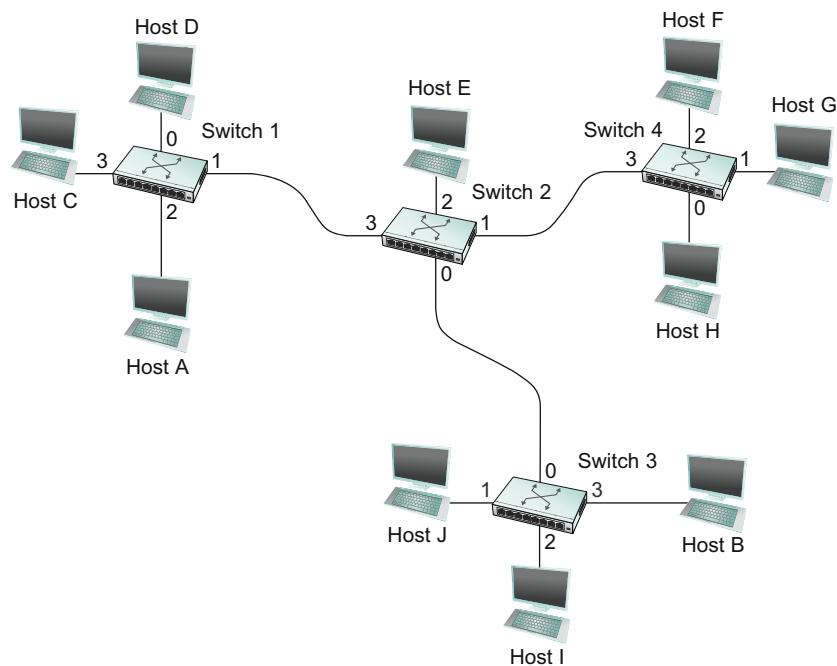


Finally, we recommend the following live references:

- <http://www.nets-find.net/>: A website of the U.S. National Science Foundation that covers the “Future Internet Design” research program.
- <http://www.geni.net/>: A site describing the GENI networking testbed, which has been created to enable some of the “clean slate” research described above.

## EXERCISES

1. Using the example network given in Figure 3.44, 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 3.44 Example network for Exercises 1 and 2.

VCI on each link, starting with 0, and that a VCI is consumed for both directions of a virtual circuit.

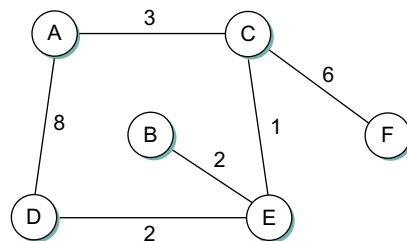
- (a) Host A connects to host C.
- (b) Host D connects to host B.
- (c) Host D connects to host I.
- (d) Host A connects to host B.
- (e) Host F connects to host J.
- (f) Host H connects to host A.



2. Using the example network given in Figure 3.44, 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 VCI on each link, starting with 0, and that a VCI is consumed for both directions of a virtual circuit.

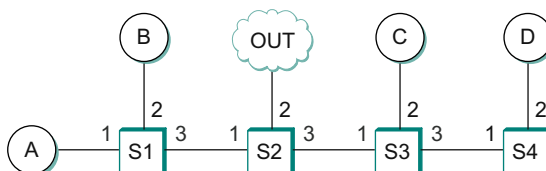
- (a) Host D connects to host H.
- (b) Host B connects to host G.
- (c) Host F connects to host A.
- (d) Host H connects to host C.
- (e) Host I connects to host E.
- (f) Host H connects to host J.

3. For the network given in Figure 3.45, 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.



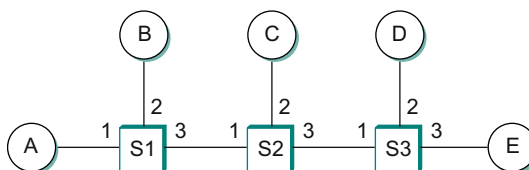
■ FIGURE 3.45 Network for Exercise 3.

4. Give forwarding tables for switches S1 to S4 in Figure 3.46. 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 3.46 Diagram for Exercise 4.

5. Consider the virtual circuit switches in Figure 3.47. Table 3.15 lists, for each switch, what  $\langle \text{port, VCI} \rangle$  (or  $\langle \text{VCI, interface} \rangle$ ) pairs are connected to what other. Connections are bidirectional. List all endpoint-to-endpoint connections.



■ FIGURE 3.47 Diagram for Exercise 5.

6. In the source routing example of Section 3.1.3, the address received by B is not reversible and doesn't help B know how to reach A. Propose a modification to the delivery mechanism that does allow for reversibility. Your mechanism should *not* require giving all switches globally unique names.
7. Propose a mechanism that virtual circuit switches might use so that if one switch loses all its state regarding connections then a sender of packets along a path through that switch is informed of the failure.
8. Propose a mechanism that might be used by datagram switches so that if one switch loses all or part of its forwarding table affected senders are informed of the failure.

**Table 3.15 VCI Tables for Switches in Figure 3.47**

Switch S1			
Port	VCI	Port	VCI
1	2	3	1
1	1	2	3
2	1	3	2

Switch S2			
Port	VCI	Port	VCI
1	1	3	3
1	2	3	2

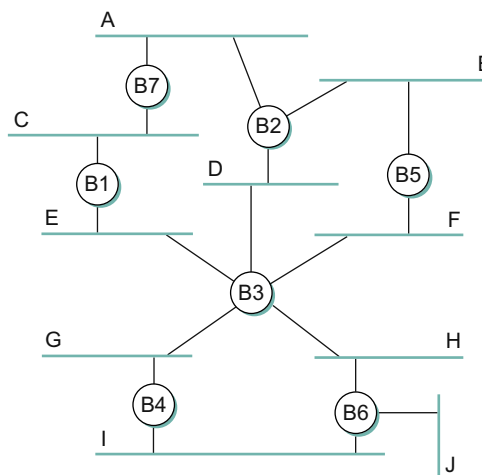
  

Switch S3			
Port	VCI	Port	VCI
1	3	2	1
1	2	2	2

9. The virtual circuit mechanism described in Section 3.1.2 assumes that each link is point-to-point. Extend the forwarding algorithm to work in the case that links are shared-media connections (e.g., Ethernet).
10. Suppose, in Figure 3.2, that a new link has been added, connecting switch 3 port 1 (where G is now) and switch 1 port 0 (where D is now); neither switch is informed of this link. Furthermore, switch 3 mistakenly thinks that host B is reached via port 1.
  - (a) What happens if host A attempts to send to host B, using datagram forwarding?
  - (b) What happens if host A attempts to connect to host B, using the virtual circuit setup mechanism discussed in the text?
11. Give an example of a working virtual circuit whose path traverses some link twice. Packets sent along this path should *not*, however, circulate indefinitely.
12. In Section 3.1.2, each switch chose the VCI value for the incoming link. Show that it is also possible for each switch to choose the VCI value for the outbound link and that the same VCI values will be

chosen by each approach. If each switch chooses the outbound VCI, is it still necessary to wait one RTT before data is sent?

13. Given the extended LAN shown in Figure 3.48, indicate which ports are not selected by the spanning tree algorithm.

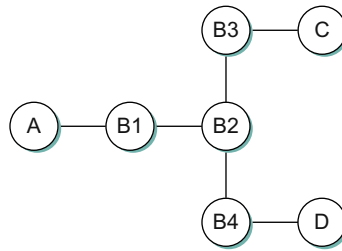


■ FIGURE 3.48 Network for Exercises 13 and 14.

- ✓ 14. Given the extended LAN shown in Figure 3.48, assume that bridge B1 suffers catastrophic failure. Indicate which ports are not selected by the spanning tree algorithm after the recovery process and a new tree has been formed.
15. Consider the arrangement of learning bridges shown in Figure 3.49. Assuming all are initially empty, give the forwarding tables for each of the bridges B1 to B4 after the following transmissions:
- A sends to C.
  - C sends to A.
  - D sends to C.

Identify ports with the unique neighbor reached directly from that port; that is, the ports for B1 are to be labeled “A” and “B2.”

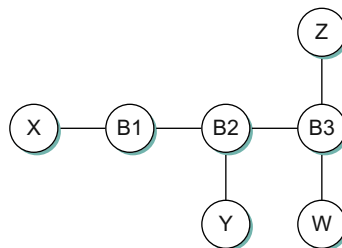
- ✓ 16. As in the previous problem, consider the arrangement of learning bridges shown in Figure 3.49. Assuming all are initially empty, give



■ **FIGURE 3.49** Network for Exercises 15 and 16.

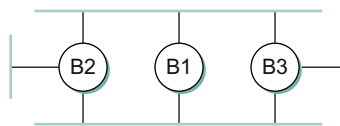
the forwarding tables for each of the bridges B1 to B4 after the following transmissions:

- D sends to C.
  - C sends to D.
  - A sends to C.
17. Consider hosts X, Y, Z, W and learning bridges B1, B2, B3, with initially empty forwarding tables, as in [Figure 3.50](#).
- (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 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?



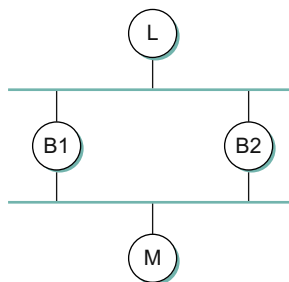
■ **FIGURE 3.50** Diagram for Exercise 17.

18. Give the spanning tree generated for the extended LAN shown in [Figure 3.51](#), and discuss how any ties are resolved.



■ FIGURE 3.51 Extended LAN for Exercise 18.

19. Suppose learning bridges B1 and B2 form a loop as shown in Figure 3.52, and do *not* implement the spanning tree algorithm. Each bridge maintains a single table of  $\langle \text{address}, \text{interface} \rangle$  pairs.
- What will happen if M sends to L?
  - 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 3.52 Loop for Exercises 19 and 20.

20. Suppose that M in Figure 3.52 sends to itself (this normally would never happen). State what would happen, assuming:
- The bridges' learning algorithm is to install (or update) the new  $\langle \text{sourceaddress}, \text{interface} \rangle$  entry *before* searching the table for the destination address.
  - The new source address was installed *after* destination address lookup.
21. Consider the extended LAN of Figure 3.10. What happens in the spanning tree algorithm if bridge B1 does not participate and
- Simply forwards all spanning tree algorithm messages?
  - Drops all spanning tree messages?

22. 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.
23. Suppose a bridge has two of its ports on the same network. How might the bridge detect and correct this?
24. What percentage of an ATM link's total bandwidth is consumed by the ATM cell headers? Ignore padding to fill cells or ATM adaptation layer headers.
25. Cell switching methods (like ATM) essentially always use virtual circuit switching rather than datagram forwarding. Give a specific argument why this is so (consider the preceding question).
26. 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?
- ✓ 27. Suppose a workstation has an I/O bus speed of 1 Gbps and memory bandwidth of 2 Gbps. Assuming 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?
28. 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?
29. Suppose that a switch is designed to have both input and output FIFO buffering. As packets arrive on an input port they are inserted



at the tail of the FIFO. The switch then tries to forward the packets at the head of each FIFO to the tail of the appropriate output FIFO.

- (a) Explain under what circumstances such a switch can lose a packet destined for an output port whose FIFO is empty.
- (b) What is this behavior called?
- (c) Assume that the FIFO buffering memory can be redistributed freely. Suggest a reshuffling of the buffers that avoids the above problem, and explain why it does so.

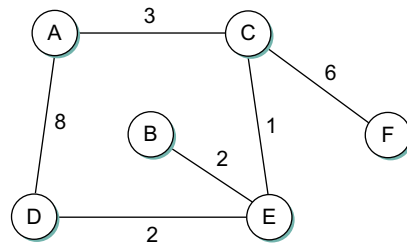
- ☆ 30. A stage of an  $n \times n$  banyan network consists of  $(n/2) 2 \times 2$  switching elements. The first stage directs packets to the correct half of the network, the next stage to the correct quarter, and so on, until the packet is routed to the correct output. Derive an expression for the number of  $2 \times 2$  switching elements needed to make an  $n \times n$  banyan network. Verify your answer for  $n = 8$ .
- ☆ 31. Describe how a Batcher network works. (See the Further Reading section.) Explain how a Batcher network can be used in combination with a banyan network to build a switching fabric.
- 32. 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?
- 33. 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?
- 34. 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.)
- 35. Some signalling errors can cause entire ranges of bits in a packet to be overwritten by all 0s or all 1s. Suppose all the bits in the packet, including the Internet checksum, are overwritten. Could a packet with all 0s or all 1s be a legal IPv4 packet? Will the Internet checksum catch that error? Why or why not?

36. 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. Give the sizes and offsets of the sequence of fragments delivered to the network layer at the destination host. Assume all IP headers are 20 bytes.
- ✓ 37. Path MTU is the smallest MTU of any link on the current path (route) between two hosts. Assume we could discover the path MTU of the path used in the previous exercise, and that we use this value as the MTU for all the path segments. Give the sizes and offsets of the sequence of fragments delivered to the network layer at the destination host.
- ☆ 38. Suppose an IP packet is fragmented into 10 fragments, each with a 1% (independent) probability of loss. To a reasonable approximation, this means there is a 10% chance of losing the whole packet due to loss of a fragment. What is the probability of net loss of the whole packet if the packet is transmitted twice,
- (a) Assuming all fragments received must have been part of the same transmission?
  - (b) Assuming any given fragment may have been part of either transmission?
  - (c) Explain how use of the `Ident` field might be applicable here.
39. Suppose the fragments of [Figure 3.18\(b\)](#) all pass through another router onto a link with an MTU of 380 bytes, not counting the link header. Show the fragments produced. If the packet were originally fragmented for this MTU, how many fragments would be produced?
40. What is the maximum bandwidth at which an IP host can send 576-byte packets without having the `Ident` field wrap around within 60 seconds? Suppose that IP's maximum segment lifetime (MSL) is 60 seconds; that is, delayed packets can arrive up to 60 seconds late but no later. What might happen if this bandwidth were exceeded?

41. Why do you think IPv4 has fragment reassembly done at the endpoint, rather than at the next router? Why do you think IPv6 abandoned fragmentation entirely? (Hint: Think about the differences between IP-layer fragmentation and link-layer fragmentation).
42. Having ARP table entries time out after 10 to 15 minutes is an attempt at a reasonable compromise. Describe the problems that can occur if the timeout value is too small or too large.
43. 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.
44. 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.
45. Suppose an IP implementation adheres literally to the following algorithm on receipt of a packet, P, destined for IP address D:  

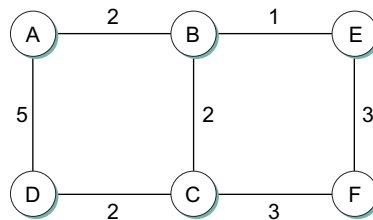
```
if ((Ethernet address for D is in ARP cache))
    <send P>
else
    <send out an ARP query for D>
    <put P into a queue until the response comes back>
```

  - (a) If the IP layer receives a burst of packets destined for D, how might this algorithm waste resources unnecessarily?
  - (b) Sketch an improved version.
  - (c) Suppose we simply drop P, after sending out a query, when cache lookup fails. How would this behave? (Some early ARP implementations allegedly did this.)
46. For the network shown in Figure 3.53, give global distance-vector tables like those of Tables 3.10 and 3.13 when
  - (a) Each node knows only the distances to its immediate neighbors.
  - (b) Each node has reported the information it had in the preceding step to its immediate neighbors.
  - (c) Step (b) happens a second time.



■ FIGURE 3.53 Network for Exercises 46, 48, and 54.

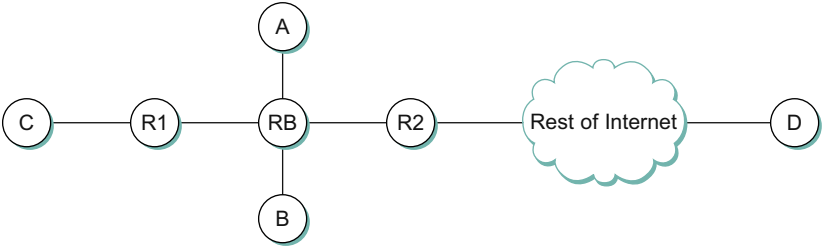
- ✓ 47. For the network given in Figure 3.54, give global distance-vector tables like those of Tables 3.10 and 3.13 when
- Each node knows only the distances to its immediate neighbors.
  - Each node has reported the information it had in the preceding step to its immediate neighbors.
  - Step (b) happens a second time.



■ FIGURE 3.54 Network for Exercise 47.

48. For the network given in Figure 3.53, show how the *link-state* algorithm builds the routing table for node D.
49. 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.
50. What will happen if *traceroute* is used to find the path to an unassigned address? Does it matter if the network portion or only the host portion is unassigned?

51. A site is shown in Figure 3.55. 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 3.55 Site for Exercise 51.

52. Suppose we have the forwarding tables shown in Table 3.16 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

- ✓ 53. Suppose we have the forwarding tables shown in Table 3.17 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 3.17 Forwarding Tables for Exercise 53**

A		
Node	Cost	Nextthop
B	1	B
C	1	C
D	2	B
F	2	C

F		
Node	Cost	Nextthop
A	2	C
B	3	C
C	1	C
D	2	C
E	1	E

54. For the network in Figure 3.53, suppose the forwarding tables are all established as in Exercise 46 and then the C–E link fails. Give:
- The tables of A, B, D, and F after C and E have reported the news.
  - The tables of A and D after their next mutual exchange.
  - The table of C after A exchanges with it.
55. Suppose a router has built up the routing table shown in Table 3.18. 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:
- 128.96.39.10
  - 128.96.40.12
  - 128.96.40.151
  - 192.4.153.17
  - 192.4.153.90

**Table 3.18** Routing Table for Exercise 55

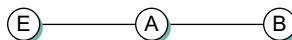
SubnetNumber	SubnetMask	NextHop
128.96.39.0	255.255.255.128	Interface 0
128.96.39.128	255.255.255.128	Interface 1
128.96.40.0	255.255.255.128	R2
192.4.153.0	255.255.255.192	R3
<default>		R4

- ✓ 56. Suppose a router has built up the routing table shown in Table 3.19. The router can deliver packets directly over interfaces 0 and 1, or it can forward packets to routers R2, R3, or R4. Assume the router does the longest prefix match. Describe what the router does with a packet addressed to each of the following destinations:
- (a) 128.96.171.92
  - (b) 128.96.167.151
  - (c) 128.96.163.151
  - (d) 128.96.169.192
  - (e) 128.96.165.121

**Table 3.19** Routing Table for Exercise 56

SubnetNumber	SubnetMask	NextHop
128.96.170.0	255.255.254.0	Interface 0
128.96.168.0	255.255.254.0	Interface 1
128.96.166.0	255.255.254.0	R2
128.96.164.0	255.255.252.0	R3
<default>		R4

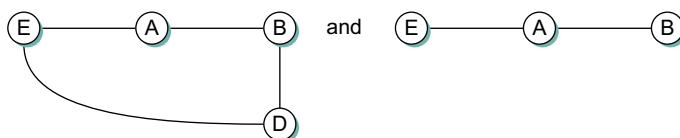
- ☆ 57. Consider the simple network in Figure 3.56, in which A and B exchange distance-vector routing information. All links have cost 1. Suppose the A–E link fails.

■ **FIGURE 3.56** Simple network for Exercise 57.

- (a) Give a sequence of routing table updates that leads to a routing loop between A and B.
  - (b) Estimate the probability of the scenario in (a), assuming A and B send out routing updates at random times, each at the same average rate.
  - (c) Estimate the probability of a loop forming if A broadcasts an updated report within 1 second of discovering the A–E failure, and B broadcasts every 60 seconds uniformly.
58. Consider the situation involving the creation of a routing loop in the network of Figure 3.29 when the A–E link goes down. List *all* sequences of table updates among A, B, and C, pertaining to destination E, that lead to the loop. Assume that table updates are done one at a time, that the split-horizon technique is observed by all participants, and that A sends its initial report of E's unreachability to B before C. You may ignore updates that don't result in changes.
59. 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.)
60. *Hold down* is another distance–vector loop-avoidance technique, whereby hosts ignore updates for a period of time until link failure news has had a chance to propagate. Consider the networks in Figure 3.57, where all links have cost 1 except E–D, with cost 10. Suppose that the E–A link breaks and B reports its loop-forming E route to A immediately afterwards (this is the false route, via A).



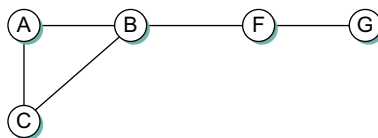
Specify the details of a hold-down interpretation, and use this to describe the evolution of the routing loop in both networks. To what extent can hold down prevent the loop in the EAB network without delaying the discovery of the alternative route in the EABD network?



■ FIGURE 3.57 Networks for Exercise 60.

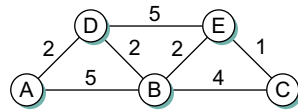
61. Consider the network in Figure 3.58, using link-state routing. Suppose the B–F link fails, and the following then occur in sequence:
- (a) Node H is added to the right side with a connection to G.
  - (b) Node D is added to the left side with a connection to C.
  - (c) A new link, D–A, is added.

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.

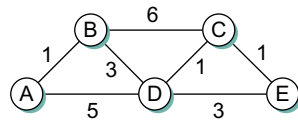


■ FIGURE 3.58 Network for Exercise 61.

62. Give the steps as in Table 3.14 in the forward search algorithm as it builds the routing database for node A in the network shown in Figure 3.59.
- ✓ 63. Give the steps as in Table 3.14 in the forward search algorithm as it builds the routing database for node A in the network shown in Figure 3.60.

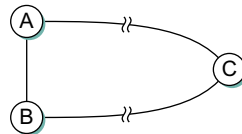


■ FIGURE 3.59 Network for Exercise 62.



■ FIGURE 3.60 Network for Exercise 63.

64. 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 3.61 Network for Exercise 64.

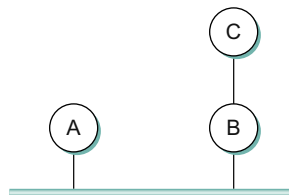
65. Suppose IP routers learned about IP networks and subnets the way Ethernet learning bridges learn about hosts: by noting the appearance of new ones and the interface by which they arrive. Compare this with existing distance–vector router learning
- (a) For a leaf site with a single attachment to the Internet.
  - (b) For internal use at an organization that did not connect to the Internet.
- Assume that routers only receive new-network notices from other routers and that the originating routers receive their IP network information via configuration.

66. IP hosts that are not designated routers are *required* to drop packets misaddressed to them, even if they would otherwise be able to forward them correctly. In the absence of this requirement, what would happen if a packet addressed to IP address A were inadvertently broadcast at the link layer? What other justifications for this requirement can you think of?
67. 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?
68. An organization has been assigned the prefix 212.1.1/24 (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.
69. Suppose hosts A and B are on an Ethernet LAN with IP network address 200.0.0/24. It is desired to attach a host C to the network via a direct connection to B (see Figure 3.62). Explain how to do this with subnets; give sample subnet assignments. Assume that



■ FIGURE 3.62 Network for Exercise 69.

an additional network prefix is not available. What does this do to the size of the Ethernet LAN?

70. An alternative method for connecting host C in Exercise 69 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?
71. Suppose two subnets share the same physical LAN; hosts on each subnet will see the other subnet's broadcast packets.
- (a) How will DHCP fare if two servers, one for each subnet, coexist on the shared LAN? What problems might [*do!*] arise?
  - (b) Will ARP be affected by such sharing?
72. Table 3.20 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: FFF0.0.0. 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

- ✓ 73. Table 3.21 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: FEF0.0.0. State to what next hop the following will be delivered:
- (a) C4.4B.31.2E
  - (b) C4.5E.05.09
  - (c) C4.4D.31.2E
  - (d) C4.5E.03.87
  - (e) C4.5E.7F.12
  - (f) C4.5E.D1.02

**Table 3.21 Routing Table for Exercise 73**

Net/MaskLength	Nexthop
C4.5E.2.0/23	A
C4.5E.4.0/22	B
C4.5E.C0.0/19	C
C4.5E.40.0/18	D
C4.4C.0.0/14	E
C0.0.0.0/2	F
80.0.0.0/1	G

74. An ISP that has authority to assign addresses from a /16 prefix (an old class B address) is working with a new company to allocate it a portion of address space based on CIDR. The new company needs IP addresses for machines in three divisions of its corporate network: Engineering, Marketing, and Sales. These divisions plan to grow as follows: Engineering has 5 machines as of the start of year 1 and intends to add 1 machine every week, Marketing will never need more than 16 machines, and Sales needs 1 machine for every 2 clients. As of the start of year 1, the company has no clients, but the sales model indicates that, by the start of year 2, the company will have 6 clients and each week thereafter will get one new client with probability 60%, will lose one client with probability 20%, or will maintain the same number with probability 20%.

- (a) What address range would be required to support the company's growth plans for at least 7 years if Marketing uses all 16 of its addresses and the Sales and Engineering plans behave as expected?
  - (b) How long would this address assignment last? At the time when the company runs out of address space, how would the addresses be assigned to the three groups?
  - (c) If, instead of using CIDR addressing, it was necessary to use old-style classful addresses, what options would the new company have in terms of getting address space?
75. Propose a lookup algorithm for an IP forwarding table containing prefixes of varying lengths that does not require a linear search of the entire table to find the longest match.