CS305: Computer Networking
2024 Fall Semester Written Assignment # 1

Due: Oct. 28th, 2024, please submit through Blackboard

Please answer questions in English. Using any other language will lead to a zero point.

Q 1. List the five layers of the Internet protocol stack. For each layer, offer a concise explanation of less than 3 sentences of its function, and give an example of a protocol or specific networking technology of that layer.

Q 2. List the different types of delays in a packet-switching network.

Q 3. For the following pairs of technical terms, provide a definition for each and explain the primary differences between them. Your response should be clear and succinct. Should you be uncertain about your definitions, you may support them with relevant examples.

(a) "Circuit-switching" and "packet-switching"

(b) "Client-server" and "peer-to-peer"

(c) "Positive ACK" and "negative ACK"

Q 4. Suppose a lunar rover on the moon capturing a 2 MB "selfie" and sending this image back to its parent robot on Earth. This transmission occurs over an error-free direct link with a data transfer rate of $R = 4$Mbps.

(a) Determine the time required to transmit this file, given its size L (in bits), using the formula $t_{\text{trans}} = L/R$. Remember that 1 MB $= 2^{20}$ bytes, and that 1 Mbps $= 10^6$ bits per second. Provide detailed calculations.

(b) Given that the Moon is roughly 385,000 kilometers away from Earth, determine the arrival time of the first bit of a photograph. Use the formula for propagation delay, $t_{\text{prop}} = \frac{\text{distance}}{\text{speed}}$, and remember that the speed of light is approximately 3 x 10^8 meters per second. Provide detailed calculations.

Q 5. Two endpoints in a voice-over IP session are connected by a path of 4 routers. All links are running at 1Mb/s and the hosts are separated by 3000km. All packets are of size 1500 bytes. Assume the bit propagation speed is 2×10^8m/s. Note that 1KB of data is 1024 bytes, but 1Mb/s is 10^6bits/s.

(a) What is the minimum round trip time (RTT), assuming there is no queueing delay and assuming processing time at each host is negligible?

(b) For this part only let us assume that one router on the path has a steady queue occupancy of 5 packets. What is the end-to-end delay (one way, not round trip) in this case?

(c) Now let us assume the maximum queue occupancy for *every* router queues is 5 packets. What is the maximum end-to-end delay?

(d) For part (c), how long should the playback buffer be at the destination voice-over IP client if each packet arrives successfully, without being dropped? Express your answer in bytes.

Q 6. A user in Chicago accesses the Internet with a 100 Mb/s (b=bits) connection and downloads a webpage (base html file) of 250 KB (B=bytes) from a server based in London. The webpage includes three images, each 500 KB. Assume a one-way propagation delay of 75 ms and that the bandwidth bottleneck is the user's access link. Estimate the time required for the entire webpage, including the images, to be displayed on the user's screen, under the assumption of non-persistent HTTP with one connection at a time (neglect queuing and transmission delays on other network links).

Additionally, calculate the time taken if persistent HTTP is utilized with a single connection.

Q 7. What are the key components of an email system? Explain each component with an example.

Q 8. The questions below are related to DNS: (i) Explain in a few sentences how caching functions within the DNS system. You do not need to explain the entire DNS process. Also, consider whether the data retrieved from a DNS cache is always current. (ii) Define a recursive name query. (iii) Define an iterative name query.

Q 9. Suppose you click on a link in your Web browser to load a webpage located on server S_0. Although the webpage (base html file) is small, it contains four objects hosted on servers S_1, S_2, S_3 and S_4. Each of these objects is 1000 bits in size. Assume each TCP connection from your device has a throughput of 10000 bits per second. Let RTT_i represent the round-trip time between your local device and server S_i. How long will it take from the moment you click the link until you receive all the objects? For this question, assume (i) all IP addresses are already cached on your local device, eliminating the need for DNS lookups, and (ii) your browser does not use persistent connections or parallel connections.