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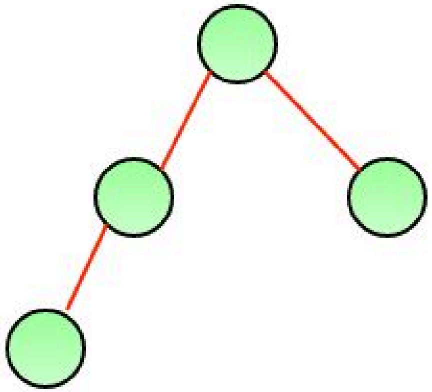
Check for Balanced Binary Tree

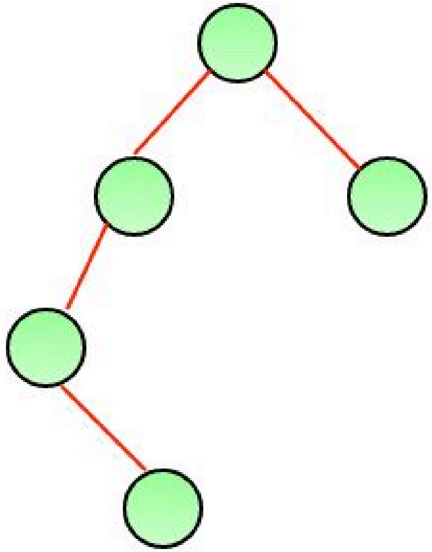
> *A **height balanced binary tree** is a binary tree in which the height of the left subtree and right subtree of any node does not differ by more than 1 and both the left and right subtree are also height balanced.*

In this article, we will look into methods how to determine if given Binary trees are height-balanced

> ***Examples:** The tree on the left is a height balanced binary tree. Whereas the tree on the right is not a height balanced tree. Because the left subtree of the root has a height which is 2 more than the height of the right subtree.*



A height balanced tree



Not a height balanced tree

Naive Approach: To check if a tree is height-balanced:

> *Get the height of left and right subtrees using **dfs** traversal. Return true if the difference between heights is not more than 1 and left and right subtrees are balanced, otherwise return false.*

Below is the implementation of the above approach.

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```
/* Java program to determine if binary tree is
height balanced or not */

/* A binary tree node has data, pointer to left child,
and a pointer to right child */
class Node {
    int data;
    Node left, right;
    Node(int d)
    {
        data = d;
        left = right = null;
    }
}

class BinaryTree {
    Node root;

    /* Returns true if binary tree with root as root is
    * height-balanced */
    boolean isBalanced(Node node)
    {
        int lh; /* for height of left subtree */

        int rh; /* for height of right subtree */

        /* If tree is empty then return true */
        if (node == null)
```

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```
            return true;

        /* Get the height of left and right sub trees */
        lh = height(node.left);
        rh = height(node.right);

        if (Math.abs(lh - rh) <= 1 && isBalanced(node.left)
            && isBalanced(node.right))
            return true;

        /* If we reach here then tree is not height-balanced
        */
        return false;
    }

    /* UTILITY FUNCTIONS TO TEST isBalanced() FUNCTION */
    /* The function Compute the "height" of a tree. Height
    is the number of nodes along the longest path from
    the root node down to the farthest leaf node.*/
    int height(Node node)
    {
        /* base case tree is empty */
        if (node == null)
            return 0;

        /* If tree is not empty then height = 1 + max of
        left height and right heights */
        return 1
            + Math.max(height(node.left),
```

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```
                    height(node.right));
    }

    public static void main(String args[])
    {
        BinaryTree tree = new BinaryTree();
        tree.root = new Node(1);
        tree.root.left = new Node(2);
        tree.root.right = new Node(3);
        tree.root.left.left = new Node(4);
        tree.root.left.right = new Node(5);
        tree.root.left.left.left = new Node(8);

        if (tree.isBalanced(tree.root))
            System.out.println("Tree is balanced");
        else
            System.out.println("Tree is not balanced");
    }
}
```

Output

```
Tree is not balanced
```

Time Complexity: O(n^2) in case of full binary tree.
Auxiliary Space: O(n) space for call stack since using recursion

Efficient implementation: Above implementation can be optimized by

> *Calculating the height in the same recursion rather than calling a height() function separately.*

- For each node make two recursion calls – one for left subtree and the other for the right subtree.
- Based on the heights returned from the recursion calls, decide if the subtree whose root is the current node is height-balanced or not.
- If it is balanced then return the height of that subtree. Otherwise, return **-1** to denote that the subtree is not height-balanced.

Below is the implementation of the above approach.

C++ Java

```
// Java code to implement the approach

import java.io.*;
import java.lang.*;
import java.util.*;

// Class to define the tree node
class Node {
    int key;
    Node left;
    Node right;
    Node(int k)
    {
        key = k;
        left = right = null;
    }
}
```

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```
class GFG {

    // Driver code
    public static void main(String args[])
    {
        Node root = new Node(10);
        root.left = new Node(5);
        root.right = new Node(30);
```

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```
        if (isBalanced(root) > 0)
            System.out.print("Balanced");
        else
            System.out.print("Not Balanced");
    }

    // Function to check if tree is height balanced
    public static int isBalanced(Node root)
    {
        if (root == null)
            return 0;
        int lh = isBalanced(root.left);
        if (lh == -1)
            return -1;
        int rh = isBalanced(root.right);
        if (rh == -1)
            return -1;
```

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```
        if (Math.abs(lh - rh) > 1)
            return -1;
        else
            return Math.max(lh, rh) + 1;
    }
}
```

Output

```
Balanced
```

Time Complexity: O(n)

- Because we are only one dfs call and utilizing the height returned from that to determine the height balance, it is performing the task in linear time.

Auxiliary Space: O(n)

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