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"

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(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 8), 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 choice-type questions. 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 Miscellaneous (10 points)

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

1.1.1	Packet switching employs statistical multiplexing.
1.1.2	A server program requests and receives services from a client program.
1.1.3	Each user on an Ethernet LAN can continuously transmit at the transmission rate of the Ethernet LAN.
1.1.4	A router only processes the Network layer in the Internet protocol stack.
1.1.5	When a data unit moves from the upper layer to the lower layers, headers are added.
1.1.6	When a wireless network is operating in infrastructure mode, its hosts are normally associated with a base station.
1.1.7	Before an 802.11 station transmits a data frame, it must first send an RTS (Request-to-Send) frame and receive a corresponding CTS (Clear-to-Send) frame.
1.1.8	TCP is always the preferred transport layer for live streaming media because it ensures that the content is transported to the client without error.
1.1.9	Circuit switching gives higher variation in the end-to-end transfer time than packet switching.
1.1.10	Connection-oriented service is always reliable.

1.2. Application Layer (10 points)

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

1.2.1	For a P2P file-sharing application, there is no notion of client and server sides of a communication session.
1.2.2	HTTP runs on top of TCP.
1.2.3	SMTP runs on top of UDP.
1.2.4	FTP sends control information out-of-band.
1.2.5	DNS (Domain Name System) is used to map hostnames to IP addresses.
1.2.6	DNS uses a distributed database implemented in a hierarchy of DNS servers.
1.2.7	Web caching cannot reduce the delay in receiving a requested object.
1.2.8	SMTP is used between mail servers in the Internet.
1.2.9	Only SMTP can be used between a user agent and a mail server.
1.2.10	POP3 servers do not carry state information across POP3 sessions.

1.3. Transport Layer (10 points)

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

1.3.1	UDP is a connectionless protocol.
1.3.2	When TCP is used, the TCP port number at the receiver side must be the same as the sender side.
1.3.3	To establish a TCP connection, the initial sequence numbers of both the sender and the receiver must be the same.
1.3.4	Flow control is needed because a sender may have too much data to send.
1.3.5	Transport layer protocol data units are processed by both routers and end hosts.
1.3.6	The sender is sending a large file to the receiver over a TCP connection. Assume the receiver has no data to send to the sender. Then, the receiver will not send acknowledgements to the sender because the receiver cannot piggyback the acknowledgements on data.
1.3.7	The sender is sending a large file to the receiver over a TCP connection. The number of unacknowledged bytes that the sender sends cannot exceed the size of the receiver buffer.
1.3.8	With the Selective-Repeat protocol, it is possible for the sender to receive an ACK for a packet that falls outside of its current window.
1.3.9	With the Go-Back-N protocol, it is possible for the sender to receive an ACK for a packet that falls outside of its current window.
1.3.10	TCP is a reliable protocol.

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	The Network Layer is responsible to provide reliable end-to-end transmission.
1.4.2	The network layer can only be connectionless.
1.4.3	In a packet-switched network, routers must remember what connection each packet belongs to.
1.4.4	The forwarding process of a router is responsible for transferring a packet from an incoming link to an outgoing link.
1.4.5	While forwarding is within a single router, routing involves all routers in a network.
1.4.6	A virtual circuit is more robust concerning network errors because it knows the destination of the packets.
1.4.7	In the Internet, a node may receive multiple copies of the same packet.
1.4.8	Each router only has one IP address.
1.4.9	With DHCP, a host may be assigned an IP address that is different each time the host is connected to the network.
1.4.10	NAT (Network Address Translation) is used to translate hostnames into IP addresses

1.5. Link Layer and LANs (10 points)
(Check in the answer page the 'True' or the 'False' box, or do not check, for each statement.)

1.5.1	If all the links in the Internet were to provide reliable delivery service, then the TCP reliable delivery service would be redundant.
1.5.2	Link layer also needs to provide flow control.
1.5.3	In CRC (Cyclic Redundancy Check), the generator polynomials used by the sender and the receiver need not be the same.
1.5.4	Dividing the binary value 10011100 by 1001 gives a remainder of 100.
1.5.5	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 **1110101**, then the value of the parity bit is **1.**
1.5.6	With half-duplex, a node cannot transmit and receive at the same time.
1.5.7	The slotted ALOHA protocol is more efficient than the pure ALOHA.
1.5.8	Hubs use the frame destination address to route frames to their destination.
1.5.9	Ethernet only provides connectionless service to the network layer.
1.5.10	Ethernet only provides unreliable service to the network layer.

1.6. Physical Layer, Wireless/Mobile Networks, & Multimedia Networking (10 points)
(Check in the answer page the 'True' or the 'False' box, or do not check, for each statement.)

1.6.1	A signal coming out of a low-pass filter of bandwidth H can be completely reconstructed by sampling at the rate of 2H.
1.6.2	Frequency modulation, amplitude modulation and phase modulation can be used together.
1.6.3	There is no limit on the maximum data rate that can be achieved by an ideal channel with no error.
1.6.4	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.
1.6.5	A binary signal with period T cannot be represented by a Fourier series with limited frequency elements.
1.6.6	It is impossible for a CDN (Content Distribution Network) to provide worse performance to a host requesting a multimedia object than if the host has requested the object directly from the distant origin server.
1.6.7	In order to maintain registration, SIP (Session Initiation Protocol) clients must periodically send REGISTER messages.
1.6.8	If stored video is streamed directly from a Web server to a media player, the application is using TCP as the underlying transport protocol.
1.6.9	With mobile IP, mobility does not affect end-to-end delays between the source and destination.
1.6.10	If a node has a wireless connection to the Internet, it has to be mobile.

2. Discuss why you think P2P (peer-to-peer) file-sharing applications are so popular. Is it because they distribute free data, music or video? Is it because they work more efficiently when there are a massive number of servers and a massive demand for large content files? Or, are there any other reasons? (5 points)

3. Explain the functionality of each of the five layers, i.e. Application, Transport, Network, Link, and Physical Layer. (10 points)

4. Consider a datagram network using 32-bit addresses. (10 points)

4.1 Suppose a router in the network has four links, numbered 0 through 3. Also suppose packets are to be forwarded to the link interfaces in the way as shown by the following table. Provide a forwarding table that has four entries, uses longest prefix matching, and forwards packets to the correct link interfaces.

Destination Address Range	Link Interface
11100000 00000000 00000000 00000000 through 11100000 11111111 11111111 11111111	0
11100001 00000000 00000000 00000000 through 11100001 00000000 11111111 11111111	1
11100001 00000001 00000000 00000000 through 11100001 11111111 11111111 11111111	2
Otherwise	3

4.2 Suppose in the network there is a router that interconnects three subnets: Subnet 1, Subnet 2, and Subnet 3. Suppose all of the interfaces in each of these three subnets are required to have the prefix 223.1.17/24. Also suppose that Subnet 1 is required to support up to 125 interfaces, and Subnet 2 and Subnet 3 are each required to support up to 60 interfaces. Provide three network addresses (of the form a.b.c.d/x) that satisfy these constraints.

5. Host A and Host B are communicating over a TCP connection, and Host B has already received from A all bytes up through byte 248. Suppose Host A then sends two segments to Host B back-to-back. The first and the second segments contain 40 and 60 bytes of data. In the first segment, the sequence number is 249, the source port number is 502, and the destination port number is 80. Host B sends an acknowledgement whenever it receives a segment from Host A. (9 points)

5.1. In the second segment sent from Host A to Host B, what are the sequence number, source port number, and destination port number?

5.2. If the first segment arrives before the second segment, in the acknowledgement of the first arriving segment, what are the acknowledgement number, the source port number, and the destination port number?

5.3. If the second segment arrives before the first segment, in the acknowledgement of the first arriving segment, what is the acknowledgement number?

6. Consider a broadcast channel with *N* nodes and transmission rate of *R* bps. (6 points)

6.1 Suppose the broadcast channel uses polling (with an additional polling node) for multiple access. Suppose the polling delay, which is the amount of time from when a node completes transmission until the subsequent node is permitted to transmit, is *d*. Suppose that within a polling round, a given node is allowed to transmit at most *Q* bits. What is the maximum throughput of the broadcast channel?

6.2 Suppose now the broadcast channel uses slotted ALOHA protocol for multiple access. The frame size is *L* bits and time is divided into slots of size *L/R* seconds. Suppose all nodes always have data frames to send, and each transmits in a slot with probability *p*. What is the probability that an arbitrary node has a successful transmission and what is the efficiency of the broadcast channel?