Data Structures

Midterm Exam, Fall 2008

Note! ***The new homework (of chapter 5) has been announced on the webpage of this course. Please remember to read its details. Thanks for your cooperation!***

1. (30%) Explain the following terms and terms comparisons:
   (a) Tree traversal
   (b) Binary search trees
   (c) FIFO lists vs. LIFO lists
   (d) Max heaps vs. Max trees
   (e) The degree of a tree node
   (f) Row major order
   (g) Complete binary trees
   (h) Full binary trees
   (i) Underflow
   (j) Algorithms vs. programs

2. (5%) Answer "True" or "False" for the following statements.
   (a) An empty binary tree is invalid while a tree may have zero nodes.
   (b) The order of children is irrelevant in a binary tree.
   (c) The order of operators in infix representation is the same as that in postfix representation.
   (d) Compared a binary search tree with a heap, the former is more suited for deleting arbitrary elements.
   (e) The time complexity of a deletion operation from a n-element max heap is $O(n)$.

3. (8%) Prove or disprove the following statements:
   (a) $\sum_{i=0}^{n} i^3 = \Theta(n^4)$
   (b) $100n^2 + 200 = O(n)$
   (c) $n! = O(n^n)$
   (d) $n^{1.001} + n \log n = \Theta(n^{1.001})$

4. (3%) Derive the worst case time complexity of the binary search function `binsearch` as follows. (Assume that there are n elements in the array `list`.)

```
int binsearch (int list[], int searchnum, int left, int right)
{
   int middle;
   while (left <= right) {
      middle = (left + right)/2;
      if (list[middle] < searchnum)
         left = middle + 1;
      else if (list[middle] == searchnum)
         return middle;
      else
         right = middle - 1;
   }
   return -1;
```

}

5. (a) (5%) How to represent polynomials as singly linked lists? Your answer should include the node structure and a pseudo code for polynomial addition.
   (b) (3%) Assume that the two arguments of the polynomial addition have m and n terms respectively. Determine the time complexity of your pseudo code.

6. (9%) Assume that it takes two units of memory location to store an integer and row major order is adopted. Consider the following array declaration:

```
int A[5][8][9];
```

   (a) If `A[0][0][0]` is stored at address 2000, calculate the memory address of `A[2][0][7]`.
   (b) If `A[0][0][0]` is stored at address 2000, indicate which array element is at the location 2080.
   (c) If `A[3][0][0]` is stored at address 2000, calculate the memory address of `A[1][5][5]`.

7. (a) (3%) During the process of transforming a parenthesized infix expression to a postfix one, why do we need two types of precedence, an *in-stack precedence* and an *incoming precedence*?
   (b) (4%) Write the postfix form of the following expressions:
      (i) A - B * D + E / F + A * D + C
      (ii) (A - B) * D + E / (F + A * D) + C

8. (a) (8%) Describe how to delete an element from a binary search tree. Calculate the time complexity of the deletion operation.
   (b) (8%) Describe how to insert an element into a min heap. Calculate the time complexity of the insertion operation.
   (c) (3%) Solving the equivalence classes problem is an application of binary search trees. Explain how to process an equivalence pair, $i \equiv j$.

9. (8%) How can we apply a linked list representation to sparse matrices? It is not necessary to follow the design introduced in the textbook.

10. (3%) Given an inorder sequence BAECDIHFGI and a postorder sequence ABCDEFGHIJ, can you derive a unique binary tree? If yes, draw the binary tree; or you have to give two distinct binary trees which can generate above sequences.