Försättsblad till skriftlig tentamen vid Linköpings Universitet

(fylls i av ansvarig)

Datum för tentamen	*Jan. 10, 2014*
Sal	*TER2*
Tid	*14-18*
Kurskod	*TDTS06*
Provkod	*TEN1*
Kursnamn/benämning	Computer networks
Institution	*IDA*
Antal uppgifter som ingår i tentamen	*9*
Antal sidor på tentamen (inkl. försättsbladet)	*1+1+4=6*
Jour/Kursansvarig	*Niklas Carlsson*
Telefon under skrivtid	*013-282644*
Besöker salen ca kl.	*15:00 and 17:00*
Kursadministratör (namn + tfnnr + mailadress)	*Madeleine Häger Dahlqvist 013-282360, madha@ida.liu.se*
Tillåtna hjälpmedel	*Dictionary from an official publisher. Hardcopy; not electronic.*
Övrigt (exempel när resultat kan ses på webben, betygsgränser, visning, övriga salar tentan går i m.m.)	*Grades: 5(36/40); 4(28/40); 3(20/40)*
Vilken typ av papper ska användas, rutigt eller linjerat	*Your choice.*
Antal exemplar i påsen	

TDTS06 – Computer Networks
Final Examination: 14:00-18:00, Friday, Jan. 10, 2014
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)
Instructor: 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.)
- Answers can be provided in either English or Swedish. (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.

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.
- 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 111.222.111.222 from a DHCP server, which is running on the closest gateway router.
- The client uses a local DNS server with IP address 111.222.1.1 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 196.222.111.111. 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 BB:BB:BB:BB:BB:AA and 111.222.111.1. The second interface has MAC and IP addresses BB:BB:BB:BB:BB:BB and 111.222.111.2. The third interface has MAC and IP addresses BB:BB:BB:BB:BB:CC and 111.222.111.3. Finally, the fourth interface has MAC and IP addresses BB:BB:BB:BB:BB:DD and 111.222.111.4.
- 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 CC:CC:CC:CC:CC:AA and 196.222.111.1. The second interface has MAC and IP addresses CC:CC:CC:CC:CC:BB and 196.222.111.2. The third interface has MAC and IP addresses CC:CC:CC:CC:CC:CC and 196.222.111.3. Finally, the fourth interface has MAC and IP addresses CC:CC:CC:CC:CC:DD 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 for each interface states 196.222.0.0/18 over interface 2, 196.222.110.0/23 over interface 3, 196.222.110.0/24 over interface 4, and 196.222.64.0/18 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 for each interface states 111.222.192.0/18 over interface 2, 111.222.0.0/18 over interface 3, 111.222.64.0/18 over interface 4, and 111.222.0.0/24 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 a figure to show and illustrate the link-layer frame and encapsulated information for the first *HTTP request* message when it reaches the outgoing network interface card (link layer) of the *gateway router closest to 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 this frame.

3) Question: DHCP, ARP and DNS (4)

Consider the same scenario as above (Q1+Q2). Please use a figure to show and explain the sequence of packets (and their corresponding header information) that were used by the client to obtain all the IP and MAC addresses that it uses when sending the HTTP GET request to the Web server. Please use a figure that clearly shows the timeline and indicates what address information is included in each of these messages. Your figure should include protocol and message information for how the following protocols are used: Dynamic Host Configuration Protocol (DHCP), Address Resolution Protocol (ARP), and Domain Name System (DNS).

4) 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 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, fast recovery, initially has ssthresh = 4, and the timeout period is (approximately) constant at 500ms. You should include a figure that clearly show when each packet is sent and received.

5) 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. In the second figure, you can assume that all communication happens through the proxy, and that the proxy has all but one of the images stored locally. Furthermore, the client and the two servers all communicate using

pipelined HTTP. 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 two servers and the client? Which connections are likely to be active for the longest period of time?

6) Question: HTTP, TCP, caches, packet losses, and throughput (4)

Please consider three mobile clients on the same wireless network in Sweden that are using HTTP-based downloading to download a (very) large file from a website hosted in the US. Assume that the link closest to the users has a high loss rate, but that there is a proxy cache placed close to the clients, on the path between the clients and the server. The first client downloads the file directly from the server without any proxy involvement. The second client downloads the file via the proxy, but the proxy does not have the file and must therefore download the file itself. Luckily, the proxy is able to download file content from the server in parallel with uploading file content to the client; of course, at a speed no greater than the speed with which the proxy itself downloads the content from the server. Finally, the third client (that made the request after the second client, for example) is served directly by the proxy cache.

While the above downloads do not necessarily take place in parallel, for simplicity, please assume that the clients will obtain download throughput that is TCP fair (suggesting reasonable relationships between TCP throughput, RTTs, and loss rates). Here, you can also assume that the round trip time (RTT) between the client and proxy is 10ms, the RTT between the proxy and server is 90ms, and the RTT directly between the client and proxy is 100ms (actually taking the path over the proxy). You can also assume that the loss rate between the client and proxy is 9 times as high as between the proxy and server or the client and server. Furthermore, assume that the first client achieves a throughput of 250kbps. Given the above information, please estimate the download speed of each client. You answer should clearly state (i) the estimated download speed of each client, and (ii) the relative rank of each client's download speed.

Note that it will help to draw the topology, identify what the conditions of each part of the network are, and reason about how the average throughput that can be achieved for the different host-to-host connections may be. Please keep in mind what protocols are used and make appropriate assumptions when needed.

7) Question: Power save mode (4)

Please use a figure and illustrate and explain the communication sequence associated with the power save mode (PSM) in 802.11 and how it can be used to save energy of mobile clients. What is the role of the client? What is the role of the access point? Also, sketch and explain the tradeoffs between latency (x-axis) and energy usage (y-axis), as well as latency (x-axis) and buffer size (y-axis) at the access point.

8) 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, 3, 9] and an updated distance vector from neighbor C which looks as follows [∞, 7, 0, 3, 8, 2, 8] . 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	9
F	? (?)	2	12	4
G	? (?)	11	5	7

9) 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, please explain what the main difference between typical (non-adaptive) HTTP-based streaming (traditionally used by YouTube, for example) and HTTP-based adaptive streaming (HAS, used by Netflix, for example) when the available bandwidth goes from bad (low available bandwidth) to good (high available bandwidth). Your answer (supported with a figure or two) should clearly explain (i) the format of the file content stored on the servers, (ii) what can be cached such as to improve client performance, when possible, and (iii) the actions taken by the two different player types. Your answer should involve reasonable assumptions, and should include an illustrative example that clearly shows the buffer occupancy and video playback quality as a function of time (using appropriate figures/graphs, for example).

Good luck!!