Note! The problem set consists of two parts:

- ***Part I: The problem specifications pages***
- ***Part II: The answer pages***

Part I: The problem specifications

NTNU
The Norwegian University of
Science and Technology
Department of Telematics

English (original)

Contacts during the exam:

Name: Yuming Jiang, Leif Arne Rønningen
Tlf.: 92643817 (Yuming) 73592665 (Leif Arne);
The exam rooms will be visited in the time period between 10am and 12am.

Exam in course:

"TTM4100 COMMUNICATION – SERVICES AND NETWORKS"

18. May 2007
09:00 – 13:00

Grading results 10. June 2007
(This is the date for sending the results from the Department of Telematics to the Student and Academic Division of NTNU)

Remedies:
D: No printed or handwritten remedies allowed.
Determined, simple calculator allowed.

Rules:

The problem set consists of two parts:

- Part I, the problem specifications pages (numbered pages 1 to 12), defines the rules to follow and the questions to be answered.
- Part II, the answer pages (numbered pages 1 to14), includes "Written text" fields and the answer alternatives for multiple-choice. The rules must be followed when answering the questions. Part II also includes 3 pages where you may give comments related to *formal issues* about Part I or Part II, or the exam in general. These pages may also be used for "Written text" answers. The sensors will read and decide how to use the comments.

The answer pages (Part II) shall be delivered as your answer. Two copies of Part II are handed out. Only one copy shall be delivered as your answer.

The student number should be written on all answer pages (Part II) ***with digits.***
Follow the rules below to avoid wrong interpretations.

Use blue or black ballpoint-pen, ***not a pencil.***

Check the boxes as clear as you can, like this: ☒

If you check the wrong box, fill it completely, like this: ■

Then check the correct box.

Other correction methods, e.g. use of eraser, correcting fluid, etc., are not permitted

Do not write outside the box fields or the student number fields.

Score

The maximum score for the exam is 100 points. A sub-problem has a defined maximum score X points. A sub-problem may be defined by using various types of box fields. In this exam we mainly have two different types of box fields:

- **Written text**. *A sub -problem shall be answered by Written text. In that case the answer shall be written in the supplied marked box in the answer page. The answer can give from 0 to max X points .*
- **True or False***: Check one box per statement, or do not check.*
  If 'True' and 'False' both are checked for a statement, it counts as an incorrect mark. If the sub-problem has M statements and the maximum score for this sub-problem is X points, then the resulting score is calculated as follows:

  $$Points = dif * \frac{X}{M}$$

  , where "dif" is the difference between the number of correct marks and the number of "discounts points" and where "discount points" are found from the Table below.

number of incorrect marks	***discount points***
1	*0*
2	*1,5*
i >= 3	*i*

Formally we have: dif =Max{(number of correct marks – discount points), 0},

This mapping between incorrect marks and discount points allows you to guess wrong once without being punished.

Note that the True or False problem does not give incorrect marks if you do not check any of the two boxes for a given statement.

1. “True” or “False” questions. (60 points)

1.1 Protocol Hierarchy and Miscellaneous (10 points)

(Check in the answer page the ‘True’ or the ‘False’ box, or do not check, for each statement.)

1.1.1	When a data packet moves from the upper layer to the lower layers, headers are removed.
1.1.2	A Layer offering a connection-oriented service must use a connection-oriented protocol.
1.1.3	Under the layering protocol hierarchy, the Physical Layer talks to the Network Layer directly.
1.1.4	The Network Layer is responsible to provide reliable end-to-end transmission.
1.1.5	Television broadcast is an example of half-duplex transmission.
1.1.6	A network’s logical topology must be the same as its physical topology.
1.1.7	Connection-oriented service is not always reliable.
1.1.8	A protocol is the set of rules that determine the behavior between entities on adjacent layers, i.e. between entities on (N+1)-layer and (N)-layer.
1.1.9	In protocol hierarchy, if the Link Layer uses a connection-oriented protocol, then the Network Layer must also use a connection-oriented protocol.
1.1.10	Packet switching based on datagram never loses packets.
1.1.11	Circuit switching gives higher variation in the end-to-end transfer time than packet switching.
1.1.12	In a network with 20 computers, mesh physical topology requires the most extensive cabling than other topologies.
1.1.13	A point-to-point connection provides a dedicated link between two devices.
1.1.14	The Internet Protocol (IP) is a connection-oriented protocol.
1.1.15	Circuit switching never wastes transmission channel capacity.
1.1.16	In a packet switching network, assume that all packets have the same length and the queuing delay is ignored. Then, for the connection-oriented service, the connection setup time is always longer than the transfer time of a packet from the sender to the receiver.
1.1.17	SMS (short message service) is supported in a digital subsystem of the GSM system and voice telephony is supported in an analogue subsystem of the GSM system.
1.1.18	In a GSM system, after the registration phase is over, a subscriber A’s HLR (Home Location Registry) has a pointer/reference to A’s current VLR (Visiting Location Registry).
1.1.19	In the Norwegian requirement for public safety network, the requirement for 2-party real time video calls is stated to be more important than the support for group call communication.
1.1.20	In both GSM and TETRA the authentication works such that: The terminal is authenticated by the network, and the network is authenticated by the terminal.

1.2. Physical Layer (10 points)

(Check in the answer page the 'True' or the 'False' box, or do not check, for each statement.)

1.2.1	A digital signal must be sent over a digital channel.
1.2.2	A modem converts a serial stream of bits to a modulated analog carrier signal.
1.2.3	The baud rate of a signal can be lower than the bit rate.
1.2.4	A cosine signal contains all the frequency components necessary to represent a digital signal as a sequence of square pulses.
1.2.5	Frequency modulation must be used alone.
1.2.6	Amplitude modulation can be used together with phase modulation.
1.2.7	Wavelength division multiplexing is a variation of frequency division multiplexing.
1.2.8	Consider a noiseless 4KHz channel. The maximum data rate achieved by the channel can be higher than 128 kbits/sec.
1.2.9	A signal coming out of a low-pass filter of bandwidth H can be completely reconstructed by making 2H samples per second.
1.2.10	The twisted pair cable suffers from at least three problems: attenuation, delay distortion, and noise.
1.2.11	Shannon theorem on data rates takes noise into account.
1.2.12	Consider the maximum data rate that can be achieved by a noisy channel. The rate calculated from the Shannon theorem is always smaller than the rate calculated from the Nyquist theorem.
1.2.13	The essential difference between message switching and packet switching is that a message can be arbitrarily long in message switching, while packet switching has a maximum packet size.
1.2.14	A network can be wireless but not mobile.
1.2.15	In a mobile phone system, when a mobile user crosses the boundary from one cell to another, the current call can be terminated, even though all the transmitters and receivers are functioning properly.
1.2.16	For a mobile phone system, hard handoff provides better service than soft handoff.

1.3. Link Layer (10 points)

(Check in the answer page the 'True' or the 'False' box, or do not check, for each statement.)

1.3.1	Asynchronous framing can be used with synchronous transmission.
1.3.2	Bit-stuffing in the link layer is required to support framing synchronization in bit-oriented protocols.
1.3.3	A CRC (Cyclic Redundancy Check) check detects all errors.
1.3.4	Error control based on odd parity means that a parity bit is added so that the number of '1's is odd.
1.3.5	Assume a code with a Hamming distance H=17. The maximum number of errors that can be corrected is 4.
1.3.6	Generator polynomials are used in CRC to generate checksums for error detection. The generator polynomials used by the sender and the receiver must be the same.
1.3.7	Suppose a parity bit is used to detect single bit errors in a bit-string of 7 bits. If **even parity** is used and the controlled bit-string has the value **0110101**, then the value of the parity bit is **1.**
1.3.8	Dividing binary value 10011110 by 1001 gives a remainder of 100.
1.3.9	The throughput of Slotted ALOHA approaches 1.0 when the offered traffic approaches infinity.
1.3.10	The Preamble of an Ethernet MAC frame is used to synchronize the receiver's clock with the sender's.
1.3.11	Consider a complete set of codewords: **00000000**; **00110011**; **11001100**; **11111111**. Then, the Hamming distance of this complete code set **is**:5.
1.3.12	The byte 10011111 is transmitted using the standard CRC method using the generator polynomial $\mathbf{x^3 + 1.}$ Then, the transmitted bit stream has bit pattern 0110000011.
1.3.13	To detect *d* single bit errors in any codeword from a set of legal codewords, the Hamming distance of the set of codewords needs to be at least (d + 1).
1.3.14	The LLC (Logical Link Control) sub-layer adapts the Data link layer to the Physical layer.
1.3.15	Bridges use IP addresses to route frames to their destinations.
1.3.16	Manchester encoding ensures that every bit period has a transition at the start of the bit period.
1.3.17	Hubs use the frame destination address to route frames to their destination.
1.3.18	In VLANs (Virtual Local Area Network) the logical topology is decoupled from the physical topology.
1.3.19	Character-stuffing (or byte-stuffing) is a mechanism used to make a sequence of characters easy to remember by the network user.
1.3.20	Wireless LANs using the PCF (Point Coordination Function) mode use a base station to control all activity in its cell.

1.4. Network Layer (10 points)

(Check in the answer page the 'True' or the 'False' box, or do not check, for each statement.)

1.4.1	A network layer service can be both connectionless and unreliable.
1.4.2	A network layer service can be both connection-oriented and reliable.
1.4.3	A sink tree for routing contains loops.
1.4.4	Distance vector routing always converges slowly in constructing the sink tree.
1.4.5	With network layer service, the transport layer should not need to know anything about the number of subnets or the type or topology of the subnets.
1.4.6	The network layer uses the end-to-end service offered by the data link layer.
1.4.7	The network layer service should be independent of the underlying network technology.
1.4.8	Network layer addresses should be global and uniform.
1.4.9	Adaptive routing adapts to topology changes of the network.
1.4.10	Datagrams require routers to remember what connections they belong to.
1.4.11	With IP, there is no guarantee that the packets will arrive in the right sequence.
1.4.12	Datagrams typically consume more bandwidth than the virtual circuit when transmitting the same amount of data.
1.4.13	A virtual circuit is more robust concerning network errors because it knows the destination of the packets.
1.4.14	The optimality principle for routing states that if router B is on the optimal path from router A to router C, then the optimal path from B to C also falls along the same route.
1.4.15	”Best effort” means that the source uses retransmission if necessary.
1.4.16	In the Internet, packets are sent independently and can use different routes through the network.

1.5. Transport Layer (10 points)

(Check in the answer page the 'True' or the 'False' box, or do not check, for each statement.)

1.5.1	To establish a connection, the initial sequence numbers of both the sender and the receiver must be the same.
1.5.2	Asymmetric and symmetric releases must be used together to release a connection.
1.5.3	Transport addresses are needed only for connection-oriented transport connections.
1.5.4	With symmetric release, data loss can be completely avoided.
1.5.5	Piggybacking in flow control helps make use of the connection more efficiently.
1.5.6	In sliding window flow control, both the sender window and the receiver window must have the same fixed window size all the time.
1.5.7	In general, sliding window flow control is more efficient in utilizing the connection capacity than stop-and-wait flow control.
1.5.8	Normally, transport layer protocol data units are processed only by end hosts.
1.5.9	In the Go-back-N error control, if an error protocol data unit (PDU) is found, the receiver discards all the PDUs with sequence numbers higher than the error PDU, until it is resent and received correctly.
1.5.10	In the Selective-Repeat error control, if an error PDU is found, the receiver is allowed to accept and buffer the PDUs following it.
1.5.11	In both flow control and error control, timeout timers are needed to ensure their proper functioning.
1.5.12	TCP provides message stream transport service.
1.5.13	TCP is a connection-oriented protocol.
1.5.14	UDP is a connectionless protocol.
1.5.15	All transport layer protocols must perform error control.
1.5.16	The Transport Layer hides transport service users from the detailed information such as technology, design and implementation of the communication subnet.

1.6. Application Layer (10 points)
(Check in the answer page the 'True' or the 'False' box, or do not check, for each statement.)

1.6.1	DNS uses a flat address hierarchy.
1.6.2	A web browser can use only one HTTP/TCP connection at one time.
1.6.3	A proxy server must be located on the same place as the web server.
1.6.4	Dynamic Web documents at the server site are created when they are requested by clients.
1.6.5	New domains can be made without any specific permission.
1.6.6	An e-mail system is made up of user agent and mailbox subsystems.
1.6.7	An e-mail delivered through the network is made up of 3 parts that are envelope, header and body.
1.6.8	E-mail does not use DNS.
1.6.9	TELNET is a transport layer protocol.
1.6.10	POP3 (Post Office Protocol Version 3) removes messages from the mail server.
1.6.11	A browser plug-in runs as an internal part of the browser software.
1.6.12	SMTP (Simple Mail Transfer Protocol) can not be used between mail servers.
1.6.13	A machine with a single DNS name can have multiple IP addresses.
1.6.14	A computer can have two DNS names that fall in different top-level domains.
1.6.15	Webmail does not use either POP3 or IMAP (Internet Message Access Protocol).
1.6.16	A domain name can be absolute or relative.
1.6.17	Error Resilience is the capability to continue decoding even when the received media stream contains errors.
1.6.18	A VoIP session can only be initiated by an IP "telephone".
1.6.19	TCP is always a preferred transport layer for live streaming media because it ensures that the content is transported to the client without error.
1.6.20	The Real Time Protocol contains timestamp and sequence numbers to ensure that the decoder can synchronize audio and video.

2. Flow control is needed in communication networks. (15 points)

2.1 What is flow control?
2.2 Which Layer (or Layers) needs (or need) flow control? Explain why.
2.3 Explain stop-and-wait flow control.
2.4 Discuss two disadvantages or problems of stop-and-wait flow control.
2.5 Assume the propagation delay between the send and receiver is 1ms. What is the maximum data rate that can be achieved by stop-and-wait flow control?

3. DNS (Domain Name System) is used in the Internet. (9 points)

3.1 Explain why DNS is needed for the Internet, and give two Internet applications that use DNS.
3.2 Internet DNS uses UDP instead of TCP. If a DNS packet is lost, there is no automatic recovery. Does this cause a problem? Why?
3.3 The Internet DNS name space is divided into zones. Normally how many DNS servers are used for a zone? Why?

4. The Data Link Layer is divided into two sub-layers: Logical Link Control (LLC) sub-layer and Medium Access Control (MAC) sub-layer. (4 points)

4.1 Explain why the MAC sub-layer is needed.
4.2 Explain how CSMA/CD (carrier sense multiple access / collision detection) works.

5. A router has the following (classless inter-domain routing) entries in its routing table:

Address/mask	Next hop
135.46.56.0/22	Interface 0
135.46.60.0/22	Interface 1
192.53.40.0/23	Router 1
Default	Router 2

For each of the following IP addresses, what does the router do if a packet with that address arrives? (5 points)

(a) 135.46.63.10
(b) 135.46.57.14
(c) 135.46.52.2
(d) 192.53.40.7
(e) 192.53.56.7

6. In mobile phone systems, a geographic region is divided into cells. (4 points)

6.1 Explain why frequencies are often reused in mobile phone systems.
6.2 In a typical mobile phone system with hexagonal cells, it is forbidden to reuse a frequency band in an adjacent cell. If 840 frequencies are available for the system, how many can be used in a given cell? Explain how you get the number.

7. Payment in GSM and PSTN systems. (3 points)

In this part of the exam, we use the following logical names:

- Fixed subscribers are named logically with names starting with Z,
- Mobile subscribers are named logically with names starting with X1 or X2

Assume that

- X1N and X2N are subscribing to GSM in Norway at OpM1N, and OpM2N respectively.
- Z is subscribing to PSTN in Norway at OpFZN.
- The same person Ola is behind both subscriptions of ZN and X2N.
- *Each subscription is independent*, so that each subscription gets a separate invoice, in particular
    - The invoices and payment related to the subscriptions ZN and X2N are regarded as different (even though both will be paid by the same person Ola in the end).
- The supplementary services in use are CFU (call forwarding unconditional) and CFNR (call forwarding on mobile subscriber not reachable). [1]

Assume that both X1N and X2N are 'at home' (in the technical sense), i.e. located in the PLMN (public land mobile network) service area of own operator.

Assume also that Ola is out on a trip in the neighbouring city, and for this reason Ola made it so that the subscription related to ZN activated CFU to X2N's mobile phone.

Assume now that X1N is calling ZN on his fixed phone so that the call will be forwarded to X2N's mobile phone.

7.1 Tell whether the following statement about billing is true or not, and explain:
X1N pays for a national call from mobile to fixed ('calling leg'), X2N pays for a national call from fixed to mobile ('mobile leg'), and ZN pays nothing.

[1] For those who know more about GSM than the curriculum: Prepaid is not in use. No IN/Camel-services are in use (IN is called MSN in the IEC tutorial). No subscription like 'Twin'/'Tvilling' or other services combining two subscriptions of one user is in use. UPT (Universal Personal Telephony) is not in use.