

Chapter 4 - Review Questions

Homework Problems and Questions

Sections 4.1- 4.4

1. What are the two main functions of a datagram-based network layer? What additional functions does a VC-based network layer have?
2. List and describe the ATM network service models.
3. Compare and contrast link-state and distance-vector routing algorithms.
4. Discuss how a hierarchical organization of the Internet has helped to millions of users.
5. Is it necessary that every autonomous system use the same intra-auto: system routing algorithm? Why or why not?

Section 4.5

6. What is the 32-bit binary equivalent of the IP address 223.1.3.27?
7. Consider a LAN to which 10 host interfaces and three router interface attached. Suppose all three LANs use class C addresses. The IN addre the 13 devices will be identical in which of the first 32 bits?
8. Consider a router with three interfaces. Suppose all three interfaces use class C addresses. Will the IP addresses of the three interfaces necessarily have the same first eight bits?
9. Suppose there are three routers between source and destination hosts. Ignoring fragmentation, an IP segment sent from source host to destination host will travel over how many interfaces? How many routing tables will be indexed to move the datagram from source to destination?
10. Suppose an application generates chunks of 40 bytes of data every 20 msec. and each chunk gets encapsulated in a TCP segment and then an IP datagram. What percentage of each datagram will be overhead and what percentage will be application data?
11. Consider sending a 3000 byte datagram into a link that has an MTU of 500 bytes. Suppose the original datagram is stamped with the identification number 422. How many fragments are generated? What are their characteristics?

12. Consider Figure 4.27. Starting with the original table in D, suppose that D receives from A the following advertisement:

Destination Network	Next Router	Number of Hops to Destination
Z	C	10
W	-	1
X	-	1
....

Will the table in A change? If so how?

13. Contrast and compare the advertisements used by RIP and OSPF.

14. RIP advertisements typically announce the number of hops to various destinations. BGP updates, on the other hand, announce the _____ (fill in the blank) to the various destinations.

15. Why are different inter-AS and intra-AS protocols used in the Internet?

Section 4.6

16. Describe three different types of switching fabrics commonly used in packet switches.

17. Why are buffers needed at the output ports of switches? Why are buffers needed at the input port of switches?

Section 4.7

18. Compare and contrast the IPv4 and the IPv6 header fields. Do they have any fields in common?

19. It has been said that when IPv6 tunnels through IPv4 routers, IPv6 treats IPv4 tunnels as link-layer protocols. Do you agree with this statement why not?

Section 4.8

20. What is an important difference between implementing the multicast via multiple unicasts, and a single network (router) supported multicast group?

21. True or False: When a host joins a multicast group, it must change its IP address to be that of the multicast group it is joining.

22. What are the roles played by the IGMP protocol and a wide-area multicast routing protocol?

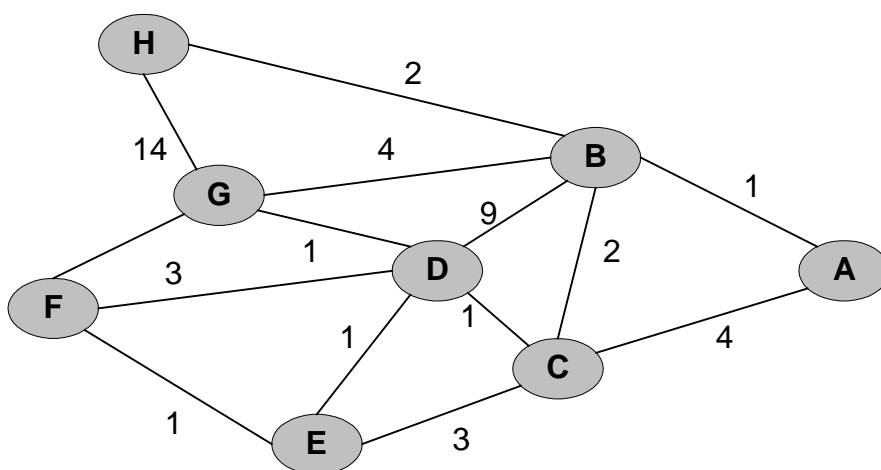
23. What is the difference between a group-shared tree and a source-based tree in the context of multicast routing?

24. True or False: In reverse path forwarding, a node will receive multiple of the same packet. True or False: In reverse path forwarding, a node may forward multiple copies of a packet over the same outgoing link.

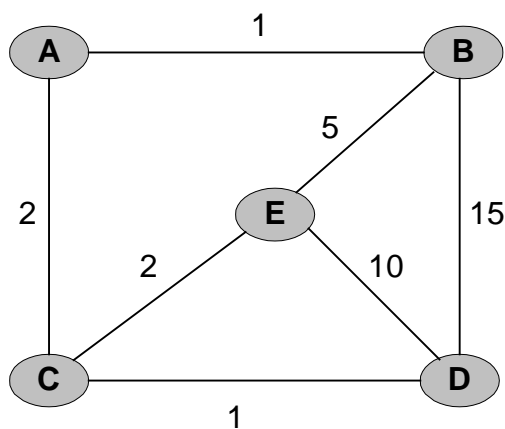
25. Classify each of the following multicast routing algorithms as either a based tree approach or a group-shared tree approach: DVMRP, MOSPF, CBT, PIM Sparse Mode, PIM Dense Mode.

Problems

- Let us consider some of the pros and cons of a connection-oriented versus connectionless architecture.
 - Suppose that in the network layer, routers were subjected to "stressfull" conditions that might cause them to fail fairly often. At a high level, what actions would need to be taken on such router failure. Does this argue for a connection-oriented or a connectionless environment?
 - Suppose that in order to provide a guarantee regarding the level of performance (e.g., delay) that would be seen along a source-to-destination path, the network requires a sender to declare its peak traffic rate. If the declared peak traffic rate and the existing declared traffic rates that have been declared are such that there is no way to get traffic from the source to the destination that meets the required delay requirements, the source is not allowed access to the network. Would such an approach be more easily accomplished within a connection-oriented or connectionless paradigm?
- In Figure 4.4, enumerate the paths from A to F that do not contain any loops.,
- Consider the following network. With the indicated link costs, use Dijkstra's shortest path algorithm to compute the shortest path from F to all network nodes. Show how the algorithm works by computing a table similar to Table 4.2.

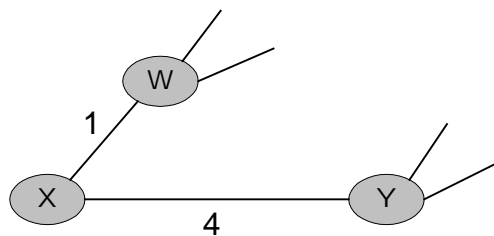


4. Consider the network shown below and assume that each node initially knows the costs to each of its neighbors. Consider the distance vector algorithm and show the distance table entries at node E .



5. Consider a general topology (i.e., not the specific network shown above) and a synchronous version of the distance vector algorithm. Suppose that at each iteration, a node exchanges its minimum costs with its neighbors and receives their minimum costs. Assuming that the algorithm begins with each node knowing only the costs to its immediate neighbors, what is the maximum number of iterations required until the distributed algorithm converges? your answer.

6. Consider the network fragment shown below. X has only two attached minimum-cost W and Y . W has a minimum-cost path to destination A of 5 and Y has a minimum-cost path to A of 6. The complete paths from W and Y to A (and between W and Y) are not shown. All link costs in the network have strictly positive integer values.



- Give X 's distance table (row) entries for destinations X , Y , and A .
- Give a link-cost change for either $c(X,W)$ or $c(X,Y)$ such that X will inform its neighbors of a new minimum-cost path to A as a result of executing lines 15 and 24 of the distance vector algorithm.
- Give a link-cost change for either $c(X, W)$ or $c(X,Y)$ such that X will *not* inform its neighbors of a new minimum-cost path to A as a result of executing lines 15 and 24 of the distance vector algorithm.

7. Compute the distance tables for X , Y , and Z shown in the rightmost column of Figure 4.7. After the computation of the new distance tables, which nodes send which updated values to which neighbors?

8. Consider the three-node topology shown in Figure 4.7. Rather than having the link costs shown in Figure 4.7, the link costs are $c(X,Y) = 5$, $c(Y,Z) = 6$, $c(Z,X) = 2$. Compute the distance tables after the initialization step and after each iteration of a synchronous version of the distance vector algorithm (as we did in our earlier discussion of Figure 4.7.)

9. Consider the eight-node network (with nodes labeled *A-H*) above. Show the minimal-cost spanning tree rooted at *A* that includes (as end hosts) nodes *C*, *D*, *E*, and *G*. Informally argue why your spanning tree is a minimal-cost spanning tree.
10. We saw in Section 4.8 that there is no network-layer protocol that can be used to identify the hosts participating in a multicast group. Given this, how can multicast applications learn the identities of the hosts that are participating a multicast group?
11. Consider the two basic approaches identified toward achieving multicast: unicast emulation and network-layer multicast. Consider a single sender and 32 receivers. Suppose the sender is connected to the receiver through a binary tree of routers. What is the cost of sending a multicast packet, in the case of unicast emulation and network-layer multicast, for this topology? Here, each time a packet (or copy of a packet) is sent over a single link, it incurs a unit of "cost." What topology for interconnecting the sender, receivers, and routers will bring the cost of unicast emulation and true network-layer multicast as far apart as possible.? You can choose as many routers as you'd like.
12. Design (give a pseudocode description of) an application-level protocol that maintains the host addresses of all hosts participating in a multicast group. Specifically identify the network service (unicast or multicast) that is used by your protocol, and indicate whether your protocol is sending messages in-band or out-of-hand (with respect to the application-data flow among the multicast group participants), and why.
13. Consider the topology from Figure 4.50. Suppose the link cost from *B* to *D* changes from 1 to 10. Find the Steiner tree that connects all of the shaded routers. (Note: You are not being asked here to program a solution to the Steiner tree problem. Instead, you should be able to construct the minimumcost tree by inspection and informally convince yourself that it is the minimum tree). If you were asked (you are *not* being asked to actually do so!), how would you prove that your tree is indeed a minimum cost tree?
14. Center-based routing. Consider the topology shown in Figure 4.50. Suppose node *C* is chosen as the center in a center-based multicast routing algorithm. Assuming that each attached router in the multicast group uses its least-cost path to node *C* to send join messages to *C*, draw the resulting center-based multicast routing tree. Is the resulting tree a minimumcost Steiner tree? Justify your answer.
15. Least unicast-cost path routing. Consider Figure 4.50. Suppose that node *E* is chosen as the source. Compute the least unicast-cost path multicast routing tre from *E* to multicast routers *A*, *B*, and *F*.
16. Reverse path forwarding. Consider the topology and link costs shown in Figure 4.50 and suppose that node *E* is the multicast source. Using arrows like those shown in Figure 4.53, indicate links over which packets will be forwarded using RPF, and links over which packets will not be forwarded, given that node *E* is the source.
17. Suppose that the cost of transmitting a multicast packet on a link is completely independent of the cost of transmitting a unicast packet on a link. Will reverse path forwarding still work in this case? Justify your answer.
18. Traffic concentration in center-based trees. Consider the simple topology shown in Figure 4.50. Suppose that each of the multicast routers receive one unit of traffic per unit of time from an attached host. This traffic must be forwarded to the other three multicast routers. Suppose that node *C* is chosen as the center node in a conter-based, multicast routing protocol (soe homework problem above). Given the resulting routing tree, compute the rate of traffic on each link in the topology. (Compute the total amount of traffic on each link, regardless of the direction of the traffic flow). Suppose next that RPF is used to build four source-specific routing trees rooted at each of the routers *A*, *B*, *E*, *F*. Recompute the rate of traffic on each of

the links in this second scenario. In this example, does a counter-based tree or source-specific tree tend to concentrate traffic?

19. Suppose that a network has G multicast groups, each with S group members (hosts), each of which can be a sender. Under DVMRP, each router must thus maintain up to S pieces of routing information (the outgoing link on the shortest reverse path to the sender, for each of the S senders) for each group. Thus, in the worst case, each router must maintain $S \cdot G$ pieces of routing information, when taking all groups into account. What is the worst-case amount of routing information needed by MOSPF, PIM Sparse Mode, and PIM Dense Mode? Justify your answers.

20. Birthday problem. What is the size of the multicast address space? Suppose now that two different multicast groups randomly choose a multicast address. What is the probability that they choose the same address? Suppose now that 1000 multicast groups are ongoing at the same time and choose their multicast group addresses at random. What is the probability that they interfere with each other?

21. Recall that in our discussion of multicast tunneling, we said that an IP multicast datagram is carried inside of an IP unicast datagram. How does the IP router at the end of the multicast tunnel know that the unicast datagram contains an IP multicast datagram (as opposed to simply being an IP unicast datagram that should be forwarded along)?

Discussion Questions

1. Suppose AS X and Z are not directly connected but instead connected by AS Y. Further suppose that X has a peering agreement with Y, and that Y has a peering agreement with Z. Finally, suppose that Z wants to transit all of Y's traffic but does not want to transit X's traffic. Does BGP allow Z to implement this policy?

2. In Section 4.7, we indicated that deployment of IPv6 has been slow to date. Why has it been slow? What is needed to accelerate its deployment? (See article by L. Garber.)

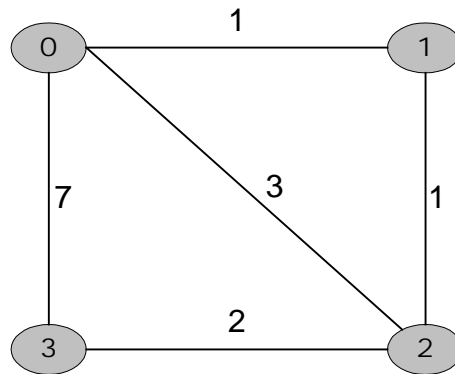
3. In Section 4.8.1 we saw that the multicast abstraction can be implemented by having a sender open an individual connection to each of the receivers. What are the drawbacks of this approach compared to the approach that provides native multicast support at the network layer? What are the advantages of this approach?

4. In Section 4.8 we identified a number of multicast applications. Which of these applications are well-suited for the minimalist Internet multicast service model? Why? Which applications are not particularly well-suited for this service model?

5. Given the CBT soft-state mechanism for maintaining a tree, why do you think there is a separate FLUSH_TREE message? What would happen if the FLUSH_TREE message were lost?

Programming Assignment

In this third programming assignment, you will be writing a "distributed" set of procedures that implement a distributed asynchronous distance vector routing for the network shown below:



You are to write the following routines that will "execute" asynchronously within the emulated environment provided for this assignment. For node 0, you will write the routines:

- *rtinit0()* This routine will be called once at the beginning of the emulation. *rtinit0()* has no arguments. It should initialize your distance table in node 0 to reflect the direct costs of 1, 3, and 7 to nodes 1, 2, and 3, respectively. In the figure above, all links are bi-directional and the costs in both directions are identical. After initializing the distance table, and any other data structures needed by your node 0 routines, it should then send its directly connected neighbors (in this case, 1, 2, and 3) the cost of its minimum-cost paths to all other network nodes. This minimum cost information is sent to neighboring nodes in a routing update packet by calling the routine *rtupdate0()*, as described in the full assignment. The format of the routing update packet is also described in the full assignment.
- *rtupdate()* (*struct rtpkt *rcvdpkt*). This routine will be called when node 0 receives a routing packet that was sent to it by one of its directly connected neighbors. The parameter **rcvdpkt* is a pointer to the packet that was received. *rtupdate0()* is the "heart" of the distance vector algorithm. The values it receives in a routing update packet from some other node *i* contain *i*'s current shortest-path costs to all other network nodes. *rtupdate0()* uses these received values to update its own distance table (as specified by the distance vector algorithm). If its own minimum cost to another node changes as a result of the update, node 0 informs its directly connected neighbors of this change in minimum cost by sending them a routing packet. Recall that in the distance vector algorithm, only directly connected nodes will exchange routing packets. Thus, nodes 1 and 3 will communicate with each other.

Similar routines are defined for nodes 1, 2, and 3. Thus, you will write eight procedures in all: *rtinit0()*, *rtinit1()*, *rtinit2()*, *rtinit3()*, *rtupdate0()*, *rtupdate1()*, *rtupdate2()*, *rtupdate3()*. These routines will together implement a distributed, asynchronous computation of the distance tables for the topology and costs shown in the figure on the previous page.

You can find the full details of the programming assignment, as well as C code that you will need to create the simulated hardware/software environment at <http://www.awl.com/kurose-ross>.