Module 2

Communication Switching

Lesson
3
Message and Packet Switching

LESSON OBJECTIVE

General

This lesson will develop the concepts of message and packet switching.

Specific

The learner shall be able to

1. Understand what are Message and Packet switching.
2. Know the application of Packet switching.
3. Know statistical multiplexing and its usefulness.

2.2.1 MESSAGE SWITCHING

It has been explained earlier that switching plays a very important role in telecommunication networks. It enables any two users to communicate with each other. Voice being a very vital medium of human communication, telephone was invented. It permitted long distance voice communication. The need of a user to talk to a desired person out of many persons on a real time basis lead to the concept of establishing a direct path between the caller and the called users. Circuit switching was conceived to be an appropriate technique for the purpose. Telephone systems use circuit switching largely to date because it serves the purpose very well. However, a major drawback of circuit switching is the requirement of a dedicated path between the calling and the called parties. This means reserving resources like the chain of switches and transmission media over the entire path. This is obviously a costly proposition. A question arises : is there a cheaper solution? It took quite some time – many years to get the answer.

However, it is interesting to know that electrical communication in the form of Telegraph arrived earlier than the Telephone. Further, telegraph was much cheaper than telephone communication. Let us understand why. Telegraph permitted message communication in the form of text through the help of operators. Further, text messages are generally non real time and non conversational in nature. Because of these simplified requirements, a concept of store and forward, as in the postal system, was

thought to be useful. An operator collected the messages from users and

forwarded to the next node without waiting to know whether the entire path to the destination was available or not. The messages were thus forwarded from node to node by the operators. A message would remain stored at a node if the forward link to the next node was not available. As and when the forward link became available, the message would be transmitted. It should be noted that every message had full addresses of the destination and the source. The addresses are also transmitted along with the user message from one node to another. No doubt that storing the message and waiting for the onward link to be free at every node caused unbounded delay in the delivery of the message. But the delay was tolerated as the message was non real time and in any case it was generally much faster than the post. When the link was available the electrical messages travel faster than the postal messages. Storage and delay at a node fortunately resulted in a much better utilization of the transmission media because the transmission of messages could be distributed over time and there may not be idle periods of time for the line. In fact this mechanism really reduced the cost of communication. In this scheme, no reservation of the network resources is actually required. At a node the messages coming from different directions had to be sorted out depending on their destinations and distributed to different operators handling different destinations. This process of collecting messages coming to different input bins corresponding to different incoming directions and distributing them to different output bins serving different outgoing directions is nothing but switching. Since messages are physically transferred (switched) from one bin to another, the process was rightly called message switching.

There were central telegraph offices which acted like nodes of telegraph network and performed the task of message switching. as the teleprinters came, Morse code was replaced by machine telegraphy resulting in faster operations. Later computers were introduced to do the function of message switching. Computer based message switching is still used many organizations having many locations of working.

2.2.2 TELEGRAPH NETWORK

Having discussed the concept of message switching, we now look at the working of a Telegraph Network with the help of Fig. L3.1 as an example of message switching. A, B, C etc. are the message switching nodes/telegraph offices.

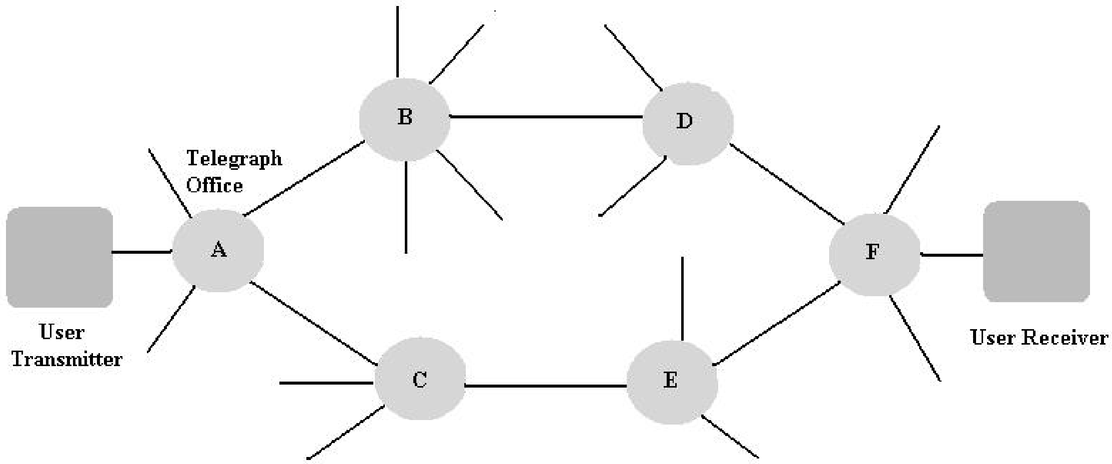

Fig. L3.1 Topology of a telegraph network

- The User who wants to send a telegraph comes to a Telegraph office with his message and hands it over to the counter operator.
- This message is sorted on the basis of the receiver's address and clubbed with other messages moving in the same direction, i.e., if in the Kolkata telegraph office the operator receives 10 messages for addresses in Mumbai, then they are bundled and are sent.
- The operator in this case does not bother if the entire path (to Mumbai) is available or not. He just forwards this message to the next node (Telegraph Office) in the path (generally predetermined).
- The operator at the next node receives all these messages, stores, sorts and forwards them.
- In the olden days the storage was done by manually. Human beings then did the sorting. Later on the storage process was automated using paper tapes. The advantage of using paper tapes is that the incoming signal is punched onto it automatically and the same tape can be directly fed into the telegraph machine for further transmission.

In the Telegraph system, unlike telephones, no circuits are switched. Information is transmitted as discrete messages. So this method of switching is known as **Message Switching**. An important concept in this context is *'Store and Forward'*. Apparently from the discussion above we can conclude that -- at each node (telegraph office) the message that arrives from the previous node in the path is stored for some time, sorted, and depending on the availability of the path from this node to the next in the path, the message is forwarded.

WHY IS THE COST OF TELEGRAPH LESS THAN TELEPHONE?

- Better utilization of transmission media
- The message switching is done over distributed time.
- Hogging (Capturing the entire path) does not occur in message switching. Only one of the links in the entire path may be busy at a given time.

However, message switching requires storage which may be costly.

As explained telegraph communication is much cheaper than the telephone communication but suffers from unbounded delay. Addresses are required to me transmitted along with the text from every mode. This is to some extent wasteful of the bandwidth. In telephones the address (telephone number) is transmitted (dialed) only once for setting up the connection before the conversation starts. Finally, telegraph could handle only text messages unlike telephones which supported voice. Therefore, with there useful features both forms of communication have existed. It is worth while to point out here that people wanted text communication with the same reliability, QoS and ease as the telephone communication. This led to the development of the TELEX system. The teleprinter was the user-end device and teleprinter exchange (TELEX) based on circuit switching provided the desired telephone type user centric text service. Today facsimile has replaced telex to a great extent to provide the text (and also to some extent graphic) service. It may be noted that people want easy and reliable communication service like the telephone and the same time they want cheaper facilities like telegraph, telex and facsimile. They also want voice as well as text and image communication services. Despite being costly, circuit switching technology is surviving. No body can say with surety that the packet switching will replace the circuit switching completely. Packet switching can be considered as a special case of message switching. In fact message switching was reborn as packet switching when computer communication and networks came. Packet switching is discussed in the following section.

THINK OVER THIS

IF THE LENGTH OF THE MESSAGE IS VERY LARGE AND VARIABLE THEN WHAT ARE THE PROBLEMS THAT MAY ARISE?

Solution

- Envisage a situation where we want to send a message M1 from node A to F in the figure above. While this transmission is in progress C wants to send a message M2 to E. The length of message M2 is much shorter than M1. Now the transmission of M1 through the link BD will unnecessarily delay the transmission of M2, which also requires the use of link BD. So for efficient usage of transmission media it is better to have shorter messages. This makes the switching system cost effective.
- If the message length is long, the intermediate nodes are required to have large buffers for storage and this increases the cost of the node. Also as the amount of storage required increases the space occupied by these nodes also increases.

2.2.3 PACKET SWITCHING

A possible solution for the above problem is to fragment the long messages into small size units, known as *packets*. It is these packets that are transmitted instead of the single long message. This method is slightly different from **Message switching** and is called **Packet switching**. Fig. L3.2 shows a message broken down into small sized packets P_1, P_2 …P5.

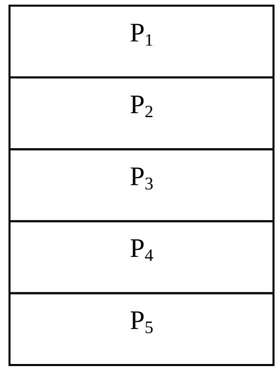

Fig. L3.2 Packets

These packets are now transmitted over the network in the same manner as the messages in message switching. The packets are stored and forwarded at every node. Obviously every packet now has to have the source and destination addresses. Even in message switching repeated transmission of addresses at every node consumes network bandwidth. In packet switching the overhead/wastage is more because every packet is now required to carry the addresses on their head. So with the user message in a packet the header is to be transmitted also. From this point of view network bandwidth consumed is maximum in packet switching and minimum in circuit switching.

Packets of the same message are launched into the network in parallel over different available forward links at a node. These packets would travel through different paths to arrive at the destination. This simultaneous transmission of packets over different paths results in further improvement of the link utilization compared to the message switching. Another advantage is that no link is engaged for a long time since the packets are of smaller size than the single message. This permits better sharing of the links amongst multiple users. However the scheme just discussed has two major drawbacks. Firstly, the packets of the same message traveling through different paths may arrive at the destination at different times due to different delays encountered in different paths. Thus the packets may arrive out of order. In order to deliver them to the destination, they need to be ordered which requires extra processing and so more delay. They need to be given sequence numbers for reordering them. The sequence number increases the overhead and require more network bandwidth. Secondly, some of the paths may not be very good and some packets may get lost. This worsen the quality. To improve quality. they require retransmission which in turn requires more processing time and more bandwidth. In spite of these drawbacks the packet switching more favored. In fact for computer communication and network packet communication was the choice. Basic reasons for this choice were: 1. the computer traffic being (at least then) being mostly text is non real time and 2. the computer data traffic is highly bursty in nature. Considering these features it becomes obvious that circuit switching was not the right kind of switching. Message switching can do the job but for better line utilization packet switching is preferable. Thus computer networks use packet switching.

Fig. L2.5 illustrates how packets move through the network. A user Pi has a long message which is required to be sent to the user Po. The message is broken in four packets which are sequenced P1, P2, P3 and P4. Source and destination addresses are attached the each of the four packets. The packet P1 takes the path A4-B4-C1-D2-E1 while the packet P2 goes through A4-B3-C3-D3-E1. The paths followed by P3 and P4 are marked in the diagram. The packets arrive at the destination node E1 out of order. The sequence in which the packets arrive are P3, P4, P1 and P2. They are required to be properly ordered. Thus no individual link gets hogged for a long time and all links which were idle are being utilized.

2.2.4 STATISTICAL MULTIPLEXING

Packet switching offers another great advantage that is permits statistical multiplexing. Statistical Multiplexing is an important technique which permits transmission of many messages on a single medium without really allocating the resource rigidly. In conventional form of multiplexing we either allot a fixed amount of time duration that is slot to a user or a fixed frequency band. Every user has a different time slot in time division multiplexing (TDM). In frequency division multiplexing (FDM) every user gets a different frequency band. The total number of different slot/bands is fixed and thus the number of users also get fixed in each of the schemes. Fig. L3.3 shows the slots and bands in TDM and FDM.

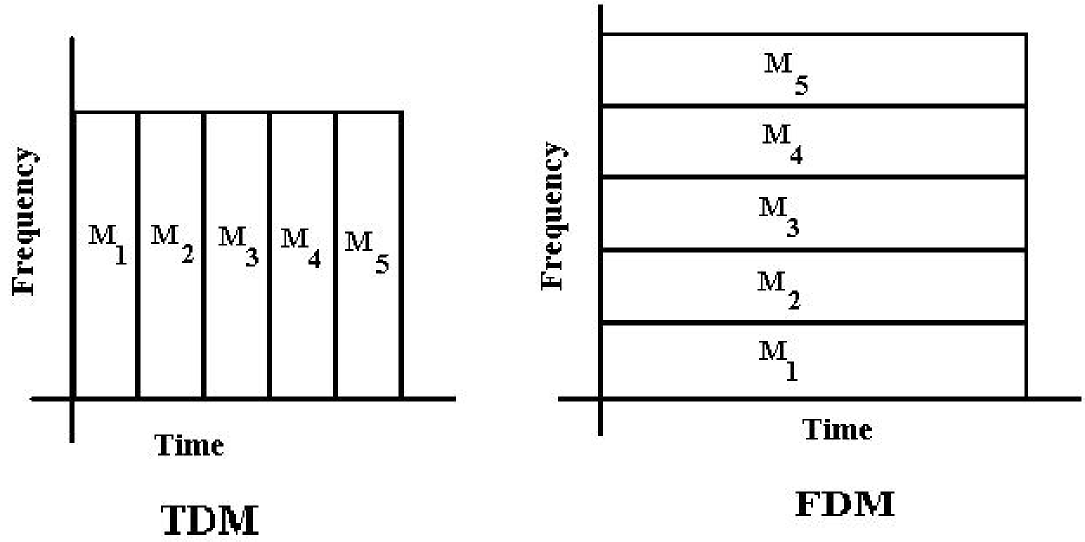

Fig. L3.3 TDM and F

These schemes are not efficient when traffic is variable bit rate and/or heterogeneous like voice, data and video because of their rigid structure. Irrespective of the data rate and the nature of traffic, the messages can be packetized. Packet of every message will have similar look and therefore they can be easily sent through a packet network. The packets will have the addresses, sequence numbers and the type tag. They will reach their respective destinations and assembled there based on their type tag. Messages requiring large bandwidth will have more number of packets than the messages with smaller bandwidth. The packets would be launched to the network statistically without any ordering. This form of multiplexing is known as **Statistical Time Division Multiplexing**. It is also known as Asynchronous TDM. Basically it is a time division multiplexing with no regularity in slots that is packets here. Because there is no time relationship between the adjacent packets it is termed as asynchronous TDM. The statistical multiplexer exploits the bursty nature of data transmission by dynamically allocating time slots on demand. As all the users are not transmitting all the time, the data rate on the multiplexed line is less than the sum of the data rates of the attached users. Using this technique we never have to send an empty time slot if there is no data to be transmitted.

☞ *CONSIDER THE FOLLOWING SITUATION*

Packets from several input lines at a node are to be statistically multiplexed to an outgoing line. Packets from all the incoming lines are stored in a buffer as shown in Fig. L3.4. These packets are numbered as P_{11}, $P_{12...}$ etc. where the first subscript corresponds to the incoming line from where the packet has arrived and the second subscript is for the packet number. A packet is selected at random and readout to the outgoing line. This form of Multiplexing is known as Statistical Multiplexing. In this process a message that has a large number of packets will have a higher probability of its packets being read out as compared to a message that has a small number of packets. Thus, we allot more time to the user that has a longer message and a lesser time to the user that has to transmit a shorter message. Statistical multiplexing is similar to TDM without fixed time slots.

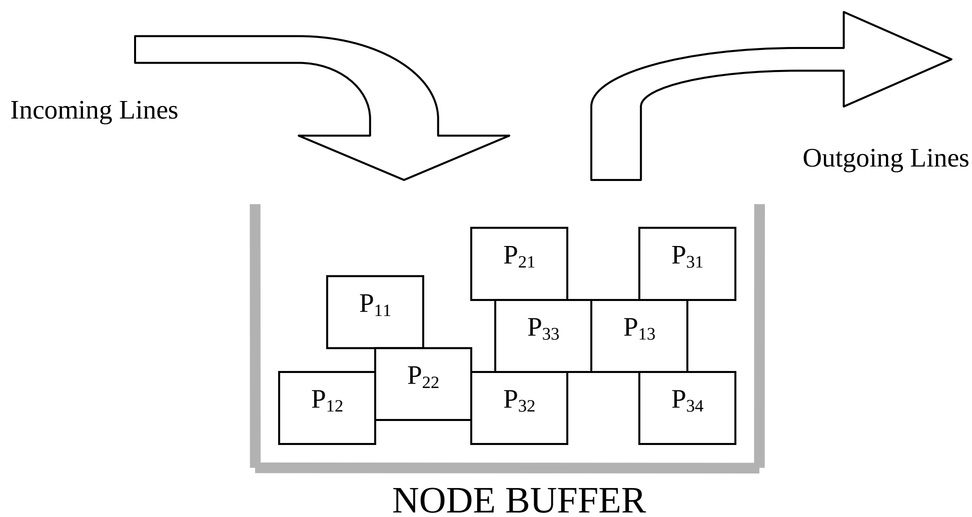

Fig. L3.4 Statistical Multiplexing

Statistical multiplexing is best suited to bursty traffic (on time is less than off time). Data traffic is very bursty in nature and so we can use Statistical multiplexing in this case. It may be mentioned here that voice is also bursty but not as much as data. Generally in telephone communication a speaker on an average speaks for 40% of the time.

In conventional TDM and FDM systems, only similar type of traffic from the input can be multiplexed. But in statistical multiplexing different formats and speeds of traffic can be carried by a single output line as long as the data from the different sources is appropriately packetized. If statistical multiplexing is to be employed then packet switching is the natural choice

Objective Questions

3.01

Subjective Questions

3.11 How would you multiplex a video and audio channel ?

3.12 Consider a network consisting of 8 nodes. If 10^6 bytes of message are to be transferred find out the packet size. Also workout and compare delays for the three switching techniques.

3.13 Explain the concept of store and forward transmission scheme with an example.

3.14 Consider that there are 6 nodes in a network. The mean size of messages is 10 units. However one of the stations occasionally issues messages that are 100 units long. If the network uses message switching what problems do you envisage and how will you overcome the problem? Explain.

3.15 What are the additional delays encountered in packet switching compared to message switching?

3.16 Explain Statistical Multiplexing

3.17 Discuss with the help of diagrams the working of message and packet switching.