EECS 3214 Midterm Test
Winter 2017 - Solutions

1. (2 points) Most stock trades today are done by computerized agents rather than by human traders as in past decades. Stock price information has to be transmitted (you may have seen this information visualized as stock tickers on television) and this data is used by agents (computer or human) to make trades. What are the service requirements of stock price data transmission?

   Solution: The requirements are reliable transmission and very low delay so that data is not lost and reaches potential traders quickly.

   Note: computerized agents place many trades a second, so the delay requirements are more stringent than for human traders.

2. (2 points) Which layer(s) of the TCP/IP architecture would you put DNS in? Justify in 1 or 2 sentences.

   Solution: It uses UDP, so it should be in the application layer. One could argue that it is part of the network layer since it is used to determine IP addresses, but then the network layer should not use the transport layer.

3. (2 points) Think of the streaming video applications of today and the old stored video applications where the entire video would have to be transferred before could playback start. List the differences in the service requirements for these two transfer sessions.

   Solution: In streaming video applications, we need a low delay and a low jitter value for the experience to be good. For non-streaming stored video the latency should be low but the jitter is far less important. Consequently, for non-streaming one could afford to use reliable services to transfer the video file error-free and improve user experience. Also, the non-streaming app needs higher bandwidths than streaming video applications.

4. (2 points) How can DNS servers be used for aliasing of different servers that serve the same URL?

   Solution: DNS uses the CNAME type records to achieve aliasing. So when a record is entered with name = X, cname = Y and type = CNAME, then Y is a server that aliases for X.

5. (2 points) Why has digital telephony reduced costs compared to analog telephony? Consider only technical aspects, not business or marketing models.

   Solution: The primary reason is the higher utilization of link capacity in packet switching used by digital telephony as compared to the circuit switching of analog telephony. This implies that more subscribers can be added to a system in digital telephony as compared to analog telephony and consequently prices come down.

6. (2 points) How is the time-to-live (TTL) header field of TCP used to implement the traceroute service?

Solution: The TTL field determines how long a packet can exist in a network before it is dropped. This is cleverly used in implementing the traceroute service in the following way. The source node sends $3k$ packets to the destination, three with TTL=1, three with TTL=2 and so on up to three with TTL=k. The parameter k is chosen to be larger than the expected number of hops between the source and the destination. So for each $i, 1 \leq i \leq k$, three packets reach the ith router along the way (ignoring congestion) and are dropped there because the TTL of these three packets expired. Each drop results in an ICMP packet being sent from the router to the source and this ICMP packet contains the time at which the packet is dropped. The sender can reconstruct the route of the packets assuming all packets have followed the same route.

7. (a) (1 point) What is Little's law? Define the variables.

   Solution: Little's Law states that $L = \lambda W$ where L is the number of jobs in the system, λ is the average arrival rate of jobs and W is the average amount of time a customer spends in the system.

   (b) (4 points) Note that as long as the arrival rate is strictly smaller than the service rate, the actual arrival process has a big influence. For example if a server gets exactly 1 packet a second (not just at an average of 1 packet/sec) and the service time is 0.9 seconds, there is no delay in the system in addition to the 0.9 seconds. However, Little's law makes a statement without any reference to the nature of the arrival patterns other than the average rate. Explain this apparent contradiction.

   Solution: There is no contradiction here because both L and W are affected by the amount of variability in the arrival process. In the given scenario, the queue never grows to bigger than 1. The number of jobs in the system is 1 90% of the time and 0 the rest of the time. Similarly the average waiting time is 0.9 sec since each packet waits exactly 0.9 sec. In a more variable scenario, we can see that the probability of the system having more than one packet may be non-zero. This would increase both L and W. Little's Law simply says that irrespective of the variability in the arrival process, the ration of L to W is fixed, and equal to λ.

8. (3 points) Suppose a trunk router satisfies the requirements of a M/M/1 queue. That is, assume it has infinite buffer space and the incoming traffic is Poisson with a mean arrival rate λ and the packet processing times follow an exponential distribution with parameter $\mu = 1000$ pkts/sec. List the utilization and the expected number of packets in the buffer for $\lambda = 900, 990, 1000$ packets/second. What conclusions can be drawn from the above calculations?

   Solution: Recalling that utilization $\rho = \lambda/\mu$ and that the expected number of packets in the buffer is $P = \frac{\rho}{1-\rho}$, we get
   if $\lambda = 900$, then $\rho = 0.9$ and $P = 9$,
   if $\lambda = 990$, then $\rho = 0.99$ and $P = 99$, and
   if $\lambda = 1000$, then $\rho = 1$ and P is not defined.

   This shows that as λ goes up, the buffer occupancy grows and when $\lambda = \mu$, the number of packets in the buffer grows unbounded. Applying Little's Law we see that the delays go up as well when λ increases.

9. (1 point) We saw that in BitTorrent, peers optimistically unchoke other peers or choke other peers. If you change the optimistic unchoking period from 30 seconds to 15 seconds or 60 seconds, how would the performance of the system be affected?

   Solution: The optimistic unchoking is done to allow new users to be introduced into the system. If the unchoking period is decreased, new users can join the network faster. If it is increased, new users would have to wait longer before getting service. It is not easy to infer the change in metrics like throughput though. If a node already has very high quality peers its throughput may be adversely affected by aggressively unchoking new peers. On the other hand if it has low quality peers, there may be a good chance that throughput may go up by unchoking more aggressively.

10. (4 points) Describe the TCP connection teardown process on both the client and server sides.

    Solution: Given directly in the book.

11. (3 points) Describe the advantages and disadvantages of using (a) an email anonymizer site versus (b) using encrypted email. Include a scenario when (a) is useful and one when (b) is useful.

    Anonymizer sites work as follows: when A sends a mail to B using the site, B receives a mail with some sender address C (C and A are different). If B replies to that email, A gets the reply as usual.

    Solution: These two schemes have different benefits. If emails are encrypted (assuming that only the body of the message is encrypted), an adversary snooping on the network can record who is sending email to whom but not the contents of the emails. If an anonymizer is used the eavesdropper can record the emails but not the recipients of the emails.

    Further, the receiver of an anonymized email will not be able to identify the sender, whereas they will be able to identify the sender of an encrypted email, assuming that no spoofing was being carried out.

    An anonymizer is useful when the sender does not want to reveal their identity to the receiver, for example when responding to an online ad for a garage sale, and encrypted emails are used for sending sensitive information, for example in communicating with one's company co-workers from outside the enterprise network.

12. (4 points) Using a pictorial proof similar to that in the book, prove that a multiplicative-increase-additive-increase (MIAD) is unfair.

    Solution: Similar to the picture drawn in class. Note that unless the nodes start at equal bandwidths, one of them (the node that started having the higher capacity) will get the entire capacity in the long run.

13. (2 points) We saw that the multiplicative decrease step in the AIMD scheme cuts the window size by half upon encountering congestion. What impact would changing the fraction from 0.5 to 0.75 or 0.25 have on the system?

    Solution: Note that there is a difference between cutting "to half" and "by half". The "teeth" in the sawtooth shaped curve will become finer if the window sized is cut by 0.25

($\beta = 0.75$) and coarser if it is cut by 0.75 ($\beta = 0.25$). When the teeth become finer, the fluctuations in bandwidth is lower and consequently the ave bandwidth is higher. However the number of times the window is cut is also higher, and the system converges towards fair shares slower.

14. (6 points) Suppose you need to implement a distributed data backup system over a P2P network. Each user encrypts their files and stores it at other peers. You may assume that the P2P system has no other function.

    (a) (2 points) Discuss the advantages and disadvantages of using structured versus unstructured overlays. For structured overlays you can restrict your attention to distributed hash tables.

    Solution: The advantage of a structured overlay is that searching and communication are easier. The disadvantages are the higher complexity of the system and the more involved steps in nodes joining and leaving the network. Unstructured overlays are simpler and make it very easy for nodes to join and leave but searches are more expensive and often there is no guarantee that an existing resource (in this case a fragment of a file) can be found.

    (b) (2 points) How would a peer select recipients for its encrypted files? That is what are good criteria to use in this choice?

    Solution: Good criteria include geographical distance, fraction of time a node is available for downloading a file fragment, and available capacity for accepting and serving files.

    (c) (2 points) Propose a scheme similar to optimistic unchoking in Bittorrent to make it easy for newcomers to join this system.

    Solution: Care must be taken to ensure that the number of copies of a file does not keep increasing over time, otherwise resources are wasted. The analogy of unchoking bittorrent peers is that a node allows a new node to exchange files with it. One way to achieve this is that every 60 minutes (say) a new peer is asked whether it will accept packets. If it agrees a peer currently in the system gives it some encrypted fragments and perhaps agrees to take its fragments as well. If the existing peer has no available fragments to send, it can either skip the unchoking step or invalidate fragments it sent to some other peer.