701. Insert into a Binary Search Tree

Binary Tree

Problem Description

Medium

In this problem, we are dealing with the operation of inserting a new node into a binary search tree (BST). A BST is a special kind of binary tree where the value of each node must be greater than all values stored in its left subtree and less than the values stored in its right subtree.

You are provided with two pieces of information:

1. The root node of the BST, which is the starting point from which we can traverse the entire tree. 2. A value that you need to insert into the BST.

Binary Search Tree

- The task is to insert the value into the BST by finding the correct position without violating the BST properties. After the

insertion, the function must return the root node of the modified BST.

It is important to note that since the value does not already exist in the BST, there won't be any duplicate values after insertion. Additionally, there can be several valid insertion points that could maintain the BST properties. The function can return any valid

final BST. Intuition

The solution approach uses Depth-First Search (DFS), which is an algorithm for traversing or searching tree or graph data

structures. The DFS approach is recursive, as it applies the same logic at each node starting from the root. Here's how we arrive at the solution approach:

1. Begin at the root and compare the value with the root.val. 2. If the value is greater than root val, the value must be inserted somewhere in the right subtree of the current node because of the BST property (all right subtree values should be greater). Thus, we perform DFS on the right child of the current node.

3. If the value is less than root val, the value must be inserted in the left subtree. We then perform DFS on the left child of the current node.

4. If at any point, we find that the current node (root) is None, it means we have reached an external point in the BST where the new node can be

1. The dfs function takes the current root node as its argument.

- attached. So, we create a new node with the value and return it. 5. As the recursion unwinds, each call updates its left or right child pointer to the newly created node if a new node was created below it.
- The recursive nature of this approach handles all possible cases for insertion and ensures the maintenance of the BST properties post-insertion.

6. When the top of the recursion stack is reached (the original root), the entire BST with the new value inserted is returned.

Solution Approach

The given problem is addressed by implementing a recursive function to perform a depth-first search (DFS) on the tree. Here is a step-by-step walk-through of dfs function implementation, considering the Reference Solution Approach provided:

o If val is greater than root. val, we recursively call dfs on the right child of the current node and update root. right with the result of that

5. Once the base case is reached and the new node is created, the recursion begins to unwind. Every recursive call returns the current state of the

2. If the current root node is None, it implies that the value should be inserted at this point. Therefore, a new TreeNode with the insert val is

returned. 3. If the current root node is not None, we compare the insert val with the current node's value (root val) to decide the direction of traversal:

subtree are larger.

Example Walkthrough

value 5.

maintaining the BST properties.

BST at every step of the recursion.

to insert the value 4 into this tree:

the left subtree of this node.

new node with value 4.

following BST:

Solution Implementation

if node is None:

return node

// Class for the binary tree node structure

// Constructor to create a node without children

return TreeNode(value)

call. o If val is less than root.val, we recursively call dfs on the left child of the current node and update root.left with the result of that call. 4. Each recursive call to dfs follows the same logic until a position to insert the new value is found (when root is None).

- root node, either unchanged (if no insertion happened in the respective subtree) or updated (if the new node was appended to the subtree). 6. Eventually, the function unwinds to the first recursive call, which returns the modified root of the entire tree with the new value inserted while
- Algorithms and data structures utilized in this approach: • Recursion: A function that calls itself, simplifying complex problems by breaking them down into self-similar sub-problems.
- DFS: A traversal algorithm that starts at the root node and explores as far as possible along each branch before backtracking. The recursive implementation efficiently uses the natural structure of a BST to locate the proper insertion point, ensuring a valid

• Binary Search Tree (BST): A binary tree with the property that for any given node, values in its left subtree are smaller, and values in its right

Let's walk through an example to illustrate the solution approach. Suppose we have the following binary search tree and we want

We then update the left child of node 5 to point to this new node.

If we've reached a null node, insert the new value here

Value is smaller or equal, go to the left subtree

node.left = insert_helper(node.left)

Return the node with its updated children

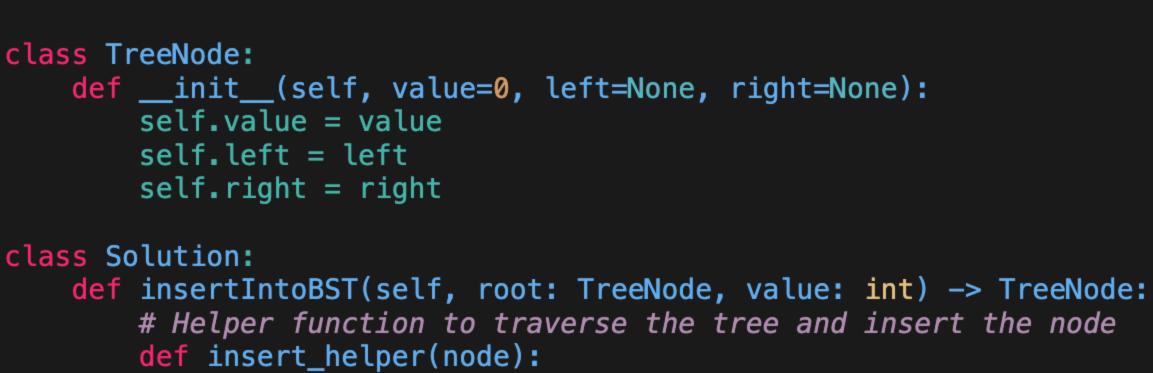
And, here are the steps we would take following the solution approach: Since the root value (3) is less than our value (4), we look to the right subtree of the root. The root has a right child with the

Now considering node with value 5 as the new root, we compare our value (4) to 5. Since 4 is less than 5, we need to explore

The left child of node 5 is None, which means this is the position where we should insert our new value (4). So, we create a

As the recursion unwinds, we return to the original root, but now its right subtree includes our new value, resulting in the

Through this recursive DFS approach, we have inserted the value 4 into the BST while maintaining the BST properties. The resulting tree is a valid binary search tree with the new node correctly placed.



Python

Decide to proceed left or right depending on the value if node.value < value:</pre> # Value is greater, go to the right subtree node.right = insert_helper(node.right) else:

```
# Call helper function to start insertion from root
       return insert_helper(root)
Java
```

};

public:

/**

class Solution {

if (!root) {

else {

value: number;

value: value,

if (root === null) {

// Return the unchanged root node.

def insert_helper(node):

if node is None:

return TreeNode(value)

return {

};

/**

leftChild: TreeNode | null;

leftChild: leftChild,

rightChild: rightChild

rightChild: TreeNode | null;

class TreeNode {

int value;

TreeNode left;

TreeNode right;

TreeNode(int value) {

this.value = value;

```
// Constructor to create a node with specified left and right children
    TreeNode(int value, TreeNode left, TreeNode right) {
        this.value = value;
        this.left = left;
        this.right = right;
class Solution {
    // Inserts a value into a Binary Search Tree (BST) and returns the updated tree root.
    public TreeNode insertIntoBST(TreeNode root, int value) {
       // If the current node is null, we've found the position for the new value.
        if (root == null) {
            return new TreeNode(value);
       // If the value is greater than the current node's value, insert into the right subtree.
        if (root.value < value) {</pre>
            root.right = insertIntoBST(root.right, value);
       // If the value is less than or equal to the current node's value, insert into the left subtree.
       else {
            root.left = insertIntoBST(root.left, value);
        // Return the node itself after performing the insertion to maintain tree connections.
        return root;
C++
/**
* Definition for a binary tree node.
struct TreeNode {
    int value;
    TreeNode *leftChild;
    TreeNode *rightChild;
```

```
// Return the unchanged root pointer.
       return root;
};
TypeScript
// Node structure for the binary search tree.
interface TreeNode {
```

// Constructor with no arguments initializes node with value 0 and null children.

// Constructor with value argument sets the node value and initializes children to null.

* Inserts a value into a binary search tree (BST) and returns the root node of the BST.

* @param root Pointer to the root node of the tree where value is to be inserted.

TreeNode(int x, TreeNode *left, TreeNode *right) : value(x), leftChild(left), rightChild(right) {}

// If root is null, the new value should be placed here, so create and return a new node.

// If the value to insert is greater than the root's value, insert into the right subtree.

// Function to create a new tree node with a value, and with left and right children initialized to null.

function createTreeNode(value: number, leftChild: TreeNode | null = null, rightChild: TreeNode | null = null): TreeNode {

} else { // If the value is less than or equal to the root's value, recursively insert into the left subtree.

// Otherwise, the value is less than or equal to the root's value, insert into the left subtree.

// Constructor with value and children arguments initializes node with given values.

TreeNode() : value(0), leftChild(nullptr), rightChild(nullptr) {}

* @param val The value to be inserted into the BST.

TreeNode* insertIntoBST(TreeNode* root, int val) {

return new TreeNode(val);

if (root->value < val) {</pre>

TreeNode(int x) : value(x), leftChild(nullptr), rightChild(nullptr) {}

* @return Returns the root of the BST after insertion of the value.

root->rightChild = insertIntoBST(root->rightChild, val);

root->leftChild = insertIntoBST(root->leftChild, val);

```
return createTreeNode(value);
// If the value to insert is greater than the root's value, recursively insert into the right subtree.
if (value > root.value) {
  root.rightChild = insertIntoBST(root.rightChild, value);
```

class Solution:

```
return root;
class TreeNode:
   def ___init__(self, value=0, left=None, right=None):
        self.value = value
        self.left = left
        self.right = right
```

* Inserts a value into a binary search tree (BST) and returns the root node of the BST.

// If the root is null, create a new node with the value to be inserted and return it.

* @param root - The root node of the tree where the value is to be inserted.

function insertIntoBST(root: TreeNode | null, value: number): TreeNode | null {

* @param value - The value to be inserted into the BST.

* @return The root of the BST after the insertion of the value.

root.leftChild = insertIntoBST(root.leftChild, value);

```
# Decide to proceed left or right depending on the value
           if node.value < value:</pre>
               # Value is greater, go to the right subtree
               node.right = insert helper(node.right)
           else:
               # Value is smaller or equal, go to the left subtree
               node.left = insert_helper(node.left)
           # Return the node with its updated children
           return node
       # Call helper function to start insertion from root
       return insert_helper(root)
Time and Space Complexity
```

def insertIntoBST(self, root: TreeNode, value: int) -> TreeNode:

Helper function to traverse the tree and insert the node

If we've reached a null node, insert the new value here

Time Complexity

The time complexity of this code is O(H), where H is the height of the binary search tree (BST). This is because in the worst-case scenario, you may need to traverse from the root to the leaf node to find the correct spot for insertion, which takes a time proportional to the height of the tree.

Space Complexity

The space complexity is also O(H) because the code uses recursive calls to insert the new node. The maximum depth of the recursive call stack would also be the height of the tree in the worst-case scenario, which makes the space complexity proportional to the height of the tree. For a balanced BST, this would be O(log N), where N is the number of nodes in the BST. However, for a skewed BST (resembling a linked list), this would be O(N).