THE BCS PROFESSIONAL EXAMINATIONS
Diploma

October 2005

EXAMINERS' REPORT

Computer Networks

General

The pass rate has significantly dropped this year. The questions were not different from those appeared in the previous years. In fact, questions in one form or another were similar to those which appeared in previous papers. This can be mainly attributed to students not having clear understanding of questions and attempting to second guess the answers. Even though some questions were answered well, the performance was not uniformly reflected in all four questions.

Question 1

1. *a)* Show, by means of a diagram, the frame format used within the IEEE 802.3 CSMA/CD LAN. **(6 marks)**

b) Why must the data field size always be equal to, or greater than, 46 octets? **(6 marks)**

c) What is meant by a *real-time system* and what quality of service do real-time systems demand from a network? **(5 marks)**

d) By considering the performance of an IEEE 802.3 LAN explain why this technology is not well suited to supporting real time services. (**8 marks)**

1 a)

Destination Address (6 bytes)	Source Address (6 bytes)	Length (2 bytes)	Data (46 to 1500 bytes)	PAD	CRC (4 bytes)

Marking scheme: 1 mark each for the destination address, source address, length and CRC fields, 2 marks for the data field showing the PAD area.

1 b)

The operation of the CSMA/CD LAN results in node sensing the cable before transmission. If the cable is busy then transmission must wait until the cable becomes clear. Once the cable is sensed as free, then transmission can begin. However, due to the propagation delay, it is possible that two nodes can sense the cable as being free and start transmission at the same time. Should this happen, then the transmission from the two nodes will interfere resulting in a collision and the loss of all data. In order to ensure that a transmitting node can detect this collision, it is essential that a collision is forced to propagate along the full length of the network. Hence, a frame must have a minimum size that ensures that a transmission will always last longer than the time taken for data to propagate along the full length of the network and for a collision to propagate back. This is known as the round trip delay. The data field must therefore always be equal to or greater than 46 octets to satisfy the requirements of a minimum frame size.

Marking scheme: 3 marks for explaining the importance of round trip delay in detecting collisions; 3 marks for explaining the relationship between round trip delay and frame size, thus justifying the minimum frame size.

1c)
A real time system is one in which there is a strict timing relationship between communicating nodes. Such systems demand a quality of service that is able to guarantee the maximum time it takes for information to be delivered from a to b, is able to control transmission delay variation and is able to provide guarantees regarding data loss.

Marking scheme: 2 marks for noting the strict timing relationship aspects; 1 mark for maximum time for transmission, 1 mark for delay variation and 1 mark for data loss.

1d)
How long does it take a node to transmit data over an IEEE 802.3 LAN? The answer is uncertain. When the traffic on the LAN is light then a node will quickly gain access to the network and transmit data. This is because the probability of sensing a cable as free is high. However, as traffic increases so the probability that the cable will be free reduces and so nodes are increasingly forced to wait for access and similarly, the chance of a collision will also increase. Hence, as the traffic load increases so the delay in transmitting data must increase through collisions and forced re-transmissions.

At any given point in time, it is impossible to determine how long it will take for a node to transmit a LAN frame. This is unacceptable for real-time systems for they require, as a minimum, a guarantee regarding the worst case transmission time. The IEEE 802.3 LAN cannot provide this guarantee. Hence, this LAN technology could only really hope to support real time services providing that overall LAN traffic loads are kept very low.

Marking scheme: 3 marks for describing the performance at low traffic levels, 3 marks for describing performance at high traffic loads and 2 marks for identifying that the key parameter is transmission delay which cannot be guaranteed.

Examiner's Comments
Part a): part a) was a straightforward question. Most of the students answering this scored all, or nearly all, the marks.

Part b): part b) was a much more difficult question. A lot of students simply did not know the answer as to <u>why</u> the data field segment on an Ethernet needs to be equal to or greater than 46 octets and simply talked around the issue without scoring marks. Those that did know it was something to do with detecting collisions usually could not give a whole and precise explanation, but scored marks according to how close they got to the actual explanation.

Part c): This part caused a lot of problems. A lot of students confused the issue of real time systems with the question of critical systems – explaining that systems needed to be reliable, with quick response and so on. In many real systems no doubt there are overlaps between the requirements of critical and real-time systems. But they are separate concepts, and video-conferencing, for instance, needs to be real time without necessarily being a critical system.

On the central issue of timing, many students said there had to be no delay. Although this acknowledges that timing is an issue, it is completely unrealistic. Overall, only a few students answered in a relevant way.

Part d): Despite the difficulties over part c) quite a lot of students could get on the right points about why a standard Ethernet was not suitable for real-time applications. A lot of them could see that the potential for collisions and the non-deterministic nature of the standard Ethernet were a problem for real-time systems.

Question 2

2. *a)* What are the basic principles of operation of a Frame Relay network? **(10 marks)**

b) When a Frame Relay virtual circuit connection is established between two end-stations, a number of traffic characteristics, such as the *committed burst size* are specified within the Call SETUP message. Why are parameters of this type important in allowing a Frame Relay network to provide dynamic bandwidth allocation? **(10 marks)**

c) If a Frame Relay packet passes through an area of congestion within the network, explain how the receiving end-station would learn that congestion exists within the network. **(5 marks)**

Answer Pointers

2a)

A Frame Relay network provides a connection orientated service. An end-station connects to the network through a single point of attachment but is able to establish multiple virtual circuits over this physical connection. The total bandwidth assigned to support these connections is limited by the physical capacity of the point of attachment but, within that limit, bandwidth assignment to each virtual circuit can vary with time to dynamically adjust to the needs to each connection.

An end-station must therefore begin by requesting a connection with a remote end-station. This connection will be assigned a data link connection identifier (DLCI) to uniquely identify each frame relay packet belonging to this connection.

During the connection process, an end-station must describe the bandwidth requirements of the connection through the definition of a traffic contract. His contact will determine if the network is able to accept the connection within the resources currently available.

Once established the connection then supports the transmission of Frame Relay packets, each identified by their unique DLCI. Each frame relay simply passes the packet onto the next relay. Errors detected along the route will simply result in the packet being discarded. The only feedback that that the network provides to the end-stations is that relating to the existence of traffic congestion.

On conclusion of the data transfer phase, the connection must be formally terminated.

Marking scheme: 2 marks for connection orientated; 4 marks for virtual circuit including the DLCI and traffic contract; 4 marks for data transfer including congestion notification.

2b)

One of the key objectives of the Frame Relay network is to provide the end-station with a dynamic level of bandwidth that matches the demands of the application or service being delivered. To achieve this it is important to know in advance the bandwidth demands of each connection. These are described within what is known as a traffic contract. This contract will define the average traffic level to be generated, the burst size which defines a level above the average that should be transmitted and an excess burst size that should be accommodated only if spare capacity exists within the network at that time.

The traffic contract is therefore defined by a series of parameters such as the committed burst size and these are conveyed within the initial connection establishment. On receipt of the Call SETUP message, each frame relay will examine the traffic contract parameters and will only allow the SETUP message to progress if that relay is able to support the traffic demands of the connection. Should a relay be unable to satisfy this traffic demand, then the call request will be terminated at that point.

During the course of the data transfer phase, the bandwidth utilisation per virtual circuit is monitored and compared against the traffic contract. If at any point the data being transmitted exceeds the limits imposed by the traffic contract then packets will be dropped to bring the traffic back within limits.

Marking scheme: 4 marks for explaining the purpose of a traffic contract; 4 marks for explaining that the parameters form the traffic contract; 2 marks for monitoring the traffic contract during the data transfer phase.

2c)
Within the frame relay packet are contained two bits – FECN and BECN – that are used by the frame relays to identify that the packet has been exposed to an area of congestion. When transmitted by an end-station, these bits are set to zero within the packet. However, as the packet is passed from relay to relay then the bit can be set to one if an area of congestion is reached.

In this particular example, the frame relay packet will start with the FECN=1 but at it passes through the area of congestion, the FECN bit will be set to 1. Once set to 1, it remains at that value. Therefore, when received, an end-station will know that this packet has passed though an area of congestion because FECN=1. Had no congestion been experienced then FECN=0.

Marking scheme: 2 marks for identifying the existence of congestion notification bits; 3 marks for showing how the FECN bit would be used in this example.

Examiner's Comments
Part a): There are lots of possible answers to 'what are the basic principles of operation of a Frame Relay network?', since the technology has a lot of aspects. The students covered a lot of ground in answering this question, and, as long as they were saying things that were sensible and true, they scored marks even if they did not necessarily focus on all the specific points mentioned in the suggested answer. This question was well done, on the whole.

Part b): This was a much more specific question than part a), and only a proportion of students understood why the call setup message needed to have specific parameters to allow a Frame Relay network to provide dynamic bandwith allocation.

Part c): Again, this was a very specific question about the detail of how Frame Relay deals with congestion. A few students did know the answer, however.

Overall: the question worked quite well, since all the students who knew something about Frame Relay could score some points, but it was necessary to know quite a lot to score highly.

Question 3

3. *a)* What are the advantages and disadvantages of using ATM networks? **(6 marks)**

b) Explain with the help of a diagram, how ATM cells are routed through a network. Explain why the cells invariably take a fixed route. **(12 marks)**

c) Explain why quality of service (QOS) is an important issue for ATM networks. **(7 marks)**

Answer Pointers

Texts: Fred Halsall: Data Communications, Computer Networks and Open Systems 4th Ed

William Stallings: Data and Computer Communications, 7th Ed

3. a) Advantages:

Explanation of

- Defined QOS – bandwidth, error rates, delays etc.
- Scaleable bandwidths
- Connection-oriented

3 marks

Disadvantages:

Explanation of

- Is a complex networking technology
- Requires an overlaying of existing protocols
- No mechanism for guaranteeing delivery

3 marks

b) A diagram of virtual ATM virtual connections with a few ATM switches with at least two users.

Explanation of virtual path set up between user 1 and user 2 through these ATM switches. VCI numbers and routing table discussion. Movement of ATM cells through switches with VCI numbers.

10 marks

There is a virtual circuit set up between the transmitting and receiving node and the cells are always delivered in the same order as they are transmitted. This is because cells cannot take alternative routes to the destination.

2 marks

c) QOS is important issue for ATM networks because they are used for real-time traffic such as audio and video. When a virtual circuit is established both transport layer and the ATM network layer must agree on a contract defining the service. This includes the traffic to be offered, the service agreed upon and the compliance requirements. The QOS parameters Re peak cell rate, sustained cell rate, minimum cell rate etc.

7 marks

Examiner's Comments

Overall, in this question, students did not score highly. The question in its three parts is quite specific, and the answer to each part is in someway linked to the other, and hence provided good opportunity to answer the question well. The QOS issues were not well explained by most students.

In part (a).the advantages include, defined QOS, scaleable bandwidths and connection-oriented, and the disadvantages includes, complex networking technology, requiring an overlaying of existing protocols and no mechanism of guaranteed delivery.

For the part (b), a diagram of virtual connections with a few ATM switches and users were expected. Explanation should include virtual path set between users through the ATM switches. The VCI numbers and routing table should be part of the explanation, which should clear touch on the movement of ATM cells through switches with VCI numbers. The explanation should clearly underline the virtual circuit set up, and the fact that the cells are always delivered in the same order as they are transmitted as they cannot take alternative routes to the destination.

Part (c) should clearly explain the importance of QOS in ATM networks in particular the real-time nature of the audio and video data. Also of importance is the contractual nature of virtual circuit as well as the traffic to be offered. Explanation should include such QOS parameters such as peak cell rate, sustained cell rate, minimum cell rate etc.

Question 4

4. *a)* Outline the basic operation of the *Open Shortest Path (OSPF)* routing protocol. **(12 marks)**

b) Why is it important for routers to know about all of the possible routes through a network topology? **(5 marks)**

c) Show, by means of a diagram, how a subnet mask can be used to extract the network identification and host identification from an IP address. **(8 marks)**

Answer Pointers

4a)

OSPF is a link state database routing algorithm.

Each router determines those routers that are adjacent to it and calculates a cost for each such link. This cost can reflect the delay currently experienced on that link, the bandwidth available, the technology and event the financial cost of using the link. The knowledge of these adjacent routers and their associated costs are stored within a link state database.

Using a protocol, each router communicates with those adjacent to it and sends a copy of its link state database. To prevent excessive traffic being generated, it is normal for one router to communicate on behalf of a group of others. So, for each subnetwork, one router will be designated and become responsible for passing on a copy of each router's link state database to the next subnetwork.

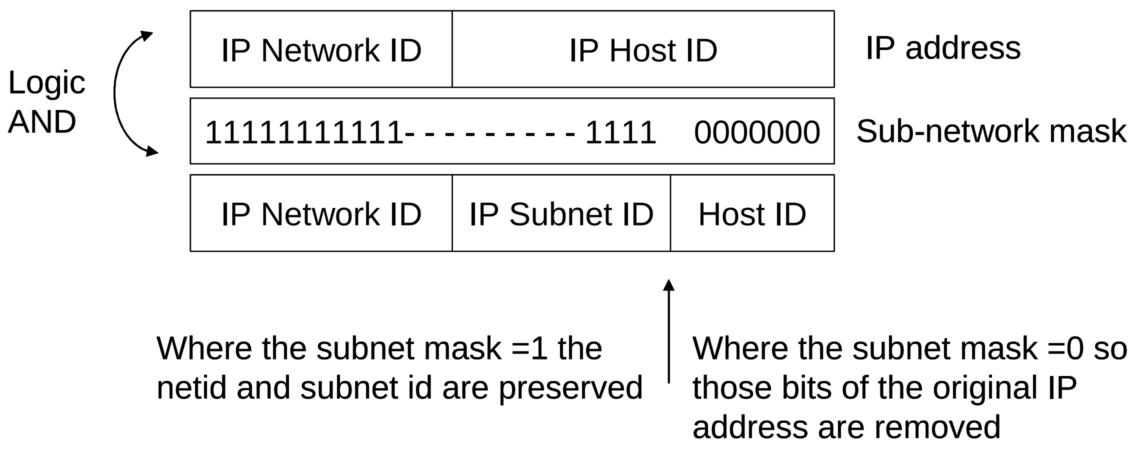
As the protocol completes a cycle, so every router will have received a copy of the link state database from every other router. From these it is possible to construct a complete map of the overall network topology and all of the associated costs. A routing algorithm – Dijkstrar's algorithm – is then able to compute the shortest path between any given two points. It is these shortest paths that routers use in order to send traffic through the network.

Marking scheme: 4 marks for the local link state database; 4 marks for copying the link state databases to every other router; 4 marks for determining the network topology map and using Dijkstrar's algorithm.

4b)
Within a network, the cost of a particular link can change due to increased traffic levels. Hardware failure can also result in increased error rates on a link and ultimately for complete link failure. The key point of an efficient routing protocol is to ensure that a route can always be found, even if certain links have failed. Hence, it is essential for a router to know all possible routes through a network such that, if the cost of a link increases or a link fails, an alternative can be used without having to re-compute a new router by communicating with the other network routers. Recovery from link failure is therefore not only transparent to the end-stations but also occurs quickly.

Marking scheme: 3 marks for the reason for why routes cease to remain available; 2 marks the need to efficient re-routing when links fail.

4c)



Marking scheme: 3 marks for showing that the subnet mask has zeros only where the true hostid field is located; 2 marks for the logical AND operation; 3 marks for showing how the subnetid is extracted.

Examiner's Comments
Evidently the phrasing of part b) was easier for the students than the phrasing of part a) which was much more open. As a consequence, they sometimes said things in answering part b) that were relevant to part a) without realizing it. If the student clearly showed knowledge of how to answer parts of question a) in part b) then some marks were given for that.

Part a): The general shortcoming here was a failure to realize that OSPF is essentially about routers communicating with each other. Very few students understood this. But they often did understand about assessing the cost of a link. And they sometimes knew abut Dijkstrar's algorithm or understood, at any rate, about the idea of calculating the shortest path.

Part b): A lot of students got the central point here about the possibility of link failure and the necessity for the routers to be able to respond to that. A lot of them knew that routers can choose between paths, which is also relevant (and also part of the answer to part a).

Part c): Most of the students who attempted this got some marks, but few got full marks. In general it was the question of exactly how the subnet mask is extracted that was the stumbling block. Most students knew the point about ones in the subnet mask corresponding to the netid and the zeros corresponding to the hosted. A lot of students mentioned the logical AND operation. But a lot of students could not show how the AND operation was used precisely to extract subnetid is extracted:

Question 5

5. *a)* Explain with the help of appropriate diagrams, the following terms:

i) amplitude modulation
ii) frequency modulation
iii) phase modulation **(6 marks)**

b) Discuss the sources of noise in data communication systems. Why it is important to consider the effect of noise on data communication systems? **(8 marks)**

c) Show with the help of appropriate diagrams how the bit patterns 100001011111 can be encoded using:

i) Manchester encoding
ii) Differential Manchester encoding.

What is the advanatage of using Differential Manchester encoding? **(11 marks)**

Answer Pointers

5. a) Standard definitions from the text books 2 marks each

b) Sources of noise:

- Thermal noise
- Cross-talk
- Impulse noise 5 marks

Explanation- corruption of data bits, bandwidth implications – signal-to-noise Ratio. 3 marks

c) Diagrams should be presented: with Manchester encoding, each bit period is divided in to two equal intervals. A binary 1 bit is sent by having the voltage set high during the first interval and low in the second one.A binary 0 is reverse to
In the Differential Manchester encoding a 1 bit i8s indicated by the
A 0 bit is indicated by the presence of a transition at the start of the interval

10 marks

The Differential Manchester encoding offers better noise immunity.

1 mark

Examiner's Comments

The largest number of students attempted this question. The question in the three parts required fairly standard answers. But contrary to expectation, the answers were less than convincing.

Part a) requires standard text both explanation of the three modulation techniques. Essential to clearly state the two signals involved, the carrier and the modulating signal in all the three techniques. Surprisingly this important aspect was not clearly mentioned in most answers, and as a result the answers did not make much sense.

Part b) answer should discuss the three sources of noise, thermal noise, cross-talk and impulse noise. Also the explanation should highlight aspects such as corruption of data bits, bandwidth implications, signal-to-noise ratio.

Part c) answer should include Manchester encoding diagram – each bit period divide into equal intervals, a binary 1 bit representing voltage set high during the first interval and low in the second one. A binary 0 is reverse to this. In the Differential Manchester encoding bit 1 is indicated by the absence of transition at the start of the interval and bit 1 the presence of transition. The main advantage of the Differential Manchester encoding is that it offers better noise immunity.

Question 6

6. *a)* What is a wireless LAN? What are the advantages and disadvantages of using wireless LANs?

(6 marks)

b) What transmission techniques are used in these LANs? **(9 marks)**

c) With the help of a diagram explain the IEEE 802.11 wireless LAN standard protocol stack.

(10 marks)

Answer Pointers

6. a)

The wireless LAN, provides an alternative to the traditional LANs based on twisted pair, coaxial cable, and optical fibre. The wireless LAN serves the same purpose as that of a wired or optical LAN: to convey information among the devices attached to the LAN. But with the lack of physical cabling to tie down the location of a node on a network, the network can be much more flexible -- moving a wireless node is easy. As opposed to the large amount of labour required to add or move the cabling in any other type of network. Also going wireless may be a better choice where the physical makeup of the building makes it difficult or impossible to run wire in the building.

6 marks

b)

Transmission techniques; spread spectrum, narrow band microwave and infrared.
Explanation such as frequency hopping spread spectrum and direct sequence spread spectrum etc. The dishes must be in line-of-sight to transmit and collect the microwave signals. Microwave is used to bypass the telephone company when connecting LANS between buildings. Infrared LANs use infrared signals to transmit data. These LANs can be set up using either a point-to-point configuration or a sun-and-moon configuration where the signals are diffused by reflecting them off of some type of surface. The major advantage of infrared is its ability to carry a high bandwidth, but its major disadvantage is that they can easily be obstructed, since light cannot pass through solid objects.

3 marks for each technique

c)

The 802.11 protocol stack with physical layer, data link layer and upper layers. The physical layer with infrared, frequency hopping and direct sequence spread spectrum protocol sub parts. The data link layer with MAC sub layer etc. Explanation of the functions.

Diagram: 6 marks, Functional explanation: 4 marks

Examiner’s Comments

A good number of students chose to answer this question. Part a) solicited good answers, but answers to parts b) and c) were poor and speculative.

An indicative answer to part a) A wireless LAN, provides an alternative to the traditional LANs based on twisted pair, coaxial cable, and optical fibre. The wireless LAN serving the same purpose as that of a wired LAN, but with the lack of physical cabling to tie down the location of a node on a network means that the network can be much more flexible. Also going wireless may be a better choice where the physical makeup of the building makes it difficult or impossible to run wire in a building.

For part b), three transmission techniques; spread spectrum, narrow band microwave and infrared should be listed and discussed. Explanation such as frequency hopping spread spectrum and direct sequence spread spectrum etc. Infrared LANs use infrared signals to transmit data. These LANs can be set up using for example a point-to-point configuration The major advantage of infrared is its ability to carry a high bandwidth, but its major disadvantage is that they can easily be obstructed, since light cannot pass through solid objects.

Answer to part c) include the 802.11 protocol stack with physical layer, data link layer and upper layers. Details such as the physical layer with infrared, frequency hopping and direct sequence spread spectrum protocol, the data link layer with MAC sub layer etc. with explanation of functions of each.