Network Systems (201600146/201600197), Test 1

February 28, 2020, 13:45–15:45

- This is an open-book exam: you are allowed to use the on-line book by Peterson & Davie and the reader that belongs to this module, and the handout about peer-to-peer communication (i.e., the part of the Kurose&Ross book distributed via Canvas). Furthermore, use of a dictionary is allowed. Use of a simple (non-graphical) calculator is allowed.
- For accessing the on-line books, use of the UT-provided Chromebook is allowed.
- Other written materials, and laptops, tablets, graphical calculators, mobile phones, etc., are not allowed. ***Please remove any such material and equipment from your desk, now!***
- Visiting the toilet without explicit permission of the supervisor is not allowed. During the last 30 minutes of the exam, no toilet visits are allowed.
- Write your answers to open questions on this paper, in the provided boxes, and hand this in.
- Questions marked with (MC) must be answered on the separate multiple-choice form, at the number indicated in the circle.
- Total number of pages: 9.
- Total number of points: 45.

Your name:

(please underline your family name (i.e., the name on your student card), so that we know how to sort)

Your student number:

Continued on next page...

1. P2P Systems

1 pt (a) Which of the following statements about the immediate successor in a Distributed Hash Table (DHT) is generally true?
1: the IP address of the immediate successor is higher than the IP address of the current node;
2: the successor is geographically close to the current node.

MC**01**
A. none
B. only 1 is true
C. only 2 is true
D. both 1 and 2 are true

Assume a circular DHT with 6 peers, which are assigned the following integers between 0 and 2^4: 2, 5, 6, 9, 11, 15. Further assume that each peer only knows its closest successor. The circular DHT stores (key, value) pairs on peers that have been assigned the closest successor to the hash of the key.

1 pt (b) Suppose the peer with integer 9 is looking for the value of a key that hashes to the integer 3. How many peers need to be contacted before the peer that stores the value belonging to 3 can return it to the requesting peer?

MC**02**
A. 1
B. 2
C. 3
D. 4
E. 5
F. 6
G. The correct peer cannot be found in this situation.

Now assume some shortcuts have been added to the circular DHT described above: ($5 \rightarrow 11$), ($9 \rightarrow 15$), ($15 \rightarrow 5$), i.e., 5 als knows 11, 9 also knows 15, and 15 also knows 5.

1 pt (c) Suppose again that the peer with integer 9 is looking for the value of a key that hashes to the integer 3. How many peers need to be contacted before the peer that stores the value belonging to 3 can return it to the requesting peer?

MC**03**
A. 1
B. 2
C. 3
D. 4
E. 5
F. 6
G. The correct peer cannot be found in this situation.

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2. Application protocols

1 pt (a) How do received e-mails typically end up in a user's mail program?

MC**04**
A. A mail server delivers them to the user's computer using SMTP.
B. A mail server delivers them to the user's computer using IMAP.
C. The user's mail program fetches them from a server using SMTP.
D. The user's mail program fetches them from a server using IMAP.
E. The server encodes the mail using base64, and MIME is used for transfer.
F. The user's program fetches the mail using base64, and decodes the MIME headers.

1 pt (b) Why is base64 encoding used for e-mail attachments like pictures?

MC**05**
A. To compress pictures into fewer bits.
B. Because each pixel of a picture needs 64 bits.
C. To detect or correct errors using added redundancy.
D. Because SMTP by itself cannot handle all possible byte values.

1 pt (c) How is HTTP/1.1 faster than HTTP/1.0 ?

MC**06**

A. It compresses data.
B. It uses error-correcting coding.
C. It reduces the number of RTTs needed.
D. It supports content-delivery networks (CDNs).
E. It moves part of the processing from the server to the browser.

1 pt (d) How is HTTP/2 faster than HTTP/1.1 ?

MC**07**

A. It compresses data.
B. It uses error-correcting coding.
C. It reduces the number of RTTs needed.
D. It supports content-delivery networks (CDNs).
E. It moves part of the processing from the server to the browser.

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3. Reliable communication performance to and from the cruise ship "Zilverling"

Due to the spreading of a virus, some cruise ships with contaminated passengers on board are not allowed to harbor anywhere in Asia. For that reason also the luxurious "Zilverling" ship is not able to harbour. On board are 1000 passengers and crew, desperate to post pictures and movies regarding their current state to their Snagchat account. Unfortunately, the only way the Zilverling is connected to the Snagchat server is through a satellite link with a 10 Mbit/s data rate. The distance from the Zilverling to the satellite and the distance from the satellite to the server are both 37 500 km, and signals travel at 300 000 km/s. The communication system used sends information in packets of 125 bytes.

1.5 pt (a) What is the propagation delay when sending a packet from the Zilverling to the Snagchat server via the satellite?

1.5 pt (b) What is the transmission delay when sending a packet from the Zilverling to the server via the satellite?

2 pt (c) Give the one-way bandwidth-delay product for the link from the Zilverling to the server via the satellite?

In order to make sure that data is delivered reliably at the servers, a scheme for reliable transmission has to be used between the Zilverling and the Snagchat server. Initially, a stop-and-wait algorithm is used to transmit data reliably.

2 pt (d) Give the maximum possible throughput of the link from the Zilverling to the server via the satellite. In your calculations, you may neglect the transmission time due to overhead of header fields and ACK packets.

Because of the poor performance of the above algorithm, the engineer of the ship (who only has a degree in engine maintenance) slightly rewrites the software of the reliable transmission algorithm, such that the transmit side of the algorithm is allowed to send one extra packet before the current one is acknowledged. Thus, the transmitter can at any moment in time have two unacknowledged packets outstanding. The engineer does not see a need to adapt the field used for sequence numbering, which is still one bit.

3 pt (e) For the ″improved″ algorithm sketched above, give in a time-sequence diagram a possible sequence of events in which data is delivered to the upper protocol incorrectly (e.g., a packet is delivered in wrong order, double or not at all).

Apart from the erroneous behaviour identified in the previous question, the performance improvement of the ″improved″ algorithm is rather limited. So the engineer embarks on a challenge to further improve the performance of the reliable transmission algorithm. He does so by implementing a sliding window protocol. In his implementation he chooses to keep the receive window size (RWS) equal to 1.

2 pt (f) What should be the minimum send window size (SWS) for the system to fully utilise the link?.

1 pt (g) How many different sequence numbers should be available for correct operation of this algorithm?

1 pt (h) What is the disadvantage of the choice to keep RWS=1, compared to choosing a higher value for RWS?

MC08

A. Packets cannot overtake each other.
B. If packets overtake each other, the algorithm will suffer from not corrected losses
C. Additional retransmissions are done if an entire window of packets is lost.
D. Additional retransmissions are done if a single packet is lost
E. The satellite might not be visible for the receiver through the receive window, causing additional packet loss.

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4. Virus diagnosis information

Because of a virus outbreak, all inhabitants of a town need to be tested, and the results sent to the capital city. The outcome of each test can be either '`healthy`', '`fever`', '`infected`', or '`ill`', with the following probabilities:

`healthy`	70%	`fever`	15%	`infected`	10%	`ill`	5%

2 pt (a) Down to how few bits (on average) can each message (test outcome) be compressed? Show your calculation.

1 pt (b) Suppose there was a fifth possible test outcome, '`asleep`', which occurs with 0% probability. What influence would this have on the required average number of bits per message?

MC09

A. Fewer bits are needed, as messages with 0% probability save information.
B. No change, since this message never needs to be transmitted.
C. Between 0 and 1 bit more, since the probability of this extra message is less than 20%.
D. One more bit is needed, as we exceed the four possibilities that fit in two bits.

1 pt (c) In reality, consecutive people to be tested are not independent, e.g. two consecutive people may be family members, so if the first is infected, the probabilty that the second is also infected is larger, and vice versa. What influence does this have on the number of bits required if optimal source coding is used?

MC10

A. Fewer bits are needed, as there is less unpredictability in the data.
B. Fewer bits are needed, as we don't need to send the information of the second person.
C. None, since optimal coding treats each message independently.
D. None, since the overall probabilities are still the same.
E. More bits are needed, as the unlikely '`ill`' message becomes more likely.
F. More bits are needed, as the lack of independence means there's more information in the data.

3 pt

(d) The table below proposes five codes for encoding the messages. Which of them can be made suitable for encoding the messages into **at most 1.5 bits** per message on average? Answer this question by selecting, for each of the proposed message encodings, a suitable codeword for the `ill` message from the following multiple-choice options; if more than one answer is suitable, choose the first suitable one:

A. 1 B. 01 C. 11 D. 000 E. 111 F. send nothing G. no suitable choice is possible

message	probability	code	code	code	code	code
`healthy`	70%	0	0	1	10	001
`fever`	15%	10	1	001	01	010
`infected`	10%	110	00	01	00	1
`ill`	5%	MC11	MC12	MC13	MC14	MC15

1 pt

(e) The previous question was about:

MC16

A. error coding
B. source coding
C. channel coding
D. error and source coding
E. error and channel coding
F. source and channel coding

2 pt

(f) In order not to break the town's quarantine, the data is transported over a wireless link. Assume this link has a signal bandwidth of 10^5 Hz, and a signal-to-noise ratio of 3. Assuming optimal coding, how many health test results can be sent over this channel per second with a negligible error probability? Show your calculation.

1 pt

(g) Besides the inhabitants of the town, also the passengers of a cruise ship are tested and their results encoded. Unfortunately, among these passengers there are far more '`ill`' cases, and fewer '`healthy`'. If we use an encoding optimized for the probabilities from the town, what is the consequence?

MC17

A. All information will be lost.
B. Some information will be lost, and fewer bits will be needed than expected.
C. Some information will be lost, and the number of bits needed is as expected.
D. Some information will be lost, and more bits will be needed than expected.
E. No information will be lost, and fewer bits will be needed than expected.
F. No information will be lost, and the number of bits needed is as expected.
G. No information will be lost, and more bits will be needed than expected.

1 pt (h) How do error-correcting codes work?

MC18

A. The sender sends each bit twice, the receiver chooses the correct one.
B. The receiver asks the transmitter to perform a retransmission when needed.
C. The sender retransmits data if no acknowledgement arrives.
D. The receiver does a long division to find the CRC (Correct eRror Code).
E. The receiver selects the valid codeword most similar to what is received.
F. The sender sends a valid codeword without redundancy.
G. Send and receive windows are chosen carefully to exclude errors.

2 pt (i) Given $C(x) = x^3 + x^1 + x^0$, calculate the CRC for the message 01110.

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5. Physical media and framing

1 pt (a) How does a glass fiber work?

MC19

A. Due to total internal reflection the light stays inside the core.
B. Due to total internal reflection the light stays inside the cladding.
C. Glass fiber must not be bent so light can travel in a straight line through it.
D. Most light is lost when the fiber is bent, but error-correcting codes make up for this.
E. Most light gets reflected to the source, but enough remains for a sensitive detector.
F. Most light gets absorbed in the cladding, but enough remains for a sensitive detector.

1 pt (b) Suppose we would make a glass fiber without cladding, and suspend it in the air instead. Would this still work properly?

MC20

A. Only if the glass does not contain any impurities.
B. Only if the glass is straight so light arrives at the other end.
C. Yes, because the air's index of reflection is lower than the glass's.
D. Yes, because the air's index of reflection is higher than the glass's.
E. No, because the air's index of reflection is lower than the glass's.
F. No, because the air's index of reflection is higher than the glass's.

1 pt (c) Radio waves can undergo multipath propagation. Which statement is true?

MC21

A. Multipath increases the bandwidth.
B. Multipath makes correct reception harder.
C. Multipath makes eavesdropping easier.
D. Multipath can be removed using diffraction.

1 pt (d) What is the purpose of bit stuffing?

MC22
A. Make sure cables do not get empty.
B. Make sure bits are all the same size.
C. Make sure bytes are all the same size.
D. Make sure the "flag" pattern cannot occur within a frame.
E. Make sure there is a "flag" at the end of each frame.
F. Prevent the "clock recovery" problem.
G. Prevent the "baseline wander" problem.

1 pt (e) Consider byte-oriented framing as used in PPP, where frames are separated by a single flag/"sentinel" byte, which is 01111110 in binary, 7E in hexadecimal notation. What would happen if a byte halfway the frame undergoes a bit error in the channel, changing it into 7E hexadecimal?

MC23
A. The frame would be received correctly.
B. The byte just after the 7E would be ignored.
C. The frame would be merged with the next frame.
D. The byte just before the 7E would be received twice.
E. The frame would be received as two smaller frames.
F. The first half of the frame would be dropped, leaving only the second half.
G. The frame would be received correctly, except that one byte would be missing.

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6. Sharing a medium

1 pt (a) Consider a CSMA/CD system, and let's change it such that once a node has successfully transmitted a packet, it is allowed to transmit 5 more packets while the others remain quiet. What consequence does this change have?

MC24
A. Efficiency worsens, and average waiting times increase.
B. Efficiency worsens, and average waiting times decrease.
C. Efficiency stays the same, and average waiting times increase.
D. Both efficiency and average waiting times stay the same.
E. Efficiency stays the same, and average waiting times decrease.
F. Efficiency improves, and average waiting times increase.
G. Efficiency improves, and average waiting times decrease.

1 pt (b) Consider a situation where there are many nodes, all of which have packets ready for transmission all of the time. They are all in radio range of each other. Which channel sharing technique would you recommend to optimize effiency?

MC25
A. ALOHA
B. CSMA/CD
C. CSMA/CA
D. Polling
E. TDMA

1 pt (c) Consider a sensor network with many battery-powered nodes, which occasionally want to transmit something to a base station. The base station can hear all nodes, but the nodes can't hear each other. Which channel sharing technique would you recommend to optimize the nodes' battery life (i.e., minimize the amount of time their radio receiver or transmitter must be on)?

MC26
A. ALOHA
B. CSMA/CD
C. CSMA/CA
D. Polling
E. TDMA

Consider a cable with 3 nodes, A, B, and C. Nodes A and C are at the two ends of the cable, and node B is in the middle, between them. The nodes use Carrier Sense Multiple Access (CSMA).

2 pt (d) Describe a scenario in a space-time diagram (analogue to Figure 5.12 in part 5 of the reader) where A and B both transmit a packet, and there is a collision which is noticed by B and C but not by A. Note: So, the answer to be given should be the space-time diagram.

End of this exam.