NUI MAYNOOTH

Ollscoil na hÉireann Má Nuad

OLLSCOIL NA hÉIREANN MÁ NUAD

THE NATIONAL UNIVERSITY OF IRELAND MAYNOOTH

JANUARY 2007 EXAMINATION

CS210

Algorithms & Data Structures 1

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Time allowed: 2 hours

Answer *three* questions

All questions carry equal marks

[25 marks]

1 **(a)** Give a definition for the Order-of-Magnitude of an algorithm (Big-O notation) and explain this concept briefly in your own words. Using the definition, show that the order of magnitude of the following function f(n) is $O(n^2)$. **[6 marks]**

$$f(n) = 3n^2 + 2n + 5$$

(b) The following method inserts an element into an ordered array. Describe how the code works and assess the algorithm's Order of Magnitude. **[5 marks]**

```java
public void insert(long value){
    int j;
    for(j=0; j<nElems; j++) {
        if(a[j] > value)
            break;
    }
    for(int k=nElems; k>j; k--){
        a[k] = a[k-1];
    }
    a[j] = value;
    nElems++;
}
```

(c) Describe in your own words the binary search algorithm for an ordered array. Provide a basic pseudocode version and discuss briefly the advantages of binary search. **[6 marks]**

(d) Compare the advantages and disadvantages of implementing a data structure using a linked list versus an array, with particular reference to stacks and queues. **[8 marks]**

[25 marks]

2 **(a)** Sort the following numbers using insertion sort, writing out the intermediate orderings that would result following each iteration of the outer loop: **[5 marks]**

```
38 16 27 39 12 28
```

(b) Complete the following Java code for the bubblesort method and the swap method that it calls. Assume that the array of ints to be sorted is called 'array' and that the number of elements in the array is stored as an int called 'nElems'. **[5 marks]**

```java
public void bubblesort(){……}
```

```java
public void swap(int one, int two){……}
```

(c) With the aid of suitable examples and diagrams, explain how the recursive mergesort algorithm works. Provide a basic pseudocode implementation. **[10 marks]**

(d) Discuss the complexity of the recursive mergesort algorithm, referring to the number of comparisons and the number of copies involved. Mention how this compares with the performance of other sorting algorithms. **[5 marks]**

[25 marks]

3 **(a)** Explain using suitable diagrams how a queue can be implemented using a circular wraparound array. Provide pseudocode describing how the insert and remove methods would be implemented for such a data structure.   [7 marks]

(b) With the aid of a suitable diagram, describe the steps involved in adding a link to the middle of a doubly-linked list.   [6 marks]

(c) The following method deletes a link from a doubly linked list. Explain the code in your own words, given that 'key' is the data associated with the link to be deleted.   [6 marks]

```
public Link delete (long key)   {
      Link current = first;
      while(current.data != key){
            current = current.next;
            if(current == null)
                return null;
      }
      if(current==first){
          first = current.next;
      }else{
          current.previous.next = current.next;
      }
      if(current==last){
          last = current.previous;
      }else{
          current.next.previous = current.previous;
      }
      return current;
  }
```

(d) Explain how a linked list can be used to implement a priority queue, mentioning the type of linked list that would be required for this purpose. Describe briefly the linked list methods that would be used by a priority queue.   [6 marks]

[25 marks]

4 **(a)** Show the resultant binary tree after the following elements are inserted in the order given: [6 marks]

<div align="center">
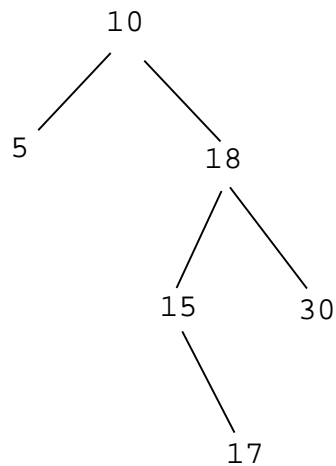
19   46   8   16   23   6   29   25

</div>

Write out the order in which each of the following tree traversals visit the nodes in this tree:

        (i)   Pre-Order
        (ii)   In-Order
        (iii)   Post-Order

(b) With the aid of suitable diagrams, explain how a node is deleted from a tree if the node to be deleted has two children. [10 marks]

Draw the tree that would result if 10 were deleted from the following tree:

```
                    10
                   /    \
                5        18
                        /    \
                     15        30
                        \
                         17
```

(c) Complete the Java code for the getSuccessor method below, assuming that 'delNode' is the node to be deleted. The method should simply find and return the successor of delNode. Explain how the algorithm works. [5 marks]

```java
private node getSuccessor(Node delNode){
        Node successor = delNode.rightChild;

        ………     //fill this in

        return successor;
}
```

(d) Describe briefly the efficiency of binary trees with reference to insertion, deletion and searching. [4 marks]