Network Systems (201600146/201600197), Test 1

February 16, 2018, 13:45–15:15

- This is an open-book exam: you are allowed to use the book by Peterson & Davie and the reader that belongs to this module. Furthermore, use of a dictionary is allowed. Use of a simple (non-graphical) calculator 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: 6.
- Total number of points: 33.

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. SpaceY's rocket link

SpaceY is a company making and launching rockets. Each rocket splits into several parts halfway during the flight, and all of those parts need to communicate with the flight control ground station using a radio channel. In order to safely land the rocket parts, message delays must have guaranteed upper bounds.

1 pt (a) Is it a good idea to use statistical multiplexing for this?

MC**01**

A. Yes, because it is very efficient, reducing the delays.
B. Yes, simply because there are no alternatives in case of a radio channel.
C. No, because statistical multiplexing may lead to large queueing delays.
D. No, because statistical multiplexing is not applicable for a radio channel.

From now on, we'll assume there's just one rocket, it's not split in parts. The SpaceY ground station needs to send 1000 commands per second to the rocket. The possible commands are as follows, with their frequency of occurrence.

`no change`	80%
`increase engine power`	9%
`decrease engine power`	9%
`self-destruct`	2%

3 pt (b) Down to how few bits (on average) per word can each message be compressed? Show your calculation.

1 pt (c) In reality, the messages are not completely independent; e.g., after a number of "increase power" messages, the engine is already at maximum power, and "increase power" messages will not be sent until there has been a "decrease power" message. What influence would this have on the amount of (Shannon) information per message?

MC**02**

A. It would be larger, since more is known about the messages.
B. It would be smaller, since the receiver learns less from the messages.
C. It would be the same, because overall the probabilities don't change.
D. For answering this, we need to know more about exactly how the dependence is.

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

A. 0 B. 1 C. 01 D. 11 E. 000 F. 100 G. no suitable choice is possible

message	probability	code	code	code	code	code
`no change`	80%	0	0	1	0	00
`increase power`	9%	1	10	01	101	01
`decrease power`	9%	00	11	001	110	10
`self-destruct`	2%	MC**03**	MC**04**	MC**05**	MC**06**	MC**07**

Suppose the radio channel to the rocket can transport 1100 bits/s, but has a bit error probability of 1%.

2 pt (e) Compute this channel's Shannon capacity.

1 pt (f) Can this channel be used for controlling the rocket?

MC**08**

A. Yes, and the message error probability can be made less than 10^{-6}.
B. Yes, but the message error probability cannot be made lower than 1%.
C. No, but it can be used if the "self-destruct" message never happens.
D. No, because the message error probability would be arbitrarily high.

1 pt (g) As we use increasingly good error-correcting codes to get closer to the Shannon limit, does the delay that the messages undergo change?

MC**09**

A. No, because the error probability becomes arbitrarily low.
B. No, because the propagation time only depends on the distance to the rocket.
C. Yes, because better error correcting codes need to process data in larger blocks.
D. Yes, because better error correcting codes transmit more bits on the channel per user message.

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2. Application protocols

SpaceY operates their own server(s) for e-mail.

1 pt (a) What server(s) are needed for a functional e-mail system?

MC**10**

A. Only an SMTP server is needed.
B. Only an IMAP server is needed.
C. Only a POP server is needed.
D. Both an SMTP server and either a POP or an IMAP server are needed.
E. Both an IMAP server and either a POP or an SMTP server are needed.
F. Both a POP server and either an IMAP or an SMTP server are needed.
G. All three (SMTP, IMAP and POP) are needed.

1 pt (b) As demonstrated in the lecture, SMTP servers can easily be used to send mails with forged addresses. If the administrator of SpaceY's SMTP server wants to install a filter to reduce the possibilities of abuse, while still allowing the normal e-mail flow, which of the following filters is a good one?

MC**11**

A. Reject all mail.
B. Accept only mails *from* SpaceY computers, reject all mail from other computers.
C. Accept only mails *to* SpaceY addresses, reject all mail to other addresses.
D. Accept only mails which come *from* SpaceY computers *and* are addressed *to* SpaceY addresses.
E. Accept only mails which are *from* SpaceY computers *or* addressed *to* SpaceY addresses (or both).
F. No filtering is possible, all mail must be accepted.

2 pt (c) SpaceY feels audacious and wants to be the first company to use a peer2peer architecture for e-mail, rather than client-server. Describe one difficulty they will encounter in doing so.

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3. Protocols and performance

Again consider SpaceY's radio link. They've upgraded the equipment, so it can now handle 1 Mbit/s of error-free bits, in both directions, even when the rocket is near the moon, 390 000 km away from earth. SpaceY uses packet switching, with 1 kilobyte packets, to download moon photographs taken by the rocket. The radio signals travel at the speed of light, 300 000 km/s.

2 pt (a) Compute the propagation time of a packet.

2 pt (b) Compute the transmission time of a packet.

2 pt (c) Suppose a sliding window protocol is used; what is the minimum Sending Window Size that will suffice to fully use the link? Explain.

1 pt (d) If SWS is chosen smaller than calculated in (c), what would happen?

MC12

A. Efficiency would suffer, but correctness would still be ok.
B. Efficiency would be the same, but correctness would suffer.
C. Both efficiency and correctness would suffer.
D. Neither efficiency nor correctness would suffer.

2 pt (e) How many bits should the sequence number have, at least, for this SWS, with RWS=SWS, assuming packets cannot overtake each other? Explain.

3 pt (f) Suppose we use a sliding-window protocol with RWS=2, SWS=2 and a sequence number space of 3 (that's the number of possible sequence numbers, not the number of bits), on a link where packets can be lost but cannot overtake each other. Sketch a time-sequence diagram in which data is delivered to the upper protocol incorrectly (e.g., a packet is delivered in wrong order, double or not at all).

Let's assume SpaceY uses standard HTTP to download the images from their rocket, and let's assume SWS and RWS have been chosen large enough to not be the limiting factor. Furthermore, the SpaceY ground station already knows the file names of the images.

1 pt (g) Which of the following HTTP/1.1 features save(s) download time in this situation?

MC13

A. Persistent connections.
B. Pipelining.
C. Both.
D. Neither.

1 pt (h) How would HTTP/1.0 with parallel connections compare to HTTP/1.1 (without parallel connections, but with both persistent connections and pipelining)?

MC14

A. Both are equally good.
B. HTTP/1.0 with parallel connections is faster.
C. HTTP/1.1 is faster.
D. Depends on the bandwidth delay product.

After downloading the images, SpaceY decides to use a peer2peer file distribution system to share the pictures with their fans all over the world.

It is known that the overall download time D for a file of size F is lower bounded as follows:

$$D \geq \max\left\{ \underbrace{\frac{F}{u_s}}_{A}, \underbrace{\frac{F}{d}}_{B}, \underbrace{\frac{F}{\frac{u_s}{n} + u}}_{C} \right\}.$$

where n is the number of peers, u_s is the server upload bandwidth, u is the peer upload bandwidth (assumed equal for all peers), and d the client download bandwidth (assumed equal for all peers).

1 pt (i) Which part of the formula represents the limit imposed by the combined uplink bandwidth of the server and the peers?

MC15

A. part A.
B. part B.
C. part C.
D. parts A and B.
E. parts A and C.
F. parts B and C.
G. all three parts.

2 pt (j) Suppose $u_s = 1$ Mbit/s, $u = 0.1$ Mbit/s, $d = 2$ Mbit/s, $F = 20$ Mbit and $n = 10$. Which of the following is a way to achieve the above lower bound?

MC16

A. Server sends the entire file at 0.1 Mbit/s to each peer; the peers do not send.
B. Server sends the entire file at 1 Mbit/s to peer 1, peer 1 sends it to peer 2, and so on.
C. Server sends one tenth of the entire file at 0.1 Mbit/s to each peer, each peer sends this to all other 9 peers.
D. Server sends half of the file at 0.1 Mbit/s to each peer, each peer sends this to one other peer.
E. Server sends one fifth of the file at 0.2 Mbit/s to each peer, each peer sends this to 4 other peers.
F. It is possible to achieve the lower bound, but not in one of the above ways.
G. It is not possible to achieve the lower bound in this case.

End of this exam.