THIS PAPER IS NOT TO BE REMOVED FROM THE EXAMINATION HALLS

UNIVERSITY OF LONDON **CO2226 ZA**

BSc Examination

COMPUTING AND INFORMATION SYSTEMS, CREATIVE COMPUTING and COMBINED DEGREE SCHEME

Software engineering, algorithm design and analysis

Date and Time: Thursday 11 May 2017: 14.30 – 17.30

Duration: 3 hours

This paper is in two parts: Part A and Part B. There are a total of THREE questions in each part. You should answer **TWO** questions from Part A and **TWO** questions from Part B.

Full marks will be awarded for complete answers to a total of **FOUR** questions, TWO from Part A and TWO from Part B. The marks for each part of a question are indicated at the end of the part in [.] brackets.

Only your first **TWO** answers from Part A and first **TWO** answers from Part B, in the order they appear in your answer book, will be marked.

There are 100 marks available on this paper.

A handheld calculator may be used when answering questions on the paper but it must not be pre-programmed or able to display graphics, text or algebraic equations. The make and type of machine must be stated clearly on the front cover of the answer book.

Part A

Question 1

a) Briefly explain the purpose of sequence diagrams in UML. How do they correspond with use case diagrams?

[5]

b) FindABargain Ltd is a company specialising in providing registered users opportunities for purchasing goods at heavily discounted prices; they offer a number of different bargains updated regularly that their users can go for; every bargain will have specific items to be sold at this price, and an end date. The following rules apply:

- Every user has to register with the website; they will have to provide their first name, last name, address details, mobile phone and e-mail address. Once they complete registration, the user chooses a username and a password to use with the system.
- The website allows for private and corporate accounts; in the case of a private account, users are limited to a maximum of 5 purchases in total of any particular bargain, while in the case of a corporate account, this amount is unlimited. In the case of a corporate account, the company registration number is needed as proof of company status.
- The user then gets presented with a choice of categories of bargains that they might be interested in – they can choose as many categories as they like, but must choose at least one.
- Every time a bargain comes in, the details of the product are recorded as well as the category(ies) under which the bargain will be listed. In order to reach as many customers as possible, the bargain may be listed under multiple categories (*e.g.* a mobile phone might be listed under phones and electrical appliances). The end time for the bargain is also recorded. The website displays all these details.
- The user selects the bargain they are interested in, and logs in using the username and password they created during the registration process.
- After they log in, the chosen bargain is added to their shopping cart. They can continue and add other purchases, but they must be logged in to be able to add bargains to their shopping cart.
- When the user is satisfied that they have added all the bargains they wish to buy to the shopping cart, they next click on the checkout button in order to pay for the goods. Payments can be made by debit/credit card, Paypal, cheque or wire transfer and, as this is not a regular sale but a bargain, the amount must be paid in full (no matter if it is a personal or a corporate account). The payment system is outside the scope of the

current system specification and a third-party payment gateway system is used to run the payment process.

- An administrator login is required for the purposes of adding details about products and bargains but also, most importantly, for reporting purposes, to monitor how the bargains perform. It is not uncommon that the price of a bargain will change if there is not much response from customers.
- The administrator should be able to see current bargains, as well as the performance of those that have expired, in order to make a judgement as to whether any changes are advisable. In order to help with this process, at the end of each month a report is generated that shows all bargains that started during the month and calculates a number of metrics for the month. These metrics need to be saved on the system along with the identity of the administrator who created the report.

Develop a class diagram for the above scenario using the appropriate naming conventions (*e.g.* class names starting with a capital letter) and suggest class attributes with name and type, as well as methods with name and return type. Illustrate associations, aggregations, and generalisation relationships between the objects. Please state any assumptions you make during the development of the diagram

[20]

Question 2

a) Explain briefly the meaning and differences of <<include>> and <<extend>> associations in the context of use case diagrams. What difference do they make to the use case they are connected to? You may use examples to illustrate your answer.

[5]

b) Prepare a use case diagram to accommodate the specification of the FindABargain Ltd system specified in **Question 1**. Your answer should include all use cases, actors and any associations between different use cases, different actors or use cases and actors. Please state any assumptions you make about the system.

[20]

Question 3

a) What is the motivation behind the concept of packages in UML diagrams? In which diagrams might you use packages and what criteria would be used to decide what to include in them? Give a brief example to illustrate your answer.

[5]

b) Create a state machine diagram describing the behaviour of an order object described in **Question 1.** The following rules apply:

- The order object is new once the payment gateway (processing the payment information received from the customer) confirms that the payment has gone through.
- After that, it is in preparation while the different items belonging to the same order are being collected (*e.g.* in order to attract more customers, a bargain for a mobile phone might include additional items like cover case, power bank, *etc.*).
- It will go into packaging once all items have been collected.
- Once packaging is completed, the order will then go into shipping mode.
- When it is shipped, it can safely be marked as dispatched (all orders are signed for and they are shipped with proof of delivery so that the company can track them and prove that they have been delivered).
- After the specified time expected for the order to be delivered, and once proof of delivery has been obtained, the order can be marked as complete.
- The order then goes through a clearing process for the finance department to confirm that the appropriate amount of money has been credited into the company's account.
- If the transfer of money cannot be found then the order will go into a waiting for clearance phase, which it will only come out of when the money transfer is traced.
- Assuming the money has been found, three months after passing clearance, the order will be archived and will only be accessible through history searches.

Design the state machine diagram using state transitions and labels with three parts. Please state any assumptions you make about the system.

[20]

Part B

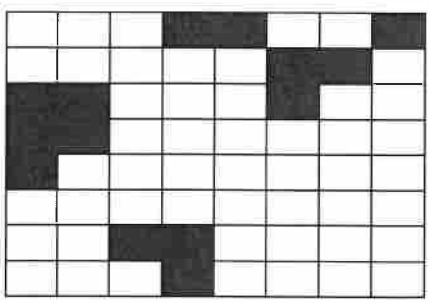
Question 4

This question focuses on graphical representation, pattern matching and heaps.

a) Describe briefly what a Quadtree is and where it may be used.

[2]

b) Convert the pixel-grid below into a Quadtree.



[6]

c) Describe how the above representation can be extended to three dimensions and state what this new representation is called.

[2]

d) Draw a figure to illustrate step by step the comparisons done by the Boyer-Moore pattern matching algorithm for the case in which the text T and the pattern P are:

T: babcbbabdcbabcbabbaa

P: babcba

[6]

e) What is a binary heap? State the **TWO** main properties of a heap. Give **ONE** example of where a binary heap would be a useful data structure.

[5]

f) A binary heap can be implemented as an array. Given a heap stored on the array below, draw the heap structure as a diagram. Explain briefly how the array and tree are mapped to each other.

1 7 5 9 11 10 8 17

[4]

Question 5

This question focuses on abstract data types and hashing.

a) Using matrices as an example, distinguish between the concepts of Abstract Data Types and Data Structures.

[4]

b) Briefly explain why the concept of an Abstract Data Type is useful in software development.

[2]

c) Explain what is meant by Hashing and give one reason why it can be useful.

[4]

d) Given a hash function *h(k) = k mod 14* and an empty hash table, show the hash table after inserting the data (1 7 24 27 42 21 101). Show the steps in the calculation.

[5]

e) Using your answer to (d) as an example, explain what Collision is and why this is an issue in hashing.

[4]

f) Describe what is meant by Closed Address Hashing, and then apply it to the data in (d) to resolve the collision.

[4]

g) Using the data item 321 as a search query what would be retrieved from the hash table produced in (f)?

[2]

Question 6

This question focuses on Huffman Coding.

a) Describe what Huffman Coding is and the idea behind how it works.

[3]

b) Provide pseudocode for the Huffman Coding compression/encoding algorithm.

[3]

c) Apply Huffman Coding to the following text (no spaces). Show your steps.

H U F F M A N M O D

[8]

d) Provide pseudocode for the Huffman decoding algorithm given a Huffman tree and an encoded message.

[3]

e) Show how the decoding process works given the coding you produced in (c) and the bit string below. Show your steps carefully.

(01111010111011100101001110000)

[4]

f) Based on your answers above, does Huffman Coding achieve a significant compression? Would Huffman coding be more or less effective on large alphabets such as ASCII? State your reasoning.

[4]

END OF PAPER