5XTA0: Telecommunication Systems

**IP Routing practice preparatory exercises**

# Distance Vector Routing

## Q1

The figure on the left (Fig. 1) illustrates a network of 5 IP routers and one link-layer hub. The distance of the link between two Ethernet ports is indicated with a number. No router has a default gateway. All IP-layer devices use *distance vector routing*. Assume an initial state for all routers, where only the directly connected networks are present in the router's routing tables. Answer the following questions.

Fig. 1

1. Provide the initial distance vectors of each router of the figure above in the matrix below:

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Distance | **R1** | **R2** | **R3** | **R4** | **R5** |
| **R1** | **0** | **5** | **5** | **inf** | **inf** |
| **R2** |  | **0** | **4** | **inf** | **5** |
| **R3** |  |  | **0** | **2** | **4** |
| **R4** |  |  |  | **0** | **1** |
| **R5** |  |  |  |  | **0** |

1. Assume now, all routers have exchanged exactly twice their distance vectors with each other. Provide the distance vectors per router after these exchanges in the matrix below:

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Distance | **R1** | **R2** | **R3** | **R4** | **R5** |
| **R1** | **0** | **5** | **5** | **4** | **8** |
| **R2** |  | **0** | **4** | **6** | **5** |
| **R3** |  |  | **0** | **2** | **3** |
| **R4** |  |  |  | **0** | **1** |
| **R5** |  |  |  |  | **0** |

1. Assume that each Ethernet port of every router is now assigned an IP address and subnet mask as shown in the table below:

|  |  |  |  |
| --- | --- | --- | --- |
| IP Address | **eth0** | **eth1** | **eth2** |
| **R1** | 192.168.56.37/30 |  |  |
| **R2** | 64.155.41.89/26 | 192.168.4**5**6.39/30 |  |
| **R3** | 192.168.56.38/24**30** | 64.155.42.33/22 | 64.155.31.12/25 |
| **R4** | 64.155.31.13/25 |  | 64.155.32.66/25 |
| **R5** | 64.155.32.67/25 | 64.155.41.90/26 | 64.155.42.34/22 |

The table contains two errors. Find and correct the errors over the same table.

1. Assume the routers have exchanged their distance vectors exactly twice as of 3.B. Given your corrected table of 3.C, fill in the routing tables of routers R1 and R3 below. Apply CIDR when possible.

|  |  |  |  |
| --- | --- | --- | --- |
| R1 | Network prefix | Subnet mask | Device |
|  | 192.168.56.36  64.155.41.64  64.155.40.0  64.155.31.0  64.155.32.0  **0.0.0.0** | 30  26  22  25  25  **0** | eth0  eth0  eth0  eth0  eth0  **eth0** |

|  |  |  |  |
| --- | --- | --- | --- |
| R3 | Network prefix | Subnet mask | Device |
|  | 192.168.56.36  64.155.41.64  64.155.41.90  64.155.40.0  64.155.42.33  64.155.31.0  64.155.31.12  64.155.32.0  192.168.56.36  64.155.41.64  64.155.41.90  ~~64.155.40.0~~  64.155.42.33  64.155.31.0  64.155.31.12  64.155.32.0 | 30  26  32  22  32  25  32  25  30  26  32  ~~22~~  32  25  32  ~~25~~**20** | eth0  eth0  eth2  eth2  eth1  eth2  eth2  eth2  eth0  eth0  eth2  ~~eth2~~  eth1  eth2  eth2  eth2 |

1. Assume that the routers of the figure above, are using *link state routing* of TTL=1. Fill in the steps of Dijkstra algorithm executed on R1 after the first exchange of LS packets. Use the router names instead of IP addresses in the table below.

|  |  |  |
| --- | --- | --- |
| Dijkstra algorithm run at router R1 | | |
| Step | Confirmed List | Tentative list |
| 1  2  3  4  5 | (R1,0,-)  (R1,0,-) (R2,5,R2)  (R1,0,-) (R2,5,R2) (R3,5,R3)  (R1,0,-) (R2,5,R2) (R3,5,R3)(R4,7,R3)  (R1,0,-) (R2,5,R2) (R3,5,R3)(R4,7,R3) (R5,9,R3) | (R2,5,R2)(R3,5,R3)  (R3,5,R3)(R5,10,R2)~~(R3,9,R2)~~  ~~(R5,10,R2)(R2,9,R3)~~(R4,7,R3)(R5,9,R3)  (R5,9,R3)  - |

## Q2

Fig. 2 below shows a network graph of 12 routers, their interconnections and the cost for each connection. Assume that at each timeslot, all nodes send their distance vectors to their neighbors.

1. At timeslot 0, no node has exchanged any distance vectors before. Generate the routing tables of nodes A, G, H and L. (Hint: first exchanges happen at timeslot 1)
2. At timeslot 3, all nodes have completed 3 distance vector exchanges. Generate the routing tables of nodes A, G, H and L.
3. At timeslot 4, no distance vectors are exchanged. Route a message from node A to node L.



Fig. 2

Solutions

1. In DV, before vector exchanges, nodes are only aware of their immediate neighbors.

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **A** | **B** | **C** | **D** | **E** | **F** | **G** | **H** | **I** | **J** | **K** | **L** |
| **A** | 0 | 1 | 4 | ∞ | ∞ | ∞ | ∞ | ∞ | ∞ | ∞ | ∞ | ∞ |
| **B** | 1 | 0 | ∞ | 1 | ∞ | 2 | ∞ | ∞ | ∞ | ∞ | ∞ | ∞ |
| **C** |  |  | 0 |  |  |  |  |  |  |  |  |  |
| **D** |  |  |  | 0 |  |  |  |  |  |  |  |  |
| **E** |  |  |  |  | 0 |  |  |  |  |  |  |  |
| **F** |  |  |  |  |  | 0 |  |  |  |  |  |  |
| **G** | ∞ | ∞ | ∞ | 3 | 4 | ∞ | 0 | ∞ | ∞ | 6 | ∞ | ∞ |
| **H** | ∞ | ∞ | ∞ | ∞ | ∞ | 1 | ∞ | 0 | ∞ | 2 | ∞ | ∞ |
| **I** |  |  |  |  |  |  |  |  | 0 |  |  |  |
| **J** |  |  |  |  |  |  |  |  |  | 0 |  |  |
| **K** |  |  |  |  |  |  |  |  |  |  | 0 |  |
| **L** | ∞ | ∞ | ∞ | ∞ | ∞ | ∞ | ∞ | ∞ | ∞ | ∞ | 1 | 0 |

1. In DV, directional paths longer than timeslot+1 length are not known. After 3 timeslots, node A will be aware of big part of the topology. Node L is unknown and any directional path longer than 4 hops is not known; e.g. A-B-F-H-J-G or A-B-F-H-J-I are unknown even if these paths were shorter. G and H will be aware of even bigger part of the topology and L will not be aware of A, B, D and F. For instance, G will not be aware of the path G-D-F-B-A-C even if it was shorter.

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **A** | **B** | **C** | **D** | **E** | **F** | **G** | **H** | **I** | **J** | **K** | **L** |
| **A** | 0 | 1 | 4 | 2 | 9 | 3 | 5 | 4 | 10 | 6 | 13 | ∞ |
| **B** | 1 | 0 | 5 | 1 | 8 | 2 | 4 | 3 | 9 | 5 | ∞ | ∞ |
| **C** |  |  | 0 |  |  |  |  |  |  |  |  |  |
| **D** |  |  |  | 0 |  |  |  |  |  |  |  |  |
| **E** |  |  |  |  | 0 |  |  |  |  |  |  |  |
| **F** |  |  |  |  |  | 0 |  |  |  |  |  |  |
| **G** | 5 | 4 | 9 | 3 | 4 | 6 | 0 | 7 | 5 | 6 | 8 | 9 |
| **H** | 4 | 3 | 8 | 4 | 11 | 1 | 7 | 0 | 7 | 2 | 9 | 10 |
| **I** |  |  |  |  |  |  |  |  | 0 |  |  |  |
| **J** |  |  |  |  |  |  |  |  |  | 0 |  |  |
| **K** |  |  |  |  |  |  |  |  |  |  | 0 |  |
| **L** | ∞ | ∞ | 10 | ∞ | 5 | ∞ | 9 | 11 | 4 | 9 | 1 | 0 |

1. Based on the table above, L is not known to A. Then, the default port will be used. Assuming the default port (gateway) is the one towards C, C knowns of a path towards L. The path will be: A-C-E-I-K-L (all nodes except A known L in their routing table). If the default gateway used by A is B, many paths are possible as none of A,B,D and F are aware of L. Then, the possible paths could be: A-B-G-E-I-K-L or A-B-D-F-H-J-I-K-L or A-B-F-H-J-I-K-L.

# Link State Routing

## Q1

The figure below illustrates a network of 6 IP routers, one Ethernet hub and three terminals. The distance of the link between two Ethernet ports is indicated with a number. No router has a default gateway. Router R1 is the default gateway of A and B. Router R5 is the default gateway of C. The table below provides the IP address of every Ethernet port of every device. All IP-layer devices use *link state routing*. Assume: if a request is sent on timeslot T=x, the reply is sent on timeslot T=x+1. Messages sent on the same timeslot travel in parallel for 1 timeslot and reach their destination in random order. Answer the following questions:



Fig. 3

|  |  |  |  |
| --- | --- | --- | --- |
|  | **eth0** | **eth1** | **eth2** |
| **A** | 192.168.67.179/30 |  |  |
| **B** | 192.168.67.178/30 |  |  |
| **C** | 64.231.199.61/30 |  |  |
| **R1** | 101.49.156.38/24 | 96.178.45.221/24 | 192.168.67.177/30 |
| **R2** | 96.178.45.234/24 | 96.178.47.72/21 |  |
| **R3** | 101.49.156.39/24 | 101.49.33.12/24 |  |
| **R4** | 96.178.47.77/21 | 112.91.122.6/24 | 101.49.5.39/30 |
| **R5** | 64.231.27.92/24 | 64.231.199.63/30 | 112.91.122.51/24 |
| **R6** | 101.49.33.32/24 | 64.231.27.54/24 | 101.49.5.37/30 |

1. At timeslot T=0, no messages have been exchanged between any device. At that moment, terminal A starts one ICMP packet every timeslot for 4 timeslots (ping –n 1 64.231.199.61). An entry of an ARP table survives for only one timeslot.
   1. Fill in the correct numbers in the following statement: From timeslot T=0 until T=3, those ping commands generated \_\_**12**\_ ARP and \_\_**12**\_ IP packets.  
      Notes:
      1. Note here that for ARP to be triggered a target IP address is needed. That is, the routers should have their routing tables configured. Hence, the best path R1-R2-R4-R6-R5 is already built.
      2. Assumption: ARP request sent from A reaching both B and R1 is considered as a single message as the HUB clones it in every interface.
   2. Fill in below the routing table of terminal A once the ping commands finish:

|  |  |  |  |
| --- | --- | --- | --- |
| Destination IP | Subnet mask | Gateway IP | Device |
| **0.0.0.0** | **0** | **192.168.67.177** | **eth0** |

1. At timeslot T=4, all IP layer devices use reliable flooding of 2 hops-to-live. Once all routing information exchange messages have expired, at timeslot T=6, router R1 calculates based on Dijkstra its own routing table.
   1. Provide in the table below all steps of the Dijkstra algorithm run at router R1.

|  |  |  |
| --- | --- | --- |
| Dijkstra algorithm run at router R1 | | |
| Step | Confirmed List | Tentative list |
| 1  2  3  4  5  6  7  8  9  10  11  12  13 | (R1,0,-)  (R1,0,-)  (R1,0,-)(A,1,A)  (R1,0,-)(A,1,A)(B,1,B)  …(A,1,A)(B,1,B)(R3,1,R3)  …(A,1,A)(B,1,B)(R3,1,R3)  …(B,1,B)(R3,1,R3)(R2,3,R2)  …(B,1,B)(R3,1,R3)(R2,3,R2)  …(R3,1,R3)(R2,3,R2)(R6,5,R3)  …(R3,1,R3)(R2,3,R2)(R6,5,R3)  …(R2,3,R2)(R6,5,R3)(R4,7,R3)  …(R2,3,R2)(R6,5,R3)(R4,7,R3)  …(R6,5,R3)(R4,7,R3)(R5,9,R3)  (R1,0,-)(A,1,A)(B,1,B) (R3,1,R3)(R2,3,R2)(R6,5,R3) (R4,7,R3) (R5,9,R3) | (A,1,A)(B,1,B)(R2,3,R2)(R3,1,R3)  (B,1,B)(R2,3,R2)(R3,1,R3)  (R2,3,R2)(R3,1,R3)  (R2,3,R2)  (R2,3,R2)(R6,5,R3)  (R6,5,R3)  (R6,5,R3)(R4,12,R2)  (R4,12,R2)  (R4,12,R2)(R4,7,R3)(R5,13,R3)  (R5,13,R3)  (R5,13,R3)(R5,9,R3)  - |

* 1. Provide the routing table of R1 below once the Dijkstra algorithm is finished. Use Classless InterDomain Routing to compact the routing table as much as possible:

|  |  |  |
| --- | --- | --- |
| Destination IP | Subnet mask | Port |
| 192.168.67.179 | /30 | eth2 |
| 192.168.67.178 | /30 | eth2 |
| 96.178.45.221 | /24 | eth0 |
| 96.178.45.234 | /24 | eth1 |
| 96.178.47.72 | /21 | eth1 |
| Everything else |  | eth0 |
| 96.178.47.72 | /32 | eth1 |
| 192.168.67.176 | /30 | eth2 |
| 0.0.0.0 | /0 | eth0 |
| 96.178.45.234 | /26 | eth1 |

1. At timeslot T=7, reliable flooding is reconfigured to have 4 hops-to-live. Provide the routing table of terminal C below once the Dijkstra algorithm is finished. Use Classless InterDomain Routing to compact the routing table as much as possible:

|  |  |  |
| --- | --- | --- |
| Destination IP | Subnet mask | Port |
| 0.0.0.0 | /0 | eth1 |

## Q2

Consider the graph of Fig. 2. All routers now run Link State Routing. Assume they all spread their Link State Packets (LSPs) with Reliable Flooding of TTL=3. At timeslot 0, every node sends her LSP to her neighbors. At timeslots 1 and 2, nodes do not generate new own LSPs but just forward incoming LSPs if necessary. Node A, at timeslot 4 rebuilds her routing table using Dijkstra’s algorithm.

1. Demonstrate the steps of Dijkstra algorithm running in node A at timeslot 4.
2. What is the routing table of node A at timeslot 4?
3. What is the route from A to L?