CS6250/4251

Spring 2021

Test 1

Important Instructions:

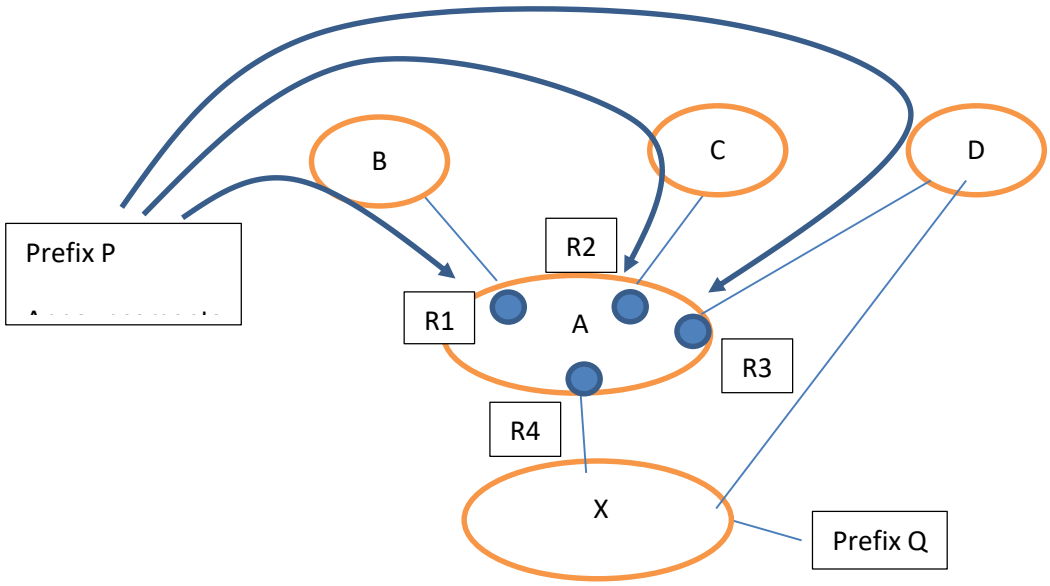
- ***Open Book and Notes***
- ***Time: Test available at 9:25am. Uploads must complete by 11:15am. Late uploads accepted until 11:30am with 20% penalty. Note system will not accept uploads after 11:30am. (All times Atlanta Time).***

- ***Please answer questions on your own paper, or tablet. Scan or convert to PDF and upload. Typed answers and converted to PDF are also OK.***
- ***You may not consult with other "humans" (students, friends, family, …)***
- ***Ask questions during the test through 6250/4251 Piazza.***

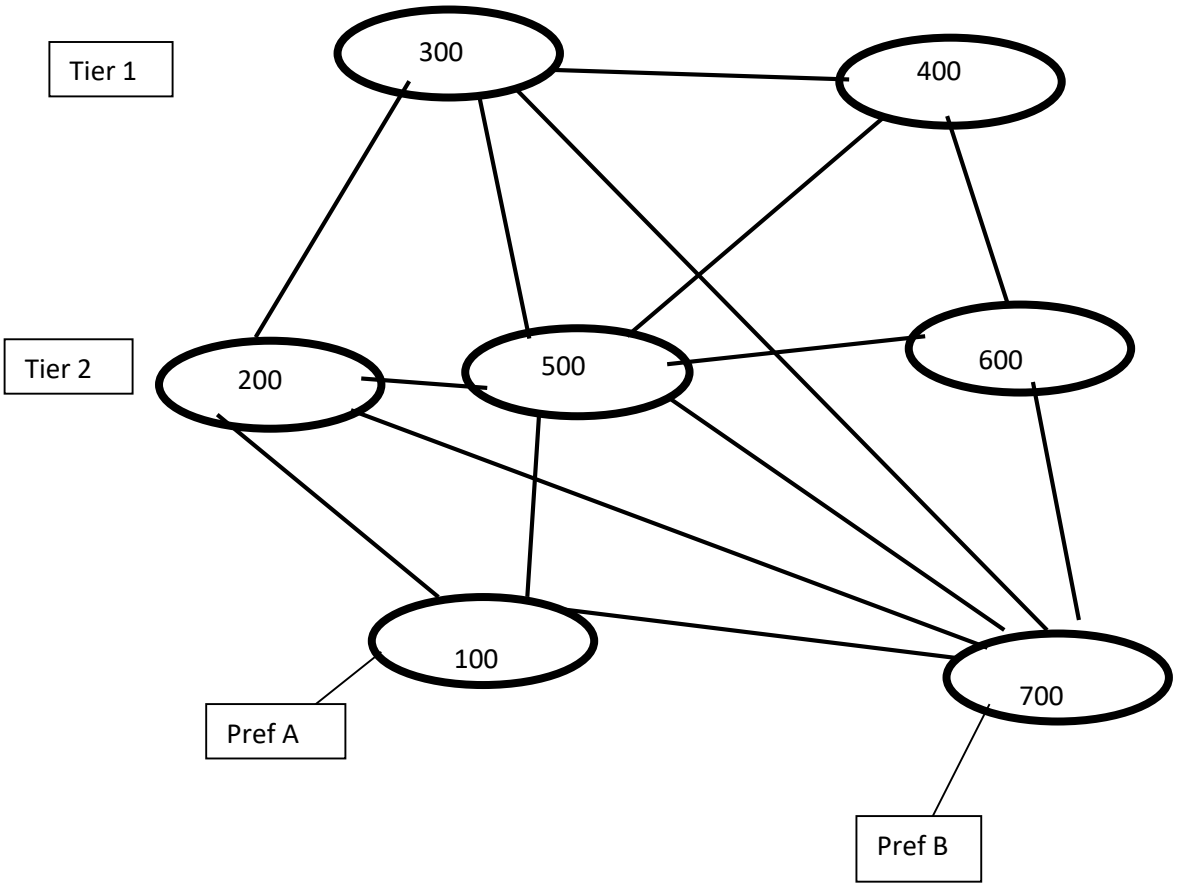
Question 1 (30 points)

a) At some point in history, Autonomous Systems in the Internet were connected as a *tree* graph with a single root (tier-1) AS. Transit (tier-2) ASes connected to the root and each stub AS had one parent tier-2 AS. Today the Inter-domain graph deviates from a tree graph in a number of ways.
   i) Describe three ways that today's AS graph deviates from a tree.
   ii) Explain the rationale for these deviations.

b) Consider the figure below: Tier 2 AS A hears BGP announcements for a specific prefix, P, from its providers. It hears an AS path attribute that has 10 ASes from Provider B, 7 ASes from Provider C and 9 ASes from Provider D. These announcements arrive at three different border routers (R1, R2, and R3). AS A is connected to a stub AS X over border router R4. Answer the following questions:
   i) Can one tell which of the AS paths are actually shorter (minimum number of router hops or minimum latency)? Why or Why not?
   ii) Suppose that the local preference (LP) for Prefix P is set as 100, 50, 40, 200 in border routers R1, R2, R3, and R4 respectively. Which of the border routers will be used to forward traffic to Prefix P? Explain your answer.
   iii) AS X announces Prefix Q to both AS D and AS A. First explain how can AS X configure these announcements to favor the use of the link from AS A for incoming traffic to Prefix Q. Second show an example where this may not work and traffic to Prefix Q will continue to arrive from AS D instead.


Prefix P
B
C
D
R2
R1
A
R3
R4
X
Prefix Q

Question 2 (20 Points)



a) Consider the AS graph above. Which of these are illegal paths between Pref A and B. For each illegal path, explain why it's illegal.

i) 100, 500 600, 700
ii) 100, 200, 500, 600, 700
iii) 100, 500, 400, 300, 200, 700
iv) 100, 200, 300, 500, 400, 600, 700

b) The following path is illegal if it shows up at AS 700 as an announcement for Pref. A. 100, 200, 500, 400, 500, 700. Ideally this path should be prevented by appropriate filtering at border routers.

i) What is the earliest point in the forward progression of this path where this path should be detected and stopped (filtered out)?
ii) If this filtering fails, where is the next point where it should be filtered out?

Question 3 (42 points)

a) Since congestion is experienced at routers, an early proposal for congestion control had routers send "Source Quench" ICMP packets to sources sending data through the router is experiencing congestion. Give one reason why this scheme did not turn out to be a good idea.

b) A proposed modification of TCP Reno congestion control has the following rules: When triple-duplicate ack is encountered the window is cut by a third (cwin ← 2/3 cwin). Afterwards as long as no other losses are encountered, cwin is increased by 2 segments every RTT. Assuming all flows have the same RTT and follow this same set of increase and decrease rules, would this provide fair network sharing among TCP flows? Make sure to explain your answer.

c) The Mathis TCP formula is said to be accurate for relatively low loss rates ($p < 5\%$). What assumption in the derivation of the formula makes it inaccurate for higher loss rates?

d) As a network engineer trying to improve the performance of TCP over your network, you are faced with one of two options: i) reduce the End-to-end latency by 50% ii) or reduce the loss rate by 50%. Your budget does not allow you to do both. Which one should you choose to maximize the improvement in TCP throughput.

e) Explain what is meant by a high *Bandwidth-Delay Product* Network Path. What problems will TCP Reno encounter when used on such a path.

f) In class we have asserted that K = CubeRoot ((1-beta) Wmax/C) is the time that TCP Cubic takes after window reduction for the window to return to its previous Wmax value assuming no packet losses are encountered. Use the TCP Cubic formula to prove this assertion.

Question 4 (8 points)

a) MPTCP Connection Establishment requires that a 3-way TCP handshake take place on each subflow. Explain why this is required.

b) An MPTCP sender has 8 data segments to send over 2 MPTCP subflows. Each subflow is responsible for sending 4 segments. Suppose the Initial data sequence number is 1 and each segment contains 4 bytes of data. Give a reasonable data sequence mapping on these three subflows. You may make up your own TCP subflow sequence numbers as long as they are consistent. Just consider the data transfer phase without showing connection or termination. (We are only looking for sequence numbers carried in data packets – no need to show ack numbers.)