CS/ECE 438: Communication Networks — Fall 2006
Problem Set 5 — Due Wednesday, November 1

Routing, Multicast, and Broadcast

1. **LS and BGP**

   (a) Refering to Figure 1, compute the least-cost paths from router a to all the other routers in AS 23 using Dijkstra's algorithm. Use a table similar to Table 4.3 on p.356 of the textbook to record your work. Here N' represents the set of routers for which the least-cost path is known, $D(v)$ represents the current best guess for distance to node v and $p(v)$ is the predecessor of v on the least-cost path towards it.

step	N'	D(b),p(b)	D,p(c)	D,p(d)	D,p(e)	D,p(f)	D,p(g)	D,p(h)	D,p(i)	D,p(j)
0	a	2,a	3,a	∞	∞	1,a	∞	∞	2,a	∞

   (b) Suppose that the gateway routers of AS 23 receive the following BGP advertisements from their BGP peers:

Network	**AS Path**
AS 56	
1.2.3.0/24	56 83 99
1.3.8.0/23	56 75
1.4.5.0/24	56 97
AS 83	
1.7.128.0/17	83 117
1.4.4.0/24	83 62 103
AS 88	
2.3.0.0/16	88 107 56 23
2.7.9.0/24	88 107
AS 45	
7.5.8.0/22	45
7.12.0.0/16	45 75 23
1.2.3.0/24	45 99

   Show the routing table in router a that will be formed as a result of these advertisements. Assume that no routes are rejected due to local policy rules. Represent the routing table in this form:

Network	**Interface**
5.5.5.0/24	if1

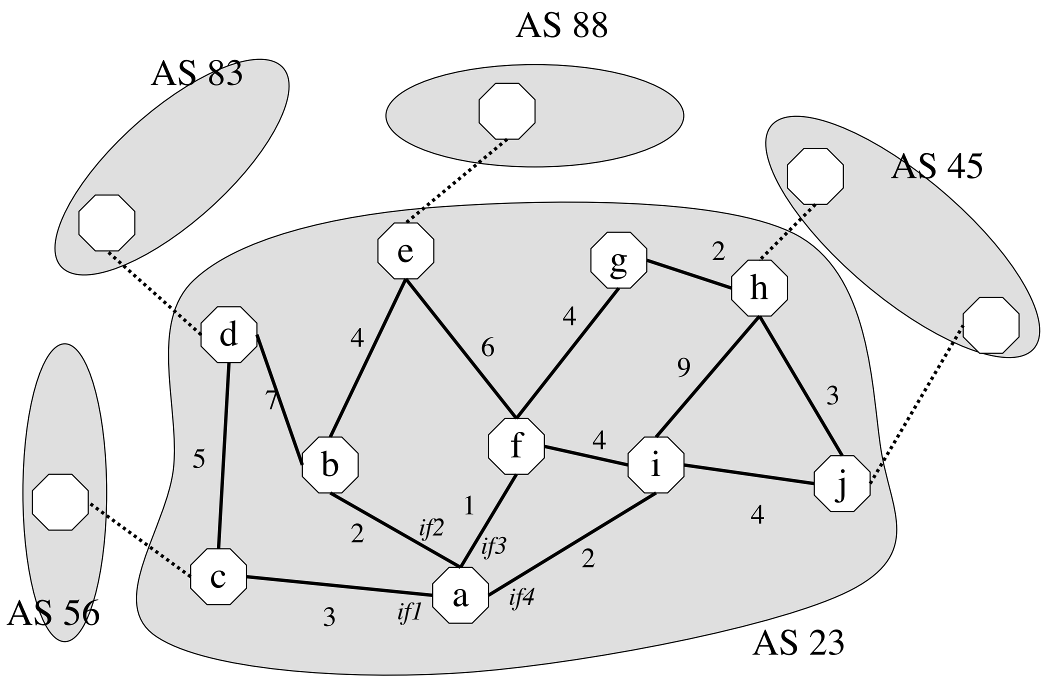

Figure 1: Diagram for Question 1.

2. **Distance Vector Routing**

(a) Suppose AS 23 from the last question runs a synchronous version of a distance vector algorithm. Every minute, at exactly the same time, each router sends its current distance vector to its neighbors. Then it updates its own vector based on what it receives, and sends out the updated vector the next minute.

Starting all routers in an initial state where they only know the cost of reaching their neighbors (i.e. the distance to all other routers is infinity), show the updated distance vector table at each router after the first exchange of distance vectors.

(b) How many minutes will it take for the routes to stabilize? Can you characterize how many rounds the DV algorithm will take to converge on an arbitrary graph?

(c) Refering to Figure 2, suppose the cost of the link between a and b changes to 100. Assuming synchronous updates once again, write down the distance vector table changes in routers b, c, and d for the next 5 minutes after the change. Assume that poison reverse is used in this case. How many rounds will it take for the routes to stabilize?

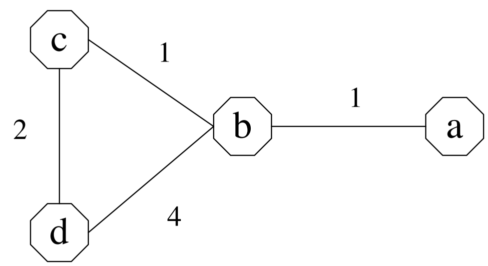

Figure 2: Diagram for question 2(c).

3. **Broadcast**

   Assume that router a in Figure 1 sends a broadcast packet to all other routers in AS 23.

   (a) If application-level broadcast is used, what is the total cost of sending this message? (Add up all the link costs traversed by each packet; i.e. if 3 packets go over a link, count three times the cost.)

   (b) If Reverse-Path Forwarding is used, list how many copies of the packet each router receives. (Hint: there is a fast way to count this.)

   (c) What is the total cost of sending the broadcast using RPF?

   (d) What is the total cost of sending the broadcast using a least-cost path tree rooted at router 1?

4. **Multicast**

   In this question, we are going to consider a modification to the MOSPF protocol that would calculate the minimum weight tree that connects all the routers in a multicast group and use that instead of a source-based least-cost path tree. (Such trees are called *Steiner trees*. They are similar to minimum spanning trees of a graph, but differ in that they do not (necessarily) cover all routers in a network graph, only the selected routers. This problem is, incidentally, NP-complete, but we will ignore this fact for the purposes of this problem.)

   (a) Show an example network graph where the least-cost path source-based tree has larger total weight than the Steiner tree.

   (b) Assuming that link costs in MOSPF represent the total delay on a link, would you use the Steiner tree or the source-based least-cost path tree for multicast?

   (c) Now suppose the costs represent the level of congestion; which tree would you use?

   (d) Suppose now that all routers are part of the multicast group, in which case the Steiner tree will be a minimum spanning tree for the entire network. Consider the link cost being 1 for all links; i.e. the total distance between two nodes is just the number of hops. Which tree (Steiner or least-cost-path) would you use for this multicast (really, broadcast) routing?