DATA COMMUNICATIONS AND NETWORKING

Chapter 08

Rising Flare Community

Made with LaTeX and ArchLinux.
Source code is available on GitHub. Feel free to check it out!

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1 Questions

1.1 Describe the need for switching and define a switch.

A switched network consists of a series of interlinked nodes, called switches. Switching is required to connect multiple devices to a single network.
A switch is a device that connects multiple devices to a single network. For example, routers, bridges, and gateways are all types of switches.

1.2 List the three traditional switching methods. Which are the most common today?

The three traditional switching methods are

- Circuit switching
- Message switching
- Packet switching

Circuit switching and Packet switching is the most common method today.

1.3 What are the two approaches to packet switching?

The two approaches to packet switching are datagram and virtual-circuit.

1.4 Compare and contrast a circuit-switched network and a packet-switched network.

In a circuit-switched network, a dedicated communication path is established between two devices. In a packet-switched network, data is divided into packets and sent over the network.

1.5 What is the role of the address field in a packet traveling through a datagram network?

The address field in a packet traveling through a datagram network is used to identify the destination device.

1.6 What is the role of the address field in a packet traveling through a virtual- circuit network?

The address field in a packet traveling through a virtual-circuit network is used to identify the virtual circuit.

1.7 Compare space-division and time-division switches.

Space-division switches use multiple paths to connect devices, while time-division switches use a single path and divide the time into slots.

1.8 What is TSI and what is its role in time-division switching?

TSI stands for Time Slot Interchange. It is used to switch time slots in a time-division switch.

1.9 Compare and contrast the two major categories of circuit switches.

The two major categories of circuit switches are crossbar switches and time-division switches. Crossbar switches use multiple paths to connect devices, while time-division switches use a single path and divide the time into slots.

1.10 List four major components of a packet switch and their functions.

The four major components of a packet switch are

- Input ports
- Output ports
- Switching fabric
- Routing processor

2 Problems

2.1 A path in a digital circuit-switched network has a data rate of 1 Mbps. The exchange of 1000 bits is required for the setup and teardown phases. The distance between two parties is 5000 km. Answer the following questions if the propagation speed is 2×10^8 m.

1. **What is the total delay if 1000 bits of data are exchanged during the data-transfer phase?**
2. **What is the total delay if 100,000 bits of data are exchanged during the data-transfer phase?**
3. **What is the total delay if 1,000,000 bits of data are exchanged during the data-transfer phase?**
4. **Find the delay per 1000 bits of data for each of the above cases and compare them. What can you infer?**

Here, in the setup phase we have to exchange data two times, and once for the teardown.
Propagation delay $= \frac{5000 \times 10^3}{2 \times 10^8} = 0.025 sec$
Transmission delay $= \frac{1000}{10^6} = 0.001 sec$
So, delay for setup and teardown phase $= 0.025 \times 3 + 0.001 \times 3 = 0.078 sec$

1. For 1000 bits of data, total delay $= 0.078 + 0.025 + \frac{1000}{10^6} = 0.104sec$
2. For 100,000 bits of data, total delay $= 0.078 + 0.025 + \frac{100000}{10^6} = 0.203sec$
3. For 1,000,000 bits of data, total delay $= 0.078 + 0.025 + \frac{1000000}{10^6} = 1.103sec$
4. For above cases,
   (a) For 1000 bits delay will be, $\frac{0.104 \times 1000}{1000} = 0.104sec$
   (b) For 1000 bits delay will be, $\frac{0.203 \times 1000}{100000} = 0.00203sec$
   (c) For 1000 bits delay will be, $\frac{1.103 \times 1000}{1000000} = 0.001103sec$

   The ratio for case c is the smallest because we use one setup and teardown phase to send more data.

2.2 Five equal-size datagrams belonging to the same message leave for the destination one after another. However, they travel through different paths as shown in Table 1.

Datagram	Path Length	Visited Switches
1	3200 km	1, 3, 5
2	11,700 km	1, 2, 5
3	12,200 km	1, 2, 3, 5
4	10,200 km	1, 4, 5
5	10,700 km	1, 4, 3, 5

Table 1: P8-2

We assume that the delay for each switch (including waiting and processing) is 3, 10, 20, 7, and 20 ms respectively. Assuming that the propagation speed is 2×10^8 m, find the order the datagrams arrive at the destination and the delay for each. Ignore any other delays in transmission.

2.3 Transmission of information in any network involves end-to-end addressing and sometimes local addressing (such as VCI). Table 8.2 shows the types of networks and the addressing mechanism used in each of them.

Network	Setup	Data Transfer	Teardown
Circuit-switched	End-to-end		End-to-end
Datagram		End-to-end	
Virtual-Circuit	End-to-end	Local	End-to-end

Table 2: P8-3

Answer the following questions:

1. **Why does a circuit-switched network need end-to-end addressing during the setup and teardown phases? Why are no addresses needed during the data transfer phase for this type of network?**

2. **Why does a datagram network need only end-to-end addressing during the data transfer phase, but no addressing during the setup and teardown phases?**

3. **Why does a virtual-circuit network need addresses during all three phases?**

2.4 We mentioned that two types of networks, datagram and virtual-circuit, need a routing or switching table to find the output port from which the information belonging to a destination should be sent out, but a circuit-switched network has no need for such a table. Give the reason for this difference.

2.5 An entry in the switching table of a virtual-circuit network is normally created during the setup phase and deleted during the teardown phase. In other words, the entries in this type of network reflect the current connections, the activity in the network. In contrast, the entries in a routing table of a datagram network do not depend on the current connections; they show the configuration of the network and how any packet should be routed to a final destination. The entries may remain the same even if there is no activity in the network. The routing tables, however, are updated if there are changes in the network. Can you explain the reason for these two different characteristics? Can we say that a virtual-circuit is a connection-oriented network and a datagram network is a connectionless network because of the above characteristics?

2.6 The minimum number of columns in a datagram network is two; the minimum number of columns in a virtual-circuit network is four. Can you explain the reason? Is the difference related to the type of addresses carried in the packets of each network?

2.7 Figure 8.27 shows a switch (router) in a datagram network.

Destination address	Output port
1233	3
1456	2
3255	1
4470	4
7176	2
8766	3
9144	2

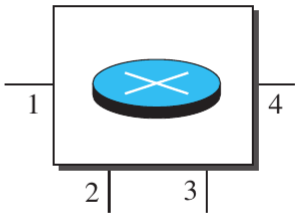

Figure 1: 8.27

Find the output port for packets with the following destination addresses:

1. **Packet 1: 7176**

2. **Packet 2: 1233**
3. **Packet 3: 8766**
4. **Packet 4: 9144**

2.8 Figure 8.28 shows a switch in a virtual-circuit network.

Incoming		Outgoing	
Port	VCI	Port	VCI
1	14	3	22
2	71	4	41
2	92	1	45
3	58	2	43
3	78	2	70
4	56	3	11

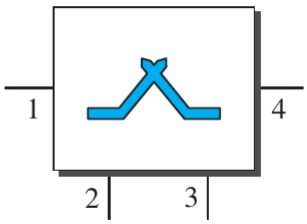

Figure 2: 8.27

Find the output port for packets with the following destination addresses:

1. **Packet 1: 3, 78**
2. **Packet 2: 2, 92**
3. **Packet 3: 4, 56**
4. **Packet 4: 2, 71**

2.9 Answer the following questions:

1. **Can a routing table in a datagram network have two entries with the same destination address? Explain.**
2. **Can a switching table in a virtual-circuit network have two entries with the same input port number? With the same output port number? With the same incoming VCIs? With the same outgoing VCIs? With the same incom- ing values (port, VCI)? With the same outgoing values (port, VCI)?**

2.10 It is obvious that a router or a switch needs to search to find information in the corresponding table. The searching in a routing table for a datagram network is based on the destination address; the searching in a switching table in a virtual-circuit network is based on the combination of incoming port and incoming VCI. Explain the reason and define how these tables must be ordered (sorted) based on these values.

2.11 Consider an n $\times$ k crossbar switch with n inputs and k outputs.

1. **Can we say that the switch acts as a multiplexer if n > k?**
2. **Can we say that the switch acts as a demultiplexer if n < k?**

2.12 We need a three-stage space-division switch with N = 100. We use 10 cross- bars at the first and third stages and 4 crossbars at the middle stage.

1. **Draw the configuration diagram.**
2. **Calculate the total number of crosspoints.**
3. **Find the possible number of simultaneous connections.**
4. **Find the possible number of simultaneous connections if we use a single crossbar (100 × 100).**
5. **Find the blocking factor, the ratio of the number of connections in part c and in part d.**

2.13 Repeat Problem 8-12 if we use 6 crossbars at the middle stage.

2.14 Redesign the configuration of Problem 8-12 using the Clos criteria.

2.15 We need to have a space-division switch with 1000 inputs and outputs. What is the total number of crosspoints in each of the following cases?

1. **Using a single crossbar.**
2. **Using a multi-stage switch based on the Clos criteria.**

2.16 We need a three-stage time-space-time switch with N = 100. We use 10 TSIs at the first and third stages and 4 crossbars at the middle stage.

1. **Draw the configuration diagram.**
2. **Calculate the total number of crosspoints.**
3. **Calculate the total number of memory locations we need for the TSIs.**