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COMPUTER SCIENCE
HIGHER LEVEL
PAPER 2

Wednesday 15 May 2013 (morning)

2 hours 15 minutes

INSTRUCTIONS TO CANDIDATES

- Do not open this examination paper until instructed to do so.
- Answer all the questions.
- A clean copy of the ***Computer Science*** *case study* is required for this paper.
- The maximum mark for this examination paper is *[100 marks]*.

8 pages

*Answer **all** the questions.*

1. A games company employs a team of programmers for the development of online games.

(a) Identify **two** benefits that the online feature provides for the users of the games. *[2 marks]*

The company employs a modular approach to programme development.

(b) Describe **two** benefits that can be gained from using this approach. *[4 marks]*

One of the games being developed is a version of Sudoku. The game is based on 3×3 grids (each consisting of nine cells). In each grid, the user must enter all of the digits from 1 to 9 once only. The grids can be represented by 2-D arrays as shown below.

Grid 1

	0	1	2
0	4	2	7
1	1	6	3
2	5	9	8

Grid 2

	0	1	2
0	7	**5**	9
1	2	4	8
2	**5**	6	3

Grid 1 (above) has been filled in correctly, however, **Grid 2** is incorrect, as the digit "5" appears twice (and the digit "1" fails to appear).

In the Sudoku program, the grid is represented by a 2-D array (called `grid`). For example, in **Grid 1**, the value represented by `grid[2][1]` would be "9".

(c) For **Grid 2**, state the value of `grid[1][2]`. *[1 mark]*

When all of the cells have been filled, the program checks the number of times each digit has been entered, in order to see if the grid has been filled in correctly.

(d) Describe the data structure, `digits`, that would be suitable for storing the number of times that each digit from 1 to 9 has been entered. *[2 marks]*

(This question continues on the following page)

(Question 1 continued)

The method `checkGrid()` inspects each square of the grid and returns the message "Success" or "Failure" depending upon whether or not the grid has been filled in correctly.

(e) Construct the method `checkGrid()`. *[7 marks]*

One version of the game consists of nine such 3×3 grids joined together as shown below. The grid has been partially filled in.

Grid 3

	0	1	2	3	4	5	6	7	8
0	2	3	6				1	8	5
1	5	1	4				7	4	9
2	7	8	9				2	6	3
3									
4									
5									
6									
7									
8									

For success, the conditions that must apply are:
- each 3×3 grid must contain each digit from 1 to 9 just once (same as before)
- each complete row must contain each digit from 1 to 9 just once
- each complete column must contain each digit from 1 to 9 just once.

In the example shown (**Grid 3**), there is a mistake in Row 1 where the digit "4" appears twice.

(f) Discuss whether the programming team will be able to reuse the `checkGrid()` method to check all of these conditions. You should include details of any modifications or conditions that would have to be made or met, to make this possible. *[4 marks]*

2. A linked list is being used to hold the marks for a class of students.

(a) With reference to memory, explain how links are formed between consecutive nodes in a linked list. *[2 marks]*

(b) Explain why a temporary variable is used when traversing a linked list. *[2 marks]*

Each node in the list is a `Student` object, the `Student` class being shown below.

```
class Student
{
  String surname;
  int id;
  Mark firstMark; //points to the first node in a linked list of marks
  Student nextStudent; //points to the next Student node, or to null
}
```

As shown above, each `Student` object includes a pointer to a linked list which contains the student's marks. Each mark is contained in an object of the `Mark` class which is shown below.

```
class Mark
{
  int score;
  Mark nextMark;
}
```

(c) Suggest why both the students and the marks are held in linked lists. *[2 marks]*

The list holds the following data about two students:

Position in list	Surname	id	Marks
1	Kuyt	475	23, 12, 45, 12
2	Peters	386	54, 87

(d) Construct a diagram showing the linked lists, using the above data. *[3 marks]*

(This question continues on the following page)

(Question 2 continued)

The class that is used by the system which manages the students' marks includes the following methods:

```
public double average(Mark firstMark){}
//returns the average mark for the list pointed to by firstMark

public Student locateStudent(int id){}
//returns the pointer to a specific node in the student linked list

public double studentAverage(int id){}
// returns the average mark for a specific student or -1 for an
// empty marks' list
```

(e) Construct the method `public double average(Mark firstMark)`. *[7 marks]*

The average mark of a specified student is determined through the method call:

```
double averageMark = studentAverage(id);
```

(f) Construct the method `studentAverage(int id)`, making use of any previously defined methods. *[4 marks]*

3. A hashing algorithm is used to locate records that are stored on a disk. The algorithm operates on an id number `(id)` to produce a hash value. This value indexes a location in a hash table.

The hash table consists of an array of objects, each of which contains an id number and the memory location of the corresponding record.

```
id ———> hashing algorithm ———> hash value
                                   |
                                   v
              hash table (array of objects)
```

(a) Outline **one** reason for choosing a hashing algorithm to access the records. *[2 marks]*

(b) If the hashing algorithm used is `id % 1000` (where `%` is the modulo operator),

(i) state the hash value produced when the id number = 24456. *[1 mark]*

(ii) state another id number which would give the same hash value. *[1 mark]*

The method `hash()` receives the id number and returns the hash value, which is used as the index to the hash table.

Each entry in the hash table consists of an object of the class `Node` as shown below.

```
class Node
{
  int idNumber;        // id number of a record
  int memoryLocation;  // identifies the memory location for that record
}
```

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(Question 3 continued)

The class that manages the hash table is partially shown below.

```
class HashTable
{
  Node [] table = new Node[?];       // see part (c)  (i) below

  void displayRecord(int memoryLocation){}
  // displays the record that is in the specified memory location

  void findRecord(int idNumber){}

  // Note: collisions are dealt with by allocating the next free space in
  // the array.
}
```

(c) Given the hash algorithm in part (b), suggest, with reasons,

(i) a value for the size of the `table` array. *[2 marks]*

(ii) a value for the number of records. *[2 marks]*

When a record is to be displayed, the method `findRecord()` is called, which carries out the following steps:

- the id number is passed as a parameter
- the hash function uses the id number to calculate the array index (hash value)
- the correct entry in the hash table is located
- the complete record is displayed.

(d) Construct the method `findRecord()`, making use of any previously defined methods. *[8 marks]*

The programmer has the choice of using a hash table or a full index to access an individual record.

(e) Suggest reasons for choosing a full index and not a hash table. *[4 marks]*

This question requires the use of the case study.

4. (a) With reference to page 4 of the case study, explain with the use of examples why RAM is also known as *dynamic memory*. *[2 marks]*

(b) Identify the data that would be stored in the *firmware* of a smartphone. *[1 mark]*

(c) Describe **two** ways in which manufacturers have overcome the limited number of options that can be displayed on a touch screen. *[4 marks]*

(d) Explain why the increase in use of 3G/4G phones might be of concern to Internet Service Providers (ISPs). *[3 marks]*

(e) By making use of both positive and negative examples, discuss whether students should be allowed to use smartphones during lessons at school. *[6 marks]*

(f) Outline why one of the chips inside a smartphone will contain an analogue-to-digital converter (ADC). *[2 marks]*

(g) Describe **two** consequences of the low power consumption of *Bluetooth* for smartphone users. *[4 marks]*

Scientists often make use of *sensors* when taking part in field studies.

(h) With reference to a specific example, describe how a smartphone could be used in these studies. *[3 marks]*

(i) Suggest **one** reason for choosing a smartphone that makes use of a "kill" switch. *[2 marks]*

(j) Explain why higher-pixel density leads to sharper images on a screen. *[3 marks]*

(k) (i) Describe a scenario in which an interrupt will cause a program to take priority in a smartphone. *[2 marks]*

(ii) For the scenario in part (k) (i) outline how the program that was initially running can be resumed. *[2 marks]*

When a name is being searched for in a smartphone's address book, entering the first letter of the name takes the user to the correct section of the book. Entering the second letter then refines the search even more.

(l) With reference to both data structures and processing, suggest how the search process is carried out. *[6 marks]*