Computer Networks
Problem Set 3A

Instructor: Shashi Prabh

Peterson and Davie, Chapter 3. Internetworking

3.1 Using the example network given in Figure, give the virtual circuit tables for all the switches after each of the following connections is established. Assume that the sequence of connections is cumulative; that is, the first connection is still up when the second connection is established, and so on. Also assume that the VCI assignment always picks the lowest unused.

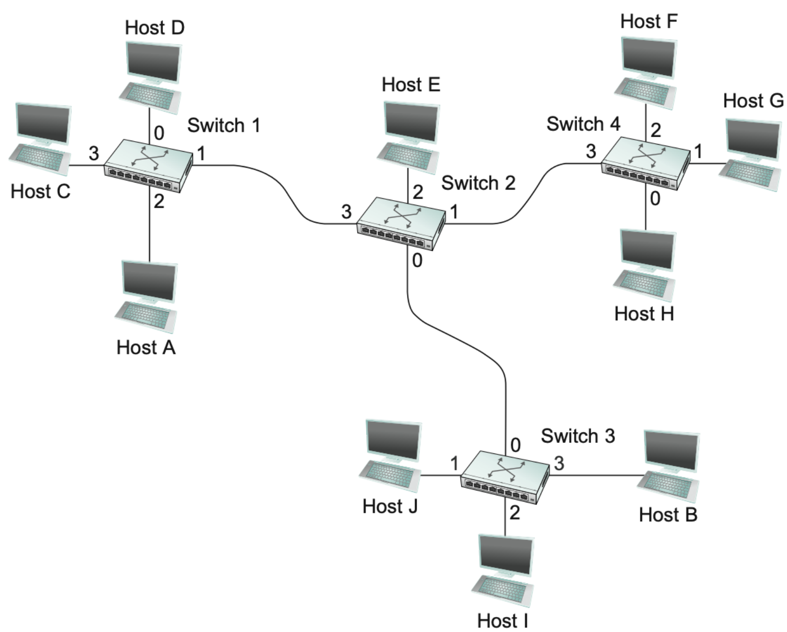

Figure 1: Exercise 3.1

3.2 For the network given below, give the datagram forwarding table for each node. The links are labeled with relative costs; your tables should forward each packet via the lowest-cost path to its destination.

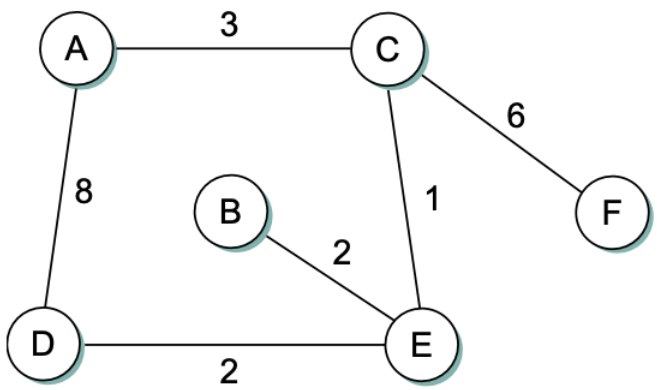

Figure 2: Exercise 3.2

3.3 Give forwarding tables for switches S1 to S4 in figure below.Each switch should have a default routing entry, chosen to forward packets with unrecognized destination addresses toward OUT. Any specific-destination table entries duplicated by the default entry should then be eliminated.

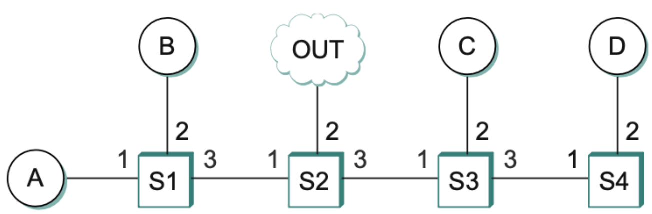

Figure 3: Exercise 3.3

3.4 Consider the virtual circuit switches in the figure below. Table 3.15 lists, for each switch, what ⟨port, VCI⟩ (or ⟨VCI, interface⟩) pairs are connected to what other. Connections are bidirectional. List all endpoint-to-endpoint connections.

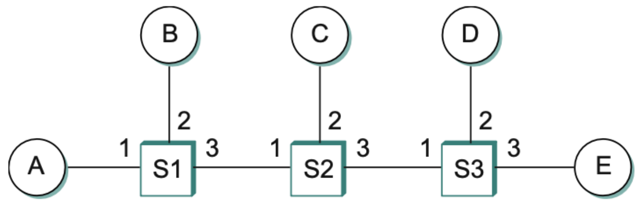

Figure 4: Exercise 3.4

Table 3.15 VCI Tables for Switches in Figure 3.47

Port	VCI	Port	VCI
Switch S1			
1	2	3	1
1	1	2	3
2	1	3	2
Switch S2			
1	1	3	3
1	2	3	2
Switch S3			
1	3	2	1
1	2	2	2

Table 1: Exercise 3.4

3.5 Given the extended LAN shown in the figure below, indicate which ports are not selected by the spanning tree algorithm.

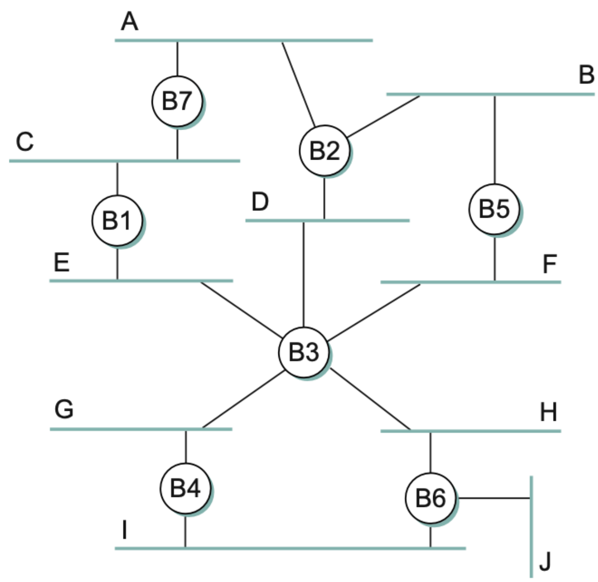

Figure 5: Exercise 3.5

3.6 Consider hosts X, Y, Z, and W and learning bridges B1, B2, and B3, with initially empty forwarding tables, as in the figure below.

a. Suppose X sends to W. Which bridges learn where X is? Does Y's network interface see this packet?

b. Suppose Z now sends to X. Which now sends to X. Which bridges learn where Z is? Does Y's network interface see this packet?

c. Suppose Y now sends to X. Which bridges learn where Y is? Does Z's network interface see this packet?

d. Finally, suppose W sends to Y. Which bridges learn where W is? Does Z's network interface see this packet?

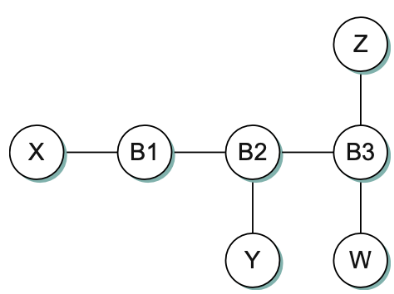

Figure 6: Exercise 3.6

3.7 Suppose learning bridges B1 and B2 form a loop as shown in figure, and do not implement the spanning tree algorithm. Each bridge maintains a single table of ⟨address, interface⟩ pairs

a. What will happen if M sends to L?

b. Suppose a short while later L replies to M. Give a sequence of events that leads to one packet from M and one packet from L circling the loop in opposite directions.

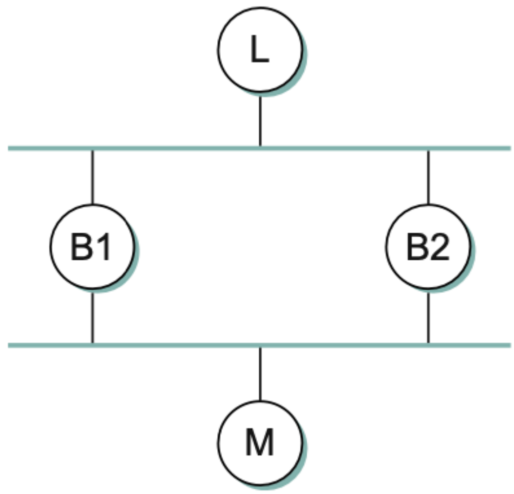

Figure 7: Exercise 3.7

3.8 Suppose that M in the figure above sends to itself (this normally would never happen). State what would happen, assuming:

a. The bridges' algorithm is to install (or update) the new ⟨source address, interface⟩ entry before searching the table for the destination address.

b. The new source address was installed *after* destination address lookup.

3.9 Suppose some repeaters (hubs), rather than bridges, are connected into a loop.

a. What will happen when somebody transmits?

b. Why would the spanning tree mechanism be difficult or impossible to implement for repeaters?

c. Propose a mechanism by which repeaters might detect loops and shut down some ports to break the loop. Your solution is not required to work 100% of the time.

3.10 Suppose a bridge has two of its ports on the same network. How might the bridge detect and correct this?

3.11 Suppose a workstation has an I/O bus speed of 800 Mbps and memory bandwidth of 2 Gbps. Assuming direct memory access (DMA) is used to move data in and out of main memory, how many interfaces to 100-Mbps Ethernet links could a switch based on this workstation handle?

3.12 Suppose a switch is built using a computer workstation and that it can forward packets at a rate of 500,000 packets per second, regardless (within limits) of size. Assume the workstation uses direct memory access (DMA) to move data in and out of its main memory, which has a bandwidth of 2 Gbps, and that the I/O bus has a bandwidth of 1 Gbps. At what packet size would the bus bandwidth become the limiting factor?

3.13 Suppose a 10-Mbps Ethernet hub (repeater) is replaced by a 10-Mbps switch, in an environment where all traffic is between a single server and N "clients." Because all traffic must still traverse the server-switch link, nominally there is no improvement in bandwidth.

a. Would you expect *any* improvement in bandwidth? If so, why?

b. What other advantages and drawbacks might a switch offer versus a hub?

3.14 What aspect of IP addresses makes it necessary to have one address per network interface, rather than just one per host? In light of your answer, why does IP tolerate point-to-point interfaces that have nonunique addresses or no addresses?

3.15 Why does the Offset field in the IP header measure the offset in 8-byte units? *(Hint: Recall that the Offset field is 13 bits long.)*

3.16 Suppose a TCP message that contains 1024 bytes of data and 20 bytes of TCP header is passed to IP for delivery across two networks interconnected by a router (i.e., it travels from the source host to a router to the destination host). The first network has an MTU of 1024 bytes; the second has an MTU of 576 bytes. Each network's MTU gives the size of the largest IP datagram that can be carried in a link-layer frame.

3.17 IP currently uses 32-bit addresses. If we could redesign IP to use the 6-byte MAC address instead of the 32-bit address, would we be able to eliminate the need for ARP? Explain why or why not.

3.18 Suppose hosts A and B have been assigned the same IP address on the same Ethernet, on which ARP is used. B starts up after A. What will happen to A's existing connections? Explain how "self-ARP" (querying the network on start-up for one's own IP address) might help with this problem.

3.19 For the network given below, show how the *link-state* algorithm builds the routing table for node D.

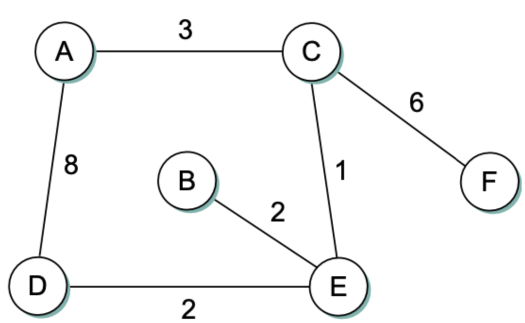

Figure 8: Exercise 3.1

3.20 Use the Unix utility `traceroute` (Windows `tracert`) to determine how many hops it is from your host to other hosts in the Internet (e.g., `cs.princeton.edu` or `www.cisco.com`). How many routers do you traverse just to get out of your local site? Read the man page or other documentation for `traceroute` and explain how it is implemented.

3.21 A site is shown in the figure below. R1 and R2 are routers; R2 connects to the outside world. Individual LANs are Ethernets. RB is a *bridge-router*; it routes traffic addressed to it and acts as a bridge for other traffic. Subnetting is used inside the site; ARP is used on each subnet. Unfortunately, host A has been misconfigured and doesn't use subnets. Which of B, C, and D can A reach?

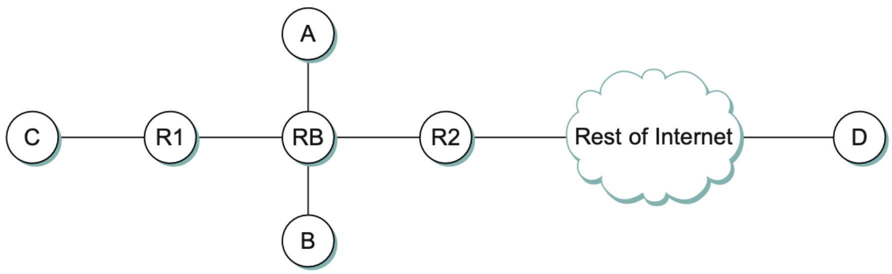

Figure 9: Exercise 3.21

3.22 Suppose we have the forwarding tables shown in the table below for nodes A and F, in a network where all links have cost 1. Give a diagram of the smallest network consistent with these tables.

Table 3.16 Forwarding Tables for Exercise 52

A

Node	Cost	Nexthop
B	1	B
C	2	B
D	1	D
E	2	B
F	3	D

F

Node	Cost	Nexthop
A	3	E
B	2	C
C	1	C
D	2	E
E	1	E

Table 2: Exercise 3.22

3.23 For the network in the figure given below, suppose the forwarding tables are all established as: Each node knows only the distances to its immediate neighbors, Each node has reported the information it had in the preceding step to its immediate neighbors, and it happens a second time; and then the C–E link fails. Give:

a. The tables of A, B, D, and F after C and E have reported the news.

b. The tables of A and D after their next mutual exchange.

c. The table of C after A exchanges with it.

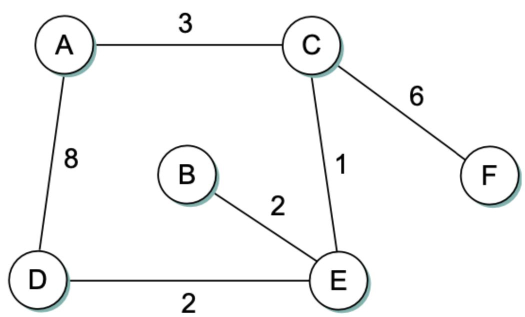

Figure 10: Exercise 3.23

3.24 Suppose a router has built up the routing table shown below. The router can deliver packets directly over interfaces 0 and 1, or it can forward packets to routers R2, R3, or R4. Describe what the router does with a packet addressed to each of the following destinations:

a. 128.96.39.10

b. 128.96.40.12

c. 128.96.40.151

d. 192.4.153.17

e. 192.4.153.90

Table 3.18 Routing Table for Exercise 55

SubnetNumber	SubnetMask	NextHop
128.96.39.0	255.255.255.128	Interface 0
128.96.39.128	255.255.255.128	Interface 1
128.96.40.0	255.255.255.128	R2
192.4.153.0	255.255.255.192	R3
⟨default⟩		R4

Table 3: Exercise 3.24

3.25 Suppose a set of routers all use the split-horizon technique; we consider here under what circumstances it makes a difference if they use poison reverse in addition.

a. Show that poison reverse makes no difference in the evolution of the routing loop in the two examples described in **Section 3.3.2**, given that the hosts involved use split horizon.

b. Suppose split-horizon routers A and B somehow reach a state in which they forward traffic for a given destination X toward each other. Describe how this situation will evolve with and without the use of poison reverse.

c. Give a sequence of events that leads A and B to a looped state as in (b), even if poison reverse is used. (Hint: Suppose B and A connect through a very slow link. They each reach X through a third node, C, and simultaneously advertise their routes to each other.)

3.26 Consider the network given below, using link-state routing. Suppose the B–F link fails, and the following then occur in sequence:

a. Node H is added to the right side with a connection to G.

b. Node D is added to the left side with a connection to C.

c. A new link, D–A, is added.

The failed B–F link is now restored. Describe what link-state packets will flood back and forth. Assume that the initial sequence number at all nodes is 1, that no packets time out, and that both ends of a link use the same sequence number in their LSP for that link, greater than any sequence number used before.

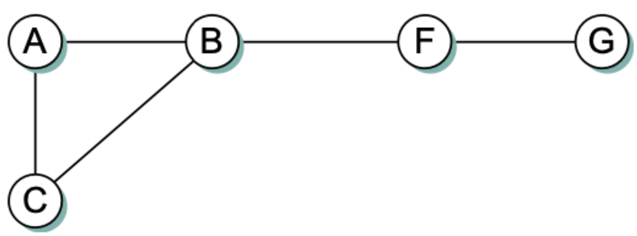

Figure 11: Exercise 3.26

3.27 According to the steps given in the table below for the forward search algorithm, build the routing database for the network given.

Step	Confirmed	Tentative	Comments
1	(D,0,–)		Since D is the only new member of the confirmed list, look at its LSP.
2	(D,0,–)	(B,11,B) (C,2,C)	D's LSP says we can reach B through B at cost 11, which is better than anything else on either list, so put it on Tentative list; same for C.
3	(D,0,–) (C,2,C)	(B,11,B)	Put lowest-cost member of Tentative (C) onto Confirmed list. Next, examine LSP of newly confirmed member (C).
4	(D,0,–) (C,2,C)	(B,5,C) (A,12,C)	Cost to reach B through C is 5, so replace (B,11,B). C's LSP tells us that we can reach A at cost 12.
5	(D,0,–) (C,2,C) (B,5,C)	(A,12,C)	Move lowest-cost member of Tentative (B) to Confirmed, then look at its LSP.
6	(D,0,–) (C,2,C) (B,5,C)	(A,10,C)	Since we can reach A at cost 5 through B, replace the Tentative entry.
7	(D,0,–) (C,2,C) (B,5,C) (A,10,C)		Move lowest-cost member of Tentative (A) to Confirmed, and we are all done.

Table 4: Exercise 3.27

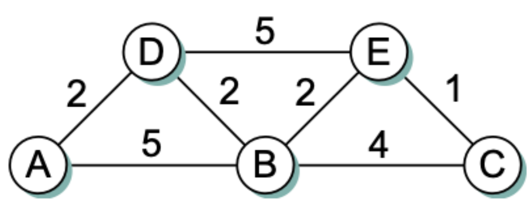

Figure 12: Exercise 3.7

3.28 Suppose that nodes in the network shown in **Figure 3.61** participate in link-state routing, and C receives contradictory LSPs: One from A arrives claiming the A–B link is down, but one from B arrives claiming the A–B link is up.

a. How could this happen?

b. What should C do? What can C expect?

Do not assume that the LSPs contain any synchronized timestamp.

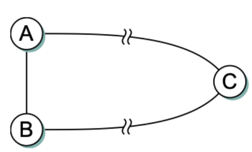

Figure 13: Exercise 3.28

3.29 Read the man page or other documentation for the Unix/Windows utility `netstat`. Use `netstat` to display the current IP routing table on your host. Explain the purpose of each entry. What is the practical minimum number of entries?

3.30 An organization has been assigned the prefix 212.1.1.1/24 (class C) and wants to form subnets for four departments, with hosts as follows:

A	75 hosts
B	35 hosts
C	20 hosts
D	18 hosts

There are 148 hosts in all.

a. Give a possible arrangement of subnet masks to make this possible.

b. Suggest what the organization might do if department D grows to 32 hosts.

3.31 An alternative method for connecting host C in the network below is to use *proxy ARP* and routing: B agrees to route traffic to and from C and also answers ARP queries for C received over the Ethernet.

a. Give all packets sent, with physical addresses, as A uses ARP to locate and then send one packet to C.

b. Give B's routing table. What peculiarity must it contain?

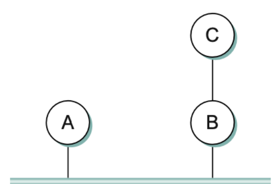

Figure 14: Exercise 3.31

3.32 Table given below is a routing table using CIDR. Address bytes are in hexadecimal. The notation "/12" in C4.50.0.0/12 denotes a netmask with 12 leading 1 bits: FF.F0.0.0. Note that the last three entries cover every address and thus serve in lieu of a default route. State to what next hop the following will be delivered:

a. C4.5E.13.87

b. C4.5E.22.09

c. C3.41.80.02

d. 5E.43.91.12

e. C4.6D.31.2E

f. C4.6B.31.2E

Table 3.20 Routing Table for Exercise 72

Net/MaskLength	Nexthop
C4.50.0.0/12	A
C4.5E.10.0/20	B
C4.60.0.0/12	C
C4.68.0.0/14	D
80.0.0.0/1	E
40.0.0.0/2	F
00.0.0.0/2	G

Table 5: Exercise 3.32