THE OPEN UNIVERSITY OF SRI LANKA
DEPARTMENT OF ELECTRICAL AND COMPUTER ENGINEERING

FINAL EXAMINATION 2008
DIPLOMA IN TECHNOLOGY – LEVEL 4

051

ECX4235 – DATA STRUCTURES AND ALGORITHMS

DATE: MARCH 29, 2009   TIME: 0930-1230 HRS

This question paper comprises of Part A and Part B. Two questions in Part A are compulsory. Answer any three questions from Part B.

PART A (40 Marks)

Answer all questions.

1.

A priority queue for a waiting list for surgeries in an operating theatre at a hospital is implemented using the **link list data structure**. Depending on the urgency of the surgery, a priority/urgency number is assigned to each patient at the time of registration. Patients are placed in the queue according to the urgency number and they will be served according to the urgency number. Hospital management has defined 10 urgency categories.
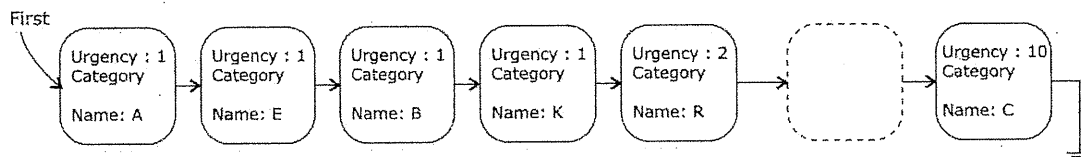

Figure 1: Current queue

It is required create another queue to divide patients equally between two queues due to the addition of a new operating theatre. Also, this division has to be done in category wise. For an example, if there are 4 patients in the urgency category 1 as shown in the Figure 1, the first two patients will remain in the current queue and the other two will be inserted to the new queue as shown in the figure 2. If the total number of patients in a category of the current queue is odd, then the number of patients to be transferred to the new queue will be one less than the number of patients to be remained in the current queue. This division has to be done for each category.

Queue of the old operating theatre

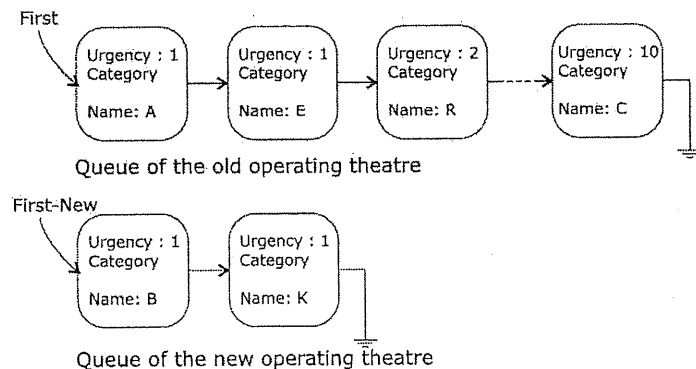Queue of the new operating theatre

Figure 2: After dividing the urgency category 1

It is required to design an algorithm for the above process. Pointers to the first nodes of both queues (First and First-New) are given to you. The number of patients in each category and the total number of patients in the current queue is not known to you.

a) Design an algorithm to perform the above task and **Write** it using pseudo codes.

[17 Marks]

b) **What** is the worst case time complexity of your algorithm?

[3 Marks]

2.

Following description is about a national level charity organisation named 'Sarana'. You are to model the scenario using object oriented (OO) techniques.

The organisation, Sarana, has international and local funding organisations that provide money to its rural development programmes. 'Foreigna' and 'Localia' are respectively an international and a local funding organisation. Sarana has four different categories of projects named Micro Finance, Energy, Construction and Livelihoods. Each project belongs to one of those categories.

Sarana has about 70 employees. The organisation is managed by an Executive Committee, which comprises the Director and another seven employees. Employment type of each employee is either permanent of contract-basis.

Beneficiaries are the people who benefit from the work carried out by a project. Each project has beneficiaries. Beneficiaries can be a set of families in a village or a special group such as children, women or people with disabilities.

In order to carry out large projects, when the staff is insufficient, Sarana goes for partnerships with Community Based Organisations (CBO). A CBO can have partnerships for many projects at Sarana. 'Naguma' is a CBO which has a partnership with a Micro Finance project at Ampara.

a) **Identify** Classes and their properties and methods.

[8 Marks]

b) **Draw** a simple class diagram (no need to show properties and methods in the diagram).

[5 Marks]

c) **Identify** four objects and their respective classes.

[2 Marks]

d) **Briefly explain** the need to have common documentation standards to communicate the algorithms and designs among a group of people work together in software development.

[5 Marks]

PART B (60 Marks)

Answer any three questions. All questions carry equal marks.

3.
a) You are given an integer array of size *n*. Each element in the array is in the range of 1 to 5. **List** two efficient sorting techniques that you might apply to sort this array in linear time. [4 Marks]

b) **Write** pseudo codes to sort the array in linear time. [8 Marks]

c) **Write** a *recursive* subroutine 'FromTo' which takes two parameters and display all integer numbers from the first parameter to the second parameter, as shown below. Separate numbers with a single space. Do **not** use a loop.
    i) FromTo (1, 5) will display 1 2 3 4 5
    ii) FromTo (2, 8) will display 2 3 4 5 6 7 8
[8 Marks]

4.
a) **List** three (3) advantages of using static data structures when compared to the dynamic data structures. [6 Marks]

b) **Write** a subroutine which takes the root of a binary tree as a parameter and check whether that binary tree is full. In a full binary tree each node has exactly zero or two children. [9 Marks]

c) **Briefly explain** why randomisation is necessary to assure good performance in quick sort? [5 Marks]

5.
a) **Write** pseudo codes for selection sort. [6 Marks]

b) **Illustrate and briefly explain** how to use a dynamic singly link list as a stack. Write pseudo code subroutines to show push and pop operations. Indicate worst case time complexities of push and pop operations using big O notation. [8 Marks]

c) You are given a dataset which is too large to fit in the main memory to be sorted. **Briefly explain** a possible solution. [6 Marks]

6.
a) **List** three 'collision resolution' techniques in hashing. Using an illustration **briefly explain** one technique. [7 Marks]

b) **Briefly explain** how is the performance of hashing decreases when the numbers of collisions are increased in the technique you described in question 6(a). [5 Marks]

c) You are given a sorted integer array to search a given element. **Write** an efficient pseudo code subroutine which takes the array as an input and perform the search. The subroutine should return true only if the item is found in the array. [8 Marks]

7.

a) **Assign** following numbers to the nodes of the following (figure 3) binary search tree.
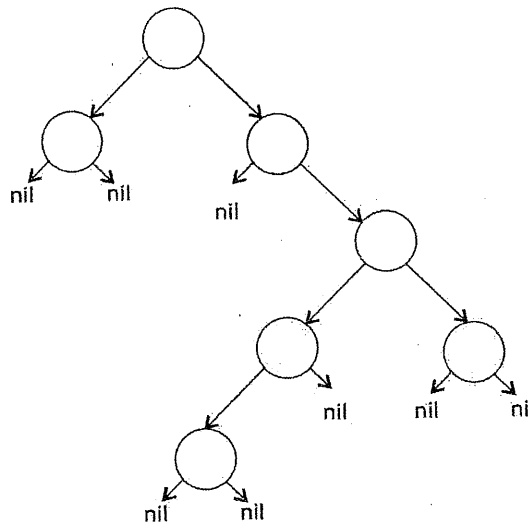5, 8, 12, 15, 20, 23, 25

Figure 3

[4 Marks]

b) **Briefly explain** why this binary search tree cannot be coloured to form a legal red-black tree. [4 Marks]

c) Following array is organised as a heap. **Illustrate** how you can arrange it to assure the heap property if you remove the element with the maximum number.
20 15 15 12 10 3 8 7 5

[5 Marks]

d) Write pseudo codes to sort the above array in O (n log n) time using heap sort. Trickle down subroutine, *Trickledown*, is given to you. You have to use the given array as the storage. You can create temporary variables when necessary within your subroutine.

Note: The trickledown subroutine find the proper place for the item found in the root of the heap while maintaining the heap property.

[7 Marks]