CO2226 ZB

BSc Examination

COMPUTING AND INFORMATION SYSTEMS, CREATIVE COMPUTING and COMBINED DEGREE SCHEME

Software engineering, algorithm design and analysis

Release date: Tuesday 25 May 2021

Time allowed: 3 hours

This paper is in two parts: **PART A** and **PART B**. There are a total of **THREE** questions in each part. Candidates 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 **TWO** from **PART B** will be marked. You should ensure any additional answers are deleted from the work you submit.

There are 100 marks available on this paper.

You may use any calculator for any appropriate calculations, but you may not use computer software to obtain solutions. Credit will only be given if all workings are shown.

PART A: answer TWO questions

FindABusiness.com scenario (to be used for all questions in PART A)

FindABusiness.com is a new online service for individuals who need to identify local businesses quickly and receive immediate access to promotional offers, and also for entrepreneurs who want to grow their business by advertising their presence through the system. The idea is that users can run a search for the type of business they want, and get promotional offers and speedy service.

- The user must register with the site, filling in a registration form where their contact details (e.g. first and last name, email address, mobile phone number) are captured and they are invited to select a username and a password.

- The user can also provide information about the types of business they regularly use — this allows them to save searches in their profile and run them just by logging in to the system, and they can also receive information on new offers without the need to search for them.

- The system offers home and corporate registration options; the home registration type is for individuals who just need to use the service to identify local businesses, while the corporate service is aimed at companies who wish to increase the volume of their businesses. If the registration is for a corporate subscription, then in addition to their contact details, the initial registration form will also require details of the company's VAT registration number and nomination for a corporate administrator.

- The user, after logging in, can run a search based on the type of business they are interested in and the date they need it by and, optionally, add some information on the details of their project. If an offer is already in the system for that type of job, the home user can accept it straight away. If nothing exists at the time of inputting the details, the user creates a new request and business owners then respond with an offer. The request will be open for a week (the user will have already specified the requirements) and upon the deadline, they will either accept one of the offers or close the request if they are not satisfied with the offers made.

- A home user registration will entitle the user to up to twenty searches per year and to open five requests. A corporate registration will enable the nominated administrator to add up to fifty promotional offers a year and respond to an unlimited number of open requests.

- In the case that a home user wants to run more searches or a business user wants to input more offers, the service also offers 'top-up' bundles. These come in units of ten for home users and twenty for business users (for business users, the ability to respond to an unlimited number of requests is not part of the bundle as it is included

UL21/0447

in the corporate registration). Bundles can be purchased at any time, and are valid for up to two years from the date of purchase. Any unused credits will roll over for one year, provided that the membership is renewed; otherwise they will be lost.

- After the service is provided by the local business (either following a direct offer or an offer accepted after a request initiated by the home user), the home user will receive a request to provide a review of the business. The review must be provided within two weeks, and will be made available to help other home users evaluate the trustworthiness and quality of work of the local business.

- The site also provides a reminder service, depending on the chosen functionality. A business user can mark a request as 'on hold' if they want to bid on it but need to do some further calculations. In this case, a reminder will be sent to them two days before the deadline for making an offer, or one day before if marked 'on hold' two days before the deadline (if the deadline is on the same day, no reminders will be sent out). In the case of the home user reviews, a reminder will be sent a week, three days and one day before the deadline (obviously, once the review is submitted, no further reminders are sent).

- Assuming that the user has provided information about the types of business they regularly use, they will receive targeted promotional offers when a business offer becomes available that matches their profile. This is done by sending out an e-mail notifying them of the offer, the time that it is available for, any rules that might apply and a summary of the feedback received to date for the business in question. This is done by the use of an external mail agent.

- The business model of the site is based on a subscription model (the subscription is paid annually), with an option for auto-renewal available for all customer types. The date on which the subscription renews is a calendar year after the registration (if it is the first renewal) or the last renewal.

- Users are given a grace period (one month for individual accounts and three months for corporate accounts) to renew if they have not already done so by the due date. A reminder is sent on the day after the renewal was due, and after that once a week until the end of the grace period. If the user chooses to ignore them, and does not renew, in accordance with GDPR regulations all their data will be deleted.

- The home user has the option to cancel an offer they have signed up for. They are required to provide a justification and are liable to pay 50% of the amount due if the cancellation is received three weeks before the work was due to start, 65% if they cancel between three and one weeks before, and 90% if they cancel in the last week. If they cancel more than three weeks before the scheduled start day, they will not have to pay anything, but must still provide a justification for the

UL21/0447

cancellation. Otherwise, payment to the business is only made after the job is completed.

- The system uses external payment gateways to collect payments. However, the resulting information (e.g. the authorisation code in the event of a card payment, the date the payment went through, clearance code for cheque payments, e-cheque details, etc.) is kept in the system as it is used to determine account access.

- At the end of every month, the system generates a number of reports so that management can make informed decisions about customer behaviours and identify areas where the service can be improved. These reports include the number of business promotions that were taken up each month, the categories of businesses and the number of cancellations. Other reports offer a breakdown for each business category and show the most active individuals/organisations. Reports can be generated on request by a systems administrator. In the case of a corporate administrator, they are able to generate admin reports for their organisation (essentially the type of reports remains the same, it is the user base that changes). The system does not need to record the actual figures from the report as these are generated on the fly from the database, but it needs to keep information about who generated a report, when and what type of report it was.

Question 1

a) How do high cohesion and low coupling contribute to good design? What do the values of these properties ensure?

[5 marks]

b) Develop a **class diagram** for the **FindaBusiness.com** system specified above, using the appropriate naming conventions (e.g. class names starting with a capital letter) and give class attributes with name and type, as well as methods with name and return type. Show associations, aggregations, and generalisation relationships between the objects.

[20 marks]

Question 2

a) What is a scenario and what is a use case? Are these two concepts linked and, if so, how? You may wish to give a brief example to justify your answer.

[5 marks]

b) Prepare a **state diagram** to accommodate the **FindABusiness.com** system specified above, for the functionality of the request process initiated by a home user. Use state transitions and labels with three parts. The following specification rules apply:

- The process starts when the home user inputs the relevant information and the request is created.
- The request is active as long as the seven-day period has not elapsed and there are no offers in response to the request
- Once a bid comes in, the request becomes contested; any new offers will not alter the state.
- At the end of the seven-day period if no offers are made, the request is rejected and the process is terminated (the same applies if the home user decides not to accept any of the offers).
- Once the home user selects an offer, the offer becomes allocated.
- While work is being done on the offer, the offer is in progress.
- When the work is completed, the offer moves to awaiting payment.
- Once payment is received and processed, the offer moves to paid.
- It is then marked as waiting for feedback for the two-week period during which the home user can submit a review.
- After the period of two weeks ends, the offer is either marked as feedback received, if a review has been provided, or marked no feedback received if no review has been provided.
- Either way the offer then progresses to completed and stays on the system for a further two months in case of any further query.
- If any query is received, then the offer goes to investigating – this is allowed only once.
- The maximum period for investigation is two weeks; either automatically after that time, or when the investigation is complete, the offer becomes concluded.
- After two months for the completed offers, or when any investigation is concluded, the offer becomes archived and is deleted from the system.

[20 marks]

Question 3

a) What are **TWO** different types of box testing and how do they work? Provide an example of what each type is concerned with during the testing process.

[5 marks]

b) Prepare a **use case diagram** to accommodate the **FindABusiness.com** system specified above. 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 marks]

Part B: answer TWO questions

Question 4

This question focuses on **sorting algorithms**.

a) State what would be a good choice of sorting algorithm for the following applications/list characteristics and briefly explain why.
   • Frequent calls to sort short (less than 50 items) lists.
   • Sorting long (many tens of thousands of items) mostly sorted lists.
   • Sorting long randomly ordered lists.

   In addition, briefly describe the **TWO** most important factors you took into consideration in making your choice.

   [5 marks]

b) For **TWO** of the applications in a) describe how **EACH** proposed sorting algorithm is used for that application. You should include the following for **EACH** application:
   • Pseudocode, with a brief explanation of its operation.
   • A walkthrough when sorting the list: (3   2   4   1   6   7   5)

   [10 marks]

c) For **ONE** of the applications in b) provide the worst-case time and space complexity of the sorting algorithm and outline how they were arrived at. Comment briefly on the practical implications in the context of the application.
   [5 marks]

d) In general terms, worst-case performance is a common focus. Discuss the advantages and disadvantages of average-case space and time performance versus worst-case space-and-time performance for the **TWO** selected applications you selected in b).
   [5 marks]

Question 5

This question focuses on **recursion**.

a) Examine the recursive code for calculating a Fibonacci number below, then:
   • Explain and correct any errors in the code.
   • Write an iterative version of it.
   • Compare the recursive and iterative versions of the code. Which version would you prefer and why?

```
static int fib(int n)
  {
  if (n <= 1)
     return n—-;
  return fib(n) + fib(n-2);
  }
```

[5 marks]

b) Adapt the corrected recursive code you produced in a) to be 'tail recursive'. Use your code to explain this concept, and what benefits it may bring.

[5 marks]

c) A programmer is writing code to process very large data structures. They have the choice of writing code iteratively, recursively or tail-recursively. What trade-offs should the programmer consider, and which approach would you recommend?

[5 marks]

d) Using an appropriate example of your choice, explain and demonstrate the concept of 'dynamic programming' to improve the efficiency of the Fibonacci implementation. Please pay particular regard to time and space complexity. In the context of the Fibonacci implementation, contrast it with the 'divide-and-conquer' approach.

[10 marks]

Question 6

This question focuses on **hashing and its application**.

One application of hashing is to link variable names to memory locations in programming language implementations.

In the planned implementation of the experimental SMEAGOL programming language, hashing is used to map each variable name to a unique array index [0 …15] in a 16-item array (this will be expanded in a later version). The base address of the array is given by `*var_pointer` and its array offset by `var_index`.
Note: variable names in SMEAGOL are case-sensitive and can only contain alpha-numerical characters.

For the purposes of this question, there are five variable names to be mapped to an array index.

- `MyPrecious`
- `NastyBaggins`
- `OneRing`
- `Nazgul9`
- `WasSneaking`

You have been asked to propose an implementation of variable name hashing for the prototype implementation.

a) Propose a method/hash function for transforming an alphanumeric variable name to a valid value for the array offset, `var_index`. Then compare it against **TWO** criteria for a good hash function. Finally, state whether your hash function is a 'perfect' hash function and explain why.

[10 marks]

b) Apply the hash function you proposed in a) to the five variable names given above, and give the array you produce, showing all your steps. Then, with an example of your choice (that is, you may use an additional variable name if you wish), explain what is meant by collision and why it is a problem for this application.

[5 marks]

c) You have been asked to propose two collision resolution methods of your choice. Apply **BOTH** of your proposed collision resolution methods to the example you produced in b) and discuss which would be a more appropriate choice. In addition, you may propose adjustments to these methods to better fit this application.

[10 marks]

END OF PAPER