LiTH, Tekniska högskolan vid Linköpings universitet
IDA, Institutionen för datavetenskap
Juha Takkinen
2007-10-23

Written examination in TDTS06 Computer Networks 2007-10-22 at 8–12

Hall

R34, R35, R36, R41, R42, and R44.

Helping materials

A basic calculator with memory erased and an English dictionary (not electronical) are allowed.

Results

The results are published at latest twelve working days after the exam.

Points

Maximum is 40 points (44 if you passed the optional assignment). For grade 3, 20 points are needed. For grades 4 and 5, 28 points and 36 points, respectively, are needed. ECTS grades are given separately.

Teachers on duty

Juha Takkinen, 0731-50 03 93, will visit the hall around 9 and at 11 o'clock.

Instructions

The examination consists of eight areas of questions, grouped according to the learning goals in the course. Read the questions carefully. Motivate your answers, if not told otherwise, and state explicitly your assumptions. The use of figures is encouraged, except where other instructions apply. Answers that are not legible will not be graded. You can use either English or Swedish.

Put only one problem on each sheet of paper, with the exception of subproblems a, b, etc., which can be on the same sheet.

Make sure that you keep *the same order* of each alternative and table entry when you copy answers from the examination paper to your sheet.

"(12) In protocol design, perfection has been reached not when there is nothing left to add, but when there is nothing left to take away."
—R. Callon, RFC 1925 "The Twelve Networking Truths"

Good luck!

1. Protocols

a. See the TCP FSM in figure 1 in the Appendix. What event/action pairs are missing in the transitions marked with the boxes A and B? Also, explain what is accomplished in these transitions, that is, who does what, and for what purpose. (2 p.)

b. Assume a user clicks on a link on a web page. Show a typical protocol stack that is invoked in this scenario. Also, list the goal of each protocol in your answer. Remember to state your assumptions. (2 p.)

c. Explain and exemplify what is meant by a *protocol interface* that *provides services*. (1 p.)

2. Networking basics

a. List two differences between the go-back-N and the selective-repeat sliding window protocols. Which protocol would perform the best, that is, send the most DATA and ACK packets, over a link that has a high bandwidth, long delay and practically no errors? Why? (2 p.)

b. List two possible reasons for packet loss in a network, that is, reasons for a packet not arriving at the destination. (1 p.)

b. Assume a network with two hosts A and B; three routers R1, R2 and R3; and five links a–e, as shown in figure 2 in the Appendix. Suppose the hosts are able to transmit small packets in 100 µs and large packets in 800 µs. The routers, on the other hand, transmit small packets in 660 µs and large packets in 5.5 ms.

i. Now assume that the different delays concerning the links a–e are as listed in the table below. Calculate the minimal total end-to-end delay from A to B for small packets. (1 p.)

Delay	a	b	c	d	e
processing	50 µs	20 µs	20 µs	30 µs	20 µs
queueing	0 µs	10 µs	10 µs	20 µs	5 µs
propagation	4 µs	18 µs	40 µs	12 µs	6 µs

ii. Calculate the time to transfer a file consisting of 2 large packets and 1 small packet along the path discovered in i) above. (1 p.)

3. Applications

a. Explain what is meant by an overlay network in a P2P context. (1 p.)

b. Is the following statement true or false? Why?
"DNS caching is not an important feature of the DNS because it is not used much in reality since hosts and mappings between hostnames and IP addresses are by no means permanent." (2 p.)

c. In the four items below, tick off True, False, or none of the two. Do not justify your answer. *Copy your answer to your answering sheet*. (2 p.)

	True	False	
i.	❑	❑	The SMTP protocol requires a new TCP connection to be opened for each e-mail message delivered to the same server.
ii.	❑	❑	Conditional GET is used by a web proxy (cache) to check if it has an up-to-date version of a web page.
iii.	❑	❑	HTTP is a stateless protocol.
iv.	❑	❑	FTP uses the same connection for both control and data packets.

(+0.5 p. for each correct, –0.5 p. for each wrong, 0 p. for no answer, and min. 0 p.)

4. TCP

a. Below is TCP's calculation of the retransmission timer. Explain how the SampleRTT is measured and what DevRTT is. (1 p.)

$$TimeoutInterval = EstimatedRTT + 4 \times DevRTT$$
$$EstimatedRTT = 0.875 \times EstimatedRTT + 0.125 \times SampleRTT$$
$$DevRTT = (1 - \beta) \times DevRTT + \beta \times |SampleRTT - EstimatedRTT|$$

b. TCP is said to be a "bytestream-oriented transport layer protocol for reliable delivery of segments on the Internet". Explain what this means. (2 p.)

c. Consider a TCP sender transferring a 600-KB file to a TCP receiver. Assume the MSS to be 512 B and the initial threshold to be 64 KB. Time is divided into transmission rounds, where each round it one RTT. Ignore transmission delays. Suppose the TCP sender starts with its first packet at time 1. During transmission round 9, the TCP sender receives a triple duplicate ACK. Assume 1 KB is 1024 B.

i. Draw a diagram with the time on the X axis and the size of the congestion window in bytes on the Y axis, showing what occurs over the duration of the connection as described above. (1 p.)

ii. Identify the intervals when slow start and congestion avoidance, respectively, are operating. (1 p.)

5. IP

a. Define what a subnet is. (1 p.)

b. Suppose Alice wants to download a file that Bob has, using a P2P filesharing application, and that Bob is behind a NAT but Alice is not. Packets to the NAT are routed from the outside using the IP address 138.76.29.7. The internal IP address of the NAT is 10.0.0.1. Explain why Alice's peer cannot initiate a TCP connection to Bob's peer, even if Alice knows the IP address of the NAT. (1 p.)

c. How many responses does the sender of an ARP request expect to receive and why? (1 p.)

d. In the four items below, tick off True, False, or none of the two. Do not justify your answer. *Copy your answer to your answering sheet*. (2 p.)

	True	False	
i.	❑	❑	Tunneling is typically the encapsulation of an IP packet in an Ethernet frame.
ii.	❑	❑	One key difference between IPv4 and IPv6 is that IPv6 does not allow fragmentation at routers.
iii.	❑	❑	IPv6 uses the Internet checksum for error detection purposes.
iv.	❑	❑	The Identification field in the IPv4 packet header is used for identifying a flow of packets in the IntServ QoS framework.

(+0.5 p. for each correct, –0.5 p. for each wrong, 0 p. for no answer, and min. 0 p.)

6. LANs

a. Consider the extended LAN in figure 3 in the Appendix. Suppose that the forwarding table in the switch (S_1) initially is empty. $H_{1–3}$ are hubs.

i. Assume that host B sends a frame to host H, and that host H replies back with sending another frame. The list below shows a number of events A–K that may or may not happen in this scenario. Show the correct order of the correct events. (1 p.)

A. The switch receives a frame.
B. Host B receives a frame.
C. The switch sends an acknowledgement back to the sender.
D. The switch broadcasts a frame on all outgoing interfaces except the one where the frame arrived.
E. Host H receives a frame.
F. Host H sends a frame
G. The switch sends a frame on one outgoing link.
H. The switch adds an entry (B, 1) to its forwarding table.
I. The switch adds an entry (H, 3) to its forwarding table.
J. Host B sends a frame.
K. The switch receives a frame.

ii. LAN broadcasts are used by both DHCP and ARP to enable their respective services. How many broadcast domains are there in the extended LAN in figure 3? Motivate your answer. (1 p.)

iii. Assume Ethernet is used to implement the network in figure 3. How many collision domains does the network have and why? (1 p.)

b. Define the following link layer services and then describe if and how they are implemented in the WiFi standard IEEE802.11b: (2 p.)

- error detection
- link access.

As an example of the required level of detail in your answer, here is the description of the link-layer service called *reliable delivery*: "The service of reliable delivery guarantees to deliver each network-layer datagram across a link and also without error. WiFi does not normally guarantee delivery of frames but an option exists to use ACKs and retransmissions to ensure delivery."

7. Routing

a. Explain and motivate the usage of flooding and calculation of spanning tree, respectively, in the link-state routing algorithm. (2 p.)

b. Consider the network shown in figure 4 in the Appendix, presupposing that each node initially knows the cost to each of its neighbours. Assume that the distance-vector routing algorithm is used and that the nodes exchange distance vectors synchronously at regular interval. What are the contents of the distance vector table after each round of received distance vectors from x's neighbours? After how many rounds does the algorithm converge for this network? Use the below table as a blueprint for your tables in the answer. (2 p.)

DV table at node x		Cost to network node				
		u	v	x	y	z
From neighbour	u					
	x					
	y					
	z					

c. Explain what an autonomouse system (AS) is, in the context of routing. Give one example of an inter-AS and an intra-AS routing protocol, respectively, as used on the Internet. (1 p.)

8. Network security

a. Suppose Alice and Bob each have their own public and private key pairs. Furthermore, assume that the public keys are public and the private keys are secret and not compromised. Alice wants to be sure that authenticity, integrity and confidentiality are assured when she sends the message to Bob. Explain if the following approach fulfills Alice's security goals for the message, or suggest a better solution: $\{\{m\}K^{+}_{B}\}K^{-}_{A}$ (2 p.)

b. Explain the following network security concepts in two sentences and as unambigously as possible: (2 p.)

   i. SSL

   ii. IEEE802.11i.

c. Explain the purpose of a gateway in a network security context. (1 p.)

Appendix

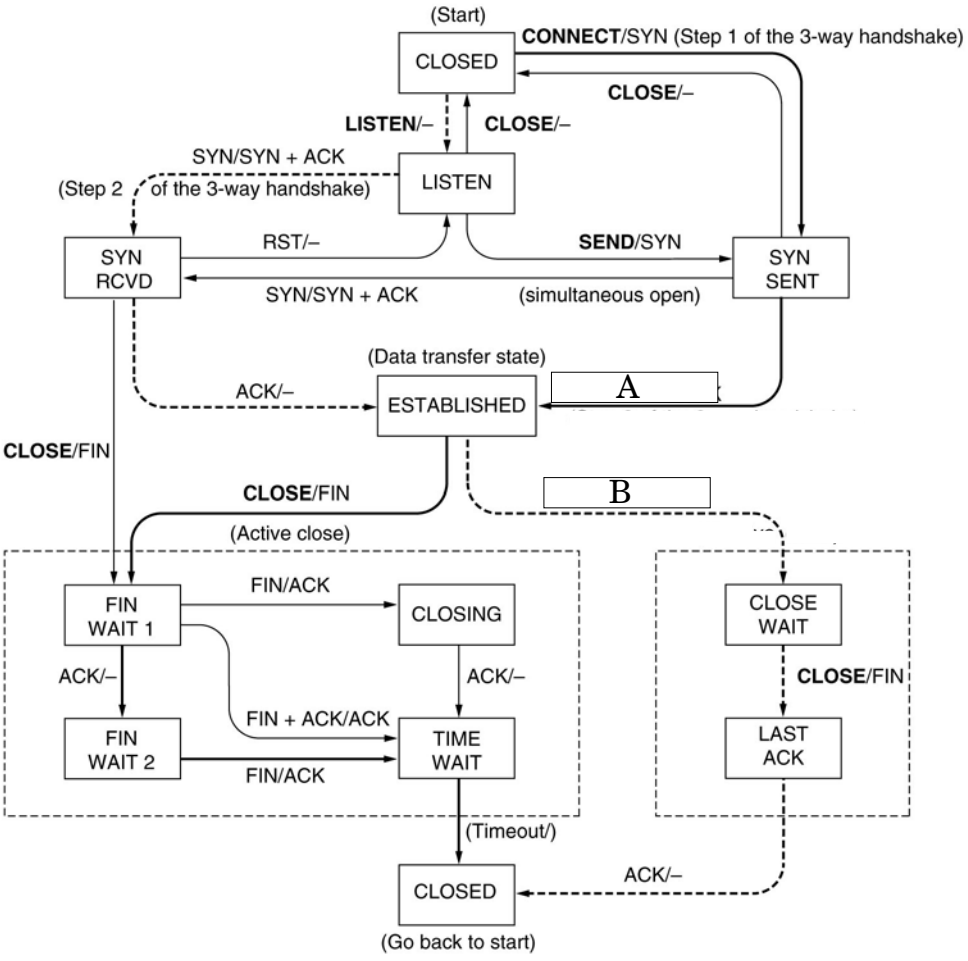

Figure 1

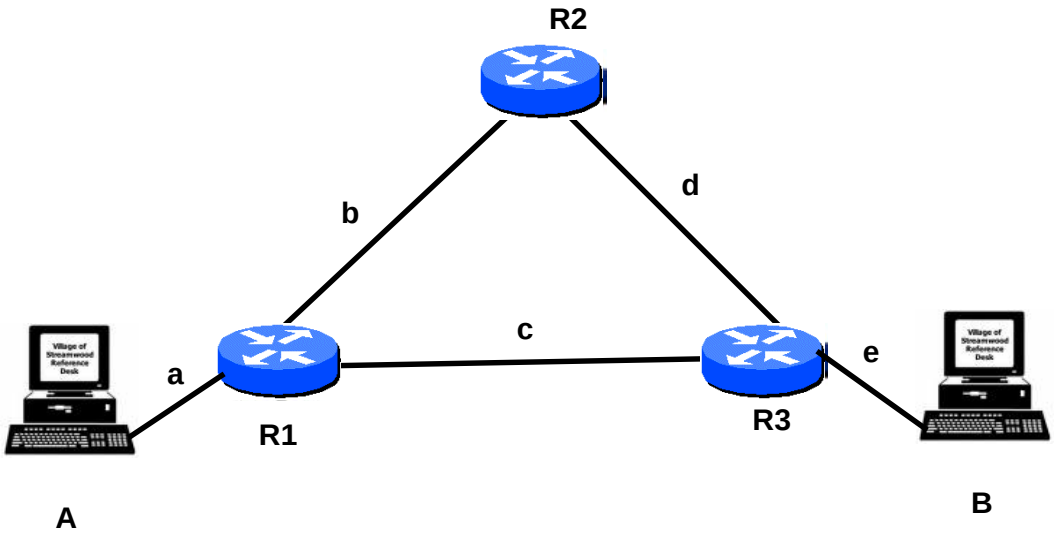

Figure 2

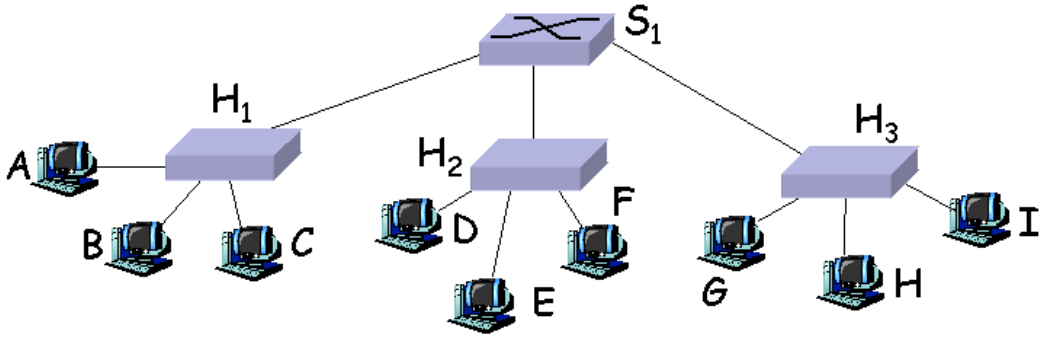

Figure 3

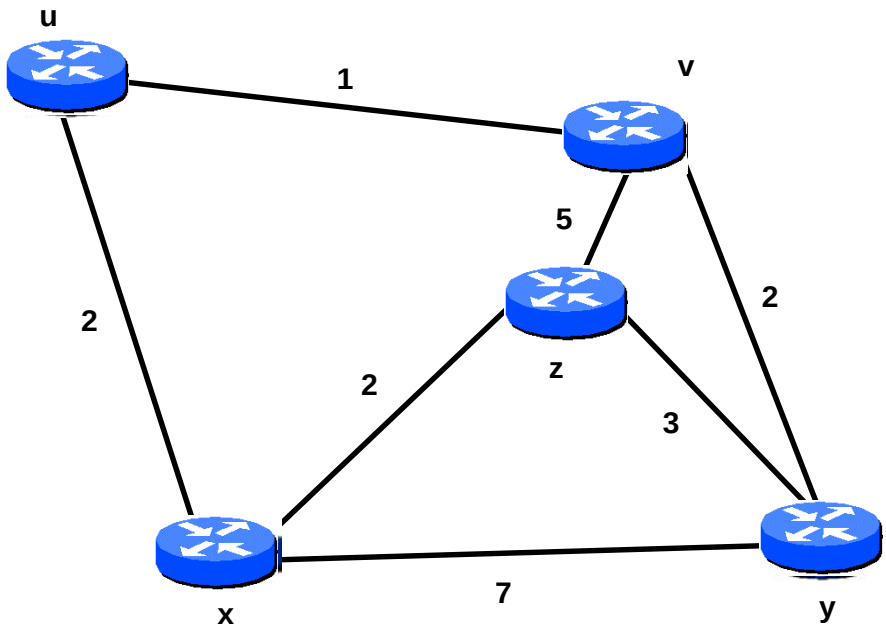

Figure 4