# Försättsblad till skriftlig tentamen vid Linköpings Universitet

(fylls i av ansvarig)

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|---|---|
| **Datum för tentamen** | *March 8, 2012* |
| **Sal** | *TER3 TER4* |
| **Tid** | *14-18* |
| **Kurskod** | *TDTS04* |
| **Provkod** | *TEN1* |
| **Kursnamn/benämning** | Computer networks and distributed systems |
| **Institution** | *IDA* |
| **Antal uppgifter som ingår i tentamen** | *10* |
| **Antal sidor på tentamen (inkl. försättsbladet)** | *1+1+4=6* |
| **Jour/Kursansvarig** | *Niklas Carlsson* |
| **Telefon under skrivtid** | |
| **Besöker salen ca kl.** | *13:00 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** | |

TDTS04 – Computer networks and distributed systems (TEN1)
Final Examination: 14:00-18:00, Thursday, March 8, 2012
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+1=10 questions (including one bonus question). 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: Encapsulation and forwarding (7)

Show and illustrate a single link-layer frame for a Simple Mail Transfer Protocol (SMTP) message (that fits into a single frame) when it is passed down to the physical layer of the gateway router closest to the client on its way towards the mail server. You do not have to show all the details of the different headers; however, you should (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). You can make the following assumptions:

- The client machine uses Ethernet, has a single interface with a MAC address AA:AA:AA:AA:AA:AA and an IP address 111.111.111.111
- The MAC and IP addresses of the SMTP server are DD:DD:DD:DD:DD:DD and 222.222.222.222. Similar to the client, the server has a single interface.
- The gateway router closest to the client has tree interfaces. The first is the interface closest to the client and has MAC and IP addresses BB:BB:BB:BB:BB:AA and 111.111.111.222. The second interface has MAC and IP addresses BB:BB:BB:BB:BB:CC and 111.111.133.133. The third interface has MAC and IP addresses BB:BB:BB:BB:BB:DD and 111.111.144.144.
- The routing table at the gateway router has many entries. However, for this question, the two most relevant entries states 222.222.0.0/16 (over interface 2) and 222.222.192.0/18 (over interface 3).

In addition to the above answers, you should also draw a picture of the topology and clearly state any assumptions you make about the topology 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 a particular route?

## 2) Question: HTTP (6)

Performance and personalized service are important aspects of building good Web services. Please answer the following three questions related to the Hypertext Transfer Protocol (HTTP).

- Please draw a picture and explain how persistent connections can help improve the delivery of a Web page with three embedded images (over non-persistent HTTP/1.0).
- Please draw a picture and explain how pipelining can (further) help improve the delivery of a Web page with three embedded images.
- HTTP is a stateless protocol. Please explain what this means and show how Web servers can keep state information about users and their interactions with the Web service. For this question you may want to draw a picture that illustrates a user that visits a site multiple times (possibly days or weeks apart).

### 3) Question: TCP fairness (4)

Consider the throughput of three users (A, B, and C) with a shared bottleneck link. Assume that they are all downloading large files from different servers, but that their bandwidth bottleneck is the shared link. Assume A uses two Transmission Control Protocol (TCP) connections, B uses one TCP connection, and C has two TCP connections *and* one TCP-friendly UDP flow (attempting to be TCP fair). The round trip time (RTT) for the connections of clients A and C are 50ms and the RTT for client B is 100ms. Furthermore assume that the total bandwidth of the link is 100Mbps. Estimate the download rate of the different clients?

### 4) Question: TCP slow start (5)

Consider two machines A and B which are located 50ms apart. Assume that A is requesting a file from B using HTTP. Draw a figure and explain the entire communication sequence, including TCP handshake and connection teardown. You can assume that the payload is 20 packets and each packet can be sent in 0.1ms. You can assume no packet losses. For simplicity, you can assume that the TCP version is implementing fast retransmit, initially have ssthresh = 4, and the timeout period is constant at 300ms.

### 5) Question: TCP (2)

Please provide an example (using a figure and support text) of a triple duplicate ACK, explain what it is and what action typically is taken at such an event.

### 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 may not be in a very good shape, and a few routing table updates may be needed to get the network back into shape.) Assume that A receives an updated distance vector from neighbor B which looks as follows [∞, 0, 3, 4, 3, 4, 2]. 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).

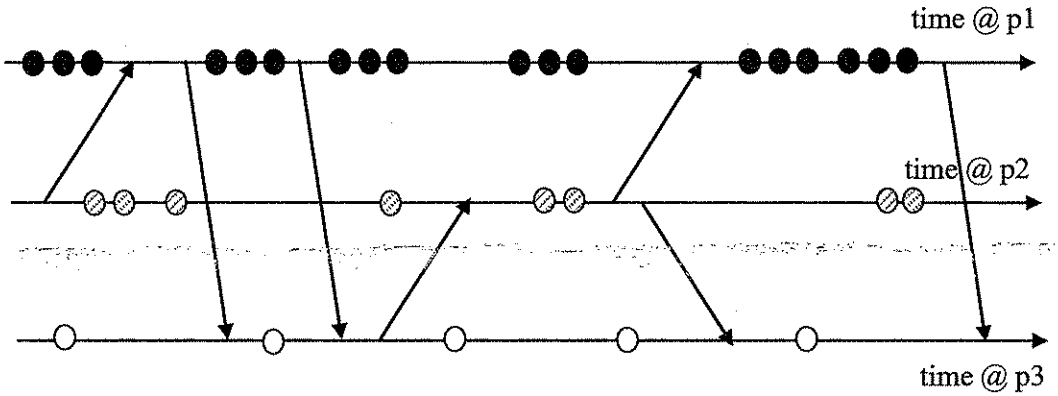
| | Costs | | | |
|---|---|---|---|---|
| Destination | A (via) | B | C | D |
| A | 0 (A) | ∞ | ∞ | ∞ |
| B | 1 (B) | 0 | 4 | 2 |
| C | 1 (C) | 2 | 0 | 3 |
| D | 1 (D) | 3 | 5 | 0 |
| E | ? (?) | 8 | 7 | 2 |
| F | ? (?) | 9 | 4 | 6 |
| G | ? (?) | 10 | 6 | 4 |

### 7) Question: Transparency (4)

Please name and explain five different types of transparency? Also, explain why transparency is important in distributed systems.

### 8) Question: Lamport's clock (4)

Assume that you have three processes p1, p2, and p3 which are implementing Lamport's clocks. There are many events that take place at these processes, including some messages being sent between the processes. In the figure below we use circles and arrows to specify in-processor events and messages being sent between processes, respectively. Please provide the logical timestamps associated with each event. You can assume that all three clocks start at zero, at the left-most point in time. (Also, explain how the processes would adjust their clocks if using Lamport's logical clocks.)




### 9) Question: Multitier system (4)

Consider a simple multi-tier system with three levels: a user interface, an application server, and a database server. Assume these layers are implemented at different geographic locations and that the average round trip time (RTT) between the machines used in consecutive layers is 40ms. Consider a fully synchronize call in which the application server require 120ms total processing and the database require 220ms processing to satisfy the request. How long time is the client process looked from the moment it makes the request to the application server? You can assume that no data is transferred between the layers; that both the original call and response fits within a single package; and messages do not need to be acknowledged. Please explain your answer and illustrate with a figure.

**Bonus Question: 802.11 channel utilization (4)**

The 802.11 protocol uses CSMA/CA with a RTS-CTS mechanism to solve the hidden terminal problem. Please draw a picture that clearly illustrates the transfer process of a message from node A to a node B. Your picture should assume that nodes A and B can hear each other; nodes B and C can hear each other; but nodes A and C cannot hear each other. You can assume that RTS, CTS, and ACK messages are X bytes, the data message to be transferred is Y bytes, and the transmission rate is R. Furthermore, an RTS require a DIFS and the other messages individual SIFS. You can also assume that nodes A and B are T ms apart. Assuming that node C does not attempt to send any data (and everything goes smoothly), what is the effective channel utilization observed for node A (from the time that it initiates communication until the message is acknowledged)? For full marks, you are also expected to provide a mathematical expression for the utilization and describe the impact of the different parameters above; most importantly, the impact of the X and Y sizes.

*Good luck!!*