Spring 2024, CS 3611: Computer Networks

Solution to Homework 5

Solution to problem 1

LSR and DVR are two main routing algorithms widely used practically. We can't say which one is better, both have its own advantages and disadvantages. The comparison is based on the following 4 facets:

1. message complexity: how many msgs sent between all n nodes?

- LS: with n nodes, E links, totally O(nE) msgs sent
- DV: exchange between neighbors only, totally O(n) msgs sent

2. computation complexity: algorithm for calculating least cost each

- LS: each node calculate using Dijkstra , $O(n^2)$
- DV: each node calculate the least cost to (n-1) nodes using Bellman-Ford equation , O(n)

3. speed of convergence: given a change, how long until the network re-stabilizes?

- LS: 1 iteration. may have oscillations
- n iterations. good news travel fast, but possible count-to-infinity problem for bad news.

4. Robustness: what can happen if a router fails or misbehaves?

- LS: robust. Node route calculations are somewhat separated
- DV: an incorrect node calculation can be diffused through the entire network. A node can advertise incorrect least-cost paths to its neighbors and then pass indirectly to its neighbor's neighbors and then to all destinations.

According the above analysis, LSR variants are suitable for small networks, and DVR variants are suitable for relatively large networks. Both are widely used in Internet. For example:

Intra-AS routing protocols:

- RIP: DVR based. The distance metric is # of hops, limits networks to 15 hops ($16 = \infty$ to avoid count-to-infinity)

- OSPF: LSR based. Hierarchical OSPF for large networks.

Inter-AS routing protocols:

- BGP: DVR based. DVR with explicit AS path avoid count-to-infinity

Solution to problem 2

Intra-AS and Inter-AS routing differ in the following 2 facets:

policy:

- Inter-AS: admin wants control over how its traffic routed, and who routes through its net. (untrusted)
- Intra-AS: single admin, so no policy decisions needed (trusted)

performance:

- Intra-AS: can focus on performance
- Inter-AS: policy may dominate over performance

Solution to problem 3

False.

A BGP router can choose not to add its own identity to the received path and then send that new path on to all of its neighbors, as BGP is a policy-based routing protocol. This can happen in the following scenario. The destination of the received path is some other AS, instead of the BGP router's AS, and the BGP router does not want to work as a transit router.

Solution to problem 4

NO, this is because that decreasing link cost won't cause a loop (caused by the next-hop relation of between two nodes of that link). Connecting two nodes with a link is equivalent to decreasing the link weight from infinite to the finite weight.

Solution to problem 5

1. eBGP
2. iBGP
3. eBGP
4. iBGP

Solution to problem 6

		Cost to				
		u	v	x	y	z
From	v	∞	∞	∞	∞	∞
	x	∞	∞	∞	∞	∞
	z	∞	6	2	∞	0

		Cost to				
		u	v	x	y	z
From	v	1	0	3	∞	6
	x	∞	3	0	3	2
	z	7	5	2	5	0

		Cost to				
		u	v	x	y	z
From	v	1	0	3	3	5
	x	4	3	0	3	2
	z	6	5	2	5	0

		Cost to				
		u	v	x	y	z
From	v	1	0	3	3	5
	x	4	3	0	3	2
	z	6	5	2	5	0

Solution to problem 7

1. $D_x(w) = 2$, $D_x(y) = 4$, $D_x(u) = 8$
2. First consider what happens if c(x,y) changes. If c(x,y) becomes larger or smaller (as long as c(x,y) ≤ 1) , the least cost path from x to u will still have cost at least 8.

Thus a change in c(x,y) (if c(x,y) $\leq$ 1) will not cause x to inform its neighbors of any changes. If c(x,y)= $\delta < 1$, then the least cost path now passes through y and has cost $\delta + 7$.

Now consider if c(x,w) changes. If c(x,w) = $\varepsilon \leq 1$, then the least-cost path to u continues to pass through w and its cost changes to 6 + ε; x will inform its neighbors of this new cost. If c(x,w) = $\delta > 7$, then the least cost path now passes through y and has cost 12; again x will inform its neighbors of this new cost.

3. Any change in link cost c(x,y) (and as long as c(x,y) $\geq$ 1) will not cause x to inform its neighbors of a new minimum-cost path to u .