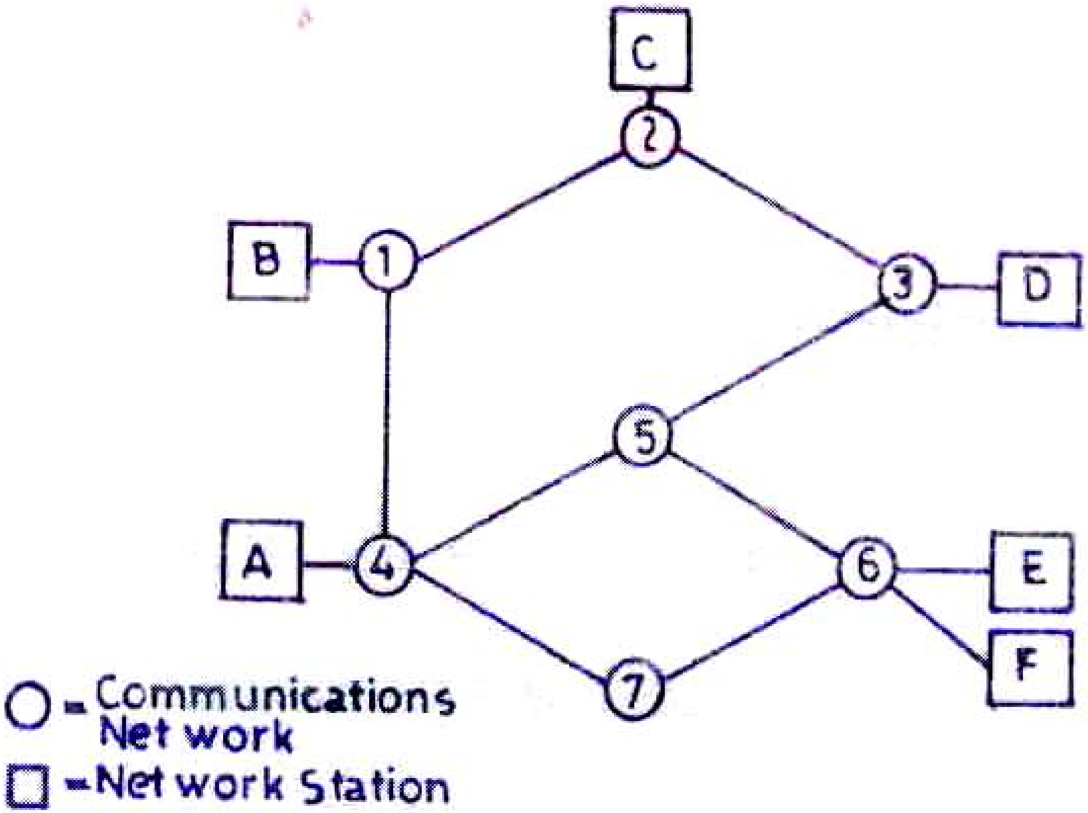
Communication Switching Techniques

Data Communication takes place between two devices that are directly connected by some form of transmission medium. However, it is impractical for two devices to be directly connected. This is so far one (or both) of the following contingencies :

-The devices are very far apart. It would be inordinately expensive.

-There is a set of devices, each of which may require a link to many of the others at various times.

The solution to this problem is to attach each device to a communication network. Transmitting is achieved by transmitting data from source to destination through a network of intermediate nodes. These nodes are not concerned with the content of the data; rather their purpose is to provide a switching facility that will move the data from node to node until they reach their destinations.



Generic Switching Network

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We have a collection of devices that wish to communicate; we will refer to them as STATIONS. The stations may be computers, terminals, telephones or other communication devices.

We also have a collection of devices whose purpose is to provide communication, which we refer as NODES.

The nodes are connected to each other in some fashion by transmission links. Each station attaches to a node. The collection nodes is referred as a COMMUNICATION NETWORK.

If the attached devices are computers and terminals, then the collection of nodes plus stations is referred to as a COMPUTER NETWORK.

Three Switching techniques are in common use :

- Circuit switching
- Message switching
- Packet switching

CIRCUIT SWITCHING

Communication via circuit switching implies that there is a dedicated communication path between two stations. That path is a connected sequence of links between nodes. On each physical link, a channel is dedicated to the connection.

The most common example of circuit switching is the telephone network.

Communication via circuit switching involves three phases :

1. CIRCUIT ESTABLISHMENT : Before any data can be transmitted, an end-to-end circuit must be established. For example, station A sends a request to node 4 requesting a connection to station E. Typically, the circuit from A to 4 is a dedicated line, so that part of the connection already exists.Node 4 must find the next leg in a route leading to node 6.

Based on routing information and measures of availability and perhaps cost, node 4 selects the circuit to node 5, allocates a free channel on that circuit and sends a message requesting connection to E. So far, a dedicated path has been established from A through 4 to 5.

Since a number of stations may attach to 4, it must be able to establish internal paths from multiple stations to multiple nodes. The reminder of the process proceeds similarly. Node 5 dedicates a channel to node 6 and internally ties that channel to the channel from node 4. Node 6 completes the connection to E. In completing the connection, a test is made to determine if E is busy or is prepared to accept the connection.

2. Data transfer : Signals can now be transmitted form A through the network to E. The data may be digital or analog. The signalling and transmission may each be either digital or analog. In any case, the path is : A-4 circuit, internal switching through 4, 4-5 channel, internal switching through 5, 5-6 channel, internal switching through 6 and 6-E circuit. Generally, the connection is full duplex and data may be transmitted in both directions.

3. Circuit Disconnect : After some period of data transfer, the connection is terminates, usually by the action of one of the two stations. Signals must be propagated to 4, 5 and 6 to reallocate the dedicated resources.

Note that the connection path is established before data transmission begins. Thus channel capacity must be available and reserved between each pair of nodes in the path and each node must have internal switching capacity to handle the connection.

The switches must have the intelligence to make these allocations and to device a route through the network.

Circuit switching can be inefficient. Channel capacity is dedicated for the duration of a connection, even if no data are being transferred.

For a voice connection, utilization may be rather high, but it still does not approach 100 %.

In terms of performance, there is a delay prior to data transfer for call establishment. However, once the circuit is established, the network is efficiently transparent to the users. The data are transmitted at a fixed rate with no delay.

Message Switching

Circuit switching is an appropriate and easily used technique in the case of data exchanges that involve a relatively continuous flow. However, it has two drawbacks :

- Both stations must be available at the same time for the data exchange.
- Resources must be available and dedicated through the network between the two stations, when available.

An alternative approach, which is generally appropriate to digital data exchange, is to exchange logical units of data, called MESSAGES. Examples of messages are telegrams, electronic mail, computer files, transaction queries and responses.

With message switching, it is not necessary to establish a dedicated path between two stations. Rather, a station wishes to send a message it appends a destination address to the message. The message is then passed through the network from node to node. At each node, the entire message is received, stored briefly and then transmitted to the next node.

A message-switching node is typically a general-purpose minicomputer, with sufficient storage to buffer messages as they come. A message delayed at each node for the time required to receive all bits of the message plus a queuing delay waiting for an opportunity to retransmit to the next node.

Consider a message from A to E. A appends E's address to the message and sends it to node 4. Node 4 stores the message and determines the next leg of the route. The node 4 queues the message for transmission over the 4-5 link. When the link is available, the message is transmitted to node 5, which will forward the message to node 6 and finally to E.

The advantages of this over circuit switching are :

Line efficiency is greater, since a single node-to-node channel can be shared by many messages over time.

Simultaneous availability of sender and receiver is not required.

When traffic becomes heavy on a circuit-switched network, some calls are blocked. On a message-switched network, messages are still accepted, but delivery delay increases.

A message-switching system can send one message to many destinations.

Message priorities can be established.

Error control and recovery procedures on a message basis can be built into the network.

The disadvantages of message switching is that it is not suited to real-rime or interactive traffic. The delay through the network is relatively long and has relatively high variance. Thus it can not be used for voice connections.

Packet Switching

Packet switching represents an attempt to combine the advantages of message and circuit switching while minimising the disadvantages of both. In situations where there is a substantial volume of traffic among a number of stations, this objective is met.

Packet switching is very much like message switching. The principal external difference is that the length of the units of data that may be transmitted is limited in a packet-switching network. A typical maximum length is 1000 to a few thousand bits. To distinguish the two techniques, the data units in the later system are referred to as packets.

Consider the transfer of a single packet for the previous example. The packet contains data plus a destination address. Station A transmits the packet to 4, which stores it briefly and then passes it to 5, which passes it to 6 and on to E. One difference from message switching is that packets are typically not filed. A copy may be temporarily stored for error recovery purposes, but that is all.

Problem :

A station has a message to send that is of length greater than the maximum packet size. It breaks the message into packets and sends these packets to its node.

Question: How will the network handle this stream of packets ?

There are two approaches :

Datagram and Virtual circuit.

In the DATAGRAM approach, each packet is treated independently, just as each message is treated independently in a message-switched network.

Suppose that station A has a 3-packet message to send to E. It pops the packets out, 1-2-3, to node 4. On each packet, node 4 must make a routing decision. Packet 1 comes in and node 4 determines that its queue of packets for node 5 is shorter than for node 7, so it queues the packet for node 5. Ditto for packet 2. But for packet 3, node 4 finds that its queue for node 7 is shortest and so queues packet for node 5 for that node.

So the packets, each with the same destination address, do not all follow the same route. Furthermore, it is just possible that packet 3 will beat packet 2 to node 6. Thus it is possible that the packets will be delivered to E in a different sequence from the one in which they were sent. It is up to E to figure out how to reorder them.

In the VIRTUAL CIRCUIT approach, a logical connection is established before any packets are sent.

For example, suppose that A has one or more messages to send to E. It first sends a Call Request packet to 4, requesting a connection to E. Node 4 decides to route the request and all subsequent data to 5, which decides to route the request and all subsequent data to 6, which finally delivers the Call Request packet to E. If E is prepared to accept the connection, it sends out a call request packet to 6.

At any time, each station can have more than one virtual circuit to any other station and can have virtual circuits to more than one station.

Circuit Switching	Message Switching	Datagram Packet Switching	Packet Switching
Dedicated transmission path	No dedicated path	No dedicated path	No dedicated path
Continuous transmission of data	Transmission of messages	Transmission off packets	Transmission of packets
Fast enough for interactive	Too slow for interactive	Fast enough for interactive	Fast enough for interactive
Messages are not stored	Messages are filed for later retrieval	Packets may be stored until delivered	Packets stored
Path is established for entire conversation	Route established for each message	Route established for each packet	Route established for entire conversation
Call setup delay; negligible transmission delay	Message transmission delay	Packet transmission delay	Call setup delay; packet transmission delay
Busy signal if called party busy	No busy signal	Sender may be notified if packet not delivered	Sender notified of connection denial
Overload may block	Overload increases	Overload increases	Overload may block

Circuit	Message	Datagram packet	Virtual CircuitPacket
call setup; no delay for established calls	message delay	packet delay	call setup; increase packet delay
Electromechanical or computerized switching nodes	Message switch center with filling facility	Small switching nodes	Small switching nodes
User responsible for message-loss pr: ection	Network responsible for messages	Network may be responsible for individual packets	Network may be responsible for packet sequences
Usually no speed or code conversion	Speed and code conversion	Speed and code conversion	Speed and code conversion
Fixed bandwidth transmission	Dynamic use of bandwidth	Dynamic use of bandwidth	Dynamic use of bandwidth
No overhead bits after call setup	Overhead bits in each message	Overhead bits in each packet	Overhead bits in each packet