THIS PAPER IS NOT TO BE REMOVED FROM THE EXAMINATION HALL

UNIVERSITY OF LONDON

CO2226 ZA

BSc EXAMINATION

COMPUTING AND INFORMATION SYSTEMS, CREATIVE COMPUTING and COMBINED DEGREE SCHEME

Software Engineering, Algorithm Design and Analysis

Tuesday 14 May 2019: 14.30 – 17.30

Time allowed: 3 hours

DO NOT TURN OVER UNTIL TOLD TO BEGIN

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 this 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.

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PART A: answer TWO questions

Question 1

a) Who would be the main audience for an activity diagram and what would you be trying to capture in it? Use an example to justify your answer.

[5]

b) SendACard.com is a new online service for people who want to send a personalised greetings card for any occasion. The user will have to be registered with the site by filling in a registration form where their contact details (*e.g.* first and last name, e-mail address, mobile phone number) are captured and they are invited to select a username and a password. The user could, possibly, specify card categories that they might be interested in (*e.g.* anniversary, get well, new baby and so on).

- The system offers home and corporate registration types; if the user registers a corporate subscription, then on top of the previous details they will be asked to provide a VAT number and nominate a corporate administrator.
- Assuming that the user is logged in, they are presented with the list of available categories, from which they make a choice; once the choice is made, the available designs for that category are displayed to the user.
- The user can select one of the pre-defined designs or they can upload their own artwork. Once the upload (if applicable) is completed, the user is asked to type the accompanying text and the postal address of the recipient (if the recipient is a member of the site as well, the user can just type the recipient's username if they know it).
- The previous process will create the card and queue it up for the standard service time of five days. If the user wants a faster service, they can choose this at the last stage of the process for an extra fee.
- The cost model of the site is based on a subscription model (the subscription is paid annually), which entitles the user to a certain number of cards that they can generate for the duration of that annual subscription (the date on which the subscription renews is a calendar year after the registration if it is the first renewal or the last renewal).
- If the user goes over that limit, they can still send cards but there will be a fee for the service. The same would apply if the user is uploading their own artwork as this means that the pre-defined templates cannot be used.
- The order for the card will not be processed until the user makes payment of the fee (if a fee is applicable); the payment process will be done through an external payment gateway, but the system will need to record the final outcome of the process as well as any authorisation codes if it were a card or Paypal payment.
- The system should provide the option for a user to register either as a home user or as a corporate account; corporate accounts will get their

own account manager and a number of free expedited card processing for a calendar year, but the VAT Registration Number for the company should be provided during registration.

- The system should give the user the option to create their own templates if they so wish (*e.g.* if they use a design multiple times they can save it on the server under a name of their choice — this design will not be available to any other users, just the user who uploaded the design).
- In the same manner with images, the customers, if they so wish, could create text snippets as templates that they can use. These snippets are saved under the customer's library and they are not available to other customers (just like the design templates); when logged in, they should be available to the user just like the design templates.
- The system should offer the user a view of where their order is at any time that they log in — this should be one of a set of pre-defined texts (*e.g.* 'order queued', 'sent to the printer', 'printing', 'card printed' and so on). As long as the status is not 'printing' or later, the customer can cancel the card order, but they will need to provide a justification for this (to be used later by the marketing department to get a better understanding of customers' habits and behaviours).
- Assuming the cancellation has happened before the 'printing' state, the customer can get a refund. If this is the case, the details of the refund should be recorded and an administrative fee of 10% kept for the use of the system.
- At the end of every month, the system should generate a number of reports to be made available to management so that they can make more informed decisions about customer behaviours and identify areas where more customised designs or text snippets might be needed. These reports would include the number of cards generated this month as well as their categories, and how many of them used a stock image or text snippet and how many used a user-defined one. The report should also offer a breakdown for each category, as well as a breakdown of how many refunds were issued and the reason that they were requested. These reports could also be generated on request by an administrator of the system. In the case of a corporate administrator, the nominated user would be able to generate admin reports for their organisation.

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.

[20]

Question 2

a) When would you use an association class in a class diagram? Illustrate your answer with an example.

[5]

b) Prepare an activity diagram to accommodate the specification of the SendACard.com system specified in **Question 1**. The following rules apply:

- The process starts when the individual customer is logged in and selects the option to send a card.
- The system should ask the user what category the user is interested in.
- The user selects the category they are interested in.
- The system, in parallel, will load up the templates for this category and check if the user has any user-defined templates for this category. If they do, then the system will load these as well.
- The user will select the image and text templates that they are interested in.
- The system asks the user to confirm their selection for the text to be entered.
- The user enters the final text to be added to the card.
- The system asks the user to confirm the choices made.
- The user confirms their choices.
- The system simultaneously checks if the user has reached the number of free cards for the annual subscription and creates the preview for what the card will look like.
- The system presents the user with the preview and the final cost for the selection.
- The user confirms that they accept the preview and the cost involved.
- If a payment needs to be made, then the user is presented with the different options available.
- The user fills in the payment information and submits the form.
- The system passes the information on to the payment gateway and waits for the result.
- If the result is unsuccessful, the system informs the user and presents the payment screen again — this repeats until the payment information is accepted.
- The system will simultaneously send the information to the printers and ask the user to confirm the recipient's address.
- The user types in the recipient's address.

- The system updates the card information and the user's record.
- The system displays a confirmation to the user that all of the information has been saved.

Show on the activity diagram the flow of control using specialised UML components, like activities, decisions, merges, forks and joins.

[20]

Question 3

a) What are the two ways in which we can deal with requirements churn?

[5]

b) Prepare a use case diagram to accommodate the specification of the SendACard.com 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. State any assumptions you make about the system.

[20]

PART B: answer TWO questions

Question 4

This question focuses on abstract data types and string matching.

a) Describe what is meant by an Abstract Data Type (ADT) and why it is useful in software development. Use the String ADT as an example.

[6]

b) The Boyer-Moore pattern matching algorithm can be used for string matching.

i. Explain what the 'Looking Glass' and 'Character Jump' heuristics are.

ii. What is the worst-case time complexity of this algorithm (when the pattern is present in the text)?

[6]

c) Show, 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: dcbabcbdbbaabcbbdb

P: abcbb

Be sure to show all stages including the comparisons made.

[8]

d) The KMP matching algorithm is a linear-time string matching algorithm. Explain the improvements that it makes to the Boyer-Moore algorithm.

[5]

Question 5

This question focuses on hashing.

a) Explain what is meant by hashing, and give two reasons why it can be useful.

[6]

b) Assuming a hashing function of h(k) = (k + 1) mod 10, provide the hash codes for the values 1, 123, 14, 21, 12 and 45. What do we mean by saying a collision occurred? Highlight but do not resolve any collisions where they exist.

[8]

c) What is the process of resolving collisions when using hashing with the linear probing method? Apply it to the result you have obtained in (b).

[4]

d) Describe what is meant by closed address hashing, and then apply it to the data in (b) to resolve the collision. Compare this method to linear probing.

[5]

e) Using the data item 42 as a search query, what would be retrieved from the resolved hash table produced in (d) above?

[2]

Question 6

This question focuses on graph representations and traversal.

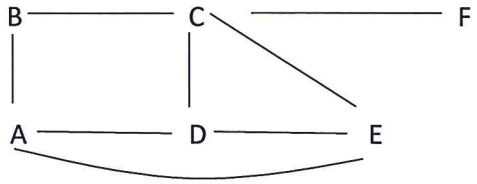
a) What is the definition of a graph? How does it differ from a digraph? You should use an example of a simple graph to illustrate your answer.

[6]

b) Explain the adjacency list, incidence matrix and adjacency matrix representations of a graph. Which of these may be the most space-efficient representation for large sparse graphs?

[8]

c) Consider the non-simple graph below.



Represent the graph as each of an adjacency list, incidence matrix and as an adjacency matrix.

[6]

d) Provide pseudo-code for breadth-first traversal of a graph.

[2]

e) For the graph in (c) above, starting from vertex A, write the vertex sequence in the order that each vertex is visited when applying the breadth-first traversal algorithm. Show the steps at each stage.

[3]

END OF PAPER