Homework 4

Handed Out: December 20th, 2023 ***Due: January 4th, 2023***

- Homework assignments must be submitted online through Blackboard. Hard copies are not accepted. Please submit a pdf file to Blackboard. 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. It is also your responsibility to ensure that your partner obeys the academic integrity rules as well.
- This assignment has a total of 100 points.
- **Please write your answer in the white space to the right of the corresponding problem**.

1 T/F (no need for justification) - 2 x 5 points

Each question may have more than one correct answer. You will only get points if you identify all the correct answers.

T 1. Packets flowing through virtual circuit carry destination host address.

T 2. In Virtual circuits, every router on source-dest path maintains "state" for each passing connection.

F 3. Consider the network layer. Routers contain state about end-to-end connections.

T 4. Consider the network layer. Datagrams for the same source-dest pair may take different paths.

F 5. Suppose that a packet is flowing from your laptop to a server. When the packet flows through routers, say R4 to R5, the packet header contains the IP address of R5.

2 Forwarding table - 2 $\times$ 4 points

Suppose that IP addresses have 4 bits only, from 0000 to 1111. Of these 16 addresses, the first 5 should be forwarded to interface 1; the next 4 ones be forwarded to interface 2; the 2 addresses after then should be forwarded to interface 3, and the last 5 ones to interface 4. Create the most optimal (7 row) forwarding table with 2column forwarding table (column 1 = Prefix, and column 2 = interface number) that the router should use. Choose all apply to answer the following questions.

ACDF 1. What will the entry/entries in the prefix column be for Interface 1?

(a) 00

(b) 01

(c) 000

(d) 001

(e) 010

(f) 0100

2. What will the entry/entries in the prefix column be for Interface 2?

(a) 01

(b) 011

(c) 100

(d) 001

(e) 0101

(f) 1000

3. What will the entry/entries in the prefix column be for Interface 3?

(a) 1

(b) 10

(c) 100

(d) 101

(e) 1001

(f) 1010

4. What will the entry/entries in the prefix column be for Interface 4?

(a) 10

(b) 11

(c) 101

(d) 110

(e) 111

(f) 1011

3 IP addressing - 3 x 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:

B

1. 192.168.1.2
   (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) 10.0.0.0/0 to port D

A

2. 192.168.32.2
   (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) 10.0.0.0/0 to port D

D

3. 192.168.255.5
   (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) 10.0.0.0/0 to port D

4 Subnet - 6 points

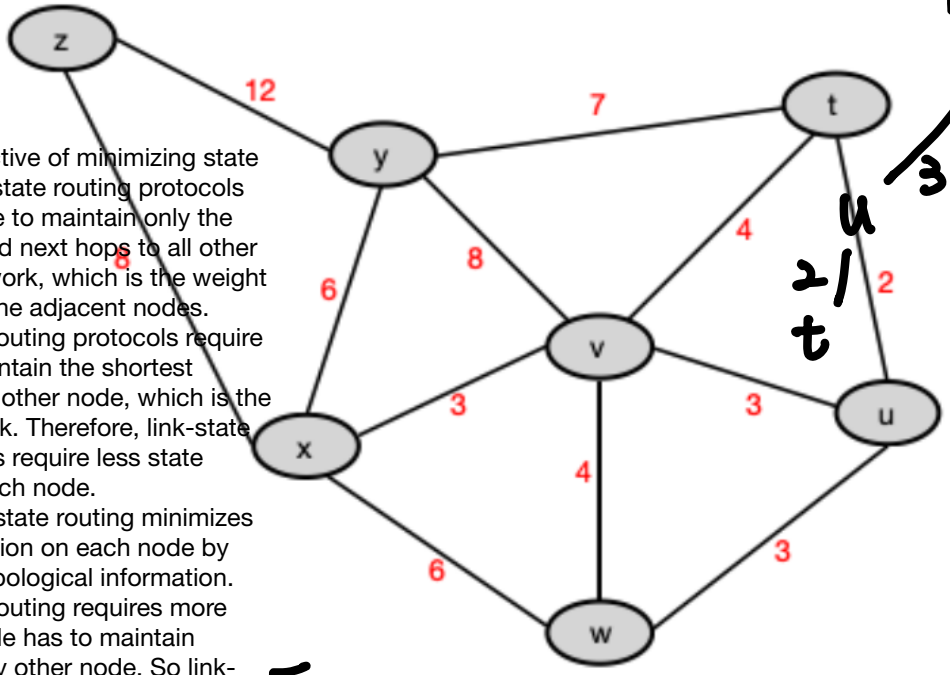
Consider a router that interconnects three subnets: Subnet1, Subnet2, Subnet3. Suppose all of the interfaces in each of these three subnets are required to have the prefix 203.1.17/24. Also suppose that Subnet 1 required to support at least 60 interfaces, Subnet 2 is to support at least 90 interfaces, Subnet3 is to support at least 12 interfaces. Provide three network addresses (of the form a.b.c.d/x) that satisfy these constraints.

Subsets: ① → 203.1.17.0/26 ② → 203.1.17.128/25

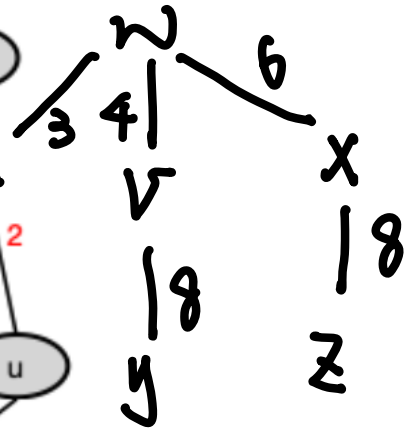
5 Dijkstra's Algorithm - 5 + 3 points

③ → 203.1.17.240/28

Consider the network topology as shown in figure



tree



Q2.

From the perspective of minimizing state information, link-state routing protocols require each node to maintain only the shortest paths and next hops to all other nodes in the network, which is the weight of each link and the adjacent nodes. Distance-vector routing protocols require each node to maintain the shortest distance to every other node, which is the weight of each link. Therefore, link-state routing algorithms require less state information on each node.
In summary, link-state routing minimizes the state information on each node by only recording topological information. Distance-vector routing requires more state as each node has to maintain distances to every other node. So link-state routing keeps less state information than distance-vector.

1. Derive and draw the shortest-path tree from node w using the Dijkstra's algorithm. Show how the cost of path and predecessor node along path converge step-by-step in a table as demonstrated in the lecture slides.

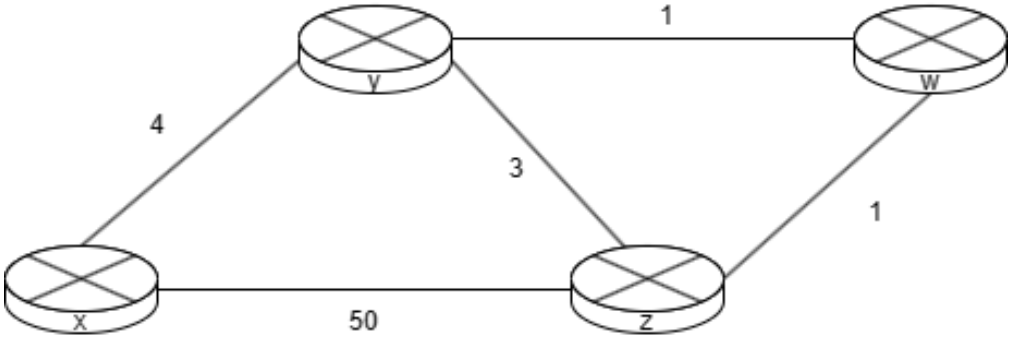
2. Sort the following protocols by the amount of state each node maintains, and give clear explanation.
- Link State
- Distance Vector

Step	D(x),p(x)	D(y),p(y)	D(z),p(z)	D(u),p(u)	D(v),p(v)	D(t),p(t)	D(w), p(w)
1	6, w	inf, None	inf, None	3, w	4, w	inf, None	0, None
2	6, w	inf, None	inf, None	3, w	4, w	5, u	0, None
3	6, w	12, v	inf, None	3, w	4, w	5, u	0, None
4	6, w	12, v	inf, None	3, w	4, w	5, u	0, None
5	6, w	12, v	14, x	3, w	4, w	5, u	0, None
6	6, w	12, v	14, x	3, w	4, w	5, u	0, None
7	6, w	12, v	14, x	3, w	4, w	5, u	0, None

6 Distance Vector Routing - 3 + 6 + 5 points

Poison reverse. The idea is simple. Suppose three routers x, y, z. If z routes through y to get to destination x, then z will advertise to y that its distance to x is infinity; that is, z will advertise to y that Dz(x)= infinity (even though z knows Dz(x) in truth). z will continue telling this little white lie to y as long as it routes to x via y. Since y believes that z has no path to x, y will never attempt to route to x via z, as long as z continues to route to x via y (and lies about doing so). (Notice for a more detailed explanation, see the textbook in Distance-Vector Algorithm)

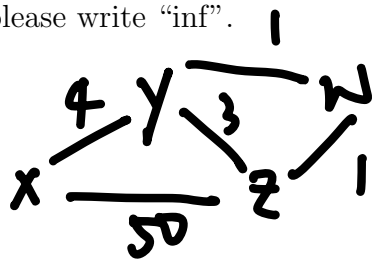
Assume four routers x, y, z, and w are connected as follows, and the cost of each link is given in the picture. Suppose that poison reverse is used in the distance vector routing algorithm.



1. Why is poison reverse needed?

Poison reverse is needed to solve the count-to-infinity problem in distance vector routing. When there is a network failure, poison reverse allows a node to advertise an infinite distance to unreachable nodes, so that it quickly informs its neighbors that the node is down. This prevents the endless exchange of distance information among nodes and helps the network quickly converge to the new reachable state.

2. 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 questions. "$D_a(b)$ 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".



(a) $D_y(x)$ to z 4

(b) $D_y(x)$ to w 4

(c) $D_z(x)$ to y 6

(d) $D_z(x)$ to w inf

(e) $D_w(x)$ to y inf

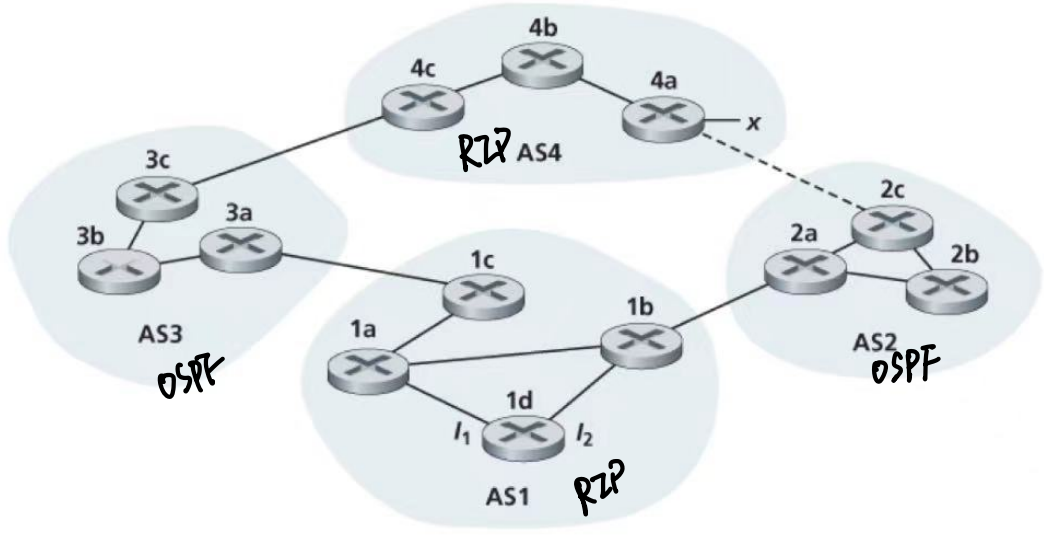
(f) $D_w(x)$ to z 5

3. Now suppose that the link cost between x and y increase to 60. Will there be a count-to-infinity problem even if poisoned reverse is used? Why or why not? If there is a count-to-infinity problem, then how many iterations are needed for the distance-vector routing to reach a stable state again? Justify your answer.

No, there won't be a count-to-infinity problem. Because as soon as the x-y link cost increases, y will first advertise an infinite distance to its neighbors z and w. When z and w receive this, they will immediately update their own distance vectors. So the network will quickly converge without the count-to-infinity problem.

7 AS Routing - 2 x 2 + 3 x 2 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.



C 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. Once router $1d$ learns about x it will put an entry (x, I) in its forwarding table.Now suppose there is a physical link between AS2 and AS4, shown by the dotted line. Suppose router $1d$ learns that x is accessible via AS2 as well as via AS3. Will I be set to I_1 or I_2? Explain why.

In this case, I would be set to I2. Because all other conditions are equal, but the path via AS2-AS4 is shorter and becomes the optimal path. So when 1d learns about this new path, it will update the forwarding table to use the inter-domain interface I2 to reach x, in order to use the most optimal inter-domain path.

4. Now suppose there is another AS, called AS5, which lies on the path between AS2 and AS4 (not shown in diagram). Suppose router $1d$ learns that x is accessible via AS2 AS5 AS4 as well as AS3 AS4. Will I be set to I_1 or I_2? Explain why.

In this case, I would be set to I1. Because when a router learns the same prefix from multiple ASes, it will prefer the internal path within its own AS. So 1d will prefer to reach x via the internal interface I1 within AS1 rather than the inter-domain path advertised by AS2.

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

A Slotted ALOHA network of $N = 32$ nodes gets separated into 4 smaller networks using a switch. Each smaller network now contains $N/4$ 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.

$P = 1 - P(\text{idle}) - P(\text{successful})$
$= 1 - (1-p)^N - Np(1-p)^{N-1} \Rightarrow P = 1 - 1.104\times10^{-5} - 1.514\times10^{-4} \approx 0.9998$

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.

$P = 1 - \left[(1-p)^{\frac{N}{4}} + \frac{N}{4}p(1-p)^{\frac{N}{4}-1}\right]^4$

≈ 0.9938

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

the switch (help) reduce the collision and increase the overall throughput in the way of reducing collision rate., as the successful rate increased a large amount.

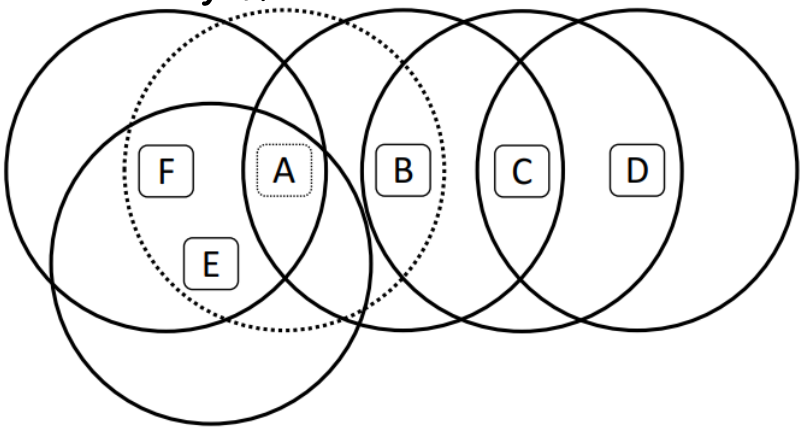
4. In this scenario, would it make any difference if the switch was replaced by a hub?

If switch is replaced by a hub, the subnets would not be isolated as it was switch, the chance of collision would (be) still.

9 Wireless - 3 + 3 + 6 points

In the diagram below, each wireless node is shown along with its transmission radius. E.g., A's transmission radius is the circle with the dashed line.

1. B is hidden to DEF; C is hidden to A ; D, E, F is hidden to B ; A is hidden to C.



2. Yes.
Explanation:
When B sends an RTS to A, then A boardcast a CTS to B, E, F.
When receiving CTS E, F would remain silent.
After transmission btw A and B ends (ACKed) then EF become active.

1.List all the hidden terminals in the above wireless network?

2. The network uses CSMA/CA. When B wants to transmit to A it sends an RTS and A replies with a CTS to reserve the channel. Is this guaranteed to avoid collisions, explain why or why not?

3. Suppose the nodes F, A, B, C, D are equally spaced by a distance of d. Assume all nodes are identical and transmit at same power level on the same frequency. Also assume the signal attenuates based on free space pathloss model.
A is transmitting to B while C is transmitting to D. Compute the SINR of C's signal at D in the following cases?
(a) The noise power at D is zero.
(b) The noise power at D is not zero and in the absence of any interference, the SNR of C's signal at D is 20.

3. (a) $SINR_C^D = \frac{S_{C\to D}}{I_D + N_D} = \frac{S_{C\to D}}{I_D}$ As Except C No node interfere D $\Rightarrow I_D = 0$

$\Rightarrow SINR_C^D \to \infty$

(b) $SNR = 20\,dB \Rightarrow 10$ $SINR = SNR = 20$.

10 Short Answer Questions - 3 x 3

1. 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 130.126.255.2. 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? Explain your answer

2. When they both log on to https://www.iplocation.net/ to check their IP address, will they observe same IP address as running ifconfig?

3. Now Carol came in. She typed ifconfig and saw her IP address is 192.168.34.103. Can she communicate directly with Bob without an external server?

1 Can Alice and Bob establish a socket connection to share files without requiring external servers?

No, they cannot. Alice and Bob are in different private IP networks (Alice 130.126.255.2, Bob 192.168.34.102). They cannot directly access each other over the public internet. External servers like an FTP server would be required to facilitate the connection.

2 When Alice and Bob log onto iplocation.net to check their IP, will the IP they observe be the same as the one from running ifconfig?

No, they will be different. Ifconfig shows Alice and Bob's private IP in their respective local networks. But iplocation.net will show the public IP assigned by the website's server.

3 Can Carol communicate directly with Bob without an external server?

Yes, she can. Carol and Bob are in the same private IP network (192.168.34.0/24). They can directly communicate using their private IPs without needing an external server.