CHAPTER 8

Switching

Solutions to Review Questions and Exercises

Review Questions

1. Switching provides a practical solution to the problem of connecting multiple devices in a network. It is more practical than using a bus topology; it is more efficient than using a star topology and a central hub. Switches are devices capable of creating temporary connections between two or more devices linked to the switch.

2. The three traditional switching methods are circuit switching, packet switching, and message switching. The most common today are circuit switching and packet switching.

3. There are two approaches to packet switching: datagram approach and virtual-circuit approach.

4. In a circuit-switched network, data are not packetized; data flow is somehow a continuation of bits that travel the same channel during the data transfer phase. In a packet-switched network data are packetized; each packet is somehow an independent entity with its local or global addressing information.

5. The address field defines the end-to-end (source to destination) addressing.

6. The address field defines the virtual circuit number (local) addressing.

7. In a space-division switch, the path from one device to another is spatially separate from other paths. The inputs and the outputs are connected using a grid of electronic microswitches. In a time-division switch, the inputs are divided in time using TDM. A control unit sends the input to the correct output device.

8. TSI (time-slot interchange) is the most popular technology in a time-division switch. It used random access memory (RAM) with several memory locations. The RAM fills up with incoming data from time slots in the order received. Slots are then sent out in an order based on the decisions of a control unit.

9. In multistage switching, blocking refers to times when one input cannot be connected to an output because there is no path available between them—all the possible intermediate switches are occupied. One solution to blocking is to increase the number of intermediate switches based on the Clos criteria.
10. A packet switch has four components: input ports, output ports, the routing processor, and the switching fabric. An input port performs the physical and data link functions of the packet switch. The output port performs the same functions as the input port, but in the reverse order. The routing processor performs the function of table lookup in the network layer. The switching fabric is responsible for moving the packet from the input queue to the output queue.

**Exercises**

11. We assume that the setup phase is a two-way communication and the teardown phase is a one-way communication. These two phases are common for all three cases. The delay for these two phases can be calculated as three propagation delays and three transmission delays or

\[
3 \left( \frac{5000 \text{ km}}{2 \times 10^8 \text{ m/s}} \right) + 3 \left( \frac{(1000 \text{ bits}/1 \text{ Mbps})}{1 \text{ Mbps}} \right) = 75 \text{ ms} + 3 \text{ ms} = 78 \text{ ms}
\]

We assume that the data transfer is in one direction; the total delay is then

\[
\text{delay for setup and teardown} + \text{propagation delay} + \text{transmission delay}
\]

a. \(78 + 25 + 1 = 104 \text{ ms}\)
b. \(78 + 25 + 100 = 203 \text{ ms}\)
c. \(78 + 25 + 1000 = 1103 \text{ ms}\)
d. In case a, we have 104 ms. In case b we have \(203/100 = 2.03 \text{ ms}\). In case c, we have \(1103/1000 = 1.101 \text{ ms}\). The ratio for case c is the smallest because we use one setup and teardown phase to send more data.

12. We assume that the transmission time is negligible in this case. This means that we suppose all datagrams start at time 0. The arrival timed are calculated as:

First: \( \frac{(3200 \text{ Km})}{(2 \times 10^8 \text{ m/s})} + (3 + 20 + 20) = 59.0 \text{ ms} \)
Second: \( \frac{(11700 \text{ Km})}{(2 \times 10^8 \text{ m/s})} + (3 + 10 + 20) = 91.5 \text{ ms} \)
Third: \( \frac{(12200 \text{ Km})}{(2 \times 10^8 \text{ m/s})} + (3 + 20 + 20 + 20) = 114.0 \text{ ms} \)
Fourth: \( \frac{(10200 \text{ Km})}{(2 \times 10^8 \text{ m/s})} + (3 + 7 + 20) = 81.0 \text{ ms} \)
Fifth: \( \frac{(10700 \text{ Km})}{(2 \times 10^8 \text{ m/s})} + (3 + 7 + 20 + 20) = 103.5 \text{ ms} \)

The order of arrival is: \(3 \rightarrow 5 \rightarrow 2 \rightarrow 4 \rightarrow 1\)

13. a. In a circuit-switched network, end-to-end addressing is needed during the setup and teardown phase to create a connection for the whole data transfer phase. After the connection is made, the data flow travels through the already-reserved resources. The switches remain connected for the entire duration of the data transfer; there is no need for further addressing.

b. In a datagram network, each packet is independent. The routing of a packet is done for each individual packet. Each packet, therefore, needs to carry an end-to-end address. There is no setup and teardown phases in a datagram network (connectionless transmission). The entries in the routing table are somehow permanent and made by other processes such as routing protocols.
c. In a virtual-circuit network, there is a need for end-to-end addressing during the setup and teardown phases to make the corresponding entry in the switching table. The entry is made for each request for connection. During the data transfer phase, each packet needs to carry a virtual-circuit identifier to show which virtual-circuit that particular packet follows.

14. A datagram or virtual-circuit network handles packetized data. For each packet, the switch needs to consult its table to find the output port in the case of a datagram network, and to find the combination of the output port and the virtual circuit identifier in the case of a virtual-circuit network. In a circuit-switched network, data are not packetized; no routing information is carried with the data. The whole path is established during the setup phase.

15. In circuit-switched and virtual-circuit networks, we are dealing with connections. A connection needs to be made before the data transfer can take place. In the case of a circuit-switched network, a physical connection is established during the setup phase and is broken during the teardown phase. In the case of a virtual-circuit network, a virtual connection is made during setup and is broken during the teardown phase; the connection is virtual, because it is an entry in the table. These two types of networks are considered connection-oriented. In the case of a datagram network no connection is made. Any time a switch in this type of network receives a packet, it consults its table for routing information. This type of network is considered a connectionless network.

16. The switching or routing in a datagram network is based on the final destination address, which is global. The minimum number of entries is two; one for the final destination and one for the output port. Here the input port, from which the packet has arrived is irrelevant. The switching or routing in a virtual-circuit network is based on the virtual circuit identifier, which has a local jurisdiction. This means that two different input or output ports may use the same virtual circuit number. Therefore, four pieces of information are required: input port, input virtual circuit number, output port, and output virtual circuit number.

17.
Packet 1: 2
Packet 2: 3
Packet 3: 3
Packet 4: 2

18.
Packet 1: 2, 70
Packet 2: 1, 45
Packet 3: 3, 11
Packet 4: 4, 41

19.
   a. In a datagram network, the destination addresses are unique. They cannot be duplicated in the routing table.
   b. In a virtual-circuit network, the VCIs are local. A VCI is unique only in relationship to a port. In other words, the (port, VCI) combination is unique. This means that we can have two entries with the same input or output ports. We can