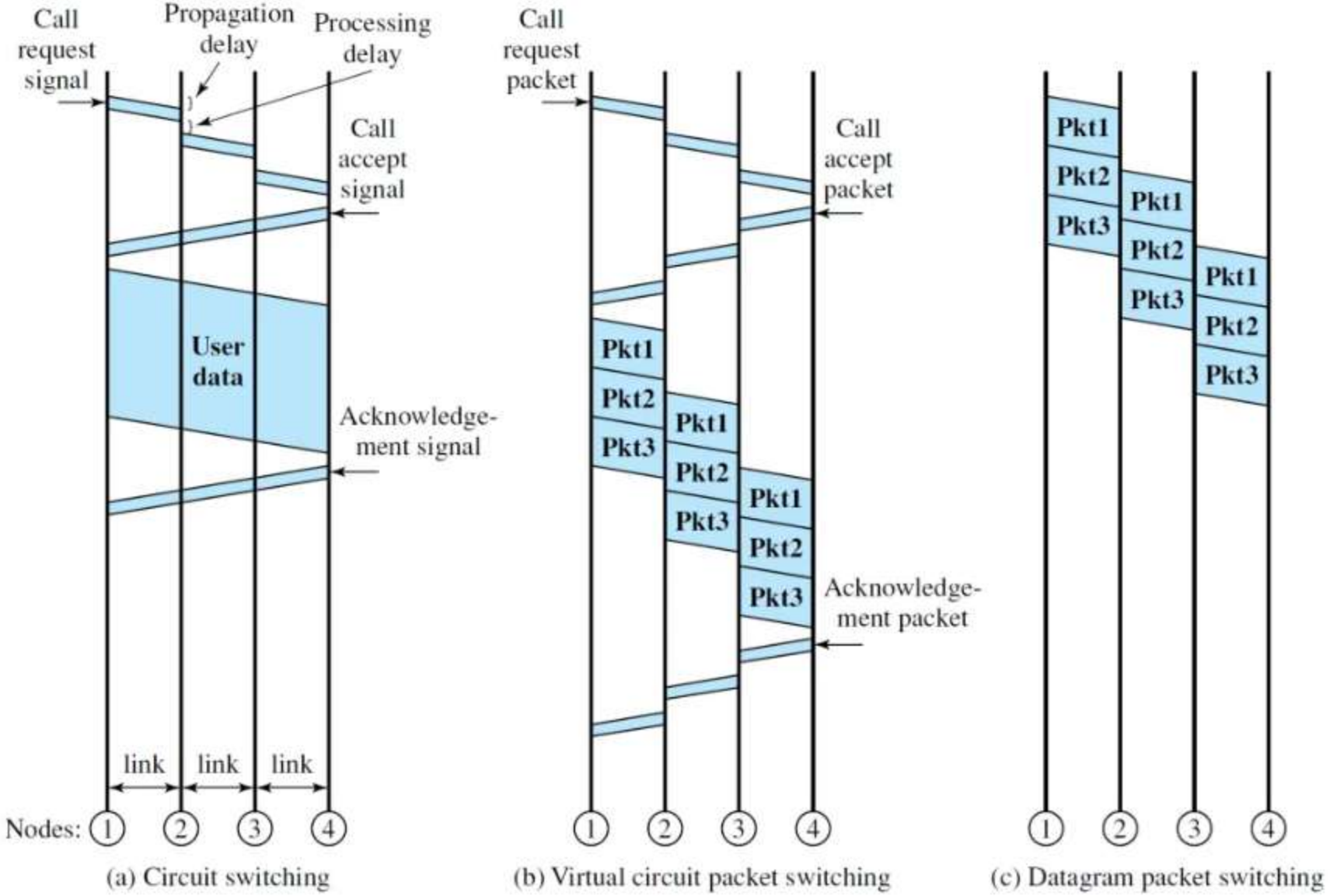
Advantages:

- Packet switching is cost effective, because switching devices do not need massive amount of secondary storage.
- Packet switching offers improved delay characteristics, because there are no long messages in the queue (maximum packet size is fixed).
- Packet can be rerouted if there is any problem, such as, busy or disabled links.
- The advantage of packet switching is that many network users can share the same channel at the same time. Packet switching can maximize link efficiency by making optimal use of link bandwidth.

Disadvantages of packet switching

Disadvantages:

- Protocols for packet switching are typically more complex.
- It can add some initial costs in implementation.
- If packet is lost, sender needs to retransmit the data.
- can’t deliver the same quality as dedicated circuits in applications requiring very little delay - like voice conversations or moving images.


Call request signal
Propagation delay
Processing delay
Call accept signal
User data
Acknowledge-ment signal
link
link
link
Nodes: 1 2 3 4
(a) Circuit switching
Call request packet
Call accept packet
Pkt1
Pkt2
Pkt3
Acknowledge-ment packet
1 2 3 4
(b) Virtual circuit packet switching
Pkt1
Pkt2
Pkt3
1 2 3 4
(c) Datagram packet switching

Feature	Circuit Switching	Packet Switching
Dedicated Path	Yes	No
Path Formation	Path dedicated for one conversation	Route is established on a per packet basis of the conversation using datagram (or per conversation with virtual circuit)
Delay	Call setup delay	Packet transmission delay (call setup delay for virtual circuit)
Bandwidth Type	Fixed Bandwidth	Dynamic bandwidth
Overload Effects	Stops call establishment	Increases packet delay (can block call establishment and increase packet delay with virtual circuit)

Total Time-

Total time taken to transmit a message in circuit switched network

= Connection set up time + Transmission delay + Propagation delay + Tear down time

where-

Transmission delay = Message size / Bandwidth
Propagation delay = (Number of hops on way x Distance between 2 hops) / Propagation speed

- Consider all links in the network use TDM with 24 slots and have a data rate of 1.536 Mbps. Assume that host A takes 500 msec to establish an end to end circuit with host B before begin to transmit the file. If the file is 512 kilobytes, then how much time will it take to send the file from host A to host B?

GIVEN DATA

- Total bandwidth = 1.536 Mbps
- Bandwidth is shared among 24 slots
- Connection set up time = 500 msec
- File size = 512 KB
- Bandwidth per user

= Total bandwidth / Number of users

= 1.536 Mbps / 24

= 0.064 Mbps

Calculating Transmission Delay-

- Transmission delay (T_t)
- = File size / Bandwidth
- = 512 KB / 64 Kbps
- = (512 x 2^{10} x 8 bits) / (64 x 10^3 bits per sec)
- = 65.536 sec
- = 65536 msec

Calculating Time Required To Send File-

- Time taken to send a file in circuit switched network

= Connection set up time + Transmission delay = 500 msec + 65536 msec

= 66036 sec

66.036 msec