

CIS-427 UM-Dearborn

HW3

With Dr. Zheng Song

Student: Demetrius Johnson

November 10, 2022

Question 1 (24 pts) Router forwarding

- Router forwards based on longest prefix matching; for example, you need to consider the IP address and subnet mask of all addresses in the routing table and select the address that has the most matching IP network bits that matches an incoming packet. Upon choosing the longest prefix max, that incoming packet will be forwarded out of the address that most closely matches (longest prefix matching).

a) 128.96.39.138

- **This packet with this address will be forwarded out of Interface 1** since 128.96.39.128/25 has the longest prefix match to 128.96.39.138 → this address is a part of the 128.96.39.128/25 network which has a network address of 128.96.39.128, a broadcast address of 128.96.39.255, and contains hosts in the range 128.96.39.129 - 128.96.39.254.

b) 128.96.39.24

- c) **This packet with this address will be forwarded out of Interface 0** since 128.96.39.0/25 has the longest prefix match to 128.96.39.24 → this address is a part of the 128.96.39.0/25 network which has a network address of 128.96.39.0, a broadcast address of 128.96.39.127, and contains hosts in the range 128.96.39.1 - 128.96.39.126.

d) 128.96.40.14

- e) **This packet with this address will be forwarded to R2** since 128.96.40.0/25 has the longest prefix match to 128.96.40.14 → this address is a part of the 128.96.40.0/25 network which has a network address of 128.96.40.0, a broadcast address of 128.96.40.127, and contains hosts in the range 128.96.40.1 - 128.96.40.126.

Question 2 (20 pts) Router forwarding pt 2

State to what next hop the following will be delivered.

I will use the same logic as in question 1 → router forward based on longest prefix match.

(a) C4.5E.8A.82

- **A**

- C4.50.00.00/12 has network address C4.50.00.00; hosts C4.50.00.01 through C4.5F.FF.FE; and broadcast address C4.5F.FF.FF. Thus, the packet will be forwarded to hop A.

(b) C4.6B.23.09

- **D**

- C4.68.00.00/14 has C4.68.00.00 as the network address; hosts C4.68.00.01 through C4.6B.FF.FE; and a broadcast address C4.6B.FF.FF. Therefore, it this address as longest prefix matching (next hop as D).

(c) 3E.43.92.12

- **G**

- 00.00.00.00/2 has 00.00.00.00 as the network address; hosts 00.00.00.01 through 3F.FF.FF.FE; and a broadcast address of 3F.FF.FF.FF. Therefore, this network has the longest prefix matching and the packet will be forwarded to next hop as G.

(d) C4.63.31.2E

- **C**

- C4.60.00.00/12 has network address C4.60.00.00; hosts C4.60.00.01 through C4.6F.FF.FE; and broadcast address C4.6F.FF.FF. Thus, the packet will be forwarded to hop C.

-

Question 3 (26 pts) Dijkstra Algorithm

a) How should the network operators set the link weights if their goal is to minimize the number of hops each packet traverses to reach its destination?

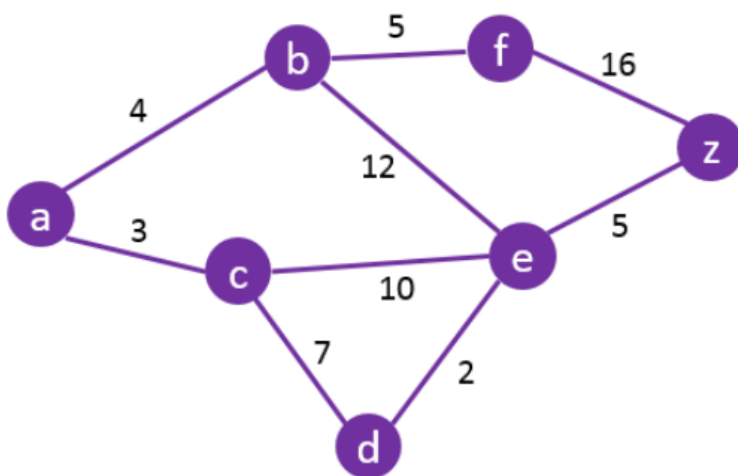
If an administrator wishes to minimize the number of hops each packet traverses to reach the destination, **then the weight used should be based on hop count**. Therefore, the heuristic (cost = link weight) he should assign for the weights of each edge is 1 → referring to 1 hop. Thus, if a packet must travel along 3 edges (for example) to go from source to destination, then the cost of that path would be 3 (3 hops). Also, if you wish to abstract some routers along the way as a single edge, this can be done; for example, if you have router A and router B, and there is an edge between them labeled with cost 4, then that means the packet had to stop at 3 other routers (abstracted as just the edge between A and B) before it reached router B.

b) How should the operators set the link weights to minimize the end-to-end delay the traffic experiences? Assume the network is lightly loaded, so queuing delay is insignificant.

In order to minimize end-to-end delay that traffic experiences, link weights (heuristic) should be set based on **latency**. Latency in this case is a measure (in time) of how long it takes to send data from one host to another (end-to-end delay). So, each edge would have a cost in unit of time that is referring to the latency to go from one hop to the next; the sum of the latency costs along all edges from source to destination would be the path cost (path latency). Latency is affected by throughput (also known as link speed and is a fraction of the bandwidth), utilization (throughput/bandwidth), and queuing delay.

In the event that the network was congested and thus routers will have longer queuing delays due not only to storing data for a packet until the full packet arrives before transmitting but also from buffering packets that have arrived and waiting to transmit them when the network is not as congested. Thus, in a heavily loaded network, you might still base weights off latency, but an alternative is to assign weights to edges based on the average queue size of the next hop. In doing this, you may be able to improve the reliability by causing all routers in the network to share the buffer load more equally along paths so that one router does not get overloaded and drop too many packets or so that packets do not have to wait in as large of a queue.

c) Using the Dijkstra shortest-path algorithm, one can compute the shortest path from node u to all network nodes. Given a 6-node network illustrated in the figure below. The table underneath indicates the steps deriving the cost (denoted by D) and previous hop (denoted by p) on the shortest paths. Now, consider the 7-node network illustrated in the figure below. Generate the table indicating the steps deriving the cost and previous hop on the shortest paths from node a to all other network nodes. Note that when the path costs are equal, add nodes to the Travel Set in alphabetic order.



Travel set	$D(b),p(b)$	$D(c),p(c)$	$D(d),p(d)$	$D(e),p(e)$	$D(f),p(f)$	$D(z),p(z)$
a	4,a	3,a	Infinity	Infinity	Infinity	Infinity
ac	4,a	-	10,c	13,c	Infinity	Infinity
acb	-		10,c	13,c	9,b	Infinity
acbf			10,c	13,c	-	25,f
acbfd			-	12,d		25,f
acbfde				-		17,e
acbfdez						-

Question 4 (30 pts) Distance Vector Protocols

Consider the network shown above in Problem 4.

a) What are A, B, C, D, E, and F's distance vectors? Note: you do not have to run the distance vector algorithm; you should be able to compute distance vectors by inspection. Recall that a node's distance vector is the vector of the least cost paths from itself to each of the other nodes in the network.

	DV in A	DV in B	DV in C	DV in D	DV in E	DV in F	DV in Z
A	0	A	3	10	12	9	17
B	4	0	7	14	12	5	17
C	3	7	0	7	9	12	14
D	10	14	7	0	2	19	7
E	12	12	9	2	0	17	5
F	9	5	12	19	17	0	16
Z	17	17	14	7	5	16	0

b) Now consider node C. From which other nodes does C receive distance vectors?

Distance Vector algorithm is based on “tell your neighbors about the world”; thus node C will only send its DV information to its neighbors: E, A, and D.

c) Consider node C again. Through which neighbor will C route its packets destined to z? Explain how you arrived at your answer, given the distance vectors that C has received from its neighbors.

After the distance vectors for all nodes has been relayed to their respective neighbors and there have been enough iterations of DV calculations and transmissions, then C's distance vector will be such that it will have (approximately) the least cost path to each node. So, in order to get from C to Z, a packet will be routed from $C \rightarrow D \rightarrow E \rightarrow Z$; thus for a packet at C destined for Z, router C will forward the packet to router D.

Note: E will know the shortest path to Z has a cost of 5 since it is directly connected \rightarrow E will then relay its distance vector to D, and D knows its least cost path to E which is directly connected is 2, so then D will compute its distance vector to Z as $2+5 = 7$. Then, D will relay its distance vector to C, informing C that the least cost path from D to Z is 7. E will also relay to C that it has a least cost path to Z with cost 5; however, C will compare cost from C to E = 10, then $+ 5 = 15$ versus cost from D to E = 7, then $+ 5 = 12$. Thus, C will disregard the distance vector from E concerning destination Z and use the distance vector it received from D concerning destination Z.