Data Structures

Midterm Exam, Fall 2008

01. **(30%)** Explain the following terms and terms comparisons:

(a) Tree traversal

(b) Binary search trees

(c) LIFO lists vs. FIFO lists

(d) Max heaps vs. Max trees

(e) The degree of a tree

(f) Row major order

(g) Complete binary trees

(h) Full binary trees

(i) Underflow

(j) Algorithm vs. programs

02. **(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 declaration operation from a *n*-element max heap is $\mathrm{O}(n)$.

03. **(8%)** Prove or disprove the following statements:

(a) $\sum_{i=0}^{n} i^3 = \Theta(n^4)$

(b) $100n^2 + 200 = \mathrm{O}(n)$

(c) $n! = \mathrm{O}(n^n)$

(d) $n^{1.001} + n\log n = \Theta(n^{1.001})$

04. **(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;
}
```

05. **(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.

06. **(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][8];
```

(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]`.

07. **(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) $(A - B) * D + E / (F + A * D) + C$

08. **(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, $i \equiv j$.

09. **(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 in-order sequence BAECDJHFGI and a post-order 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.