

THIS PAPER IS NOT TO BE REMOVED FROM THE EXAMINATION HALLS

UNIVERSITY OF LONDON

291 0226 ZA

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

The following description is a time plan submitted by an IT firm for the proposed development of a new company database.

“In weeks 1 and 2, we will talk to the clients in detail and carry out interviews with a sample of the staff members who would use the system. In week 3 we will produce an overview of the system and describe it to the client in a meeting at the end of the week.

This will be followed by 3 months of work by our engineers, after which the product will be presented to the clients for user, acceptance and performance testing in weeks 17 and 18.

We aim to have the full product deployed by the end of week 19. One of our engineers will remain on site for one week after deployment to deal with any technical difficulties that may arise”

Briefly answer the following questions:

- (a) What development phase are they describing for weeks 1-2? [1]
- (b) What is performance testing? [1]
- (c) What development phase(s) do you think the firm intend to carry out in weeks 4-16? [3]
- (d) What sort of software development model do the firm appear to be following here? [1]
- (e) What effect would significant failures in the on-site testing have to this plan? [1]
- (f) Is this an appropriate model to use? Justify your answer. [3]
- (g) Draw a UML state machine diagram showing the development stages of this model [5]
- (h) Using *activities* or otherwise, how would you incorporate the timings from the plan into your diagram? Illustrate your answer with one state and its transitions. [3]
- (i) Name a different software development model from the one named in (d) above. [1]
- (j) How would the state machine diagram differ for the model you name in (i) from that in your answer to (d)? [3]
- (k) What are the advantages and disadvantages of the model named in (i) compared with that described in (d)? [3]

Question 2 Use Cases, Class and Sequence Diagrams

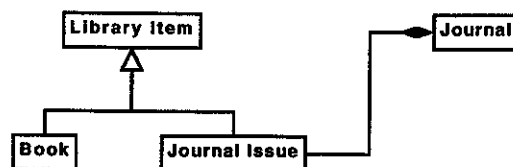
The following use case describes the process of ordering a book to refer to in a British Library reading room.

Use Case: Taking out a book

Primary actor: British Library Reader

- 1 The reader enters his reader pass number and password
- 2 The reader searches the catalogue and adds the desired book to their request list.
- 3 The reader selects the book on the request list and orders it, giving the number of his desk.
- 4 The system passes a message to the relevant book storage area.
- 5 A fetcher in the book storage area scans the book's barcode to indicate that it has been fetched and then places it on a conveyor mechanism for the reading room of the reader
- 6 The librarian at the issue desk scans the barcode of the book when it arrives and places it on a shelf.
- 7 The system turns on a light at the reader's desk (to indicate that the reader should go to the issue desk).
- 8 The librarian at the issue desk scans the reader's pass and brings the books from the shelf that are indicated onscreen.
9. The librarian scans the barcodes of the books again to confirm checkout.

- (a) (i) What actors are involved in this use case? [2]
- (ii) Readers are allowed to request up to 14 items, but can only take 6 out to their desks at a time. Give the extensions you would add to this use case to show this [4]
- (iii) Why might the text in step 2 of the use case be underlined? [1]
- (iv) Using the noun identification technique or any other method, list candidates for classes for the system. Mark any candidates you can rule out with a cross. [6]
- (v) Draw a sequence diagram for steps 1-3 of the use case. You should use the classes you have discovered and include any relevant extensions from your answers above. [6]
- (b) The following is an extract from a library system class diagram



- (i) Describe the relationship between Book (or Journal Issue) and Library Item. [2]
- (ii) Describe the relationship between Journal Issue and Journal. [2]
- (iii) The library has the facility to allow users to search for individual articles in a journal. Draw a diagram showing the relationship between the two classes Article and Journal Issue, indicating the *multiplicities* of the relationship on your diagram [2]

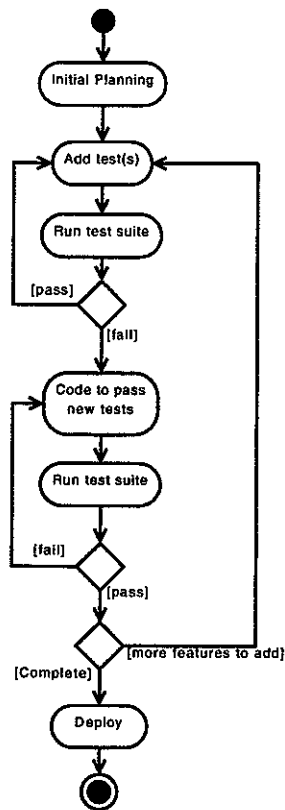
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Question 3 Testing

- (a) Explain the distinction between *verification* and *validation* [4]
- (b) What is *software regression*? How can it be avoided? [2]
- (c) Explain the distinction between *white box* and *black box* testing [2]
- (d) What is refactoring? Why is it useful for quality assurance? [2]
- (e) A quadratic equation is an equation of the form $ax^2 + bx + c = 0$. A function takes three integer values for a , b and c and returns possible values for x .
 - (i) Just on this basis, suggest at least 4 possible sets of values for a , b and c that you might use to test the function, aiming to show up possible issues [2]
 - (ii) We are told that the function relies on calculating the square root of $b^2 - 4ac$. What additional values might we test for using this knowledge? (if you have mentioned any of these earlier, give them again). [2]
 - (iii) We are further told that the last stage in the function involves dividing by $2a$. What values might you consider adding to your test? (if you have mentioned these earlier, give them again) [1]

(question continues on next page)

(f) The diagram below shows a test-driven development lifecycle



- (i) What sort of UML diagram is this? [1]
- (ii) Why does 'Run test suite' happen twice in this process? Why is the response to failure different in each case? [4]
- (iii) Is this model iterative? [1]
- (iv) What is requirements churn? How does the model handle this? [3]
- (v) Is this a predictive or an adaptive model? [1]

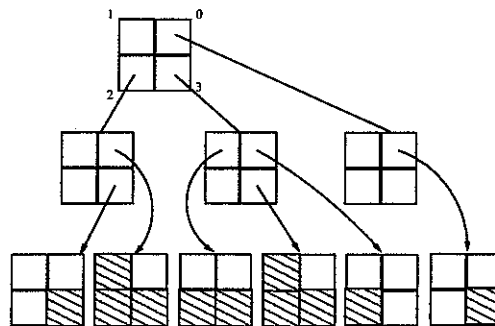
Section B

Question 4

- (a) Consider the *closest-pair problem*.
- (i) Describe the problem and two different instances of the problem including one *special case*. [5]
Hint: A special case can be a situation where a special solution is required. Specify your assumptions if necessary.
 - (ii) Propose a suitable data structure to use in solving the problem. Design and outline an exhaustive-search algorithm for this problem. Justify your choice. [10]
 - (iii) Demonstrate how to analyse the time complexity of your algorithm for the worst case. [5]
- (b) Write an algorithm to compute the degree of each vertex in a simple graph. The graph is represented using adjacency lists. Let `adjacentList[i]` refer to the first adjacent node to vertex i , where $i = 1, \dots, n$ and n is the number of nodes of the graph. [5]

Question 5

- (a) Distinguish between an *algorithm* and a (computer) *program*. [2]
- (b) Professor John thinks that algorithm efficiency is less important today because the speed of computers has increased dramatically. Do you agree with him? Write about your view concisely and give one convincing example to support your argument. [8]
- (c) Given the quad-tree below, draw the original black-white (b-w) pixel block (image) that the tree represents. [5]



Question 6

- (a) What is the meaning of the term *computational complexity* in the context of Algorithms? Give your answer in one sentence. 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  $i \geq 1$  do
3:   for  $j \leftarrow 1; j < n; j \leftarrow j + 1$  do
4:      $x \leftarrow x + 1$ 
5:   end for
6:    $i \leftarrow i \text{ div } 2$ 
7: end while
```

- (b) Derive and demonstrate the contents of an open-address hash table $H[0..22]$ after insertion of the keys $(3, 4, 5, 26, 6, 7, 23, 16, 39, 17, 22, 55)$, one by one in that order. You may assume a double hashing with $h(k) = k \bmod 23$ with *linear probing* $(h(k) + i) \bmod 23, i = 0, \dots, 22$ for collisions, and the hash table is empty initially. [5]
- (c) Describe an algorithm `balancedBrackets()` that takes a string as an input and checks whether the brackets "[" and "]" in the string are matched correctly. For example, `balancedBrackets("[x][[xy]]")` would return *true* but `balancedBrackets("[[x[y]]")` would return *false*. [10]
- (d) Write a recursive algorithm `AscendOrder(bTreeNode T)` in pseudocode to display integers stored in a Binary Search Tree in ascending order. Indicate clearly the input and the output of your algorithm and the meaning of each variable used. [5]