Cornell CS4450/5456 Homework 2

September 30, 2024

Instructions

1. Submit the assignment via Gradescope
2. Answer all questions in the box provided
3. Each subpart of a question is worth 5 points, overall the homework is worth 100 points.
4. The homework is due on October 9^{th}
5. Good luck!

1 STP with weighted links

(25 points) Consider the Layer 2 networks shown in Figure 1. Nodes in these networks are Ethernet switches. MAC addresses of switches in this network are represented with alphabets. Assume that $A < B < C...$ Links in these networks are weighted. These networks run a version of Spanning Tree Protocol that takes into account link weights while computing shortest paths.

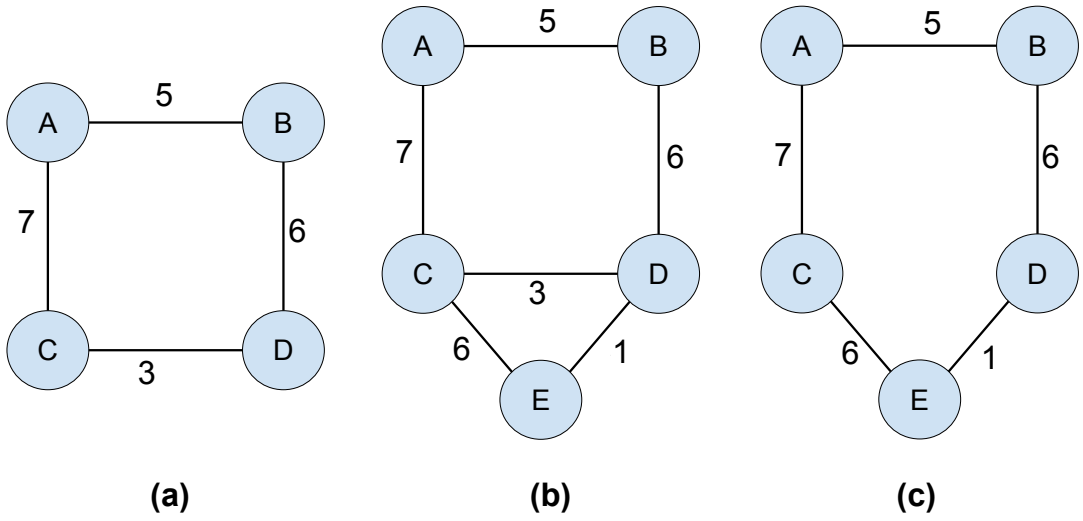


Figure 1: Layer 2 networks.

1. Consider the network in Figure 1(a). Which links will be disabled after STP converges in this network?

   (a) link C-D

   (b) link A-B

   (c) link A-C

   (d) link B-D

   Put your answer here:

2. Consider that a new node (E) is added to the network shown in Figure 1(a), resulting in the network shown in Figure 1(b). The new node E is added using two new links, EC of weight 6 and ED of weight 1. STP had already converged in the original network before E (and EC and ED) was added. What is the first STP message broadcasted by node E once it joins the network? (note: option (d) and the answer box are on the next page!)

   (a) E, 0, E

   (b) A, 11, E

   (c) C, 6, E

(d) D, 1, E

Put your answer here:

3. After node E broadcasts it's first message, what will node D respond with?

   (a) C, 3, D
   (b) B, 6, D
   (c) A, 11, D
   (d) A, 10, D
   (e) D, 0, D

   Put your answer here:

4. Assume that STP has re-converged after the addition of node E (and edges EC, ED). Which links are disabled in the network shown in Figure 1(b)?

   (a) link A-C
   (b) link B-D
   (c) link C-E
   (d) link A-C and C-E
   (e) link B-D and C-E

   Put your answer here:

5. Assume that link C-D in Figure 1 fails, resulting in the network graph show in Figure 1(c). The link failure forces STP to re-converge again. After STP reconverges, which links are disabled in Figure 1(c)?

   (a) A-C
   (b) B-D
   (c) D-E
   (d) C-E
   (e) A-C and B-D

   Put your answer here:

2 Forwarding Tables

A		
Node	**Cost**	**Nexthop**
B	1	B
C	2	D
D	1	D
F	2	B

F		
Node	**Cost**	**Nexthop**
A	2	B
B	1	B
C	2	B
D	3	B
E	1	E

(20 points) Suppose we have a network in which all links have cost 1. Suppose the above forwarding tables are given for nodes A and F. Note that an entry is missing in node A's forwarding table. Construct the smallest network consistent with these tables. You can assume that the forwarding tables represent correct routing state, that is, the network does not have dead-ends or loops. Assume smallest here means a network with the fewest nodes and edges.

1. How many edges does your network have?

   Put your answer here: [ ]

2. What is the maximum degree of a node in your network?

   Put your answer here: [ ]

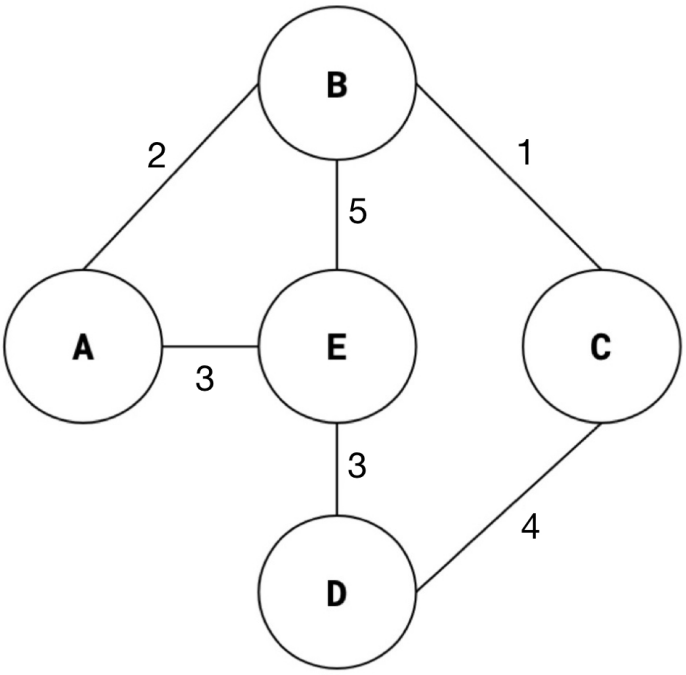
3. Consider the missing entry in node A's forwarding table. This entry is corresponding to node E. Assume that the nexthop in this missing entry is revealed to be node B. What will be the path cost?

   Put your answer here: [ ]

4. Consider the missing entry in node A's forwarding table. This entry is corresponding to node E. Assume that the nexthop in this missing entry is revealed to be node D. What will be the path cost?

   Put your answer here: [ ]

3 Least Cost Routing



(20 points) In the above Layer 3 network, links are labeled with their costs. Assume the network implements least cost routing. Construct for your reference, the routing tables for this network. Using these routing tables, answer the following questions.

a) Which node is farthest from Node A in terms of path cost?

Put your answer here:

b) Let X be the node farthest from Node A. What is the next-hop to X in Node A's routing table?

Put your answer here:

c) Let's assume that the B-E link fails in the above network and the routing protocol is forced to re-converge. Does the routing table of Node A change? Answer Yes or No.

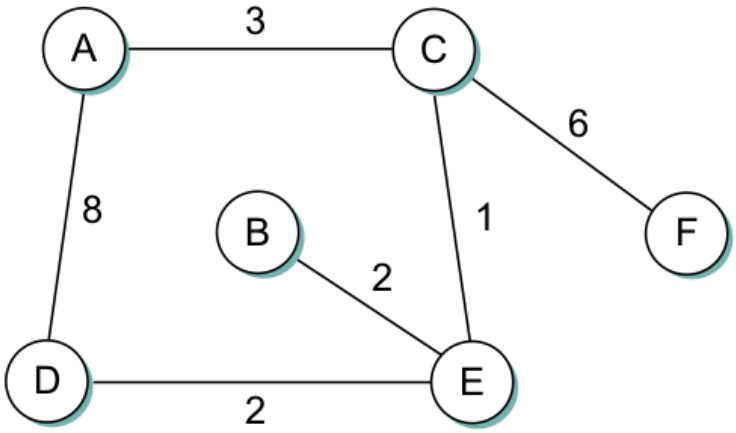
Put your answer here:

d) Let's assume that the B-E link fails in the above network and the routing protocol is forced to re-converge. Does the routing table of Node D change? Answer Yes or No.

Put your answer here:

4 Link State Routing

(10 points) Nodes in the following network are routers and the link weights represent cost of traversing an edge between the routers. Routers in this network run a link state routing protocol.



1. Assuming all other routers have computed their shortest routes, what path does a packet take from F to D? (Your answer should be of the form: FBCD, if the path is $F \rightarrow B \rightarrow C \rightarrow D$)

   Put your answer here: [ ]

2. After all routers have computed their shortest routes, the cost of the link between routers C and E unexpectedly increases from 1 to 15. Can this change cause packets to enter a loop before the network re-converges to acknowledge this new cost? Answer Yes or No.

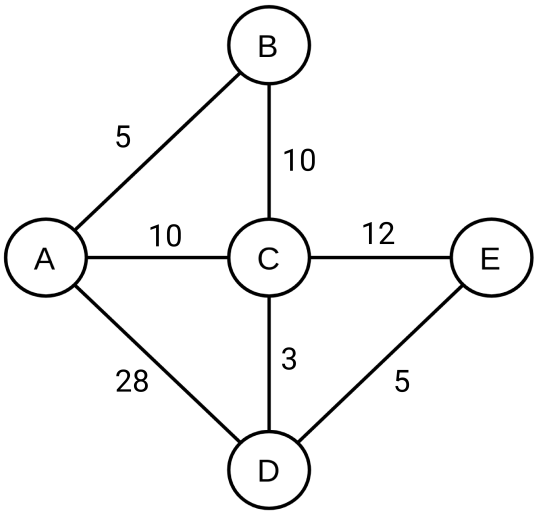
   Put your answer here: [ ]

5 Distance Vector Routing

(25 points) Consider the following network. The weight on a link between any pair of nodes is the latency between the two nodes (equal to the propagation delay for both data packets and control packets). We will use latency, cost and distance interchangeably in this problem.

- Assume distance-vector routing and that at time t = 0, each node knows the distance only to its immediate neighbors.
- Assume that all nodes send their current distance vectors to all neighbors at every 10 seconds, starting at t = 0.
- Assume the nodes' clocks are perfectly synchronized. This means that each node agrees on what time it is.
- Assume that transmission delay is 0 for both data packets and control packets.
- Assume that processing a received distance vector and updating the routing/forwarding tables takes no time.
- Assume that if the entry to a particular destination has cost/latency/distance equals to ∞, then a packet to that destination is dropped.

Given the above assumptions, below is node A's routing/forwarding table at t = 0.



A's Forwarding Table at t=0

Destination	Next Hop	Cost
B	B	5
C	C	10
D	D	28
E	-	∞

(a) At time t=7 seconds, router A wants to send packets to router E. What is the cost of the route from A to E at this time?

Put your answer here: [ ]

(b) At time t=17 seconds, router A wants to send packets to router E. What is the cost of the route from A to E at this time?

Put your answer here: [ ]

(c) At time t=17 seconds, router A wants to send packets to router E. What is the route taken by these packets? (your answer should be of the form: ABCD, if the path is $A \to B \to C \to D$)

Put your answer here: [ ]

(d) At time t=27 seconds, router A wants to send packets to router E. What is the cost of the route from A to E at this time?

Put your answer here: [ ]

(e) At time t=27 seconds, router A wants to send packets to router E. What is the route taken by these packets? (your answer should be of the form: ABCD, if the path is $A \to B \to C \to D$)

Put your answer here: [ ]