

# ETSF05 – Internet Protocols

The questions in this exam give a total of **100** points. Minimum **60** points are needed to pass the exam. You get part of the points for a question if your answer is only partially correct.

Use all the time given to you. Choose your words carefully in order not to write vague answers; unclear, confused, and too generic answers will decrease your marks!

**Always motivate your answers, especially when they are calculation-based.**

You may use a pocket calculator if you want.

**Good luck!**

*Kaan & Jens*

## Questions

- [10 points]** A private network is connected to the Internet via a NAT router with a single global IP address. Two users in the private network want to upload a file to the same FTP server on the Internet at the same time. They run the same FTP client, and they use the same source port number. How does the NAT router handle this situation? Show what kind of information is kept in the NAT table and what needs to be changed in the IP packets sent to and received from the FTP server.
- [10 points]** Using the information given (in decimal) below, construct the IPv4 header, shown below, by filling in the fields (in hexadecimal). You can ignore the header checksum. Show your calculations.
  - There are no options in the header. The service type field is all zeroes.
  - The payload size is 1200 Bytes. The packet's identification number is 316.
  - It is the last fragment of an originally 4200 Bytes long payload. Set the flags accordingly.
  - The packet is allowed to go through 23 more routers. It contains a TCP segment (value = 6).
  - The source address is 173.194.32.33, and the destination address is 173.194.32.37.

VER 4 bits	HLEN 4 bits	Service 8 bits	Total length 16 bits	
Identification 16 bits			Flags 3 bits	Fragmentation offset 13 bits
Time to live 8 bits		Protocol 8 bits	Header checksum 16 bits	
Source IP address				
Destination IP address				
Option				

- [10 points]** A Go-Back-N system is using 8 bits to number its frame sequence. The sender's window size is set correctly to the maximum allowed.  $S_f = 151$  (first frame sent but not yet acknowledged),  $S_n = 190$  (next frame to be sent). Assume that the sender sends 100 more frames, and then ACK#180 is received. What are the new values of  $S_f$  and  $S_n$ ? Justify your answer.
- [10 points]** Point-to-Point Protocol (PPP) can be used to set up an Internet connection between a customer's computer and an ISP's system server. What are the phases of this connection setup? How many frames, excluding the data, are exchanged between the parties during this process?

*Continues overleaf...*

5. [20 points] Given the routing tables of routers A to F below:

A		
<i>d</i>	<i>c</i>	<i>n</i>
A	0	-
B	3	-
C	2	-
D	4	B
E	7	B
F	7	B

B		
<i>d</i>	<i>c</i>	<i>n</i>
A	3	-
B	0	-
C	2	-
D	1	-
E	4	-
F	4	D

C		
<i>d</i>	<i>c</i>	<i>n</i>
A	2	-
B	2	-
C	0	-
D	3	B
E	6	B
F	6	B

D		
<i>d</i>	<i>c</i>	<i>n</i>
A	4	B
B	1	-
C	3	B
D	0	-
E	4	F
F	3	-

E		
<i>d</i>	<i>c</i>	<i>n</i>
A	7	B
B	4	-
C	6	B
D	4	F
E	0	-
F	1	-

F		
<i>d</i>	<i>c</i>	<i>n</i>
A	7	D
B	4	D
C	6	D
D	3	-
E	1	-
F	0	-

*d* = destination; *c* = cost; *n* = next hop

5.1. Draw the network graph, showing all the routers and the links with their link costs.

Now, let a new router G to be added to the network, advertising the link state information below. Assume that all routers have received the new piece of information.

G	
<i>c</i>	<i>n</i>
1	C
3	E

*c* = cost; *n* = next hop

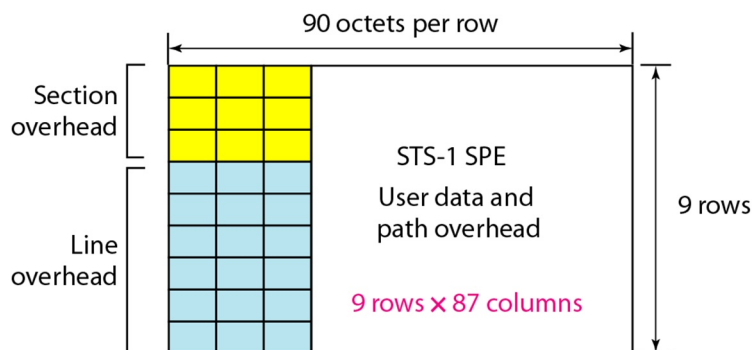
5.2. Run Dijkstra's algorithm on router E after the addition of the new router G, showing step by step how E's least cost tree is built. Show E's updated routing table.

6. [15 points] The efficiency of a communications system can be defined as the percentage of user data contained in the total data being transmitted. In this regard, calculate the efficiency of the following two time division multiplexing (TDM) systems. Justify your answers.

6.1. Synchronous TDM with 12 incoming links. 6 of these links are idle all the time, so only 6 links are active. The outgoing link uses 1 byte slots, and there is an extra synchronisation byte per frame.

6.2. Asynchronous TDM with 12 incoming links. On the average, only 6 of these links are used at the same time, so there are only 6 slots of 1 byte in each outgoing frame, and 3 address bits per slot.

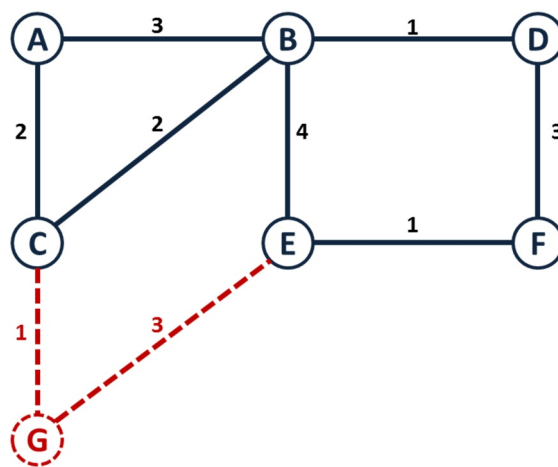
7. [10 points] In SONET, small bit rate adjustments can be made if the *payload data rate* is close to but slightly different from the *user data rate* of the STS level being used. If the payload data rate is lower, for instance, 1 byte needs to be left empty in each SONET frame for this transmission. If it is higher, on the other hand, one of the overhead fields (H3) can be used to carry an extra byte in each frame. Assume we are using STS-1, and calculate the minimum and maximum of the payload data rate that can be supported with this method. Use the figure below for help if you need.



8. [15 points] ATM networks are called "virtual circuit networks"; they set up a virtual circuit, which does not change for the whole duration of a connection, between the source and the destination. All ATM cells belonging to the same connection are routed by ATM switches through this virtual circuit. Still, we need a network layer protocol like IP, and we need IP addresses. Why?

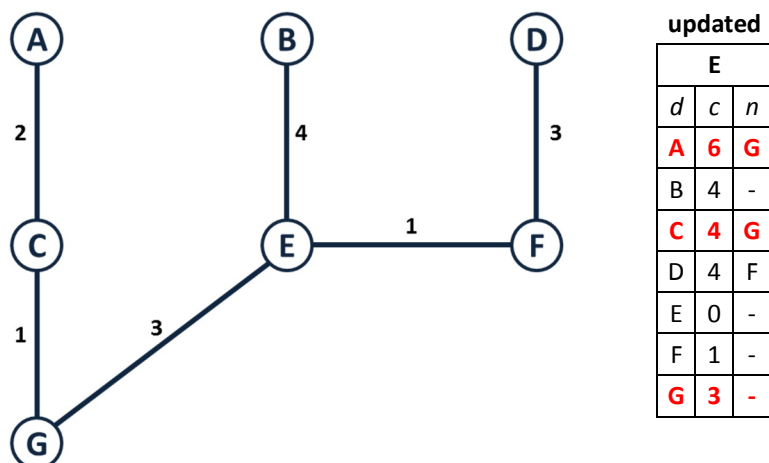
## Answers

- The NAT router assigns unique global source ports to each outgoing connection request from the private network. It keeps these port numbers in its translation table, which looks like this: [private source IP | private source port | global source port | global destination IP | global destination port | protocol]. When request packets arrive from the private clients, private source IP is replaced by global source IP of the NAT router, and private source port by global source port created by the NAT router. When responses arrive from the FTP server, the NAT router checks its translation table and matches the incoming packet's destination port with the port number it created previously. Then, it replaces the destination port number and IP with the private values it reads from the matching row.
- [4 | 5 | 00 | 04C4 | 013C | 0 | 177 | 17 | 06 | 00B7 | AD C2 20 21 | AD C2 20 25]
- $S_{n,new} = (S_{n,old} + 100) \bmod 256 = (190 + 100) \bmod 256 = 34$ .  $S_{f,new} = 180$ .
- Connection establishment (2 LCP frames), authentication (2 PAP or 3 CHAP frames), network layer configuration (2 IPCP frames for IP), open (data transfer), connection termination (2 LCP frames).
- The solid lines denote the initial network topology and the dotted lines the one after the change.



**[You can show the algorithm's iterations graphically. There's no need to describe in writing.]**

Node E builds its least cost tree as follows: ① Make (E) root. Add (B, F, G) to temporary list. Check path costs. ② Add (F) to tree since it has the least cost of 1, and remove it from temporary list. Add (D) to temporary list with path cost 1+3. Compare all costs on temporary list (B, D, G). ③ G wins; it has the least cost. Remove (G) from temporary list, add to tree. Add (C) to temporary list with path cost 3+1. Compare all costs on temporary list (B, C, D). All costs are 4, pick one arbitrarily. ④ Add (B) to tree; remove it from temporary list. Add (A) to temporary list with path cost 4+3. Compare all costs on temporary list (A, C, D). Pick (C) or (D); they both have cost 4. ⑤ Add (D) to tree via (F); remove it from temporary list. Nothing to add to temporary list (A, C); compare all costs. ⑥ (C) wins. Add (C) to tree via (G); remove from temporary. Update cost of (A) to 3+1+2 since it is lower than 4+3. ⑦ Add (A) to tree via (C); remove from temporary list, which is now empty, which means we can stop.



6. In synchronous TDM, the frame size is  $(12 * 1 + 1)$  Bytes = 13 Bytes, with only 6 Bytes of user data in each frame. The efficiency is  $6/13$ . In asynchronous TDM, the slot size is  $(8 + 3)$  bits = 11 bits, with only 8 bits of user data per slot. The efficiency is  $8/11$ .
7. The *user data rate* of STS-1 is  $(8 \text{ bits/Byte} * (90-4) \text{ Bytes/row} * 9 \text{ rows/frame} * 8000 \text{ frames/s})$ . This is equal to 49.536 Mbps. The adjustment method allows us to send 1 Byte more or 1 Byte less per frame, which is  $(8 \text{ bits/Byte} * 8000 \text{ frames/s})$ . This is equal to 0.064 Mbps. So, the *payload data rate* can be  $(49.536 \pm 0.064)$  Mbps.
8. ATM virtual circuits (VC) and virtual paths (VP), making up the virtual connection, have only local meaning, i.e. they are defined locally at each switch, and the values are edited in the ATM cell headers as these travel through the network. To be able to set up an end-to-end virtual connection using the VCI and VPI values, we still need a higher-level addressing scheme. In addition, ATM is a WAN technology, so the LANs at both ends of the WAN also need a meaningful address. IP addresses provide this global, computer-to-computer connection.