BCS HIGHER EDUCATION QUALIFICATIONS
BCS Level 5 Diploma in IT

April 2012

EXAMINERS' REPORT

Computer Networks

General Comments

The responses to questions overall showed a slight improvement this time, although a majority of candidates still needing better grasp of concepts. Section A questions are answered slightly better than those in Section B. However, a few answers in Section B were very good too. We need more of these, and that means better preparation from candidates. Candidates still are not reading the questions carefully and well, which leads to poor understanding of what is expected as answers to those questions. It is essential that candidates should spend some time in reading the questions before answering them. There were less borderline categories this year. The number of blank answer books returned was less too

Given the choices of questions to answer, a poor performance indicates poor preparation. It is worth repeating this year too that candidates need significantly better preparation based on good understanding of concepts to have a realistic chance of passing the paper, or getting better marks. The questions cover all parts of the syllabus, and hence familiarity with syllabus is important. The examiners reports such as this will help in examination preparation process for this paper.

Section A

A1. This question is about physical layer transmission systems and fibre optics.

a. A digital transmission system uses a coding scheme that defines a symbol as a voltage that can have one of four possible values. If the system operates at a transmission rate of 2400 symbols per second, determine the data transmission rate measured in:

i. Baud

(2 marks)

ii. Bits per second

(4 marks)

b. By considering a fibre optic transmission system, explain how wavelength division multiplexing (WDM) can be used to increase the data carrying capacity.

(6 marks)

c. A fibre optic transmission cable links two cities, A and B, and comprises 3 fibre pairs. A fibre pair provides full-duplex communications with one of the pair carrying data from A to B whilst the other carries data from B to A. Each

individual fibre can support up to 16 different wavelengths of light and each wavelength can operate at 2.5Gbps.

i. Determine the total bit carrying capacity of this cable measured in bits per second. Include both the A to B and B to A transmissions.

(5 marks)

ii. If a telephone voice call generates 64kbps of full-duplex data, determine how many simultaneous voice calls can be carried by the cable.

(8 marks)

Answer Pointers

a). Baud is defined as the number of symbols per second. Therefore if the system transmits at 2400 symbols per second then the data rate is also 2400 baud.

1 mark for Baud = 1 symbol per second, 1 mark for correction: 2400 baud.

A symbol is a voltage level that can have one of 4 possible values. Four levels can be represented by 2 bits. Therefore one symbol represents 2 data bits.

If each symbol represents 2 bits then the transmission rate in bits per second will be 2400 x 2 = 4,800 bits per second.

2 marks for determining each symbol represents 2 bits and 2 marks for 4,800 bits per second.

b). Wave division multiplexing (WDM) is a technique used in fibre optics in which different wavelengths of light are transmitted along the same fibre. Each wavelength carries its own data stream. In this way multiple data streams are 'multiplexed' over the same fibre at the same time with each stream carrying its own separate data. Therefore the combines fibre comprises a series of transmission channels. A fibre that uses only one wavelength of light is in effect a single channel and therefore WDM with its multiple channels offers an increase in capacity equal to the number of wavelengths supported.

2 marks for noting that different wavelengths of light (colours) are transmitted over the same fibre, 2 marks for noting that each wavelength carries its own independent data stream, 2 marks for noting that the different wavelengths are in effect multiplexed data channels leading to an increase in overall capacity is increased compared to a single wavelength fibre.

c). 3 fibre pairs is 6 fibres in total. Each fibre supports 16 different wavelengths and each of these operates at 2.5Gbps. Therefore the total capacity of the cable is:

6 x 16 x 2.5 Gbps = 240 Gbps

1 mark for recognising that there are 6 fibres in total, 2 marks for recognising that each fibre carries 16 different data streams, 2 marks for final answer.

A full-duplex telephone call will be carried on a fibre pair. There are 3 fibre pairs and each fibre pair carries 16 x 2.5 = 40 Gbps. Therefore the number of simultaneous telephone calls is

$$3 \times \frac{16 \times 2.5 \times 10^9}{64 \times 10^3} = 1.875 \times 10^6 = 1{,}875{,}000$$

2 marks for recognising that a fibre pair is needed for a telephone call, 2 marks for calculating the data carrying capacity of a fibre pair, 2 marks for the method of calculation and 2 marks for the final answer.

Examiners' Guidance Notes

Question 1 was the least popular question in section A of the paper. It was attempted by 128 candidates. A relatively easy question to answer, however the average mark was only 10 out of 25. Part A was correctly answered by the majority of the candidates. Part B is about wave division multiplexing was not well answered, indicating that the topic was not well understood by the candidades. In part C, many candidates indicated that there were only three fibres instead of six. There were also many errors with their calculations.

A2. This question is about the ISO Reference Model.

a. The ISO Reference Model defines seven protocol layers, each of which is responsible for a specific range of functions. By considering this model, explain the main functions performed by a protocol operating at:

i. The Physical layer

(3 marks)

ii. The Transport layer

(3 marks)

b. In a Local Area Network, personal computers (PCs) are connected to a switch. Consider two PCs communicating with each other via this switch. Produce a protocol layer diagram that shows how data is passed between these two PCs and in which you clearly show all of the layers of the ISO Reference model that are used within each PC and within the switch. Clearly mark on this diagram what is meant by a peer to peer protocol.

(12 marks)

c. A protocol that operates at a particular layer of the ISO Reference Model adds additional bytes to the data it receives from the layer above it. These additional bytes are often referred to as the protocol header and footer or simply, the protocol overhead. By considering layer 3 of the ISO Reference Model, explain what might be included within these protocol overhead bytes.

(7 marks)

Answer Pointers

a) i. Physical layer

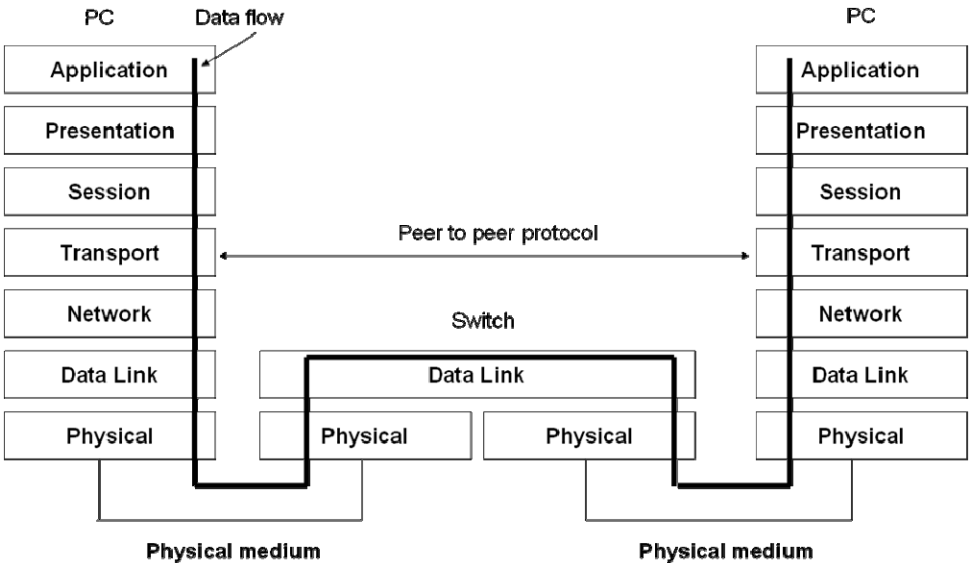
- Defines the electrical interface to a transmission medium
- The physical properties of the transmission medium
- The process by which digital data is represented on the transmission medium (coding)

1 mark per point identified.

b) ii. Transport layer

- Manages the end to end communications
- Responsible for multiplexing higher layer services
- Offers either a reliable (connection orientated) or unreliable (connectionless) service

1 mark per point identified.



2 marks for correctly identify the seven layers and in the correct sequence; 2 marks for noting that each PC has all seven layers present; 2 marks for noting that the switch only has the first 2 layers; 2 marks for showing the two physical layer connections at the switch – one to each PC; 2 marks for showing a peer to peer protocol operating horizontally between two layers at the same level; 2 marks for showing the data flow path travelling vertically through the model.

c). A layer 3 protocol is responsible for end to end communications. Therefore the protocol header will contain:

- Global destination address
- Global source address
- Information relating to the size of the packet
- A possible indication of the type of data contained within the packet – e.g. class of service and priority
- Packet fragmentation and reassembly information
- A time to live field to allow old packets to be discarded
- A header checksum to detect errors
- Pointers to other extension headers
- A protocol version code

2 marks for global addresses; 1 mark for other relevant fields up to a maximum of 5 marks. Candidates may choose to reference the IPv4 or IPv6 headers as examples

Examiners' Guidance Notes

This was a poorly answered question. Although it was attempted by 169 candidates (most popular) question, the average mark was only 9.6 out of 25, clearly indicating lack of preparation for the ISO reference model. The majority of the marks were obtained from part A only. Many of the candidates lost marks in part B for not identifying correctly the layers of a switch.

A3. This question is about the TCP and UDP protocols.

a. What is the difference in the quality of service (QoS) offered to applications by the TCP and UDP protocols?

(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?

(7 marks)

c. By considering the operation of the TCP protocol, explain how it is able to overcome errors in the transmission and ensure that data is transferred reliably over a network.

(9 marks)

Answer Pointers

a). 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.

UDP – 2 marks for connectionless, 1 mark for no error control, 1 mark for no flow control. TCP – 2 marks for connection orientated, 1 mark for reliable data transfer, 1 mark for flow/congestion control.

b). Both TCP and UDP provide services to higher layer protocols however multiple higher layer protocols can be multiplexed onto 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 pre-defined and are therefore referred to as "well known ports", for example port 80 refers to the higher layer http protocol.

2 marks for recognising that port numbers are 16 bits in length; 2 marks for knowing that they identify the higher layer protocol to which the data stream is destined, 2 marks for explaining what a well known port is, and 1 mark for an example of a well known port.

c). Explanation should cover the following key points:

- Every octet transmitted through TCP is uniquely identified by a 32 bit sequence number which increases by one for each new octet.

- Data is transmitted and acknowledged by the receiving end station. Acknowledgements are identified by means of the ACK bit and acknowledgement number within the TCP header.

- A positive acknowledgement is indicated by virtue of the fact that the ACK bit is set and then the acknowledgement number will indicate the number of the first non-acknowledged octet. In other words all octets up to an including acknowledgement number -1 have been successfully received.

- If data is corrupted or lost in transit then this must be detected by the transmitter. If an acknowledgement has not been received within a given time – determined by a timer – then the transmitter simply sends the data again. It is the responsibility of the receiver to ignore any duplicates it receives. Hence, the transmitter will continue re-sending data until a positive acknowledgement is received.

2 marks for knowing that each octet is uniquely identified by a sequence number; 4 marks for the acknowledgement using an ACK bit and the operation of the acknowledgement number; 2 marks for ACK timeout at the transmitter and 2 marks for re-sending until a positive ACK is received.

Examiners' Guidance Notes

This question was attempted by 80 per cent of the candidates. This question had the highest average mark (12 out of 25). Many candidates did not attract high marks in part A. however, there was a different story for part B since it was answered correctly by the majority. Answers to part C were weak, many candidates included a diagram but without any description or explanation.

Section B

B4. The two main functions of an Internet Protocol router are the forwarding of individual packets (“switching”) and the maintenance of routing tables (“routing”).

a. Routing within a single corporate network is often established using distance vector protocols. Briefly explain the behaviour of distance vector protocols and the problems associated with them.

(4 marks)

b. The protocol known as RIP (Routing Information Protocol) is a distance vector protocol. Describe the problems and restrictions that are present in RIPv1 and how RIPv2 solves some of them.

(8 marks)

c. Routing between large networks operated by different administrations is often achieved using the Border Gateway Protocol (BGP).

i. Briefly explain why RIP would be unsuitable in this environment.

(3 marks)

ii. Briefly explain the behaviour of BGP, the messages it exchanges and the particular important of the Path Attribute known as the AS_Path.

(10 marks

Answer Pointers

a). Distance vector protocols operate via routers broadcasting a complete routing table (1) on a regular basis, typically once every 30 seconds (1 mark). Candidates could now raise anyone of several issues. One of the main problems is related to the relatively large amount of data they transmit (1 mark). Another problem is they are relatively slow to converge (1 mark). They are also vulnerable to routing loops (1mark). Total mark limited to 4.

b). RIP is a distance vector protocol and so suffers from the issues noted in part a) (1 mark). RIPv1 only copes with class-based addressing (1 mark) and also does not possess any form of authentication (1 mark) and it is thus not that hard for hackers to insert false routing information (1). RIPv1 also broadcasts to all machines on the local network which have to process the traffic even if they are not interested in it (1 mark). RIPv2 includes a field for a netmask and so can handle classless addressing (1 mark). RIPv2 also has some optional fields that can be used for authentication (1 mark) RIPv2 also transmits to a multicast address thus meaning that any hosts not interested in routing updates do not have to process the RIPv2 messages (1 mark).

c). i. RIP in any of its versions simply cannot cope with the more complex network arrangements that prevail in large networks (1 mark). In this scenario routing protocols need to be able to cope with multiple ASs which RIP cannot handle (1 mark). The transmission of all routing tables, as RIP does, is simply not scalable (1 mark). All other valid comments will be awarded up to a maximum of 3 marks.

ii. BGP is designed to allow routers (which the standard calls gateways) to exchange messages with routers in other autonomous systems (1 mark). It is also sometimes used in an “interior” manner inside large complex corporate networks (1 mark). BGP routers exchange messages via TCP (1 mark) with other routers which it has formed adjacencies (1 mark). There are four messages (1 mark), open, update, keepalive and notification (1 mark). The open messages are used to form the adjacencies (1 mark). The keep alive messages merely confirm a router is still alive and causes timers to be reset (1 mark). The update messages are perhaps the most important and are used to announce the reachability of other networks (1 mark) and the withdrawal of any destinations which are no longer reachable (1 mark). The notification message is used

to report error conditions (1 mark). The marks to this point will be capped at a maximum of 7. The question explicitly asks the candidates about the AS_Path attribute. This attribute is contains a list of all ASs that would be crossed for packets associated with any one route (1 mark). This enables a company's routers to implement routing policies (1mark), perhaps avoiding networks of their competitors (1 mark). The AS_Path information could also be used to pick paths based on knowledge of technical metrics (1 mark). The discussion of AS_Path will be capped at 3 marks.

Examiners' Guidance Notes

This question was attempted by only 21% of the candidates of whom only a small proportion (24%) achieved a pass mark.

While a small numbers of good quality answers were submitted, many answers were fairly weak. Candidate's knowledge of BGP in particular appeared to be very lacking. In the earlier parts of answers, many candidates confused the properties of distance vector protocols with those of link state protocols.

B5. This question concerns wireless local area network (WLAN) technology and the IEEE 802.11 standards.

a. Briefly describe the nature of a network known as an Ad-Hoc Wireless LAN and the connectivity that it directly provides.
(3 marks)

b. What frequency ranges are typically used by IEEE 802.11 Wireless LANs and what other types of equipment also use some of those frequency ranges.
(6 marks)

c. Briefly explain the role of an Access Point within an infrastructure Wireless LAN.
(4 marks)

d. Describe the issue known as the "hidden station problem".
(6 marks)

e. Discuss how the use of "distributed coordination function with request to send / clear to send" (DCF with RTS/CTS) helps to solve the hidden station problem.
(6 marks)

Answer Pointers

a). An Ad-Hoc wireless network is one formed without the use of access points (1 mark) and is a connection directly formed between two wireless stations (1 mark). It thus provides direct connectivity between only two systems (1 mark).

b). The frequencies used are those normally referred to as "microwave" (1 mark). Almost all current usage is around 2.4 Ghz (1 mark) or 5.8 GHz (1 mark) although the standard does also include infrared (1 mark). A lot of other types of equipment use these frequency bands including microwave ovens (1 mark) and radars (1 mark). In many countries, some of the frequencies also specified for unlicensed ISM (industrial, scientific and medical) equipment (1 mark). Mark capped at a maximum of 6.

c). An Access Point acts as the central piece of equipment in an infrastructure Wireless LAN (1 mark). The access point passes data between all other stations in the network (1 mark). The access point also implements the central component of any network security (1 mark). The Access Point is of course also involved in the various media access control procedures (1 mark).

d). The issue known as the “hidden station problem” is that of some stations not being heard by others (1 mark). The physical spread on the nodes around the access point may be such that while they are in signal reach of the access point (1 mark) they are a relatively long way away from it and thus not in range of other stations at the far side of the access point (1 mark). This leads to a variety of problems but in essence, stations transmit over the signals of other stations (1 mark) causing signal and thus data corruption (1 mark).

e). DCF is all about distributed control of access to the Wireless LAN (1 mark). A station with traffic to transmit first senses the media, and if it appears free (1 mark) it transmits a very short request-to-send (RTS) frame (1 mark). This will get received by an intended immediate destination (typically the access point) (1 mark). In response a clear-to-send frame is sent (1 mark) and because this has come from the access point, it will be received by all stations (1 mark). They will then note that they cannot use the airwaves for the time noted in the CTS (1 mark) and they will thus not transmit over another station's data traffic even if they can’t here it (1 mark). Any other relevant remarks will be rewarded too with the overall mark capped at 6.

Examiners' Guidance Notes

This question was attempted by about 43% of the candidates of whom only a small proportion (26%) achieved a pass mark.

Most candidates thought that the standards only allowed for 2.4 Ghz. The hidden station problem was described well by some candidates but clearly misunderstood by others. DCF with RTS/CTS was understood by a small number of candidates but other answers were rather confused.

B6 This question is about designing an appropriate network configuration to fit a given scenario. Imagine you are an expert consultant who has been engaged to produce the network design plan.

A local company is expanding its business and is moving into brand new buildings on a new industrial estate. The company will have three buildings (X, Y and Z) which are approximately 50 metres apart and are in line of sight of each other. Building X will contain six three-person offices for the administrative staff. Each member of the administrative staff will have a desktop computer. Building Y contains a central computer room with three high capacity fileservers, two web servers, a database server and two high performance computation servers. The company allows customers to buy products from a catalogue accessible on one of the web servers. Building Z contains the staff canteen and lounge area and also a large open-plan office used by the company's sales staff who work on laptop computers.

a. What type of network and supporting equipment should be deployed in building X?

(5 marks)

b. What type of network and supporting equipment should be deployed in building Y and its computer room?

(5 marks)

c. What type of network and supporting equipment should be deployed in building Z?

(5 marks)

d. What are the networking options to interconnect the three buildings?

(10 marks)

Answer Pointers

a). The key issues here are the collection of small offices with what are clearly fixed desktop computers (1). Clearly a cabled network should be deployed and this could be 100mbps or a 1gbs network (2). We don't know how big the building is and how far apart the offices are but perhaps a single Ethernet switch could be installed (1) and all computers cabled back to that. If the building is large, then perhaps multiple switches will be needed (1). Other relevant remarks rewarded with the total mark capped to 5.

b). The key aspect of the second building is its computer room full of high performance servers (1). The computers are clearly fixed so again a cabled network is appropriate (1). Being high performance servers, a 1gbps network would be appropriate (1). Only eight servers are mentioned, so making allowance for inter-building connections, a 16 port gigabit switch could be appropriate (1). However, knowing the products currently on the market, a larger switch is probably justified thus allowing for future expansion (1). The scenario also talks about the public having access to the web server and so some type of router (1) and Internet connection (1) will be required. Candidates should NOT be nominating ADSL connections as their asymmetric nature is very unlikely to be appropriate (1). Other relevant remarks, such as a discussion of the potential role of a firewall, will also be rewarded with the total mark capped to 5.

c). The key issues here are flexible nature of the space and the use of laptop computers (1) and no doubt other mobile devices (1). Clearly a wireless network should be deployed (1). Given the multiple rooms and the open-plan office being described as large, it would seem that multiple WLAN access points will be needed (1). Some sort of cabled connection will be needed to interlink the Access Points (1). Other relevant remarks rewarded with the total mark capped to 5.

d). Various options are available here. The buildings are all on a new private industrial estate and within 50 metres of each other (1). The use of copper technologies to interlink the buildings is not really recommended (1) but might be possible if the estate has ducting installed or such ducting can be dug (1). A more recommended guided media installation would be via the installation of fibre optic cabling (2). Such fibre is now NOT expensive (1) and fibre interfaces to network switches are not expensive (1). The nearness of the building does also mean that Wireless technology could be used (1), perhaps WLAN equipment with directional antennas (1). Clearly, the connectivity should be making its way back to the central computer room (1). Other relevant remarks, for instance a discussion of security issues, will be rewarded with the total mark capped to 10.

Examiners' Guidance Notes

This question was attempted by nearly 90% of the candidates of whom a large proportion (66%) achieved a pass mark.

Some candidates still suggested very out-of-date solutions in some areas. As we have said before, while we still very much expect candidates to understand the original co-axial cable based versions of Ethernet, it is now not really appropriate to deploy them for new installations. Indeed, many co-axial components are now in short supply or are disproportionately expensive. Some candidates also still suggest the use of "hubs" rather than switches in twisted pair installations. Hubs are still available, and sometimes appropriate, but if "cost" is the factor users are better off deploying unmanaged switches as opposed to managed switches as a way to save. Even managed switches are now not expensive; in British pounds, simple eight port managed switches, with gigabit connectivity on all ports are available for around 80 pounds in 2012 from some manufacturers. Unmanaged switches of a similar capability are currently available for less than 50 pounds. Larger switches and sophisticated products do of course cost significantly more. Most candidates managed to distinguish between the key features of the locations described in a), b) and c) above and make appropriate suggestions. In part c), many candidates clearly indicated that they believed all wireless access point had to be routers whereas that is not true; some APs act more like bridges than routers. The issue of building interconnection in part d) was perhaps less well answered. In particular, the question asked for a discussion of "options" (i.e. plural) and many candidates only presented one solution.