TDTS11/TEN1 – Computer networks and Internet protocols
TDDD93/TEN1 – Large-scale distributed systems and networks

Final Examination: 8:00-12:00, Wednesday, June 10, 2015
Time: 240 minutes
Total Marks: 40
Grade Requirements: Three (20/40); four (28/40); and five (36/40).
Assistance: None (closed book, closed notes, and no electronics)
Examiner: Niklas Carlsson

Instructions:
- Read all instructions carefully (including these)!!!! Some questions have multiple tasks/parts. Please make sure to address *all* of these.
- The total possible marks granted for each question are given in parentheses. The entire test will be graded out of 40. This gives you 10 marks per hour, or six minutes per mark, plan your time accordingly.
- This examination consists of a total of 9 questions. Check to ensure that this exam is complete.
- When applicable, please explain how you derived your answers. Your final answers should be clearly stated.
- Write answers legibly; no marks will be given for answers that cannot be read easily.
- Where a discourse or discussion is called for, be concise and precise.
- If necessary, state any assumptions you made in answering a question. However, remember to read the instructions for each question carefully and answer the questions as precisely as possible. Solving the *wrong* question may result in deductions! It is better to solve the *right* question incorrectly, than the *wrong* question correctly.
- Please write your AID number, exam code, page numbers (even if the questions indicate numbers as well), etc. at the top/header of each page. (This ensures that marks always can be accredited to the correct individual, while ensuring that the exam is anonymous.)
- Please answer in English to largest possible extent, and try to use Swedish or "Swenglish" only as needed to support your answers. In general, questions are designed to be answered using figures/tables.
- If needed, feel free to bring a dictionary from an official publisher. Hardcopy, not electronic!! Also, your dictionary is not allowed to contain any notes; only the printed text by the publisher.
- Good luck with the exam.

TDTS11 – Computer networks and Internet protocols
TDDD93 – Large-scale distributed systems and networks
Final Exam: 8:00-12:00, Wednesday, June 10, 2015

1) Question: Forwarding (6)

Please carefully show, illustrate, and explain the path of (i) the *first SYN packet* and (ii) the *first SYN-ACK response* between a Web client (browser) and a Web server. You can make the following assumptions:

- The client is located in Sweden and the server in China.
- The client machine uses Ethernet, has a single interface with a MAC address AA:AA:AA:AA:AA:AA.
- The client downloads a webpage (www.aa.com/index.html) of size 20 kB without any embedded images. The end-to-end path allows packets of size 1.5kB.
- The client has obtained a dynamic IP address 123.123.123.123 from a DHCP server, which is running on the closest gateway router.
- The client uses a local DNS server with IP address 123.123.1.1 and MAC address EE.EE.EE.EE.EE.EE.
- The MAC and IP addresses of the Web server are DD:DD:DD:DD:DD:DD and 198.222.111.111. Similar to the client, the server has a single interface.
- The gateway router closest to the client has four interfaces. The first is the interface closest to the client and has MAC and IP addresses B1:B1:B1:B1:B1:B1 and 123.123.111.1.   The second interface has MAC and IP addresses B2:B2:B2:B2:B2:B2 and 123.123.111.2. The third interface has MAC and IP addresses B3:B3:B3:B3:B3:B3 and 123.123.111.3. Finally, the fourth interface has MAC and IP addresses B4:B4:B4:B4:B4:B4 and 123.123.111.4.
- The gateway router closest to the server has four interfaces. The first is the interface closest to the server and has MAC and IP addresses C1:C1:C1:C1:C1:C1 and 198.222.111.1. The second interface has MAC and IP addresses C2:C2:C2:C2:C2:C2 and 198.222.111.2. The third interface has MAC and IP addresses C3:C3:C3:C3:C3:C3 and 198.222.111.3. Finally, the fourth interface has MAC and IP addresses C4:C4:C4:C4:C4:C4 and 198.222.111.4.
- The forwarding table at the gateway router closest to the client has many entries. However, for this question, the four most closely related entries states: 196.0.0.0/6 over interface 2, 198.0.0.0/8 over interface 2, 198.192.0.0/10 over interface 3, and 198.222.0.0/18 over interface 4.
- The forwarding table at the gateway router closest to the server has many entries. However, for this question, the four most closely related entries states: 123.123.192.0/18 over interface 2, 123.123.0.0/19 over interface 2, 123.123.64.0/18 over interface 3, and 123.123.0.0/16 over interface 4.

For this question you should also draw a picture of the topology, clearly indicate the path taken by the packet in this topology, and clearly state any assumptions you make about the topology (including parts of the networks not explained above) or anything else needed to solve the question. As with all your answers it is important that you also explain how you derived your answer. For example, why was the packet taking this particular route and not some other route?

TDTS11 – Computer networks and Internet protocols
TDDD93 – Large-scale distributed systems and networks
Final Exam: 8:00-12:00, Wednesday, June 10, 2015

2) Question: Encapsulation (6)

Consider the same scenario as above (Q1). First, explain how many messages of each of the following types of message occurrences you would expect in the scenario from Q1. Second, for each of the message examples *with one or more occurrence*, please use figures to show and illustrate the link-layer frame and encapsulated information.

1. *SYN-ACK* messages when they reach the *outgoing* network interface card (link layer) of the *DNS server*;
2. *DNS query/request* message when they reach the *incoming* network interface card (link layer) of the *gateway router closest to the client*; and
3. *HTTP data response* messages including data of the web object index.html when they reach the *incoming* network interface card (link layer) of the *client*.

You do not have to show all the details of the different headers; however, you should provide a figure that clearly (i) specify what protocols the different headers are associated with, and (ii) provide the address information associated with the source and destination fields for each of the different headers contained within these two frames.

3) Question: TCP slow start (4)

Consider the download of the above file *index.html*, located on the server hosting *www.aa.com*. Assume that the client and server are using non-persistent HTTP/1.0, and that there is a 100ms round trip time (RTT) between them. Please draw a figure and explain the entire communication sequence associated with the file download, including the TCP handshake and connection teardown. You can assume that the payload is 20 packets, that each packet can be sent in 1ms, and that the fifth (5) payload packet is lost. You can also assume that the TCP version is implementing fast retransmit and fast recovery, that the initially *ssthresh* value is 8, and that the timeout period is (approximately) constant at 300ms. You should include a figure that clearly show when each packet is sent and received.

4) Question: HTTP and replication (6)

Performance and personalized service are important aspects of building good Web services. Please draw a picture illustrating the communication sequence when the client above downloads a smaller version of the above file *www.aa.com/index.html* (than in question Q1), which in this question is only 7KB but instead includes six embedded images. The main document and three of the embedded images can be found on the original Web server *www.aa.com* and the final three embedded images can be found on the server *www.bb.com*. You can assume that no proxy cache is used and the client communicates directly with the server *www.aa.com using pipelined HTTP* and directly with the server *www.bb.com using pipelined non-persistent HTTP*. Your picture should illustrate the client, all involved Web servers, and the communication sequence. Your picture should also clearly show connection establishment and teardown messages, as well as any other messages needed for the file transfer. You can assume that the size of the HTML page is 7KB, the size of each embedded image is 2.5KB, the MSS is 1.5KB, and both webservers have the same RTT and the client's connections do not experience any packet losses. Also, how many packets are being sent between each of the two servers and the client? Which connections are likely to terminate last?

TDTS11 – Computer networks and Internet protocols
TDDD93 – Large-scale distributed systems and networks
Final Exam: 8:00-12:00, Wednesday, June 10, 2015

5) Question: Distance vector routing (4)

Consider a node A with neighbors B, C, and D. Node A currently has the distance table below. (Note that the network currently is not in a very good shape, and a few routing table updates will be needed to get the network back into shape.) Assume that it receives an updated distance vector from neighbor B which looks as follows $[\infty, 0, 1, 2, 4, 5, 7]$ and an updated distance vector from neighbor C which looks as follows $[\infty, 2, 0, 3, 3, 2, 4]$. First, update the table below, including A's own distance vector. Second, assume that poison reverse is implemented, and show and explain exactly what information the node sends to each its neighbors (after the table has been updated).

	Costs			
Destination	A (via)	B	C	D
A	0 (A)	∞	∞	∞
B	1 (B)	0	4	5
C	1 (C)	2	0	9
D	1 (D)	3	5	0
E	? (?)	5	8	6
F	? (?)	8	12	6
G	? (?)	4	5	6

6) Question: Switching fabric (2)

Give an example of head-of-line blocking at a router. Please support your answer with a figure.

7) Question: Packet losses (4)

Give a concrete example how interleaving can be used to handle packet losses in video streaming? Then, briefly and precisely explain and discuss the tradeoff between buffering and protection against bursty losses when using interleaving-based approaches.

8) Question: HTTP-based Adaptive Streaming (4)

In mobile environments, the network conditions experienced by a client may vary significantly over the duration of a session. In this context, you should first explain what the main advantages of HTTP-based adaptive streaming (HAS), used by Netflix, for example, is relative to non-adaptive HTTP-based streaming. Your answer should provide concrete examples (preferably using a figure of buffer conditions, network conditions, and playback quality, for example) of when and why HAS performs better in your example scenarios. Second, in the context of client playback performance, please explain the potential advantages of (i) splitting a file into multiple chunks, and (ii) using HTTP.

TDTS11 – Computer networks and Internet protocols
TDDD93 – Large-scale distributed systems and networks
Final Exam: 8:00-12:00, Wednesday, June 10, 2015

9) Message integrity (4)

Message integrity can be achieved with the help of symmetric keys (e.g., as with message authentication codes) or public keys (e.g., as with signed message digests). Please clearly and briefly explain what message integrity is. Then, please draw a figure explaining how each of these two schemes work, and list the main advantages/disadvantages when sending one/many large/small messages between two nodes (say Alice and Bob). A table capturing the cases with one vs. many and large vs small messages is helpful here.

Good luck!!