Data Communication & Computer Network

Switching Techniques

Switched Networks

A switched network consists of a series of interlinked nodes, called switches. Switches are devices capable of creating temporary connections between two or more devices linked to the switch. In a switched network, some of these nodes are connected to the end systems. Others are used only for routing.

Switching is process to forward packets coming in from one port to a port leading towards the destination.
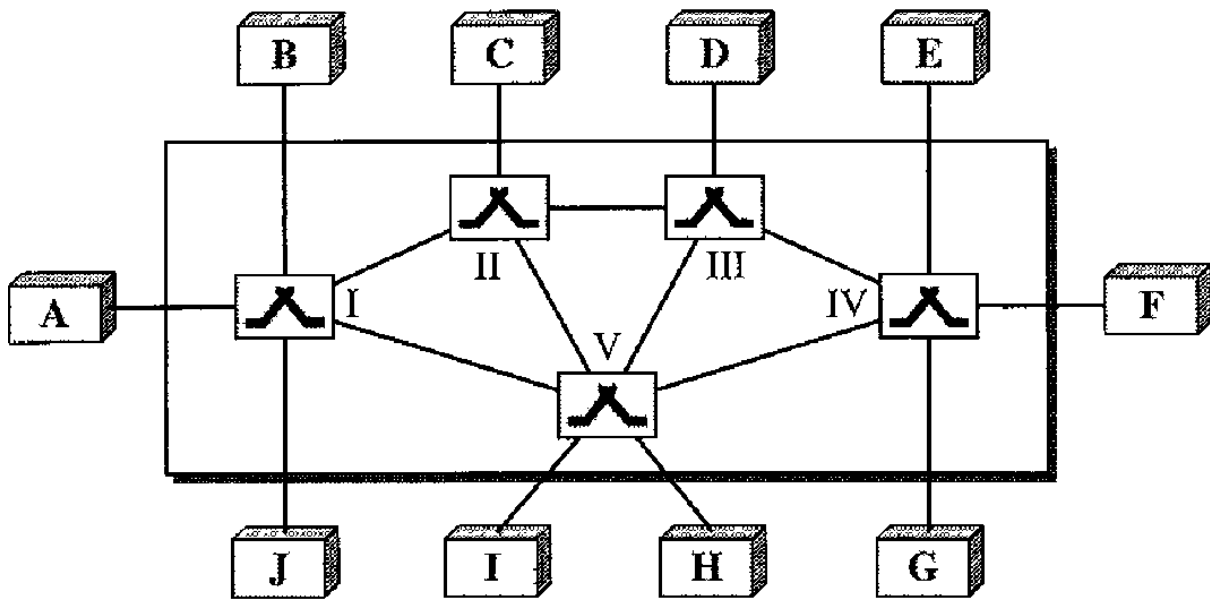
The end systems (communicating devices) are labelled A, B, C, D, and so on, and the switches are labelled I, II, III, IV, and V. Each switch is connected to multiple links.


Traditionally, there are three methods of switching:
   i) Circuit switching
   ii) Packet switching
   iii) Message switching

Switched networks → Circuit-switched networks, Packet-switched networks, Message-switched networks

Packet-switched networks → Datagram networks, Virtual-circuit networks
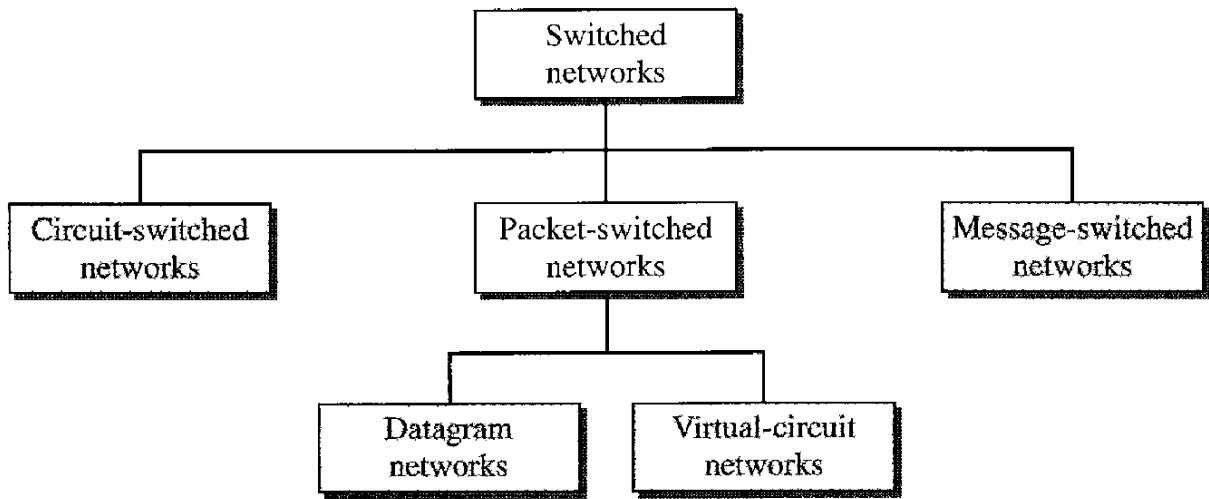
1. Circuit Switched Networks

- A circuit-switched network is made of a set of switches connected by physical links, in which each link is divided into *n* channels.
- 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 takes place at the physical layer.
- Before starting communication, the stations must make a reservation for the resources to be used during the communication. These resources, such as channels (bandwidth in FDM and time slots in TDM), switch buffers, switch processing time, and switch input/output ports, must remain dedicated during the entire duration of data transfer until the teardown phase.
- Data transferred between the two stations are not packetized (physical layer transfer of the signal). The data are a continuous flow sent by the source station and received by the destination station, although there may be periods of silence.
- There is no addressing involved during data transfer. The switches route the data based on their occupied band (FDM) or time slot (TDM). Of course, there is end-to-end addressing used during the setup phase
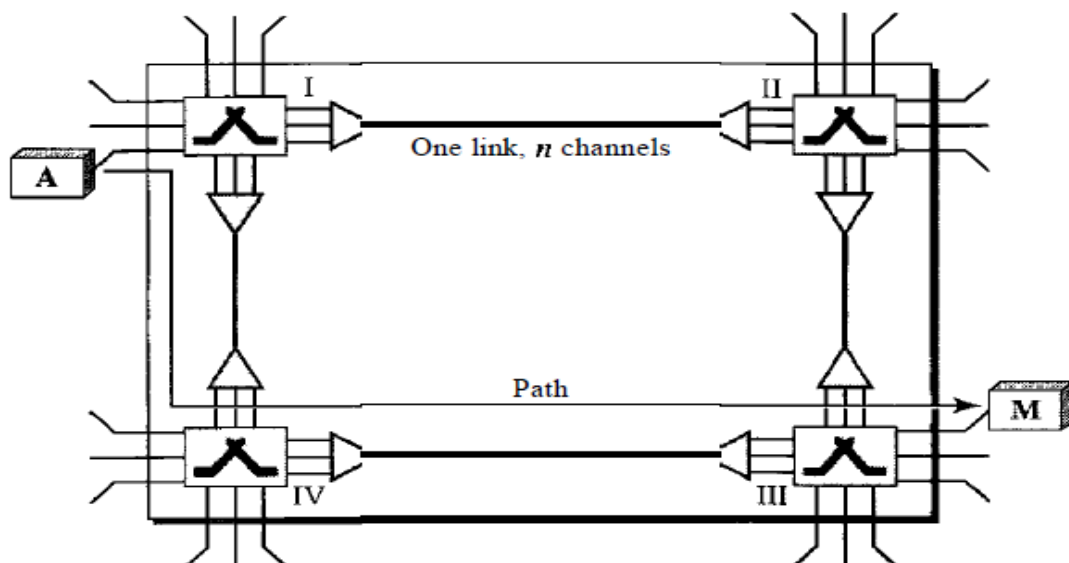
The actual communication in a circuit-switched network requires three phases:

i) connection setup phase
ii) data transfer phase
iii) connection teardown phase

i)   Setup Phase

Before the two parties (or multiple parties in a conference call) can communicate, a dedicated circuit (combination of channels in links) needs to be established. The end systems are normally connected through dedicated lines to the switches, so connection setup means creating dedicated channels between the switches. For example, in above figure, when system A needs to connect to system M, it sends a setup request that includes the address of system M, to switch I. Switch I finds a channel between itself and switch IV that can be dedicated for this purpose. Switch I then sends the request to switch IV, which finds a dedicated channel between itself and switch III. Switch III informs system M of system A's intention at this time. In the next step to making a connection, an acknowledgment from system M needs to be sent in the opposite direction to system A. Only after system A receives this acknowledgment is the connection established.

Note that end-to-end addressing is required for creating a connection between the two end systems.

ii)   Data Transfer Phase

After the establishment of the dedicated circuit (channels), the two parties can transfer data.

iii)   Teardown Phase

When one of the parties needs to disconnect, a signal is sent to each switch to release the resources.

**Efficiency of circuit switched network**

It can be argued that circuit-switched networks are not as efficient as the other two types of networks because resources are allocated during the entire duration of the connection. These resources are unavailable to other connections.

Delay in circuit switched network

Although a circuit-switched network normally has low efficiency, the delay in this type of network is minimal. During data transfer the data are not delayed at each switch; the resources are allocated for the duration of the connection.

2. Message Switched Networks

- This technique was somewhere in middle of circuit switching and packet switching. In message switching, the whole message is treated as a data unit and is switching / transferred in its entirety.
- A switch working on message switching, first receives the whole message and buffers it until there are resources available to transfer it to the next hop. If the next hop is not having enough resource to accommodate large size message, the message is stored and switch waits.
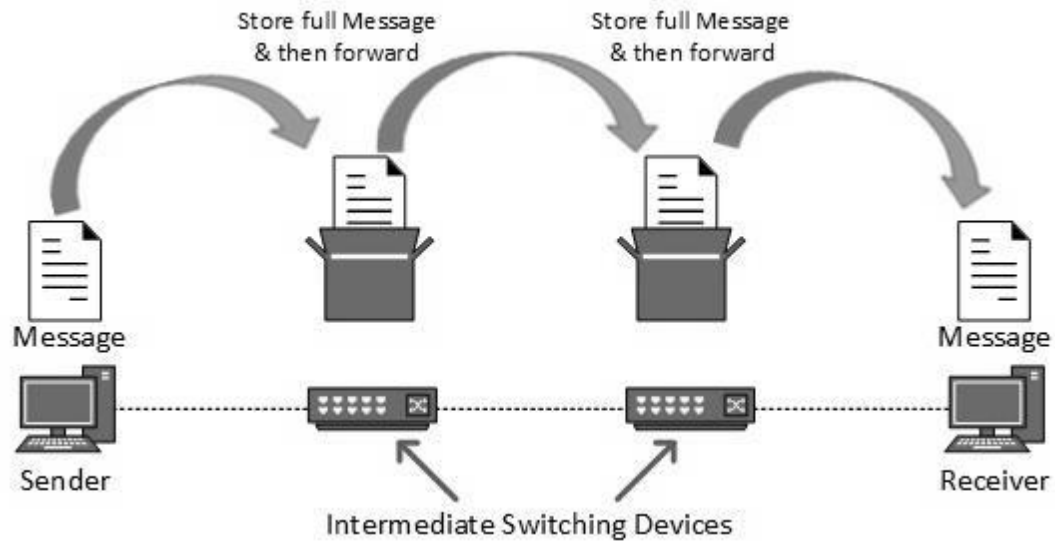
This technique was considered substitute to circuit switching. As in circuit switching the whole path is blocked for two entities only. Message switching is replaced by packet switching. Message switching has the following drawbacks:

i)   Every switch in transit path needs enough storage to accommodate entire message.

ii)   Because of store-and-forward technique and waits included until resources are available, message switching is very slow.

iii)   Message switching was not a solution for streaming media and real-time applications.

3. Packet Switched Network

- The entire message is broken down into smaller chunks called packets.
- The switching information is added in the header of each packet and transmitted independently.
- In packet switching, there is no resource allocation for a packet. This means that there is no reserved bandwidth on the links, and there is no scheduled processing time for each packet.
- Resources are allocated on demand. The allocation is done on a first-come, first-served basis.
- It is easier for intermediate networking devices to store small size packets and they do not take much resources either on carrier path or in the internal memory of switches.
- It is of two types: i) Datagram network
                          ii) Virtual circuit identifier

i)   Datagram Network

- In a datagram network, each packet is treated independently of all others. Even if a packet is part of a multi-packet transmission, the network treats it as though it existed alone. Packets in this approach are referred to as datagrams.
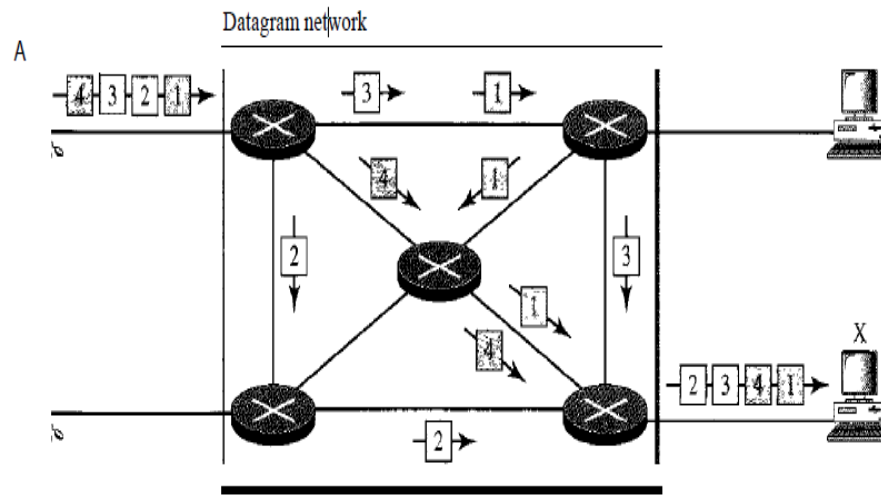- Datagram switching is normally done at the network layer.

Datagram network

Figure shows how the datagram approach is used to deliver four packets from station A to station X. The switches in a datagram network are traditionally referred to as routers.

In this example, all four packets (or datagrams) belong to the same message, but may travel different paths to reach their destination. This is so because the links may be involved in carrying packets from other sources and do not have the necessary bandwidth available to carry all the packets from A to X. This approach can cause the datagrams of a transmission to arrive at their destination out of order with different delays between the packets. Packets may also be lost or dropped because of a lack of resources. In most protocols, it is the responsibility of an upper-layer protocol to reorder the datagrams or ask for lost datagrams before passing them on to the application.

The datagram networks are sometimes referred to as connectionless networks. The term *connectionless* here means that the switch (packet switch) does not keep information about the connection state. There are no setup or teardown phases. Each packet is treated the same by a switch regardless of its source or destination.

Routing table

If there are no setup or teardown phases, how are the packets routed to their destinations in a datagram network? In this type of network, each switch (or packet switch) has a routing table which is based on the destination address. The routing tables are dynamic and are updated periodically. The destination addresses and the corresponding forwarding output ports are recorded in the tables. This is different from the table of a circuit switched network in which each entry is created when the setup phase is completed and deleted when the teardown phase is over.

Destination Address

Every packet in a datagram network carries a header that contains, among other information, the destination address of the packet. When the switch receives the packet, this destination address is examined; the routing table is consulted to find the corresponding port through which the packet should be forwarded. This address, unlike the address in a virtual-circuit-switched network, remains the same during the entire journey of the packet.