Clone a Binary Tree with Random Pointers

Given a Binary Tree where every node has following structure.

```
struct node {
    int key;
    struct node *left,*right,*random;
}
```

The random pointer points to any random node of the binary tree and can even point to NULL, clone the given binary tree.

We strongly recommend that you click here and practice it, before moving on to the solution.

Method 1 (Use Hashing)
The idea is to store mapping from given tree nodes to clone tre node in hashtable. Following are detailed steps.

1) Recursively traverse the given Binary and copy key value, left pointer and right pointer to clone tree. While copying, store the mapping from given tree node to clone tree node in a hashtable. In the following pseudo code, 'cloneNode' is currently visited node of clone tree and 'treeNode' is currently visited node of given tree.

```
   cloneNode->key  = treeNode->key
   cloneNode->left = treeNode->left
   cloneNode->right = treeNode->right
   map[treeNode] = cloneNode
```

2) Recursively traverse both trees and set random pointers using entries from hash table.

```
   cloneNode->random = map[treeNode->random]
```

Following is C++ implementation of above idea. The following implementation uses map from C++ STL. Note that map doesn't implement hash table, it actually is based on self-balancing binary search tree.

```
// A hashmap based C++ program to clone a binary tree with random pointers
#include<iostream>
#include<map>
using namespace std;

/* A binary tree node has data, pointer to left child, a pointer to right
   child and a pointer to random node*/
struct Node
{
    int key;
    struct Node* left, *right, *random;
};

/* Helper function that allocates a new Node with the
   given data and NULL left, right and random pointers. */
Node* newNode(int key)
{
    Node* temp = new Node;
    temp->key = key;
    temp->random = temp->right = temp->left = NULL;
    return (temp);
}

/* Given a binary tree, print its Nodes in inorder*/
void printInorder(Node* node)
{
    if (node == NULL)
        return;

    /* First recur on left sutree */
    printInorder(node->left);

    /* then print data of Node and its random */
    cout << "[" << node->key << " ";
    if (node->random == NULL)
        cout << "NULL], ";
    else
        cout << node->random->key << "], ";

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

// This function creates clone by copying key and left and right pointers
// This function also stores mapping from given tree node to clone.
Node* copyLeftRightNode(Node* treeNode, map<Node *, Node *> *mymap)
{
    if (treeNode == NULL)
        return NULL;
    Node* cloneNode = newNode(treeNode->key);
    (*mymap)[treeNode] = cloneNode;
    cloneNode->left  = copyLeftRightNode(treeNode->left, mymap);
    cloneNode->right = copyLeftRightNode(treeNode->right, mymap);
    return cloneNode;
}

// This function copies random node by using the hashmap built by
// copyLeftRightNode()
void copyRandom(Node* treeNode,  Node* cloneNode, map<Node *, Node *> *mymap)
{
    if (cloneNode == NULL)
        return;
    cloneNode->random =  (*mymap)[treeNode->random];
    copyRandom(treeNode->left, cloneNode->left, mymap);
    copyRandom(treeNode->right, cloneNode->right, mymap);
}

// This function makes the clone of given tree. It mainly uses
// copyLeftRightNode() and copyRandom()
Node* cloneTree(Node* tree)
{
    if (tree == NULL)
        return NULL;
    map<Node *, Node *> *mymap = new  map<Node *, Node *>;
    Node* newTree = copyLeftRightNode(tree, mymap);
    copyRandom(tree, newTree, mymap);
    return newTree;
}

/* Driver program to test above functions*/
int main()
{
    //Test No 1
    Node *tree = newNode(1);
    tree->left = newNode(2);
    tree->right = newNode(3);
    tree->left->left = newNode(4);
    tree->left->right = newNode(5);
    tree->random = tree->left->right;
    tree->left->left->random = tree;
    tree->left->right->random = tree->right;

    //  Test No 2
    //    tree = NULL;

    //  Test No 3
    //    tree = newNode(1);

    //  Test No 4
    /*    tree = newNode(1);
        tree->left = newNode(2);
        tree->right = newNode(3);
        tree->random = tree->right;
        tree->left->random = tree;
    */

    cout << "Inorder traversal of original binary tree is: \n";
    printInorder(tree);

    Node *clone = cloneTree(tree);

    cout << "\n\nInorder traversal of cloned binary tree is: \n";
    printInorder(clone);

    return 0;
}
```

Run on IDE

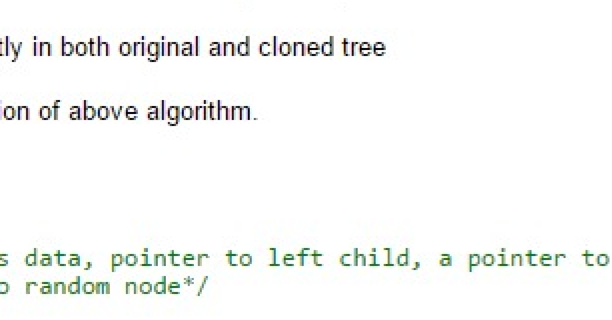
Output:

```
Inorder traversal of original binary tree is:
[4 1], [2 NULL], [5 3], [1 5], [3 NULL],

Inorder traversal of cloned binary tree is:
[4 1], [2 NULL], [5 3], [1 5], [3 NULL],
```

Method 2 (Temporarily Modify the Given Binary Tree)

1. Create new nodes in cloned tree and insert each new node in original tree between the left pointer edge of corresponding node in the original tree (See the below image).
i.e. if current node is A and it's left child is B (A — >> B), then new cloned node with key A wil be created (say cA) and it will be put as A — >> cA — >> B (B can be a NULL or a non-NULL left child). Right child pointer will be set correctly i.e. if for current node A, right child is C in original tree (A — >> C) then corresponding cloned nodes cA and cC will like cA —- >> cC



2. Set random pointer in cloned tree as per original tree
i.e. if node A's random pointer points to node B, then in cloned tree, cA will point to cB (cA and cB are new node in cloned tree corresponding to node A and B in original tree)

3. Restore left pointers correctly in both original and cloned tree

Following is C++ implementation of above algorithm.

```
#include <iostream>
using namespace std;

/* A binary tree node has data, pointer to left child, a pointer to right
   child and a pointer to random node*/
struct Node
{
    int key;
    struct Node* left, *right, *random;
};

/* Helper function that allocates a new Node with the
   given data and NULL left, right and random pointers. */
Node* newNode(int key)
{
    Node* temp = new Node;
    temp->key = key;
    temp->random = temp->right = temp->left = NULL;
    return (temp);
}

/* Given a binary tree, print its Nodes in inorder*/
void printInorder(Node* node)
{
    if (node == NULL)
        return;

    /* First recur on left sutree */
    printInorder(node->left);

    /* then print data of Node and its random */
    cout << "[" << node->key << " ";
    if (node->random == NULL)
        cout << "NULL], ";
    else
        cout << node->random->key << "], ";

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

// This function creates new nodes cloned tree and puts new cloned node
// in between current node and it's left child
// i.e. if current node is A and it's left child is B ( A --- >> B ),
//      then new cloned node with key A wil be created (say cA) and
//      it will be put as
//      A --- >> cA --- >> B
// Here B can be a NULL or a non-NULL left child
// Right child pointer will be set correctly
// i.e. if for current node A, right child is C in original tree
// (A --- >> C) then corresponding cloned nodes cA and cC will like
// cA ---- >> cC
Node* copyLeftRightNode(Node* treeNode)
{
    if (treeNode == NULL)
        return NULL;

    Node* left = treeNode->left;
    treeNode->left = newNode(treeNode->key);
    treeNode->left->left = left;
    if(left != NULL)
        left->left = copyLeftRightNode(left);

    treeNode->left->right = copyLeftRightNode(treeNode->right);
    return treeNode->left;
}

// This function sets random pointer in cloned tree as per original tree
// i.e. if node A's random pointer points to node B, then
// in cloned tree, cA wil point to cB (cA and cB are new node in cloned
// tree corresponding to node A and B in original tree)
void copyRandomNode(Node* treeNode, Node* cloneNode)
{
    if (treeNode == NULL)
        return;
    if(treeNode->random != NULL)
        cloneNode->random = treeNode->random->left;
    else
        cloneNode->random = NULL;

    if(treeNode->left != NULL && cloneNode->left != NULL)
        copyRandomNode(treeNode->left->left, cloneNode->left->left);
    copyRandomNode(treeNode->right, cloneNode->right);
}

// This function will restore left pointers correctly in
// both original and cloned tree
void restoreTreeLeftNode(Node* treeNode, Node* cloneNode)
{
    if (treeNode == NULL)
        return;
    if (cloneNode->left != NULL)
    {
        Node* cloneLeft = cloneNode->left->left;
        treeNode->left = treeNode->left->left;
        cloneNode->left = cloneLeft;
    }
    else
        treeNode->left = NULL;

    restoreTreeLeftNode(treeNode->left, cloneNode->left);
    restoreTreeLeftNode(treeNode->right, cloneNode->right);
}

//This function makes the clone of given tree
Node* cloneTree(Node* treeNode)
{
    if (treeNode == NULL)
        return NULL;
    Node* cloneNode = copyLeftRightNode(treeNode);
    copyRandomNode(treeNode, cloneNode);
    restoreTreeLeftNode(treeNode, cloneNode);
    return cloneNode;
}


/* Driver program to test above functions*/
int main()
{
/*  //Test No 1
    Node *tree = newNode(1);
    tree->left = newNode(2);
    tree->right = newNode(3);
    tree->left->left = newNode(4);
    tree->left->right = newNode(5);
    tree->random = tree->left->right;
    tree->left->left->random = tree;
    tree->left->right->random = tree->right;

//  Test No 2
//  Node *tree = NULL;
/*
//  Test No 3
    Node *tree = newNode(1);

//  Test No 4
    Node *tree = newNode(1);
    tree->left = newNode(2);
    tree->right = newNode(3);
    tree->random = tree->right;
    tree->left->random = tree;

  Test No 5
    Node *tree = newNode(1);
    tree->left = newNode(2);
    tree->right = newNode(3);
    tree->left->left = newNode(4);
    tree->left->right = newNode(5);
    tree->right->left = newNode(6);
    tree->right->right = newNode(7);
    tree->random = tree->left;
*/
//  Test No 6
    Node *tree = newNode(10);
    Node *n2 = newNode(6);
    Node *n3 = newNode(12);
    Node *n4 = newNode(5);
    Node *n5 = newNode(8);
    Node *n6 = newNode(11);
    Node *n7 = newNode(13);
    Node *n8 = newNode(7);
    Node *n9 = newNode(9);
    tree->left = n2;
    tree->right = n3;
    tree->random = n2;
    n2->left = n4;
    n2->right = n5;
    n2->random = n8;
    n3->left = n6;
    n3->right = n7;
    n3->random = n5;
    n4->random = n9;
    n5->left = n8;
    n5->right = n9;
    n5->random = tree;
    n6->random = n9;
    n9->random = n8;

/*  Test No 7
    Node *tree = newNode(1);
    tree->left = newNode(2);
    tree->right = newNode(3);
    tree->left->random = tree;
    tree->right->random = tree->left;
*/
    cout << "Inorder traversal of original binary tree is: \n";
    printInorder(tree);

    Node *clone = cloneTree(tree);

    cout << "\n\nInorder traversal of cloned binary tree is: \n";
    printInorder(clone);

    return 0;
}
```

Run on IDE

Output:

```
Inorder traversal of original binary tree is:
[5 9], [6 7], [7 NULL], [8 10], [9 7], [10 6], [11 9], [12 8], [13 NULL],

Inorder traversal of cloned binary tree is:
[5 9], [6 7], [7 NULL], [8 10], [9 7], [10 6], [11 9], [12 8], [13 NULL],
```