Department of Electrical and Information Technology

Final Exam – 2011 ht1 *(korttenta)*

2011-10-19, 09:00 – 11:00

ETSF05 – Internet Protocols

The questions in this exam give a total of **100** points. Minimum **60** points are needed to pass the exam.

Questions with Answers

1. **[10 points]** A demultiplexer in a synchronous time division multiplexing (TDM) system has 1 incoming link and 10 identical outgoing links. The frames on the incoming link arrive at a bit rate of 10 Mbps. There is 1 byte of control data at the beginning of each frame, and one time slot contains exactly 2 bytes.

   1.1. What is the frame size in bits and frame duration in seconds?

   *Frame size is (1 byte + 10 * 2 bytes). Frame duration is (21 bytes * 8 bits/byte divided by 10 Mbps).*

   1.2. What is the bit rate of the outgoing links?

   *10 Mbps * 2/21. This is the portion of data put on each outgoing link.*

2. **[5 points]** Given S_f = 17 (first frame sent but not yet acknowledged), S_n = 43 (next frame to send), assuming the sender's window size is set to the maximum value allowing Go-Back-N ARQ to function correctly:

   2.1. What is the number of the last frame in the sender's "sliding window"?

   15. This value does not depend on the maximum available sequence number.

   2.2. What is the minimum number of bits that can have been allocated to sequence numbers?

   Since the biggest number we know of is 43, the nearest larger number which can be represented as 2^x is 64. So, the minimum number of bits used could be 6, allowing for numbers from 0 to 63.

3. **[10 points]** Point-to-Point Protocol (PPP) uses the following (sub)protocols to maintain connections through the various phases shown in the diagram below: Link Control Protocol (LCP); Password Authentication Protocol (PAP); Challenge Handshake Authentication Protocol (CHAP); Internet Protocol Control Protocol (IPCP). Match each protocol to the phase it is used in and explain briefly its purpose.

   LCP: <u>Establishment</u>, maintenance, configuration and <u>termination</u> of connections.
   PAP and CHAP: <u>Authentication</u> of the user, validating its identity.
   IPCP: Configuration of the <u>network</u> layer according to the L3 protocol to be used.

4. **[10 points]** When frames of a lower bit rate are multiplexed into a higher bit-rate frame in SONET, synchronous TDM with interleaving is used. Name one advantage and one disadvantage of interleaving and explain why.

   Advantage: It becomes easy to add and remove individual frames of the lower-bit-rate stream.
   *Disadvantage: Hierarchical multiplexing at higher data rates is not possible; you need to demultiplex e.g. 3 STS-3 frames into 3*3 individual STS-1 frames in order to multiplex them again into 1 STS-9 frame.*

5. **[10 points]** In SONET, small bit rate adjustments can be made if the data rate of the payload is close to but slightly different from the user data rate of the STS level being used. If the payload's data rate is slightly lower, for instance, 1 byte needs to be left empty in each SONET frame for this transmission. Given that a data stream with a data rate of 49.530 Mbps is being carried by STS-1 frames, shown below, how many frames per second should leave one byte empty?

   *The user data rate of the STS-1 frame is (8 bits/byte * (90-4) bytes/row * 9 rows/frame * 8000 frames/s). This is equal to 49.536 Mbps. The difference is 6000 bits = 750 bytes. This is the number of bytes to be left empty each second. In other words, 750 frames out of every 8000 should carry 1 empty byte.*

6. **[10 points]** Explain the following ATM concepts and their relation to each other: Transmission path (TP), virtual path (VP), virtual circuit (VC). Describe how routing is performed by an ATM switch using VP and VC.

   TP: The actual connection, the physical link, in the ATM network.
   VP: The logical bundle of individual connections (VC); a number of VP may share a common TP.
   VC: The logical connection between two endpoints. They are bundled together to form a VP.
   Routing: The switch reads VPI/VCI in the ATM header of the incoming cell, matches them with the outgoing VPI/VCI in its routing table. Then the header is updated and the cell is switched to the outgoing link.

7. **[10 points]** ATM uses fixed-size cells (53 bytes) and asynchronous TDM, also known as "statistical multiplexing". These two features together eliminate two problems, one of which is associated with variable frame sizes and the other with synchronous TDM, at once. What are these two problems and how do ATM's features mentioned here solve these?

   Problem 1: Variable size frames make it difficult to shape and predict the data rate. Switches and routers become more complex when they have to deal with frames with different sizes. By having a fixed size for the frames, ATM simplifies header processing at switches/routers and introduces deterministic data rates.
   Problem 2: Synchronous TDM wastes available bandwidth as some of the time slots remain empty when there are users occupying those time slots but not sending any data. By employing "statistical multiplexing", ATM eliminates these empty slots, and the cells are "labelled" using the cell header.

8. **[10 points]** Network Address Translation (NAT), in its basic form, cannot support two internal hosts trying to connect to the same external IP address. There are two solutions to this problem. Explain these.

   Solution 1: The NAT router uses multiple external IP addresses. Two clients in the private network connecting to the same server on the Internet are then assigned different external IP addresses.
   Solution 2: In addition to the private IP addresses of the clients in the private network, the NAT router also keeps their port numbers in its routing table. This also helps a single computer to run multiple applications.

9. **[5 points]** What is the fundamental difference between IPv6 and IPv4 addresses? What is the motivation behind this? What are the address notations used? Answer by giving one example for each address type.

   IPv4 addresses have 32 bits = 4 bytes, and the notation is dotted decimal. (ex. 123.456.789.012)
   IPv6 addresses have 128 bits = 16 bytes, and the notation is hexadecimal, grouping the address into 8 blocks of 2 bytes separated by a colon. (ex. 12FC:0000:0000:0200:1234:5000:ABCD:0000) Addresses can be abbreviated. (ex. 12FC:0:0:200:1234:5000:ABCD:0 and further 12FC::200:1234:5000:ABCD:0)
   The motivation is that we simply ran out of addresses. $2^{32} \ll 2^{128}$.

10. **[10 points]** Use the network topology (with the cost of each link also given) shown in the diagram below. Start with the distance vector routing tables of nodes C and D. Assume that a new link with cost 2 is established between C and D. Show the updated version of C's table. Then, assume that C sends its updated table to D and show how D processes this information step-by-step and row by row to update its own table. Finally, show the updated version of D's table.

C's new table:

A	2	-
B	4	-
C	0	-
D	2	-
E	4	-

D's new table:

A	3	-
B	6	C
C	2	-
D	0	-
E	6	C

11. **[10 points]** Use once again the initial network topology shown in the diagram above (ignore all the routing tables). Assume that the whole topology is known to all the nodes after the flooding of the individual "link state" knowledge. Perform Dijkstra's shortest path tree algorithm, draw the tree step-by-step and derive the routing table for node B.

   B is the root. (A, C, E) enter the tentative list. Add E to the tree since it has the link with the least cost. E has no neighbours to be added to the tentative list, so continue with (A, C). C goes next on to the tree, linked only to B. Then goes A. The tentative list contains now only A's neighbour (D). Finally, D is taken from the list and added to the tree. The resulting tree is shown in the figure with thick lines.