Note! The problem set consists of two parts:

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

Part I: The problem specifications

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English (original)

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The exam rooms will be visited in the time period between 10am and 12am.

Exam in course:

"TTM4100 COMMUNICATION – SERVICES AND NETWORKS"

23. May 2006
09:00 – 13:00

Grading results 14. June 2006
(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 13), defines the rules to follow and the questions to be answered.
- Part II, the answer pages (numbered pages 1 to12), 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. Principles of Switching (2+2+3+7=14 points)

(Write the answer as Written text in the box in the answer page for the question.)

1.1	Explain circuit switching. (2 points)

(Write the answer as Written text in the box in the answer page for the question.)

1.2	Explain packet switching. (2 points)

(Write the answer as Written text in the box in the answer page for the question.)

1.3	What are the differences between circuit switching and packet switching? (List at least 3 differences.) (3 points)

(Write the answer as Written text in the box in the answer page for the question.)

1.4	Compare the total delay in sending ***x*** bits of user data over a ***k***-hop path in a circuit-switched network and a packet-switched network. Here, the total delay is defined to be the time from the data starts to be delivered to the network till all the data bits have been received at the end of the path. For the packet-switched network, it is assumed that the network is lightly loaded and the queuing delay at each switching node is ignored, and in addition, the packet header size is ignored. For both networks, there is no loss. The circuit setup time is ***s*** second, the propagation delay is ***d*** second per hop, each packet contains ***p*** data bits, and the bit rate of the line on each hop is ***b*** bps. 1) What is the total delay, if the message is sent over the circuit-switched network? (3 points) 2) What is the total delay, if the message is sent over the packet-switched network? (3 points) 3) Under what condition does the packet-switched network have a lower delay? (1 points)

2. Protocol Hierarchy and Miscellaneous (6+5+5=16 points)

(Write the answer as Written text in the box in the answer page for the question.)

2.1	Explain the functionality of Layer 2, Layer 3 and Layer 4 in the OSI Reference Model: 1) Explain the functionality of Layer 2. (2 points) 2) Explain the functionality of Layer 3. (2 points) 3) Explain the functionality of Layer 4. (2 points)

(Write the answer as Written text in the box in the answer page for the question.)

2.2	Explain connection-oriented service and connectionless service: 1) Explain connection-oriented service. (2 points) 2) Explain connectionless service. (2 points) 3) What is the principal difference between connection-oriented service and connectionless service? (1 point)

2.3. Which of the following statements are true? (5 points)
(Check in the answer page the 'True' or the 'False' box, or do not check, for each statement.)

2.3.1	A Layer offering a connectionless service must use a connectionless protocol.
2.3.2	A Layer offering a connection-oriented service must use a connection-oriented protocol.
2.3.3	The Network Layer directly provides information to the user of an Application Layer service.
2.3.4	A protocol architecture with a network layer using a connectionless network protocol must use a connection-oriented transport protocol.
2.3.5	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.
2.3.6	Circuit switching never wastes transmission channel capacity.
2.3.7	Connection-oriented service is always reliable.
2.3.8	A network's logical topology is always the same as its physical topology.
2.3.9	When a data packet moves from the upper layer to the lower layers, headers are added.
2.3.10	The physical layer is the layer closest to the transmission medium.

3. Application Layer (4+4+4+8=20 points)

3.1 Internet DNS (Domain Name System): Which of the following are true? (4 points)
(Check in the answer page the 'True' or the 'False' box, or do not check, for each statement.)

3.1.1	A domain name can be absolute or relative.
3.1.2	There is no overlap in the zones of a name domain.
3.1.3	DNS uses a flat address hierarchy.
3.1.4	DNS is used to map hostnames to IP addresses.
3.1.5	In DNS, only primary DNS servers can have cache.
3.1.6	New domains can be made without any specific permission.
3.1.7	Naming follows geographical boundaries.
3.1.8	Naming follows organizational boundaries.

3.2 Internet E-mail: Which of the following statements are true? (4 points)
(Check in the answer page the 'True' or the 'False' box, or do not check, for each statement.)

3.2.1	An e-mail system is typically made up of two subsystems that are user agents and message transfer agents.
3.2.2	An e-mail delivered through the network is made up of 3 parts that are envelope, sender filed and receiver field.
3.2.3	E-mail does not use DNS.
3.2.4	SMTP (Simple Mail Transfer Protocol) is a simple ASCII protocol.
3.2.5	POP3 (Post Office Protocol Version 3) always keeps email messages in the mail server.
3.2.6	IMAP (Internet Message Access Protocol) always moves messages from the mail server to the user's computer.
3.2.7	IMAP makes it possible for the user to manage several mailboxes in the server.
3.2.8	Webmail systems require server-side dynamic Web page generation.

3.3 HTTP (Hypertext Transfer Protocol) and WWW (World Wide Web): Which of the following statements are true? (4 points)
(Check in the answer page the 'True' or the 'False' box, or do not check, for each statement.)

3.3.1	A browser plug-in runs as an internal part of the browser software.
3.3.2	URL is short for Uniform Resource Locator.
3.3.3	A URL always starts with http://
3.3.4	Dynamic Web documents at the server site are created when they are requested by clients.
3.3.5	A proxy server is always located on the same place as the web server.
3.3.6	HTML is a language used for writing Web pages.
3.3.7	HTTP must use TCP.
3.3.8	HTTP is a request / response based protocol.

3.4 Multimedia: Internet telephony using H.323 (8 points)

Figure 1 shows an architectural model for Internet telephony. The PC calls a remote Telephone. Fill in one mark per column in the answer pages to show the sequence of the following Messages/packets/signals/sub-sequence:

Messages/packets/signals/sub-sequence

Q.931 Telephone call
H.225 RAS Admission
H.225 RAS (Registration/Admission/Status)
Q.931 CALL PROCEEDING
H.245 Negotiation of call parameters
Q.931 ALERT
H.225 Gatekeeper Discovery
H.225 Response to Gatekeeper Discovery
H.225 Response to RAS
H.225 Response to RAS Admission
H.225 Establish TCP connection
Q.931 SETUP
Q.931 CONNECT
N.245 Setup of data RTP channels

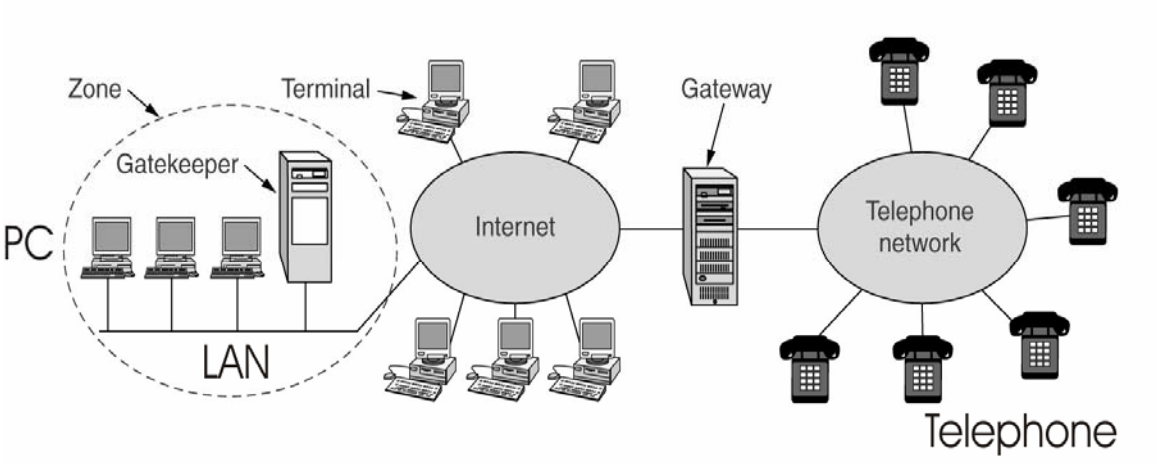

Figure 1 . The H.323 architectural model for Internet telephony

*(Check in the table in the answer page. Only **one mark per column**; **more than one mark per row is allowed**.)*

4. Transport Layer (5+5+8=18 points)

(Write the answer as Written text in the box in the answer page for the question.)

4.1	Discuss the problems and solutions related to connection release in TCP. (5 points)

(Write the answer as Written text in the box in the answer page for the question.)

4.2	What is flow control? Explain how stop-and-wait flow control works. (5 points)

4.3 Which of the following statements are true? (8 points)

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

4.3.1	Normally, transport layer protocol data units (TPDUs) are processed only by end hosts.
4.3.2	The Transport Layer hides transport service users from the detailed information such as technology, design and implementation of the communication subnet.
4.3.3	The transport address alone is sufficient for establishing a connection between two hosts.
4.3.4	To establish a connection, the initial sequence numbers of both the sender and the receiver must be the same.
4.3.5	The three-way handshake method can be used to establish connections.
4.3.6	Asymmetric release can cause data loss.
4.3.7	Asymmetric and symmetric releases must be used together to release a connection.
4.3.8	Flow control is needed because the sender may not have enough data to send.
4.3.9	In sliding window flow control, both the sender window and the receiver window must have the same fixed window size all the time.
4.3.10	In general, sliding window flow control is more efficient in utilizing the connection capacity than stop-and-wait flow control.
4.3.11	In general, the Selective-Repeat error control allows better use of the connection capacity than the Go-back-N error control.
4.3.12	All transport layer protocols must perform error control.
4.3.13	In both flow control and error control, timeout timers are needed to ensure their proper functioning.
4.3.14	UDP is a connectionless protocol.
4.3.15	Since the transport service provided by UDP is unreliable, there is no need to use UDP.
4.3.16	TCP provides message stream transport service.

5. Network Layer (3+7=10 points)

(Write the answer as Written text in the box in the answer page for the question.)

5.1	What is the optimality principle for routing? (3 points)

5.2 Which of the following statements are true? (7 points)
(Check in the answer page the 'True' or the 'False' box, or do not check, for each statement.)

5.2.1	The network layer service should be independent of the underlying network technology.
5.2.2	The network layer can only be connection-oriented.
5.2.3	The network layer service must always be reliable.
5.2.4	Network layer addresses should be global and uniform.
5.2.5	Network layer offers routing.
5.2.6	A sink tree for routing contains loops.
5.2.7	Distance vector routing always converges quickly in constructing the sink tree.
5.2.8	In a link state routing protocol, each router needs to discover its neighbors and their network addresses, measure the delay or cost to each of its neighbors, tell all other routers this discovered and measured information, and compute the shortest path to every other routers.
5.2.9	Adaptive routing adapts to topology changes of the network.
5.2.10	Datagrams require routers to remember what connections they belong to.
5.2.11	Datagrams have longer set-up time than virtual circuits.
5.2.12	A virtual circuit is more robust concerning network errors because the network knows the destination of the packets.
5.2.13	With IP, there is no guarantee that the packets will arrive in the right sequence.
5.2.14	With IP, there is no guarantee that the packets will arrive at all.

6. Data Link Layer (2+4+8 = 14 points)

(Write the answer as Written text in the box in the answer page for the question.)

6.1	Consider a complete set of codewords: **00000000**; **00110011**; **11001100**; **11111111**. What is the Hamming distance of this complete code set? (2 points)

6.2 Which of the following statements are true? (4 points)
(Check in the answer page the 'True' or the 'False' box, or do not check, for each statement.)

6.2.1	Link Layer Framing gives an agreement on synchronization points in the stream of bits received from the physical layer.
6.2.2	Character-stuffing (or byte-stuffing) is a mechanism used to make a sequence of characters easy to remember by the network user.
6.2.3	A CRC (Cyclic Redundancy Check) check detects all errors.
6.2.4	In CRC, the generator polynomials G(x) used by the sender and the receiver do not need to be the same.
6.2.5	Suppose a parity bit is used to detect single bit errors in a bit-string of 7 bits. If **odd parity** is used and the controlled bit-string has the value **0100101**, then the value of the parity bit is **1.**
6.2.6	Assume error control based on CRC and a generator pattern G of g bits. Also, assume that the length of the frame F to be error controlled is f bits. Then, the length of the transmitted frame with error check pattern is $(f + g - 1)$ bits.
6.2.7	Dividing binary value 10011111 by 1001 gives a remainder of 101.
6.2.8	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 $(d + 1)$.

6.3. MAC (Medium Access Control) Sub-Layer: Which of the following statements are true? (8 points)
(Check in the answer page the 'True' or the 'False' box, or do not check, for each statement.)

6.3.1	The throughput of Slotted ALOHA approaches 1.0 when the offered traffic approaches infinity.
6.3.2	Manchester encoding ensures that every bit period has a transition at the start of the bit period.
6.3.3	The Preamble of an Ethernet MAC frame is used to synchronize the receiver's clock with the sender's.
6.3.4	The binary exponential backoff algorithm behaves such that after i collisions each station always waits 2^i -1 slots before trying to send again.
6.3.5	The Gigabit Ethernet feature 'frame bursting' is introduced to extend the radius of the network.
6.3.6	The LLC (Logical Link Control) sub-layer adapts the Data link layer to the Physical layer.
6.3.7	Wireless LANs using the PCF (Point Coordination Function) mode use a base station to control all activity in its cell.
6.3.8	See Figure 2. If A's ACK timer expires before the ACK frame from B is received, A starts with a new RTS.
6.3.9	See Figure 2. Since the first RTS is not addressed to C, C may not use the information in the RTS frame.
6.3.10	See Figure 2. Since D does not hear the RTS from A, it cannot assert the virtual channel busy.
6.3.11	Hubs use the frame destination address to route frames to their destination.
6.3.12	Bridges use IP addresses to route frames to their destinations.
6.3.13	Switches use frame addresses to route frames to their destination.
6.3.14	In VLANs (Virtual LAN) the logical topology is decoupled from the physical topology.
6.3.15	A number of computers can be organized into VLANs using switches or bridges.

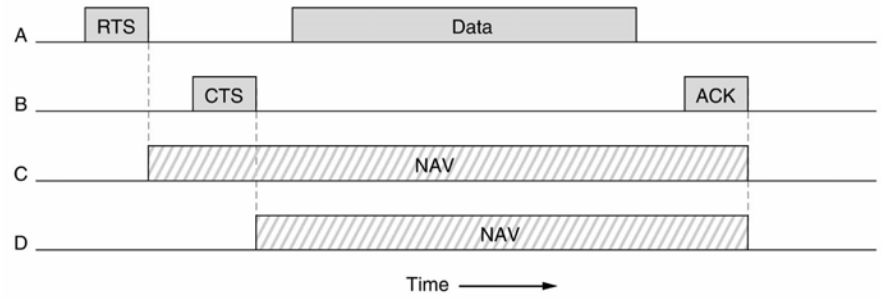

Figure 2. The use of virtual channel sensing using CSMA/CA

7. Physical Layer (2.5+2.5 = 5 points)

Note: The Nyquist theorem for a noiseless channel with bandwidth *H* Hz tells that the maximum data rate that can be achieved by the channel is: maximum data rate=$2H\log_2 V$ bits/second, where *V* is the discrete level of the signal on the channel. For a noisy channel whose bandwidth is *H* Hz and signal-to-noise ratio is *S/N*, Shannon's theorem tells that the maximum data rate that can be achieved by the channel is given by: maximum data rate=$H\log_2(1+S/N)$ bits/second.

7.1 Suppose a **binary** signal is sent over a channel with bandwidth *H*=4K Hz, whose signal-to-noise ratio is 20 dB, where the decibel (dB) of a quantity *S/N* is given by $10\log_{10}(S/N)$. Which of the following bit rates can be achieved by the channel? (2.5 points)
(Check in the answer page the 'True' or the 'False' box, or do not check. By checking 'True' in a box, it means the corresponding rate can be achieved.)

7.1.1	4 kbits/sec
7.1.2	8 kbits/sec
7.1.3	16 kbits/sec
7.1.4	64 kbits/sec
7.1.5	256 kbits/sec

7.2 A modem has a constellation diagram as shown in Figure 3 with data points at the coordinates: (1,1), (1,-1), (-1,1) and (-1,-1). Which of the following statements are correct? (2.5 points)
(Check in the answer page the 'True' or the 'False' box, or do not check, for each statement.)

7.2.1	The modulation applied is phase shift keying with constant amplitude.
7.2.2	The modem operates at 4 frequencies.
7.2.3	Assume a symbol rate at 2000 baud. Then, the maximum bit rate is 2000 bits/sec.
7.2.4	Assume a symbol rate at 2000 baud. Then, the maximum bit rate is 4000 bits/sec.
7.2.5	Assume a symbol rate at 2000 baud. Then, the maximum bit rate is 8000 bits/sec.

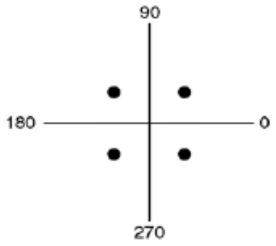

Figure 3. Modulation constellation diagram

8. Mobile Networks (3 points)

GSM: Global System for Mobile communications; FDM: Frequency Division Multiplexing; TDM: Time Division Multiplexing; CDMA: Code Division Multiple Access

8.1 Which of the following statements are true? (3 points)
(Check in the answer page the 'True' or the 'False' box, or do not check, for each statement.)

8.1.1	Mobile networks must be wireless networks.
8.1.2	A network can be mobile even if it is not wireless.
8.1.3	In a mobile phone system, frequencies may be re-used in different cells.
8.1.4	For mobile phone systems, hard handoff is always preferred to soft handoff.
8.1.5	GSM uses both FDM and TDM.
8.1.6	Mobile IP is based on CDMA.