IK1203 Networks and Communication

Solutions

2018-03-16

Instructions

The exam consists of two sections: Section A (20 points) and Section B (16 points). Section A consist of 20 multiple choice questions, where every question has exactly one correct alternative. Each correct answer is worth one point. If you do not score at least 14 points on Section A, Section B will not be marked.

Submit your answers for Section A on the separate solution sheet labelled "Section A Solution Sheet".

Important: the exams are individual, and marked with a *grading code* that you should copy to the solution sheet. It is very important that you copy the grading code to your solution sheet; if you do not, Section A of your exam cannot be graded.

Section B consist of questions (typically worth 2 to 6 points each) where *answers are handed in on separate sheets, one answer per sheet.* Label each sheet with the question number and your name. Keep your solutions short and to the point.

This exam consists of 10 pages. Before you start, make sure that you have all pages.

Grading

The *preliminary grading scale* for this exam is as follows:

- grade A, at least 14 points on Section A, and 13 points on Section B
- grade B, at least 14 points on Section A, and 10 points on Section B
- grade C, at least 14 points on Section A, and 6 points on Section B
- grade D, at least 13 points on Section A
- grade FX, at least 12 points on Section A (changed to grade E upon completion of complementary assignment)
- grade F, less than 12 points on Section A

Tools

No tools allowed.

Grading code 1234

Copy the grading code to "Section A Solution Sheet", under "2 Grading code"

Section A

1. Which statement about the transport layer is correct?

   A. There are several different transport protocols on the Internet, and in order to use a certain transport layer protocol for communication between client and server, all IP routers between the client and the server must support that transport protocol.

   B. The transport layer is application-specific, meaning that each application has its own transport protocol.

   C. Transport protocols are often implemented in hardware, for instance on network interface cards.

   D. Transport protocols often reside in the operating system, and provide communication services to applications.

   Comment: Transport protocols are independent of applications and routers.

2. Consider a connection over a link where the signal propagation time is 2 ms. The link rate is 4 Mb/s. The sender transmits a packet with size 1000 byte. How long time does it take from that the sender starts the transmission until the receiver has received the whole packet?

   A. 2 ms.

   B. 4 ms.

   C. 12 ms.

   D. 16 ms.

   Comment: Let $L = 8 \times 10^3$ be the packet size (in bits) and $B = 4 \times 10^6$ the link rate (bits per second). The the transmission delay is L/B, which is 2 milliseconds. The total delay is the propagation delay plus the transmission delay: 4 milliseconds.

3. Suppose that you want to send an email message to a recipient on another computer. You write the message with an email client on your computer, and then you send the message. Which of the following statements describes best *what happens in the next step*?

   A. The email client opens an outgoing connection to the recipient's computer, and sends the email message over this connection.

   B. The configuation information on your computer includes, among other things, a server for outgoing mail. The email client opens a connection to this server, and sends the email message.

   C. The email client performs a DNS lookup to get the incoming mail server for the recipient's domain. The email client opens a connection to this server and sends the email message.

   D. The email client stores the message in a queue for outgoing email on your computer. At the same time, the email client opens a connection to the recipient's computer to inform it that there is a new email message from you. When the recipient wants to read the message, a connection is opened from the recipient's computer to your computer, and the email message is retrieved.

   Comment: Outgoing email is stored on an outgoing mail server, which takes care of the delivery.

4. You type the following into the navigation field of your web browser:

   ```
   http://www.lookupserver.org/search?key=help
   ```

   This results in an HTTP request sent to the server. The first line of the request is:

   ```
   GET <data> HTTP/1.1
   ```

   What is `<data>`?

   A. `http://www.lookupserver.org/search?key=help`

   B. `www.lookupserver.org/search?key=help`

   C. `search?key=help`

   D. `key=help`

   Comment:

5. Suppose that you use DNS (Domain Name System) to translate a hostname to an IP address. There is a local DNS server in the network where you are. You therefore send a DNS query to the local DNS server. Assume that the local DNS server does not have the answer to the query. What happens?

   A. The local DNS server replies with an error message.

   B. The local DNS server refers you to another DNS server.

   C. The local DNS server will send the query to one of the Internet's 13 root servers, which will then find out the answer for you.

   D. The local DNS server will send queries in a certain order to other DNS servers on the Internet, until a DNS server is found that can give the answer.

   Comment: The local DNS server will perform an iterative query where it queries DNS servers according to the Internet's domain tree structure, starting at the root of the tree.

6. A server that uses TCP communicates with five different clients at the same time. Assume that all TCP port numbers involved are different. How many port numbers are then used in total?

   A. 10

   B. 1

   C. 6

   D. 11

   Comment: One port per client (with dynamic or "ephemeral" port numbers) and one port on the server (with a well-known, pre-determined port number).

7. Study the Java code below for a communication application. (The code is simplified.)

```
ServerSocket listenSocket = new ServerSocket(9876);
while (true) {
    Socket connectionSocket = listenSocket.accept();
    BufferedReader inFromClient =
        new BufferedReader(new InputStreamReader(connectionSocket.getInputStream()));
    DataOutputStream  outToClient =
        new DataOutputStream(connectionSocket.getOutputStream());
    String request =  inFromClient.readLine();
    if (request != null) {
        String response = processRequest(request);
        outToClient.writeBytes(response);
    }
}
```

Which is the best description of the code?

A. A sequential UDP server.

B. A concurrent UDP server.

C. A concurrent TCP server.

D. A sequential TCP server.

Comment:

8. Which of the following statements about TCP congestion control is (most) correct?

A. With TCP congestion control, routers detect congestion and signal this back to the sender so that the sender can adapt the sending rate.

B. With TCP congestion control, the sender detects congestion based on missing ACKs, and the sender then adapts the sending rate.

C. With TCP congestion control, the receiver detects congestion and signals this back to the sender so that the sender can adapt the sending rate.

D. With TCP congestion control, the sender will send probe messages to measure how fast it can send without losing segments.

Comment:

9. Which of the following statements about TCP connections is (most) correct?

A. Closing a TCP connection normally requires only two segments to be exchanged between client and server.

B. Closing a TCP connection normally requires only three segments to be exchanged between client and server.

C. The first TCP segment sent during connection establishment is a TCP SYN.

D. The last TCP segment sent during TCP connection termination is a TCP FIN.

Comment:

10. Which of the following statements about UDP is (most) correct?

A. UDP is connectionless and offers a reliable data transfer.

B. UDP is connection-oriented and offers a reliable data transfer.

C. UDP is connection-oriented and offers an unreliable data transfer.

D. UDP is connectionless and offers an unreliable data transfer.

Comment:

11. Assume we have a transport level connection with a capacity of 4 Mbit/s and that the connection between sender and receiver has an RTT (Round Trip Time) of 4 ms. Which is the optimal window size the sender should use?

A. 20000 byte.

B. 2000 byte.

C. 16000 byte.

D. 8000 byte.

Comment:

12. Eight bits of data, protected by an additional parity bit for error detection, are transmitted over a link where bit errors are likely to occur. The error detection algorithm is *even parity*. Consider the transmission of the nine bits "0110 1101 1" when an error occurs (where the last bit is the parity bit). The error could affect one or more bits. Which of the following erroneous transmissions would be detected by the receiver?

    A. "0100 1001 1"

    B. "0110 0101 0"

    C. "0111 1101 1"

    D. "1100 1101 1"

    Comment: The number of ones should be even.

13. An Ethernet switch connects a number of computers into a network. Which of the following statements is correct?

    A. There can be only one computer connected to each port.

    B. The switch is self-learning, and uses ARP (Address Resolution Protocol) to learn the addresses of the connected computers.

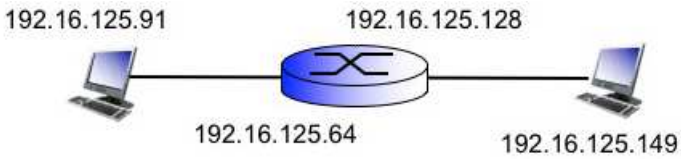
    C. Unlike an IP router, a switch is *transparent*, and does not modify any parts of the data it switches.

    D. Before a computer can use the switch, it needs to *associate* to the network by sending an "association request" to the switch.

    Comment:

14. Consider the network in the figure below with two subnets, with one host on each subnet and a router between the subnets. The IP addresses of the devices are shown. (The router has two IP addresses, 192.16.125.64 on the left subnet and 192.16.125.128 on the right). The host with IP address 192.16.125.91 sends a "ping" (ICMP Echo Request) to IP address 192.16.125.149, which is answered.

    Based on this transmission, what IP addresses will be in the ARP (Adress Resolution Protocol) table for the host with IP address 192.16.125.149?



    A. 192.16.125.64, 192.16.125.91, 192.16.125.128

    B. 192.16.125.91, 192.16.125.128

    C. 192.16.125.128

    D. 192.16.125.91

    Comment: En ARP-tabell innehåller endast IP-adresser från samma subnät.

15. Consider a device that wants to transfer data over a wireless LAN (IEEE 802.11 WLAN) to an access point. The sender can first request to make the transfer by sending RTS (Request to Send), to which the access points responds by sending CTS (Clear to Send).

    What is it in this procedure with RTS/CTS that prevents a collision from happening?

    A. By transmitting CTS the access point confirms that it has capacity available.

    B. The sender transmits RTS to check that there are no other tranmissions going on at the same time.

    C. When other devices in the network receive CTS, they know that they should be silent and not do any transmissions during a certain period of time.

D. The sender transmits RTS to make sure that it has radio contact with the access point.

Comment: RTS/CTS reserves the media.

16. Which of the following statements about IP is (most) correct?

A. The TTL (*Time To Live*) field gives the maximum delay in milliseconds and is decreased with a time constant in each router along the packet's path.

B. The *Identifier* field is used by IP to convey the sender ID of a packet.

C. The field *Source IP address* in the IP packet is updated in each router along the packet's path.

D. The field *Header checksum* is recalculated in each router along the packet's path.

Comment:

17. Which of the following statements about ICMP is correct?

A. ICMP is used by IP to detect and correct errors.

B. ICMP uses UDP as the transport protocol.

C. An ICMP error message returns a part of the IP datagram which caused the error message.

D. The Traceroute program uses ICMP router discovery.

Comment:

18. Consider a subnet (IP version 4) with the prefix 123.11.22.0/24. Which of the following statements is correct?

A. The address 123.11.20.3 belongs to the subnet.

B. The subnet has 512 different addresses.

C. The subnet's prefix can be aggregated with the prefix 123.11.23.0/24 to form the prefix 123.11.22.0/23.

D. A packet sent from a host on the subnet and destined to the address 123.11.22.97 will go through a router.

Comment:

19. Which of the following statements about NAT (Network Address Translation) is *not* correct?

A. If you use NAT between your local network and your Internet provider, it is enough to have only one public IP address even though you have several computers connected to your local network.

B. If you use NAT between your local network and your Internet provider, you can renumber you addresses on your local network without notifying your operator and still be able to access the Internet.

C. If you use NAT between your local network and your Internet provider, you have to use a proxy server at the provider to make a server on your local network reachable to clients outside your local network.

D. If you use NAT between your local network and your Internet provider, you can change to another Internet operator without having to renumber the addresses on your local network.

Comment:

20. Which of the following statements about distance vector routing is (most) correct?

    A. Distance vector routing is based on the Bellman-Ford algorithm to calculate the best paths between nodes.

    B. In distance vector routing, each node sends routing information to all other nodes in the network.

    C. OSPF is an example of a distance vector routing protocol.

    D. Distance vector routing is suitable for large networks with many nodes, because of its short convergence time.

    Comment:

Section B

1. A client has just established a TCP connection to a server and is about to transfer 48 kB of data. The one-way delay is 5 ms, RTT (Round Trip Time) is 10 ms, and the receiver window is 16 kB. Assume that the initial value for CWND (congestion window) is 1 kB. There is no congestion in the network and the transmission time is negligible. Calculate the total transfer time. (2 p)

> **Solution:**
>
> TCP starts up in slow start. First, TCP sends 1 kB (initial CWND). After 1 RTT, TCP sends 2 kB, after 2 RTT another 4 kB, after 3 RTT another 8 kB, after 4 RTT another 16 kB, after 5 RTT another 16 kB (full receiver window now), and finally, after 6 RTT, TCP sends the remaining 1 kB (1 + 2 + 4 + 8 + 16 + 16 + 1 = 48 kB). It thus takes 6*RTT + RTT/2 = 6*10 + 10/2 = 65 ms. If we calculate also the ACK for the last segment, the total transfer time will be 70 ms. So, depending on how we define transfer time, it takes 65 ms or 70 ms.

2. DNS (Domain Name System) consists of a few so called root servers that keep track of who is responsible for the top-level domains on the Internet (".com", ".se", etc). There are currently 13 root servers. (Which are replicated at several places around the world, but that is not what this question is about.) (2+1 p)
   (a) Explain how it is possible to have only a few root servers, despite the large amount of DNS lookups that are going on all the time on the Internet?
   (b) DNS uses UDP, so there is no automatic error handling if a packet is lost. How does DNS solve that?

> **Solution:**
>
> (a) A local name server (any resolving name server really) "remembers" the answers to previous questions in a cache, so it is seldom that a question needs to be sent to a root server. Also clients can store answers to previous questions.
>
> (b) DNS has its own mechanism to detect lost packet. If there are no response within a certain period of time, the question is retransmitted!

3. Consider a router R1 in a network where RIP is used. R1 has the following routing table: (2 p)

Destination network	Next router	Distance
N1	R2	11
N2	R3	5
N3	R3	6
N4	R2	6
N5	R4	7
N6	R4	2

R1 receives a RIP message from R2 with the following distance vector:

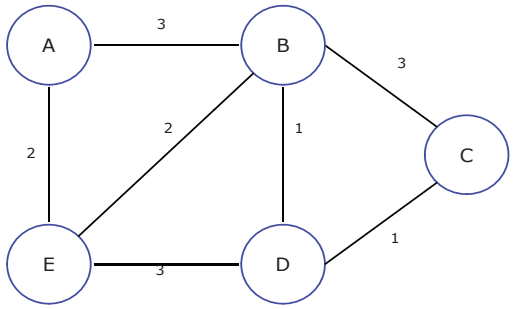
Destination network	Distance
N1	3
N2	15
N3	6
N4	5
N5	5
N6	2

What does the updated routing table in R1 look like when R1 has processed the routing message?

Solution:

Destination network	Next router	Distance
N1	R2	4
N2	R3	5
N3	R3	6
N4	R2	6
N5	R2	6
N6	R4	2

4. Consider the network graph below with given link costs. (3 p)



Calculate, by using Dijkstra's algorithm, the shortest paths (the paths with least cost) from node A to all other nodes in the network. Every step in the algorithm must be shown. Use the following table template, which you copy onto your solutions sheet, and fill in.

step	N'	$D(B), p(B)$	$D(C), p(C)$	$D(D), p(D)$	$D(E), p(E)$
0					
1					
2					
⋮					

Solution:

step	N'	$D(B), p(B)$	$D(C), p(C)$	$D(D), p(D)$	$D(E), p(E)$
0	A	$3, A$	∞	∞	$2, A$
1	AE		∞	$5, E$	
2	AEB		$6, B$	$4, B$	
3	$AEBD$		$5, D$		
4	$AEBDC$				

5. A server should be able to serve multiple clients at the same time. This can be a challenge when it comes to designing the server software, where it is important to serve many clients simultaneously in an effective way, and at the same time be ready to accept and serve new clients. (2+4 p)

   Here are three different ways of organizing server software to deal with multiple clients at the same time. In all cases, TCP is used for communication between server and client, where each client establishes one TCP connection with the server.

   1. A new process is created for each client. The client requests a TCP connection to the server. The server confirms the connection and creates a new process to serve the client. When the client is done, the process is terminated.
   2. A fixed pool of processes is created in advance. The client requests a TCP connection to the server. The server takes a process from the pool to serve the client, and confirms to the client. When the client is done, the process is returned to the pool.
   3. All connections are handled by the same process. The server uses a function in the operating systems that make it possible to deal with multiple connections at the same time in the same, single process. Through this function, the server can check ("poll") what connections have data that need to be processed by the server. The program code in the server is organized as a loop, where the server takes any connection that needs processing, serves it, and then takes the next connection, etc.

      (Linux has, for example, a system call "select" that can be used for this, but you don't need to know any details about select to answer this question.)

   The three methods above result in systems with different properties. This question is about comparing the three methods by analysing the properties of the resulting systems.

   (a) First define two criteria that you think are relevant for comparing the systems' properties. Explain and motivate your choice of criteria.

   (One might suggest to use how "easy" it is for the programmer to implement the three methods as a criterion, but that is not a system property. Here, it is about technical criteria that that are possible to evaluate, for instance through measurements.)

   (b) Make an evaluation where you relate the three systems' properties to each other with respect to your chosen criteria.

Solution:

(a) Examples of suitable criteria include: the time it takes to accept a new client and set up a new connection; the amount of resources consumned in the server, such as memory and process space; predictability, in the sense of controlling the resource consumption of the server; control over process execution and other resources, osv.

(b) A comparative analysis of the three methods can for instance cover the following characteristics:

(c) With this method, it takes time to accept a new client, since a new process should be created, which can be a costly operation for the operating system. The total amount of resources vary over time, depending on the number of clients. This means that resource consumption increases with the number of clients, which makes the system's behaviour difficult to predict and it could even make it more vulnerable to attacks. Processes execute independently of each other (and therefore the clients are served independently), which means that the distribution of resources among clients is dependent of the operating system.

(d) The main difference between this methods and the previous is that it give constant resource consumption of processes, independent of the number of clients. There is no dynamics in the system, as all processes are allocated permanently. This method is the most demanding in terms of resources, in that it requires all processes to be allocated from the start, and the system is dimensioned for peak load. In theory, the system can therefore not be overloaded. Accpting a new client goes relatively fast, since processes are created in advance. In other respects, the system is similar to the above.

(e) This method is probably the most resource efficient, since everything is made within one single process. Accepting a new connection is fast, and relatively little resources are required for each process. The server application can decide itself how resources are distributed among clients.