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Binary Tree to Binary Search Tree Conversion

Difficulty Level : Medium • Last Updated : 24 May, 2021

Given a Binary Tree, convert it to a Binary Search Tree. The conversion must be done in such a way that keeps the original structure of Binary Tree.

Examples

Example 1

Input:

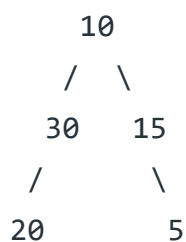


Output:



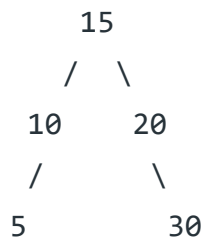
Example 2

Input:



Output:





Solution

Following is a 3 step solution for converting Binary tree to Binary Search Tree.

1) Create a temp array `arr[]` that stores inorder traversal of the tree. This step takes $O(n)$ time.

2) Sort the temp array `arr[]`. Time complexity of this step depends upon the sorting algorithm. In the following implementation, Quick Sort is used which takes (n^2) time. This can be done in $O(n \log n)$ time using Heap Sort or Merge Sort.

3) Again do inorder traversal of tree and copy array elements to tree nodes one by one. This step takes $O(n)$ time.

Following is C implementation of the above approach. The main function to convert is highlighted in the following code.

C



```

/* A program to convert Binary Tree to Binary Search Tree */
#include <stdio.h>
#include <stdlib.h>

/* A binary tree node structure */

```

```
struct node {
    int data;
    struct node* left;
    struct node* right;
};

/* A helper function that stores inorder traversal of a tree rooted
with node */
void storeInorder(struct node* node, int inorder[], int* index_ptr)
{
    // Base Case
    if (node == NULL)
        return;

    /* first store the left subtree */
    storeInorder(node->left, inorder, index_ptr);

    /* Copy the root's data */
    inorder[*index_ptr] = node->data;
    (*index_ptr)++; // increase index for next entry

    /* finally store the right subtree */
    storeInorder(node->right, inorder, index_ptr);
}

/* A helper function to count nodes in a Binary Tree */
int countNodes(struct node* root)
{
    if (root == NULL)
        return 0;
    return countNodes(root->left) + countNodes(root->right) + 1;
}

// Following function is needed for library function qsort()
int compare(const void* a, const void* b)
{
    return (*(int*)a - *(int*)b);
}

/* A helper function that copies contents of arr[] to Binary Tree.
This function basically does Inorder traversal of Binary Tree and
one by one copy arr[] elements to Binary Tree nodes */
void arrayToBST(int* arr, struct node* root, int* index_ptr)
{
    // Base Case
    if (root == NULL)
        return;

    /* first update the left subtree */
    arrayToBST(arr, root->left, index_ptr);

    /* Now update root's data and increment index */
```



```
root->data = arr[*index_ptr];
(*index_ptr)++;

/* finally update the right subtree */
arrayToBST(arr, root->right, index_ptr);
}

// This function converts a given Binary Tree to BST
void binaryTreeToBST(struct node* root)
{
    // base case: tree is empty
    if (root == NULL)
        return;

    /* Count the number of nodes in Binary Tree so that
    we know the size of temporary array to be created */
    int n = countNodes(root);

    // Create a temp array arr[] and store inorder traversal of tree in arr[]
    int* arr = new int[n];
    int i = 0;
    storeInorder(root, arr, &i);

    // Sort the array using library function for quick sort
    qsort(arr, n, sizeof(arr[0]), compare);

    // Copy array elements back to Binary Tree
    i = 0;
    arrayToBST(arr, root, &i);

    // delete dynamically allocated memory to avoid memory leak
    delete[] arr;
}

/* Utility function to create a new Binary Tree node */
struct node* newNode(int data)
{
    struct node* temp = new struct node;
    temp->data = data;
    temp->left = NULL;
    temp->right = NULL;
    return temp;
}

/* Utility function to print inorder traversal of Binary Tree */
void printInorder(struct node* node)
{
    if (node == NULL)
        return;

    /* first recur on left child */
    printInorder(node->left);
```



```

    /* then print the data of node */
    printf("%d ", node->data);

    /* now recur on right child */
    printInorder(node->right);
}

/* Driver function to test above functions */
int main()
{
    struct node* root = NULL;

    /* Constructing tree given in the above figure
        10
       / \
      30 15
     /   \
    20    5 */
    root = newNode(10);
    root->left = newNode(30);
    root->right = newNode(15);
    root->left->left = newNode(20);
    root->right->right = newNode(5);

    // convert Binary Tree to BST
    binaryTreeToBST(root);

    printf("Following is Inorder Traversal of the converted BST: \n");
    printInorder(root);

    return 0;
}

```

Java

```

/* A program to convert Binary Tree to Binary Search Tree */
import java.util.*;

public class GFG{

    /* A binary tree node structure */
    static class Node {
        int data;
        Node left;
        Node right;
    };

    // index pointer to pointer to the array index
    static int index;

```

/* A helper function that stores inorder traversal of a tree rooted with node */

```
static void storeInorder(Node node, int inorder[])
{
    // Base Case
    if (node == null)
        return;

    /* first store the left subtree */
    storeInorder(node.left, inorder);

    /* Copy the root's data */
    inorder[index] = node.data;
    index++; // increase index for next entry

    /* finally store the right subtree */
    storeInorder(node.right, inorder);
}
```

/* A helper function to count nodes in a Binary Tree */

```
static int countNodes(Node root)
{
    if (root == null)
        return 0;
    return countNodes(root.left) + countNodes(root.right) + 1;
}
```

/* A helper function that copies contents of arr[] to Binary Tree. This function basically does Inorder traversal of Binary Tree and one by one copy arr[] elements to Binary Tree nodes */

```
static void arrayToBST(int[] arr, Node root)
{
    // Base Case
    if (root == null)
        return;

    /* first update the left subtree */
    arrayToBST(arr, root.left);

    /* Now update root's data and increment index */
    root.data = arr[index];
    index++;

    /* finally update the right subtree */
    arrayToBST(arr, root.right);
}
```

/* This function converts a given Binary Tree to BST

```
static void binaryTreeToBST(Node root)
{

```



```
// base case: tree is empty
if (root == null)
    return;

/* Count the number of nodes in Binary Tree so that
we know the size of temporary array to be created */
int n = countNodes(root);

// Create a temp array arr[] and store inorder traversal of tree in arr[]
int arr[] = new int[n];

storeInorder(root, arr);

// Sort the array using library function for quick sort
Arrays.sort(arr);

// Copy array elements back to Binary Tree
index = 0;
arrayToBST(arr, root);
}

/* Utility function to create a new Binary Tree node */
static Node newNode(int data)
{
    Node temp = new Node();
    temp.data = data;
    temp.left = null;
    temp.right = null;
    return temp;
}

/* Utility function to print inorder traversal of Binary Tree */
static void printInorder(Node node)
{
    if (node == null)
        return;

    /* first recur on left child */
    printInorder(node.left);

    /* then print the data of node */
    System.out.print(node.data + " ");

    /* now recur on right child */
    printInorder(node.right);
}

/* Driver function to test above functions */
public static void main(String args[])
{
    Node root = null;
```



```

/* Constructing tree given in the above figure
    10
   / \
  30 15
 /    \
20     5 */
root = newNode(10);
root.left = newNode(30);
root.right = newNode(15);
root.left.left = newNode(20);
root.right.right = newNode(5);

// convert Binary Tree to BST
binaryTreeToBST(root);

System.out.println("Following is Inorder Traversal of the converted BST: ");
printInorder(root);

}
}

// This code is contributed by adityapande88.

```

Python

```

# Program to convert binary tree to BST

# A binary tree node
class Node:

    # Constructor to create a new node
    def __init__(self, data):
        self.data = data
        self.left = None
        self.right = None

# Helper function to store the inorder traversal of a tree
def storeInorder(root, inorder):

    # Base Case
    if root is None:
        return

    # First store the left subtree
    storeInorder(root.left, inorder)

    # Copy the root's data
    inorder.append(root.data)

```



```
# Finally store the right subtree
storeInorder(root.right, inorder)

# A helper function to count nodes in a binary tree
def countNodes(root):
    if root is None:
        return 0

    return countNodes(root.left) + countNodes(root.right) + 1

# Helper function that copies contents of sorted array
# to Binary tree
def arrayToBST(arr, root):

    # Base Case
    if root is None:
        return

    # First update the left subtree
    arrayToBST(arr, root.left)

    # now update root's data delete the value from array
    root.data = arr[0]
    arr.pop(0)

    # Finally update the right subtree
    arrayToBST(arr, root.right)

# This function converts a given binary tree to BST
def binaryTreeToBST(root):

    # Base Case: Tree is empty
    if root is None:
        return

    # Count the number of nodes in Binary Tree so that
    # we know the size of temporary array to be created
    n = countNodes(root)

    # Create the temp array and store the inorder traversal
    # of tree
    arr = []
    storeInorder(root, arr)

    # Sort the array
    arr.sort()

    # copy array elements back to binary tree
    arrayToBST(arr, root)

# Print the inorder traversal of the tree
```



```
def printInorder(root):
    if root is None:
        return
    printInorder(root.left)
    print root.data,
    printInorder(root.right)

# Driver program to test above function
root = Node(10)
root.left = Node(30)
root.right = Node(15)
root.left.left = Node(20)
root.right.right = Node(5)

# Convert binary tree to BST
binaryTreeToBST(root)

print "Following is the inorder traversal of the converted BST"
printInorder(root)

# This code is contributed by Nikhil Kumar Singh(nickzuck_007)
```

Output

Following is the inorder traversal of the converted BST
5 10 15 20 30

Complexity Analysis:

- **Time Complexity:** $O(n \log n)$. This is the complexity of the sorting algorithm which we are using after first in-order traversal, rest of the operations take place in linear time.
- **Auxiliary Space:** $O(n)$. Use of data structure 'array' to store in-order traversal.

We will be covering another method for this problem which converts the tree using $O(\text{height of the tree})$ extra space.

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