Department of Computer Science and Engineering
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Data Structures Quiz, Chapters 5, Dec. 13, 2021

1. Let b_n denote the number of distinct binary trees with n nodes.

   (a) It is known that b_3=5. Please draw the five binary trees with 3 nodes. (10%)

   (b) Please present the recurrence formula for computing b_n. (20%)

2. Write a recursive C++ function to return the maximum value of the nodes stored in a binary tree, where each node stores one positive value in "data". (35%)

```
class TreeNode {
   int data;
   TreeNode *left, *right;    // pointer to leftChild and rightChild
};
int maxB( TreeNode *root)
// Return maximum value of the binary tree pointed by "root".
// Return -9999 if the binary tree is empty.
{
```

Please write the body of maxB ( ).

```
} // end of maxB ( )
```

3. Write a C++ function to insert a new node r as the right child of node s in a threaded binary tree. The right subtree of s becomes the right subtree of r after the insertion. (35%)

```
class TreeNode {
   int data;
   TreeNode *leftChild, *rightChild;
   bool leftThread,rightThread; //leftThread, rightThread
     /* if rightThread == true, then rightChild is a thread
              (pointer to inorder successor)
        otherwise, rightChild is a pointer to the real right child */
};
void insertR(TreeNode *s, TreeNode *r)
{
```

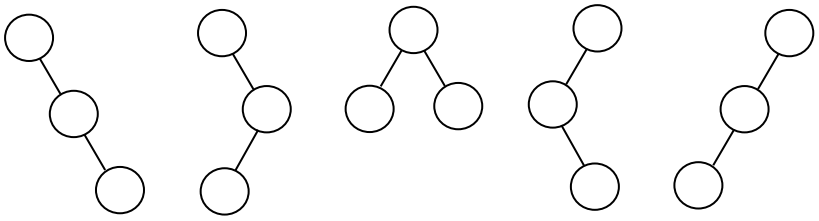
Please write the remaining body of insertR ( ). // Insert r as the right child of s.

```
   if (! r -> rightThread) {// rightChild is not a thread
      treeNode *q = InorderSucc (r); // return inorder successor of r
      q -> leftChild = r;
   }
} // end of insertR ( )
```

Answers:

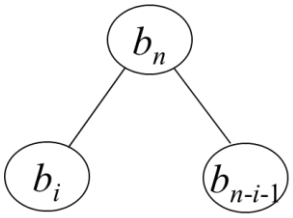
1.

(a)



(b)

$$b_n = \sum_{i=0}^{n-1} b_i b_{n-i-1}\ , \quad n \geq 1\text{, and } b_0 = 1, b_1 = 1$$



2.

```
class TreeNode {
   int data;
   TreeNode *left, *right;
};
int maxB( TreeNode *root)
// Return maximum value of the binary tree pointed by "root".
// Return -9999 if the binary tree is empty.
{
int leftM, rightM;
if( root == 0 )
   return -9999;      // Return -9999 if the binary tree is empty.
leftM = maxB( root->left );
rightM = maxB( root->right );
if ( leftM >= rightM )
   return root->data > leftM ? root->data : leftM;
            // left subtree is larger
else
   return root->data > rightM ? root->data : rightM;
            // right subtree is larger
} // end of maxB ( )
```

3.

```
class TreeNode {
   int data;
   TreeNode *leftChild, *rightChild;
   bool leftThread,rightThread; //leftThread, rightThread
    /* if rightThread == true, then rightChild is a thread
            (pointer to inorder successor)
       otherwise, rightChild is a pointer to the real right child */
};
 void insertR(TreeNode *s, TreeNode *r)
{
// Insert r as the right child of s.
   r -> rightChild = s -> rightChild;
   r -> rightThread = s -> rightThread;
   r -> leftChild = s;
   r -> leftThread = True; // leftChild    is a thread
   s -> rightChild = r;
   s -> rightThread = false;
   if (! r -> rightThread) {// rightChild is not a thread
      treeNode *q = InorderSucc (r); // return inorder successor of r
      q -> leftChild = r;
   }
} // end of insertR ( )
```