UNIVERSITY OF EDINBURGH

FACULTY OF SCIENCE AND ENGINEERING

COMPUTER SCIENCE 2Bh

Thursday 5 September 2002

14:00 to 16:30

Examiners

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INSTRUCTIONS TO CANDIDATES

Section A questions are worth 10 marks each.

Section B questions are worth 30 marks each.

Answer all FOUR questions in Section A.

Answer any TWO of the three questions in Section B.

If you are in the third or later year of your degree course, please tick the box on the front cover of the script book.

Section A

1. (a) Explain briefly the difference between a *class method* and an *instance method* in a Java class.

   [2 marks]

   (b) Write complete Java code for a method `append` that takes two arguments `a` and `b`, both references to object arrays, and returns a new array containing in order all the elements of `a` followed by all the elements of `b`. The method `append` must never raise an exception; if either of its arguments is null, it should return a null result.

   [8 marks]

2. Consider the algorithm `recMax` described by the following pseudo code. If A is an array that contains items with comparable keys and i, j are two indices such that $0 \leq i \leq j \leq A.length - 1$, then $\mathsf{recMax}(A, i, j)$ returns an item with maximum key in the subarray $A[i \dots j]$.

   Algorithm $\mathsf{recMax}(A, i, j)$

   if $i < j$ **then**
       $m \leftarrow \lfloor \frac{i+j}{2} \rfloor$
       $\mathit{leftmax} \leftarrow \mathsf{recMax}(A, i, m)$
       $\mathit{rightmax} \leftarrow \mathsf{recMax}(A, m+1, j)$
       if $\mathit{leftmax}.\mathit{key} \geq \mathit{rightmax}.\mathit{key}$ **then**
           return $\mathit{leftmax}$
       else
           return $\mathit{rightmax}$
   else
       return $A[i]$

   (a) Give a recurrence for the worst-case asymptotic time complexity of `recMax`.

   [5 marks]

   (b) Solve the recurrence in (a) using the Master Theorem and give a Θ-expression for the worst-case asymptotic time complexity of `recMax`.

   [5 marks]

3. A relational database contains two tables EMP and DEPT with information about employees and departments respectively. Consider the following SQL query, noting that it contains a nested subquery:

```
SELECT D.NAME
FROM DEPT D
WHERE D.DEPTNO IN
  (SELECT E.DEPTNO
   FROM EMP E
   WHERE JOB = 'CLERK');
```

   (a) State in English the information requested in this query.
   Note that this question requires you to describe the *information* requested, rather than the SQL constructs used in the query.

   [3 marks]

   (b) Rewrite the query so that it does not use a subquery.

   [7 marks]

4. Consider the problem of sorting an array A that contains items whose keys are all either 0 or 1. Let us call this problem the *0-1-sorting-problem*.

   (a) Of course all general-purpose sorting algorithms can be applied to the 0-1-sorting problem.
   What is the asymptotic worst-case running time of mergeSort when applied to the 0-1-sorting problem? Briefly justify your answer.

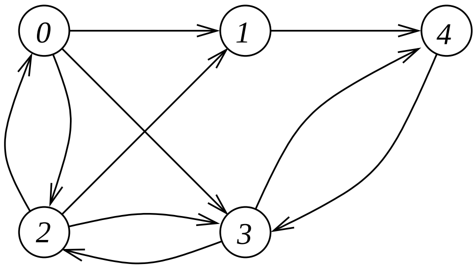
   [4 marks]

   (b) Is there an algorithm for the 0-1-sorting problem whose asymptotic time complexity is $O(n)$? If your answer is 'yes', give the pseudo-code for an algorithm for the 0-1-sorting problem achieving this time complexity. If your answer is 'no', justify this answer.

   [6 marks]

Section B

5. Consider the following graph G:



(a) Suppose we want to traverse G by a breadth-first search (BFS) starting at vertex 0. Give two different orders in which a BFS starting at 0 may traverse the graph.

[4 marks]

(b) Now we want to traverse G by depth-first search (DFS). Give two different orders in which a DFS starting at 0 may traverse the graph.

[4 marks]

(c) In this part of the problem, we want to compute the distances of all vertices of G from the "source" 4.

Draw a shortest path tree for G with root 4 and give the distances of all vertices of G from 4.

[4 marks]

Next, we want to solve the all-pairs-shortest path problem using the Floyd-Warshall algorithm. Recall that when run on a graph with vertex set

$$\{0, \dots, n-1\},$$

the algorithm computes a sequence of matrices

$$D^{(k)} = (d_{ij}^{(k)})_{0 \le i,j \le n-1}$$

for $-1 \le k \le n-1$. Also recall that the matrix $D^{(-1)}$ is just the adjacency matrix of the graph with 0s replaced by ∞s and 0s on the diagonal.

(d) What is the intuitive meaning of the entry $d_{ij}^{(k)}$, for $0 \le i, j, k \le n-1$?

[4 marks]

(e) How is $d_{ij}^{(k)}$, for $0 \le i, j, k \le n-1$, computed from the entries of the matrix $D^{(k-1)}$?

[4 marks]

(f) Suppose that the Floyd-Warshall algorithms is run on the graph G displayed above and compute the values $d_{40}^{(0)}, d_{04}^{(0)}, d_{04}^{(1)}, d_{40}^{(3)}$.

[4 marks]

(g) Suppose you had to write a program computing distance matrices for graphs. Furthermore, suppose that you had the additional information that the program would only be applied to graphs in which every vertex has out-degree at most 2. Your program is supposed to handle very large input graphs as efficiently as possible.

Which algorithm would you choose? Justify your answer.

[6 marks]

6. (a) The Java 2 collection libraries in java.util include the following.

Set, AbstractSet, HashSet.

Describe each of these and their uses. You should state their relationship in the class hierarchy, and for each one explain how it is implemented and what it is useful for.

[15 marks]

(b) Give an example of a wrapper class from the Java standard library. State the class name, what it does, and give a line or two of code showing it in use.

[5 marks]

(c) A *Gaussian integer* is a complex number $(x + yi)$ where both the real part x and the imaginary part y are integers. Write out code for a class GI of Gaussian integers, with operations to create a new Gaussian integer, get its real and imaginary parts, and convert it to a string. Include a static method add that adds two Gaussian integers. Make sure that the class and these operations are available to all other code.

(You need not write an equals method.)

[10 marks]

7. SGML, HTML and XML are all *markup* languages.

   (a) What is the difference between the *document compiler* approach and the *WYSIWYG* approach to presenting formatted textual information for human reading? Make it clear in your answer where the markup languages listed above fit in. You should cover two to four points of contrast in your answer.

   [6 marks]

   (b) What is the distinction between *markup* and *content*? The markup languages listed above all distinguish one from the other in documents in the same way – what is that? You should cover all the main aspects of the micro-syntax of XML and HTML in the second part of your answer.

   [6 marks]

   (c) What are CSS and XSLT? How do they fit in to your answer to question (a) above? You should cover three or four main aspects of each in your answer.

   [8 marks]

   (d) Contrast XML and HTML in terms of design goals, functionality and use in practice. Be sure to identify strengths and weaknesses in each case.

   [10 marks]