TDTS11/TEN1 – Computer networks and Internet protocols
TDDD93/TEN1 – Large-scale distributed systems and networks
TDDE35/TEN1 – Large-scale distributed systems and networks

Final Examination: 8:00-12:00, June 12, 2019
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)
Examiners: Andrei Gurtov and 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. One question is an extra bonus above 40p.
- When applicable, please state assumptions and show/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.
- 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.
- Yet, some question(s) may be ambiguous or have contradicting information. If necessary, please clearly identify any such instance and clearly state any additional necessary assumptions needed in answering such a question.
- 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 and utilize figures and tables to the largest extent.
- 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.
- **Write down AID for later results checking**
- Good luck with the exam.

1) Question: Forwarding (6)

Show, illustrate, and explain the path of (i) the *first HTTP request* and (ii) the *first HTTP 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 USA.
- Trump is the president in the USA.
- The client machine uses Ethernet, has a single interface with a MAC address AA:AA:AA:AA:AA:AA.
- The GET request is for a webpage: www.aa.com/index.html.
- 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 197.222.111.111. 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 196.222.111.1. The second interface has MAC and IP addresses C2:C2:C2:C2:C2:C2 and 196.222.111.2. The third interface has MAC and IP addresses C3:C3:C3:C3:C3:C3 and 196.222.111.3. Finally, the fourth interface has MAC and IP addresses C4:C4:C4:C4:C4:C4 and 196.222.111.4.
- 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: 197.0.0.0/8 over interface 2, 196.0.0.0/6 over interface 3, 197.128.0.0/9 over interface 4, and 197.222.0.0/18 over interface 2.
- 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, 123.123.0.0/18 over interface 3, 123.123.64.0/18 over interface 4, and 123.123.0.0/24 over interface 2.

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?

2) Question: Encapsulation (4)

Consider the same scenario as above (Q1). Please use figures to show and illustrate the link-layer frame and encapsulated information for:

1. the first *DNS query/request* message when it reaches the *incoming* network interface card (link layer) of the *gateway router closest to the client*; and
2. the first *HTTP request* message when it reaches the *outgoing* 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 (i.e., address information at all layers, including the application layer).

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 150ms 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 22 packets, that each packet can be sent in 1ms, and that the eight (8) 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 4, and that the timeout period is (approximately) constant at 350ms. 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. To improve performance when downloading multiple objects from the same server, both pipelined HTTP and proxy caches can be used. Please draw two pictures illustrating the communication sequence when the client above downloads a smaller version of the above file *www.aa.com/index.html*, which in this question is only 5KB, but the webpage also include four embedded images. The main document and two of the embedded images can be found on the original Web server *www.aa.com* and the final two embedded images can be found on the server *www.bb.com*.

In the first figure you can assume that no proxy cache is used and the client communicates directly with the servers *using pipelined HTTP*. In the second figure, you can assume that all communication happens through the proxy, and that the proxy has the html file, but none of the images, stored locally. Furthermore, for the second figure, *persistent connections* are used **but** *none of the requests are pipelined*. Your pictures should illustrate the client, its local proxy cache, 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. (Please also clearly state any assumptions regarding the operation of the proxy.) You can assume that the HTML page and each of the images are 5KB each, the MSS is

1.5KB, and both webservers have the same RTT and loss rates to the client. Also, how many packets are being sent between each of the machines? Which connections are likely to terminate last?

5) Question: IP fragmentation (4)

Consider a 4,000 byte IPv4 datagram which traverses 10 links on its path from A to B. Assume that links 3, 5 and 7 have a maximum transmission unit (MTU) of 5,000 bytes and the other links have an MTU of 1,500 bytes.

(a) Please use a figure and explain when fragmentations occurs, and into how many fragments the datagram is fragmented/defragmented as it traverses each link of the forwarding path from A to B.

(b) Please use a figure and explain how this scenario will change if all routers on the path used IPv6. You can assume that the MTUs are the same as for the IPv4 case.

6) 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 [∞, 0, 2, 3, 6, 5, 8] and an updated distance vector from neighbor C which looks as follows [∞, 2, 0, 3, 8, 3, 5] . 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	7
D	1 (D)	3	5	0
E	? (?)	7	8	4
F	? (?)	2	12	4
G	? (?)	11	5	7

7) Question: Routing (4)

(a) Please explain the main difference between forwarding and routing.
(b) What are the main advantages/disadvantages of link state vs. distance vector routing?
(c) Give examples of both link state and distance vector protocols.

8) Question: 802.11 collision avoidance (4)

The 802.11 protocol can handle some hidden-terminal problems using the RTS-CTS mechanism. (a) Please explain what is the hidden-terminal problem? When and how does it occur? (b) How does the RTS-CTS mechanism help towards solving the hidden-terminal problem? Please illustrate with the communication sequence when two nodes A and C both want to communicate with an intermediate node B. (c) Explain why despite the above advantages, 802.11 typically do not use the RTS-CTS mechanism.

9) Question: SSL/TLS (4)

Please draw a picture that shows location of TLS in the protocol stack. Does HTTPS use symmetric or asymmetric keys to encrypt the traffic? Also, please draw a picture and use it to explain how the used key(s) is/are obtained and used with TLS?

Good luck!!