ECE/CS 438: Homework 3: Network and Link Layer

Fall 2018, UIUC

November 28, 2018

Network Layer

1. State True or False and provide a brief justification (2X5=10 points)

(a) A router propagates distance vector updates whenever the cost of one of its links changes.

(b) Dijkstra's algorithm works even when some link costs are zero.

(c) Dijkstra's algorithm outputs the least cost path between S and D as [S, A, B, C, M, N, D]. This means that the least cost path between B and N is [B, C, M, N].

(d) Routers, switches, and hubs, all of them separate packet collision domains.

(e) NAT boxes can support no more than N IP addresses, where N is the number of ports supported by the network.

2. Complete the sentence (2X5=10 points)

(a) Even though the link layer runs a CRC check, the network layer still includes parity checks because ...

(b) A switch is called a plug and play device because ...

(c) The main advantage of longest prefix matching (compared to full IP matching) is that ...

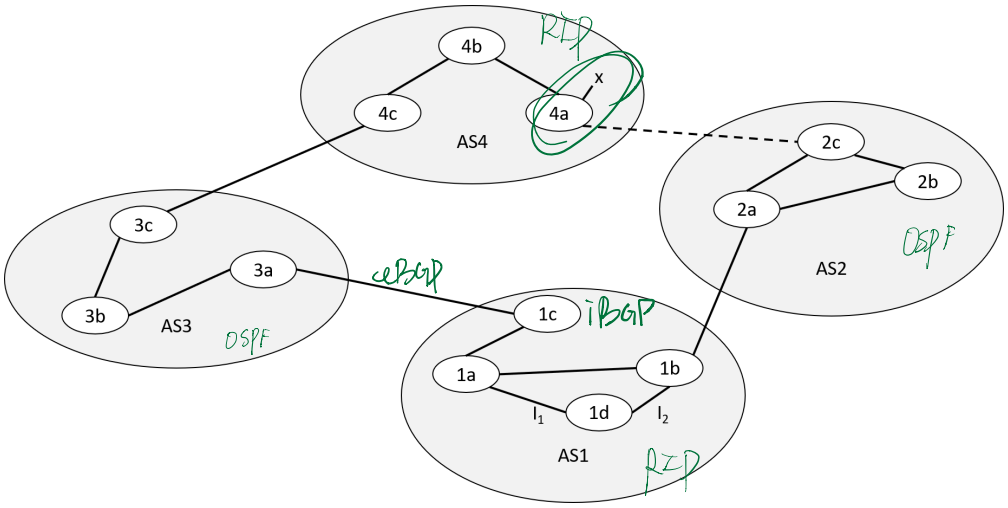
(d) Head of the line blocking happens in a router when ...

(e) The distance vector routing is a dynamic program, because each node caches ...

3. Routing algorithms and BGP, RIP, OSPF (25 points)

(a) Suppose, Alice wants to get a file from Bob (5X2=10 points).

1. She runs ifconfig on her Linux machine and sees that her IP address is 192.168.107.54. She calls Bob on the phone and asks him to check his IP address the same way. Bob sees 10.27.1.101. Bob informs her that he is running a server program on port 8551, that can give her the required file. She tries to initiate a socket connection with Bob's IP address and port but fails. What could be causing an issue here? Assume the Internet functions well, and no programming errors.
2. Alice realizes what the issue is here. For some reason, Bob cannot change his IP address, so Alice comes up with an alternative solution. She calls up her ISP and asks for a real-internet address for herself. She gets 137.78.34.65 as her IP address from the ISP provider. Of course, she still cannot connect to Bob's server. Is there a way for Alice to receive the file she needs from Bob with this IP address setup (Alice=137.78.34.65, Bob=10.27.1.101), without going through a third-party service? If yes, explain the setup. If no, give reasons.
   Bonus question: where probably does Alice work? (0 points)

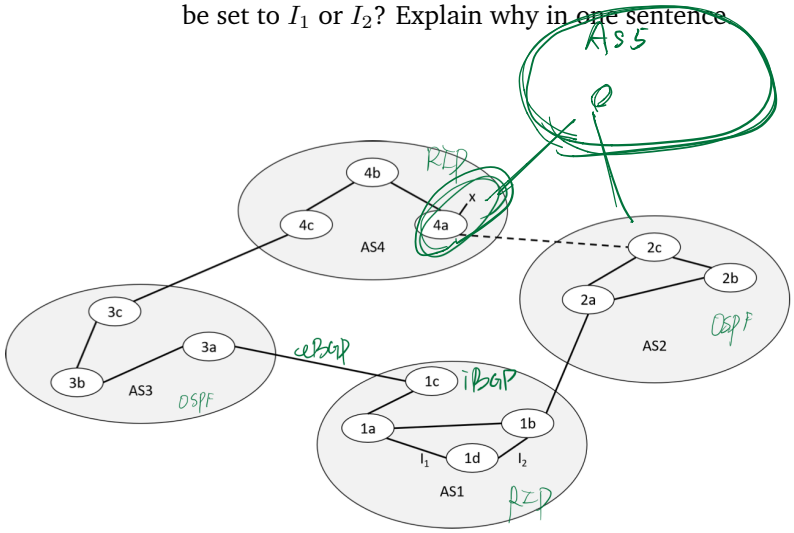


(b) Consider the network shown above. Suppose AS3 and AS2 are running OSPF for their intra-AS routing protocol. Suppose AS1 and AS4 are running RIP for their intra-AS routing protocol. Suppose eBGP and iBGP are used for the inter-AS routing protocol. Initially suppose there is no physical link between AS2 and AS4 (1X5=5 points).

1. Router 3c learns about prefix x from which routing protocol: OSPF, RIP, eBGP, or iBGP? RIP & eBGP
2. Router 3a learns about x from which routing protocol? RIP & eBGP & iBGP
3. Router 1c learns about x from which routing protocol? RIP & eBGP & iBGP
4. Router 1d learns about x from which routing protocol? RIP & eBGP & iBGP
5. Router 4c learns about x from which routing protocol? RIP

(c) Once router 1d learns about x it will put an entry (x, I) in its forwarding table (3+3+4=10 points).

1. Will I be equal to I_1 or I_2 for this entry? Explain why in one sentence. No. I_1 is the shorter entry.
2. Now suppose that 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 one sentence. I_1. If the cost of each link is same, then through AS2 is the shorter one.
3. 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 one sentence. AS2 > AS4. less BGP cost.



Link Layer

4. State True or False and provide a brief justification (2X5=10 points)

(a) The unslotted ALOHA protocol is worse than slotted ALOHA in channel utilization. Explain the reason.

(b) We know that CSMA/CD assumes the signal sensed at the transmitter's location is identical to that at the receiver's location. Therefore, it will work on wireless channels without any modification.

(c) RTS/CTS solves the hidden terminal problem.

(d) The following can be valid CDMA codes: [1 1 1 1] and $[e^0\ e^{j\theta}\ e^{j2\theta}\ e^{j3\theta}]$, where θ is $45°$.

(e) The following can be valid CDMA codes: [1 1 1 1] and $[e^0\ e^{j\theta}\ e^{j2\theta}\ e^{j3\theta}]$, where θ is $90°$.

5. Randomized Backoff (5X2=10 points)

In randomized MAC protocols, backoff durations are counted in terms of time-slots. Of course, shorter slots are better but these slots cannot be arbitrarily small.

(a) What determines the minimum value of the time-slot?

(b) Show with an example how the protocol may behave incorrectly if the time-slot is less than this minimum value.

6. Channel Utilization (15 points)

First, compute the maximum expected channel utilization of SLOTTED ALOHA for N nodes (as discussed in class). You should compute p^*, and then use it to derive maximum utilization for each N. Then, plot a graph of the maximum channel utilization for increasing number of nodes (up to N =10,000 nodes). Your graph should have utilization on the Y axis, and "number of nodes (N)" on the X axis.

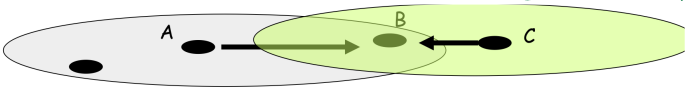
7. Wireless SNR (10 points)

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 transmitting to D, and F transmitting to E, and that they all use the same transmit power, compute the SINR at D as a function of r and α. Ignore noise.

8. Mobile Networks (5X2=10 points)

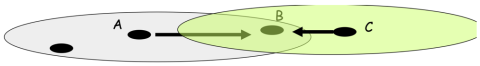
(a) Using a simple example, describe the *triangle routing problem*.

(b) State one disadvantage each for indirect and direct routing in mobile IP networks.



$$SINR = \frac{SignalOfInterest(SoI)}{Interference(I) + Noise(N)}$$

$$SoI_B^A = \frac{P^A_{transmit}}{d^\alpha_{AB}} \qquad I_B^C = \frac{P^C_{transmit}}{d^\alpha_{CB}} \rightarrow SINR_B^A = \frac{\frac{P^A_{transmit}}{d^\alpha_{AB}}}{N + \frac{P^C_{transmit}}{d^\alpha_{CB}}}$$



$$SINR = \frac{SignalOfInterest(SoI)}{Interference(I) + Noise(N)}$$

$$SoI_B^A = \frac{P^A_{transmit}}{d^\alpha_{AB}}$$

$$I_B^C = \frac{P^C_{transmit}}{d^\alpha_{CB}}$$

$$\rightarrow \quad SINR_B^A = \frac{\frac{P^A_{transmit}}{d^\alpha_{AB}}}{N + \frac{P^C_{transmit}}{d^\alpha_{CB}}}$$

$$SoI_D^C = \frac{P^C_{transmit}}{d^\alpha_{CD}} = \frac{Power}{r^\alpha}$$

$$I_E^F = \frac{P^F}{d^\alpha_{FE}} = \frac{Power}{(2r)^\alpha}$$

$$I_D^A = \frac{P^A}{d^\alpha_{AB}} = \frac{Power}{(3r)^\alpha}$$

$$\Rightarrow \frac{\frac{P}{r^\alpha}}{\frac{P}{(2r)^\alpha} + \frac{P}{(3r)^\alpha}} = \frac{\frac{1}{r^\alpha}}{\frac{1}{(2r)^\alpha} + \frac{1}{(3r)^\alpha}}$$