UNIVERSITY OF WESTMINSTER

ELECTRONICS AND COMPUTER SCIENCE

2012-2013

Code: ECSE502

Title: Algorithms and Data Structures

Date: 17 May 2013

Time: 10:00

Duration: 2 Hours

Module Leader: Epaminondas Kapetanios

INSTRUCTIONS TO CANDIDATES

This paper contains 9 (nine) questions. You need to answer ALL nine questions.

QUESTION 1:

Name the seven (7) common order-of-growth classifications being used for measuring the time complexity of algorithms. Consequently, study the following code in Java and estimate its time complexity by using one of the sever order-of-growth classifications and justify your answer based on the control structures being used.

```
int count = 0;
for (int i = 0; i < N; i++)
   for (int j = i+1; j < N; j++)
      for (int k = j+1; k < N; k++)
         if (a[i] + a[j] + a[k] == 0)
            count++;
```

[10 Marks]

QUESTION 2:

What is the order of growth of the worst case running time of the following code fragment as a function of N?

```
int sum = 0;
for (int i = 0; i*i < N; i++)
   for (int j = 0; j*j < 4*N; j++)
      for (int k = 0; k < N*N; k++)
         sum++;
```

[9 Marks]

QUESTION 3:

Assuming you run an algorithm by doubling the input size N and recorded the following times spent and their ratio of change. Estimate the time complexity in terms of the well-established orders of growth and justify your answer.

[7 Marks]

N	seconds	ratio	log(base of 2) ratio
512	0.12	4.14	2.05
1024	0.49	4.24	2.08
2048	2.08	4.24	2.08
4096	8.83	4.24	2.08

QUESTION 4:

In the table below, the algorithmic complexity of six operations over ordered and unordered arrays are given. Justify briefly and in plain text the complexity (right column) for each case.

Algorithm	Running Time in Big O Notation
Linear search	O(N)
Binary search	O(log N)
Insertion in unordered array	O(1)
Insertion in ordered array	O(N)
Deletion in unordered array	O(N)
Deletion in ordered array	O(N)

[9 Marks]

QUESTION 5:

Study the following algorithm in pseudo-code and explain the algorithm and its purpose. Subsequently, estimate the time complexity of the algorithm.

```
USE variables half-array, found, middle element
SET half-array = initial array;
SET found = TRUE;

Boolean  SearchOverOrderedArrays(half-array)
        FIND middle element in half-array;
        Compare search key with middle element;
        IF middle element = search key THEN
          SET found = TRUE;
        ELSE
        IF search key <  middle element THEN
                SET half-array = lower half of initial array;
        ELSE
                SET half-array = upper half of initial array;

        SearchOverOrderedArrays(half-array)
```

[12 Marks]

QUESTION 6:

Assuming the following declarations (figure on the left) and implementation (figure on right) hold, what is the data structure being defined and its definition in plain text.

[7 Marks]

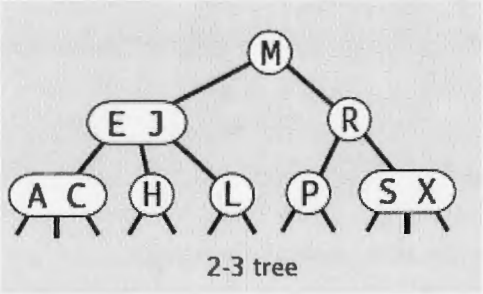
```
private class Node
{
   private Key key;
   private Value val;
   private Node left, right;
   public Node(Key key, Value val)
   {
      this.key = key;
      this.val = val;
   }
}
```

```
public Value get(Key key)
{
   Node x = root;
   while (x != null)
   {
      int cmp = key.compareTo(x.key);
      if      (cmp  < 0) x = x.left;
      else if (cmp  > 0) x = x.right;
      else if (cmp == 0) return x.val;
   }
   return null;
}
```

QUESTION 7:

Provide the definitions of 2-3 (balanced) and red-black trees. Subsequently, study the 2-3 balanced tree below and transform it into its corresponding leaning left red-black balanced tree and explain the role of the red and the black links. You may label links as red, no need to use a red pen.

[14 Marks]



2-3 tree

QUESTION 8:

Let us assume you are given a graph with vertices {A, B, C, D} and the relationships/edges {A leads to B}, {B leads to A, C, D}, {C leads to B}, {D leads to B}.

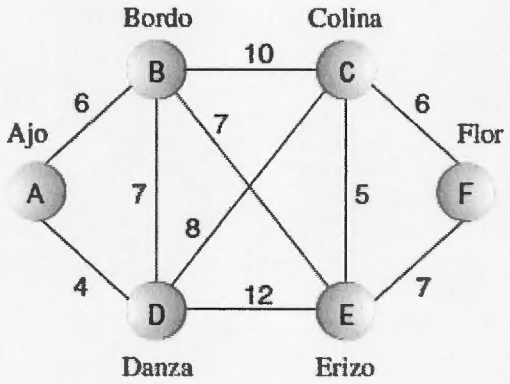
A) Provide the corresponding adjacency matrix in terms of {0, 1} elements, which reflect the graph above, and justify whether the feature of symmetry for the matrix holds or not.

B) Subsequently, provide an alternative representation of the graph to be implemented with the help of a single array.

[12 Marks]

QUESTION 9:

Let us assume you are given the following graph representing the potential costs (weights on the edges) associated with laying out a cable TV network among different cities (nodes on the graph). Suggest a network solution for connecting all cities at the minimum cost possible. Justify your approach by briefly explaining the method (algorithmic approach) you followed.



[20 Marks]

END OF EXAM PAPER