BCS THE CHARTERED INSTITUTE FOR IT

BCS Higher Education Qualifications
BCS Level 5 Diploma in IT

March 2017 Sitting

EXAMINERS' REPORT

Computer Networks

General comments on candidates' performance

The overall pass rate for this module continues to be satisfactory. The number of desperately weak candidates, those gaining less than 20%, has declined significantly, with the result that, while the pass rate has remained the same, the mean mark has increased significantly. It is at least plausible to infer that candidates or their teachers have taken note of the advice given in previous examiners' reports, to the effect that such candidates waste their own time and money, and should strongly discouraged from entering for the exam. The examiners were pleased to see that 13.6% of the candidates gained marks of 70% or over, the traditional border for first class honours in UK universities.

Questions 1, 2 and 6 were the most popular questions and they were the best answered in terms both of pass rate and average mark. Despite being straightforward, question 4 was both unpopular and badly answered, perhaps because it included some elementary arithmetic.

While they have no firm evidence, the examiners have the impression that some of those teaching courses to prepare candidates for this examination:

- do not cover the whole course but concentrate on what they believe to be the easier parts of the syllabus (see Q4);
- do not draw candidates' attention to the existence of the examiners' report nor encourage them to read them;
- do not themselves read and take notice of the examiners' reports;
- do not prepare candidates to answer questions relating to specific scenarios.

Twenty per cent of the candidates who registered for the module failed to present themselves for the examination. The centre with the largest number of candidates also had the highest proportion (23%) of registered candidates failing to appear.

Question A1

A1. This question is about fibre optic transmission systems.

a) Explain how data is transmitted along a fibre optic cable and indicate at least three advantages fibre optic cable has over copper cable. **(12 marks)**

b) Briefly explain how wave division multiplexing (WDM) is able to increase the amount of data that can be transmitted along a single fibre optic cable. **(6 marks)**

c) A fibre optic transmission system uses wave division multiplexing with eight different wavelengths of light. Each of these wavelengths is able to operate at 1Gbps. If it requires 32,000 bps to transmit an uncompressed telephone call, determine approximately the maximum number of telephone calls that can be transmitted at the same time using this fibre optic cable. **(7 marks)**

Syllabus section: Digital Communication

Answer Pointers

Part (a)

Data is transmitted along a fibre optic cable as light using either a laser or LED. The fibre core is made of a very thin strand of high purity glass and is surrounded by a cladding. Light entering the core is reflected internally by the cladding and passes along the core with very little loss. The cladding itself is surrounded by an outer layer simply for protection of the core; the outer layer plays no part in the transmission of signals.
Advantages over copper:

- Fibre exhibits less loss (attenuation) than copper over the same length.
- Fibre has less dispersion (distortion) than copper which allows for higher data rates to be achieved.
- Fibre is less prone to external electromagnetic interference than copper and also does not itself generate such interference.

(Marking scheme: 6 marks for indicating how data is transmitted along a fibre optic cable and 2 marks per advantage.)

Part (b)

Wavelength division multiplexing (WDM) is a technique used to allow multiple data streams to be transmitted simultaneously along the same fibre. Each data stream is allocated a carrier signal with a different wavelength. In this way multiple data streams are 'multiplexed' over the same fibre at the same time with each stream carrying its own separate data. Modern systems allow for up to 160 simultaneous data streams and permit bidirectional transmission.

(Marking scheme: 2 marks for indicating what WDM is and 4 marks for indicating how it increases the amount of data.)

Part (c)

Fibre system uses 8 wavelengths of light. Each wavelength operates at 1Gbps,
Total capacity of the fibre is therefore 8Gbps = 8×10^9 bps.
Telephone call requires 32×10^3 bps
Therefore total number of telephone calls = $8 \times 10^9 / 32 \times 10^3 = 250{,}000$.
[An answer using 1 Gbps = 2^{30} bps would also be acceptable.]

(Marking scheme: 3 marks for the appropriate calculations (reasoning), 4 marks if the correct answer is given.)

Examiner's Comments

Attempted by 87% of candidates, 66% of whom attained a pass mark. Two candidates gained full marks for the question and 16% gained marks of 80% or over.

Despite the generally high standard, it was disappointing that many candidates did not attempt part (c); of those who did, many made simple errors such as treating 1Gbps as 10^6bps instead of 10^9.

Question A2

A2. This question is about the Transmission Control Protocol (TCP) and User Datagram Protocol (UDP).

a) Explain how a network connection is established between a user and a server over the Internet using the TCP protocol. **(8 marks)**

b) Both the TCP and UDP protocols use port numbers. What are these port numbers used for and what is meant by the term **well-known port**? Give an example of a well-known port. **(6 marks)**

c) What is the difference in the quality of service (QoS) offered to applications by the TCP and UDP protocols? **(8 marks)**

d) For each of the following three applications, state whether you would use TCP or UDP.

i. file transfer
ii. video streaming
iii. an audio conference.

(3 marks)

Syllabus section: Inter Networks

Answer Pointers

Part (a)

A TCP connection is unidirectional which means that for two way communications, a connection must be established from the user to the server and separately from the server to the user. Each process does, however, follow the same three way handshake procedure. The user will issue a TCP segment with the SYN flag set and the sequence number equal to some initial value – say x. The server, if it wants to accept the connection request, will return a TCP segment with both the SYN and ACK flags set. It will also choose a sequence number starting value – say y. The acknowledgement field of this segment will be set to x+1 to acknowledge receipt of the connection request segment. When the user receives this response it will issue one further TCP segment with the ACK field set. The acknowledgement in this segment will be y+1 and the sequence number will be x+1.

(Marking scheme: 4 marks for indicating the way the three-way handshake works, 4 marks for indicating the expected values of the sequence numbers.)

Part (b)

Both TCP and UDP provide services to higher layer protocols however multiple higher layer protocols can be multiplexed on to a single UDP or TCP layer. Each

of these higher layer protocols are then differentiated by means of UDP/TCP port numbers. Port numbers are 16 bits in length. Therefore the port number identifies the particular higher layer protocol to which a given data stream is destined.

Some of these port numbers are predefined and are referred to as "well known ports"; port 80, for example, refers to the higher layer http protocol.

(Marking scheme: 4 marks for the explanation, 2 marks for the example.)

Part (c)

UDP operates above IP and provides a connectionless, unacknowledged service to the upper layers. There is no error detection or recovery and no flow control provided by UDP. It is a best effort service. TCP operates above IP and provides a connection orientated service in which end-to-end data transfer is guaranteed, with flow control and congestion avoidance capabilities. It is a reliable service.

(Marking scheme: 4 marks for explaining QoS in UDP, 4 marks for explaining QoS in TCP.).

Part (d)

i. TCP
ii. UDP
iii. UDP

(Marking scheme: 1 mark per correct answer.)

Examiner's Comments

This question was attempted by 95% of the candidates and 61% of them achieved a pass mark. One candidate got full marks and 16% got marks of more than 80% for the question.

Question A3

A3. Infotronics is a private college that provides part-time and full-time courses in IT and business. It is planning to move to a new site and is considering the networking that should be installed. The site consists of three buildings. The Grace Hopper Building contains a dedicated computer room with a number of high performance dedicated servers. The servers provide services to students and staff who may access them either over the Internet or over the College's own internal network. The Maurice Wilkes Building contains the staff offices, for both lecturers and administrative staff. They have desktop computers on fixed desks, from which they need access to the Internet and to other College servers. The Hopper Building and the Wilkes Building are linked by an underground duct. The Alan Turing Building contains a reception desk, lecture rooms and a café. There is no duct linking it to the other buildings. The lecture rooms have a desktop computer at the front for use by the lecturers, but some lecturers prefer to use their own laptop or tablet computer. All the students use laptop or tablet computers to take notes and keep in touch with their friends.

a) What type of network should be deployed in the Grace Hopper Building and what equipment should be installed? **(5 marks)**

b) What type of network should be deployed in the Maurice Wilkes Building and what equipment should be installed? **(5 marks)**

c) What type of network should be deployed in the Turing building and what equipment should be installed? **(5 marks)**

d) What type of network connections should be used to link the buildings together and where and how should the College's Internet connection be made? **(10 marks)**

Syllabus section: Local Area Networks

Answer Pointers

Part (a)

It is clear that the Grace Hopper Building contains fixed, high performance computers. (1 mark)

A cabled network is appropriate, probably using high performance switches. (2 marks)

A minimum of a 1Gbps network should be specified although perhaps a case for 10 Gbps could be made. (1 mark)

There seems little need for a Wi-Fi network although a case for Wi-Fi to support systems staff using laptops could be argued. (1 mark)

Part (b)

It is clear that the Wilkes Building contains fixed, medium performance computers (1 mark).

As in the Grace Hopper Building, a cabled network is appropriate probably using medium performance switches. (2 marks)

A minimum of a 100 Mbps network should be specified although perhaps a case for 1 Gbps could be made. (2 marks)

Since we are told that that some staff use laptop/tablet computers there is an argument for providing Wi-Fi support. (1 mark)

Part (c)

We are told about fixed computers and lots of laptop/tablet use. It is clear that we therefore want some cabled network sockets in lecture rooms and to cash tills in the café together with a network switch. (3 marks)

It seems, however, that most of the usage in this building is from mobile devices, laptops and tablets. A Wi-Fi Network is therefore definitely needed, with multiple access points. (2 marks)

Part (d)

The Hopper Building and the Wilkes Building can clearly be connected by laying some form of cable in the duct. Fibre optic would be the better choice. (2 marks)

We are told that there is no duct to the Turing Building and we are not allowed to install one and so a cabled interconnection is not really possible. We can therefore perhaps best connect the Turing Building by using Wi-Fi technology (1) and directional aerials. (3 marks).

Considering all the factors, it seems the best place to make the Internet connection would be the Hopper Building. As access from outside the university campus is needed, ADSL is not really appropriate and some form of symmetric service would be better. (3 marks)

Security needs to be considered. Wi-Fi connections should use a good quality security/authentication technique and good practice would see a firewall installed between the Internet and the College network. (2 marks)

Examiner's Comments

A reasonably popular question attempted by 68% of the candidates. Some 10% of the candidates gained marks of 80% or over but 47% failed to attain a pass mark.

As so often, candidates seemed to have great difficulty in applying their classroom knowledge to a specific scenario. Most answers were unnecessarily long, with many words expended on describing the technology instead of specifying what was required.

Question B4

This question is about error detection and correction in data communication.

a) Explain in outline how the Hamming (7,4) code works and what its error detection and correction capabilities are. **(6 marks)**

b) Two communicating devices are using a single-bit even parity check for error detection. The transmitter sends the byte 10101010 and, because of the channel noise, the receiver gets the byte 10011010. Indicate, with a brief explanation, whether or not the receiver will detect the error. **(4 marks)**

c) Calculate the Hamming distances among the following code words and give the minimum distance for each of the two sets.: **(11 marks)**
   i. 00000, 10101, 01010
   ii. 000000, 010101, 101010, 1101110

d) The Cyclic Redundancy Check (CRC) algorithm is widely used for error detection in data communications. Given the message 110100111 and the polynomial 1011, indicate how many bits will be padded into the message to prepare it for transmission and express the polynomial algebraically. **(4 marks)**

Syllabus section: Errors

Answer Pointers

Part (a)

The Hamming (7,4) code encodes four bits of data into seven bits by adding three parity bits. It can be used either to detect and correct all single bit errors or to detect (but not correct) all single bit and two-bit errors.

Part (b)

Two bits are changed. The single bit even parity check will not therefore detect the error, since it can only detect errors that cause an odd number of bits to change.

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Part (c)

i. d(00000, 10101) = 3
d(00000, 01010) = 2
d(10101, 01010) = 5
The minimum distance is 2

ii. d(000000,010101) = 3
d(000000,101010) = 3
d(000000,110110) = 4
d(010101,101010) = 6
d(010101,110110) = 3
d(101010,110110) = 3
The minimum distance is 3

Part (d)

Since the polynomial is of degree three, the padding will consist of three bits. The polynomial is x^3+x+1.

Examiner's Comments

This was by far the least popular question, being attempted by only 9% of the candidates. It was much the most badly answered, with only 30% of the candidates attempting it achieving a pass mark.

In the examiners' opinion, this was the most straightforward and least time-consuming question on the paper. They suspect that those teaching courses for this module avoid the topic, perhaps because students lack the necessary elementary mathematical skills.

Question B5

This question is about the network layer and its functionality.

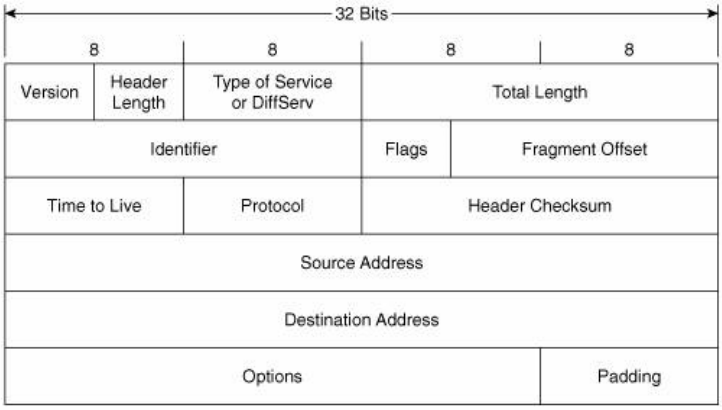
a) The network layer, or OSI layer 3, provides services to allow end devices to exchange data across the network. To accomplish this end-to-end transport, the network layer uses four basic processes: addressing of end devices, encapsulation, routing and de-encapsulation. Briefly describe be purpose of each of those basic processes. **(8 marks)**

b) The IP protocol is said to be:

i. connectionless,
ii. best effort, *and*
iii. media independent.

Briefly indicate what is meant by each of these terms. **(6 marks)**

c) The image below depicts the format of the IP header. Briefly indicate the purpose of the following IPv4 header fields: (i) version, (ii) differentiated services, (iii) time-to-live, (iv) protocol, (v) source IP address, and (vi) destination IP address. **(6 marks)**



d) Indicate five advantages of IPv6 against IPv4. **(5 marks)**

Syllabus section: Wide Area Networks

Answer Pointers

Part (a)

- Addressing of end devices: end devices must be configured with a unique IP address for identification on the network.
- Encapsulation: the network layer encapsulates the PDU from the transport layer into a packet.
- The encapsulation process adds IP header information, such as the IP address source and destination hosts.
- Routing: the network layer provides services to direct packets to a destination host on another network.

(2 marks for each process)

Part (b)

- Connectionless – will send a packet even if the destination host is not able to receive it. No contact is made with the destination host before sending a packet.
- Best effort – does not guarantee that the packet will be delivered fully without errors. Packet delivery is not guaranteed.
- Media independent – fibre, microwave, copper, satellites, and wireless can all be used to route the same packet. Will adjust the size of the packet sent depending on what type of network access will be used.

(3 marks for each term)

Part (c)

- Version – identifies the version of IP been used (0110 for IPv4)
- Differentiated services – identifies the priority of each packet
- Time-to-live – commonly referred to as hop count
- Protocol – identifies the upper-layer protocol to be used next
- Source IP address – identifies the IPv4 address of the sending host
- Destination IP address – identifies the IPv4 address of the recipient host.

(One mark each)

Part (d)

- Simplified header format for efficient packet handling.
- Larger payload for increased throughput and transport efficiency.
- Hierarchical network architecture improves routing efficiency.
- Auto configuration for addresses.
- Much larger address space eliminates the need for network address translation (NAT) between private and public addresses.

(One mark each.)

Examiner's Comments

Question 5 was attempted by 60% of candidates, of whom 55% achieved a pass mark.

Candidates' knowledge and understanding of this topic seemed insufficient.

Question B6

This question is about the quality of service (QoS) provided by a communication network.

a) The following terms relate to the quality of service provided by a network:

(1) Code delay
(2) Propagation delay
(3) Packet loss
(4) Jitter
(5) Queue
(6) Bandwidth
(7) Serialization delay
(8) Congestion

The following are descriptions or definitions of the terms (in a different order)

(A) This happens when congestion occurs
(B) The fixed amount of time it takes to transmit a frame from the NIC (Network Interface Controller) to the wire
(C) Holds packets in memory until resources become available to transmit them
(D) The number of bits that can be transmitted in a single second
(E) The fixed amount of time it takes to compress data at the source before transmitting to the first internetworking device
(F) When the demand for bandwidth exceeds the amount available
(G) Caused by variations in delay
(H) The variable amount of time it takes for the frame to traverse the links between the source and destination

For each term, write down the description or definition that most closely matches it, e.g. (9) – (Z). **(8 marks)**

b) For each of the following traffic characteristics, state whether it applies to video traffic, voice traffic or data traffic. **(7 marks)**

i. Can be very greedy, consuming a large portion of network capacity.
ii. Without adequate QoS and sufficient bandwidth, this traffic typically degrades.
iii. Cannot be retransmitted if lost.
iv. Traffic can be predictable and smooth.
v. Does not consume a lot of network resources.
vi. Traffic can be smooth or bursty.
vii. Very sensitive to delays and dropped packets.

c) Explain the purpose of a Service Level Agreement (SLA) and describe briefly four items that it should cover. **(10 marks)**

Syllabus section: Introduction

Answer Pointers

Part (a)

(1) – (E), (2) – (H), (3) – (A), (4) – (G), (5) – (C), (6) – (D), (7) – (B), (8) – (F)

(One mark each.)

Part (b)

(i) Data (ii) Video (iii) Voice (iv) Voice (v) Voice (vi) Data (vii) Voice

(One mark each.)

Part (c)

A **service-level agreement** (**SLA**) is a contractual document that specifies the level of service that a service provider, such as an internet service provider, promises to provide to the customer. Typical items that are covered in such an agreement include:

- availability, that is, what proportion of the time that the service is supposed to be available is it actually available;
- if a fault develops, how long will it take to fix;
- the data rate that will be provided;
- quality of service parameters such as error rate and jitter.

Examiner's Comments

This was the second most popular question on the paper, being attempted by 79% of the candidates, 72% of whom passed.

The first two parts of the question were essentially multiple choice. It seems likely that this may have helped candidates whose command of formal written English is inadequate to demonstrate their command of the subject matter of the question.