CS224 (m): Computer Networks (minor)
Tutorial 10, 05/07 Oct 2016

Concepts tested: Routing, Distance Vector, Link State

1. **[10 HP] Extra: Dijkstra's algorithm** is as follows. V is the set of vertices, while E is the set of edges in a graph. $C(e)$ (assumed positive) is the cost of an edge e. Vertex v_s is the source from which shortest paths to each of the other vertices have to be computed.

   (a) D (for done) is set of vertices for which the algorithm has already computed shortest paths from v_s. Initially $D = v_s$.

   (b) Denote by $C(v_i)$ the cost of the shortest path from v_s to v_i, as computed so far. Initially $C(v_s) = 0$ while $C(v_i) = \infty$ for all other v_i.

   (c) Choose the lowest cost node l in D.

   (d) Expand l. That is, update the costs of each of its neighbours x, but only if $C(x)$ is lowered via the path via l.

   (e) Now add the lowest cost node in $V - D$ to D. Go back to step (c) if D is not yet V.

   Ask your friend to create an example network with 7-8 nodes, and 10-12 edges, and positive edge costs. Hand execute Dijkstra's algorithm, and convince yourself that the shortest paths are indeed correct.

2. Suppose a router employing DV currently has the following routing table. It then receives an advertisement from a neighbor B, to which it is connected with a link of cost 2.

Destination	Next-hop	Cost
A	E	7
B	B	2
C	C	4
D	D	10
E	E	2

Figure-1

Destination	Cost
A	1
C	2
D	1
E	6

Figure-2

Figure 1: Distance vector routing table

   Draw the routing table of the router after processing the received advertisement.

3. In distance vector, suppose we define a round as an interval during which each node exchanges with its neighbor its routing table information.

   Assume N number of nodes and E number of edges in the graph. How many total messages are exchanged in a round as a function of N and E?

4. Consider a network topology with N nodes, E edges and a diameter of d. Diameter is the hop count of the longest path between any two nodes in the network without loops.

   Assume a synchronous version of distance vector that works in rounds. In each round, each node exchanges its distance vector with its neighbors and receives their distance vectors. Initially, each node knows only the cost to its immediate neighbors.

   What is the maximum number of rounds needed for the distance vector algorithm to converge? Express it as a function of N, E and d. Also assume that the network topology does not change during the rounds.

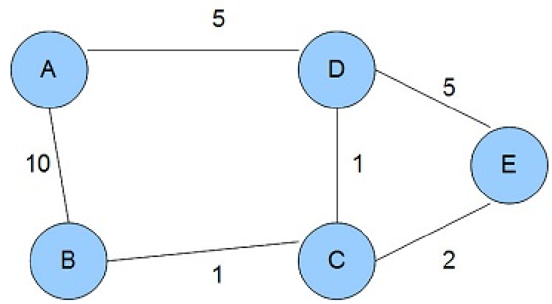

Figure 2: Topology

5. See the network topology in Fig. 2. At the beginning each node knows only the distances to its immediate neighbors.

   (a) In step 1, each node exchanges its routing table with all of its neighbors and all update their routing tables accordingly. In step 2, step 1 repeats i.e. each node again exchanges its routing table with all of its neighbors. After step 2, at node A, what are the costs associated with nodes B,C,D and E.

   (b) After DV convergence, focusing on node B and specific routing entry within corresponding to node D. If the cost of the link B-A were to change, for what value of the change will node B inform its neighbors of a new minimum cost path to D?

   (c) After DV convergence, suppose the link D to C were to break. What are the costs that node A maintains to nodes B, C, D and E after D informs node A of failure of the link?

6. Consider the topology as shown. Link costs are all '1'. A — B — C

   (a) Suppose link B–C were to fail. List all sequence of message exchanges that cause a routing loop in the above topology. Assume no preventive approaches like split horizon etc are used.

   (b) Suppose the B–C link fails. What is the probability of a loop forming if B broadcasts a triggered update within 1 sec of detecting link failure, while A broadcasts periodic updates once every 120 sec.

7. So far the discussion about link state dealt with finding routes (hence next hop) to routers. In reality, we are interested in finding routes to networks (IP prefixes). So, what information should a router include in the link state packet that it floods?

8. In link state routing, if the time interval between periodic updates is T, which of the following should hold true with respect to the ageing timer A associated with a link state packet entry at a router?
   A less than T
   A more than T
   A = T

9. Suppose a node A receives the following link state packets from others. The entries following "from", capture the specific node's neighbors and cost to the neighbors.

   From B: A 1, C 3, D 1
   From C: A 2, B 3, D 4
   From D: B 1, C 4

   Based on this information, to reach D, which next hop node would A use?

10. Can a node C receive two link state packets with same sequence number, one claiming that the link A-B is up and another claiming the link A-B is down? If so, how is this possible? If not, why not? Assume that the links are undirected.