THE BCS PROFESSIONAL EXAMINATION
Diploma

April 2005

EXAMINERS' REPORT

Computer Networks

General

The general performance is about average, at an overall 55.3%, a drop in last year's average. However, answers to a selective few questions demonstrated a very good level of understanding of basic concepts, but this was not repeated in respect of other questions. Hence the drop in the average mark.

Question 1

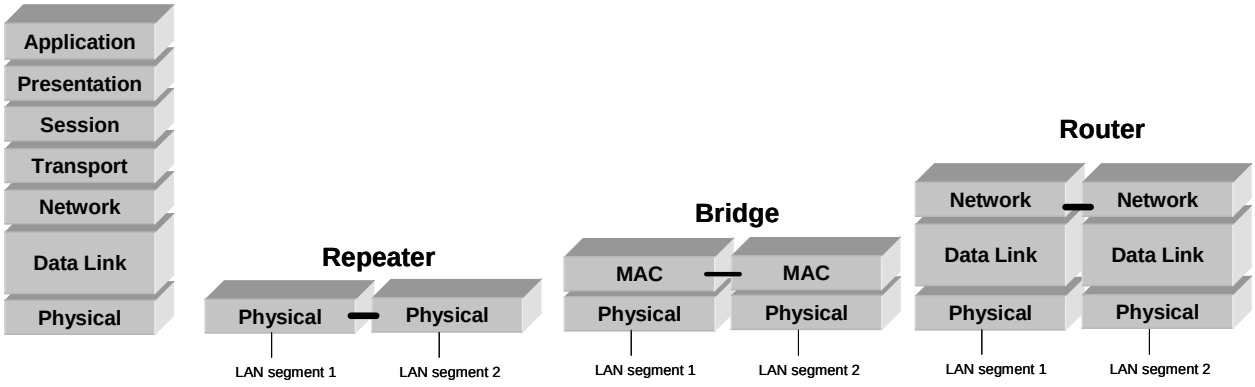
1. *a)* Explain the difference in operation of a *repeater*, *bridge* and *router* and show how these relate to the ISO 7 layered model. **(12 marks)**

b) An organisation operates an IEEE 802.3 CSMA/CD LAN and an IEEE 805.2 token ring LAN. By considering the operation of these two LAN technologies, identify the key differences that exist at the MAC layer. **(8 marks)**

c) By means of a protocol layer diagram show how an IEEE 802.3 and IEEE 802.5 LAN can be interconnected by a *router*. **(5 marks)**

Answer Pointers

a)



A repeater operates at the ISO Physical Layer and simply provides signal amplification and conditioning to allow the network cable to be extended. Information contained within a LAN frame cannot be read and signals received on one LAN segment, are simply retransmitted onto the next segment. All frames are retransmitted by a repeater. Repeaters connect LANs of the same technology and cable type.

A bridge operates at the MAC sub-layer (part of the ISO layer 2). Here LAN frames are received and processed before retransmission. Addressing information is checked and if the destination address is located on the LAN segment from which the frame was received, it will not be retransmitted. In this way, a bridge is able to partition traffic within the network. The two LAN segments therefore operate as separate LANs. Bridges are able to connect LANs of the same technology.

A router operates at the ISO Network layer. Frames that are received from one network are passed up to the Network layer where the layer 3 PDU is analysed and addressing is checked with a routing decision being made as to where the PDU should be sent next. Because a router operates at layer 3, it is ideally suited to interconnecting networks that use different technologies.

Marking scheme: 4 marks allocated for each device with 1 mark for identifying the layer at which a device operates; 2 marks for their operation; and 1 mark for the type of technology that can be interconnected.

b)

Frame format:

Both technologies use different frame formats and permit different maximum and minimum frame sizes. They do however, both use the same IEEE 48 bit addressing format.

IEEE 802.3: frame contains:- preamble, start of frame delimiter, destination address, source address, length, data and CRC.

IEEE 802.5: frame contains:- start delimiter, access control, frame control, destination address, source address, data, crc, end delimiter and frame status

Access method:

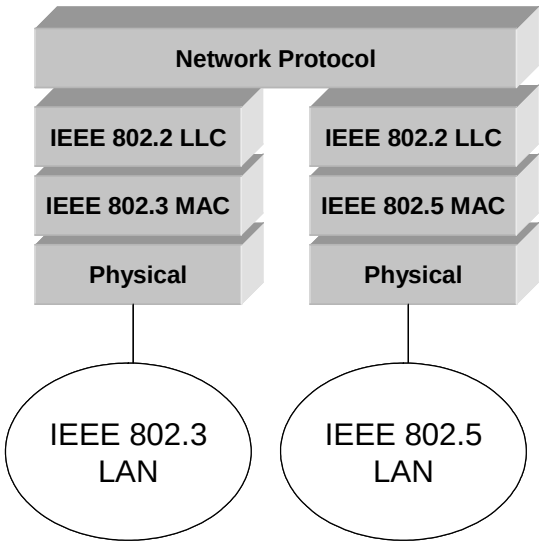
Both technologies use significantly different access methods resulting in IEEE 802.3 offering a non-deterministic performance and IEEE 802.5 providing a deterministic performance.

IEEE 802.3 uses a random access method based on sensing the cable and transmitting if free. If the cable if not sensed to be free that a node will wait. Should two nodes transmit at the same time then a collision detection process forces then to stop, wait and retry.

IEEE 802.5 uses an access method controlled by passing a token. Only that node that holds the token is able to transmit. A strict token passing scheme is used to ensure that nodes do not hold the token for too long and that all nodes receive the token within a known maximum time limit. A prioritisation system allows allows for frames to be differentiated with the most important being send first.

Marking scheme: 4 marks for determining the differences in frame format and 4 marks for describing the different access method used.

c)



Marking scheme: 2 marks for the 802.3 stack, 2 marks for the 802.5 stack and 1 mark for noting that layer 3 connects the two LAN stacks.

Examiners' Comments

Part (a): part (a) was quite well done on the whole. In terms of bridges the model answers said that "bridges are able to connect LANs of the same technology". A considerable number of students were aware of translation bridges which can connect LANs of dissimilar technologies. In light of that marks were given if the student said that bridges can connect LANs of different technologies if they mentioned the concept of translation bridges.

Part (b): not many students scored highly here, since they usually did not answer on - both the aspect of frame format and access method. It would probably have been a good idea to mention the two aspects explicitly in the question. Some students did however score on both aspects of the question.

Part (c): The students did not do very well on this part of the question, on the whole. Many simply drew a diagram of a network showing a router somewhere in the network and clearly did not understand what type of diagram was necessary. The question asks for a protocol layer diagram. Where the student did understand what was required, some marks were given for being on the right track, although few scored the whole 5 marks.

Question 2

2. *a)* Explain the term *baud* rate. **(2 marks)**

b) A transmission system uses a coding scheme that defines a symbol as comprising one of eight possible voltage levels. How many bits of information can be represented by each symbol? **(4 marks)**

c) If the coding scheme described in part *b)* is used to transmit information at the rate of 100 baud, what is the information rate measured in bits/sec? **(4 marks)**

d) What are the advantages of using Manchester encoding to transmit digital information over a Serial transmission system? **(6 marks)**

e) Show, with the aid of a diagram, how the bit pattern `10010111` would be encoded using Manchester encoding. **(9 marks)**

Answer Pointers

a) Baud rate is the number of 'symbols' transmitted per second, e.g. one baud is one symbol per second.

Marking scheme: 2 marks for definition.

b) One symbol is a voltage level, taken from a set of eight possible values. Eight discrete values can be used to represent 3 binary bits, i.e. $2^3=8$

Hence, one symbol represents 3 bits of information.

Marking scheme: 4 marks for identifying that 3 bits are represented by one symbol.

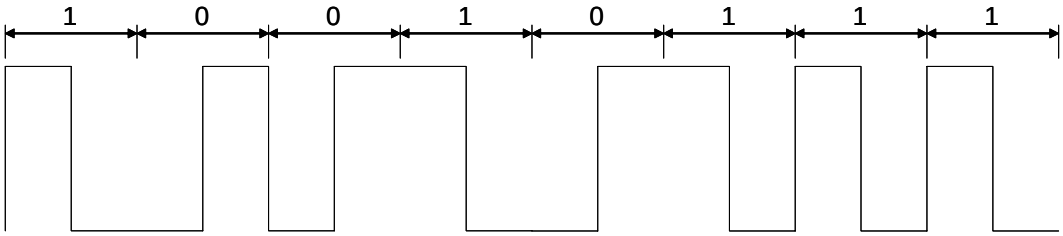
c) Information is transmitted at a rate of 100 baud. This is 100 symbols per second. However, each symbol represents 3 bits and so the information rate is 300 bits/sec.

Marking scheme: 4 marks for identifying that the information rate is 300 bits/sec.

d) Manchester encoding:
The encoded bit stream contains both the digital content – bit values of 0 and 1 – and also clock information.

Marking scheme: 4 marks for noting that the encoded waveform contains both data and clock and 2 marks for the lack of a dc level.

e) The resulting encoded waveform does not contain a dc level, but contains frequencies at the clock and half the clock frequency.
Marking scheme: 4 marks for noting that the encoded waveform contains both data and clock and 2 marks for the lack of a dc level.



Marking scheme: 2 marks for the logic 1 encoding, 2 marks for the logic 0 encoding, 5 marks for the overall bit pattern produced.

Examiners' Comments
Part (a): To explain the term baud rate, there were a number of answers the students could give that were meaningful – some students did use the concept of 'symbols', others referred to carrier signal transitions. If they did not state 'per second' then they lost one mark.

Part (b): a good many students understood that 8 voltage levels per symbol corresponded to 3 bits of information.

Part (c): Provided the students got the previous part right, then this part was easy. If they got the previous part wrong, but followed the correct method of multiplying by 100 then they were allocated some marks.

Part (d): Not many students responded in exactly the way anticipated in the marking scheme, but quite a few said that the advantage of Manchester encoding over NRZ is that there are no continuous streams of ones or zeros – 3 marks were given for that.

Part (e): The students did well on this question. A respectable number got all 9 marks. Some got the logic zero encoding and the logic one encoding back to front, but otherwise maintained consistency in the diagram. Provided they were consistent then they could still score 5 marks out of 9.

Question 3

3. *a)* Explain the basic operation of an ATM network. **(10 marks)**

b) Illustrate, by means of a diagram, the cell format used with an ATM network. **(5 marks)**

c) Explain the difference between a *virtual path* and a *virtual channel*. **(4 marks)**

d) What function is performed by the ATM adaption layer (AAL)? **(6 marks)**

Answer Pointers
a) An ATM network is a connection orientated network that has been designed to provide guaranteed levels of quality of service for a wide range of multimedia applications and service types.

It comprises end-stations connected to ATM switches, with ATM switches themselves being interconnected for form an overall network topology.

An end-station must first request a connection with another end-station. This connection must be accepted by the called end-station for it to become live.

As part of the connection establishment process a traffic contract will be agreed that will determine the volume, rate and type of traffic that can be transmitted. Each ATM switch will monitor the cells it receives and any that fall outside of this contract will be discarded.

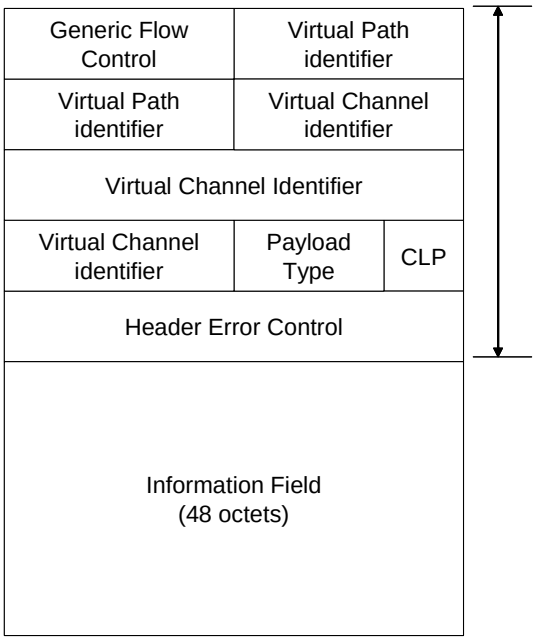
All traffic and all signalling messages are transmitted through the network as a series of fixed size 53 octet cells. These cells contain a virtual circuit number identifier that allows each cell to be related to an end-station to end-station virtual circuit. Each virtual circuit identifier must be unique on each point to point link within the network.

The ATM protocol, which is a layer 2 protocol, does not provide error recovery but it does offer congestion management.

Once all data has been transmitted, the ATM connection must be formally terminated by the end-stations.
Marking scheme: 2 marks for general description of the topology, 2 marks for connection establishment; 2 marks for ATM cells; 2 marks for traffic contract; 2 marks for connection termination.

b)

(5 marks)



Marking scheme: 2 marks for the 5 octet header; 2 marks for the 48 octet payload; 1 mark for identifying that the header contains VC/VP addressing

c) A virtual channel defines a single point to point connection, identified by its virtual channel identifier (VCI).

A virtual path however, is a bundle of virtual channels that share the same end-point. Hence, a virtual path can be considered as a container that contains several virtual channels. Each virtual path is identified by its unique virtual path identifier (VPI).
Marking scheme: 2 marks for the VC, 2 marks for the VP.

d) The ATM Adaptation Layer Protocol (AAL) allows various user applications and higher layer protocols to use the facilities offered by ATM. The AAL protocols are end to end protocols and hence, only present in the end-stations. The basic function of AAL is to segment data from the higher layer protocols into cells and to reassemble a received cell stream into data structures acceptable by the higher layer protocols. Where an application requires a strict timing relationship to be maintained between communicating end-stations then it is the responsibility of the AAL protocol to achieve and maintain this. Equally, the AAL must overcome the problem of lost cells and provide flow and timing control.
Marking scheme: 2 marks for noting that AAL is only in the end-stations; 2 marks for mapping higher layer protocols onto ATM cells; 2 marks for recovering lost cells/flow control/timing control.

Examiners' Comments
This question did not work well from the point of view of the students. Many simply did not know what an ATM network was. Some thought ATM stood for automatic teller machine (which is right in a different context).

Part (a): the majority of those who did know what the question referred to could only speak in the most general terms about ATM networks – e.g. that they supported fast transmission. Most had great difficulty explaining the technology.

Part (b): In general the students who attempted this question could not draw the diagram of the cell format for ATM. They were not even sure about the 5 octet header and the 48 octet payload, by and large. So it was difficult to give many marks here.

Part (c): The fact that a virtual path is a bundle of virtual channels and that a virtual channel is simply a point to point link escaped most students. As a result their answers tended to become convoluted and somewhat obscure (since they were essentially guessing).
Part (d): This part was done a little better, because the notion of an adaptation layer is fairly generic. Even when they were not really sure of their ground, therefore, the students might score a few marks.

Having said all that, there was a minority of students who actually did know the material for question 3 and answered perfectly well.

Question 4

4. *a)* What are the advantages of internetworking? List, and briefly describe, the typical devices you would use for internetworking. **(10 marks)**

b) Identify and explain the major issues that must be addressed in a typical internetworking environment.

(15 marks)

Answer Pointers

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

William Stallings: Data and Computer Communications, 7th Ed

a) Advantages of internetworking:

- Increase of number of nodes that can connect to the network
- Extension of the range of network
- Localise traffic within a network
- Merge existing networks
- Isolate network faults 4 marks

Devices: Repeater, Bridges, hubs, switches and routers
Repeater operating in layer 1extend the physical reach
Bridges operating at layer 2 pass data frames between networks(MAC address)
Hubs allow interconnection of nodes
Switches allows simultaneous communication between nodes
Routers operate at level 3 pass data packets between networks
6 marks

b) Major issues:

- Network service
- Addressing
- Routing
- Quality of service (QOS)
- Maximum packet size
- Flow and congestion control
- Error reporting 3 marks

Network service: Types of service such as connectionless or connection-oriented, Harmonisation of different types of services in different networks etc..

Addressing: A complete different set of network service access point addresses are required to identify each network service user etc.. Relationship between network service access point address and network point of attachment etc..

Routing: Multiple networks present routing problems for example, how does an intermediate system determine the network point of attachment addresses of end systems attached to networks

QOS: transit delay, level of protection etc..

Maximum packet size: with multiple networks network layer needs to perform necessary segmentation operations to match that particular network parameters.

Flow and congestion control: Congestion control algorithm need to harmonise between different packet flows arising out of different services

Error reporting: A common means of error reporting across all networks.
12 marks

Examiners' Comments

The responses to this were mixed. Part of the question attracted good answers and for the remainder the answers were indifferent.

For the question 4 a), the advantages include increasing number of nodes, extending the range of network, localising traffic within a network ,merging existing networks and isolating network faults. Very few got all these points right. But many were able to discuss correctly the devices used for internetworking. For question 4 b), the major issues are network service, addressing, routing, QOS, maximum packet size, flow and congestion control and error reporting. Again only a few were able to identify all of these and were able to explain them.

Question 5

5. *a)* Explain clearly, with schematic diagrams, the methods used for detecting single-bit and two-bit errors in data transmitted between a sender and a receiver. What are the limitations, if any, of the two-bit error detection scheme? **(9 marks)**

i) Explain with the help of an example the term *burst errors*. **(2 marks)**

ii) A message frame 1101011011 is to be transmitted using a Cyclic Redundancy Check (CRC) scheme with a generator polynomial of 10011. Determine the transmitted message frame. Briefly explain how the CRC scheme helps to track the burst errors in this case. **(14 marks)**

Answer Pointers

a) Methods: Parity single-bit errors
Block sum check- two-bit errors

Parity- diagram with XOR scheme

4 marks

Block sum-Block with longitudinal and transverse bit entries
Limitation if no two bit errors occur in the same column at the same time.

5 marks

b) i) Burst errors: A group of contiguous string of bit errors
Transmitted message: bbbbbbxxxxbbbbbbbbxxxx
xxxxx – burst errors

2 marks

ii) Frame: 1101011011
Generator: 10011

Message with 4 zero bits appended at the end: 11010110110000 2 marks

Carry out modulo 2 division: 11010110110000 by 10011
10 modulo 2 division steps performed and the remainder is 1110 9 marks

Hence transmitted frame: 1101011011 + the remainder =11010110111110

When the receiver receives this frame it divides it by the generator bits, if the Remainder is zero, no error has occurred but if it is error has occurred etc..

3 marks

Total- 14 marks

Examiners' Comments
This was by far the most popular question.

A majority of students answered this question correctly. The correct definition of the burst error as a group of contiguous string of bit errors transmitted message appeared in most answers. As part of determining the message frame the modulo-2 division of 11010110110000 by 10011 was correctly performed, and the transmitted message frame was correctly obtained.

However, there were weak answers to the CRC scheme of tracking the burst errors.

Question 6

6. *a)* Explain why the use of private keys alone for message encryption is not attractive for transactions in a large-scale network such as the Internet. **(2 marks)**

b) Show the main steps of an RSA algorithm and comment on factors such as key size, message block, speed of execution etc. associated with the algorithm. **(15 marks)**

c) Briefly explain the problem of message authentication. How do the RSA encryption and decryption schemes help to overcome this problem? **(8 marks)**

Answer Pointers

a) Private keys: In large scale networks creating hundreds of private keys. Each type of transaction by each user needing many private keys and producing impossible administrative overhead. 2 marks

b) RSA algorithm steps -summary:

i) Select two large positive prime numbers P and Q
ii) Choose a public key so that X =(P-1)*(P-1)
iii) Choose an integer E which is prime relative to X
iv) Compute N =P*Q

To create private key compute D such that MOD (D*E, X) =1

v) The cipher text (encryption) C =MOD (P^E ,N)
vi) The plaintext (decryption) P = MOD (C^D, N)

The algorithm is based on the assumption that large numbers are difficult to factorise I a realistic time. The prime number selection is important and have to be large. The value of N determines the maximum message length that can be encrypted.

15 marks

c) Message authentication- making recipient sure that the sender is the legitimate source.

The public and private key properties of the RSA can be used to accomplish this. First the sender encrypts the plain text and the receiver receives the encrypted message using the RSA encryption. If this encrypted text can be decrypted by the public key sent by the sender then this is the proof that the sender is the legitimate source.

Since the above process is computation intensive, A shorter version of the plain text can be encrypted using the sender's private key and appended to the larger text. This trailer can then be decrypted usin g the receiver's public key sent by the sender. The trailer will then become a digital signature. 8 marks

Examiners' Comments
The responses to this question again were mixed.

Question 6 a) requires explanation such as large scale networks creating hundreds of private keys, each type of transaction by each user needing many private keys and producing impossible administrative overhead. The emphasis here is on administrative overhead, and no one got this right. As far as question 6 b) is concerned, most answers produced correct RSA algorithm as well as good comments on the governing factors of the algorithm. Question 6 c) dealing with message authentication attracted good answers with explanation of the encryption and decryption protocols that are particular application attributes of the algorithm.