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07 December 2025 08:58

🎄 Binary Tree Topics

1. Binary Tree Fundamentals

- Introduction to **Binary Trees**
- Binary Tree - **Constructor**
- **Display** a Binary Tree
- **Size, Sum, Max, and Height** of a Binary Tree

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2. Binary Tree Traversal Methods

- **Traversals** in a Binary Tree (Recursive: Pre, Post, In-Order)
- **Level Order Traversal** in a Binary Tree
- **Iterative Pre, Post and In-Order Traversal** in Binary Tree
- **Bottom View** of Binary Tree

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3. Paths and Levels

- **Node to Root Path**
- **Print K Levels Down**
- **Print Nodes K Level Far**
- **Path to Leaf from Root**

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4. Structure Transformation and Filtering

- **Transform to Left Cloned Tree**
- **Transform Back from a Left Cloned Tree**
- **Print Single Child Nodes**
- **Remove Leaves**

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5. Advanced Metrics

5. Advanced Metrics

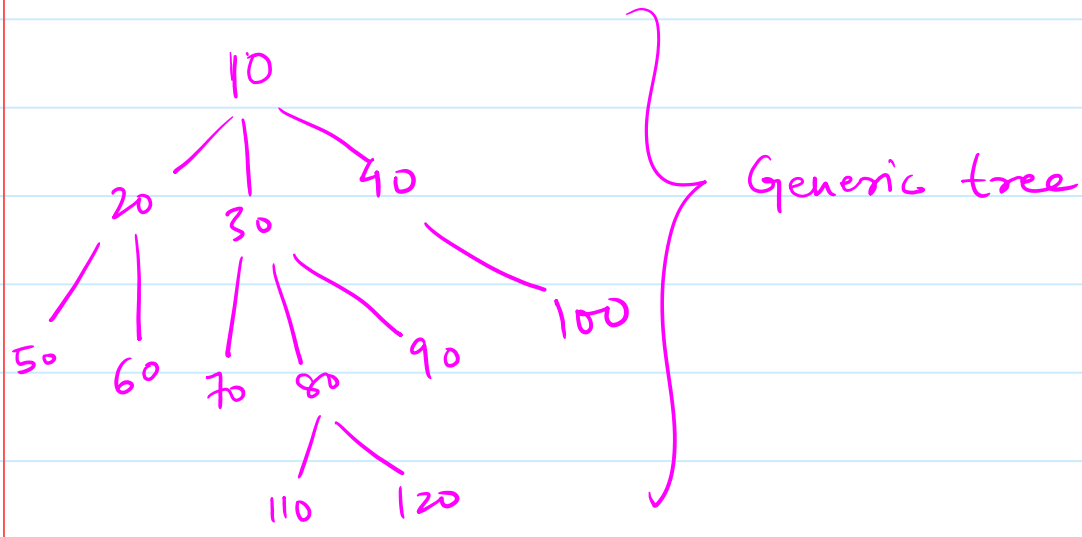
- **Diameter** of a Binary Tree
- **Tilt** of a Binary Tree
- Is a tree **Binary Search Tree**?
- **Balanced Binary Tree**
- **Largest BST Subtree**

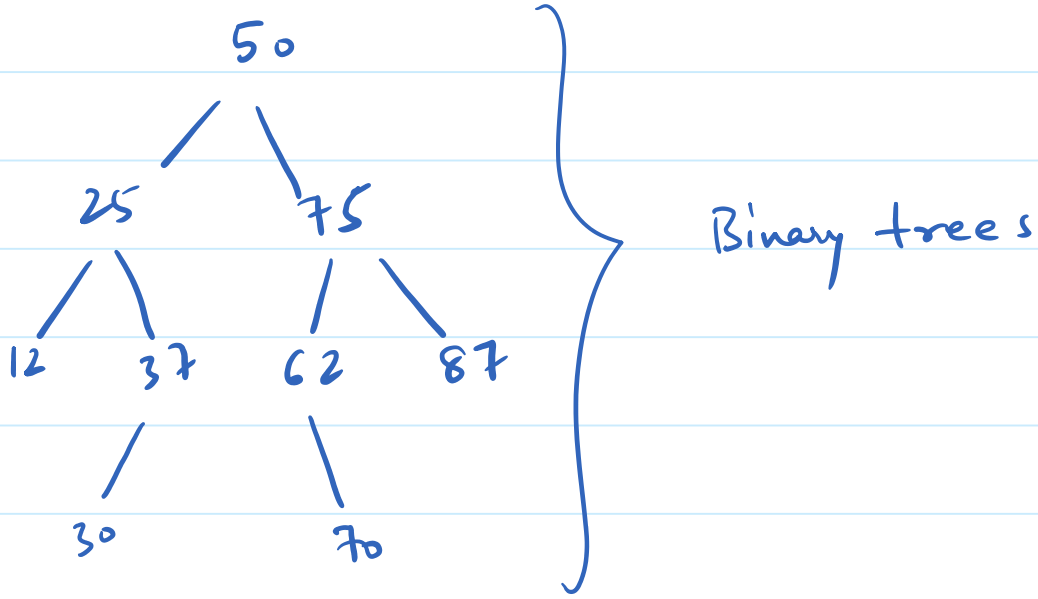
Gemini has grouped topics and given names so that we can remember it and revise.

08 August 2022 12:27

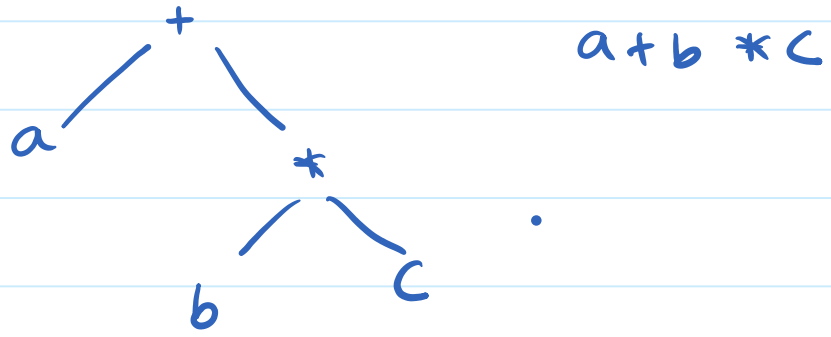
Jaise generic tree me kitne bhi child ho sakte the

Binary tree me
-> no child
-> 1 child
-> 2 child





They are used in Mathematical expressions.



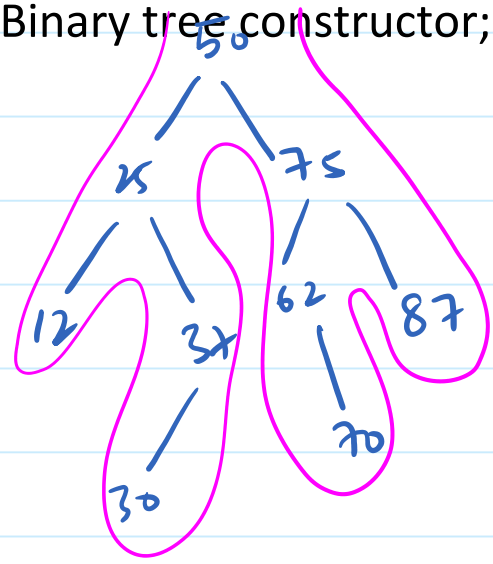
How node will be represented?

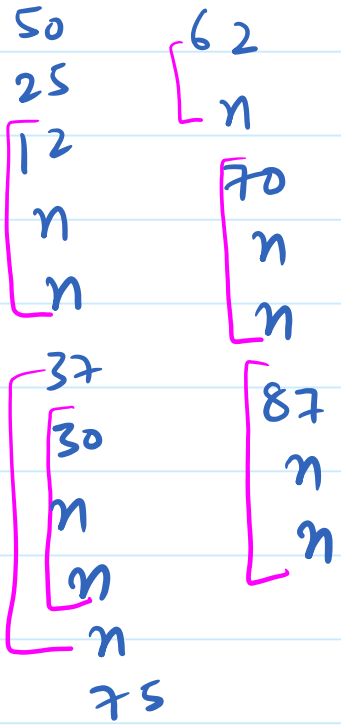
```
public static class Node {
    int data;
    Node left;
    Node right;

    Node(int data, Node left, Node right){
        this.data = data;
        this.left = left;
        this.right = right;
    }
}
```

09 August 2022 12:07

https://github.com/AlgoMagnet/0or1/blob/main/BinaryTree/BinaryTreeConstructor.java

Binary tree constructor;'





That's a great approach! The code snippet you provided is an implementation of an **Iterative Binary Tree Construction** algorithm using a stack and a state machine, based on a **Pre-order Traversal** array representation.

To help you understand this and write the code more easily, here is the algorithm broken down step-by-step.

Algorithm for Binary Tree Construction (Pre-order Array)

This algorithm simulates a recursive pre-order construction using a **Stack** to manage the parent nodes and a **State** to track whether the left or right child is being processed.

1. Data Structures & Setup

Structure	Purpose
`Node`	Stores `data`, `left` child, and `right` child.
`Pair`	A helper class to store a `Node` and its current `state` of processing (0, 1, or 2).
`Stack<Pair>`	Used to manage the parent nodes whose children we still need to process.
`Integer[] arr`	The input array representing the tree structure in pre-order, with `null` for missing children.
`idx` **(Integer)**	A global index to track the current element in the input array `arr`.

Export to Sheets

2. Initialization

1. Initialize the array index `idx = 0`.
2. Create the `root` node using `arr[0]`.
3. Create the root `Pair` (root_pair) with the `root` node and initial `state = 0`.
4. Increment `idx` to point to the next element (`arr[1]`).
5. Push the root_pair onto the `Stack`.

3. Iterative Construction Loop

Repeat the following steps while the `Stack` is not empty:

1. **Peek** at the top `Pair` on the stack (let's call it `top`).
2. **Check** `top.state`:
   - **Case 1:** `top.state == 0` **(Process Left Child)**
     - Increment `top.state` to 1.
     - Check `arr[idx]`:
       - **If not** `null`:
         - Create a `temp` node with the value `arr[idx]`.
         - Set `top.node.left = temp`.
         - Create a new `Pair` (temp_pair) with the `temp` node and `state = 0`.
         - Push temp_pair onto the `Stack`.
     - Increment `idx`.
   - **Case 2:** `top.state == 1` **(Process Right Child)**
     - Increment `top.state` to 2.
     - Check `arr[idx]`:
       - **If not** `null`:
         - Create a `temp` node with the value `arr[idx]`.
         - Set `top.node.right = temp`.
         - Create a new `Pair` (temp_pair) with the `temp` node and `state = 0`.
         - Push temp_pair onto the `Stack`.
     - Increment `idx`.
   - **Case 3:** `top.state == 2` **(Processing Complete)**
     - Pop the `top` pair from the `Stack`. (This node and both its subtrees are now fully built and attached.)

4. Termination

1. When the `while` loop finishes (the `Stack` is empty), the entire tree has been constructed.
2. **Return** the `root` node.

The data on the RHS will be provided and based on this the tree will be created.

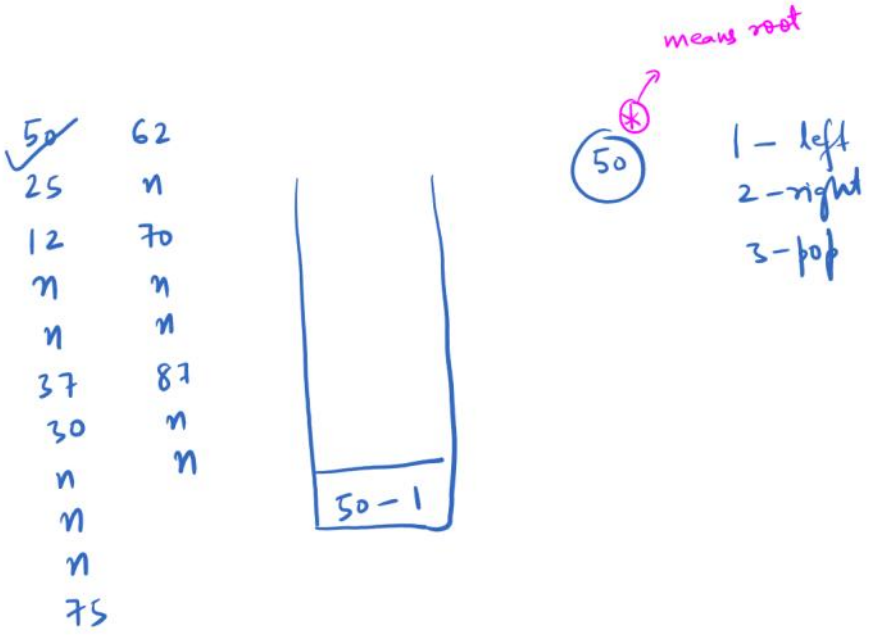
Data is written on the basis of preorder traversal in the binary tree. This data will be given in the array form.

Nodes with no children will have both the NULL like (30)

You will be given with this data and then you will have to apply preorder iterative trick of generic tree to construct the binary tree.

Generic tree ka **preorder iterative trick** will be used.

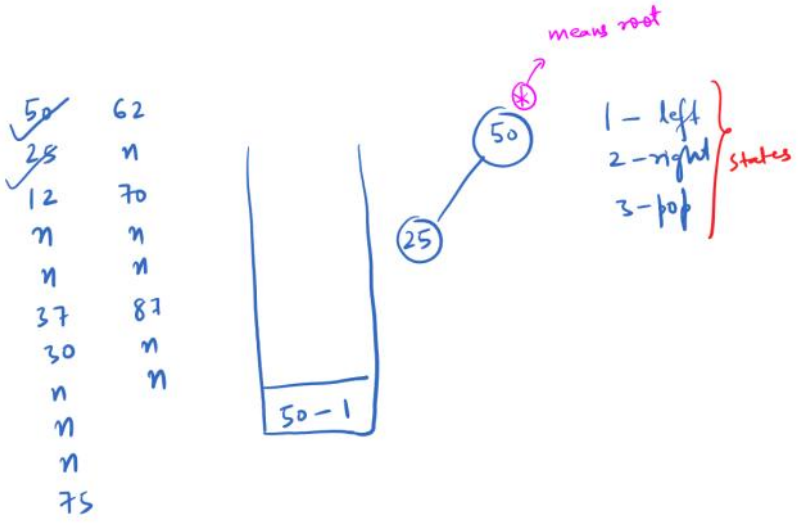
50 ko read kiya, stack abhi empty hai to uske naam ka ek node banaya aur 50 ko 1 flag ke sath push kar diya.



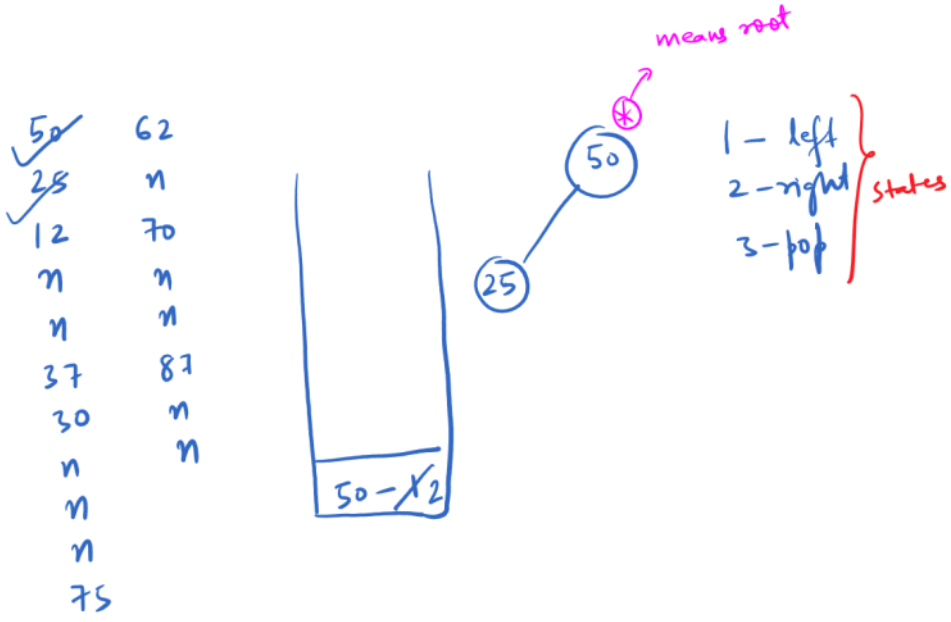
Stack ke top pe dekha. Stack ke top ko read karna hai.

State 1 hai iska matlab, next node left me lagega
State 2 hai iska matlab, next node right me lagega
State 3 hai iska matlab, pop hoga

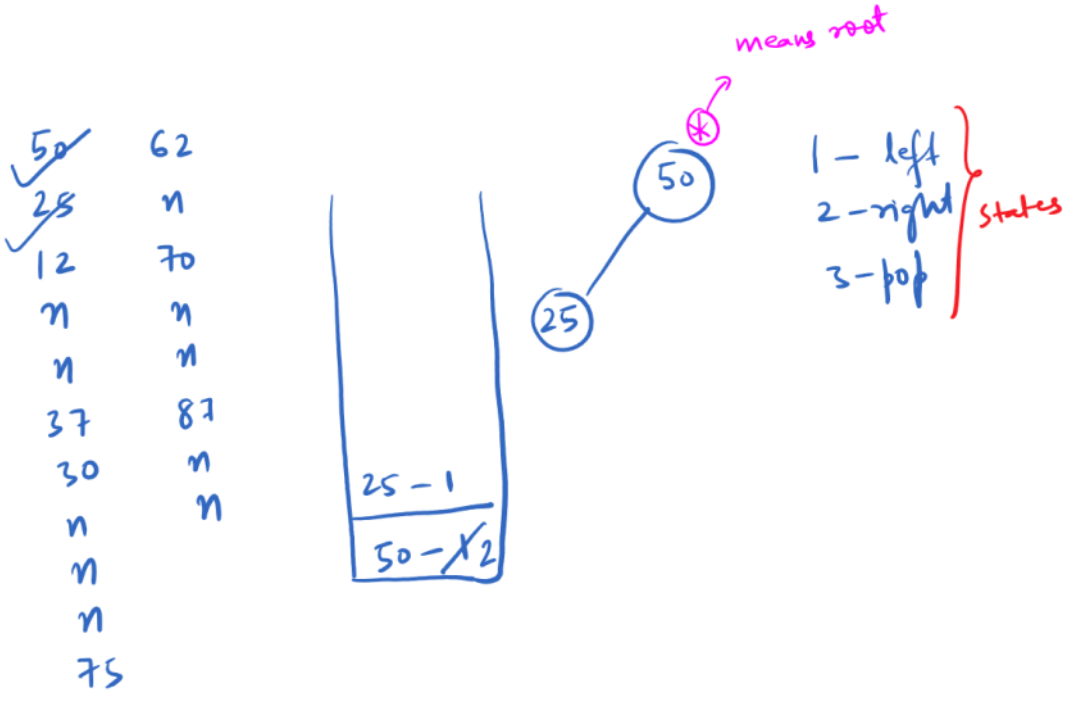
Hamne read kiya 25 ko,
step 1. Node banaya 25 ka
Aur isko uske left me lagaya



Left me laga ke 50 ka state badhaya

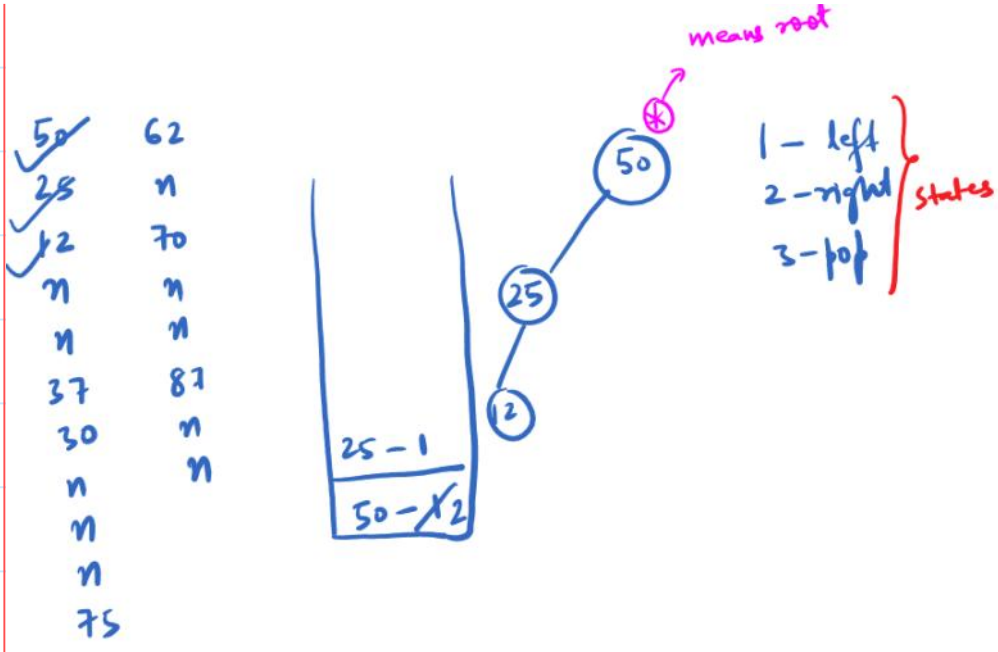


Aur fir 25 ko push kar diya, with state 1

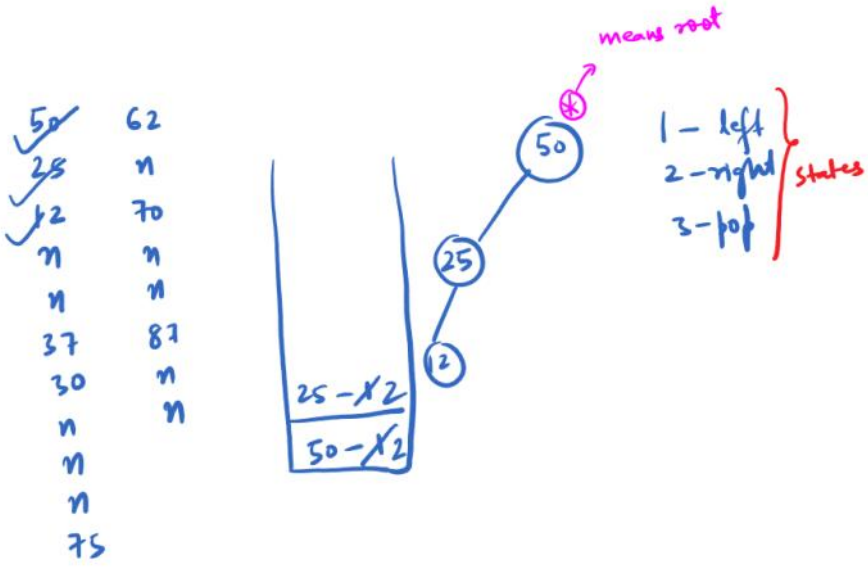


Now again, read the top of stack. Top pe state hai 1, Read karo 12 aur usko 25 ke left me laga do

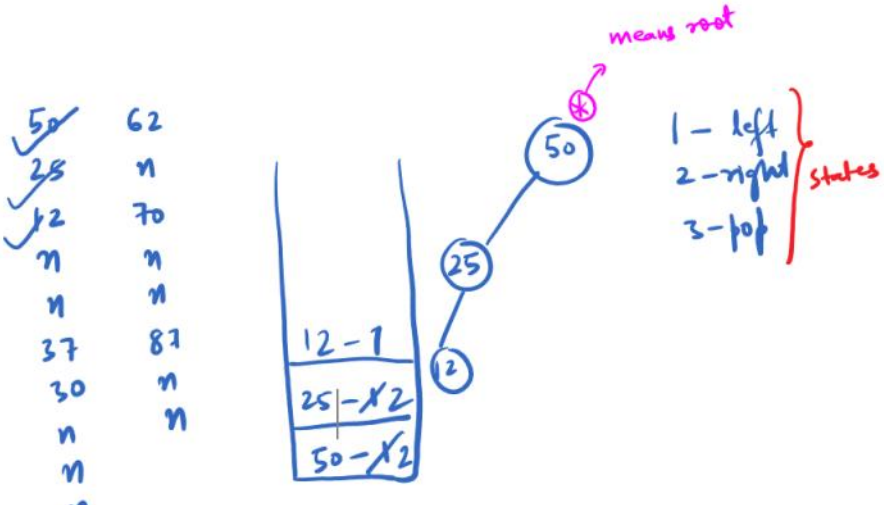
Pehle value 12 ka node banao, fir left me lagao

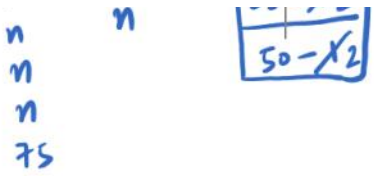


Fir state change karo 25 ka



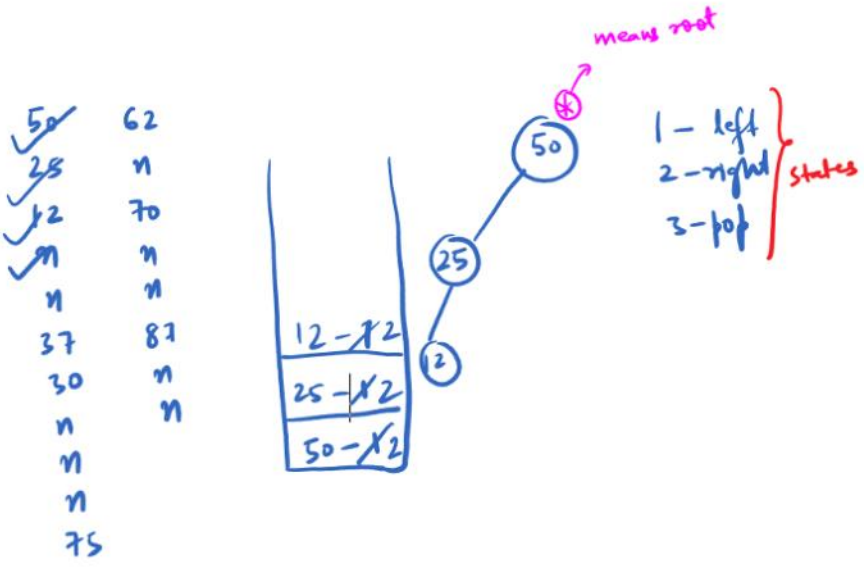
aur 12 ko stack me push kar do state 1 ke sath



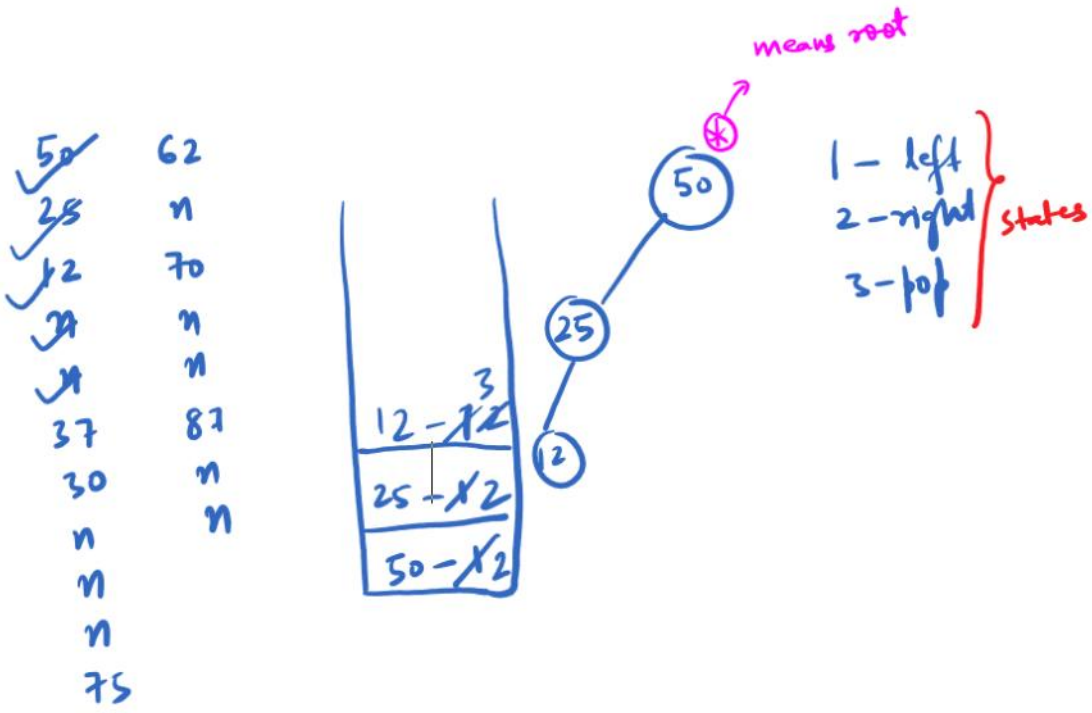


Now again,
stack ke top ko read kiya to 1 mila, Next value hai null
12 ke left me kuch na lagaye aur state change kar de

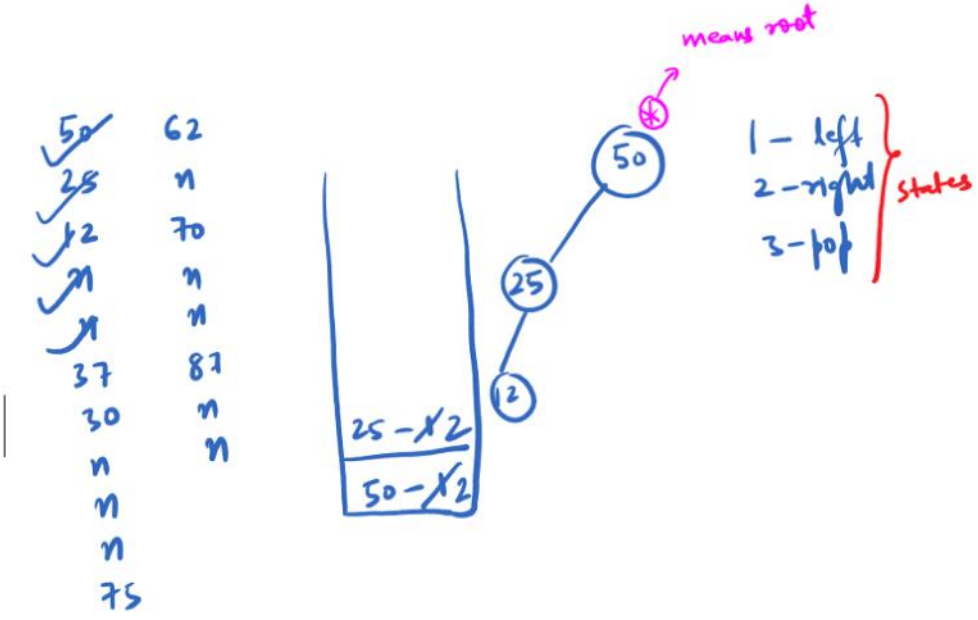
State badha de aur kuch bhi na push kare



Fir stack ke top pe 2 hai, matlab right me lagega
Ab next vlaue hai null, to kuch na lagyae aure state change kar de

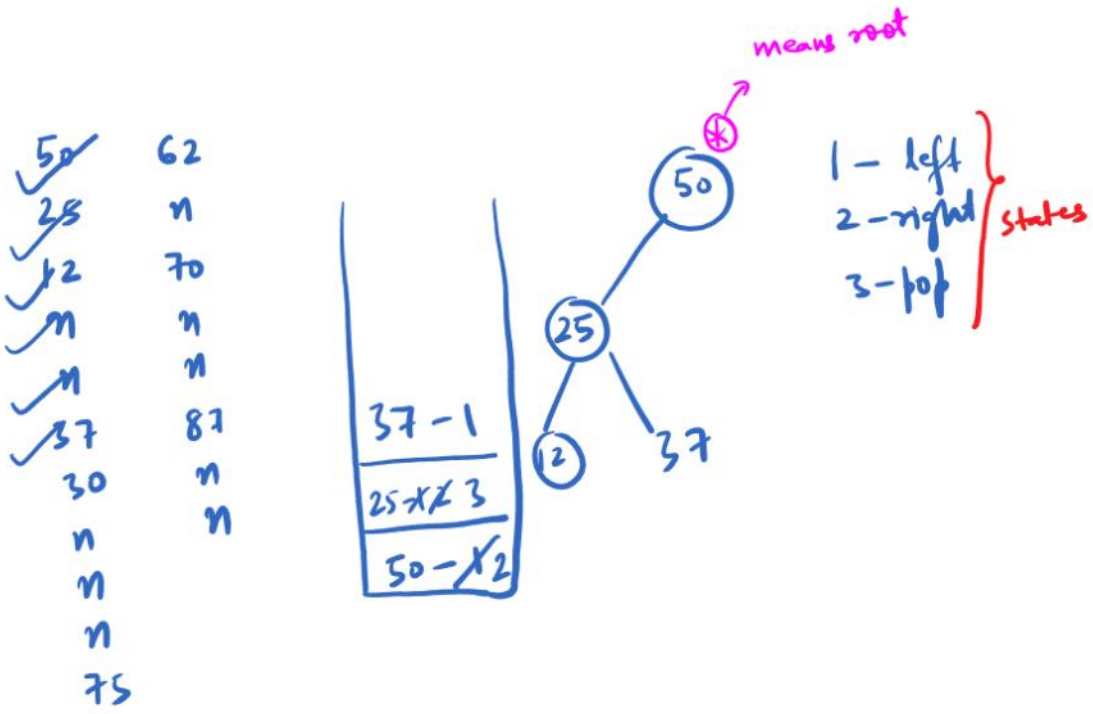


Ab stack ke top pe 3 dikhai diya, to matlab pop kar dena hai



Ab stack ke top me 2 hai, matlab right lagana hai
37 ko read kiya, node banaya, right me add kiya

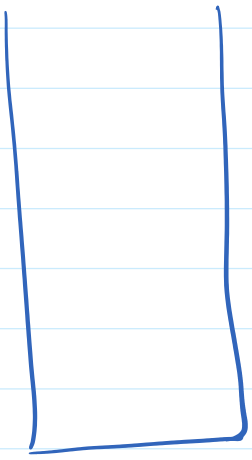
State badhaya aure push kar diya


means root
50
25
12
37
37 - 1
25 - 3
50 - 2
1 - left
2 - right
3 - pop
states

08 September 2022 10:33

Create a binary tree with the given Array of data.

50 62
25 n
12 70
n n
n n
37 87
30 n
n n
n
n
n
75



https://github.com/AlgoMagnet/0or1/blob/main/BinaryTree/BinaryTreeConstructor.java

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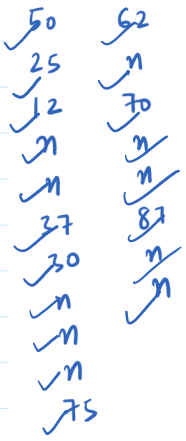
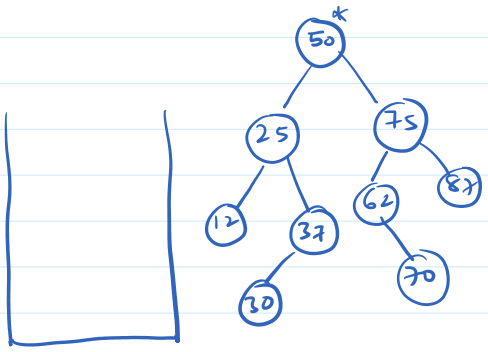
Create a binary tree with the given Array of data.





https://github.com/AlgoMagnet/0or1/blob/main/BinaryTree/BinaryTreeConstructor.java

Life is more than just thinking about probable failures. Just make the right goal, break down into achievable targets, do it daily without fail and also reward yourself continuously so that you keep on doing it no matter what happens. Finally you will feel that what used to feel unachievable will become something which can be accomplished by you and what can be designed by you and then you will become like a painter good in the skillset which you are supposed to be good at..

Make small goals, break into small achievable targets

Smash them as you wish to.

Graph
Generic tree

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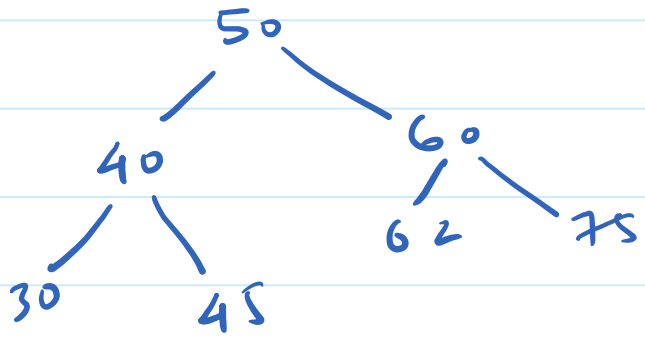
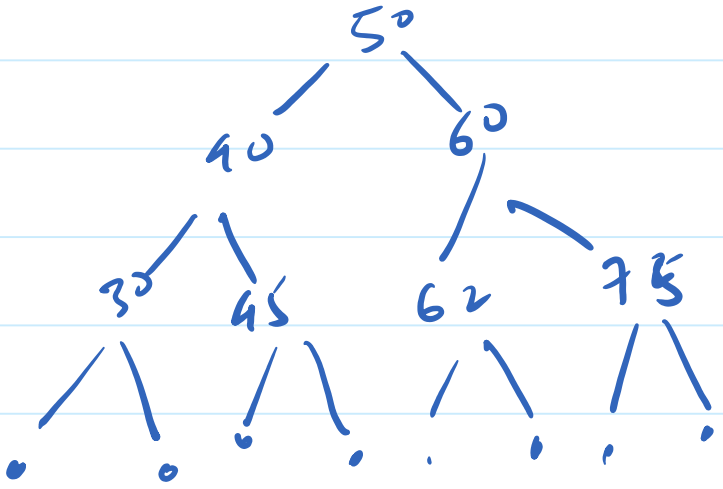
Let's try to code it.





https://github.com/AlgoMagnet/0or1/blob/main/BinaryTree/BinaryTreeConstructor.java

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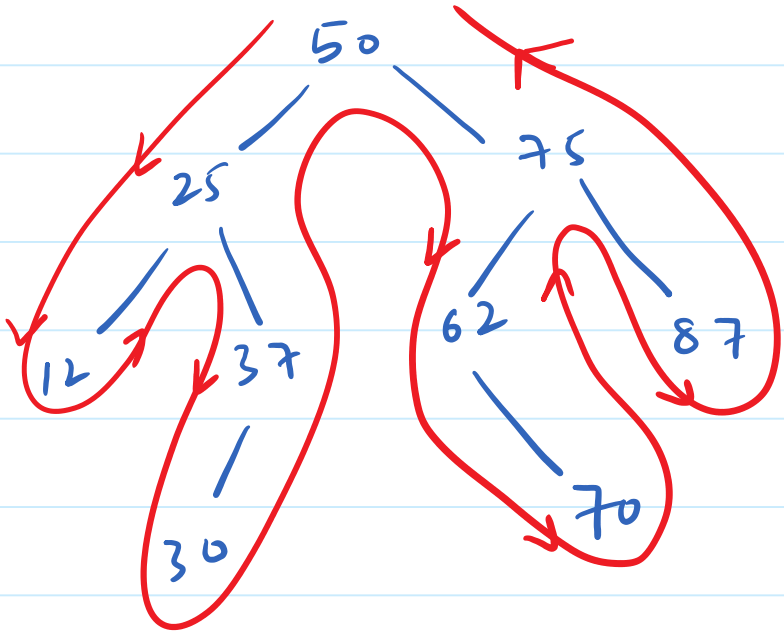
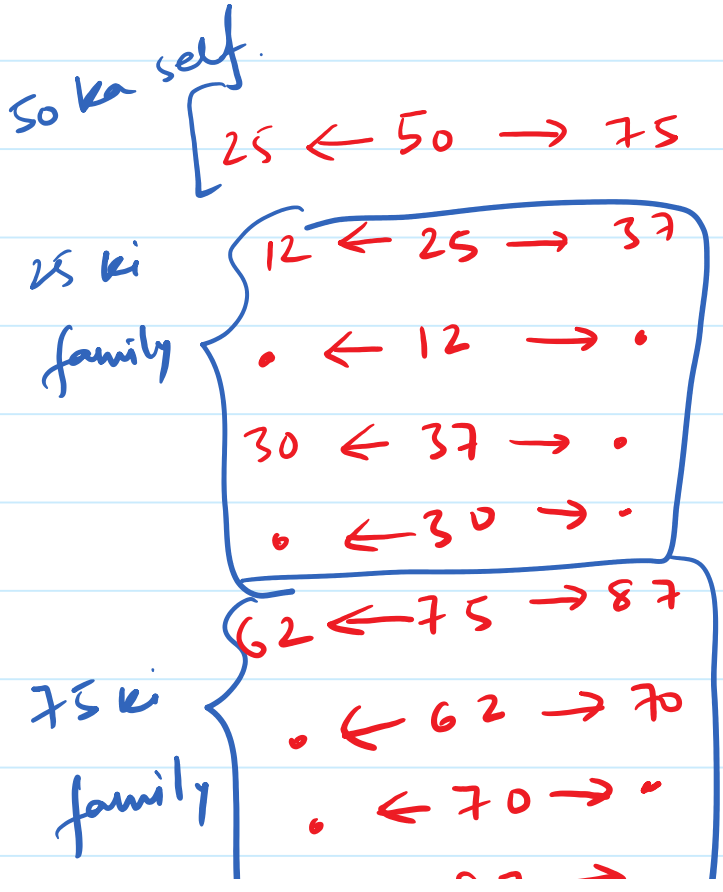
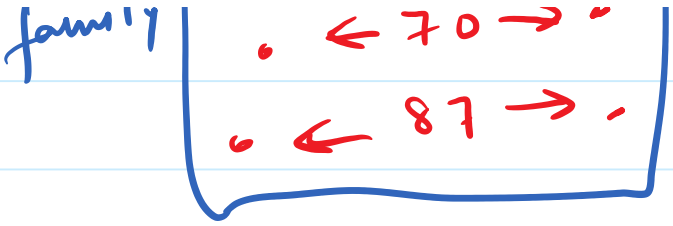
Display the binary tree.



We will move on this Euler path and on each node, we will print the data and the left and right data.





why do we have to initialize the string as String str = "";

BTree.java:35: error: variable str might not have been initialized
str += (node.left == null)? "." : node.left.data + " ";...

That error message, `error: variable str might not have been initialized`, is a clear indication that the Java compiler is trying to protect you from a potential **runtime error** by enforcing a rule called **Definite Assignment**.

Here is a detailed breakdown of why this happens and why initializing the string as `String str = "";` solves the problem.

---

1. 🔴 The Problem: Definite Assignment (Compiler Safety)

Java has a strict rule: **all local variables must be explicitly initialized** before they are read (used). The compiler cannot guarantee that your variable `str` will have a valid value assigned to it *before* the line where you use the `+=` operator.

The Code Context (Inferred):

The compiler is looking at code structured something like this (where the variable `str` is declared, but not guaranteed to be assigned a value):

Java

```
public String someBTreeMethod() {
    String str; // Declaration without initialization

    if (some_condition_is_true) {
        str = "Initial Value"; // Assignment happens here
    }

    // Line 35: The compiler flags an error here.
    // What if 'some_condition_is_true' was FALSE?
    // 'str' would have no value, and using += would crash the program.
    str += (node.left == null)? "." : node.left.data + " ";

    return str;
}
```

Why the Compiler Complains:

The `+=` operator is a **compound assignment operator**. It is shorthand for:

$$str = str + (\text{new\_content})$$

Before Java can calculate the right side of the equation (`str + ...`), it **must** read the current value of `str` . If `str` has not been guaranteed to be assigned a value in **all possible execution paths**, the compiler throws the error to prevent you from trying to add to a variable that holds garbage or no value at all.

2. ✅ **The Solution:** `String str = "";`

Initializing the variable as `String str = "";` solves the definite assignment rule by guaranteeing that `str` starts with a known, valid value (an empty string).

When you write:

Java

```
String str = ""; // Initialization: str now holds a valid empty string.
```

The compiler is now certain that `str` has a value. The subsequent line of code:

Java

```
// Line 35: No error, because str is guaranteed to be "" or some other assigned v
str += (node.left == null)? "." : node.left.data + " ";
```

is interpreted as:

$$str = "" + (\text{new\_content})$$

This is a safe operation, as you are simply concatenating your new content onto an empty string, effectively setting the initial content of `str` .

print a visualization of a Binary Tree in a specific format, often called a "left-node-right" or "preorder-like" display, where the relationship of each node to its immediate children is shown on one line.

🌳 Algorithm for Binary Tree Visualization (`display` method)

This algorithm follows a **Preorder Traversal** pattern (Node → Left → Right) for recursion, but the printing logic is custom to show node structure.

🎯 Goal:

To print a line for *every node* in the tree showing: **(Left Child Data) <- (Current Node Data) -> (Right Child Data)**.

Algorithm Steps:

1. Base Case (Stopping Condition)

- **Check:** Is the current `node` reference equal to `null`?
- **Action:** If **Yes**, stop the function and return immediately (the end of a branch has been reached).

2. Prepare the Visualization String (Current Node)

- Initialize an empty string variable, `str` (e.g., `String str = "";`).
- **Left Child:**
  - Check if `node.left` is `null`.
  - If **Yes**, append a placeholder `.` (dot) to `str`.
  - If **No**, append the data of the left child (`node.left.data`) followed by a space to `str`.
- **Current Node:**
  - Append the structural indicators and the current node's data: `<-` + `node.data` + `->` to `str`.
- **Right Child:**
  - Check if `node.right` is `null`.
  - If **Yes**, append a placeholder `.` (space + dot) to `str`.
  - If **No**, append the data of the right child (`node.right.data`) to `str`.

3. Print the Result

- Print the fully constructed string (`str`) to the console.

4. Recurse (Traverse the Subtrees)

- **Recurse on Left:** Call the `display` function on the left child (`display(node.left)`).
- **Recurse on Right:** Call the `display` function on the right child (`display(node.right)`).

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Size sum max height

https://github.com/AlgoMagnet/0or1/blob/main/BinaryTree/BinaryTreeSizeSumMaxHeight.java

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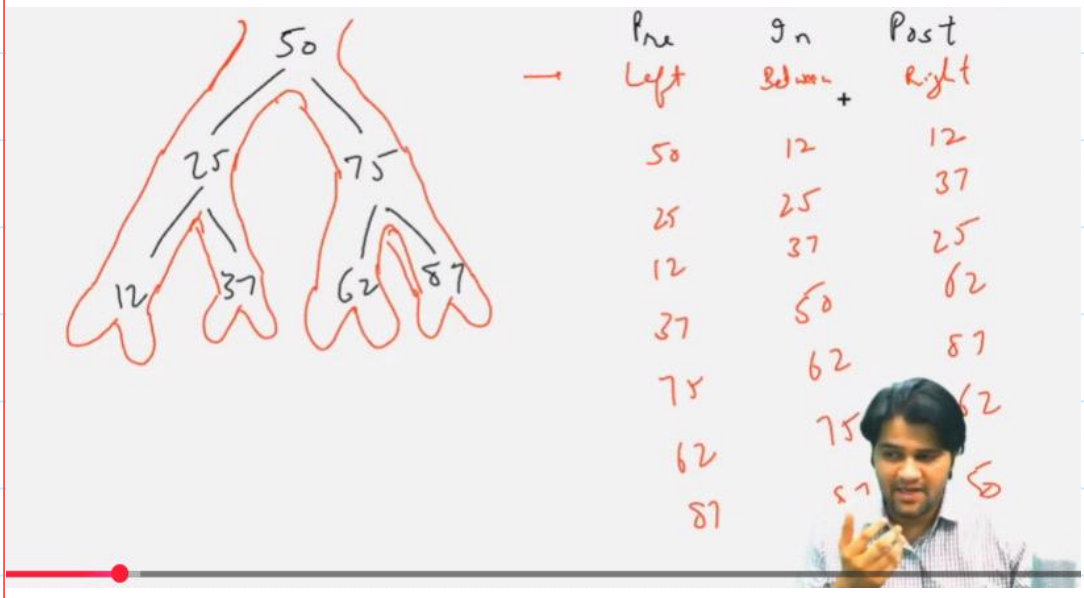
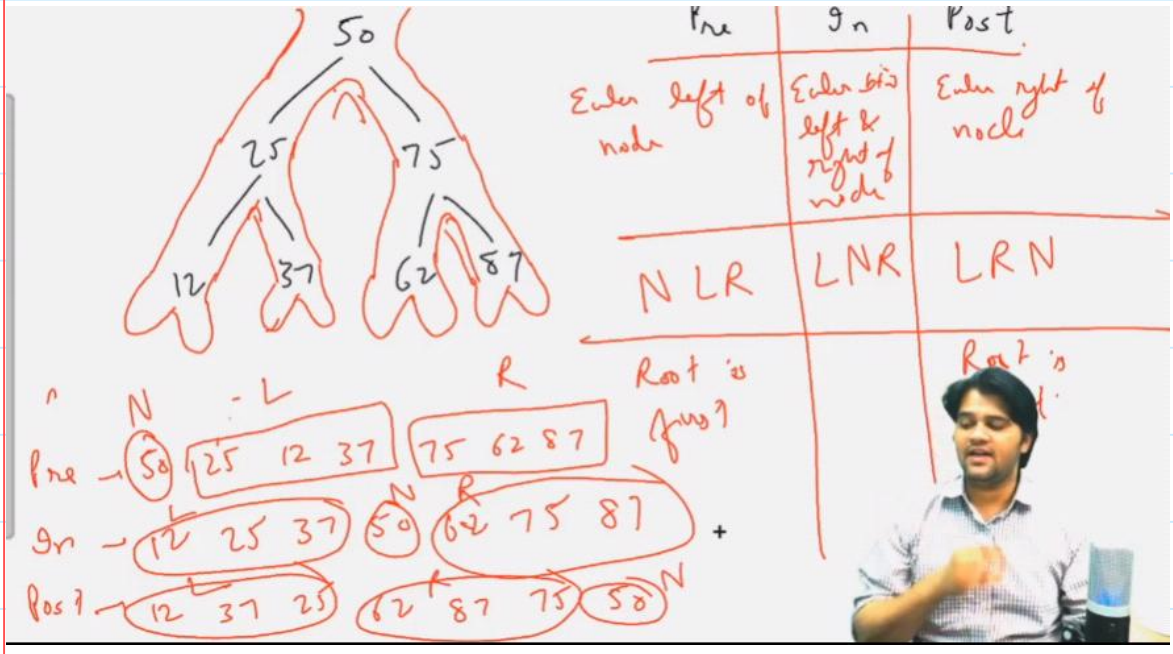
Traversal in Binary tree



Node(N) Left(L) Right[R]



https://github.com/AlgoMagnet/0or1/blob/main/BinaryTree/BinaryTreeTraversal.java

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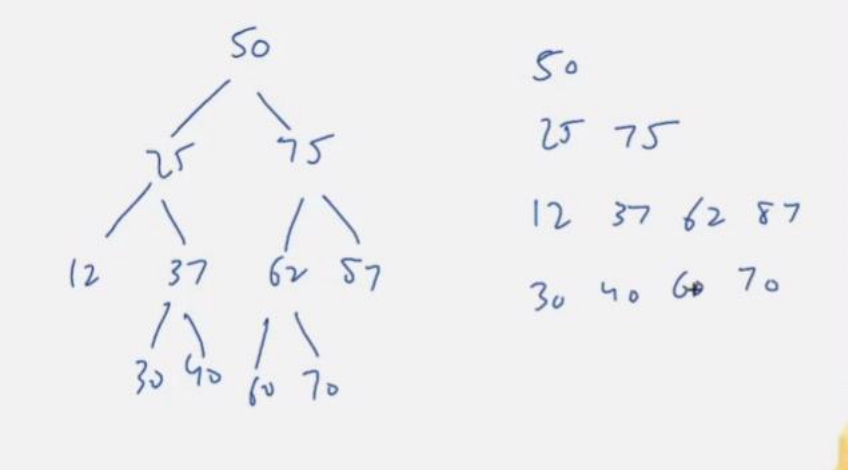
Level order traversal of Binary tree



Remove Print Add children(RPA);

https://github.com/AlgoMagnet/0or1/blob/main/BinaryTree/BinaryTreeLevelOrder.java

To remember this algorithm (which is a form of Breadth-First Search, or BFS), you need a mnemonic and a clear conceptual breakdown.

Here is the **Queue-Loop-Children (QLC) Algorithm** for Level Order Traversal:

🧠 Algorithm: Level Order Traversal (The QLC Method)

Level Order Traversal is fundamentally a **Queue** operation. The key to the level-by-level implementation is using the size of the queue at the start of the loop to distinguish one level from the next.

1. Initialization (The Queue)

The entire traversal revolves around the Queue data structure.

- **Setup:** Create a Queue (e.g., `ArrayDeque`) to store nodes.
- **Start:** If the `root` node is not null, immediately **enqueue** the root node.

2. Main Loop (The Loop Structure)

The core logic runs until the Queue is empty, meaning all nodes have been visited.

Concept	Action	Purpose
While Loop	`while (q.size() > 0)`	Continues until the entire tree is processed.
Level Size	`int count = q.size();`	**CRUCIAL STEP:** Captures exactly how many nodes are in the *current* level before we start adding nodes from the *next* level.
For Loop	`for (int i = 0; i < count; i++)`	Ensures we process **only** the `count` nodes belonging to the current level.

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3. Processing (The Children)

Inside the `for` loop, we execute the three essential steps of BFS for the node at the front of the queue:

Step	Action	Description
1. Dequeue	`Node f = q.remove();`	Take the node out of the queue to process it.
2. Print/Process	`System.out.print(f.data);`	Perform the required operation (printing, adding to a list, etc.).
3. Enqueue Children	`if (f.left != null) q.add(f.left);`	Add the children (if they exist) to the back of the queue. They will be processed in the *next* iteration of the `while` loop.
	`if (f.right != null) q.add(f.right);`	

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4. Spacing

- After the `for` loop finishes, the entire current level has been printed. Use `System.out.println()` to move to a new line, cleanly separating the levels.

💡 Mnemonic to Remember the Level-by-Level Code

Think of the code's structure as an **I-L-P** sequence:

1. **I**nitialize the Queue.
2. **L**ook at the Queue's **Size** (to mark the current level).
3. **P**rocess the level nodes: **P**op (remove), **P**rint, and **P**ush (add) children.

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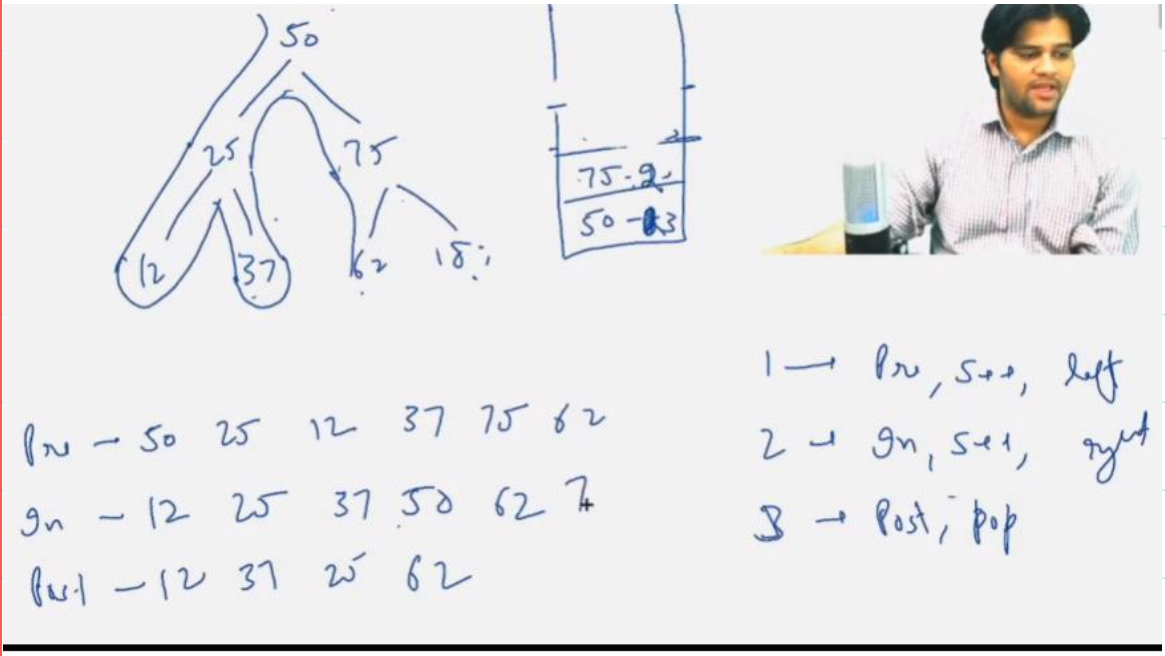
04 December 2025 21:58

Iterative traversal



This elegant code uses a single stack and a **state machine** (represented by the `Pair` class) to perform all three primary Depth-First Search (DFS) traversals (**Preorder, Inorder, and Postorder**) simultaneously.

The key to remembering this algorithm is to understand the **Euler Tour** or **Three-Visit** pattern of recursion, which the iterative code perfectly simulates.

🧠 Algorithm to Remember Iterative Traversal (State Machine)

The entire logic hinges on the `state` variable within the `Pair` object, which tracks which part of the Euler Tour (the path around the node) the traversal is currently on.

---

1. The Core Data Structure

- **Node:** Holds data, left child, and right child.
- **Pair:** The crucial memory unit. It holds a **Node** reference and an **integer** `state` (1, 2, or 3).
- **Stack (`st`):** Stores `Pair` objects. It simulates the recursive call stack: the node currently being processed is always at the **top** of the stack (`st.peek()`).

---

2. State Machine Logic (The 3 Rules)

The `while(st.size() > 0)` loop continuously checks the `state` of the `Pair` at the top of the stack and follows one of three rules:

State	Action on `top.node.data`	State Change	Push New Node?	Traversal Order
1	**Record Data (Preorder)**	$\text{state} \rightarrow 2$	**Yes**, push **Left** child (state 1)	**Preorder** (Root, Left, Right)
2	**Record Data (Inorder)**	$\text{state} \rightarrow 3$	**Yes**, push **Right** child (state 1)	**Inorder** (Left, Root, Right)
3	**Record Data (Postorder)**	pop the Pair	**No** (Done with node)	**Postorder** (Left, Right, Root)

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💡 Remembering the Order:

- **State 1 (Preorder):** You visit the **Root** first. So, as soon as you see the node, **print** it (`pre`), and then move to its **Left** child.
- **State 2 (Inorder):** You visit the **Root** in the middle. By State 2, the Left subtree is **finished** (popped or fully processed). So, **print** the node (`in`), and then move to its **Right** child.
- **State 3 (Postorder):** You visit the **Root** last. By State 3, both Left and Right subtrees are **finished**. So, **print** the node (`post`), and **pop** it off the stack, effectively returning to its parent.

---

3. Step-by-Step Algorithm

1. **Initialize:** Create three empty strings (`pre` , `in` , `post`). Initialize an empty `Stack<Pair>` .
2. **Start:** Create the root `Pair` with `state = 1` and push it onto the stack.
3. **Loop:** While the stack is not empty, peek at the `Pair` (`top`).
4. **Process State 1 (Preorder / Go Left):**
   - Append `top.node.data` to the `pre` string.
   - Increment `top.state` to 2.
   - If `top.node.left` is not null, create a new `Pair(left_node, 1)` and push it onto the stack (this is the simulated recursive call).
5. **Process State 2 (Inorder / Go Right):**
   - Append `top.node.data` to the `in` string.
   - Increment `top.state` to 3.
   - If `top.node.right` is not null, create a new `Pair(right_node, 1)` and push it onto the stack.
6. **Process State 3 (Postorder / Pop):**
   - Append `top.node.data` to the `post` string.
   - Pop the `Pair` off the stack (simulating the return from the recursive call).
7. **Final Output:** After the loop finishes (stack is empty), print the three strings.

https://github.com/AlgoMagnet/0or1/blob/main/BinaryTree/BinaryTreeIterativeTraversal.java

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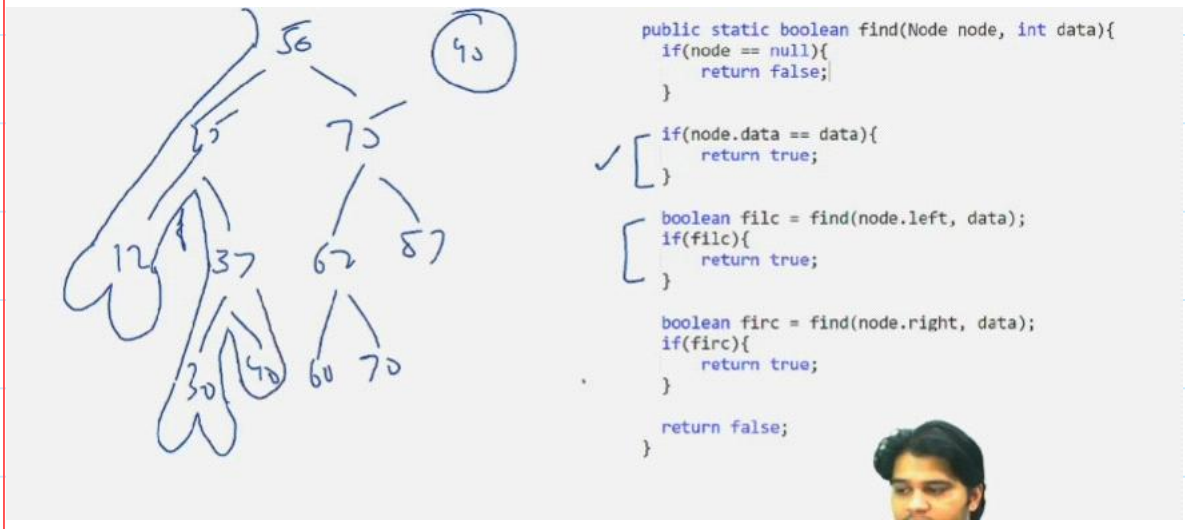
05 December 2025 08:52

Find the node in binary tree.

Code is In 5 parts:



🧠 Algorithm to Remember: "The Three Checks"

The recursive approach to searching a Binary Tree follows the core principles of **Depth-First Search (DFS)**, specifically a **Preorder Traversal** pattern combined with **short-circuiting** (stopping early when the goal is met).

You can remember the flow by the **Three Checks** and the **Two Base Cases**:

1. The Two Base Cases (The Safety Net)

These determine when recursion stops:

Case	Condition	Action	Why?
Null Node (Stop)	`if (node == null)`	`return false`	You've fallen off the tree; nothing to check here.
Found Node (Success)	`if (node.data == data)`	`return true`	You've found the target; no need to explore further!

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2. The Three Checks (The Recursive Dive)

This is the main logic for exploring the tree:

Check	Action	Why?
Check Current	**(Part of Base Case)** Check `node.data == data` first.	It's the fastest answer. If it's here, we're done.
Check Left	`filc = find(node.left, data)`	Dive into the left subtree. **If `filc` is true, STOP and return true immediately.**
Check Right	`firc = find(node.right, data)`	If not found on the left, dive into the right subtree. **If `firc` is true, STOP and return true immediately.**

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The Core Mantra:

> **"Check me, check left, check right. If any check succeeds, RETURN TRUE."**

If you finish checking all three parts (self, left, and right subtrees) and haven't returned `true`, the node doesn't exist in the current subtree, so you must **return false** as the final step.

https://github.com/AlgoMagnet/0or1/blob/main/BinaryTree/BinaryTreeFind.java

Untitled

05 December 2025 09:41

Use find function to write Node to root path

https://github.com/AlgoMagnet/0or1/blob/main/BinaryTree/BinaryTreeNodeToRootPath.java

💡 Algorithm to Remember: "Find then Climb"

This algorithm is based on the idea that the **path is built on the return journey** (the backtracking phase of recursion).

1. The Core Idea: The "True" Signal

The boolean return value (`true` or `false`) acts as a **signal** that is passed up the recursion stack.

- `true` = "The target was found in the subtree below me. I am on the path."
- `false` = "The target was not found in my subtree."

2. The Three-Step Logic (For the Current Node)

At any given `node` , the logic is simple:

Step	Action	Path Building	Why this order?
I. Base Cases	Check if `node` is `null` (return `false`) or if `node.data == data` (add to path, return `true`).	Only on success	Stop searching immediately.
II. Search Left	Call `nodeToRootPath(node.left, data)` .		
III. Check & Climb	`if (result_from_left_call_is_true)` : **Add** `node.data` **to the path** and immediately `return true` .	**Crucial**	This node is the next step up.
IV. Search Right	Call `nodeToRootPath(node.right, data)` .		Only if not found on the left.
V. Check & Climb	`if (result_from_right_call_is_true)` : **Add** `node.data` **to the path** and immediately `return true` .	**Crucial**	This node is the next step up.

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If neither the left nor the right call returns `true` , it means the target wasn't found in this entire branch, so you return `false` .

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05 December 2025 09:38

print k levels down.

why am I not able to think of soluton by myself
That's a very common and completely normal feeling when you're learning Data Structures and Algorithms (DSA), especially with recursion and trees!

You're likely hitting a conceptual wall because the problem "print k levels down" is a variation of **Level Order Traversal (BFS)** or **Depth-First Search (DFS)**, and moving from basic traversal to a specific-depth traversal requires a subtle shift in how you think about recursion or queue management.

Here is the solution for printing nodes at a distance 'k' from the root using recursion (DFS), along with an algorithm breakdown and tips on how to train yourself to think of these solutions.

💻 Solution: Print Nodes K Levels Down (DFS)

The most intuitive way to solve this using recursion (DFS) is to track the current depth or distance from the root.

1. The `kLevelDown` Function

We'll use a recursive function that takes the current `node` and the remaining `k` distance.

Java

```java
public static void printKLevelsDown(Node node, int k) {
    // 1. Base Case: If the current node is null, there's nothing to do.
    if (node == null) {
        return;
    }
// 2. Target Check: If k becomes 0, we have reached the target level.
    if (k == 0) {
        System.out.print(node.data + " ");
        return;
    }
// 3. Recursive Step: Move one level down and decrement k.
    // The distance to the next level is k-1.
    printKLevelsDown(node.left, k - 1);
    printKLevelsDown(node.right, k - 1);
}
```

🧠 Algorithm: How to Think of the Solution

The key to solving recursive tree problems is not to think about the whole tree, but to trust the recursion and focus only on **three things** for the current node:

1. Trust the Recursion (The Leap of Faith)

- **Goal:** I need to print nodes k steps away.
- **Recursive Thought:** If I move to my left child, the remaining distance I need to cover is $k-1$. If I move to my right child, the remaining distance is also $k-1$.
- **Function Signature:** The function must take the current `node` and the remaining distance `k`.

2. Define the Base Case (When to Stop)

- **Stop 1 (Failure):** What if I fall off the tree? → If `node == null`, return.
- **Stop 2 (Success):** When have I reached the target level? → When the distance ***k* reaches 0**, that node is the answer. Print it and return.

3. Write the Recursive Call (The One Step)

- You are at the current node. You have two options: go left or go right.
- `printKLevelsDown(node.left, k - 1);`
- `printKLevelsDown(node.right, k - 1);`

The combination of these simple rules defines the entire algorithm. You don't need to worry about what happens 10 levels deep; the recursion handles it.

💡 Why You Might Be Struggling (And How to Fix It)

Struggling with DSA is often a sign that you are moving from rote learning to **problem-solving**, which requires a different type of mental muscle.

1. The Recursion Barrier 😨

- **The Problem:** You are trying to manually trace the recursion stack in your head for the entire tree.
- **The Fix (The Faith):** Stop tracing the whole path! When writing a recursive function, assume the sub-problems (the recursive calls) **magically work**. Just focus on: "What is my job at this node, and what input do I pass to my children?" (See the algorithm above).

2. Lack of Pattern Recognition 🤯

- **The Problem:** You see a tree problem and think it's brand new.

- **The Fix (The Library):** Every tree problem is a variation of 3 or 4 fundamental patterns:
- **DFS (Pre/In/Post):** Good for height, size, or finding paths.
- **BFS (Level Order):** Good for shortest path, or anything involving layers (like your problem!).
- **Modify Return Type:** The problem requires returning some data (e.g., maximum depth, a path).
- **Modify Argument:** The problem requires passing extra state (like your required distance `k`).
- **Action:** When you see a new problem, immediately ask: **"Is this a DFS problem where I need to pass down extra state?"** (Yes, in this case, the state is `k`).

3. BFS vs. DFS Confusion 🔄

- **The Problem:** You might have initially thought of using a Queue (BFS) because the problem mentions "levels."
- **The Fix (Tool Choice):** While BFS can solve this, DFS is often simpler when you need to know the *distance* from the root.
- **BFS (Queue):** Good if you want the **output by level** (e.g., 50,25,75,...).
- **DFS (Recursion):** Good if you just want the **elements themselves** and can manage the depth using an argument like `k`.

Keep practicing these patterns, and your confidence will grow! Would you like to solve another variation of this, such as **"Print nodes K distance away from a specific *target node*?"**

From <https://gemini.google.com/app/4e0276445c9d3b85>

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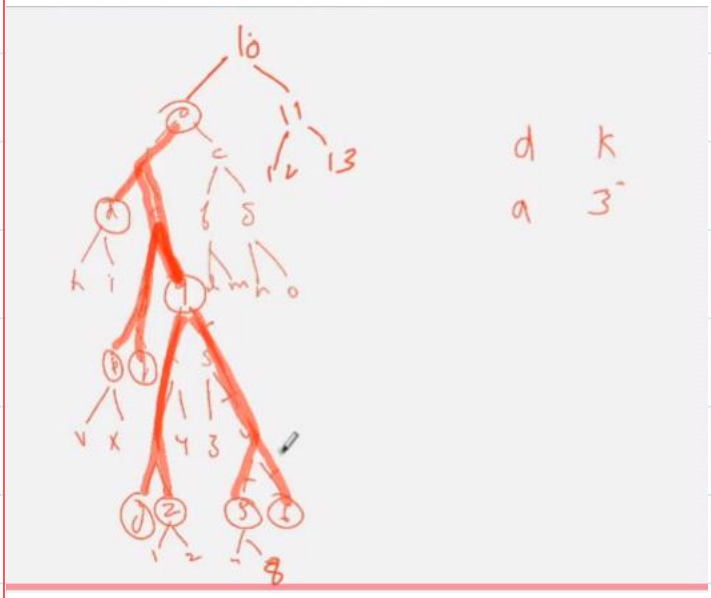
05 December 2025 09:42

Print Nodes K level Far



https://github.com/AlgoMagnet/0or1/blob/main/BinaryTree/BinaryTreeNodesKLevelFar.java

🧠 Algorithm: K Distance from Target Node

This problem is solved by splitting the search into two independent parts: **Down** (through the target's subtrees) and **Up** (through the target's ancestors).

Phase 1: Preparation (The Path Finder)

The goal of this phase is to establish a map for the upward search.

1. **Find the Path:** Use a modified DFS (your `nodeToRootPath` function) to find the path from the **Root** to the **Target**.
    - **Mantra:** Recursively search left/right. If the target is found in a sub-branch, add the **current node** to a global list (the `Path`) **before** returning `true`.
    - **Result:** The `Path` list now stores nodes from **Target** → **Parent** → **Grandparent** → ... → **Root.**

Phase 2: The Downward Search (The Simple Part)

This handles all the nodes below the target.

2. **Immediate Search:** Call the `printKLevelDown` helper function starting from the **Target node** itself, using the full distance K.
    - **Helper Logic:** The helper function works by simply decrementing k in each recursive call until $k = 0$ (the base case). Since no `blocker` is used here, it searches the target's entire subtree.

Phase 3: The Upward Search & Slicing (The Complex Part)

This handles all the nodes in the ancestors' *other* subtrees.

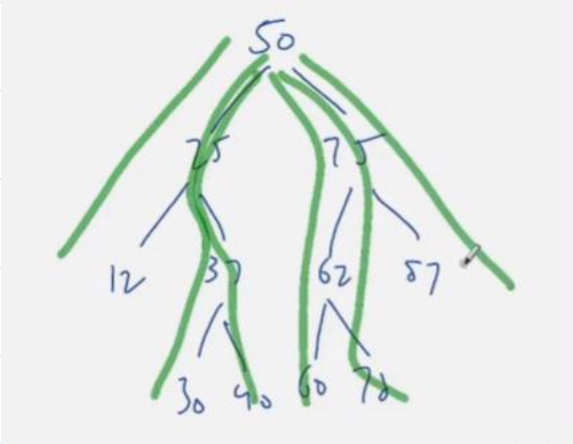
3. **Iterate Ancestors:** Loop through the `Path` array, starting from the **Target's Parent** ($i = 1$) up to the **Root**. In this loop:
   - **Current Node:** This is the **Ancestor** (`Path.get(i)`).
   - **Node-We-Came-From:** This is the child that connects the ancestor back to the target (`Path.get(i-1)`).
4. **Calculate Remaining Distance:** For each ancestor, calculate the remaining distance needed for the final jump:
   - **Distance Down to Target:** $d = i$ (this is the index in the `Path`).
   - **Required Distance for New Search:** $K_{\text{new}} = K - d$.
5. **Search the Other Side (Slicing):** Call the `printKLevelDown` helper function on the **Ancestor** with K_{new}, but critically, use the **Node-We-Came-From** as the **Blocker**.
   - **Blocker Logic:** The `blocker` parameter prevents the search from diving back down the branch that leads to the target, ensuring we only explore the ancestor's *other* subtree (the "fresh" side).

🛠️ Key Takeaway for Recall

The problem is solved by reducing it to a series of simple **"K Levels Down"** problems. The complexity lies only in:

1. **Finding the Path** (to know which direction is up).
2. **Calculating the correct** K_{new} (subtracting distance already covered).
3. **Setting the Blocker** (to avoid going back toward the target).

Path to leaf from root.



6 leaf nodes, so 6 node to leaf path

```
public static void pathToLeafFromRoot(Node node,
String path, int currentSum, int lo, int hi) {

        // Base Case 1: If the node is null,
terminate the path and return.
        if (node == null) {
            return;
        }
        // Calculate the new running sum up to the
current node.
        int newSum = currentSum + node.data;

        // Base Case 2: If the current node is a
leaf (end of a path).
        if (node.left == null && node.right ==
null) {

            // Check if the final path sum is
within the required range [lo, hi].
```

```
            if (newSum >= lo && newSum <= hi) {
                // Print the complete path
including the leaf node's data.
                System.out.println(path +
node.data);
            }
            return;
        }
        // Prepare the new path string to be
passed down.
        String newPath = path + node.data + " ->
";

        // Recursive Step 1: Go Left
        pathToLeafFromRoot(node.left, newPath,
newSum, lo, hi);

        // Recursive Step 2: Go Right
        pathToLeafFromRoot(node.right, newPath,
newSum, lo, hi);
    }
```

Left clone tree

07 December 2025 09:35

```
public static Node createLeftCloneTree(Node node){
     if(node == null){
         return null;
     }
     Node lcr = createLeftCloneTree(node.left);
     Node rcr = createLeftCloneTree(node.right);
     Node nl = new Node(node.data, lcr, null);
     node.left = nl;
     node.right = rcr;
     return node;
 }
```

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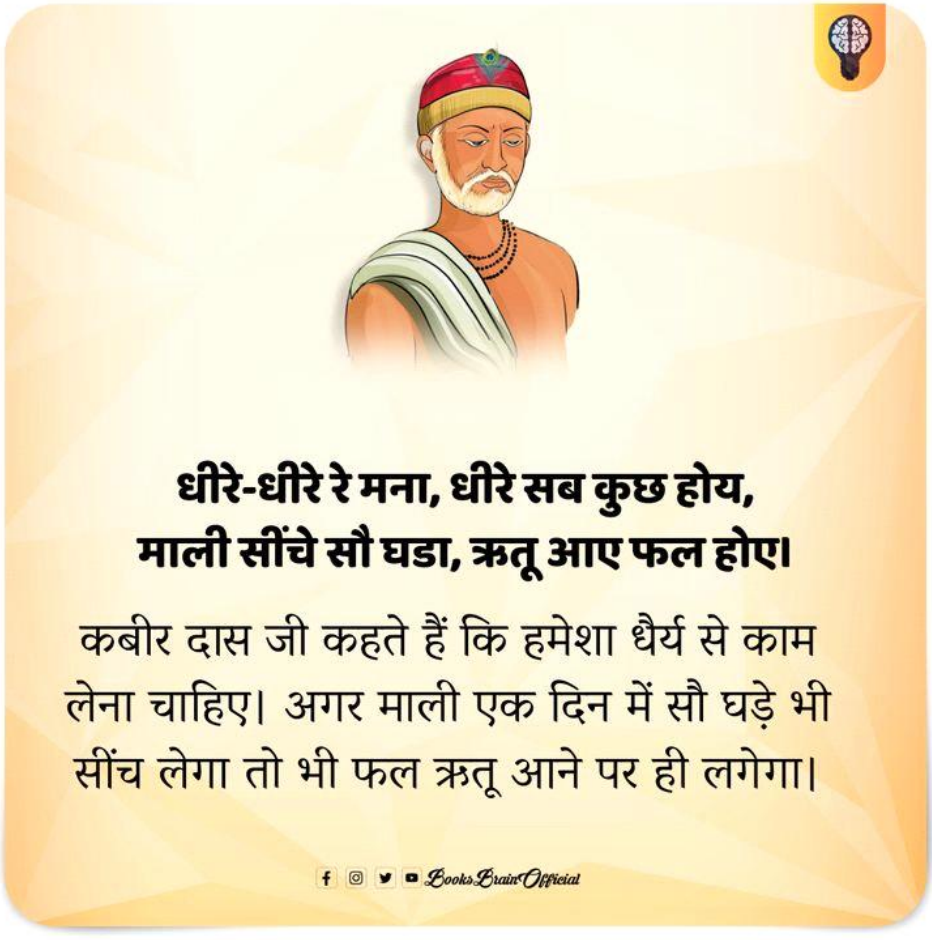
07 December 2025 09:17

धीरे-धीरे रे मना, □□□□ □□ □□□ □□□,
□□□□ □□□□□ □□ □□□□, ऋतु आए फल होय॥"

यह □□□ □□□□ का प्रसिद्ध दोहा है, जिसका अर्थ है कि मन में धीरज रखो, सब कुछ धीरे-धीरे और सही समय पर होता है; जैसे एक माली सौ घड़े पानी सींचने के बाद भी फल के लिए ऋतु (सही मौसम) का इंतज़ार करता है, वैसे ही हमें जल्दबाजी नहीं करनी चाहिए, क्योंकि हर काम का एक निश्चित समय होता है और उसे पूरा होने के लिए धैर्य और निरंतर प्रयास की ज़रूरत होती है.



High level understadnig ke baad, hameseha low level code ka dry run karo.

[Transform Back from a Left Cloned Tree | Solution | Binary Tree | Data Structure and Algorithm]

Watch from this time.

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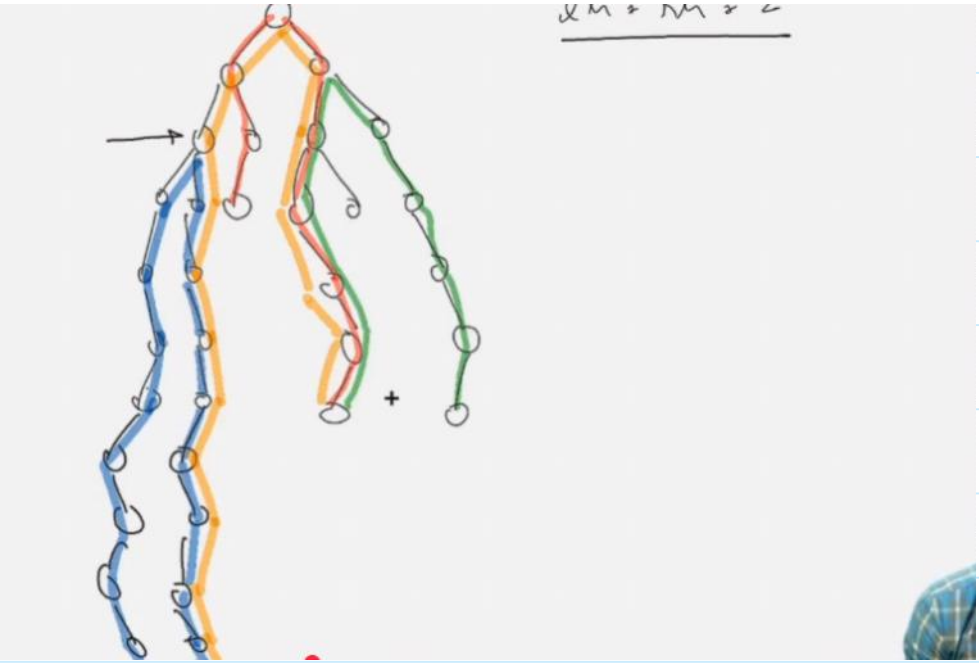
07 December 2025 09:19

Diameter of a binary tree.
(distance between two farthest nodes).

Diameter will not always pass from the root node



https://github.com/AlgoMagnet/0or1/blob/main/BinaryTree/BinaryTreeDiameter1.java

This is o(N square), here in post order after both diameter1 call, an euler is getting fired again for height.

The provided solution for calculating the diameter of a binary tree, implemented in the `diameter1` method, is **not efficient**.

It has a time complexity of $O(N^2)$ in the worst-case scenario, where N is the number of nodes in the tree.

Why it is $O(N^2)$

The inefficiency stems from calling the `height` function repeatedly inside the recursive `diameter1` function.

1. **The `diameter1(node)` function:**
   - Recursively calls itself twice: `diameter1(node.left)` and `diameter1(node.right)`.
   - Calls the `height` function twice: `height(node.left)` and `height(node.right)`.
2. **The `height(node)` function:**
   - Takes $O(N')$ time, where N' is the number of nodes in the subtree rooted at `node`. This is because it traverses the entire subtree.
3. **The Resulting Complexity:**
   - For the root node, `diameter1` calls `height` on the left and right subtrees, essentially performing a full tree traversal *just* to get the heights.
   - This height calculation happens at every single node in the tree during the diameter calculation.
   - In a **skewed tree** (worst case, like a linked list), the work done resembles: $N + (N-1) + (N-2) + \cdots + 1$, which is the sum of the first N integers, leading to an $O(N^2)$ overall time complexity.

🚀 The Efficient $O(N)$ Solution

The efficient way to calculate the diameter is to compute both the **height** and the **diameter** of a subtree simultaneously in a single pass of recursion. This reduces the time complexity to $O(N)$.

Method: Return a Pair/Custom Class

Instead of just returning the diameter, your recursive function should return a helper object containing both:

1. **Height** of the current subtree.
2. **Diameter** of the current subtree.

Here is how you would implement the $O(N)$ version (often called `diameter2` or similar):

Java

```java
public static class DiaPair {
    int height;
    int diameter;
}

public static DiaPair diameter2(Node node) {
    if (node == null) {
        DiaPair bp = new DiaPair();
        bp.height = -1; // -1 for null tree
        bp.diameter = 0;
        return bp;
    }

    DiaPair lp = diameter2(node.left);  // Result from left child
    DiaPair rp = diameter2(node.right); // Result from right child

    DiaPair mp = new DiaPair();

    // 1. Calculate new diameter through the current node
    int f = lp.height + rp.height + 2;

    // 2. The diameter of the current subtree is the max of the three possibilities
    mp.diameter = Math.max(f, Math.max(lp.diameter, rp.diameter));

    // 3. Calculate new height
    mp.height = Math.max(lp.height, rp.height) + 1;

    return mp;
}
```

This approach ensures every node is visited exactly once, making the solution linear, or $O(N)$.

It's a good video type to teach
[Diameter of Binary Tree (LeetCode 543) | Full Solution with Examples | Study Algorithms]

Untitled

07 December 2025 10:08

The transition from the $O(N^2)$ diameter approach (`diameter1`) to the efficient $O(N)$ approach (`diameter2`) is not something that naturally occurs to most students. It represents a fundamental shift in algorithmic thinking that is typically **taught as a key optimization concept** in data structures and algorithms courses.

Here's how you can think about the thought process and why it's a learned pattern:

🧠 The Thought Process: Identifying and Fixing Redundancy

The efficient approach is born from a critical analysis of the inefficient one. The core idea is to follow this pattern:

1. Identify the Redundancy (The Why)

- **Problem:** In the $O(N^2)$ approach (`diameter1`), for any given node, you are doing two separate full traversals of its entire subtree:
  - One traversal for the recursive call to find the **diameter** ($\text{diameter1}(\text{node.left})$).
  - A completely separate traversal for the call to find the **height** ($\text{height}(\text{node.left})$).
- **Realization:** Both the height and the diameter calculation require visiting every node in the subtree. Since we need both pieces of information to solve the problem at the current node, why traverse the subtree twice? *

2. Formulate the "Ask" (The How)

- The goal of the recursive call changes from: "What is your diameter?" to: "**What is the maximum information you can give me in one visit?**"
- For the current node to calculate its diameter, it needs three things from its children:
  1. The largest **diameter** found entirely within the left child's subtree.
  2. The largest **diameter** found entirely within the right child's subtree.
  3. The **height** of both the left and right subtrees (to calculate the diameter that passes *through* the current node).

Since we need the **Height** and the **Diameter** from the child in one call, the recursive function must be designed to return both pieces of data together—hence the need for a **Custom Return Type** (the `DioPair` class).

3. Implement the Consolidation (The Solution)

The $O(N)$ approach (`diameter2`) is a classic example of **memoization within recursion** or **dynamic programming on trees**, where you calculate and store *multiple* necessary values during a single post-order traversal:

1. **Recurse:** Call `diameter2` once on left, once on right.
2. **Combine/Compute:** When the calls return, you have the height and diameter from both sides.
3. **Update Height:** $\text{new\_height} = \max(\text{L.height}, \text{R.height}) + 1$
4. **Update Diameter:** $\text{new\_diameter} = \max(\text{L.diameter}, \text{R.diameter}, \text{L.height} + \text{R.height} + 2)$
5. **Return Pair:** Return the consolidated `DiaPair` containing both new values.

🎯 Conclusion: A Learned Algorithm Pattern

The concept of optimizing recursive calls by **returning a composite object that contains multiple calculated values** is a standard and essential **algorithmic pattern** that must be explicitly taught and practiced.

- **Has to be Taught:** The idea of using a `Pair` or custom class to return multiple results in a single recursion is a formal technique taught to achieve linear $O(N)$ efficiency in many tree problems (e.g., checking if a tree is balanced and finding its height simultaneously).
- **Not Natural:** While smart students might eventually stumble upon it, most will first arrive at the redundant $O(N^2)$ solution because it feels more intuitive to write separate functions for separate required values (like separate `diameter` and `height` functions).

Learning this pattern is crucial for solving similar complex tree problems efficiently!

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07 December 2025 12:14

Tilt of a binary tree.

The **tilt of a binary tree** is defined as the **sum of the tilts of all nodes** in the tree.

Node Tilt Definition

The **tilt of a single node** is the **absolute difference** between the sum of the node values in its left subtree and the sum of the node values in its right subtree.

$$\text{Tilt}(\text{Node}) = |\text{Sum}(\text{Left Subtree}) - \text{Sum}(\text{Right Subtree})|$$

- If a node is missing a left or right child, the sum of the corresponding subtree is treated as **0**.
- Leaf nodes always have a tilt of **0** because both their left and right subtrees are null (sum = 0).

Travel and change strategy

All will return the sum of itself and its children.
And will keep on changing a variable : tilt.

Return sum and change tilt.

https://github.com/AlgoMagnet/0or1/blob/main/BinaryTree/BinaryTreeTiltOfBT.java

It uses a single **Post-Order Traversal (Depth-First Search)** to simultaneously calculate the subtree sum and the node tilt at every step, achieving an optimal $O(N)$ **time complexity**, where N is the number of nodes.

This recursive approach successfully combines the two necessary calculations into a single depth-first traversal, avoiding the redundant work that would lead to an $O(N^2)$ solution.

💡 How the $O(N)$ Solution Works

The function `tiltOfBT(Node node)` doesn't just calculate the tilt; it is designed to perform two critical tasks simultaneously:

1. The Return Value (What the Parent Needs)

- The function **returns the total sum of all node values** in the subtree rooted at `node`.

$$\text{Return Value (Sum)} = \text{Sum(Left Subtree)} + \text{Sum(Right Subtree)} + \text{node.data}$$

2. The Side Effect (What the Tree Needs)

- During its execution, it calculates the **tilt for the current node** and accumulates it into the **static global variable** `tilt`.

$$\text{Node Tilt} = \left| \underbrace{\text{lt}}_{\text{Left Subtree Sum}} - \underbrace{\text{rt}}_{\text{Right Subtree Sum}} \right|$$

Line of Code	Purpose
`int lt = tiltOfBT(node.left);`	Recursively gets the **sum** of the left subtree.
`int rt = tiltOfBT(node.right);`	Recursively gets the **sum** of the right subtree.
`tilt += Math.abs(lt - rt);`	Calculates the **current node's tilt** and adds it to the running total.
`int sum = lt + rt + node.data;`	Calculates the **total sum** of the current subtree.
`return sum;`	Passes the subtree sum up to the parent node.

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🛠️ Minor Improvement (Best Practice)

While your logic is perfectly correct, using a **static variable (** `static int tilt` **)** is generally avoided in production code for recursive tree algorithms. This is because:

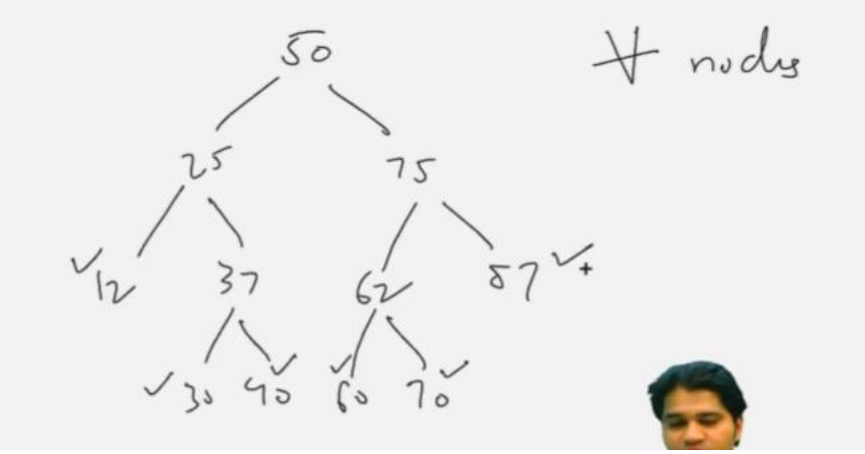
1. It is **not thread-safe**.
2. It requires the developer to **manually reset** it to `0` before calculating the tilt for a new tree.

A better practice is to wrap the logic inside a non-static public function and use a **wrapper object** (like an array or a custom class) or modify the function to return a composite result (similar to the $O(N)$ diameter solution).

However, given the context of a typical coding problem, the implementation you provided is the standard and most concise way to implement the $O(N)$ tilt algorithm.

Is a binary search tree

IN BST



For all nodes, left side children< node.data < right side children.

🌳 The BST Property for Each Node

The **Binary Search Tree (BST) Property** is a recursive rule that must hold true for **every single node** in the tree, making it an **ordered binary tree**.

For a given node with key N:

1. **Left Subtree Rule:** Every node in the **left subtree** must have a key value **less than** N.
2. **Right Subtree Rule:** Every node in the **right subtree** must have a key value **greater than** N.

$$\text{Left Subtree Key} < N < \text{Right Subtree Key}$$

Key Implications

- **Recursive Nature:** The left and right subtrees of a node must themselves also be Binary Search Trees.
- **Unique Keys (Typically):** In the strictest definition, keys in the tree must be unique (no duplicates). However, some implementations allow duplicates, often placing them all in the right subtree (i.e., less than or equal to for the left, and strictly greater than for the right, or vice versa).
- **Search Efficiency:** This property is what allows for fast searching, insertion, and deletion operations (on average $O(\log n)$ time complexity), as at each node, you eliminate half of the remaining data.

🧠 Algorithm: The Min/Max Range Check for BST (The Recursive Gatekeeper)

This algorithm focuses on the idea that every node acts as a **"gatekeeper"**, restricting the values its descendants can hold.

The Rule to Remember

Every node's data (N) must satisfy the condition:

$$\text{Min\_Bound} < N < \text{Max\_Bound}$$

Step-by-Step Algorithm (`isBST(Node, Min, Max)`)

Step	Focus	Condition / Action	Mnemonic
1. Stop	**Base Case**	**IF** `Node` is `NULL`, **RETURN** `TRUE`.	An empty branch is perfectly ordered.
---	---	---	---
2. Check	**Current Node**	**IF** `Node.data` $\leq$ `Min` **OR** `Node.data` $\geq$ `Max`, **RETURN** `FALSE`.	Does the current value obey its ancestors' rules?
---	---	---	---
3. Go Left	**Left Child**	**CALL** `isBST` on: `(Node.Left, Min, Node.Data)`	The left child must be less than the parent, so the parent becomes the **NEW MAX** restriction.
---	---	---	---
4. Go Right	**Right Child**	**CALL** `isBST` on: `(Node.Right, Node.Data, Max)`	The right child must be greater than the parent, so the parent becomes the **NEW MIN** restriction.
---	---	---	---
5. Combine	**Final Result**	**RETURN** the result of **(Step 3 AND Step 4)**.	If both halves are valid, the whole tree is valid.

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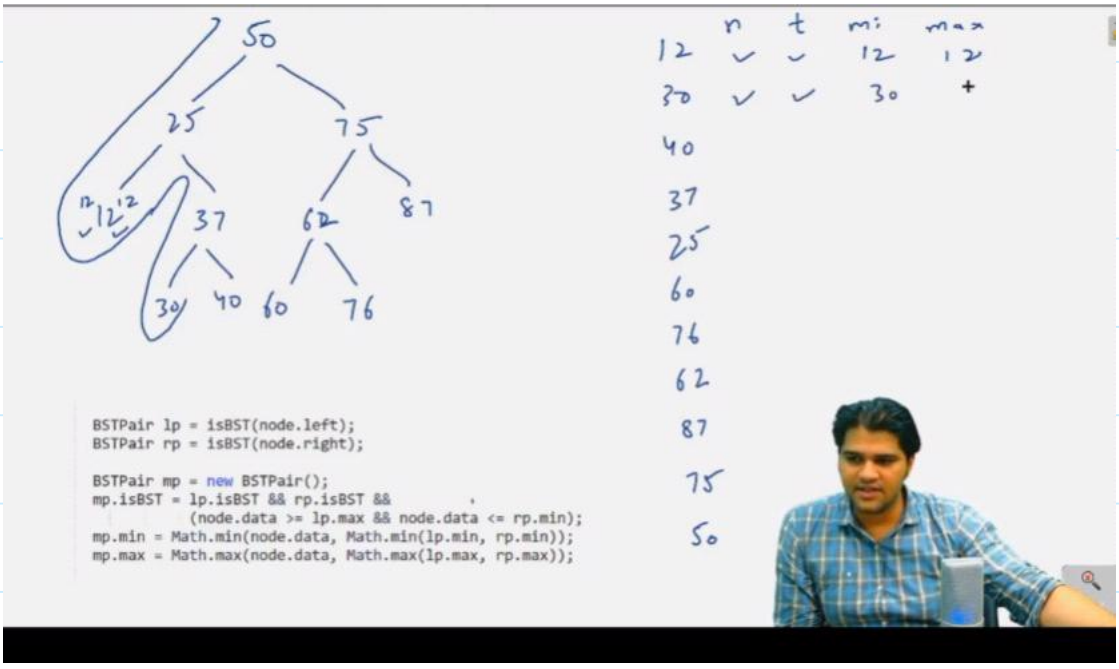
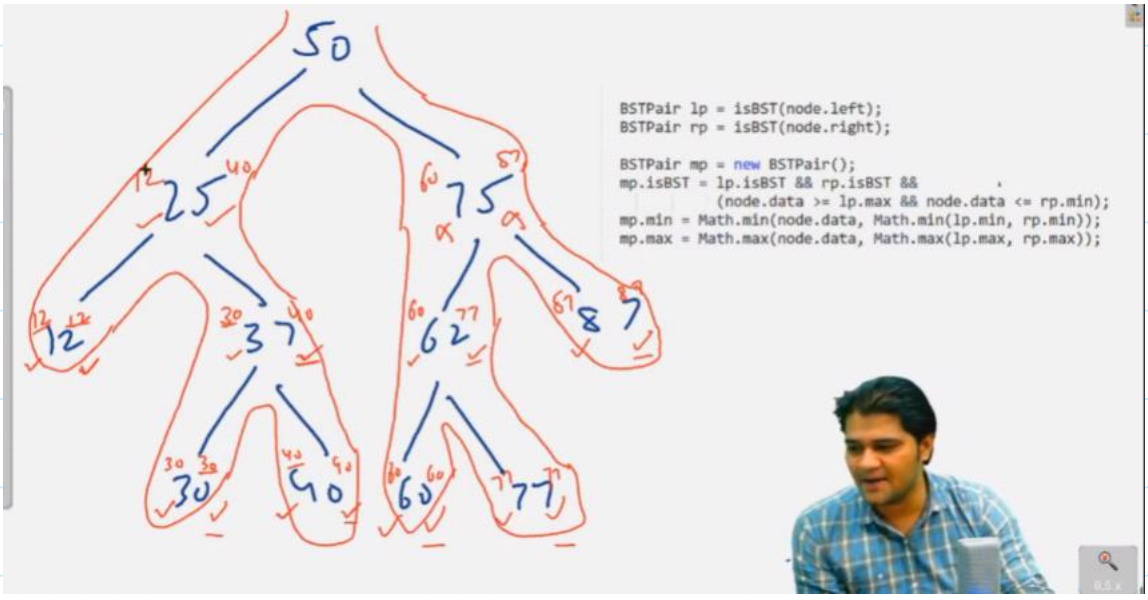
Initial Call Setup

To start the process at the root, you must use the absolute minimum and maximum values for your data type:

$$\text{isBST}(\text{Root}, \text{Negative\_Infinity}, \text{Positive\_Infinity})$$

https://github.com/AlgoMagnet/0or1/blob/main/BinaryTree/BinaryTreeIsBST.java

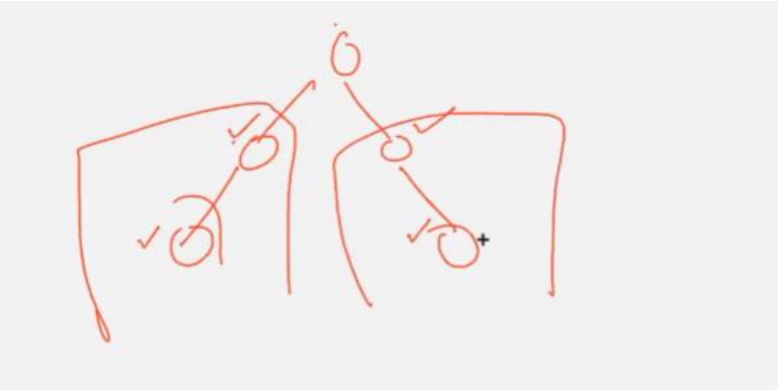




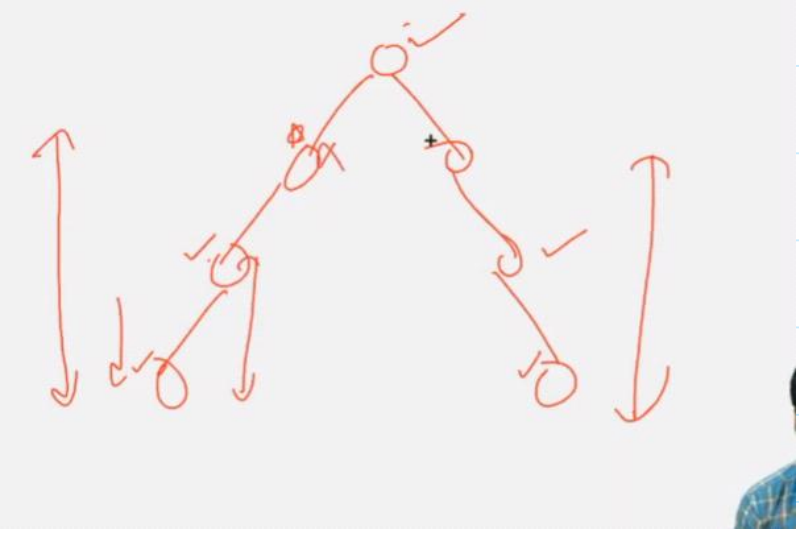
Is balanced tree

08 December 2025 09:51

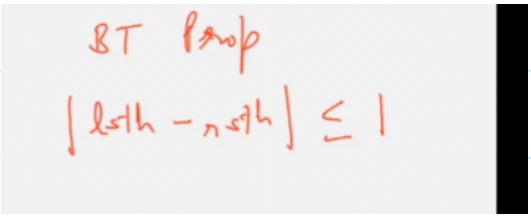
Pass case



Failed balanced tree property



Property



|Left sub tree ht - right sub tree ht| <=1

it from correctly calculating the height of the subtree. It also uses a **global static variable** (`isBal`) which is generally discouraged in recursive functions for its side effects, especially if the function is called multiple times on different trees.

https://github.com/AlgoMagnet/0or1/blob/main/BinaryTree/BinaryTreeIsBalanced.java

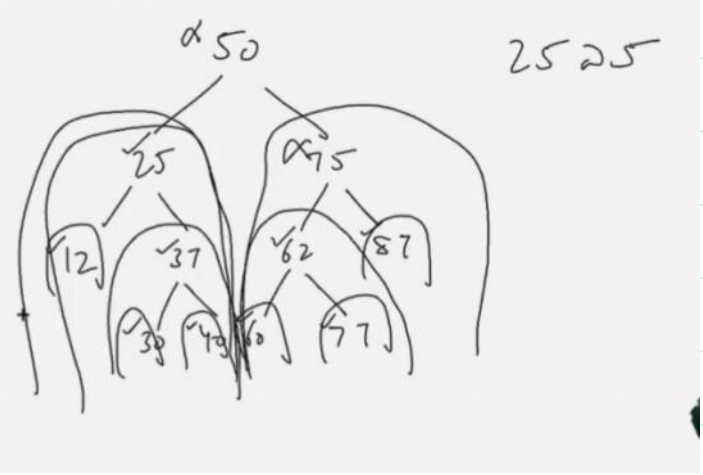
By using pair, instead of global static variable

https://github.com/AlgoMagnet/0or1/blob/main/BinaryTree/BinaryTreeIsBalancedOptimized.java

Untitled

08 December 2025 20:05

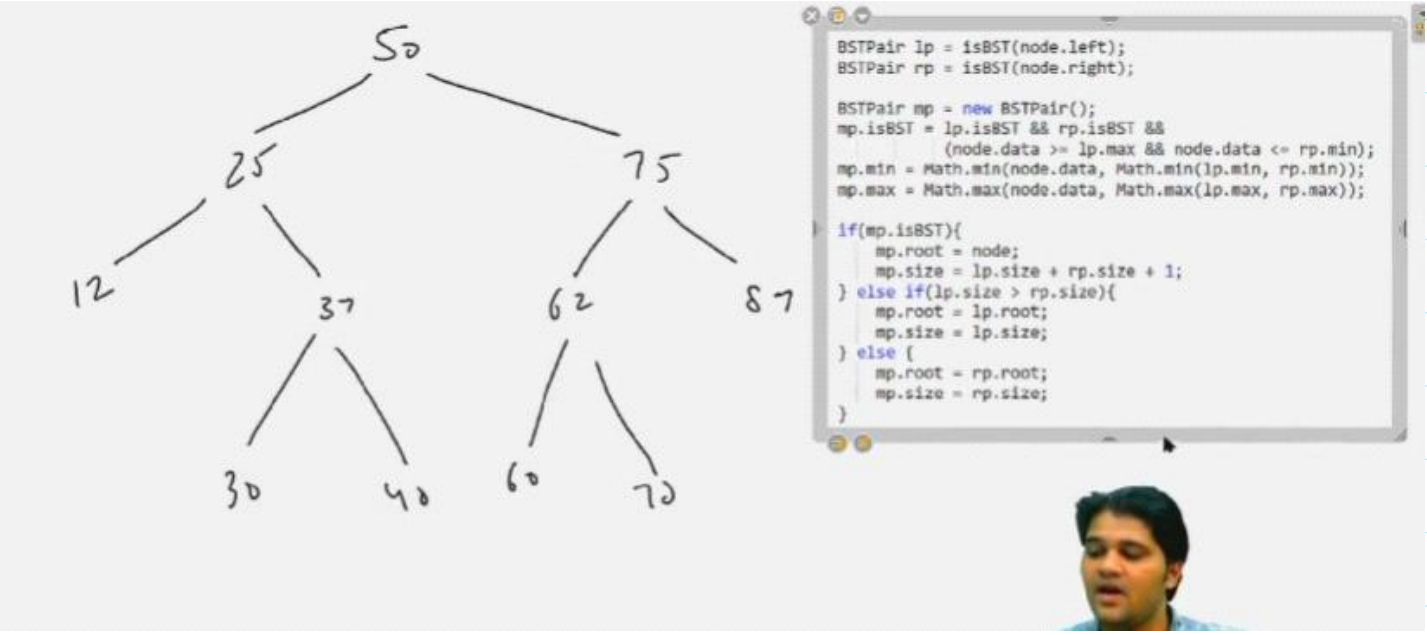
Largest binary search tree subtree.



The subtree which is bst and largest among all

https://github.com/AlgoMagnet/0or1/blob/main/BinaryTree/BinaryTreeLargestBSTSubtree.java

Do dry run on



[Largest BST Subtree - Solution | Binary Trees | Data Structure and Algorithms in JAVA]

watch only here to understand what is meaning of root and size.

Root or size on any node represent the largest bst subtree's root and size present under it.