BCS HIGHER EDUCATION QUALIFICATIONS
BCS Level 5 Diploma in IT

October 2010

EXAMINERS' REPORT

Computer Networks

General Comments

The responses to questions were no different than April 2010 examinations, with the quality of answers significantly lower. As in April 2010, this time again a number of students were on the borderline or near borderline pass category, but the number of failures were higher. The number of passes as a result was lower than the previous examination. Good answers were fewer There were significantly higher number of blank answer books returned without any answers in them. There were also answer books with very few questions attempted. Needless to say, these students did not prepare for the examination. Those who were serious and made sincere attempts and did not do well, repeating the previous examiners' report, these students need significantly better preparation based on good understanding of concepts to have realistic chance of good performance. It is also worth saying again that the students are strongly advised to read examiners reports such as this as part of their preparation for the examination besides preparing answers for questions..

Section A

1.

a. What is meant by the term *virtual circuit*?

(2 marks)

b. Explain how a network connection is established between a user and a server over the Internet using the TCP protocol.

(9 marks)

c. If a server is unable to receive data at the rate that the user is sending it over a TCP connection, explain how TCP is able to reduce the flow of data.

(6 marks)

d. Explain how you could secure the transmission of data over the Internet.

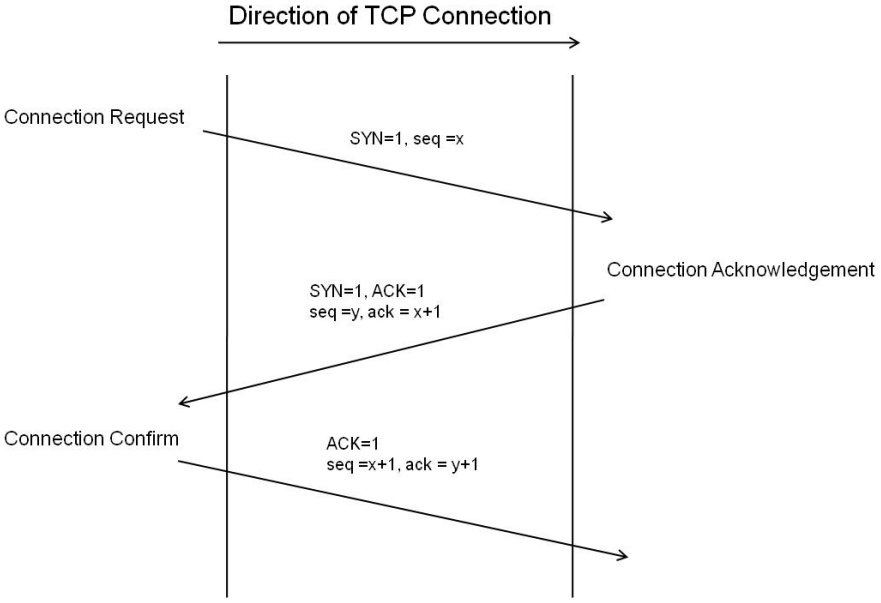
(8 marks)

Answer Pointers

a) A virtual circuit is a means of establishing a connection between two points on a packet switched network. It is virtual in the sense that it appears as though there is a dedicated link between these two points. 1 mark for it being a connection and 1 mark for the appearance of a dedicated link

b) A TCP connection is uni-directional which means that for two way communications, a connection must be established from the user to the server and separately from the server to the user. Each process does however, follow the same three way handshake procedure.

The user will issue a TCP segment with the SYN flag set and the sequence number equal to some initial value – say x. The server – if it wants to accept the connection request – will return a TCP segment with both the SYN and ACK flags set. It will also choose a sequence number starting value – say y. The acknowledgement field of this segment will be set to x+1 to acknowledge receipt of the connection request segment. When the user receives this response it will issue one further TCP segment with the ACK field set. The acknowledgement in this segment will be y+1 and the sequence number will be x+1



1 mark for a need for two uni-directional connections; 3 marks for the connection request (SYN=1); 3 marks for the connection acknowledgement (SYN=ACK=1) and 2 marks for the connection confirm.

c) This is achieved by using the 16 bit window size field within the TCP header.

The window size signals the number of bytes that a transmitter can send before having to stop and wait for an acknowledgement.
The server could therefore reduce the widow size in the next TCP PDU it sends to the user. The user is then able to send data up to this window size before having to stop and wait for an acknowledgement.

2 marks for recognising that it is the 16 bit window size field that is used; 2 marks for explaining what the window size means; 2 marks for explaining how it would be used in this case)

c) Data being sent over the Internet needs to be encrypted using a technique such as IPsec. The two ends of the communication will need to have agreed on the encryption scheme to be used. The data payload of the IP datagrams sent from the user will therefore be encrypted and decoded by the receiver and vice versa. The header remains unencrypted so that datagrams can be routed.
Whilst that data is passed over the Internet and could be detected by others, it cannot be decoded without knowledge of the security protocol being used by A and B. The data being sent from B to A can use a different security protocol.

2 marks for knowledge of encryption within IP; 2 marks for knowing that it is the payload and not the header that is encrypted; 2 marks for both ends having previously agreed on the encryption scheme; 2 marks for the fact that the data is secure from third parties trying to capture and read it.)

Examiner's Comments

Many candidates failed to even attract a pass mark for this question.
Part a), was correctly answered by the majority of candidates. However, there was some confusion when answering the remaining parts.
When answering part b), many candidates used creative ways to explain how a network connection is established, while others only defined TCP protocol.
Answering part c) also caused some confusion. Some candidates discussed only stop-and-wait or buffering flow control. None of the candidates recognised the 16-bit TCP window size.
Part d) attracted many varied responses where some candidates discussed encryption methods in quite detail while others described the processes required by a user to ensure a secure web connection (ie. login with a secure password, etc). The majority of candidates didn't discuss the technical requirements that make up a secure data transmission, such as encrypting the payload only and for communicating parties to agree to a set encryption scheme.

2.

a. A transmission system uses a data coding scheme that defines a symbol as a voltage that can have one of eight possible values. If the system operates at a transmission rate of 400 symbols per second, determine the data rate measured in

   i) baud;

   (2 marks)

   ii) bits per second.

   (4 marks)

b. Show by means of a diagram how a logic 1 and a logic 0 is represented by using Manchester encoding.

   (4 marks)

c. Show by means of a diagram how the bit sequence, 10001101 would be transmitted using Manchester encoding.

   (4 marks)

d. The Link Access Protocol (LAP-D) used within the Integrated Services Digital Network (ISDN) has a frame structure that begins and ends with a flag comprising the bit sequence 01111110. The following bytes are to be transmitted within the data portion of the frame

   00110011 11110101 01111110 01001101 11111100

   Show by means of a diagram how zero bit insertion (bit stuffing) is used to ensure that the flag sequence of 01111110 can never occur within the data portion of the frame when sending the above sequence of bytes.

   (9 marks)

e. When transmitting the data sequence shown in part (d), how many bits in total have to be sent?

   (2 marks)

Answer Pointers

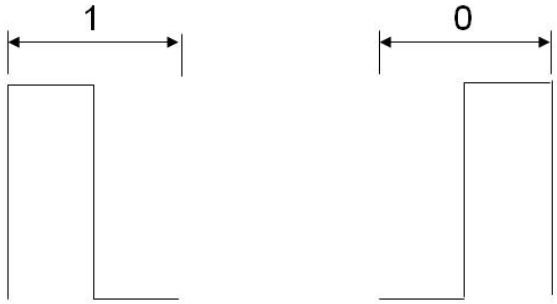
a) i) One baud is one symbol per second. If the transmission system operates at 400 symbols per second then the data rate is- 400 baud

2 marks knowing that baud rate = symbols per second

ii) A symbol is a voltage level that can have one of eight possible values. Eight unique values represent the combinations generated by two bits, i.e. 2^3=8. Therefore one symbol equals three bits. At 400 symbols per second this gives a data rate of 1200 bits per second.

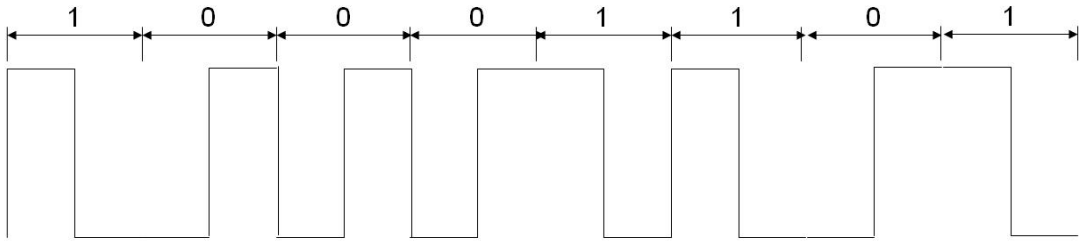
2 marks for calculating that each symbol represents 3 bits and 2 marks for calculating the speed in bits per second)

b)



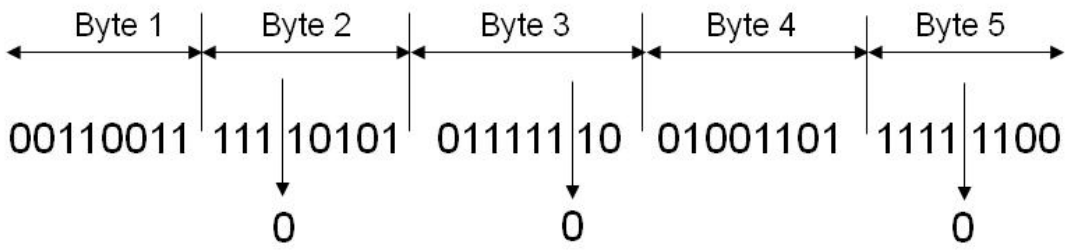
2 marks for the logic 1 encoding, 2 marks for the logic 0 encoding. The key feature is that there is a transition in the centre of the bit. Half marks if the transitions are the other way up.

c)



0.5 marks for each bit. Important that a transition occurs within the centre of each bit with additional transitions where subsequent bits have the same value.

d) With zero bit insertion, when five consecutive 1s are detected then an additional zero bit is inserted in the data stream as shown below. Note that the transmitted bytes must be considered as a continuous data stream.



1 mark for knowing that zero bit insertion means adding logic 0s into the data stream; 2 mark for knowing that this must be done after 5 consecutive logic 1s; 2 marks for noting that a 0 needs to be inserted within byte 3; 2 marks for knowing that a 0 has to be inserted within byte 2 and 2 marks for byte 5 as shown above.
e) Note that an additional 3 logic 0s have had to be inserted. This means that (8x5) + 3 bits need to be sent = 43 bits. (59 when including the start and end flags)
1 mark for 43 and 1 mark for 59.

Examiner's Comments
Much better responses in this question compared to question 1. The majority of candidates answered correctly part a). although some candidates confused symbols with bits per second. More than half of those who answered part b), correctly identified Manchester encoding for 0 and 1. However, a few mixed the transitions.
Candidates that correctly answered part b), also answered part c). A little disappointed to see that a small number of candidates confused Manchester encoding to NRZ.
In part d), there were many mixed responses. A large number of candidates correctly explained how zero bit insertion works. However most candidates identified only zero bit insertion in bytes 3 and 5 missing out byte 2. This was a good challenging question.
A good proportion of candidates lost marks in part e because their answer was only a plain number – that number was wrong. If they had showed their working, they could have attracted some marks provided that their working was correct. Only a handful of candidates received full marks.

3.

a. Within Asynchronous Transfer Mode (ATM) networks, all information is sent as a sequence of ATM cells. How large are these cells and what information is contained within the cell header?

(4 marks)

b. Explain what is meant by the process of *connection admission control*.

(5 marks)

c. Within the context of an ATM network, explain what the different is between constant bit rate (CBR) and available bit rate (ABR) traffic.

(6 marks)

d. What function is performed by the ATM Adaptation Layer (AAL) protocol?

(6 marks)

e. Where within an ATM network is the AAL protocol located?

(2 marks)

f. What type of traffic, typically, would you send over an ATM network using AAL5?

(2 marks)

Answer Pointers

a) All cells are 53 octets.

Header is 5 octets and comprised VPI and VCI fields, error checking, payload type and cell loss priority bit, generic flow control field

1 mark for a 53 octet cell size; 1 mark for VPI/VCI fields, 1 mark for header error check and 1 mark for one other valid field.

b) When an end-station wishes to establish an ATM connection it must issue a call request message that identifies the remote end of the connection and also the quality of service required from the connection. Each ATM switch on receiving this request will determine if it has the resources to support such a connection. If it can then the request is passed onto the next switch along the route and so on until it reaches the intended destination. If any switch is unable to commit the necessary resources then the connection will fail. This process is called connection admission control.

1 mark for being associated with establishing connections through the network, 1 mark for the fact that the connection request specifies the QoS required, 2 marks for the fact that switches check the request against the resources they have reserve capacity as required, 1 mark for the fact that the connection will fail if any switch cannot support the request.

c) The Available Bit Rate service is intended for applications that require a variable bandwidth from the network. Nodes are allowed to transmit cells and providing that capacity exists within the network, these will be carried. However, if the network is unable to carry the traffic being submitted to it, then it will provide feedback to force ABR traffic sources to modify their cell generation rates.

Constant Bit Rate (CBR) is designed for applications which have a known and constant bandwidth requirement. Capacity is reserved within the network and data is transmitted at a fixed rate throughout a connection.

ABR – 2 marks for variable bandwidth, 1 mark for including active feedback to regulate the flow; CBR – 2 marks for constant and fixed bandwidth, 1 mark for cells being sent at the same rate throughout the connection)

d) The ATM Adaptation Layer (AAL) protocol is responsible for

- Accepting data from higher layer protocols and mapping them onto 53 octet cells
- Receiving ATM cells and combining these into data structures that are acceptable to the higher layer protocol
- Providing the quality of service required by the connection by managing the flow of AM cells which includes transmission rate, guaranteed delivery time etc.

3 marks for mapping higher layer protocols to a stream of ATM cells and vice versa; 3 marks for delivering QoS required including an example of which parameters are controlled – cell rate, delivery time)

e) The AAL protocol exists only within the end stations and is not present within ATM switches.

2 marks for recognising that AAL is not used within switches and therefore only exists within end stations.

f) AAL5 is designed for best-effort services – typically IP

2 marks either for best effort or IP

Examiner's Comments

Part a) was answered correctly by the majority of candidates. Most responses included a diagram showing the ATM cell.

Varied responses again for parts b), c) and d). Some answers were very poor clearly showing that these candidates hadn't prepared enough to answer questions on ATM. Many of the responses were creative.

Many candidates misunderstood the question in part e). They explained where AAL exists within the ATM protocol stack but not within the ATM network.

Answers to part f were poor. Almost none candidate linked AAL5 to IP or best-effort services. Instead many responses included random internet application that might or might not use AAL5. The majority of the responses were very short; about one sentence long.

Section B

4. IPv4 internetworks operated by a single organisation sometimes use link state protocols to manage the transfer of routing information.

   a) i) Explain the behaviour of link state protocols and illustrate your answer by reference to the OSPF (Open Shortest Path First) protocol.
   (8 marks)

   ii) Discuss how OSPF uses the concept of network hierarchy.
   (7 marks)

   b) Link state protocols are often claimed to be better than distance vector protocols in some respects. Briefly discuss why people make this claim.
   (10 marks)

Answer Pointers

a) i) The candidates may observe that protocols used for routing within the networks of a single organisation are normally referred to as interior routing protocols [1 mark]. OSPF is one such IRP that uses the link-state algorithm [1 mark]. The general behaviour of link-state is that routers are directly responsible for making announcements about direct connections to themselves and the costs of those links [2 marks]. These announcements are then forwarded to all routers within the organisation's network [1 Mark]. Thus, all routers become aware of the full connectivity/topology of the network, that is, they all have a copy of a common link-state database [2 marks]. Routers calculate their own routing tables to all destinations based on that database [1 mark].
a) ii) As even single organisation networks (Autonomous Systems) can be large, OSPF uses the concepts of hierarchy to split the network into a set of areas, one of which is known as the backbone area [2 marks]. With OSPF, routers with all interfaces within a single area only end up with full topological knowledge of only that area [2 marks]. Routers with interfaces in two (or more) areas are known as Area Border Routers and are responsible for injecting summaries of one area into another [2 marks]. A router which connects to the AS and has at least one interface coupling to an external network is known as an Autonomous System Boundary Router [1 mark].
b) Distance vector protocols have several problems, many of which are handled better in link state. Distance vector protocols are slow to converge [2 marks] and send fairly large

amounts of data into the network on a regular basis [2 marks]. There are several situations in which distance vector protocols can lead to the formation of routing loops [2 marks]. Distance vector protocols can not easily load share over multiple links [2 marks]. Distance vector protocols only retain a single route to each destination, because link state protocols have full topology knowledge they effectively retain knowledge of all possible routes [2 marks].

Examiner's Comments

This question was attempted by about 45% of the candidates. Overall, the answers to this question were fairly poor. As we have seen in previous sittings, quite a lot of candidates confused the activity of the creation and updating of routing tables with the activity of actual packet forwarding. The creation and updating of routing tables only happens only relatively rarely, whereas packet forwarding happens on every packet. Some candidates seem to think that when a router is about to forward a packet, it will, at that time, start to ask other routers where it should send it. This is completely wrong. At the time of deciding how to forward a given packet, the router will ONLY use information that it already has in its routing tables. Most students do not seem to know the material related to part a) ii) of this question. Only a small number of students seem to know that OSPF will split an overall network into areas and the way that this helps. The answers to part b) indicated that many students do not properly understand the difference between link-state and distance vector routing protocols; many answers confusing the two.

5. Imagine you are the network manager of a medium sized company that is about to move into a new office building. The new building has an air conditioned computer room, a set of small offices with fixed desks and a large open-plan office. You have been asked to design a new local area network for the new building. In answering the following parts of this question you must provide a **full justification** of all decision and recommendations that you make.

   a) The computer room will house about 12 high performance servers and will be the location of their Internet connection. What type of local area network technology should be installed and what equipment and cabling will be required?

   (9 marks)

   b) The small offices with fixed desks will be equipped with desktop computers. What type of local area network technology should be installed and what equipment and cabling will be required?

   (8 marks)

   c) The large open plan office, which has flexible seating arrangements, is used by the sales staff who also spend a large amount of their time working on customers premises. The sales staff have all been equipped with modern laptop computers. What type of local area network technology should be installed and what equipment and cabling will be required?

   (8 marks)

Answer Pointers

a) We are told that these are high performance machines and clearly in a fixed location. The students will thus choose some form of fixed cable network [2 marks]. It is likely that the students will suggest some form of gigabit Ethernet technology [2 marks]. They will clearly need to provide a high performance gigabit switch [2 marks] and they need some form of router device to terminate the incoming Internet feed [2 marks]. Either copper or fibre cabling could be used [1 mark]. There are alternative choices and they will be awarded marks as appropriate if suggested. They may also mention the need to allow for connections to the other offices.
b) The computers in this office are in fixed locations and are desktop style computers. As in a), a fixed cabled network is probably the most appropriate [1 mark]. The students will probably suggest the use of 100Mbit/sec Ethernet but the case for 1Gbit/sec Ethernet could also be made [2 marks]. They will need to provide some type of small switch in each office [2 marks]. They will also need to run cabling from each room back to the main computer room [1 mark] it is likely that they will propose those links to be a gigabit/sec standards with (at least one) port on each office switch being a gigabit speed.[2 marks].
c) In this part of the question we are told that the room has flexible seating arrangement and that the users have laptops and often work elsewhere. It is fairly clear that some type of wireless LAN technology would be most appropriate [2 marks]. They will thus need to provide one or more wireless access points depending on the size of the room [2 marks]. They will need to provide cabling from those access points back to the main computer room [2 marks]. The final 2 marks will be awarded for suitable extra details, such as the pros and cons of various WiFi standards, the security/password issues, or the possible provision of hardwired sockets and so on.

Examiner's Comments

This question was attempted by nearly 80% of the candidates and was thus the most popular question in section B. We were therefore pleased that this "scenario" style of question proved popular. In addition, we had a large number of high quality answers to this question. Unfortunately, we also had a significant numbers of answers that proposed very old fashioned technology solutions. For instance, while we expect candidates to understand the behaviour of co-axial cable based Ethernets and we might, and indeed often do, examine such knowledge in more theoretical questions, we would not expect co-axial Ethernet to be proposed as a solution for deployment in new installations. There may be a few circumstances where an existing co-axial network needs to be extended and there will be circumstances where an IT professional will need to monitor and maintain such a network, however it is not appropriate for new deployments. A small number of students proposed Token Ring solutions. Again, this has problems. Token Ring equipment is not readily available today at reasonable cost and in any case, token ring interfaces are only available for a small number of computing products. Many people's answers stated that fibre optic cable and interfaces/equipment was very expensive. While such products may be more expensive that copper, the price is often not prohibitive, especially for longer runs within or between buildings. Some students proposed the provision of an ADSL connection to link the company's network to the Internet. This may, or may not be appropriate depending on circumstances. Students should realise that ADSL is an "asymmetric" service. While the speed towards the customer may be high, the uplink speed is often really quite low. If people elsewhere on the Internet were attempting to gain access to services provided by this company on their servers (perhaps web sites etc), then the distance customers might be likely to get very poor performance if this company used ADSL to connect its servers.

6. a) Briefly explain what is meant by the term **forward error control** (FEC).

(4 marks)

b) Discuss why FEC is often used with satellite systems but is less used in terrestrial communication systems.

(6 marks)

c) You are told that a block code system has a Hamming distance of 3. What does this mean in terms of how the codewords differ?

(3 marks)

d) If we wish to be able to **detect** all 5-bit errors, what must be the Hamming distance of the code we choose to use?

(2 marks)

e) If we wish to be able to automatically **correct** all 5-bit errors, what must be the Hamming distance of the code we choose to use?

(2 marks)

f) Design a Hamming block code to be used to transmit 2-bit values and which can both detect and correct all 1-bit errors.

(8 marks)

Answer Pointers

a) Forward error control is the name given to error control techniques which not only transmit enough information for errors to be detected but include sufficient for the errors to be corrected [4 marks].
b) FEC techniques typically involve the transmission of a large number of otherwise redundant bits [2 marks]. On terrestrial systems, which typically have short round trip times, the transmission of this large amount of extra information is not the best approach. It is typically better to just detect errors and then have a separate mechanism to request retransmission [2 marks]. However, with satellite systems it is often simply not possible to request retransmission and in any case, the round trip time would be relatively long. This could mean several hundred megabits were transmitted before a request for re-transmission of earlier information was even received by the original sender [2 marks].
c) The distance of a hamming code is the (minimum) number of bits that differ between any pair of valid codewords. Thus, in this case, the block code system's codewords must all differ by at least three bits [3 marks].
d) The simple rule is that the hamming distance of the code must be one larger than the number of bit errors we wish to detect. Thus, we need a hamming distance of 6. [2 marks]
e) The simple rule is that the hamming distance of the code must be 2N+1 where N is the number of bit errors we wish to detect and correct. Thus, we need a hamming distance of 11 [2 marks].
f) The set of four bit values are 00, 01, 10 and 11. To create a hamming block code, you insert extra digits in all positions that match to a power of two [2 marks]. Thus, the hamming block code will look like

Original		Data bit	Check bit	Data bit	Check bit	Check bit
data	Bit number	5	4	3	2	1
00		0	X	0	X	X
01		0	X	1	X	X
10		1	X	0	X	X
11		1	X	1	X	X

We now need to calculate the check bits. For each row you add up (using modulo-2 arithmetic) the bit positions of all positions where the data bit is a one [2 marks].
In the first row, no data bits are 1s and thus all check bits will be 000.
In the second row, only the data bit in position 3 is a 1 and thus the check bits will be 011.
In the third row, only the data bit in position 5 is a 1 and thus the check bits will be 101.
In the fourth row, the data bits in positions 3 and 5 are both 1. We thus add 3 to 5 using modulo-2 arithmetic. 011 + 101 = 110. [4 marks]
Substituting the check bits into our table the final code is

Original data		Data bit	Check bit	Data bit	Check bit	Check bit
	Bit number	5	4	3	2	1
00		0	0	0	0	0
01		0	0	1	1	1
10		1	1	0	0	1
11		1	1	1	1	0

The student could answer this question with explanations, or tables, or a mixture of both as above.

Examiner's Comments

This question was attempted by about 35% of the candidates. A small numbers of those attempting this question provided quite good answers, but many of the answers were fairly poor. A significant number of answers for part a) state that "data retransmission" is used as part of FEC. This is completely wrong. For part b), candidates should consult the outline answer given above. For part c), several candidates falsely stated that that the Hamming distance was the difference in the number of bits in code and data words. Even though candidates may have answered part c) incorrectly, they sometimes went on to offer correct answers to parts d) and e). While (as stated above) we were willing to accept answers to part f) in either textual or numeric form, very few students presented answers and only a small number of those