CS 655: Computer Networks
Fall 2020

Sample Midterm Examination

<u>NAME:</u>

Please write clearly and neatly. Be precise in your answers – do not just re-iterate what you know about the topic. Clearly state any assumptions you make. The exam has 4 questions over 5 pages. Answer all questions.

Problem 1 (Error Control)

A 3000-km long, 1 Mbps link is used to transmit 1000-bit data packets using the *Selective Repeat* protocol. If the speed of light in this link is 2×10^5 km/second, what is the minimum number of bits the sequence numbers should be? Assume no flow control, and negligible transmission and processing times for acknowledgments. Take 1M = 1000,000.

NAME:

Problem 2 (Protocol Specification)

Consider a scenario in which Host A and Host B want to send messages to Host C. A, B, and C are connected by a ***perfect broadcast*** channel (that is, any message sent will be received by the ***other two*** entities correctly; the channel will ***not*** corrupt, lose, or re-order packets). Also, assume that any message sent will be received by the other two entities at the same exact time. The transport layer at Host C should alternate in delivering messages from A and B to the layer above; that is, it should first deliver the data from a packet from A, then the data from a packet from B, and so on. Host A should first get data from the layer above before it sends a packet to C, then B gets data from the layer above before it sends a packet to C, and so on.

Draw a FSM specification for this protocol (one FSM for A, one for B, and one for C). (*Hint:* The FSM for B should be essentially the same as for A.) You should define and use events and actions, including:

- **rdt_send**(data): call from above to send a data message.
- **udt_send**(packet = <data, src=A, dest=C, …>): your protocol sends a packet containing the data message, source A, destination C, and any other packet header fields that you may need for your protocol to work correctly.
- **udt_rcv**(packet): your protocol receives a packet from the channel.
- **extract**(packet, data): function to extract data from the packet structure and deliver data to layer above your protocol.

Your protocol does ***not*** have to use ACK messages. Make sure you indicate the initial state for each entity's FSM.

NAME:

Problem 3 (HTTP Performance)

Consider the performance of persistent HTTP. Suppose a web client wants to download a base html page of size O = 100K bits from a web server. This base html page contains ten embedded objects (img01.jpg, img02.jpg, … , img10.jpg) of the same size O = 100K bits each. All ten embedded objects reside on the same web server. The (minimum) round-trip *propagation* delay RTP = 300 msec, and the channel rate R = 100 Mbps.

Assume the client uses persistent HTTP (HTTP 1.1) with pipelining to retrieve the ten embedded objects, how long is the *response time*—the time it takes to receive the base page and its ten embedded objects from the web server? In answering this question, assume error-free transmission. Be sure to consider TCP connection establishment (1 RTP) and the data transmission delay for the base file and the embedded objects. Ignore header / control bits. To support your answer, show all steps of your calculations along with associated expressions in terms of O, R, and RTP. Take 1M = 1000,000.

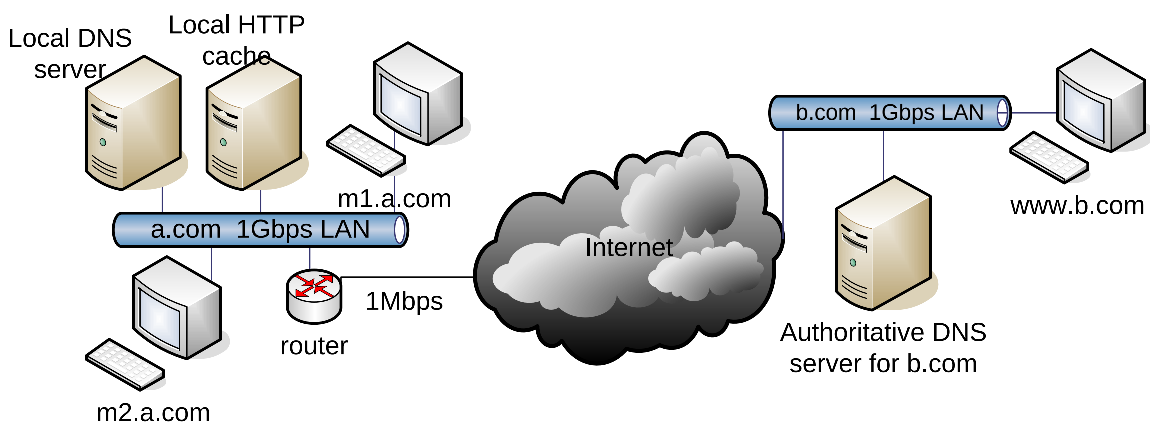
.

NAME:

Problem 4 (Caching)

Consider a 1 Gbps local-area network (LAN) "a.com", with a local HTTP cache and a local DNS server, connected to the Internet through an access (bottleneck) link of 1Mbps. Suppose that there are two user machines, m1.a.com and m2.a.com, in the network a.com. Suppose the user at m1.a.com types in the URL www.b.com/bigfile.htm into a browser to retrieve a large file of 1G bits (1000M bits) from another 1Gbps LAN "b.com" on the Internet. See figure below.

(a) Assume that every HTTP request by m1.a.com is first directed to the HTTP cache in a.com, and that the cache is initially empty. Assume that the local DNS server already has a mapping of www.b.com to its IP address. Also, assume that a local machine knows the IP addresses of both the local HTTP cache and the local DNS server.



How long does it take from the point that the URL is entered into the browser at m1.a.com until the file is completely received? Briefly explain how you arrived at your answer. In answering this question, you can assume the following:

- The packets containing DNS commands and HTTP commands such as GET are very small compared to the size of the file. Therefore, their transmission times (but not their propagation times) can be neglected.
- Propagation delays within the same LAN are small enough to be ignored.
- The *one-way* propagation delay from/to anywhere in a.com to/from any other site in the Internet (including b.com) is 500 msec.
- Ignore processing delays.

Make sure to include delays due to TCP connection establishment, but ignore other TCP details. (*Hint:* consider that transmission delay over a path is dictated by the bottleneck link.)

NAME:

Problem 4 (Caching continued)

(b) Now assume that machine m2.a.com makes a request to the same URL that m1.a.com requested. Consider now that the file is cached and will be directly served from the HTTP cache. What is the response time in this case?

(c) If the local DNS server does *not* have a mapping of www.b.com to its IP address, how much does this mapping resolution add to the response time? Assume that to resolve a non-local hostname, the local DNS server first queries a Root DNS server, which knows how to reach the .com DNS server. Also assume all DNS requests are processed iteratively.