CMPE 150/L – Introduction to Computer Networks – Winter16
Midterm Exam

November 10, 2015

Name :

Student ID :

E-mail :

- Duration: 100 minutes.
- Closed book, closed notes.
- 10 multi-item questions.
- Total of 100 points.
- Read all questions carefully before you start.
- Explain all your answers.
- Budget your time.

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Total	

Question 1 Voice-over-IP (VoIP) applications provide voice services over the Internet. They offer an alternative to "traditional" phone services which use traditional telephone network technology, also known as Plain Old Telephone Service (POTS). **(6 points)**

(a) Can VoIP services guarantee the same quality of service throughout the duration of the call? Explain.

(b) How about calls that use POTS technology?

Question 2 Network performance **(14 points)**

(a) In class, we discussed a number of factors that contribute to network latency. List them and explain what they measure. (2 points)

(b) How do you calculate the *bandwidth-delay product* of a communication channel? What is the unit used to express the *bandwidth-delay product*? (2 points)

(c) Why is the *bandwidth-delay product* an important metric to understand the performance of networks and their protocols? (2 points)

(d) Throughput is one of the metrics of network performance we covered in class. How is average throughput defined? (2 points)

(e) What is "bottleneck link"? (2 points)

(f) Suppose that Alice connects to her institutional network through a 100Mbps link. But the link that connects her institution to the Internet is 10Mbps. What is the average throughput of Alice's connection to the Internet assuming she is the only one connecting to the Internet from her institution? Explain. (2 points)

(g) Same scenario as above but now Alice and 19 other users from her institution are connected simultaneously. What is Alice's connection average throughput assuming each user gets a fair share of the networks capacity? Explain. (2 points)

Question 3 In class, we discussed three different locations for Web caches, namely: (1) on the user's host, (2) on the user's institutional network, and (3) on the content provider's network. Explain how each of these caches operate and how they improve performance. **(9 points)**

Question 4 The 2016 Summer Olympics will take place in Rio de Janeiro, Brazil. Your company was hired to help get the country's network ready for the event. In order to broadcast the games to the whole world, a low-earth orbit (LEO) satellite constellation will be employed. The LEO satellites orbit the earth at an altitude of around 12,000km and transmit at 10Mbps. **(11 points)**

(a) What is the propagation delay between the source broadcasting the games in Rio and a ground station in the US considering that the propagation speed is $24 * 10^7$m/s? Show your work. (2 points)

(b) Assuming that an ARQ protocol is being used for reliability, what is the channel utilization if Stop-and-Wait is employed with 10Kbit segment size (assuming no losses)? Show your work. (3 points)

(c) What would be the network utilization if a pipelined protocol with a window of 10 were used instead? Show your work. (2 points)

(d) For the scenario in (b), how many sequence numbers are needed? And for the scenario in (c)? Explain. (4 points)

Question 5 Part of the proceeds from the 2016 Olympics will be used to help interconnect villages in remote parts of Brazil to the Internet. The project will interconnect the village's community center, school, local bank, etc. using a 100Mbps local area network (LAN). However, there will only be enough funds to get each village connected to the Internet through a 10Mbps link.

Assume that the delay to retrieve an object from the Internet is on average 2.5s, while the delay to get an object of similar size residing in the LAN is 15ms. You were hired to propose a way to improve the average response time. So you decide to install a Web cache in the village's network whose miss ratio is 40%. Assume that the time to transmit an object is negligible.**(8 points)**

(a) What is the average response time to get a page from the Web assuming that on average, Web pages consist of the main page plus 4 embedded objects? Assume non-persistent HTTP is used. Show your work.

(b) Same as above using persistent HTTP.

Question 6 Under the program described in Question 5 above, each remote village in Brazil will have its own DNS domain using the format: $VillageName.br$. Each village will also have its own DNS local name server. **(6 points)**

(a) Suppose that a user logged to *host1* in a village called Tucano (*tucano.br*) is issuing a request for an object from *www.pbs.org*. Show the sequence of steps to resolve the Web's server name before the request can be issued. Assume name resolution is done recursively.

(b) Subsequently, another user from the same village requests an object from *www.fordfoundation.org*. Assuming that information about the .org name server was cached by the local DNS name server, show the sequence of steps to resolve *www.fordfoundation.org*.

Question 7 Suppose that a sender is using an ARQ protocol with a 8-segment window to transfer data reliably to a receiver. **(20 points)**

(a) Does this protocol use pipelining? Explain. (2 points)

(b) How many sequence numbers are needed in this protocol? How many bits are needed to represent them? Explain. (2 points)

(c) The sender sends segments 0 to 4. Then the application generates additional data. Can the sender send additional segments without receiving acknowledgments for segments 0 to 4? If so, why and which segments? If not, why not? (3 points)

(d) Later, the sender sends segments 10 to 17 (having received acknowledgments for all previously sent segments). The receiver gets segments 10, 11, 12, 13, 16, 17 and generates acknowledgments for the received segments. The sender then receives the acknowledgments generated by the receiver. Assume segments that were not received were lost. Draw the time diagram for this scenario if Go-Back-N ARQ is used. Which segment(s) will be retransmitted by the sender, if any? Explain. (3 points)

(f) Suppose the same situation as above but sender and receiver use Selective-Repeat ARQ. Draw the time diagram for this case. Which segment(s) will be retransmitted, if any? Explain. (3 points)

(g) Can cumulative ACKs be used in (d)? And in (f)? Explain. (4 points)

(h) Describe the additional function(s) the Selective-Repeat ARQ receiver has to perform when compared to the Go-Back-N receiver. Explain. (3 points)

Question 8 UDP **(6 points)**

(a) If a network application is using UDP as its transport protocol, does it need to establish a connection to the receiver before sending data? Explain. (2 points)

(b) UDP does not guarantee reliable data delivery. However, UDP may carry an optional checksum in its header. How does UDP use its checksum? Describe what takes place both at the UDP sender and UDP receiver. (4 points)

Question 9 TCP connection management **(10 points)**

(a) Describe the mechanism TCP uses to establish a connection between two communicating end points. Use a time diagram to explain your answer. (3 points)

(b) In a network where the latency between two communicating endpoints is 90ms, how long does it take before the two endpoints can send data over a TCP connection? Explain. (2 points)

(c) TCP also has a mechanism to tear down a connection. Why is tearing down connections important? (2 points)

(d) In TCP, connections can be closed "asynchronously". Use a time diagram to explain how that is accomplished. (3 points)

Question 10 TCP error control **(10 points)**

(a) In class we covered five (5) mechanisms TCP uses in order to provide reliable data delivery. List these mechanisms and explain their role in TCP's error control. (5 points)

(b) TCP's RTT estimation uses an exponentially moving average using the parameter α as its "smoothing factor" as follows:

$$SRTT = (1 - \alpha) * SRTT + \alpha * RTT \tag{1}$$

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where $SRTT$ is TCP's current RTT estimate (or "smooth" RTT) and RTT is the current RTT measurement. Why do you think TCP uses a "smooth" RTT instead of the actual RTT values it measures? (3 points)

(c) The parameter α is a number between 0 and 1. In a network where conditions do not change very often, should α's value be set close to 1 or to 0? Explain. (2 points)