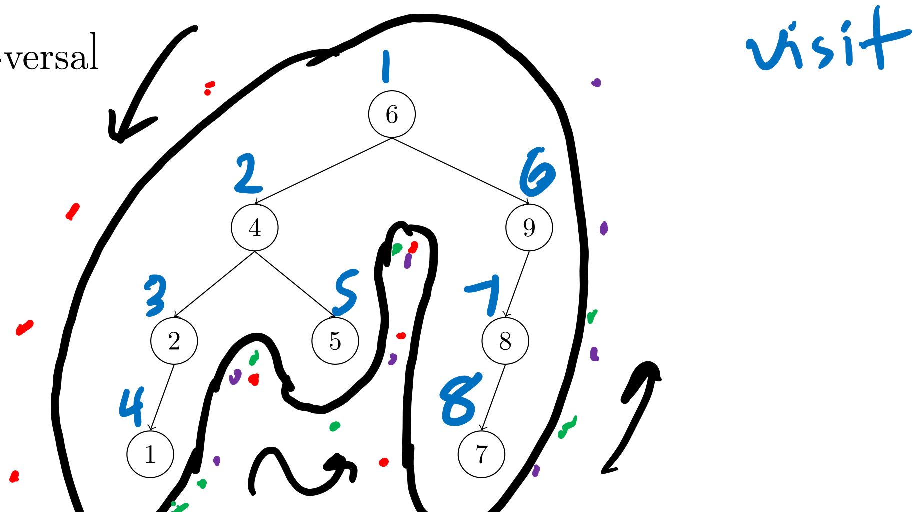
CS 61BL Summer 2021 — Trees and Tree Traversals

Recurring Section 7: Tuesday July 20, 2021

1 Tree-versal



a) What is the pre-order traversal of the tree?

6 4 2 1 5 9 8 7

b) What is the post-order traversal of the tree?

1 2 5 4 7 8 9 6

c) What is the in-order traversal of the tree?

1 2 4 5 6 7 8 9

d) What is the level-order traversal of the tree?

6 4 9 2 5 8 1 7

2 Runtime Questions

Provide the best case and worst case runtimes in theta notation in terms of N, and a brief justification for the following operations on a binary search tree. Assume N to be the number of nodes in the tree. Additionally, each node correctly maintains the size of the subtree rooted at it. [Taken from Final Summer 2016]

```
boolean contains(T o); // Returns true if the object is in the tree
```

Best: Θ(1) Justification: Object is at root

Worst: Θ(N) Justification: Object is at the end of a spindly tree

```
void insert(T o); // Inserts the given object.
```

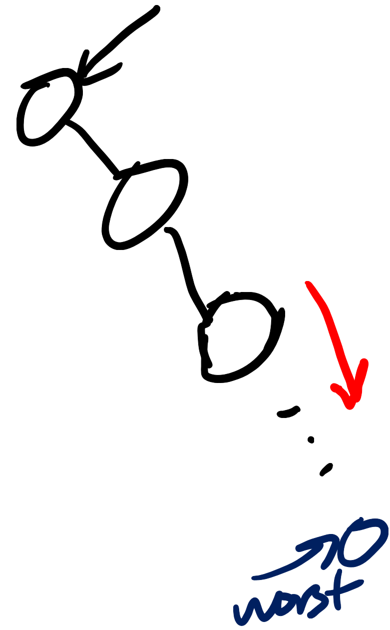
Best: Θ(1) Justification: Left of root in a right spindly tree

Worst: Θ(N) Justification: Right of last node in a right spindly tree

```
T getElement(int i); // Returns the ith smallest object in the tree.
```

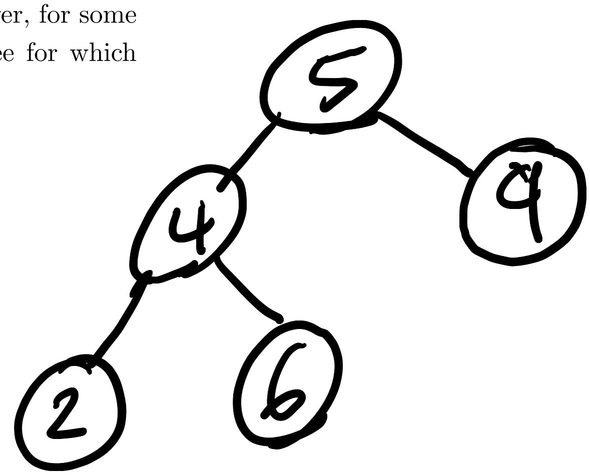
Best: Θ(1) Justification: I = 1, tree is right spindly tree

Worst: Θ(N) Justification: I = n, tree is right spindly tree



3 Is This a BST?

The following code should check if a given binary tree is a BST. However, for some trees, it returns the wrong answer. Give an example of a binary tree for which `brokenIsBST` fails.



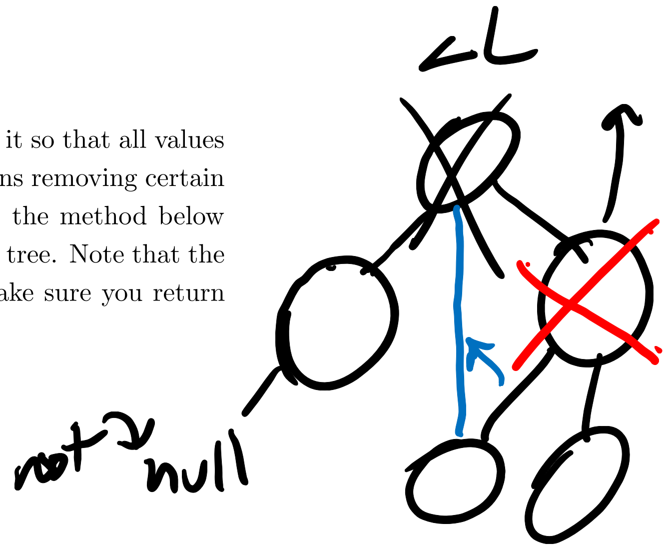

```
public static boolean brokenIsBST(TreeNode T) {
    if (T == null) {
        return true;
    } else if (T.left != null && T.left.val > T.val) {
        return false;
    } else if (T.right != null && T.right.val < T.val) {
        return false;
    } else {
        return brokenIsBST(T.left) && brokenIsBST(T.right);
    }
}
```

Now, write `isBST` that fixes the error encountered in part (a).
Hint: You will find `Integer.MIN_VALUE` and `Integer.MAX_VALUE` helpful.

```
public static boolean isBST(TreeNode T) {
    return isBSTHelper(                                             );
}

public static boolean isBSTHelper(                                   ) {











}
```

4 Pruning Trees

Assume we have some binary search tree, and we want to prune it so that all values in the tree are between L and R, inclusive. Pruning simply means removing certain items and adjusting the tree so that it is still a BST. Fill out the method below that takes in a BST, as well as L and R, and returns the pruned tree. Note that the root of the original tree might not be between L and R, so make sure you return the root of the new pruned tree.



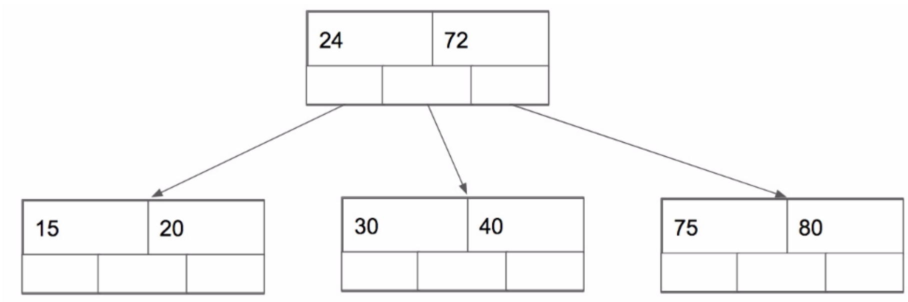

```
class BST {
    int label;
    BST left; // null if no left child
    BST right; // null if no right child
}

public BST pruneBST(BST root, int L, int R) {
    if (root == null) {
        return null;
    } else if (root.label < L) {
        return pruneBST(root.right, L, R);
    } else if (root.label > R) {
        return pruneBST(root.left, L, R);
    }
    root.left = pruneBST(root.left, L, R);
    root.right = pruneBST(root.right, L, R);
    return root;
}
```

5 BTree Motivation

1. Why does a binary search tree have a worst case runtime of $\theta(n)$ for `contains`?

2. Give a sequence of operations, such that if they were inserted in the order they appear, would result in a "poor" binary search tree.

3. Examine this B-tree with order 3. Mark the paths taken when the user calls `contains(40)`.



4. Now call `insert(35)`, and draw the resulting tree.

5. What property of a B-tree rectifies problems of binary search trees, such as the one in 1.1? Why would you not use a B-tree?