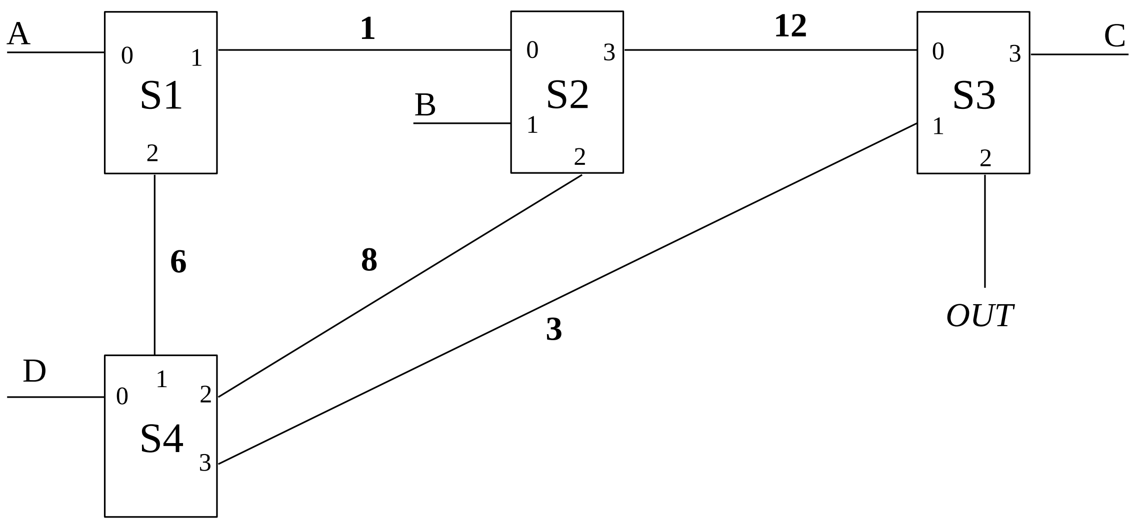
**ECE 4380/6380: Computer Communications** **Spring 2017**
**Problem Set 5** **Due: in class, Friday, March 10**

Assigned reading: Peterson and Davie, Chapter 3. All problems have equal weight. This homework set draws from material in Section 3.1 only.

1. **Datagram forwarding.** Chapter 3, number 4**.**
2. **Virtual Circuit forwarding.** Chapter 3, number 5**.**
3. **Source routing.** Chapter 3, number 6**.**
4. **Forwarding Tables.**

Consider the network shown in the figure. The links are labeled with relative costs. The cost of a path is the sum of the costs for the links in the path. For example, the cost for the path from *A* to the "OUT" port is 13 if the path is S1-S2-S3, and the cost is 9 if the path is S1-S4-S3. The three parts of this problem deal with datagram forwarding, circuit-switched forwarding, and source-routed forwarding, respectively.




a) Give the datagram forwarding table at switch S2, assuming least-cost paths are used. There is a row in the table for each possible destination (including the default destination OUT). List the output port number and the distance.

b) Suppose virtual circuit forwarding is used for the same network as shown above with the forwarding tables shown below. Also assume for a given link and a given direction, whenever a new virtual circuit is set up through the link, the smallest unused (on the given link and direction) virtual circuit identifier is selected. Indicate how the routing tables are modified after the following two changes. (i) First the circuit beginning with (port, VCI) = (0, 0) at switch S1 is torn down. (ii) Subsequently, a new circuit is set up from host D to host B using a least-cost path.

| S1 | | | |
|---|---|---|---|
| $port_{in}$ | $VCI_{in}$ | $port_{out}$ | $VCI_{out}$ |
| 0 | 0 | 2 | 0 |
| 0 | 1 | 1 | 0 |
| 1 | 0 | 0 | 0 |

| S3 | | | |
|---|---|---|---|
| $port_{in}$ | $VCI_{in}$ | $port_{out}$ | $VCI_{out}$ |
| 0 | 0 | 3 | 0 |
| 0 | 1 | 3 | 1 |
| 3 | 0 | 0 | 0 |

| S2 | | | |
|---|---|---|---|
| $port_{in}$ | $VCI_{in}$ | $port_{out}$ | $VCI_{out}$ |
| 0 | 0 | 2 | 0 |
| 2 | 0 | 3 | 0 |
| 2 | 1 | 1 | 2 |
| 2 | 2 | 1 | 1 |
| 3 | 0 | 1 | 0 |

| S4 | | | |
|---|---|---|---|
| $port_{in}$ | $VCI_{in}$ | $port_{out}$ | $VCI_{out}$ |
| 0 | 0 | 2 | 0 |
| 0 | 1 | 2 | 1 |
| 1 | 0 | 2 | 2 |
| 2 | 0 | 0 | 0 |

c) Assume source routing is used. Indicate the sequence of port identifiers to be found in a packet header for a packet sent by host B destined for host C along the least-cost path. (Assume the sequence of port identifiers in the header is transmitted in the order written, from left to right.)

## 5. Forwarding

Consider a network that has nodes designated as A, B, C, D, E, and F. There is a positive integer cost assigned to each link in the network, and do not assume that the cost is the same in each direction on a link. For example, you can easily see in the tables below that the cost of the link from A to B is 3 but the cost of the link from B to A is 1. You are able to observe the current state of the forwarding tables at three of the nodes: nodes A, B, and C. Assume that the routing protocol has built the forwarding tables so that the minimum cost route is selected for each destination, where the cost of a route is simply the sum of the costs of the links in the route. The forwarding tables for these nodes are shown below.

| A's table | | | B's table | | | C's table | | |
|---|---|---|---|---|---|---|---|---|
| Destination | Next Node | Cost | Destination | Next Node | Cost | Destination | Next Node | Cost |
| A | A | 0 | A | A | 1 | A | A | 2 |
| B | B | 3 | B | B | 0 | B | A | 5 |
| C | C | 2 | C | A | 3 | C | C | 0 |
| D | C | 8 | D | A | 9 | D | F | 6 |
| E | B | 7 | E | E | 4 | E | A | 9 |
| F | C | 6 | F | A | 7 | F | F | 4 |

a) Draw the network connectivity and give the costs for the links that can be positively verified based upon the entries in the forwarding tables. Note, it is possible that the cost cannot be determined for some links.
b) Costs for one or more links change in the network and C's forwarding table is updated to the following entries. Nodes A and B have not yet been notified of any of the changes, and their tables have not yet been updated. What links have new values?

| C's table | | |
|---|---|---|
| Destination | Next Node | Cost |
| A | A | 2 |
| B | B | 1 |
| C | C | 0 |
| D | B | 11 |
| E | B | 5 |
| F | F | 4 |

c) After the change to C's forwarding table, there is a problem with the forwarding information. Describe the problem. (Notice this illustrates a problem with updating forwarding tables. During the period before all the final changes have been made to all tables, problems can exist.)

## 6. Ethernet Bridges.

Suppose that three Ethernet LAN's are connected with two bridges as shown in Figure 1 below. Each Ethernet LAN operates at the rate of 10 Mbps, and assume that the efficiency of each Ethernet is 80 percent (i.e., the maximum throughput on a LAN is 8 Mbps). There are $N$ hosts connected to *each* LAN (and a total of $3N$ hosts). Each host transmits frames at the average rate of $R$ bps, and each frame is equally likely to be destined for a host on one of the three LAN's. We are interested in the average behavior so assume that the bridges have learned the locations of all the hosts.

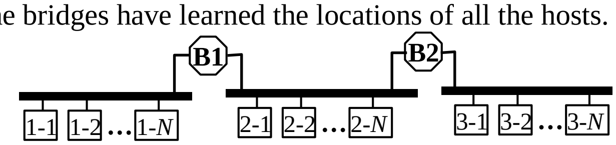



**Figure 1. Linear network**

(a). For the topology in Figure 1, find the maximum value for $N$ that can be supported if $R$ is equal to 100 Kbps. (Answer: 34.)

(b) For the topology given in Figure 2, there are three bridges connected with a common backbone LAN. The backbone LAN also operates at the rate of 10 Mbps, and assume its efficiency is also 80%. There are no hosts directly connected to the backbone LAN. Under the same assumptions as for part a, find the maximum value for $N$.

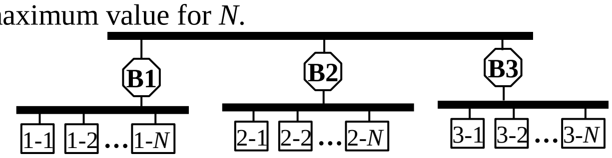



**Figure 2. Backbone network**

(c) Consider the same network as for part (b) but assume that the backbone LAN is upgraded to operate at 100 Mbps (but still assume its efficiency is 80%). What is the maximum value for $N$ after this change?