# CSCI-UA.0480-009 2018 midterm (47 points)

October 17, 2021

## Instructions

1. Write your name and N number on top.
2. Provide concise and clear explanations for all your answers.
3. Use the other side of each sheet if you need more space. If you need even more space, ask us for additional sheets.
4. Some useful conversions: 1 Gbit = $10^9$ bits, 1 Mbit = $10^6$ bits, 1 kbit = $10^3$ bits
5. Questions are roughly in order of the lectures.
6. You should have 9 pages with questions.

1. (3 points) What are the units of throughput, queueing delay, window size, capacity, RTT, and Bandwidth-Delay Product?

2. (3 points) What are the 5 layers of the Internet stack? What is each responsible for?

3. (2 points) How does the idea of layering achieve the Internet's goal of generality?

4. (3 points) Recall assignment 1 where you had to implement a relay that replaced bad words in a string that was being sent from the sender to the receiver. The service provided by the relay, which is malware detection and removal, is commonly provided today by devices called middleboxes. Middleboxes are deployed inside the networks of companies to keep the employees' desktops and laptops free from malware. Do you think the presence of these middleboxes violates the end-to-end principle? Why or why not?

5. (2 points) Unlike circuit switching, why does packet switching need end hosts to insert the destination address into the packet header?

6. (2 points) How do private IP addresses solve the problem of exhaustion of IP addresses?

7. (4 points) If you were given the task to choose either between TCP or UDP for four applications (video conferencing, file downloads, instant messaging, and live video streaming), what would you choose and why?

8. (2 points) Give two examples of failure conditions that a reliable transport protocol like the sliding-window or stop-and-wait protocol is designed to handle.

9. (2 points) Give two examples of failure conditions that a reliable transport protocol like the sliding-window or stop-and-wait protocol is NOT designed to handle.

10. (2 points) What are the benefits/drawbacks of using a larger/smaller $\alpha$ in the computation of the mean RTT in TCP's retransmission timer?

11. (2 points) Why does TCP use an adaptive algorithm to compute a retransmission timeout (i.e., the rtt_mean + 4.rtt_var algorithm)? What would be the drawback of using a fixed retransmission timeout?

12. (3 points) Let's say you were running TCP on a network where there were no losses whatsoever because the queues could grow infinitely large. Let's assume you were using the TCP congestion control algorithm (Slow Start + Congestion Avoidance) for dynamically adjusting your window on this network. Would your window ever decrease in size? Why or why not?

13. (4 points) What is the queueing delay (i.e., the round-trip time minus the minimum round-trip time) when a sliding window sender's window size exceeds the network's bandwidth-delay product? Express your answer in terms of the window size $W$, the connection's bottleneck bandwidth $C$, and minimum round-trip time along the path $RTT_{min}$, and justify your answer.

14. (1 point) What is the queueing delay in the previous question if the window size is below the bandwidth-delay product?

15. (3 points) The Internet is often known for "triangle inequality" violations, where the path from host A to host B on the Internet has longer latency than the sum of the latency from host A to host C and the latency from host C to host B. In other words, $Latency_{AC} + Latency_{CB} < Latency_{AB}$. Here latency between two points P1 and P2 (i.e., $Latency_{P1P2}$) is the sum of the transmission delay and the propagation delay from P1 to P2. Notably, latency here does not include queueing delay.
    Give one plausible reason for these triangle inequality violations by providing a network topology/graph that explains this violation. The nodes in this topology should be autonomous systems or domains, and you should clearly indicate which domain hosts A, B, and C belong to. Hint: You should think in terms of how inter-domain routing's goals might be different from a user's goals.

16. (3 points) Explain the two kinds of relationships between domains that are relevant to Internet inter-domain routing.

17. (3 points) Recall that BGP has two variants: external BGP and internal BGP. What purpose do each of these two variants serve in the context of inter-domain routing?

18. (3 points) What are the two planes (or classes of functionality) implemented by routers within a network? In response to what kinds of events does each plane get executed?