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## Engineering, Built Environment and IT

### Department of Computer Science

#### Module name

COS 332

#### Assessment opportunity

22 July 2022

#### Examiners

Internal: Prof MS Olivier

External: Prof DT van der Haar (UJ)

#### Instructions

1. Read the question paper carefully and answer all the questions below.
2. The assessment opportunity comprise of 11 questions on 18 pages.
3. An answer sheet and script for calculations are provided separately.
4. You have 3 hours to complete the paper.
5. This is a closed book paper. You are therefore not allowed to have any study material with you.
6. You may use a basic calculator (+, -, X, ÷, √, =) or any variant of the Casio FX-82 calculator (or equivalent).
7. Answer all questions.
8. All answer sheets must be completed in indelible ink. Answer sheets completed in pencil or erasable ink will not be marked and you will not qualify for an additional assessment opportunity.
9. When a question can be answered by means of an acronym it is not necessary to provide the phrase that the acronym represents.
10. Please switch off your cell phone, and keep it off for the duration of the paper.
11. Students are allowed to write on the examination paper.
12. Please consult the module website for the perusal.

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#### Integrity statement:

The University of Pretoria commits itself to produce academic work of integrity. I affirm that I am aware of and have read the Rules and Policies of the University, more specifically the Disciplinary Procedure and the Tests and Examinations Rules, which prohibit any unethical, dishonest or improper conduct during tests, assignments, examinations and/or any other forms of assessment. I am aware that no student or any other person may assist or attempt to assist another student, or obtain help, or attempt to obtain help from another student or any other person during tests, assessments, assignments, examinations and/or any other forms of assessment.

1 App  
2 Pres  
3 Session  
4 Trans  
5 Netw  
6 Data  
7 Phys

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#### Question 1

In each case select the alternative that fits the question best and write only the corresponding letter on your answer sheet.

- 1) A layer in the protocol stack generally provides services for
  - A: The layer above it
  - B: The layer below it
  - C: Its peer layer
  - D: The application layer
  - E: The physical layer
- 2) A NIC (network information centre)
  - A: Provides information about the current status of an ISP's network.
  - B: Allocates IP addresses to ISPs and some other organisations.
  - C: May serve as a TLD registry.
  - D: More than one of the above
  - E: All of the above
- 3) Which of the following standards describe(s) directory access protocols?
  - A: LDAP
  - B: X.500
  - C: CMOT
  - D: More than one of the above
  - E: All of the above

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4) The primary metric used by interior gateway protocols is

- A: Cost
- B: Hop count
- C: Distance
- D: Static routing tables
- E: Speed
- F: Noise

5) DHCP is an example of a ... protocol

- A: Network management
- B: Bootstrapping
- C: Routing
- D: Directory access
- E: Database handling and copying

6) On which of the ISO OSI layers do(es) error checking primarily occur?

- A: 7
- B: 4
- C: 2
- D: More than one of the above
- E: All of the above

7) In order to organise and rearrange various X11 windows on a display, one needs

- A: A Linux computer
- B: A window manager at the X11 server
- C: A window manager at the X11 client
- D: Multiple screens
- E: An X11 window environment on the 'terminal'

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8) Which of the following data streams generally work(s) better with an unreliable layer 4 protocol?

- A: Web page
- B: File transfer
- C: Audio
- D: More than one of the above
- E: All of the above

9) When writing an application that will serve as a server in a client-server architecture, the application would (in its role as server) open a socket that would

- A: Be specified as an address and port number
- B: Initiate connections
- C: Wait for connections
- D: More than one of the above
- E: All of the above

10) UTF-8 is deemed to be self-synchronising because

- A: Two computers that both use UTF-8 are able to communicate in a meaningful manner.
- B: A recipient will be able to inspect the incoming octets and automatically determine that the UTF-8 encoding scheme is used.
- C: If a transmission error occurs, the recipient will be able to determine where a new character starts.
- D: The SYN and ACK characters are supported by UTF-8.
- E: None of the above, because UTF-8 is not self-synchronising.

- 11) Suppose a computer that is primarily used to work with documents in Greek requests a web page from a server that hosts only documents in Greek. In order to transmit a GET request, the browser

- A: May use ΓΕΤ as a substitute for GET.
- B: Must send GET (encoded in US ASCII).
- C: May use ΠΑΙΡΝΩ (the Greek for 'I get') as a substitute for GET
- D: More than one of the above
- E: All of the above

- 12) A multipart MIME representation uses a 'boundary' to indicate the start of a new part. This boundary contains

- A: A random string of characters.
- B: A sequence of non-printable characters.
- C: One or more carefully selected keywords that depend on the types of the various parts.
- D: A number that indicates the length of the part that follows.
- E: Words such as mixed, alternative and related, that indicate the relationship of the parts of the content to one another.

- 13) TCP attempts to reduce data loss on the network under the assumption that ... is the primary cause of data loss.

- A: Jitter
- B: Network speed
- C: Data corruption
- D: Limited amount of memory available for buffers
- E: Congestion

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- 14) Suppose process A establishes a TCP connection with node B. A sends a SYN message to node B. B sends a SYN+ACK to node A. Node A sends an ACK to node B, but lightning strikes and this final ACK never reaches node B. Node A's plan was to send some brief message, M, once the connection has been established. Which of the following claims is true?

- A: The connection is not established and both A and B immediately report an error to the upper layer. A does not transmit M.
- B: A assumes the connection has been established successfully and transmits M. B considers the handshake incomplete, reports an error to its upper layers and ignores M. Only when B fails to acknowledge M after repeated transmissions of M does A abort communication and report an error to its upper layers.
- C: A sends M, which includes an ACK flag; B accepts this ACK as the final phase of the handshake. The connection is established, but M is lost (until A retransmits it).
- D: A sends M, which includes an ACK flag; B accepts this ACK as the final phase of the handshake. The connection is established, and B accepts M. Communication can proceed normally.
- E: None of the scenarios above accurately depict what will happen.

- 15) Some years ago the IPng version of IP was widely discussed. Currently IPng would be referred to as

- A: Simply IP
- B: IPv4
- C: IPv5
- D: IPv6
- E: None of the above

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- 16) When class-based addresses were still in use, the address 120.15.1.1 would have been part of a class ... network address.
- A: A  
B: B  
C: C  
D: D  
E: E
- 17) Routers within an organisation typically discover other routers on OSI layer 3 by using
- A: Unicasting  
B: Multicasting  
C: Broadcasting  
D: Anycasting  
E: Podcasting
- 18) IPv4 network addresses are typically used
- A: To broadcast messages to an entire network.  
B: In routing tables, to identify a network.  
C: For anycasting.  
D: More than one of the above  
E: All of the above
- 19) Which of the following is a private network address (or are private network addresses)?
- A: 176.16.0.0  
B: 172.31.0.0  
C: 172.32.0.0  
D: More than one of the above  
E: All of the above

- 20) In a routing table, the entry 0.0.0.0/0
- A: Identifies the default gateway.  
B: Would never occur.  
C: Is used by DHCP  
D: Refers to the router in whose routing table in which the entry occurs.  
E: More than one of the above
- 21) Suppose a subnet is formed that contains the network range 169.1.64.0 to 169.1.127.255. The network address of this netblock (in CIDR) is
- A: 169.1.64.0/16  
B: 169.1.64.0/18  
C: 169.1.127.0/16  
D: 169.1.127.0/17  
E: 169.1.127.0/24
- 22) If a router send a *Destination unreachable* ICMP message, the value of the ICMP code field will
- A: Explain the reason the destination is unreachable.  
B: Always be 0 because the code field is not used for *Destination unreachable*.  
C: Is by definition 3 because the code that identifies *Destination unreachable* is 3.  
D: Is the IP address of the unreachable destination.  
E: None of the above
- 23) Which of the following IPv6 addresses are routable on the public Internet?
- A: 2001:4860:4860::8888  
B: {e80::44d8:2b01:378b:a817  
C: fe::1  
D: ::ffff:192.168.4.3  
E: More than one of the above

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24) The 'host' f.root-servers.net is

- A: A single (virtual or physical) computer with a single IP address.
- B: A distributed set of synchronised computers that all have the same IP address.
- C: A distributed set of synchronised computers that have different IP addresses.
- D: A distributed set of computers that operate independently, but all have the same address.
- E: A distributed set of computers that operate independently, and each of them has its own IP address.

25) In networking *tunneling* refers to

- A: A mechanism to get blocked traffic via a firewall.
- B: The use of higher layer protocols lower in the stack than lower layer protocols.
- C: A routing mechanism that bypasses intermediate routers and therefore reduces the length of the path between a source and a destination.
- D: Encapsulating packets of one protocol in packets of another protocol, where the second protocol was not designed (or intended) to carry packets of the former protocol.
- E: Forwarding IPv4 traffic to hosts with IPv6 addresses.

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## Question 2

The 'code point' (or sequence number) of a Unicode character is written as 'U+' (to indicate that it is a Unicode code point), followed by the code of the character in hexadecimal. The *Latin Capital letter Z* is, for example, represented as U+005A. When UTF-8 representation is used, the shortest possible sequence of bytes will be used — hence the leading byte will never encode a 0 (except for the null character).

- a) Translate the following characters to UTF-8. In other words, provide the sequence of bytes (in hexadecimal) that would represent the character in UTF-8. Leave a space between the bytes in your answer.
  - (i) The Cyrillic Capital Letter Ukrainian Ie (U+0404) (2)
  - (ii) The Beating Heart Emoji (U+1F493) (3)
- b) Consider the following string encoded in UTF-8: 4E CE B5 F0 9F 85 83. Which (5) Unicode code points does this string represent?

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## Question 3

Provide the acronyms that identify the five Regional Internet Registries (RIRs). For each acronym state the region for which the RIR manages the allocation and registration of Internet number resources.

Provide the region that is identified in the acronym. (For example, if there is a RIR for say, Eurasia, named ERIR, just write ERIR - Eurasia; it is not necessary to describe Eurasia any further). [5]

11/...

## Question 4

Your company uses 172.33.0.0/16 as its network address. The company plans to open a new branch. The subnet 172.33.64.0/18 is assigned to this branch. (In general they use an 18-bit network prefix to address branches.) You are tasked to subnet this subnet, such that at least 30 departments in this branch may each be assigned its own subnet address and each of these subnets should be able to handle at least 500 hosts.

- a) On which branch subnet is 172.33.123.141 located?

- b) On which branch subnet is 172.33.201.141 located?

Use subnet 172.33.64.0/18 for the remaining questions.

- c) The *network* address of department 4 at this branch will have the form 172.33.X.Y/Z. What is the value of X?

- d) The *network* address of department 4 at this branch will have the form 172.33.X.Y/Z. What is the value of Y?

- e) The *network* address of department 4 at this branch will have the form 172.33.X.Y/Z. What is the value of Z?

- f) The *broadcast* address of department 4 at this branch will have the form 172.33.X.Y. What is the value of X?

- g) The *broadcast* address of department 4 at this branch will have the form 172.33.X.Y. What is the value of Y?

- h) The *netmask* of any department at this branch will have the form 255.255.X.Y. What is the value of X?

[8]   
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## Question 5

Your organisation uses the network address 192.168.201.0/24. (For the purposes of this question assume it is a public IP address whether or not it is actually public.)

However, your organisation has grown to such an extent that it needs a larger address space; in fact you now need the ability to address up to 800 hosts. You speak to the ISP and they indicate that the address you have is part of a larger (supernetted) block that has been allocated to them. Moreover, the blocks from 192.168.177.0/24 to 192.168.220.0/24 are not allocated to customers yet, and they are willing to provide you with a supernet that includes your current block (192.168.201.0/24) that will be able to accommodate the 800 hosts you now need to handle. However, they will provide the smallest such supernet that meets your needs. Your new address will be of the form 192.168.X.Y/Z. The broadcast address is of the form 192.168.P.Q.

Use this scenario to answer the following questions.

- a) What is the value of X?

- b) What is the value of Y?

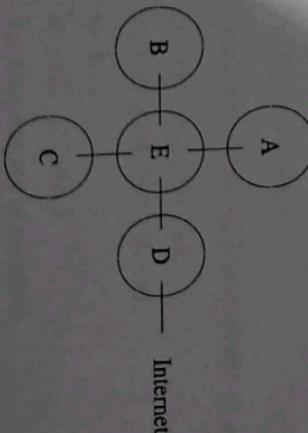
- c) What is the value of Z?

- d) What is the value of P? 255

- e) What is the value of Q? 255

## Question 6

Consider the following network topology:



**Question 6 (Continued)**

The network addresses in use on the various networks are

- A — 192.168.1.0/8
- B — 192.168.2.0/8
- C — 192.168.3.0/8
- D — 192.168.4.0/8
- E — 192.168.5.0/8

The interfaces of the routers connecting the various networks to node E are the following:

- A — 192.168.1.1
- B — 192.168.2.1
- C — 192.168.3.1
- D — 192.168.4.1

Node E has four interfaces that have the following addresses (despite using the network 192.168.5.0/8 for addresses within node E):

- Connected to A — 192.168.1.11
- Connected to B — 192.168.2.11
- Connected to C — 192.168.3.11
- Connected to D — 192.168.4.11

Node D has an interface 192.168.6.100 that is connected to address 192.168.6.1 of the Internet gateway.

Your task is to compile a routing table for the router in network C that connects the various networks. This routing table will consist of two columns: The destination network, and the next hop. The destination network has to be specified in CIDR notation. The next hop will be an ordinary IPv4 address.

[5]

**Question 7**

Consider a zone file for the domain `xx.co.za`.

- a) The address associated with `aa.xx.co.za` is 10.1.1.1. How would you state this in the `xx.co.za` zone file? (1)
- b) Mail to any email address `...@xx.co.za` should be delivered at `example.org`. Provide the entry that you will use in the `xx.co.za` zone file to achieve this. (3)
- c) Suppose `zz.xx.co.za` should resolve to the same IP address as `example.com`. What entry will you use in the `xx.co.za` zone file to achieve this? (1)
- d) Suppose you want to use nslookup to determine the IPv6 address of some host. Write down the set command that you will enter, before you enter the name to be resolved. (2)
- e) Suppose the name `yy.xx.co.za` resolves to 192.168.3.5. Which 'name' would be created (with the aid of a DNS PTR RR) in the appropriate zone file to map the address back to the name? Just provide this name as a FQDN. (3)

[10]

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### Question 8

Assume processes A and B are communicating using TCP.

For the sake of this question assume that all actions are atomic; when a message is sent, it is received essentially immediately at the other end. Stated differently, two events will never overlap, with one exception — see events 3 and 4 below.

Assume A has just sent a message to B with SEQ=100, LEN=500, ACK=1000 and WIN=2000. Immediately after that B sent a message to A with LEN=300 and WIN=1000. Then the following events happen in sequence outlined below. However, events 3 and 4 happen at exactly the same moment and these messages both arrive at their destinations a split second later.

- 1 A sends a message to B with LEN=200. ✓
- 2 B consumes 500 bytes from its buffer. ✓
- 3 A sends a message to B with LEN=600. *Overlap*
- 4 B sends a message to A with LEN=200. ✓
- 5 A consumes 1000 bytes from its buffer.
- 6 A sends a message to B with LEN=300.

During events 1, 3, 4 and 6 messages are sent between A and B. For each of these messages, indicate on your answer sheet what

- a) The sequence number (Seq),
- b) Acknowledgement number (Ack), and
- c) Window advertisement (Win)

are in the header of the respective segment.

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### Question 9

Suppose a network uses the Bellman-Ford algorithm to perform routing. At some time  $t_0$  the routing tables at routers C, D and E contain the information provided below. Each routing table consists of three columns: destination, cost, and the next hop to achieve delivery at the indicated cost.

Node C	Node D	Node E
A 10 B	A 20 E	A 15 F
B 2 B	C 3 C	D 4 D
D 3 D	E 4 E	F 5 F
	G 8 E	G 5 F

The only exchanges of routing tables that occur during the time period of interest are the following: At time  $t_1 > t_0$  node C sends its routing table to node D. At time  $t_2 > t_1$  node E sends its routing table to node D.

- a) What will the entry for destination A be in node D's routing table, after receiving (and processing) the routing table from node C (but prior to  $t_2$ )? (1)
- b) What will the entry for destination B be in node D's routing table, after receiving (and processing) the routing table from node C (but prior to  $t_2$ )? (1)
- c) What will the entry for destination F be in node D's routing table, after receiving (and processing) the routing table from node E? (1)
- d) What will the entry for destination G be in node D's routing table, after receiving (and processing) the routing table from node E? (2)

[5]

[12]

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## Question 10

Dijkstra's algorithm works by adding one node at a time to a set of nodes that are reachable from some given node. Assume this set is called  $S$ . If we want to determine routes from node A then the set  $S$  will be

$$S = \{A\}$$

during round 1. In general, the round number,  $i$  is therefore

$$i = |S|$$

for the contents of  $S$  at the start of that round.

Assume your network consists of five routers, A, B, C, D, E. The costs of the routers that are linked directly are as follows:

A↔B:	1
A↔C:	10
B↔D:	2
C↔D:	5
C↔E:	1
D↔E:	3

- a) Which node is added to  $S$  when progressing from round 3 to round 4? (1)
- b) What will the initial cost be to send a message between A and C (during round 1)? (1)
- c) Which node will perform the final delivery to node C at the end of round 3? (1)
- d) What will the calculated cost be to send a message between A and C at the end of round 4? (1)
- e) During which round does node E become reachable from node A? (1)  
[5]

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## Question 11

Assume that IPv6 addresses that start with the prefix fd00::/8 are deemed to be 'private' addresses.

- a) Briefly, but clearly, describe the bit pattern that would identify an address as an IPv6 private address. . (1)
- b) The next part of such an address is a 40-bit random number for uniqueness. In what sense is such an address unique? (2)
- c) What is the intended use of the 16-bit subnet field that follows? (2)
- d) Given the inclusion of the subnet field, what is the expected length of the routing prefix of such a 'private' address (in bits)? (1)
- e) The maximum number of hosts that may be addressed with such a private address is about  $10^x$ . What is the value of  $x$ ? (1)
- f) Consider the address prefix fc00::/7. Do private addresses (as defined above) fit in the block defined by this prefix? Briefly justify your answer. (2)
- g) Is an address with the prefix fe00::/8 a valid private address (as defined above)? (1)

[10]

TOTAL

END OF PAPER

[100]