

Questions for Week1

General Probability Questions (these questions will test your basic probability skills. The exam will not have such questions, however you will see questions where similar concepts can be applied for networking related problems)

- 1) If there are N students taking COMP 3331/9331, what is the probability that none of them has a birthday on the first day of the class? (Assume there are exactly 365 days in a year)
- 2) How many students would there need to be in the class for the probability in (1) to be less than 50%?
- 3) What is the probability that five years running, no student has a birthday on the first day of the class? (Assume the same number of students take the class each year, and no one repeats the class.)
- 4) Would your answer to (3) above be larger or smaller if one or more students retook the class within the five-year period?

Networking Questions

In statistical multiplexing, data from multiple users (senders) is sent over a link. If one user does not use its share of the bandwidth, it is then free to be used by other users. Thus, senders share the link bandwidth, with no user having all of the link bandwidth allocated to it.

Q1) What is meant by the term **statistical multiplexing**?

Q2) Consider two hosts, A and B, connected by a single link of rate R bps. Suppose that the two hosts are separated by m meters, and suppose the propagation speed along the link is s meters/sec. Host A is to send a packet of size L bits to Host B.

- (a) Express the propagation delay, d_{prop} in terms of m and s .
- (b) Determine the transmission time of the packet, d_{trans} in terms of L and R .
- (c) Ignoring the processing and queuing delays, obtain an expression for the end-to-end delay.
- (d) Suppose Host A begins to transmit the packet at time $t=0$. At time $t=d_{\text{trans}}$, where is the last bit of the packet?
- (e) Suppose d_{prop} is greater than d_{trans} . At time $t=d_{\text{trans}}$, where is the first bit of the packet?
- (f) Suppose d_{prop} is less than d_{trans} . At time $t=d_{\text{trans}}$, where is the first bit of the packet?

Q3) Suppose users share a 1Mbps link. Also suppose each user requires 100 kbps when transmitting, but each user transmits only 10 percent of the time.

(a) When circuit switching is used, how many users can be supported?

(b) Suppose packet switching is used for the rest of the problem. Find the probability that a given user is transmitting.

(c) Suppose there are 40 users. Find the probability that at any given time, exactly n users are transmitting simultaneously. (Note: You should simply express this as an expression rather than computing the exact probability value)

Q4) Suppose there is exactly one packet switch between a sending host and the receiving host. Assume that the transmission speed of the links between the sending host and the switch and the switch and the receiving host are R_1 and R_2 respectively. Assuming that the switch uses store-and-forward packet switching, what is the total end-to-end delay to send a packet of length L ? Ignore queuing, propagation and processing delays.

Q5) Review the car-caravan analogy in Section 1.4 of the textbook. Assume a propagation speed of 100 km/hr.

(a) Suppose the caravan travels 200km, beginning in front of one tollbooth, passing through a second tollbooth and finishing just before a third tollbooth. What is the end-to-end delay? (b) Repeat (a), now assuming that there are seven cars in the caravan instead of 10.

Note: The car-caravan analogy can be used to understand transmission and propagation delays. However, it cannot be used to determine the location of the bits inside a transmission medium, say a wire, unless you make an additional assumption. That's why the lecture notes use a different method to explain transmission and propagation delays. If you want to use the car-caravan analogy to determine the location of the bits, you will need to make an additional assumption that the cars are stretchable. I will let you think about it.

Q6) Consider sending a large file of F bits from Host A to Host B. There are two links (and one router) between A and B, and the links are uncongested (that is, no queuing delays). Host A segments the file into segments of S bits each and adds 40 bits of header to each segment, forming packets of $L = 40 + S$ bits. Each link has a transmission rate of R bps. Find the value of S that minimizes the delay of moving the file from Host to Host B. Disregard propagation delay.

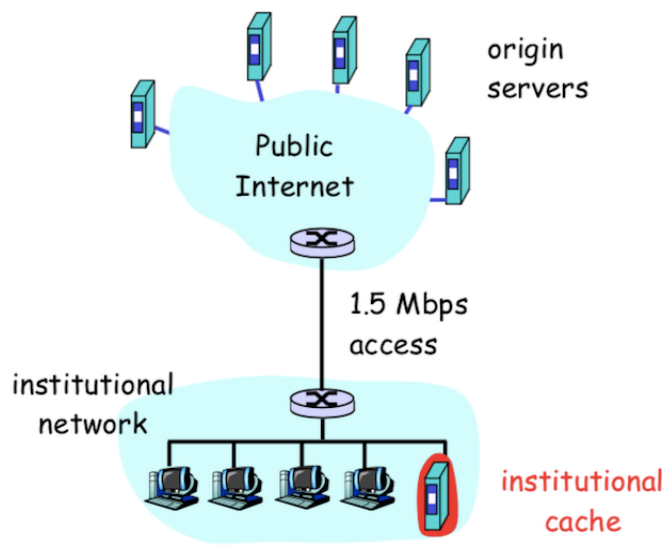
Q7) In this problem we consider sending real-time voice from Host A to Host B over a packet-switched network (VoIP). Host A converts analog voice to a digital 64kbps bit stream on the fly. Host A then groups the bits into 48-byte packets. There is one link between Host A and B; its transmission rate is 1 Mbps and its propagation delay is 2msec. As soon as Host A gathers a packet, it sends it to Host B. As soon as Host B receives an entire packet, it converts the packet's bits to an analog signal. How much time elapses from the time a bit is created (from the original analog signal at Host A) until the bit is decoded (as part of the analog signal at Host B)?

Q8) Suppose Alice and Bob are sending packets to each other over a computer network. Suppose Trudy positions herself in the network so that she can capture all packets sent by Alice and send

whatever she wants to Bob; she can also capture all packets sent by Bob and send whatever she wants to Alice. List some of the malicious things Trudy can do from this position.

Q9) Consider the queuing delay in a router buffer (preceding an outbound link). Suppose all packets are L bits, the transmission rate is R bps and that N packets simultaneously arrive at the buffer every LN/R seconds. Find the average queuing delay of a packet. You can assume that the buffer is empty before the arrival of the first batch of N packet.

Q10) Consider the figure below, for which there is an institutional network connected to the Internet. Suppose that the average object size is 900,000 bits and that the average request rate from the institution's browsers to the origin server is 1.5 requests per second. Also suppose that the amount of time it takes from when the router on the Internet side of the access link forwards a HTTP request until it receives the response is 2 seconds on average. Model the total average response time as the sum of the average access delay and the average Internet delay. For the average access delay, use $A/(1-AB)$ where A is the average time required to send an object over the access link and B is the arrival rate of objects to the access link. Note that the delay on the institutional LAN is to be neglected.



(a) Find the total average response time.

(b) Now suppose a cache is installed in the institutional LAN. Suppose the hit rate is 0.4. Find the total response time.

Q11) Suppose you needed to use HTTP to download a web page with three embedded images. Draw diagrams, similar to those from the lecture slides, depicting the main interactions between the client and server when using non-persistent HTTP, persistent HTTP without pipelining, and persistent HTTP with pipelining.

Q12) Multiple Choice Questions – Choose one from the possible choices:

A) In the lecture we solved a problem, which involved finding the total delay incurred in downloading objects assuming that the web cache hit ratio was 40%. Now assume that the cache hit rate is 50% (i.e. 50% of the requests are satisfied locally from the web cache). The rest of the parameters are the same as in that problem. The average delay to download the objects is:

- (i) between 1.2 and 1.3 seconds
- (ii) greater than two seconds
- (iii) between 1.0 and 1.1 seconds
- (iv) none of the above

B) Suppose a client sends an HTTP request message with the If-modified-since: header. Suppose the object in the server has not changed since the last time that client retrieved the object. Then the server will send a response message with the status code:

- (i) 304 Not Modified
- (ii) 404 Not Found
- (iii) 200 OK
- (iv) 403 Permission Denied

C) HTTP request and response messages are not humanly readable

- (i) True
- (ii) False