Data Structures and Algorithms (CS F211)

Binary Search Trees

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1 Definition

Binary Search Tree(BST) is a tree with the following properties:

1. It is a Binary Tree.
2. The value of nodes present in the left subtree of a root is less than (or equal to) value of root and the value of nodes present in the right subtree is greater than (or equal to) the value of the root.

2 Inserting elements

Inserting elements in a BST is very straight forward (maybe).
Using the definition of BST, we will insert elements in the BST.
The pseudocode is as follows:

```
node* insert (node* root, int x){
  if (root==NULL){
    root=new node();
    root->left=NULL;
    root->right=NULL;
    root->value=x;
    return root;
  }
  else if (root->value>x){
    root->left=insert(root->left,x);
  }
  else{
    root->right=insert(root->right,x);
  }
  return root;
}
```

The average case time complexity of inserting elements is $O(\log(N))$.

3 Searching Elements

In a similar way as inserting elements, we can search elements in the BST. One needs to use the fact that unless the element is found, if the current node is greater than the value to be searched, search in the left subtree, else in the right subtree.
Pseudocode is almost similar:

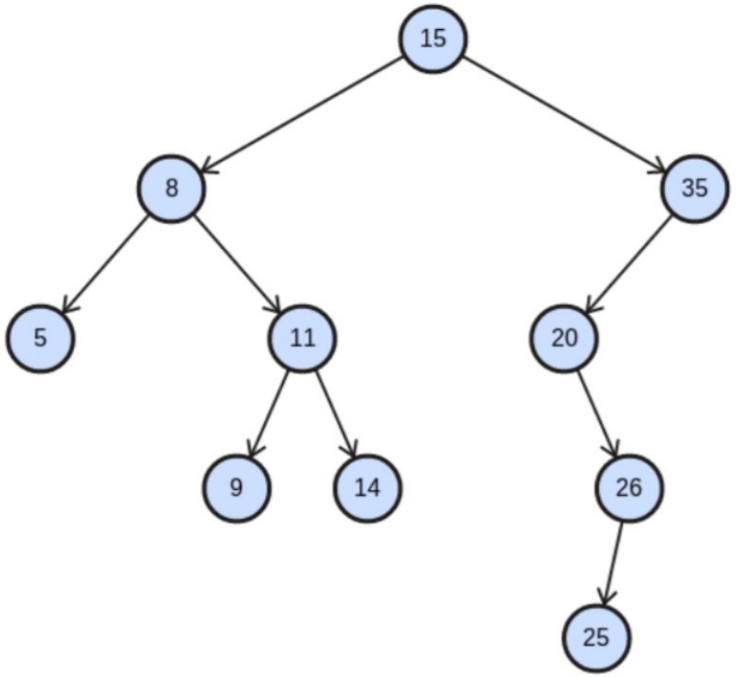
```
    void search(node* root, int x){
  if(root==NULL){
    cout << "Not found";
    return;
  }
  if(root->data == x){
    cout << "Found";
    return;
  }
  if(x<=root->data){
    search(root->left, x);
  }else{
    search(root->right,x);
  }
}
```

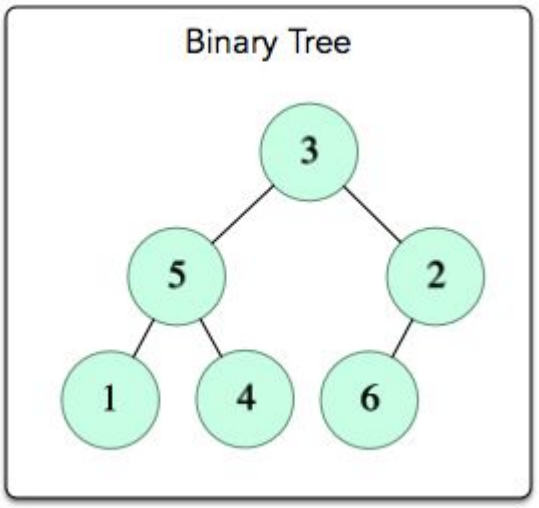
Problems

1. Inorder Successor and Predecessor of BST.
2. Check whether a given binary tree is BST. Problem Link
3. Find the Least Common Ancestor of 2 nodes.
   Problem Link
4. Construct Tree from a given Pre-order traversal.
5. Two of the nodes of a Binary Search Tree (BST) are swapped. Fix (or correct) the BST. Problem Link

Practise Questions

6. https://www.interviewbit.com/problems/kth-smallest-element-in-tree/
7. https://www.interviewbit.com/problems/bst-iterator/
8. Count BST subtrees that lie in given range. For example- let's take the range as [8,15], then the subtree rooted at leaf 9, 14 are in the range, and the subtree rooted at node 11 is also in the range, because the minimum value and the maximum value in that subtree (9 and 11 respectively) are within the mentioned range. The subtree rooted at 8 is not in the range, because the minimum value 5 in this subtree is out of the given range. Hence, answer=3 (3 subtrees possible) (See Below figure)
9. There is an empty set and Q queries of the following type are performed on it:
   • 1 x meaning add the element x to the set.
   • 2 x meaning remove x from the set if it exists.
   • 3 k meaning print the k th smallest element till now.
   (1 ≤ Q ≤ 10^6)
10. https://www.hackerrank.com/contests/dsa-lab-bst-heaps/challenges/wrong-turns/problem (Last Year Lab)






```
Input Tree:
      10
     /  \
    5    8
   / \
  2   20
```