Network Systems (201300179/201400431), Test 1

February 12, 2016, 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, and the handout about peer-to-peer communication (i.e., the part of the Kurose&Ross book distributed via Blackboard). 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!***
- Although the questions are stated in English, you may answer in English or Dutch, whichever you are more comfortable with.
- You should always explain or motivate your answers, with so much detail that the grader can judge whether you understand the material; so just saying "yes" or giving a formula without explanation is not enough.
- 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.

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1. Protocols and performance

Consider SMTP delivering e-mails over a transatlantic cable, with an RTT of 100 ms and a bandwidth of 100 Mbps. Assume for now that the underlying protocols do not use sliding windows or otherwise limit how many packets can be sent.

The SMTP protocol consists of a number of messages/command (`HELO`, etc.) sent to the server, to each of which the server responds.

3 pt (a) Assuming that the client cannot send the next message before it gets a response from the server to the previous one, how many RTTs does it take to transfer one 10 kB e-mail?

2 pt (b) Same question, but assuming that the client can send the next message before it gets a response from the server to the previous one.

2 pt (c) The protocol difference between the previous two questions corresponds to a difference between HTTP/1.0 and HTTP/1.1. Which difference?

Now let's move to another protocol layer, which is used by SMTP to enable reliable data transfer over this (unreliable) transatlantic cable

2 pt (d) Would this protocol layer be "above" or "below" the protocol layer in which SMTP belongs? Explain.

Let's assume this reliable data transfer is implemented using a sliding-window protocol, using 10-bit sequence numbers.

3 pt (e) Draw a time-sequence diagram showing how things can go wrong if SWS=1024 is used.
Of course, you don't need to draw a thousand packets; just draw a few and indicate which range of sequence numbers they have, with sufficient detail that it is clear what you mean.

3 pt (f) Assuming SWS is safely chosen as 1023, how large should the packets at least be to be able to fully utilize the link bandwidth? Explain.

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2. Information theory and error-correcting codes

The HTTP protocol has a number of response messages; let's assume only the following are used, with the associated probabilities:

`200 OK`	80%
`304 Not modified`	5%
`403 Forbidden`	5%
`404 Not found`	10%

3 pt (a) Down to how few bits (on average per message) can these messages be compressed?

3 pt (b) Propose a way to encode the observations in less than 1.5 bits on average, and show that your code indeed achieves this.

Consider a binary symmetric channel with a raw speed of 100 bits/s and an error probability of 1%.

3 pt (c) Compute this channel's Shannon capacity, and explain what it means.

2 pt (d) Would the use of a 4×4 parity matrix code be a good way to get close to this channel's capacity? Explain.

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3. Peer-to-peer applications

Consider distribution of a large file among a set of peer nodes.

2 pt (a) In the lectures we derived a formula for how long this would take. This formula was independent of the RTTs. Why is the RTT not important?

Assume we have N peers and no separate server. All peers have the same download speed d bits/s, and the same upload speed u bits/s. However, only half of the peers are willing to upload (the others are impolitely called "leechers")[1]. One peer initially has a file of F bits.

3 pt (b) Give an expression for how long it take until all peers have the file; explain.

2 pt (c) Is the scalability significantly affected by the fact that only half of the peers are willing to upload? Explain.

End of this exam.

[1] Real P2P protocols, like BitTorrent, take measures to exclude "leechers", but we assume here that the leechers are simply allowed to download the data without uploading anything.