13

SWITCHING CONCEPTS

Unit Structure

13.0 OBJECTIVE

- ✓ Introduce switching concept
- ✓ Define switching node
- ✓ Define packet switching
- ✓ Switching mode

13.1 INTRODUCTION

Switching is the generic method for establishing a path for point-to-point communication in a network. It involves the nodes in the network utilizing their direct communication lines to other nodes so that a path is established in a piecewise fashion. Each node has the capability to ‘switch’ to a neighbouring node (i.e., a node to which it is directly connected) to further stretch the path until it is completed.

One of the most important functions of the network layer is to employ theswitching capability of the nodes in order to route messages across the network.There are two basic methods of switching circuit switching and packet switching.

13.2.1. Circuit Switching

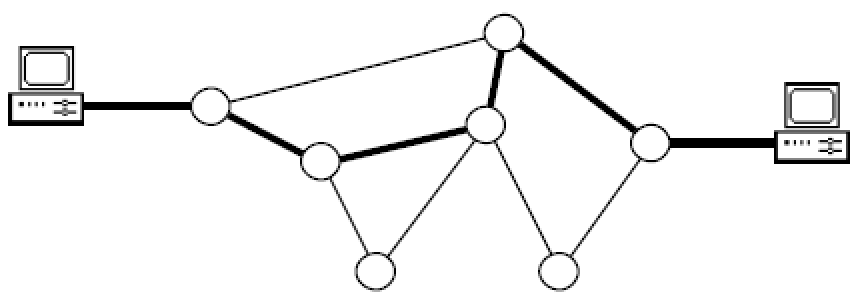


Figure 13.2.1 A ‘switched’ path.

In circuit switching, two communicating stations are connected by a *dedicated* communication path which consists of intermediate nodes in the network and thelinks that connect these nodes.

Figure **13.2.1** shows a simple circuit switch which consists of a 3×3 matrix, capable of connecting any of its inlets (*a*, *b*, and *c*) to any of its outlets (*d*, *e*, and *f*). Each crosspoint appears as a circle. A hollow circle means that the crosspoint is *off* (i.e., the two crossing wires are not connected). A solid circles means that the crosspoint is *on* (i.e., the crossing wires are connected).

Switches may also have more inlets than outlets, or more outlets than inlets.)

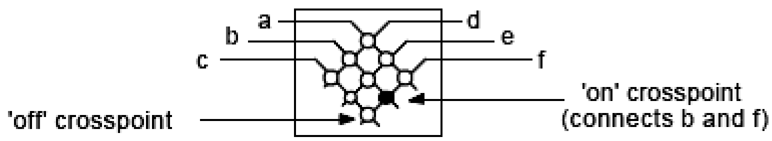


Figure 13.2.2 A simple circuit switch.

When the two hosts shown in the figure initiate a connection, the network determines a path through the intermediate switches and establishes a circuit which is maintained for the duration of the connection. When the hosts disconnect, the network releases the circuit.

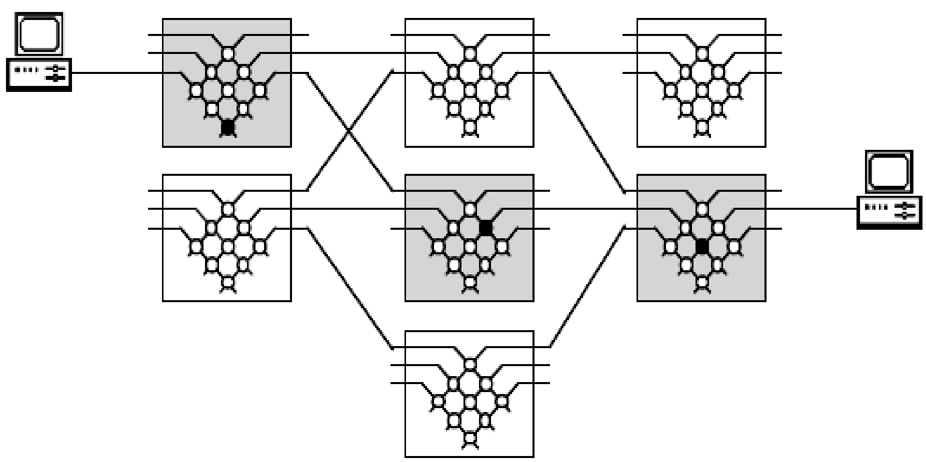


Fig 13.2.3 Circuit switching.

Communication via circuit switching implies that there is a dedicated communication path between the two stations. The path is a connected through a sequence of links between network nodes. On each physical link, a logical channel is dedicated to the connection. Circuit switching is commonly used technique in telephony, where the caller sends a special message with the address of the callee (i.e. by dialling a number) to state its destination. It involved the following three distinct steps, as shown in Fig. **13.2.3**

Circuit Establishment: To establish an end-to-end connection before any transfer of data.

Some segments of the circuit may be a dedicated link, while some other segments may be shared.

Data transfer:

Transfer data is from the source to the destination.
The data may be analog or digital, depending on the nature of the network.
The connection is generally full-duplex.

Circuit disconnect:

Terminate connection at the end of data transfer.
• Signals must be propagated to deallocate the dedicated resources.

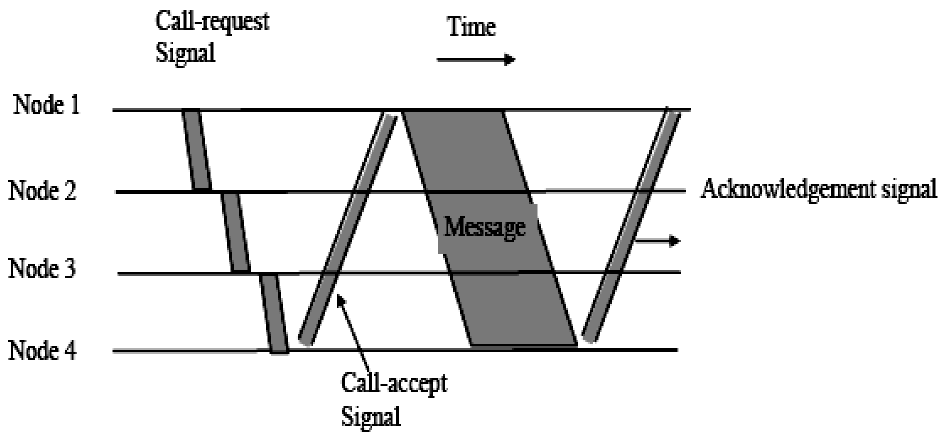


Fig: 13.2.4 Circuit Switching technique

13.2.2 Switching Node

Let us consider the operation of a single circuit switched node comprising a collection of stations attached to a central switching unit, which establishes a dedicated path between any two devices that wish to communicate.

Major elements of a single-node network are summarized below:

***Digital switch*:** That provides a transparent (full-duplex) signal path between any pair of attached devices.

Network interface:That represents the functions and hardware needed to connect digital devices to the network (like telephones).

Control unit:That establishes, maintains, and tears down a connection.

An important characteristic of a circuit-switch node is whether it is *blocking* or *non-blocking*.

A blocking network is one, which may be unable to connect two stations because all possible paths between them are already in use. A non-blocking network permits all stations to be connected (in pairs) at once and grants all possible connection requests as long as the called party is free. For a network that supports only voice traffic, a blocking configuration may be acceptable, since most phone calls are of short duration. For data applications, where a connection may remain active for hours, non-blocking configuration is desirable.

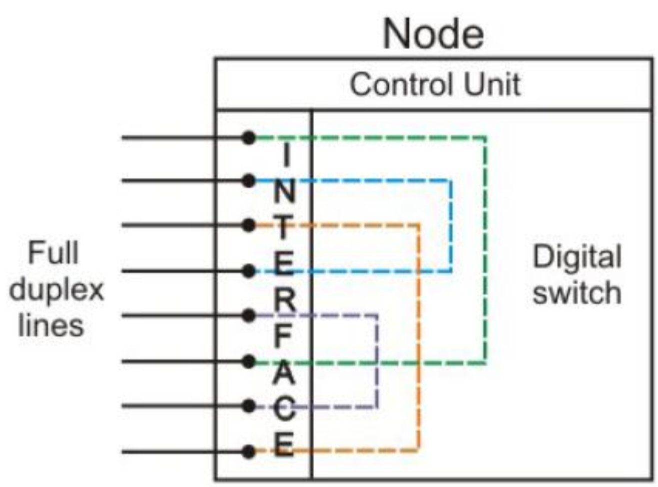


Fig 13.2.5 Schematic Diagram of a Switching node

Circuit switching uses any of the three technologies: **Space-division** switches, **Time-division** switches or a **combination of both**. In Space-division switching, the paths in the circuit are separated with each other spatially, i.e. different ongoing connections, at a same instant of time, uses different switching paths, which are separated spatially. This was originally developed for the analog environment, and has been carried over to the digital domain. Some of the space switches are crossbar switches, Multi-stage switches (e.g. Omega Switches). A **crossbar** switch is shown in Fig. **Fig 13.2.6 .** Basic building block of the switch is a metallic crosspoint or semiconductor gate that can be enabled or disabled by a control unit.

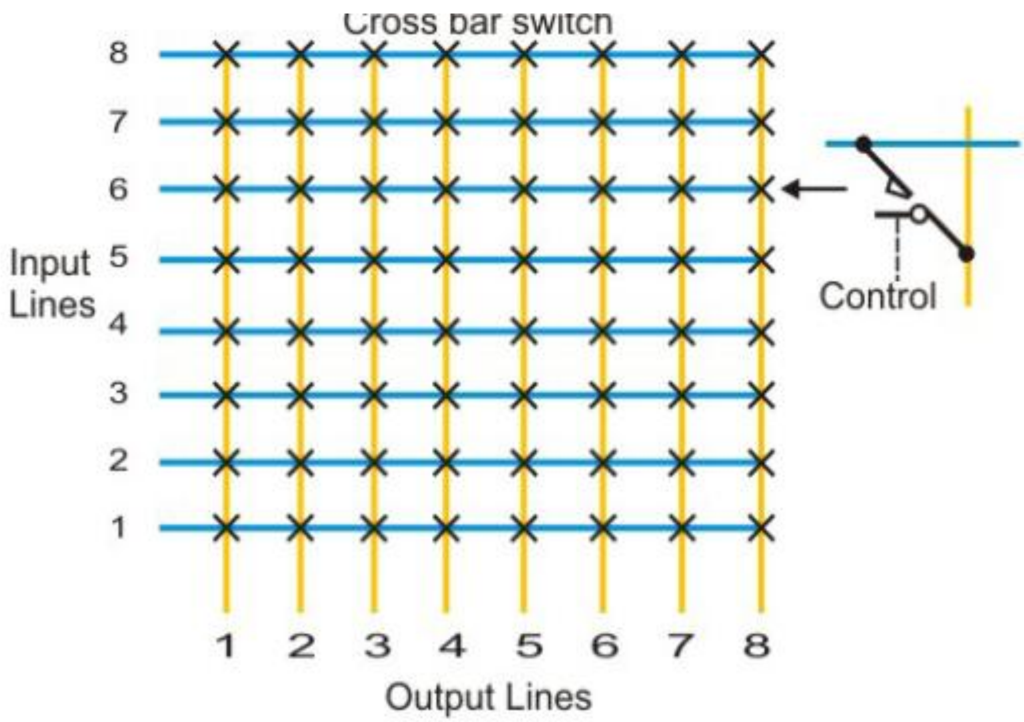


Fig 13.2.6 Schematic diagram of a crossbar switch

Limitations of crossbar switches are as follows:

- The number of crosspoints grows with the square of the number of attached stations.
- Costly for a large switch.
- The failure of a crosspoint prevents connection between the two devices whose lines intersect at that crosspoint.
- The crosspoints are inefficiently utilized.
- Only a small fraction of crosspoints are engaged even if all of the attached devices are active.

Some of the above problems can be overcome with the help of *multistage space division* switches. By splitting the crossbar switch into smaller units and interconnecting them, it is possible to build multistage switches with fewer crosspoints.

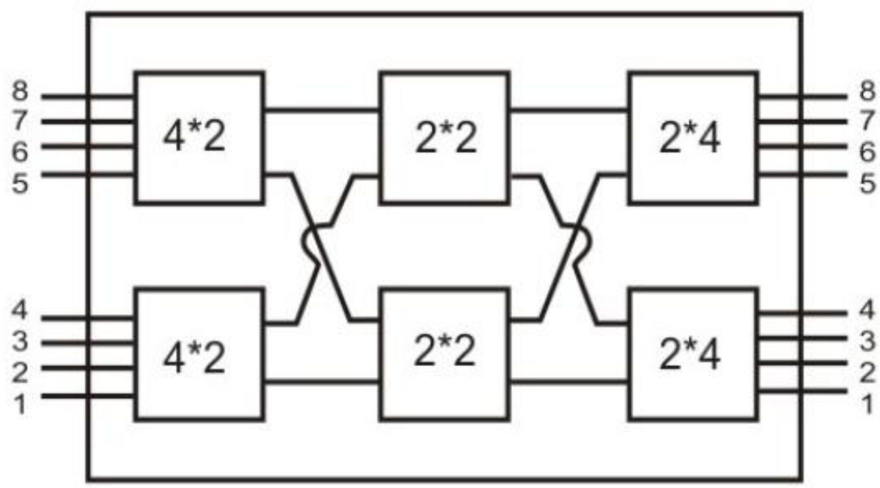


Fig 13.2.6 A three-stage space division switch

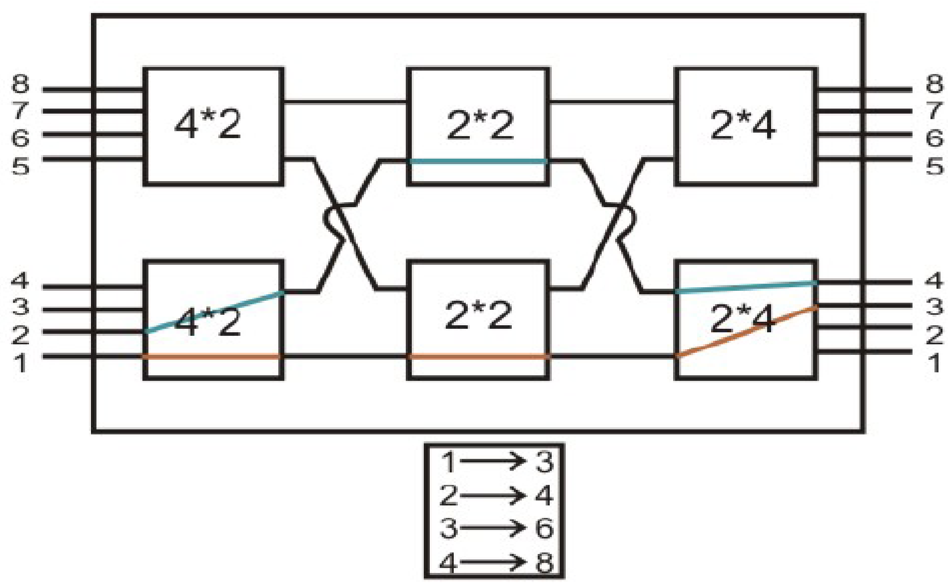
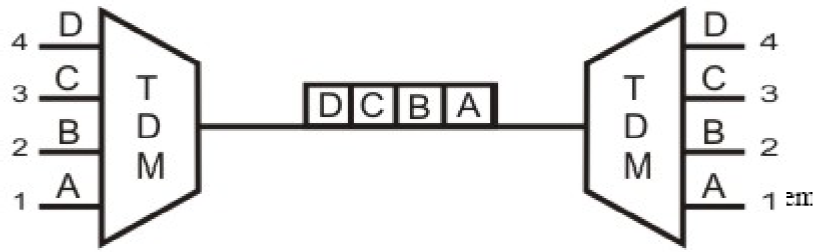


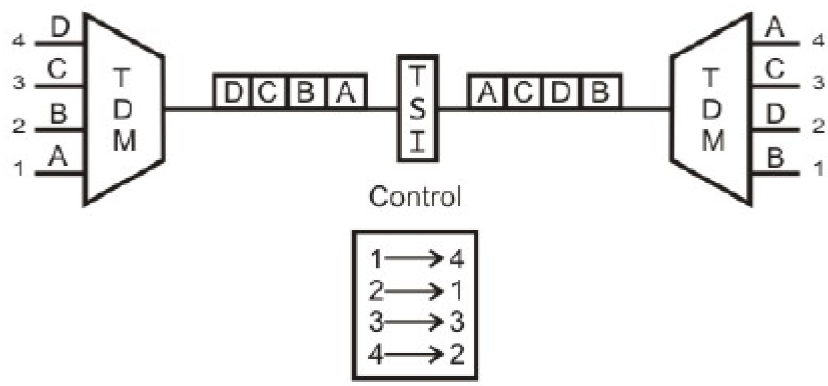
Fig 13.2.7 Block nature of the switch

Figure **Fig 13.2.6** shows a three-stage space division switch. In this case the number of crosspoints needed goes down from 64 to 40. There is more than one path through the network to connect two endpoints, thereby increasing reliability. Multistage switches may lead to *blocking*. The problem may be tackled by increasing the number or size of the intermediate switches, which also increases the cost. The blocking feature is illustrated in Fig. **Fig 13.2.7** . As shown in Fig. **Fig 13.2.7** , after setting up connections for 1-to-3 and 2-to-4, the switch cannot establish connections for 3-to-6 and 4-to-5.

13.2.3 Time Division Switching

Both voice and data can be transmitted using digital signals through the same switches. All modern circuit switches use digital time-division multiplexing (TDM) technique for establishing and maintaining circuits. Synchronous TDM allows multiple low-speed bit streams to share a high-speed line.





13.2.8 TIME Division Multiplexing

Time-division switching uses time-division multiplexing to achieve switching, i.e. different ongoing connections can use same switching path but at different interleaved time intervals.

13.2.4 Packet Switching

Packet switching was designed to address the shortcomings of circuit switching in dealing with data communication. Unlike circuit switching where communication is continuous along a dedicated circuit, in packet switching, communication is discrete in form of packets. Each packet is of a limited size and can hold up to a certain number of octets of user data. Larger messages are broken into smaller chunks so that they can be fitted into packets. In addition to user data, each packet carries additional information (in form of a header) to enable the network to route it to its final destination.

A packet is handed over from node to node across the network. Each receiving node temporarily stores the packet, until the next node is ready to receive it, and then passes it onto the next node. This technique is called **store-and-forward** and overcomes one of the limitations of circuit switching. A packet-switched network has a much higher capacity for accepting further connections. Additional connections are usually not blocked but simply slow down existing connections, because they increase the overall number of packets in the network and hence increase the delivery time of each packet. Figure 13.2.9 shows a simple packet switch with six I/O channels (*a* through *f*). Each channel has an associated buffer which it uses to store packets in transit. The operation of the switch is controlled by a microprocessor. A packet received on anynof the channels can be passed onto any of the other channels by the microprocessor moving it to the corresponding buffer.

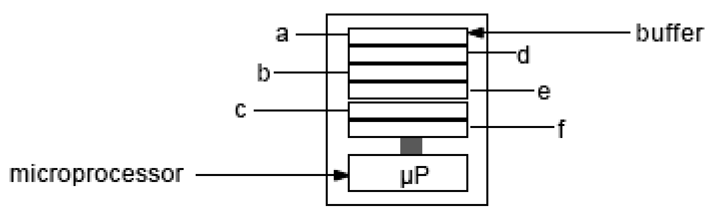


Figure 13.2.9 A simple packet switch.

Two variations of packet switching exist: virtual circuit and datagram. The **virtual circuit** method (also known as **connection-oriented**) is closer to circuit switching. Here a complete route is worked out prior to sending data packets. The route is established by sending a connection request packet along the route to the intended destination. This packet informs the intermediate nodes about the connection and the established route so that they will know how to route subsequent packets. The result is a circuit somewhat similar to those in circuit switching, except that it uses packets as its basic unit of communication. Hence it is called a virtual circuit.

Each packet carries a virtual circuit identifier which enables a node to determine to which virtual circuit it belongs and hence how it should be handled. (The virtual circuit identifier is essential because multiple virtual circuits may pass through the same node at the same time.) Because the route is fixed for the duration of the call, the nodes spend no effort in determining how to route packets.

Fig 13.2.10 illustrates the virtual circuit method using the switch. When the two hosts initiate a connection, the network layer establishes a virtual circuit (denoted by shaded switches) which is maintained for the duration of the connection. When the hosts disconnect, the network layer releases the circuit. The packets in transit are displayed as dark boxes within the buffers. These packets travel only along the designatedvirtual circuit.

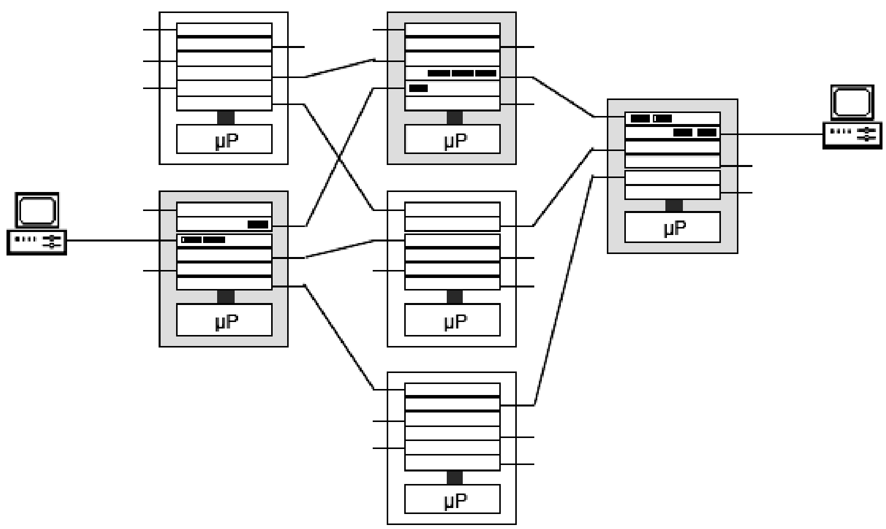
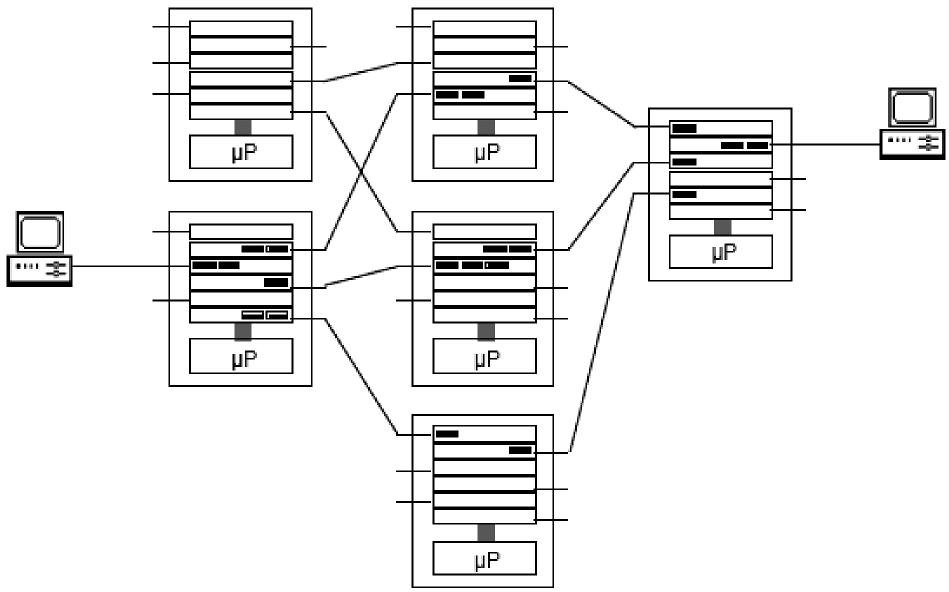


Figure 13.2.10 **Packet switching with virtual circuits.**

The **datagram** method (also known as **connectionless**) does not rely on a pre-established route, instead each packet is treated independently. Therefore, it ispossible for different packets to travel along different routes in the network to reach the same final destination. As a result, packets may arrive out of order, or even never arrive (due to node failure). It is up to the network user to deal with lost packets, and to rearrange packets to their original order. Because of the absence of a preestablishedcircuit, each packet must carry enough information in its header to enable the nodes to route it correctly.

Figure 13.2.11 illustrates the datagram method. Note how the packets exercise different routes.



13.2.11 Packet switching with datagrams.

The advantage of the datagram approach is that because there is no circuit, congestion and faulty nodes can be avoided by choosing a different route. Also, connections can be established more quickly because of reduced overheads. This makes datagrams better suited than virtual circuits for brief connections. For example, database transactions in banking systems are of this nature, where each transaction involves only a few packets.

The advantage of the virtual circuit approach is that because no separate routing is required for each packet, they are likely to reach their destination more quickly; this leads to improved throughput. Furthermore, packets always arrive in order.

Virtual circuits are better suited to long connections that involve the transfer of large amounts of data (e.g., transfer of large files). Because packet switching is the more dominant form of switching for data communication, we will focus our attention on this form of switching from now on.

13.2.5 Switching Modes

Any delay in passing traffic is known as latency. Switches offer three ways to switch the traffic depending upon how thoroughly you want the frame to be checked before it is passed on. The more checking you want, the more latency you will introduce to the switch.

The three switching modes to choose from are:

- Cut-through
- Store-and-forward
- Fragment-free

➢ **Cut-through Mode**

Cut-through switching is the fastest switching method meaning it has the lowest latency. The incoming frame is read up to the destination MAC address. Once it reaches the destination MAC address, the switch then checks its CAM table for the correct port to forward the frame out of and sends it on its way. There is no error checking, so this method gives you the lowest latency. The price, however, is that the switch will forward any frames containing errors.

The process of switching modes can best be described by using a metaphor.

➢ **Store-and-forward** Mode

Here the switch reads the entire frame and copies it into its buffers. A cyclic redundancy check (CRC) takes place to check the frame for any errors. If errors are found, the frame is dropped. Otherwise the switching table is examined and the frame forwarded.

➢ **Fragment-free (modified cut-through/runt-free) Mode**

Since cut-through can ensure that all frames are good and store-and-forward takes too long, we need a method that is both quick and reliable. Using our example of the nightclub security, imagine you are asked to make sure that everyone has an ID and that the picture matches the person. With this method you have made sure everyone is who they say they are, but you do not have to take down all the information. In switching we accomplish this by using the fragment-free method of switching.

13.3 SUMMARY

The generic method for establishing a path for point-to-point communication in anetwork is called **switching**. There are two general switching methods: circuitswitching and packet switching.

In **circuit switching** two communicating stations are connected by a dedicatedcommunication path.

In **packet switching** communication is discrete in form of packets. The packetsare handled by the intermediate nodes in a store-and-forward fashion. Packetswitching is either based on **virtual circuits** or on **datagrams**.

The task of selecting a path for the transport of packets across the network iscalled **routing**. The three classes of routing algorithms are: **flooding**, **staticrouting**, and **dynamic routing**.

13.4 REVIEW QUESTIONS

1. Define Circuit Switching
2. Explain Switching Node
3. Explain Time Division Switching

13.5 LIST OF REFERENCES

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