Computer Networks
5th of February, 2015

- This exam consists of 6 questions with subquestions. Every subquestion counts for 10 points.

- Mark every page with name and student number.

- Use of books, additional course material, and calculator is prohibited.

- Always explain your answers. At the same time, keep your answers short and to the point. Do not use pencil or red ink. Give your answers on the exam paper (if needed, you may request additional paper.)

- Answers can be in English or Dutch.

1. **Multiple choice**

   Please answer the following questions. For each question, mark the correct answer. There is exactly one correct answer per question. The full question is worth 10 points: you are awarded 2 points for each correctly answered subquestion. *If needed, you are allowed to add one line of explanation to each answer – but no more.*

   i. Two hosts simultaneously send data through a link of capacity 1Mbps. Host A generates data with a rate of 1Mbps and uses TCP. Host B uses UDP and transmits a 100bytes packet every 1ms. Which host will obtain higher throughput?

   (a) Host A.
   (b) Host B.
   (c) They obtain roughly the same throughput.
   (d) They experience congestion collapse and negligible throughput.

   ii. Host A sends a TCP segment (Seq = 43, ACK = 103), to which host B replies with a TCP segment (Seq = 103, ACK = 57). The payload of the first TCP segment is

   (a) 14 bytes long.
   (b) 43 bytes long.
   (c) 46 bytes long.
   (d) 57 bytes long.
   (e) 60 bytes long.

   iii. A user requests a web page that consists of some text and 3 images. The browser's cache is empty. For this page, the client's browser:

   (a) sends 1 http request message and receives 1 http response messages.
   (b) sends 1 http request message and receives 3 http response messages.
   (c) sends 1 http request message and receives 4 http response messages.
   (d) sends 3 http request messages and receives 3 http response messages.
   (e) sends 4 http request messages and receives 4 http response messages.

iv. Stop-and-wait

    (a) is a sliding windows protocol with a window size of 1

    (b) does not really need any sequence numbers as it waits for the acknowledgmenr of every segment

    (c) is bad for congestion as it does not allow the sender to reduce its rate

    (d) works well with TCP-like slow start and additive increase

v. Various

    (a) CDMA only works if the chipping sequences of all subparties are orthogonal, i.e., the exclusive OR for each pair of chipping sequences should be 0.

    (b) Go-back-n is an implementation of a sliding window flow control.

    (c) Despite caching in the Domain Name System, every name lookup for names outside the local domain still has to be sent to a root server.

    (d) Stop-and-wait flow control allows multiple blocks of data to be in transit on the line at one time.

2. **Physical Layer**

  (a) What is the formula for the Nyquist bound?

  (b) Say the bandwidth is 4 kHz, there are 4 signal levels, and the signal-to-noise ratio is 20 dB. (i) How much stronger is the signal than the noise? (ii) Is this channel suitable for 16 kbit/s communication?

3. **Datalink and network**

  (a) What is the CRC checksum of the following message: 100101100 (given in binary), using a

CRC generator 1001? Show your calculation.

(b) We have seen how the datalink layer provides framing (putting bits in distinct frames). Someone says: "Who cares about frames? If there are only 2 communicating parties on a link, we do not need frames at all - we can just send streams of bits." Explain why you agree or disagree.

(c) With no more than 2^{32} addresses, addresses in IPv4 are quite scarce. We do not have this problem in Ethernet, where we have a whopping 2^{48} address to play with. Since collisions are no longer a problem in modern-day Ethernet and switches automatically learn the 'routes' in the network, would it be possible (in theory) to build a worldwide network (such as the Internet) with millions of users using just Ethernet (i.e., dropping IP altogether)?[1] Why/why not? (If your answer is 'no', give the 3 main technical reasons why not. If your answer is yes, argue why also using at least 3 arguments.)

[1]Ignore simple problems such as DNS, as we could easily support MAC addresses in DNS also.

4. **Routing** The Dijkstra Routing Algorithm is a link state routing algorithm where every node knows the topology of the network and the cost of every link. Consider the topology below.
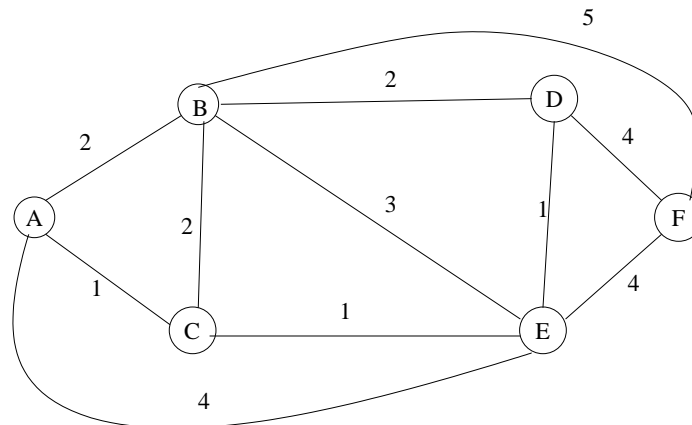
(a) Use Dijkstra to calculate the shortest routes from node **F** to every other node. Show all steps.

(b) Assume that C is buggy and erroneously (and consistently) announces that it has a direct connection of cost 1 to D. Otherwise, the node behaves correctly. Specifically, the bug is *only* in the announcement and it *forwards* the traffic correctly (i.e., without trying to use the non-existing connection). Question: What will be the consequences? Specifically, will there be nodes that can no longer be reached? If so, which and if not, why not?

5. **TCP.**

"Happy new year!". As the champagne corks fly, that is the message your Romanian friend wants to send you over a TCP connection. Of course, the time difference between Bucharest and Amsterdam is 1 hour and the message takes a bit of time to send, so your friend is trying to figure out what time to send the message in order to have it arrive at 0:00h (Amsterdam time) exactly. In the following subquestions, assume that:

- the bandwidth between your friend's smartphone and yours is 10 Mbps;

- receiving a message (of any size) together with all protocol processing takes a constant 0.05 ms, while tranmission takes place at the link rate;
- no connection has been established yet and slow start starts only *after* the connection is established;
- the latency between Amsterdam and Bucharest is 50 ms;
- the MSS is 1000 bytes (but a segment may contain fewer bytes than that).

(a) At what time should your friend start the transmission for you to have received it at 0:00h exactly? Be as exact as possible and give your answer in Bucharest time. →Assume ideal circumstances

A single text message is boring and your friend decides to record an elaborate video greeting of 36 Gbit of *data* (note: we do not interpret kilo, mega, giga, etc., in powers of 2 →everything is powers of 10). Moreover, he makes sure that a TCP connection is pre-established by 0:00h (Bucharest time) and then starts transmitting at the maximum rate.

(b) To his surprise, the video is nowhere near completely transmitted at 1:00h. He calls you and explains how he did the calculation, saying: "Look, 36 Gb of data at 10 Mbps during one hour: it should fit!" Explain to your friend what he did wrong.

(c) Is it possible in TCP that the value of the threshold *grows* after a packet loss is detected? If not, why not? If so, under what circumstances?

6. **Sockets.**

NOTE: This question is only for those students who failed their socket assignments

Consider the following Java Code:

```
1:   public class TCPServer {
2:      public static void main(String argv[]) throws Exception {
3:         String clientSentence;
4:         String capitalizedSentence;
5:         ServerSocket welcomeSocket = new ServerSocket(6789);
6:         while(true) {
7:            Socket connectionSocket = ... ;
8:            BufferedReader inFromClient = new BufferedReader(
9:              new InputStreamReader(connectionSocket.getInputStream()));
10:           DataOutputStream outToClient = new DataOutputStream(
11:             connectionSocket.getOutputStream());
12:           clientSentence = inFromClient.readLine();
13:           capitalizedSentence = clientSentence.toUpperCase() + \n;
14:           outToClient.writeBytes(capitalizedSentence);
15:        }
16:     }
17:  }
```

(a) Subquestion (i): Line (7) needs to be completed. Should it read:
(a) `new Socket("hostname", portnumber)`,
(b) `new DatagramSocket()`, or
(c) `welcomeSocket.accept()`
Subquestion (ii): can this server handle multiple connections at the same time? Explain.

(b) Assume that 3 different machines connect to the server (sequentially). As a result, how many Socket objects will be created by the server, and how many TCP ports will be assigned to the server (not including the already assigned port 6789)?

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(c) List at least 4 socket calls and explain what they do in at most 2 sentences each.

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