UNIVERSITY OF DUBLIN

TRINITY COLLEGE

Faculty of Engineering and Systems Sciences

Department of Computer Science

B.A. (Computer Science)
SENIOR FRESHMAN EXAMINATION

Trinity Term 2006

2BA5
Telecommunications and Information Management

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Answer **five** questions, at least **two** from each section.
Use separate answer books for each section.

Section A

1. The data link layer is responsible for the communication between two nodes that are connected by a physical medium. Data compression, error detection and error correction are part of the data link layer.

   (a) The following bit sequence 1001011001111001 was received and is to be checked using the polynomial x^5+x^2+x+1. Use polynomial long division to show that the message has not been transmitted correctly.

   Show the data bits and CRC bits of the bit sequence that was received and determine the CRC for the data bits as they were received.

   (10 marks)

   (b) Error correction can be achieved through either resending data or through forward correction. Demonstrate the encoding and decoding of the following 7 bits using Hamming code: 1011011 and explain how the result of the decoding may be used by a receiver.

   (5 marks)

   (c) Huffman encoding uses statistical analysis of texts to determine the optimal codes for individual characters. Table 1 lists the distribution of characters from a text. Give the binary tree for Huffman encoding as a diagram and use this binary tree to determine the code for the following sequence of characters: "telecommunication". Remember: The tree is built by combining the sub-trees with the smallest weights.

e	10
c	2
o	6
l	5
t	3
i	8
m	7
n	4
a	2
u	2

Table 1: Distribution of characters

(5 marks)

(Total 20 marks)

2. The communication between two nodes is governed by network layer protocols such as the Internet Protocol (IP) and by routing protocols for various elements of the network infrastructure.

   (a) An Internet Service Provider (ISP) has bought the right to use the IP addresses in the range from 213.49.0.0 to 214.57.255.255. It uses Classless Inter-Domain Routing (CIDR) to route traffic to these addresses. It receives a number of requests from companies. First company A buys a block of 15,000 addresses, then company B requests 5,000, followed by company C with 900 addresses and company D requests 350 addresses. The ISP processes these requests in the order it receives them. What is the address range allocated for each client? Give the first and last address of the range, the number of significant bits and the subnet mask. If CIDR wasn't used, what classes of network addresses would be allocated to each client? How many addresses would be allocated in total? What would be the fraction of addresses actually used by each client? Compare this to the use of CIDR.

   (8 marks)

(b) The Point-to-Point Protocol (PPP) is used to provide line management for dial-up, ADSL and serial connections. Explain the life cycle of a PPP connection and give a diagram that shows the relationship of the individual states of the protocol and the actions that lead to state changes.

(7 marks)

(c) Approaches to routing are divided into routing between autonomous systems and routing within autonomous systems. Outline two approaches to routing within autonomous systems. The explanation of each approach should be accompanied by a diagram that demonstrates the distribution of information within the autonomous system.

(5 marks)

(Total 20 marks)

3. The Transport Control Protocol (TCP) is widely used to transfer data between computers. In order to fulfil this task efficiently a number of mechanisms have been developed that adopt TCP to limitations of networks and computers.

(a) The following table was recorded from a TCP data flow and shows the value of the congestion value at the time the recording was started and the arrival of acknowledgements or the occurrence of time outs.

Time in ms		Congestion Window
0		8
10	ACK	
20	ACK	
30	ACK	
40	ACK	
50	Timeout	
60	ACK	
70	ACK	
80	ACK	
90	ACK	
100	Timeout	
110	ACK	

Demonstrate the behaviour of a TCP mechanism using additive increase/ multiplicative decrease (AIMD) and a mechanism employing a basic slow start algorithm by drawing diagrams of the value of the congestion window for each mechanism and give an explanation for each diagram.

(8 marks)

(b) Explain the term "flow control" and what it aims to achieve. Give diagrams that demonstrate the characteristic behaviour for a "stop and wait" mechanism and a "sliding window" mechanism and discuss the advantages and disadvantages of the two mechanisms using the diagrams.

(6 marks)

(c) Explain the life cycle of a TCP connection including connection establishment, data exchange and connection termination. The explanation should include a diagram with a list of segments that are exchanged between the two endpoints.

(6 marks)

(Total 20 marks)

4. Medium access control is used to coordinate the communication over a shared medium. A number of protocols have been developed that provide various degrees of flexibility in the access to the shared medium.

(b) Carrier Sense Multiple Access (CSMA) is used in technologies such as Ethernet and 802.11b to coordinate access to a medium. Describe the basic behaviour of a CSMA mechanism. The description should explain terms such as binary exponential backoff, collision detection and collision avoidance and include diagrams that visualize the behaviour of a CSMA mechanism. Explain why a wireless system that employs 802.11b can not use collision detection but instead uses collision avoidance.

(9 marks)

(a) Time Division Multiple Access (TDMA) and Frequency Division Multiple Access (FDMA) are very similar approaches to medium access control. Describe the general behaviour of TDMA and FDMA.

(3 marks)

(c) Assume a network with three mobile phones, stations 1, 2 and 4, and a base station, station 3. The three mobile phones want to send 101, 110 and 101 respectively; the base station is silent. A 0 is encoded as -1, a 1 is encoded as +1 and silence is represented by 0. Give the signal that the base station receives.

Chip Sequences:

Station 1: +1 −1 −1 +1

Station 2: +1 +1 −1 −1

Station 3: +1 +1 +1 +1

Station 4: +1 −1 +1 −1

(8 marks)

(Total 20 marks)

Section B

5. (a) Outline the three components of magnetic disk access time. Which component is most significant? Mention one consequence of this.

(6 marks)

(b) When sequential files are stored on disk, provision needs to be made to accommodate inserted records in the appropriate place in the file. Outline **two** techniques for insertion of records into sequential files, from the four presented in the module. Compare the two techniques you have chosen in terms of (i) efficiency of sequential processing and (ii) space used.

(8 marks)

(c) Explain why in-memory sorting algorithms (e.g. quick sort, bubble sort) are not suitable for sorting large files. Describe the keysort algorithm and characterise the approximate cost to sort a file of N records.

(6 marks)

(Total 20 marks)

6. (a) Write a note on B-trees, indicating what they are, what they are used for, what kinds of access they support, and why they are so suitable for their role.

(10 marks)

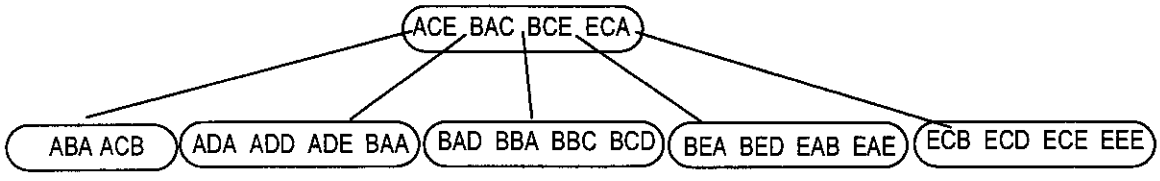
(b) Insert BCA into the 5-way B-tree below.

(3 marks)

(c) Delete from the resulting tree, successively, ACE, ADE, and ABA.

(7 marks)

(Total 20 marks)



7. (a) Outline the basic model of an information retrieval system.

(5 marks)

(b) What is the role of indexing in an IR system ?

(4 marks)

(c) Outline a simple term frequency-based indexing strategy for a collection of English text documents. In your answer explain the terms *stemming* and *stopword*.

(6 marks)

(d) What weakness of the simple frequency weighting does the inverse document frequency (idf) weighting address? How?

(5 marks)

(Total 20 marks)

8 (a) What is XML Schema and what is it used for? Describe at least one of the statements in XML Schema which has no equivalence in DTDs.

(3 marks)

(b) Based on the evidence presented in the following XML document (figure 1 over) called "book.xml", show what the 'book.dtd' would be.

(7 marks)

(c) Discuss the advantages/disadvantages of Xquery over those of Xpath. In addition, define and explain Xquery statements for each of the following queries posed over the "book.xml" document of figure 1 (over). In addition, show expected results.

(i) Return all the section titles of book.xml in an element called <section_titles>

(ii) Return information for each section in the following format:

Section title: xxxx

Section difficulty: yyyy

where xxxx is the value of the appropriate title element and yyyy is the appropriate attribute value

(iii) Prepare a (flat) figure list for the book, listing all the figures and their titles. Preserve the original attributes of each <figure> element, if any.

(10 marks for part (c))

(Total 20 marks)

```
<?xml version="1.0"?>
<!DOCTYPE book SYSTEM "book.dtd">
<book>
 <title>Data on the Web</title>
 <author>Serge Abiteboul</author>
 <author>Peter Buneman</author>
 <author>Dan Suciu</author>
 <section id="intro" difficulty="easy" >
  <title>Introduction</title>
  <p>Text ... </p>
  <section>
   <title>Audience</title>
   <p>Text ... </p>
  </section>
  <section>
   <title>Web Data and the Two Cultures</title>
   <p>Text ... </p>
   <figure height="400" width="400">
    <title>Traditional client/server architecture</title>
    <image source="csarch.gif"/>
   </figure>
   <p>Text ... </p>
  </section>
 </section>
 <section id="syntax" difficulty="medium" >
  <title>A Syntax For Data</title>
  <p>Text ... </p>
  <figure height="200" width="500">
   <title>Graph representations of structures</title>
   <image source="graphs.gif"/>
  </figure>
  <p>Text ... </p>
  <section>
   <title>Base Types</title>
   <p>Text ... </p>
  </section>
  <section>
   <title>Representing Relational Databases</title>
   <p>Text ... </p>
   <figure height="250" width="400">
    <title>Examples of Relations</title>
    <image source= »relations.gif »/>
   </figure>
  </section>
  <section>
   <title>Representing Object Databases</title>
   <p>Text ... </p>
  </section>
 </section>
</book>
```

Figure 1: book.xml