ECE/CS 438: Communication Networks **Fall 2023**

Homework 4

Handed Out: November 1st, 2023 *Due: 11:59pm, November 27th, 2023*

Students Name:

- Homework assignments must be submitted online through Gradescope. Hard copies are not accepted. Please submit a pdf file to Gradescope (`https://www.gradescope.com/courses/581425`). You can either type your solution or scan a **legible** hand-written copy. We will not correct anything we do not understand. Contact the TAs via email if you face technical difficulties in submitting the assignment.
- While we encourage discussion within and outside of the class, cheating and copying is strictly prohibited. Copied solutions will result in the entire assignment being discarded from grading at the very least and a report filed in the FAIR system. It is also your responsibility to ensure that your partner obeys the academic integrity rules as well.
- This assignment has a total of 110 points. The grade will be capped at 100 points.
- **Please write your answer in the white space to the right of the corresponding problem.**

1 T/F (no need for justification) - 1×5 points

1. Packets flowing through virtual circuit (VC) networks use VC identifiers instead of IP addresses.
2. Routers in VC networks do not maintain any state.
3. Routing happens more frequently than forwarding.
4. VC identifiers are used in VC networks because IP addresses are in shortage.
5. A packet is flowing from your laptop to a Youtube server. When the packet flows through routers, say R5 to R6, the packet header contains the IP address of R6.

2 Choose all the correct answers - 1×4 points

Imagine IP addresses are 4 bit addresses, from 0000 to 1111. Now, consider the following scenario at a router: of the 16 addresses, the first 5 must be forwarded to interface 1, the second 4 to interface 2, the third 2 to interface 3, and the final 5 to interface 4. Create the most optimal (7 row) forwarding table with 2-column forwarding table (column 1 = Prefix, and column 2 = interface number) that the router should use. Answer the following questions with respect to the forwarding table:

1. What will the entry/entries in the prefix column be for Interface 1?
   (a) 010
   (b) 0100
   (c) 00
   (d) 01
   (e) 000

(f) 001

2. What will the entry/entries in the prefix column be for Interface 2?
   (a) 01
   (b) 011
   (c) 0101
   (d) 011
   (e) 1000
   (f) 100
3. What will the entry/entries in the prefix column be for Interface 3?
   (a) 1001
   (b) 1010
   (c) 10
   (d) 101
   (e) 100
   (f) 1
4. What will the entry/entries in the prefix column be for Interface 4?
   (a) 101
   (b) 1011
   (c) 111
   (d) 11
   (e) 110
   (f) 10

3 Choose the correct answer - 4 points

Assume that 6 nodes are placed on a straight line as follows: A–B–C–D–E–F. Assume that the distance between adjacent nodes is equal and denoted by r and that the pathloss index is α. Assuming A is transmitting to B, C to D, and F to E, and that they all use the same transmit power, compute the SINR at D as a function of r and α. Assume noise is zero.

(a) $6^\alpha/(2^\alpha + 3^\alpha)$

(b) $3^\alpha/(1 + 3^\alpha)$

(c) $(6r)^\alpha/(2^\alpha + 3^\alpha)$

(d) $1/r^\alpha$

4 Choose all the correct answers - 2×4 points

1. A switch without a routing function (L2 switch)
   (a) gets its IP by DHCP when it's connected to the internet.

(b) normally broadcasts all the packets it received to all the ports except for the incoming port.

(c) serves as the gateway and DHCP server for the LAN devices.

(d) forwards the packets to the corresponding port according to the MAC table

2. Alice and Bob wanted to share files with each other by setting up a socket connection. Both of them typed ifconfig on their Linux machine to obtain their IP addresses. Alice's IP address is 130.126.255.1. Bob's IP address is 192.168.34.102. Assume they both have access to the Internet. Can they set up the socket connection without requiring other external servers?

   (a) Yes. Bob needs to set up the server and wait for Alice to connect.

   (b) Yes. Alice needs to set up the server and wait for Bob to connect.

   (c) No. Their IP addresses are not in the same subnet so they cannot communicate.

   (d) No. One of them is using a local IP address so the socket cannot be established.

3. (Continuing Q4.2) When they both log on to https://www.iplocation.net/ to check their IP address, what should they observe?

   (a) Alice will see the same address as ifconfig result.

   (b) Alice will see a different address from ifconfig result.

   (c) Bob will see the same address as ifconfig result.

   (d) Bob will see a different address from ifconfig result.

4. (Continuing Q4.2 and 4.3) Now Carol came in. She typed ifconfig and saw her IP address is 192.168.34.101, but she cannot ping Bob's IP address. You are told that the network condition is normal, and there are not any firewalls blocking etc. Assume Carol also has access to internet, and both of Bob and Carol's subnet masks are 255.255.255.0. Which of the following statements are correct?

   (a) There are some ways to directly set up socket and send files between Carol and Bob without any external server.

   (b) They cannot share files even using the external server because they cannot ping each other.

   (c) The scenario described should not happen because Bob and Carol are in the same subnet, then they should be able to ping each other.

   (d) They might be able to communicate with each other through an external server.

5 Choose all the correct answer - 3×3 points

For every IP in the sub-questions, please select the correct forwarding rule according to the routing table as shown in the choices:

1. 192.168.1.1

   (a) 192.168.0.0/17 to port A

(b) 192.168.0.0/23 to port B

(c) 192.168.2.0/24 to port C

(d) 0.0.0.0/0 to port D

2. 192.168.255.255

(a) 192.168.0.0/17 to port A

(b) 192.168.0.0/23 to port B

(c) 192.168.2.0/24 to port C

(d) 0.0.0.0/0 to port D

3. 10.0.0.1

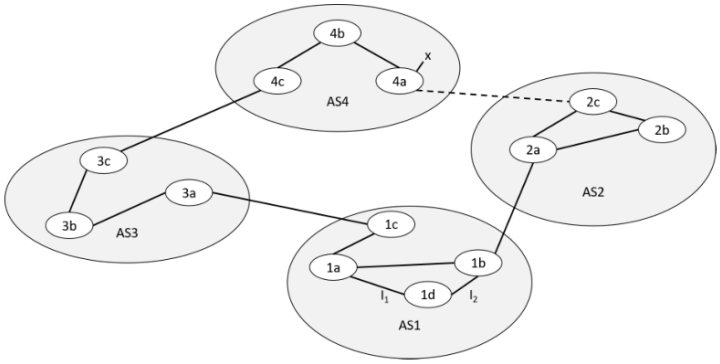
(a) 192.168.0.0/17 to port A

(b) 192.168.0.0/23 to port B

(c) 192.168.2.0/24 to port C

(d) 0.0.0.0/0 to port D

6 AS Routing - 2×5 points



Consider the network shown above. Suppose AS3 and AS2 are running OSPF for their intra-AS routing protocol. Suppose AS1 and AS4 are running RIP for their intra-AS routing protocol. Suppose eBGP and iBGP are used for the inter-AS routing protocol. Suppose there is no physical link between AS2 and AS4 (ignore the dashed line).

1. Router 3c learns about prefix x from which routing protocol?

(a) OSPF

(b) RIP

(c) eBGP

(d) iBGP

2. Router 3a learns about x from which routing protocol?

(a) OSPF

(b) RIP

(c) eBGP

(d) iBGP

3. Router 1c learns about x from which routing protocol?
   (a) OSPF
   (b) RIP
   (c) eBGP
   (d) iBGP
4. Router 1d learns about x from which routing protocol?
   (a) OSPF
   (b) RIP
   (c) eBGP
   (d) iBGP
5. Router 4c learns about x from which routing protocol?
   (a) OSPF
   (b) RIP
   (c) eBGP
   (d) iBGP

7 Subnet - $3 + 4$ points

A company IlliNet has a CIDR address of 220.34.12.0/26. Because of unsatisfactory Internet service, it decides to change its ISP from CastCom to TTA.

1. The company IlliNet can support at most _____computers.

2. CastCom's router should now remove IlliNet's entry when routing advertisements are sent to other routers. (T/F), please justify your answer.

8 Switch - $5 + 5 + 2 + 2$ points

A Slotted ALOHA network of N = 24 nodes gets separated into 3 smaller networks using a switch. Each smaller network now contains N/3 nodes.

1. Before the switch was installed, calculate the probability of collisions in the network. Assume that each node attempts transmission in a given slot with a probability p = 0.3. Your answer should be correct up to 4 decimal places. Please also write the equation in terms of N and p.

2. After the switch was installed, assume that sender-receiver pairs are always within a smaller network (i.e., traffic does not cross the switch). Calculate the probability of collisions in the whole network, i.e, probability that collision occurs in any of the three smaller networks. Your answer should be correct up to 4 decimal places. Please also write the equation in terms of N and p.

3. Explain the advantages of the switch in terms of collision probability and overall network throughput.

4. In this scenario, would it make any difference if the switch was replaced by a hub?

9 Hidden terminal - 3 points

Draw a labeled diagram to demonstrate that hidden terminal problems can occur despite the exchange of RTS/CTS.

10 Complete the sentence in no more than 15 words: - 3×5 points

1. Using VC identifiers is more efficient than IP address-based forwarding because

2. Poison reverse is needed to

3. Collision detection is possible in a wired network because

4. The triangular routing problem in cellular networks can be avoided by

5. Select one sentence (A or B) that is true and complete it in less than 15 words: Consider a cheap switch that does not have a switching table and therefore forwards each incoming packet on all other interfaces. (A) This switch will still be better than a hub because ... (B) This switch will not be better than a hub because ...

11 Ethernet Collision - 5 points

Show that when transmit time is greater than twice the propagation delay, then all nodes in a wired Ethernet will detect collisions. Assume that the time to detect collisions in the network interface card (NIC) is negligible.

You are required to show this through a well-labeled diagram.

12 RTS/CTS - 5 points

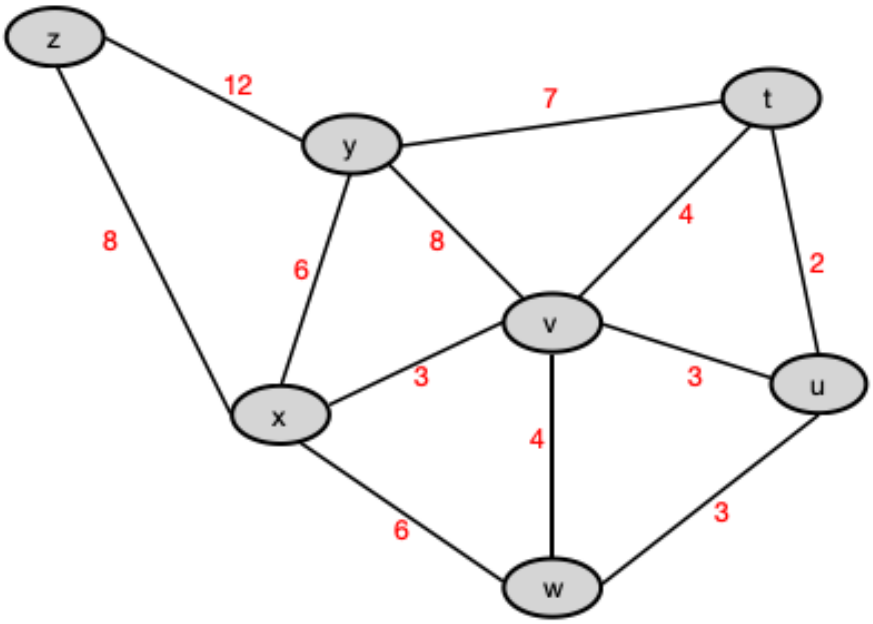
Consider an alternative WiFi protocol in which RTS/CTS is not exchanged, instead, the transmitter directly sends the DATA packet (after performing carrier sense and backoff).

Does this alternative protocol reduce the number of collisions?

If yes, explain why RTS packets would experience less collisions than DATA packets. If no, explain why RTS/CTS is exchanged in today's WiFi protocol? Your answer should not exceed 20 words.

13 Link State Routing - 2×5 points

The figure below represents different nodes in a network; they run Dijkstra's algorithm for Link State (LS) Routing.



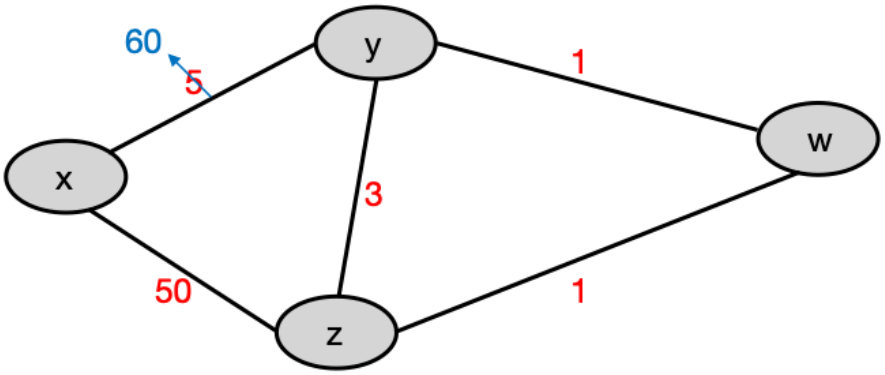
Consider node t running the Dijkstra's Algorithm to calculate the shortest path to all nodes in the shown network. Answer the following questions with regards to the given information.

1. (T/F) Assume link states have been exchanged, and node t now begins to run the routing algorithm. At this point, node t is not aware about the existence of nodes x, z and w, and will find out about their existence by running the algorithm.
2. The shortest path to z is determined at step/iteration number (Assume that the algorithm begins with the determined=t at step/iteration = 0):
3. The cost of shortest path to z determined by t after running the algorithm is _____.
4. And z's predecessor along the shortest path from t is _____.

5. Draw a table demonstrating LS algorithm running at t, step by step. For each step, the table should include:
   (a) The step number (starting from 0).
   (b) Subset N of nodes to which the least cost path has been determined as of the current step number.
   (c) For each destination node n, the table should include the cost D(n) of the least-cost path from the source node t to destination n as of that step of the algorithm.

14 Distance Vector Routing and Poisoned Reverse - $1 \times 6 + 2 + 3$ points

Given below is a diagram of a network that uses Distance Vector Routing along with poisoned reverse.



Initially, the cost of different links are: $c(x, y) = 5, c(x, z) = 50, c(y, z) = 3, c(y, w) = 1, c(z, w) = 1$

When distance vector routing has stabilized (by starting with the initial costs specified above), routers w, y, and z communicate to each other their distance vectors to router x (i.e., $D_w(x)$, $D_y(x)$, $D_z(x)$). What are the values of these distance vectors? Fill in the following blanks (i.e, blanks in Q14.1, Q14.2 and Q14.3). "$D_a(b)$ to c" denotes the value of router a's distance vector to router b, which is sent to router c. If the answer is infinity, please write "inf".

1. $D_y(x)$ to z
2. $D_y(x)$ to w
3. $D_z(x)$ to y
4. $D_z(x)$ to w
5. $D_w(x)$ to y
6. $D_w(x)$ to z

7. Now, when the link cost between x and y increases to 60, as shown in the diagram, y is the first router to send out updates. What will be the value of distance vector $D_y(x)$ shared with router z and w? ($D_y(x)$ to z and $D_y(x)$ to w)

8. Will there be a count-to-infinity problem in this case? Answer yes or no. Please justify your answer

   Hint- The order of distance vector updates after link cost $c(x, y)$ changes to 60 will be as follows: $D_y(x) \rightarrow D_w(x) \rightarrow D_z(x)$ This means that $D_y(x)$ updates first and z, w are informed about this update. $D_w(x)$ updates next and z, y are informed about it. Following this, $D_z(x)$ is updated and y, w are informed about this update.