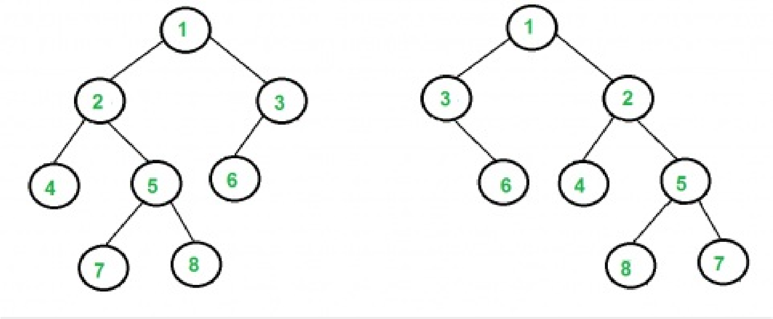
Tree Isomorphism Problem

Write a function to detect if two trees are isomorphic. Two trees are called isomorphic if one of them can be obtained from other by a series of flips, i.e. by swapping left and right children of a number of nodes. Any number of nodes at any level can have their children swapped. Two empty trees are isomorphic.

For example, following two trees are isomorphic with following sub-trees flipped: 2 and 3, NULL and 6, 7 and 8.



We simultaneously traverse both trees. Let the current internal nodes of two trees being traversed be **n1** and **n2** respectively. There are following two conditions for subtrees rooted with n1 and n2 to be isomorphic.
1) Data of n1 and n2 is same.
2) One of the following two is true for children of n1 and n2
……**a)** Left child of n1 is isomorphic to left child of n2 and right child of n1 is isomorphic to right child of n2.
……**b)** Left child of n1 is isomorphic to right child of n2 and right child of n1 is isomorphic to left child of n2.

C++

```
// A C++ program to check if two given trees are isomorphic
#include <iostream>
using namespace std;

/* A binary tree node has data, pointer to left and right children */
struct node
{
    int data;
    struct node* left;
    struct node* right;
};

/* Given a binary tree, print its nodes in reverse level order */
bool isIsomorphic(node* n1, node *n2)
{
 // Both roots are NULL, trees isomorphic by definition
 if (n1 == NULL && n2 == NULL)
    return true;

 // Exactly one of the n1 and n2 is NULL, trees not isomorphic
 if (n1 == NULL || n2 == NULL)
    return false;

 if (n1->data != n2->data)
    return false;

 // There are two possible cases for n1 and n2 to be isomorphic
 // Case 1: The subtrees rooted at these nodes have NOT been "Flipped".
 // Both of these subtrees have to be isomorphic, hence the &&
 // Case 2: The subtrees rooted at these nodes have been "Flipped"
 return
 (isIsomorphic(n1->left,n2->left) && isIsomorphic(n1->right,n2->right))||
 (isIsomorphic(n1->left,n2->right) && isIsomorphic(n1->right,n2->left));
}
```

```
}

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

    return (temp);
}

/* Driver program to test above functions*/
int main()
{
    // Let us create trees shown in above diagram
    struct node *n1 = newNode(1);
    n1->left        = newNode(2);
    n1->right       = newNode(3);
    n1->left->left  = newNode(4);
    n1->left->right = newNode(5);
    n1->right->left  = newNode(6);
    n1->left->right->left = newNode(7);
    n1->left->right->right = newNode(8);

    struct node *n2 = newNode(1);
    n2->left         = newNode(3);
    n2->right        = newNode(2);
    n2->right->left   = newNode(4);
    n2->right->right   = newNode(5);
    n2->left->right   = newNode(6);
    n2->right->right->left = newNode(8);
    n2->right->right->right = newNode(7);

    if (isIsomorphic(n1, n2) == true)
       cout << "Yes";
    else
      cout << "No";

    return 0;
}
```

Java

```
// An iterative java program to solve tree isomorphism problem

/* A binary tree node has data, pointer to left and right children */
class Node
{
    int data;
    Node left, right;

    Node(int item)
    {
        data = item;
        left = right;
    }
}

class BinaryTree
{
    Node root1, root2;

    /* Given a binary tree, print its nodes in reverse level order */
    boolean isIsomorphic(Node n1, Node n2)
    {
        // Both roots are NULL, trees isomorphic by definition
        if (n1 == null && n2 == null)
            return true;
            return true;

        // Exactly one of the n1 and n2 is NULL, trees not isomorphic
        if (n1 == null || n2 == null)
            return false;

        if (n1.data != n2.data)
            return false;

        // There are two possible cases for n1 and n2 to be isomorphic
        // Case 1: The subtrees rooted at these nodes have NOT been
        // "Flipped".
        // Both of these subtrees have to be isomorphic.
        // Case 2: The subtrees rooted at these nodes have been "Flipped"
        return (isIsomorphic(n1.left, n2.left) &&
                                         isIsomorphic(n1.right, n2.right))
        || (isIsomorphic(n1.left, n2.right) &&
                                         isIsomorphic(n1.right, n2.left));
    }

    // Driver program to test above functions
    public static void main(String args[])
    {
        BinaryTree tree = new BinaryTree();

        // Let us create trees shown in above diagram
        tree.root1 = new Node(1);
        tree.root1.left = new Node(2);
        tree.root1.right = new Node(3);
        tree.root1.left.left = new Node(4);
        tree.root1.left.right = new Node(5);
        tree.root1.right.left = new Node(6);
        tree.root1.left.right.left = new Node(7);
        tree.root1.left.right.right = new Node(8);

        tree.root2 = new Node(1);
        tree.root2.left = new Node(3);
        tree.root2.right = new Node(2);
        tree.root2.right.left = new Node(4);
        tree.root2.right.right = new Node(5);
        tree.root2.left.right = new Node(6);
        tree.root2.right.right.left = new Node(8);
        tree.root2.right.right.right = new Node(7);

        if (tree.isIsomorphic(tree.root1, tree.root2) == true)
            System.out.println("Yes");
        else
            System.out.println("No");
    }
}

// This code has been contributed by Mayank Jaiswal
```

Python

```
# Python program to check if two given trees are isomorphic

# A Binary tree node
class Node:
    # Constructor to create the node of binary tree
    def __init__(self, data):
        self.data = data
        self.left = None
        self.right = None

# Check if the binary tree is isomorphic or not
def isIsomorphic(n1, n2):

    # Both roots are None, trees isomorphic by definition
    if n1 is None and n2 is None:
        return True

    # Exactly one of the n1 and n2 is None, trees are not
    # isomorphic
    if n1 is None or n2 is None:
        return False

    if n1.data != n2.data :
        return False
    # There are two possible cases for n1 and n2 to be isomorphic
    # Case 1: The subtrees rooted at these nodes have NOT
    # been "Flipped".
    # Both of these subtrees have to be isomorphic, hence the &&
    # Case 2: The subtrees rooted at these nodes have
    # been "Flipped"
    return ((isIsomorphic(n1.left, n2.left)and
            isIsomorphic(n1.right, n2.right)) or
            (isIsomorphic(n1.left, n2.right) and
            isIsomorphic(n1.right, n2.left))
            )


# Driver program to test above function
n1 = Node(1)
n1.left = Node(2)
n1.right = Node(3)
n1.left.left = Node(4)
n1.left.right = Node(5)
n1.right.left = Node(6)
n1.left.right.left = Node(7)
n1.left.right.right = Node(8)

n2 = Node(1)
n2.left = Node(3)
n2.right = Node(2)
n2.right.left = Node(4)
n2.right.right = Node(5)
n2.left.right = Node(6)
n2.right.right.left = Node(8)
n2.right.right.right  = Node(7)

print "Yes" if (isIsomorphic(n1, n2) == True) else "No"

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

Output:

```
Yes
```

Time Complexity: The above solution does a traversal of both trees. So time complexity is O(m + n) where m and n are number of nodes in given trees.