

THIS PAPER IS NOT TO BE REMOVED FROM THE EXAMINATION HALLS

UNIVERSITY OF LONDON

291 0226 ZB

BSc Examination
for External Students

**COMPUTING AND INFORMATION SYSTEMS AND
CREATIVE COMPUTING**

Software Engineering, Algorithm Design and Analysis

Dateline: Monday 18 May 2009 : 10.00 – 1.00 pm

Duration: 3 hours

Candidates should answer **FOUR** questions. Full marks will be awarded for complete answers to a total **FOUR** questions. Candidates must answer **TWO** questions from **Section A** and **TWO** questions from **Section B**.

Each question carries 25 marks. The marks for each part of a question are indicated at the end of the part in [] brackets.

There are 100 marks available on this paper.

No calculators may be used.

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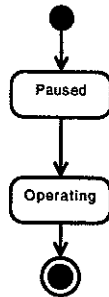
Section A

Question 1 Software Development Models and Processes

A large company is considering bids from various firms for a customer-facing IT project. One has proposed following a *waterfall model*, one an *iterative model* and another has proposed what they call an *Extreme Programming Solution*.

- (a) Briefly, define the following:
 - (i) Waterfall model [2]
 - (ii) Iterative model [2]
 - (iii) Extreme Programming [2]
- (b) What is the first phase of the waterfall model? [1]
- (c) What is involved in this phase? [3]
- (d) Briefly list the strengths and weaknesses of the waterfall model. You should aim for at least four points. [4]
- (e) Briefly list the advantages and disadvantages of an iterative model over a waterfall model. You should aim for at least four points. [4]
- (f) Is Extreme Programming iterative? [1]
- (g) What is a software development model? [3]
- (h) Why do software engineers follow development models rather than designing timetables and strategies from scratch for each client as the need arises? [3]

Question 2 State Machine Diagram

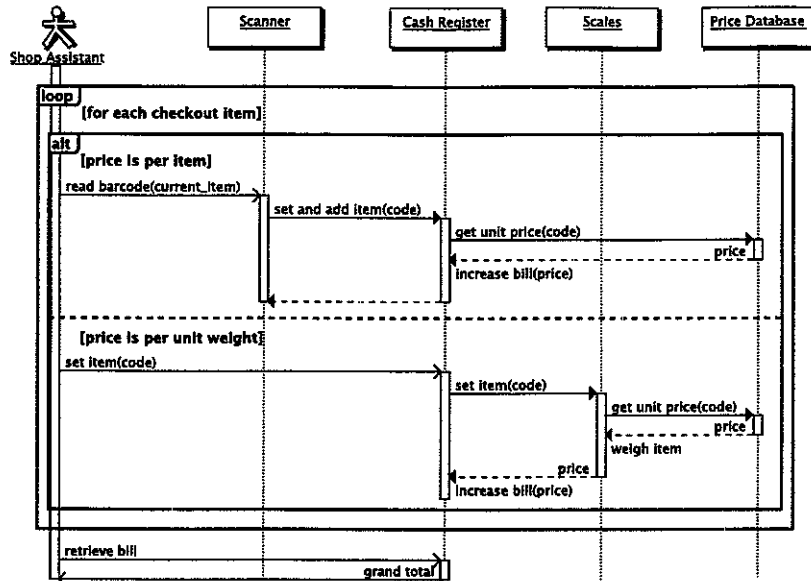


- (a) The above state-machine diagram represents the main states of a washing machine. When it is first switched on, it is in a paused state, and then pressing the start button activates it.
- (i) What is a pseudostate? Which pseudostates are represented in the diagram? [2]
 - (ii) The **Operating** state consists of three substates: **Washing**, **Rinsing** and **Spinning**. Redraw the state diagram to show this. [2]
 - (iii) When the door is opened in mid-cycle, reclosing it and pressing the start button should resume the cycle from where it left off. Show this in your diagram. What is the symbol used called? [2]
 - (iv) Add triggers for the transitions of your diagram. [2]
 - (v) The washing machine door will only open when the programme has not locked it. Show this on your diagram [2]
 - (vi) When the cycle finishes, the washing machine beeps. Show this on your diagram. [2]
- (b) WhirlpoolTM are developing a 'smart' washing machine that can be monitored and controlled by computers and mobile phones. An example of how this works is that, if you put on a wash whilst watching television, an alert message is displayed on the screen when the wash is finished and allows you to start a drying cycle running via the television set or to go and remove the wash load.
- (i) What actors would be involved in such an interaction? [2]
 - (ii) Write a use case illustrating this alert functionality. [5]
 - (iii) If the door was not properly closed when the cycle was started, a message is displayed on the washing machine screen. If nothing is done for 5 minutes, an alert is delivered to the television. Add an extension to your use case to illustrate this [2]
 - (iv) Whirlpool conducted testing by setting the system up in a number of households in Atlanta. Was this verification or validation? Explain your answer. [2]
 - (v) What challenges would Whirlpool's software engineers have faced testing just the software components of their system in the new washing machine? How might they have approached the problem? [2]

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Question 3 Sequence and Class diagrams

The following sequence diagram shows the process of operating a supermarket checkout for a given customer



- (a) (i) Why is the actor in this diagram not the customer? [1]
- (ii) Explain the behaviour of loop and its guard in the diagram. [2]
- (iii) Explain the behaviour of alt and its guards in the diagram. [2]
- (b) (i) What classes are involved in this diagram? [1]
- (ii) What class or classes interact with the price database? [1]
- (iii) Draw a class diagram showing the details of the classes depicted in the sequence diagram. [5]
- (c) When they pay for their goods, customers may present a loyalty card, which keeps a record of each customer's purchases. The system implementing this includes a class for each of CustomerRecord, for Transaction and for Product.
 - (i) Draw a simple class diagram showing these three classes and the relationship between them (include multiplicities in your diagram). [3]
 - (ii) Draw an activity diagram to show the shop assistant taking payment for a transaction and then—if the customer has a loyalty card—adding the transaction to their record. [6]
- (d) (i) What aspects of the system might you subject to stress testing? [1]
- (ii) What other performance testing might you carry out? [1]
- (iii) The barcode scanner is only subjected to black box testing. What does this mean, and why might this be the case? [2]

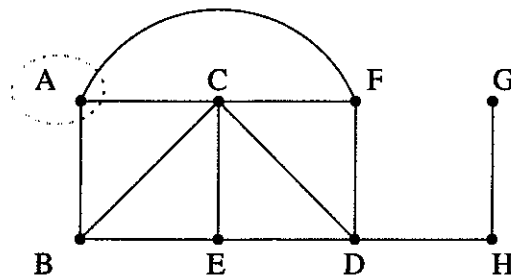
Section B

Question 4

- (a) Explain in one sentence the term *computational complexity* in the context of Algorithms. Discuss briefly the time complexity in the *worst* case for the algorithm below. Indicate the basic operations you have counted. Assume that i, j and n are positive integers. [5]

```
1:  $i \leftarrow n, j \leftarrow n$ 
2: while  $j \geq 1$  do
3:   for  $i \leftarrow 1; i < j; i \leftarrow i + 1$  do
4:      $x \leftarrow x + 1$ 
5:   end for
6:    $j \leftarrow j \text{ div } 3$ 
7: end while
```

- (b) Draw the binary search tree for the sequence of characters (c,a,e,k,m,g,b), where the alphabet letters are inserted in the given order. Demonstrate a pre-order traversal of the binary search tree. [4]
- (c) Write a recursive algorithm for a pre-order traversal of a binary tree. [3]
- (d) Would it be possible for the above binary tree structure to be preserved in an array? If yes, explain and demonstrate how. If no, explain why not. [3]
- (e) Explain, with the aid of an example, in what situations the divide and conquer approach may be inefficient. Justify your answer. [5]
- (f) Consider the connected graph below. Starting from vertex A, write the vertex sequence in the order that each vertex is visited applying the *depth first* traversal algorithm. Justify your answer. [5]



Question 5

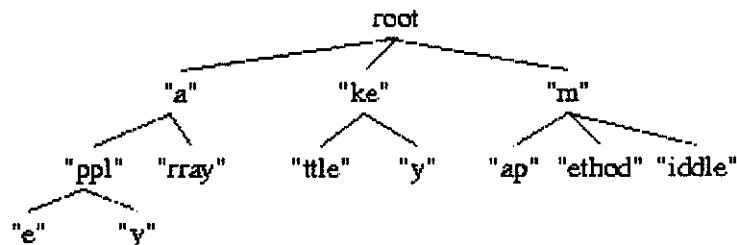
- (a) What is it meant by a polynomial time algorithm? Analyse the algorithm below. Explain why the algorithm is not normally considered as a polynomial time algorithm in the context of efficient algorithms. [5]

```
int algorithmX(n)
1: result ← 2
2: for i ← 1 to n do
3:   result ← result * result
4: end for
5: return result
```

- (b) Outline the Boyer-Moore pattern matching algorithm, with an example where the text T and the Pattern P are as below. Demonstrate step by step the shifts and comparisons performed by the algorithm. [10]

T: a b a c a a b a d c a b a c a b a a b b
P: a b a c a b

- (c) Consider the diagram below. Name the data structure and list all the strings represented in the structure. [5]



- (d) Write an algorithm to compute the degree of each vertex of a simple graph. The graph is represented by its adjacency matrix $adjMatrix[i, j]$, where $i = 1, \dots, n$, $j = 1, \dots, n$ and n is the number of vertices of the graph. [5]

Question 6

- (a) Consider a task of packing n objects into a minimum number of bins. To simplify the problem, we assume that everything is two dimensional, i.e. bins and objects are merely rectangles. The height of the n objects are h_1, h_2, \dots, h_n . The width of the objects are all the same in size and can just be fitted in the rectangular bins. The available bins are all of capacity C . [12]
- (i) Draw a diagram to show one instance of the problem.
 - (ii) Classify the problem based on your algorithmic knowledge.
 - (iii) How 'easy' is this problem from algorithmic point of view?
 - (iv) What is the so-called "greedy approach"?
- (b) Following the above, design and propose an approximation algorithm for the bin-packing problem using a greedy approach. Show all your work and highlight (or mark clearly) the final version of the algorithm. [13]

Hint: You may like to first sort in descending order the objects according to their sizes. Then take a so-called first-fit strategy placing an object in the first bin in which it fits, and starting a new bin if it does not fit in.