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Check whether a given Binary Tree is Complete or not

Given a Binary Tree, write a function to check whether the given Binary Tree is Complete Binary Tree or not.

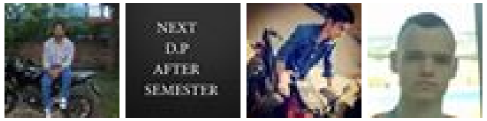
A complete binary tree is a binary tree in which every level, except possibly the last, is completely filled, and all nodes are as far left as possible. See following examples.

```
The following trees are examples of Complete Binary Trees
    1
  /   \
 2     3

       1
    /    \
   2       3
  /
 4


       1
    /    \
   2      3
  /  \    /
 4    5  6
```

```
The following trees are examples of Non-Complete Binary Trees
    1
      \
```



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```
      3

      1
   /    \
  2       3
   \     /  \
    4   5    6

      1
   /    \
  2      3
        /  \
       4    5
```

Source: Write an algorithm to check if a tree is complete binary tree or not

The method 2 of level order traversal post can be easily modified to check whether a tree is Complete or not. To understand the approach, let us first define a term ‘Full Node’. A node is ‘Full Node’ if both left and right children are not empty (or not NULL).
The approach is to do a level order traversal starting from root. In the traversal, once a node is found which is NOT a Full Node, all the following nodes must be leaf nodes.
Also, one more thing needs to be checked to handle the below case: If a node has empty left child, then the right child must be empty.

```
   1
 /   \
2     3
 \
  4
```

Thanks to Guddu Sharma for suggesting this simple and efficient approach.

```
// A program to check if a given binary tree is complete or not
#include <stdio.h>
#include <stdlib.h>
#include <stdbool.h>
#define MAX_Q_SIZE 500
```

Geometric Algorithms

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

/* frunction prototypes for functions needed for Queue data
   structure. A queue is needed for level order tarversal */
struct node** createQueue(int *, int *);
void enQueue(struct node **, int *, struct node *);
struct node *deQueue(struct node **, int *);
bool isQueueEmpty(int *front, int *rear);
```

```
/* Given a binary tree, return true if the tree is complete
   else false */
bool isCompleteBT(struct node* root)
{
  // Base Case: An empty tree is complete Binary Tree
  if (root == NULL)
    return true;

  // Create an empty queue
  int rear, front;
  struct node **queue = createQueue(&front, &rear);

  // Create a flag variable which will be set true
  // when a non full node is seen
  bool flag = false;

  // Do level order traversal using queue.
  enQueue(queue, &rear, root);
  while(!isQueueEmpty(&front, &rear))
  {
    struct node *temp_node = deQueue(queue, &front);

    /* Ceck if left child is present*/
    if(temp_node->left)
    {
       // If we have seen a non full node, and we see a node
       // with non-empty left child, then the given tree is not
       // a complete Binary Tree
       if (flag == true)
         return false;
```

```
       enQueue(queue, &rear, temp_node->left);  // Enqueue Left Child
    }
    else // If this a non-full node, set the flag as true
       flag = true;

    /* Ceck if right child is present*/
    if(temp_node->right)
    {
       // If we have seen a non full node, and we see a node
       // with non-empty left child, then the given tree is not
       // a complete Binary Tree
       if(flag == true)
         return false;

       enQueue(queue, &rear, temp_node->right);  // Enqueue Right Chil
    }
    else // If this a non-full node, set the flag as true
       flag = true;
  }

  // If we reach here, then the tree is complete Bianry Tree
  return true;
}


/*UTILITY FUNCTIONS*/
struct node** createQueue(int *front, int *rear)
{
  struct node **queue =
   (struct node **)malloc(sizeof(struct node*)*MAX_Q_SIZE);

  *front = *rear = 0;
  return queue;
}

void enQueue(struct node **queue, int *rear, struct node *new_node)
{
  queue[*rear] = new_node;
  (*rear)++;
}

struct node *deQueue(struct node **queue, int *front)
{
  (*front)++;
  return queue[*front - 1];
}
```

Recent Comments

affiszerv Your example has two 4s on row 3, that's why it...

Backtracking | Set 7 (Sudoku) · 35 minutes ago

RVM Can someone please elaborate this Qs from above...

Flipkart Interview | Set 6 · 55 minutes ago

Vishal Gupta I talked about as an Interviewer in general,...

Software Engineering Lab, Samsung Interview | Set 2 · 55 minutes ago

@meya Working solution for question 2 of 4f2f round....

Amazon Interview | Set 53 (For SDE-1) · 1 hour ago

sandeep void rearrange(struct node *head) {...

Given a linked list, reverse alternate nodes and append at the end · 2 hours ago

Neha I think that is what it should return as, in...

Find depth of the deepest odd level leaf node · 3 hours ago

```
bool isQueueEmpty(int *front, int *rear)
{
   return (*rear == *front);
}

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

  return(node);
}

/* Driver program to test above functions*/
int main()
{
   /* Let us construct the following Binary Tree which
      is not a complete Binary Tree
            1
          /   \
         2     3
        / \     \
       4   5     6
    */

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

  if ( isCompleteBT(root) == true )
      printf ("Complete Binary Tree");
  else
      printf ("NOT Complete Binary Tree");

  return 0;
}
```

Output:

```
NOT Complete Binary Tree
```

Time Complexity: O(n) where n is the number of nodes in given Binary Tree

Auxiliary Space: O(n) for queue.

Please write comments if you find any of the above codes/algorithms incorrect, or find other ways to solve the same problem.

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Writing code in comment? Please use **ideone.com** and share the link here.

37 Comments GeeksforGeeks

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AlienOnEarth • 18 days ago

@Geeksforgeeks:

Easy and recursive solution.

```
int isNotCompleteBT(struct node *root)

{

if(root == NULL)

return 0;

if((root->left == NULL && root->right != NULL) || isNotCompleteBT(root->left) ||

{
return 1;

}
return 0;
}
```

^ | ˅ • Reply • Share ›

master ➦ AlienOnEarth • 12 days ago

Lets say a tree has a root and 2 child nodes. These 2 child nodes have
But your code will return true.

^ | ⌄ • Reply • Share ›

AlienOnEarth ➦ master • 10 days ago

@master, thank you for the comment. The updated code:

```
bool isCompleteBT(struct node *root)

{

if(root == NULL)

return true;

if(((root->left != NULL && root->right == NULL) && root->left ->l

/*

1

/

2

/
```

see more

^ | ⌄ • Reply • Share ›

ISha • a month ago

Different approach: We count the number of nodes in the tree and then check
they had to be put in an array, where if root has index i then index of its left chil
be 2*i+2.

Code:

```
#include <iostream>

#include <stdlib.h>

using namespace std;

struct btree {

int data;

struct btree *left;

struct btree *right;

};
```

see more

˄ | ˅ • Reply • Share ›

Mohaan Raja • 2 months ago

```
#include <stdio.h>
#include <stdlib.h>

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

/* Helper function that allocates a new node with the
given data and NULL left and right pointers. */
```

```
struct node* newNode(int data)
{
struct node* node = (struct node*)
malloc(sizeof(struct node));
node->data = data;
```

see more

Reply • Share ›

lokesh921 • 4 months ago

Another approach.
Do a reverse in-order traversal. Note the height of the first leaf in this traversal
If ((the height of other leaves is more than the max_height) || (a node has only

else the tree is complete

Reply • Share ›

Vivek • 5 months ago

im

Reply • Share ›

xiaoguangye • 6 months ago

I have one Time O(n), Space O(lgn) solution. Please let me know if it flaws.
A: Get height of tree, can check if (!node->left && node->right) as well.

B: Allocate int * level = malloc(height * sizeof(int)) to count nodes on each leve
Only allow deepest level to have none 2^n number of nodes

C: Use preorder traversal to check the second deepest level nodes. Every one need to be leaf.

If the tree passes above three tests, it is a complete tree.

Reply • Share ›

Vivek • 6 months ago

O(n) solution without using any extra space.

please go through this solution.

```
#include <stdio.h>
#include <stdlib.h>

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

int max(int a, int b)
{
        return a>b?a:b;
}
int height(struct node *root)
{
```

see more

1 ^ | ⌄ • Reply • Share ›

Jayanth ➦ Vivek • 6 months ago

1
/ \
2 3
/ \
4 5

ur code returns true for above tree which isn't a complete tree

Edit : The tree is not clear in the diagram...
the tree desc is
root = 1
1->left = 2;
1->right = 3;

2->left = 2->right = NULL;

3->left = 4;
3->right = 5;

⌃ | ⌄ • Reply • Share ›

Vivek ➦ Jayanth • 5 months ago

my code does check this condition.
if (height (root->left)<height(root->right))
then its not a complete binary tree

⌃ | ⌄ • Reply • Share ›

ISha ➦ Vivek • a month ago

It is giving incorrect results for this tree:

struct node *root = newNode(1);

root->left = newNode(2);

root->right = newNode(3);

root->left->left = newNode(4);

root->left->right = newNode(5);

root->left->left->left = newNode(6);

root->left->left->right = newNode(7);

root->right->left = newNode(8);

^ | ⌄ • Reply • Share ›

digiter • 6 months ago

How about this one?

```
#include <cmath>

#include <cstdio>

#include <cstdlib>

#include <cstring>

#include <algorithm>

#include <iostream>

#include <map>

#include <set>
```

see more

^ | ⌄ • Reply • Share ›

Olivier • 7 months ago

Hi,
Just wondering if this code will work too.. I think it should:

```
public boolean isComplete(Node<integer> node) {
       if (node == null) return true;
```

```
        if (node.left == null && node.right != null) return false;
        int leftHeight = 0;
        int rightHeight = 0;
        leftHeight = node.left != null ? tree.height(node.left) : 0;
        rightHeight = node.right != null ? tree.height(node.right) : (
        if( rightHeight > leftHeight)return false; //right height can
        if( leftHeight > 0 && rightHeight > 0){    //leftheight and r:
            if( (leftHeight-rightHeight) > 1)return false;
        }else{
            if( leftHeight>1 || rightHeight > 1 )return false;
        }

        return isComplete(node.left) && isComplete(node.right);

    }
```

^ | ˅ • Reply • Share ›

pavansrinivas • 7 months ago

code in java...

```
boolean isComplete(){

                Node temp = root;
                boolean isFirstLeaf = false;
                 Queue<node> Q = new LinkedList<>();
                    Q.add(root);
                    while (!Q.isEmpty())
                    {
                        temp = Q.remove();
                        if(temp.left==null&&temp.right!=null){
                                return false;
}
                        if(temp.left==null&&temp.right==null){
                                isFirstLeaf = true;
                        }
```

see more

^ | ⌄ • Reply • Share ›

draganwarrior • 7 months ago

can we do as follows

http://ideone.com/SNXRqe

^ | ⌄ • Reply • Share ›

rajeevprasanna • 7 months ago

Why can't we simply check if level before the last level is completely filled or n

1) Calculate height(h) of the tree
2) Count number of node at level h-1
3) Check if node count is equal to 2 power(h-1)
if matches, it is complete tree otherwise not.

Let me know if there are any flaws in this approach.

^ | ⌄ • Reply • Share ›

Sriharsha g.r.v ➦ rajeevprasanna • 6 months ago

u aproach fals for thiscase

1
/ \
2 3
/
4

i mean the child should be towards left..that criteria is missing in ur alg

⌃ | ⌄ • Reply • Share ›

Guest ➦ rajeevprasanna • 7 months ago

need to have a check for following cases..

1
/ \
2 3
\
4

⌃ | ⌄ • Reply • Share ›

xiaoguangye ➦ Guest • 6 months ago

this can be checked by if (!node->left && node->right).
I think you mean:
1
/\
2 3
/ /
4 5

⌃ | ⌄ • Reply • Share ›

xiaoguangye ➦ xiaoguangye • 6 months ago

add:
4). check every node on the second deepest level. ever
to be leaf.

⌃ | ⌄ • Reply • Share ›

Trilok Sharma • 10 months ago

/* c++ version */

```
#include
#include
using namespace std;

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

struct node* newNode(int data)
{
struct node* node = new(struct node);
node->data = data;
node->left = NULL;
node->right = NULL;
```

see more

Reply • Share ›

Saurabh Tamrakar • 10 months ago

```
#include<stdio.h>
#include<conio.h>
#include<malloc.h>
struct node
{
struct node *leftnext;.
int data;
struct node *rightnext;.
};
int check(struct node *ps);.
```

```
void append(struct node **, int);.
void inorder(struct node *);.
void postorder(struct node *);.
void preorder(struct node *);.
int leaf(struct node *ps);.
int size(struct node *ps); //Number of Elemens in Tree.
int main()
{
```

see more

⌃ | ⌄ • Reply • Share ›

abhishek08aug • a year ago

Intelligent :D

⌃ | ⌄ • Reply • Share ›

FAISAL • 2 years ago

Time complexity :O(n)

⌃ | ⌄ • Reply • Share ›

FAISAL • 2 years ago

```
[sourcecode language="C++"]
/* #include<iostream>
using namespace std;
class Node
{
public:
int data;
Node* left;
Node* right;
Node(int d,Node* l = 0,Node* r = 0)
{
```

```
data = d;
right = r;
left = l;
}
};
bool check(Node* root1,Node* root2)
{
```

see more

^ | ˅ • Reply • Share ›

atul007 • 2 years ago

Time complexity = O(n)
space complexity = O(1)
int flag=0;
ht=height(root);
call : CheckComplete(root,ht-1,&flag)
if return 1 -> Complete Binary Tree
if return 0 -> NOT Complete Binary Tree

```
 /* Paste your code here (You may delete these lines if not writing co

int height(node *root)
{
int l=0,r=0;

        if(!root)
                return 0;
        l=height(root->left);
        r=height(root->right);
```

see more

Reply · Share ›

mrn ➦ atul007 · 8 months ago

stack implicitly takes O(n) space ..

⌃ | ⌄ · Reply · Share ›

White Tiger · 2 years ago

```
void checkCompleteTree(struct BSTnode* root)
{
int level=0,count=0,flag=0,temp_flag=0;
struct BSTnode* temp;
insert(root);
while(!isQueueEmpty())
{
temp=extract();
if(flag==0)
{
if(temp->left!=NULL && temp->right!=NULL)
{
insert(temp->left);
insert(temp->right);
}
else if(temp->right==NULL)
{
if(temp->left!=NULL)
```

see more

⌃ | ⌄ · Reply · Share ›

lohith · 2 years ago

```
[sourcecode language="C++"]
#include<iostream>
```

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

typedef struct node * Node;

Node newNode(int val)
{
Node temp = new node;
temp->left = NULL;
temp->right = NULL;
temp->value = val;
```

see more

^ | ˅ • Reply • Share ›

Lakshmanan ➦ lohith • 2 years ago

This algorithm fails for the following case... Counting the balance betw
them can't be complete (either if then can be full / only one of them sho
criteria used in ur approach)...

```
1
/ \
2 3
/ \ /
4 5 6
/
7
```

```
thunder:7% g++ iscomplete.C
thunder:8% ./a.out
yes
thunder:9% cat iscomplete.C
#include<iostream>
using namespace std;
```

see more

^ | ˅ • Reply • Share ›

BackBencher ➦ Lakshmanan • a year ago

@Lakshmanan and lohit:

Can u please expalain algo, i am bit confused in code logic. Please reply ASAP..

^ | ˅ • Reply • Share ›

lohith ➦ Lakshmanan • 2 years ago

Yeah. I dint notice. Thanks.

^ | ˅ • Reply • Share ›

deep ➦ lohith • 2 years ago

@lohith
i tried for many tries ur program is running well

^ | ˅ • Reply • Share ›

deep ➦ lohith • 2 years ago

@lohith
i tried for many tries ur program is running well

```
 /* Paste your code here (You may delete these lines if not wr:
```

Reply • Share ›

lohith lohith • 2 years ago

[sourcecode language=""]
A simple check, (left sub-tree value - right sub-tree value) <2 &&
(left sub-tree value - right sub-tree value)>=0
at each node will be sufficient to decide if a tree is complete or not.

Reply • Share ›

lohith lohith • 2 years ago

A simple check, (left sub-tree value - right sub-tree value) =0 at each n
is complete or not.

Reply • Share ›

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