BCS THE CHARTERED INSTITUTE FOR IT

BCS HIGHER EDUCATION QUALIFICATIONS
BCS Level 5 Diploma in IT

COMPUTER NETWORKS

EXAMINERS' REPORT

Friday 2nd October 2015
Answer **any** FOUR questions out of SIX. All questions carry equal marks

The marks given in brackets are **indicative** of the weight given to each part of the question.

Only **non-programmable** calculators are allowed in this examination.

General comments

The performance in this session has not improved much from that of the April 2015 session. As before, the candidates are not preparing well reading the examiners' reports and past examination papers. The section A performance which used to be good, in previous years has dipped in 2015 both in April and October sessions. Except a small core of candidates who have made serious attempts to answer questions, the rest seem to have given up, when just a bit more effort is all that was needed. This can be attributed to lack of preparation which leads to guessing answers and hence resulting in erroneous answers. The only solution here is to use past examination papers, helped by the examiners' reports which have often complete solutions to questions and prepare for the examination using the recommended textbook.

Section A

1. This question is about fibre optic transmission systems.

a) Explain how data is transmitted along a fibre optic cable.

(6 marks)

Answer pointers:

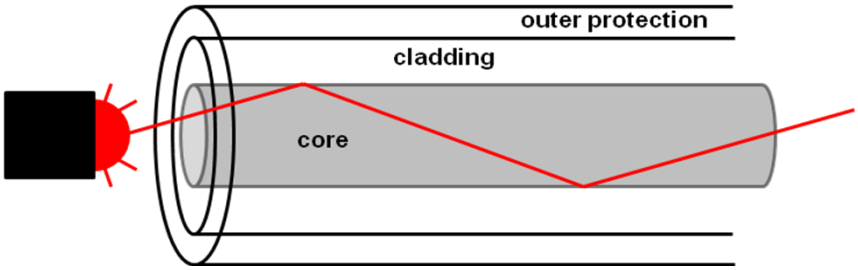
Data is transmitted along a fibre optic cable as light using either a laser or LED.

The fibre core is made of a very thin strand of high purity glass.

The fibre core 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 outer layer simply provides protection for the core and plays no part in the transmission of signals.



(Marking scheme: 1 mark for use of light; 1 mark for LED or laser; 1 mark for fibre core being glass; 1 mark for cladding; 2 marks for internal reflection)

b) Identify three physical characteristics of fibre optic cables that make them more suitable for high speed digital data transmission than copper cables.

(6 marks)

Answer pointers:

Advantages over copper:

The 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: 2 marks for lower losses; 2 marks for higher data rates; 2 marks for being less prone to interference)

c) Describe what is meant by *wave division multiplexing* (WDM) and explain how it is used to deliver high rate data transmission over a fibre optic cable.

(6 marks)

Answer pointers:

A fibre that uses only one wavelength of light is in effect a single channel.
Wavelength 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 fibre comprises a series of transmission channels.

(Marking scheme: 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)

d) A fibre optic transmission system uses wave division multiplexing with 16 different wavelengths of light. Each of these wavelengths is able to operate at 2.5Gbps. What is the maximum data carrying capacity of this transmission system? If you require 4Mbps to stream one high definition video, determine how many such videos could be transmitted at the same time using this fibre optic transmission system.

(7 marks)

Answer pointers:

Fibre system uses 16 wavelengths of light. Each wavelength operates at 2.5Gbps, therefore the total capacity of the fibre is 16 x 2.5 = 40Gbps.

(Marking scheme: 2 marks for 40 Gbps)

40 Gbps = 40 x 1024 x 1024 x 1024 bps (also accept: 40 x 1000 x1000 x 1000)

4 Mbps = 4 x1024 x 1024 bps

Therefore total number of high definition videos

= (40 x 1024 x 1024 x 1024) / (4 x 1024 x 1024)
= 10, 240

(accept 10,000 when 1000 is used instead of 1024)

(Marking scheme: 2 marks for 40Gbps; 2 marks for converting Gbps to bps; 1 mark for knowing that you need to divide fibre capacity by the video bandwidth; 2 marks for final answer)

Examiner's Guidance Notes:

The purpose of this question is to determine the understanding of the fibre option communication. Fibre optics plays such an important part in today's high speed Internet broadband system that domestic users enjoy these days. Some good answers and others have conceptual difficulties. Easy questions, and a good preparation should solve these difficulties.

2. 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)

Answer pointers:

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)

(Marking scheme: 1 mark per point identified)

ii. The Transport layer

(3 marks)

Transport layer

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

(Marking scheme: 1 mark per point identified)

b) What is meant by the term peer to peer protocol?

(3 marks)

Answer pointers:

In a layered protocol architecture data flows vertically through each of the layers of the model whereas protocols appear to operate horizontally. A peer to peer protocol is defined as the communication that takes place between two layers at the same level in different end-stations.

(Marking scheme: 1 mark for protocol operating horizontally and 2 marks for communication between two layers at the same level.)

c) Give one example of a device on a network that is required to operate all seven layers of the OSI Reference Model.

(2 marks)

Answer pointers:

End-station = personal computer, laptop etc.
or
Server

(Marking scheme: 2 marks for either answer)

d) Figure 1 shows part of a network in which two personal computers A and B, are each connected to a switch (LAN switch 1 and 2) which are themselves

interconnected by a router. Consider the transmission of data from personal computer A to B and produce a protocol layer diagram that clearly shows how data passes through all of the layers of the ISO Reference model that are used within the PCs, switches and router.

(14 marks)

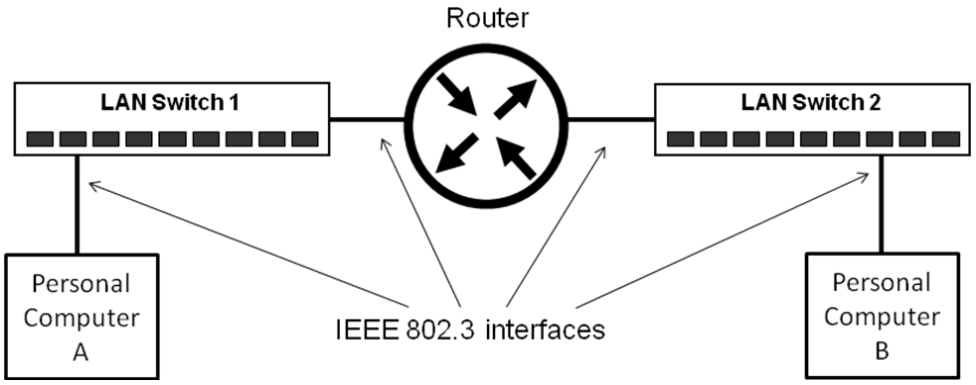
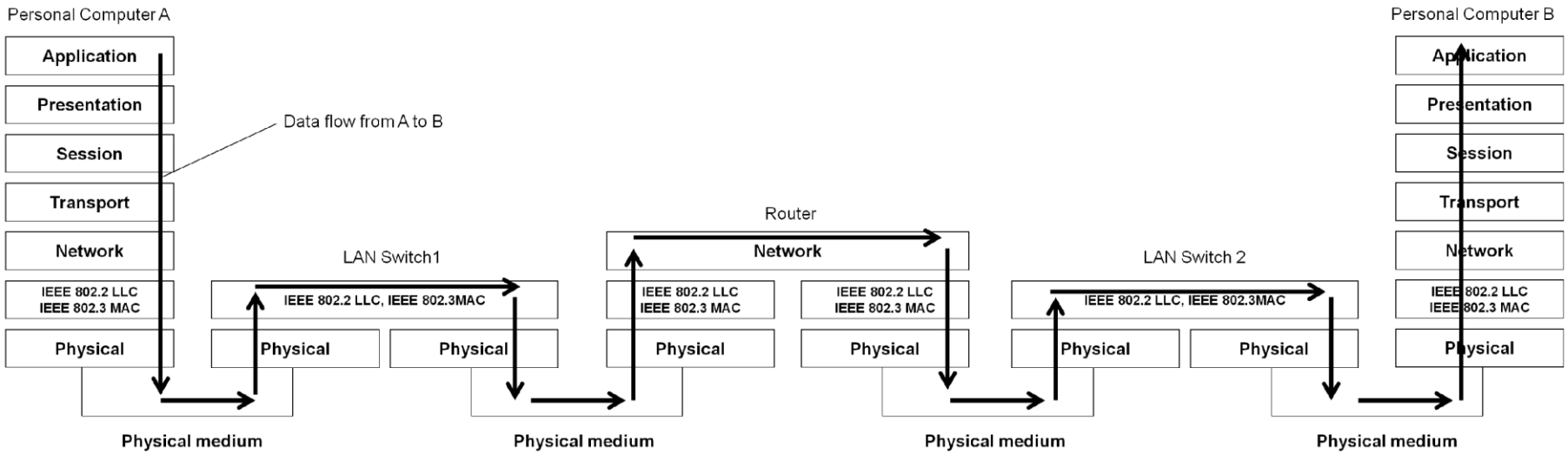


Figure 1

Answer pointers:

See diagram on next page for answer

(Marking scheme: 2 marks for PC A showing all 7 layers; 2 marks for switch 1 showing layer 2 spanning both physical ports; 4 marks for the router showing layer 3 spanning both ports with each port having its own layers 1 and 2; 2 marks for LAN switch 2; and 2 marks for PC B. 2 marks for showing the data flow from PCA to PCB.)


Personal Computer A
Application
Presentation
Session
Transport
Network
IEEE 802.2 LLC
IEEE 802.3 MAC
Physical
Data flow from A to B
LAN Switch1
IEEE 802.2 LLC, IEEE 802.3MAC
Physical
Physical
Router
Network
IEEE 802.2 LLC
IEEE 802.3 MAC
Physical
IEEE 802.2 LLC
IEEE 802.3 MAC
Physical
LAN Switch 2
IEEE 802.2 LLC, IEEE 802.3MAC
Physical
Physical
Personal Computer B
Application
Presentation
Session
Transport
Network
IEEE 802.2 LLC
IEEE 802.3 MAC
Physical
Physical medium
Physical medium
Physical medium
Physical medium

Examiner's Guidance Notes:

The core purpose of this question is to test the understanding of the ISO reference model and functions of the layers of this model and their role in an example network. The next popular question chosen.

3. This question is about global network services and specifically a comparison between the Internet and Multi-protocol label switching (MPLS).

a) A global organisation has offices located in different countries around the world and wishes to connect these together with a network that can transfer data and telephone calls between each office. Explain how the Internet could be used to provide this network.

(4 Marks)

Answer pointers:

Each office would need to have a local connection to an Internet Service Provider (ISP) who in turn would provide access to the global internet.

Each office would then become part of the Internet and data could be transferred between them with a knowledge of the IP addresses that have been allocated to each office site.

(Marking scheme: 2 for each of the above points)

b) What limitations in terms of the Quality of Service it offers does the Internet have in respect of providing the network described in part A3a)?

(6 Marks)

Answer pointers:

Internet QoS:

- The Internet is a best effort service which means that there is no guarantee that data will be delivered and if it is delivered, there is no way of predicting how long it will take.
- No differentiation – all traffic types handled equally which means that you cannot differentiate time critical application, such as the telephone traffic from non time critical ones, such as basic data transfer.
- The volume of traffic on the Internet cannot be predicted which means that the bandwidth being delivered between any two locations for a service cannot be predicted either.

(Marking scheme: 2 marks for each of the above points)

c) How does the Quality of Service offered by Multi-protocol label switching (MPLS) differ from that offered by the Internet?

(6 Marks)

Answer pointers:

MPLS network can establish single or multiple virtual circuits between offices.

Each traffic type can be allocated to its own virtual circuit which in turn can be offered a different class of service. Hence, the telephone calls can be differentiated from the data and given a different class of service.

MPLS is therefore able to offer a guaranteed QoS for all traffic passing over the network between the organisation's offices.

(Marking scheme: 2 for each of the above points)

d) How could the global organisation described in part A3a) use Multi-protocol label switching (MPLS) to create its network and explain how MPLS would be able to provide a different Quality of Service for the transfer of data and telephone calls.

(9 Marks)

Answer pointers:

Each office would firstly need to be connected to the MPLS service through a single point of attachment.

Thereafter virtual circuits can be established through the MPLS network connecting each of the organisation's offices, with each virtual circuit having its own QoS.

As traffic enters the MPLS network, the ingress router classifies the traffic and allocates it to one of the virtual circuits and assigns a label to it.

All intermediate routers within the MPLS network process/route each packet based on the value of its label only. A given label is therefore linked to a specific QoS requirement and it is up to each router to ensure that packets are given the appropriate priority when being processed.

Telephone traffic has strict requirements in terms of the maximum transmission delay it can endure whereas data has no such restrictions. Therefore it is important for the telephone traffic to be differentiated from the data by defining two classes of service. Labels will be assigned for each class of service and these will be allocated to each data packet as it enters the MPLS network and is classified.

On arrival at the final router in the route (egress router), the label is removed and the packet transmitted to the destination.

(Marking scheme: 1 for each office attached through a single point of attachment, 1 for establishment of virtual circuits between offices, 2 for labels being assigned to virtual circuits, 2 for label switching within the MPLS network, 2 for telephone and data differentiation, 1 for removal of label at egress router.

Examiner's Guidance Notes:

The purpose of this question is to look at the global Internet services and the protocols related to them, in particular the significance of the MPLS switching. As well as this, the importance of the QOS and that data is to be differentiated from the voice communication. This question is answered by all students.

Section B

B4. This question is about IPv4 addressing.

a) In classful addressing, the IP address space is divided into 5 classes. Indicate the classes of each of the following address expressed in binary. Indicate how the class was identified.

- **00000001 00001011 00001011 11101111**
- **11000001 10000011 00011011 11111111**
- **10100111 11011011 10001011 01101111**
- **11110011 10011011 11111011 00001111**

(8 marks)

b) A host was given the 192.168.3.219 /27 IP address, indicate:

- **The network address to which the host belongs.**
- **The network broadcast address to which the host belongs.**
- **The total number of hosts available in the network**

(6 marks)

c) Describe the concept of classless addressing, indicating the reason why it was proposed and providing an example of a classless IP address.

(5 marks)

d) Considering classes addressing, an organization is granted a block of addresses with the beginning address 14.24.74.0/24. The organization needs to have 3 subblocks of addresses to use in its three subnets as shown below:

- **One subblock of 120 addresses.**
- **One subblock of 60 addresses.**
- **One subblock of 10 addresses.**

Indicate the network IP address and the subnet mask for each of the subblocks.

(6 marks)

Answer pointers:

a. In the binary notation, the first few bits can immediately tell us the class of the address:

Class A starts in 0
Class B starts in 10
Class C starts in 110

Class D starts in 1110
Class E starts in 1111

Therefore the address given are:

- 00000001 00001011 00001011 11101111 – Class A
- 11000001 10000011 00011011 11111111 – Class C
- 10100111 11011011 10001011 01101111 – Class B
- 11110011 10011011 11111011 00001111 – Class E

(Marking scheme: 2 marks per address correctly identified, 8 marks in total)

b. To work with this question we need first to convert the IP address to its binary representation: 192.168.3.219 = 11000000.10101000.00000011.11011011

- If we apply the AND function to the binary representation of the IP address and the network mask (255.255.255.224) we will obtain the network address: Network address: 192.168.3.192

- The broadcast address is represented by putting as 1s all the bits belonging to the host portion: 192.168.3.223

- The total number of hosts is given by the following formula: $2^n - 2$, where n represents the number of bits available in the host portion. In this case n = 5, which means that we have 25 – 2 hosts or 30.

(Marking scheme: 2 marks per correct answer)

c. With the growth of the Internet, it was clear that a larger address space was needed as a long-term solution. The larger address space, however, requires that the length of IP addresses to be increased, which means the format of the IP packets needs to be changed. Although the long-range solution has already been devised and is called IPv6, a short-term solution was also devised to use the same address space but to change the distribution of addresses to provide a fair share to each organization. The short-term solution still uses IPv4 addresses, but it is called classless addressing. In other words, the class privilege was removed from the distribution to compensate for the address depletion.

(Marking scheme: 2 marks for describing the concept, 2 for the reason why it was proposed and 1 for the example).

d. For 120 addresses we need 7 bits in the host portion, therefore the network address is: 14.24.74.0/25, leaving 14.24.74.128/25 available for other networks.

For 60 addresses we need 6 bits in the host portion, therefore the network address is: 14.24.74.128/26, leaving 14.24.74.192/26 available for other networks.

For 10 addresses we need 4 bits, therefore the network address is 14.24.74.192/28 leaving 3 more subblocks of 14 hosts each available.

(Marks: 2 marks per correct answer)

Examiner's Guidance Notes:

The purpose of this question was to evaluate the understanding of the student of the IPv4 addressing scheme, which is one of the fundamental topics required in a networking degree. Question 4 was the one with more attempts, 68% or 92 candidates, of section B of the paper. However, only 49% got a passing mark. Compared to previous exams related to IP I would consider the results encouraging as it demonstrates that students are familiar with the IPv4 addressing scheme.

B5. This question concerns wireless local area networks (WLAN) technology and IEEE802.11 standards.

a) The data link layer in the IEEE standard is divided into two sublayers: LLC and MAC. Indicate the functions performed by each sublayer.

(5 marks)

b) Draw the flow diagram of the Carrier Sense Multiple Access/Collision Avoidance mechanism used by 802.11 (CSMA/CA).

(6 marks)

c) Indicate at least the reasons why CSMA/CD cannot be implemented by Wireless LANs.

(6 marks)

d) The IEEE 802.11 addressing mechanism specifies four cases, defined by the value of the two flags in the FC field, *ToDs* and *FromDS*. Explain the values those flags could take and the values the different addresses should take. Use the following table to provide your answer:

(8 marks)

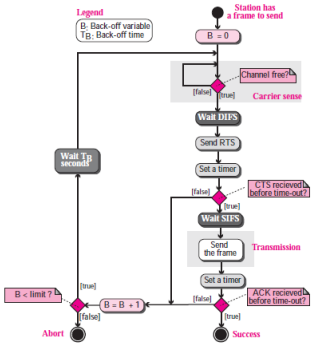
ToDS	*FromDS*	*Address 1*	*Address 2*	*Address 3*	*Address 4*
0	**0**				
0	**1**				
1	**0**				
1	**1**				

Answer Pointers:

a. Logical Link Control: handles framing, flow control, and error control. Media Access Control: defines the access method and the framing format specific to the corresponding LAN protocol.

(Marking scheme: 1 mark per correct function in each sublayer)

b.



(Marking scheme: 2 marks for the back off mechanism, 2 marks for the persistent strategy, 2 marks for the collision detection mechanism)

c. For collision detection a station must be able to send data and receive collision signals at the same time. This can mean costly stations and increased bandwidth requirements.
Collision may not be detected because of the hidden station problem. We will discuss this problem later in the chapter.
The distance between stations can be great. Signal fading could prevent a station at one end from hearing a collision at the other end.

(Marking scheme: 2 marks per reason given)

d. The frame specifies 4 MAC address and the value will depend on whether the information is going from the distribution system or to the distribution system, if that is the case then one of the MAC address will represent the Access Point whilst the other ones will contain the sender and/or the receiver. Address 4 will only be used when the communication happens within a bridging network.

ToDS	***FromDS***	***Address 1***	***Address 2***	***Address 3***	***Address 4***
0	0	Destination	Source	BSS ID	N/A
0	1	Destination	Sending AP	Source	N/A
1	0	Receiving AP	Source	Destination	N/A
1	1	Receiving AP	Sending AP	Destination	Source

(Marking scheme: 1 mark per correct cell value)

Examiner's Guidance Notes:

Question 5 was the second most popular question of section B but only by a small percentage. 54% of the candidates attempted this question and only 22% got a passing mark. This question evaluates understanding of layer 2 implementation in the IEEE 802.11 standard.

A common error was for candidates to confuse the MAC sublayer with the MAC address, although physical addressing is part of layer 2 functionality, it is not covered in the MAC sublayer. Candidates also tried to explain the CSMA/CD mechanism instead of CMSA/CA as indicated in the question and the ones who attempted an explanation did it ended up just drawing some computers connected to a network. It is clear that students do not understand the difference between wireless and wired requirements in terms of medium access control. Most of the candidates didn't complete section D of this question.

B6. This question is about the concept of Quality of Service (QoS).

a) **Traditionally, four types of characteristics are attributed to a flow: reliability, delay, jitter, and bandwidth. Briefly explain how each concept is related to QoS.**
(8 marks)

b) **Briefly explain the concept of RSVP and the three reservation styles defined by RSVP.**
(8 marks)

c) **Describe two problems with Integrated Services**
(4 marks)

d) **Briefly explain the concept of Differentiated Services and one of the per-hop behaviours specified by it.**
(5 marks)

Answer pointers:

a. Reliability is a characteristic that a flow needs. Lack of reliability means losing a packet or acknowledgment, which entails retransmission. However, the sensitivity of application programs to reliability is not the same. For example, it is more important that electronic mail, file transfer, and Internet access have reliable transmissions than telephony or audio conferencing.

Source-to-destination delay is another flow characteristic. Again applications can tolerate delay in different degrees. In this case, telephony, audio conferencing, video conferencing, and remote log-in need minimum delay, while delay in file transfer or e-mail is less important.

Jitter is the variation in delay for packets belonging to the same flow. For example, if four packets depart at times 0, 1, 2, 3 and arrive at 20, 21, 22, 23, all have the same delay, 20 units of time. On the other hand, if the above four packets arrive at 21, 23, 21, and 28, they will have different delays: 21, 22, 19, and 24. For applications such as audio and video, the first case is completely acceptable; the second case is not. For these applications, it does not matter if the packets arrive with a short or long delay as long as the delay is the same for all packets. For this application, the second case is not acceptable. Jitter is defined as the variation in the packet delay.

High jitter means the difference between delays is large; low jitter means the variation is small.

Different applications need different bandwidths. In video conferencing we need to send millions of bits per second to refresh a colour screen while the total number of bits in an e-mail may not reach even a million.

(Marking scheme: 2 marks per explanation)

b. In the Integrated Services model, an application program needs resource reservation. This means that if we want to use IntServ at the IP level, we need to create a flow, a kind of virtual-circuit network, out of the IP, which was originally designed as a datagram packet-switched network. A virtual-circuit network needs a signalling system to set up the virtual circuit before data traffic can start. The Resource Reservation Protocol (RSVP) is a signalling protocol to help IP create a flow and consequently make a resource reservation.

When there is more than one flow, the router needs to make a reservation to accommodate all of them. RSVP defines three types of reservation styles:

Wild Card Filter Style In this style, the router creates a single reservation for all senders. The reservation is based on the largest request. This type of style is used when the flows from different senders do not occur at the same time.

Fixed Filter Style In this style, the router creates a distinct reservation for each flow. This means that if there are n flows, n different reservations are made. This type of style is used when there is a high probability that flows from different senders will occur at the same time.

Shared Explicit Style In this style, the router creates a single reservation that can be shared by a set of flows.

(Marking scheme: 2 marks per description of RSVP, 2 marks per style)

c. Scalability. The Integrated Services model requires that each router keep information for each flow. As the Internet is growing every day, this is a serious problem.

Service-Type Limitation. The Integrated Services model provides only two types of services, guaranteed and control-load. Those opposing this model argue that applications may need more than these two types of services.

(Marking scheme: 2 marks per problem)

d. Differentiated Services (DS or Diffserv) was introduced by the IETF (Internet Engineering Task Force) to handle the shortcomings of Integrated Services. Two fundamental changes were made:

1. The main processing was moved from the core of the network to the edge of the network. This solves the scalability problem. The routers do not have to store information about flows. The applications, or hosts, define the type of service they need each time they send a packet.

2. The per-flow service is changed to per-class service. The router routes the packet based on the class of service defined in the packet, not the flow. This solves the

service-type limitation problem. We can define different types of classes based on the needs of applications.

The Diffser model defines three per-hop behaviours (PHBs) for each node that receives a packet.

DE PHB. The DE PHB (default PHB) is the same as best-effort delivery, which is compatible with TOS.

EF PHB. The EF PHB (expedited forwarding PHB) provides the following services:

- ❑ Low loss
- ❑ Low latency
- ❑ Ensured bandwidth

This is the same as having a virtual connection between the source and destination.

AF PHB. The AF PHB (assured forwarding PHB) delivers the packet with a high assurance as long as the class traffic does not exceed the traffic profile of the node. The users of the network need to be aware that some packets may be discarded.

(Marking scheme: 3 marks for explaining DiffServ and 2 marks for explaining one of the PHBs.)

Examiner's Guidance Notes:

Question 6 of section B was the least popular amongst the candidates. Only 39% of the candidates attempted the question with only 15% obtaining a passing mark. The question evaluated the student's understanding of the two most important QoS protocols. In the first part of the question, students were asked to describe the concepts of reliability, delay, jitter, and bandwidth but most of the students decided not to describe them and decided to name other elements that are related to QoS. Candidates need to be careful when reading the question and have to make sure that they are being asked before attempting to put an answer.