Tree

树

All in one =>

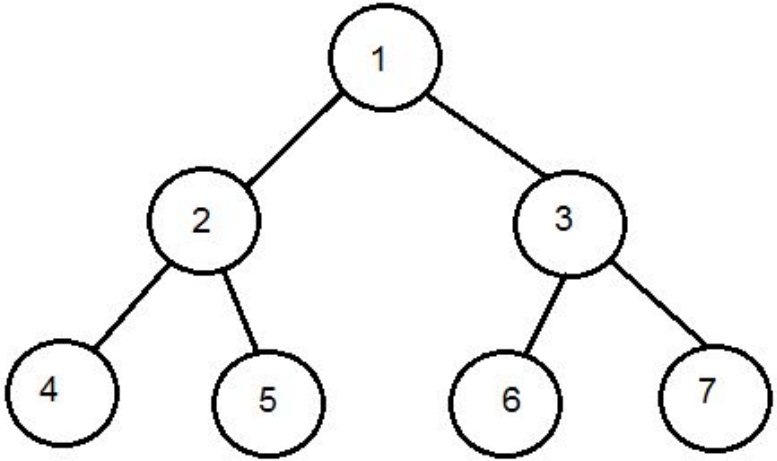
1. Preorder / Inorder / postorder traversal (and construct)
   - recursive(dfs) / iterative (stack)

2. Data Structure

3. DFS, return result of children

4. BFS, level order traversal

Inorder, preorder, postorder



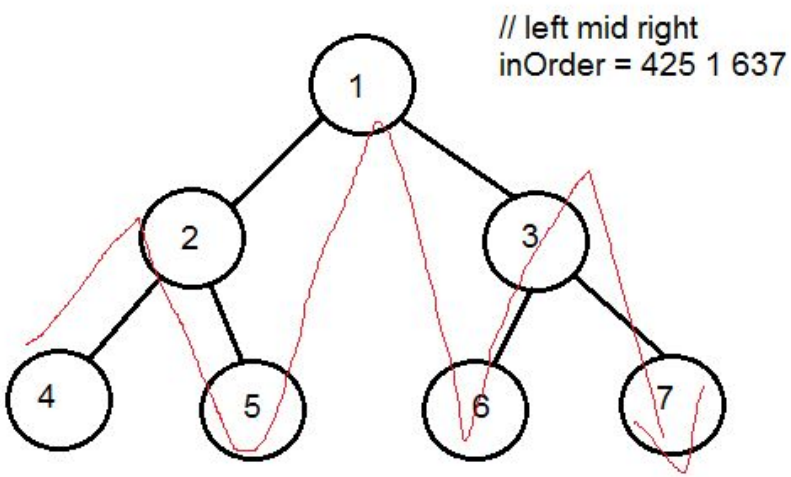
// left mid right
inOrder = 425 1 637

// mid left right
preOrder = 1 245 367

// left right mid
postOrder = 452 673 1

94. Binary Tree Inorder Traversal

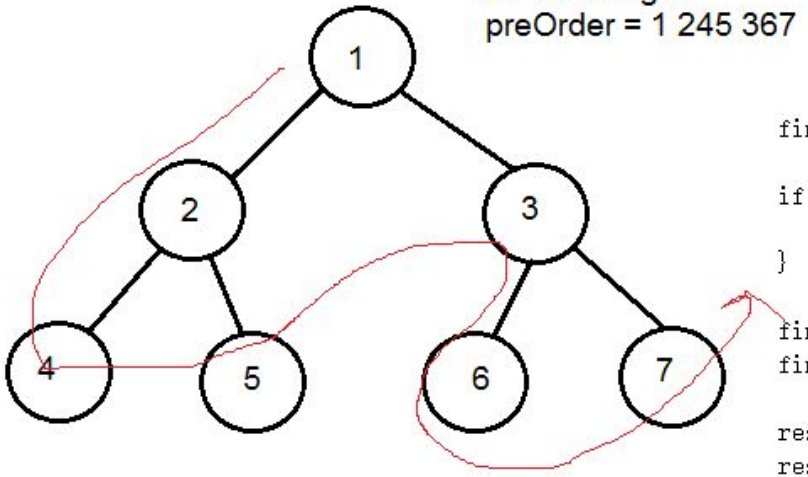
https://leetcode.com/problems/binary-tree-inorder-traversal/




```
final List<Integer> results = new LinkedList<>();

if (root == null) {
    return results;
}

final List<Integer> leftResults = inorderTraversal(root.left);
final List<Integer> rightResults = inorderTraversal(root.right);

results.addAll(leftResults);
results.add(root.val);
results.addAll(rightResults);

return results;
```

144. Binary Tree Preorder Traversal

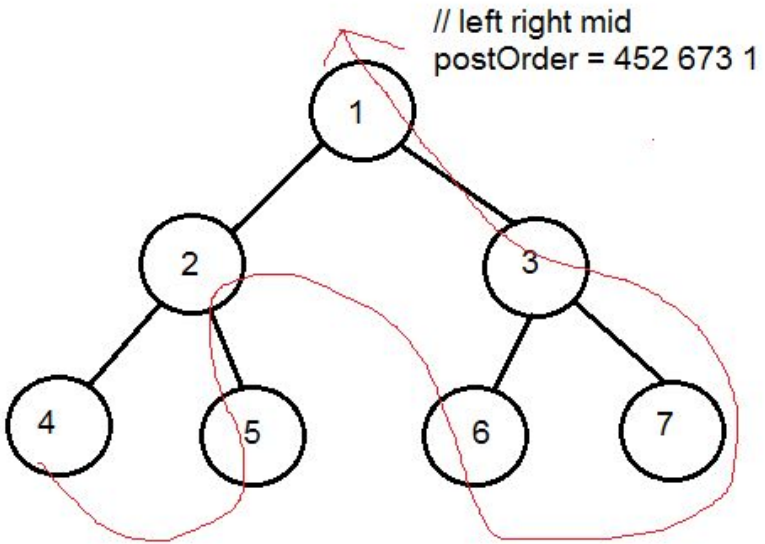
https://leetcode.com/problems/binary-tree-preorder-traversal/




```
final List<Integer> results = new LinkedList<>();

if (root == null) {
    return results;
}

final List<Integer> leftResults = preorderTraversal(root.left);
final List<Integer> rightResults = preorderTraversal(root.right);

results.add(root.val);
results.addAll(leftResults);
results.addAll(rightResults);

return results;
```

145. Binary Tree Postorder Traversal

https://leetcode.com/problems/binary-tree-postorder-traversal/




```
final List<Integer> results = new LinkedList<>();

if (root == null) {
    return results;
}

final List<Integer> leftResults = postorderTraversal(root.left);
final List<Integer> rightResults = postorderTraversal(root.right);

results.addAll(leftResults);
results.addAll(rightResults);
results.add(root.val);

return results;
```

105. Construct Binary Tree from Preorder and Inorder Traversal

https://leetcode.com/problems/construct-binary-tree-from-preorder-and-inorder-traversal/

Inorder ==> left root right

preorder ==> root left right

1. the root is preorder[0]

2. then find root in inorder array

3. now we know how many left nodes, then do it recursively.

```
if (iStart > iEnd || pStart > pEnd) { return null;}
final TreeNode treeNode = new TreeNode(preorder[pStart]);
int index = iStart;
while (iStart < inorder.length && inorder[index] != treeNode.val) {
    ++index;
}
treeNode.left =
        construct(inorder,
                iStart,
                index - 1,
                preorder,
                pStart + 1,
                pStart + index - iStart);
treeNode.right =
        construct(inorder,
                index + 1,
                iEnd,
                preorder,
                pStart + index - iStart + 1,
                pEnd);
return treeNode;
```

106. Construct Binary Tree from Inorder and Postorder Traversal

https://leetcode.com/problems/construct-binary-tree-from-inorder-and-postorder-traversal/

Inorder ==> left root right

postorder ==>left right root

1. the root is postorder[size-1]

2. then find root in inorder array

3. now we know how many left nodes, then do it recursively.

```
final TreeNode treeNode = new TreeNode(postorder[pEnd]);
int index = iStart;
while (iStart < inorder.length && inorder[index] != treeNode.val) {
    ++index;
}
treeNode.left =
        construct(inorder,
                iStart,
                index - 1,
                postorder,
                pStart,
                pStart + index - 1 - iStart);
treeNode.right =
        construct(inorder,
                index + 1,
                iEnd,
                postorder,
                pStart + index - iStart,
                pEnd - 1);
return treeNode;
```

889. Construct Binary Tree from Preorder and Postorder Traversal

https://leetcode.com/problems/construct-binary-tree-from-preorder-and-postorder-traversal/

preorder ==> root left right

postorder ==> left right root

1. root is preorder[0]

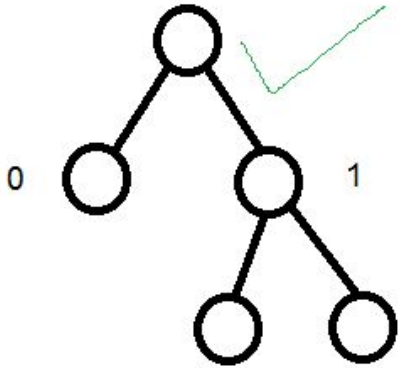
2. find the first left value, preorder[rootIndex +1]
in postorder,
the first left value in preorder is the last left value in postorder

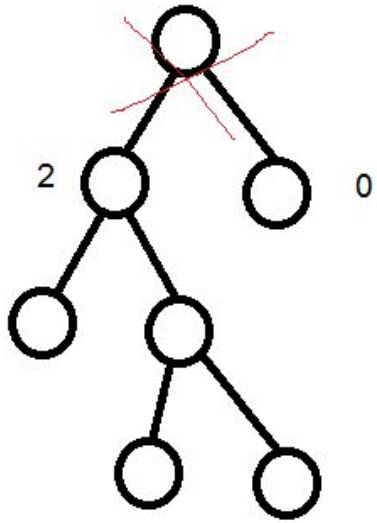
3. do it recursively.

```
/*
preorder = 1 245 367
postorder = 452 673 1
root = 1
leftStartValue = 2
then just find the 2 in postorder
 */
```

110. Balanced Binary Tree

https://leetcode.com/problems/balanced-binary-tree/





balanced ?

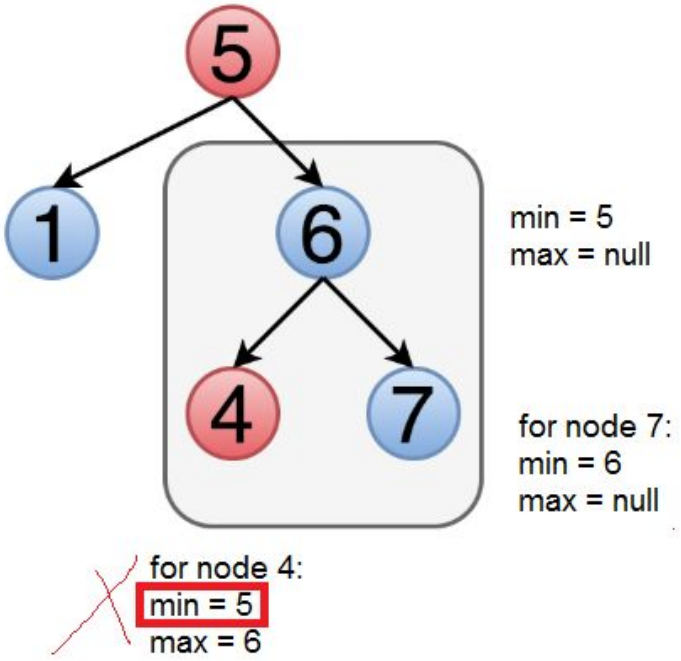
1. left tree is balanced ?

2. right tree is balanced ?

3. abs (leftHeight - rightHeight) <= 1

98. Validate Binary Search Tree

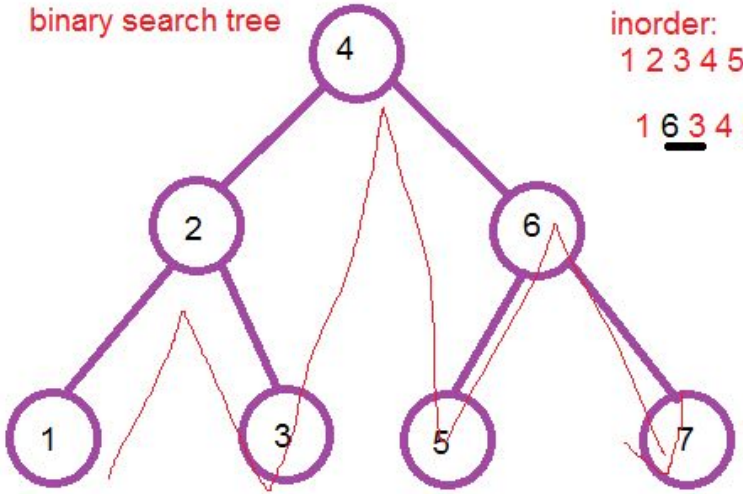
https://leetcode.com/problems/validate-binary-search-tree/




```
private boolean helper(TreeNode root, Integer min, Integer max) {
    if (root == null) {
        return true;
    }

    if (min != null && root.val <= min) {
        return false;
    }
    if (max != null && root.val >= max) {
        return false;
    }

    return helper(root.left, min, root.val) &&
           helper(root.right, root.val, max);
}
```

99. Recover Binary Search Tree

https://leetcode.com/problems/recover-binary-search-tree/



inorder:
1 2 3 4 5 6 7

1 6 3 4 5 2 7

current = 4

parent = 2
parent = 3

3. right = 4

current = 2

parent = 1
1. right = 2

current = 1

trait 1

current = 1.right = 2

parent = 1
but 1.right = 2 == current

so 1. right = null

trait 2

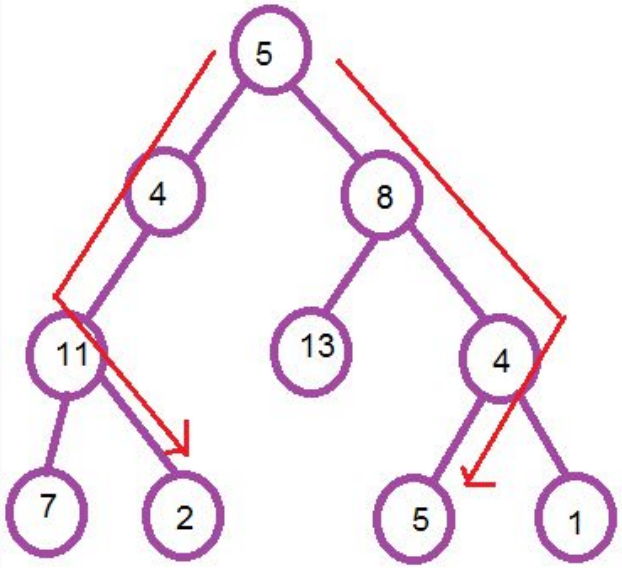
current = 3

trait 3

current = 3.right = 4

113. Path Sum II

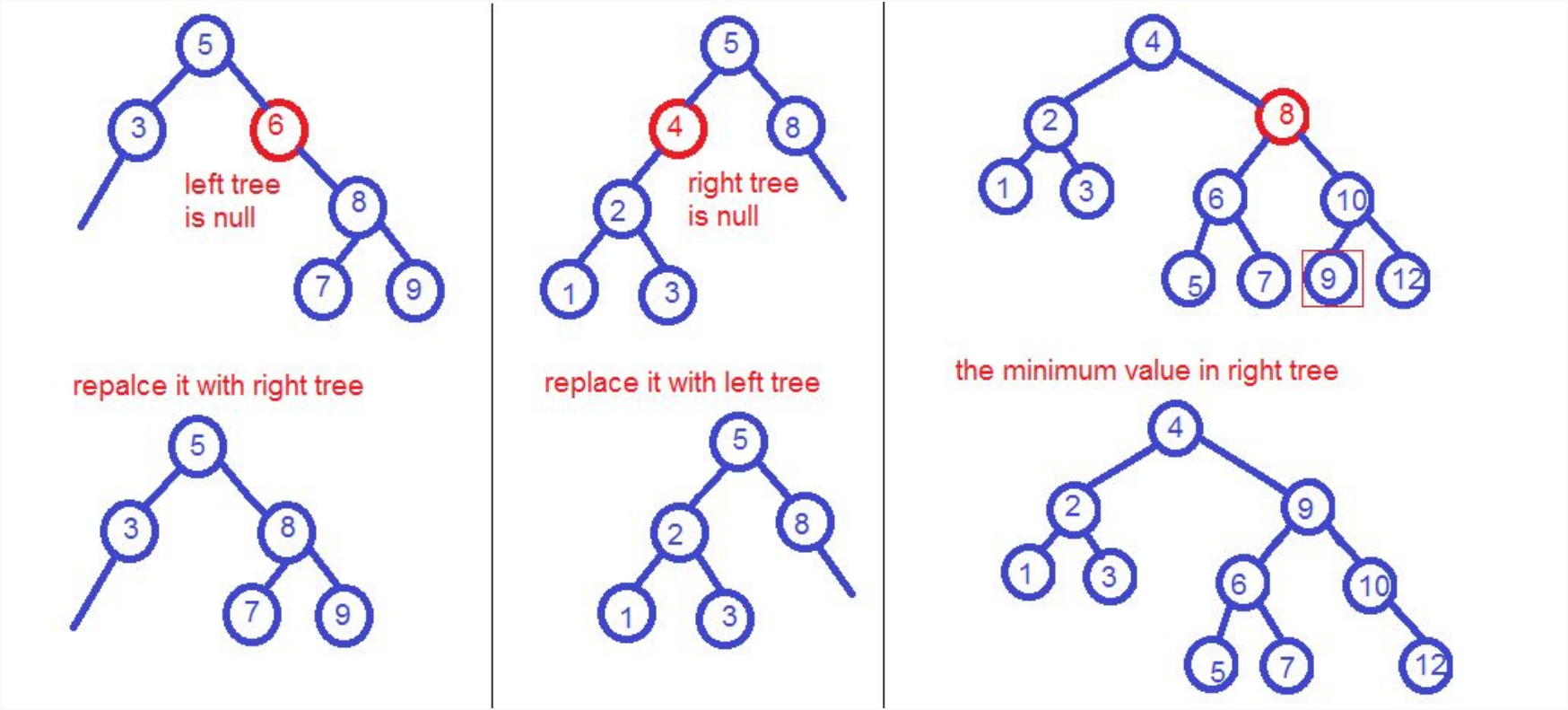
https://leetcode.com/problems/path-sum-ii/




```
private void helperDfs(
        TreeNode root,
        int current,
        int sum,
        List<Integer> subsets,
        List<List<Integer>> results) {
    if (root == null) { return; }
    subsets.add(root.val);
    final int currentSum = current + root.val;
    if (root.left == null && root.right == null) {
        if (currentSum == sum) {
            results.add(new ArrayList<>(subsets));
        }
        subsets.remove(subsets.size() - 1);
        return;
    }
    helperDfs(root.left, currentSum, sum, subsets, results);
    helperDfs(root.right, currentSum, sum, subsets, results);
    subsets.remove(subsets.size() - 1);
}
```

450. Delete Node in a BST

https://leetcode.com/problems/delete-node-in-a-bst/



116. Populating Next Right Pointers in Each Node

https://leetcode.com/problems/populating-next-right-pointers-in-each-node/

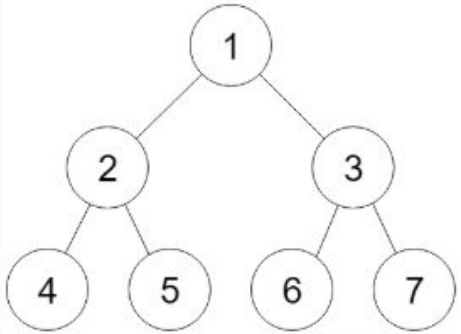


Figure A

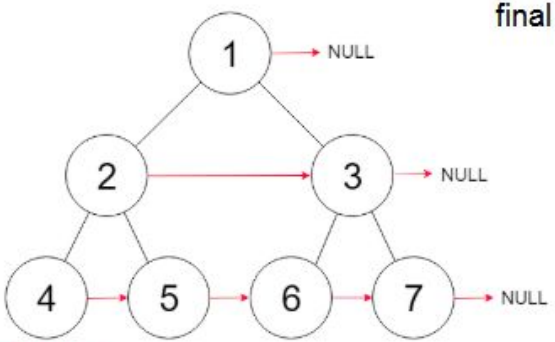


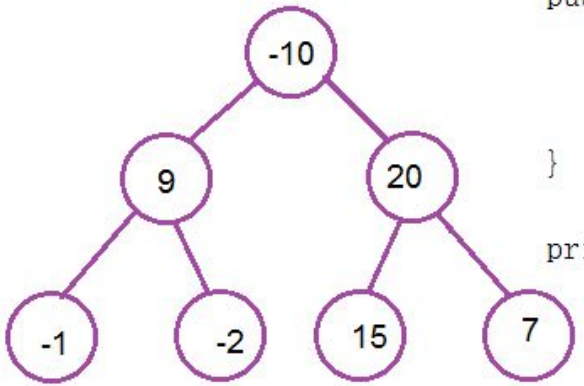
Figure B

```
while (start.left != null) {
    current = start;
    while (current != null) {
        current.left.next = current.right;
        if (current.next != null) {
            current.right.next = current.next.left;
        }
        current = current.next;
    }
    start = start.left;
}
```

```
final int currentSize = queue.size();
        Node previous = null;
        for (int size = 0; size < currentSize; size++) {
            final Node current = queue.poll();
            if (previous != null) {
                previous.next = current;
            }
            previous = current;
            if (current.left != null) {
                queue.offer(current.left);
            }
            if (current.right != null) {
                queue.offer(current.right);
            }
        }
```

124. Binary Tree Maximum Path Sum

https://leetcode.com/problems/binary-tree-maximum-path-sum/

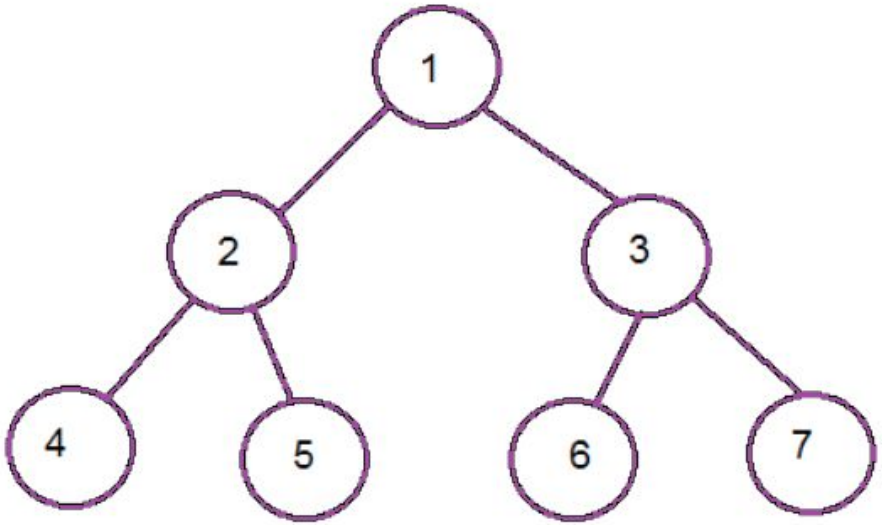


1. if child node < 0, then take 0
2. for each node, the sum will be
   maxOf(left,right) + current value

```
public int maxPathSum(TreeNode root) {
    result = Integer.MIN_VALUE;
    dfs(root);
    return result;
}

private int dfs(TreeNode root) {
    if (root == null) {
        return 0;
    }
    final int leftResult = Math.max(0, dfs(root.left));
    final int rightResult = Math.max(0, dfs(root.right));
    result = Math.max(result, leftResult + rightResult + root.val);
    return Math.max(leftResult, rightResult) + root.val;
}
```

297. Serialize and Deserialize Binary Tree

https://leetcode.com/problems/serialize-and-deserialize-binary-tree/



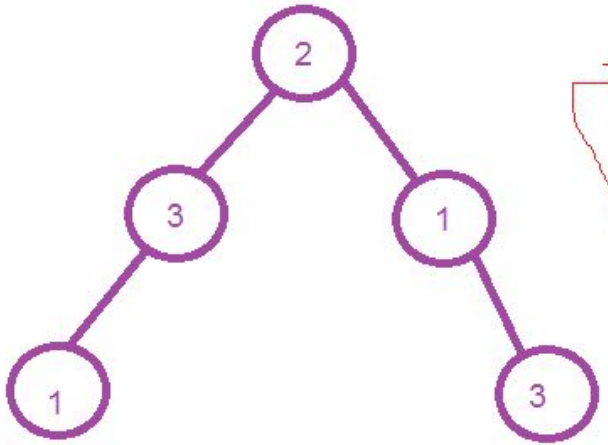
// left mid right
inOrder = 425 1 637

// mid left right
preOrder = 1 245 367

// left right mid
postOrder = 452 673 1

337. House Robber III

https://leetcode.com/problems/house-robber-iii/



main idea is to keep an array of length 2, see comments

```
/*
results[0] : take current node value
results[1] : do not take current, but take child nodes' values
 */
private fun dfs(root: TreeNode?): IntArray {
    if (root == null) {
        return intArrayOf(0, 0)
    }
    if (root.left == null && root.right == null) {
        return intArrayOf(root.`val`, 0)
    }
    val leftResults = dfs(root.left)
    val rightResults = dfs(root.right)
    val results = IntArray(2)
    // take current, so we can't take child nodes' values
    results[0] = root.`val` + leftResults[1] + rightResults[1]
    // do not take current, take max of left/right
    results[1] = maxOf(leftResults[0], leftResults[1]) +
            maxOf(rightResults[0], rightResults[1])
    return results
}
```

501. Find Mode in Binary Search Tree

https://leetcode.com/problems/find-mode-in-binary-search-tree/

[1 2 2 4 4 6 6 6 6 7] how to find mode?

1. define a results to store temp candidat.
2. preValue, max, count

recurrsive inorder traversal

iterative inorder traversal (stack)

```
// compare with preValue
if (preValue == current.`val`) {
    ++count
} else {
    count = 1
}

// compare with max
if (count > max) {
    max = countds
    results.clear()
    results.add(current.`val`)
} else if (count == max) {
    results.add(current.`val`)
}

// reassign preValue
preValue = current.`val`
```

530. Minimum Absolute Difference in BST

https://leetcode.com/problems/minimum-absolute-difference-in-bst/

BST : Binary Search Tree

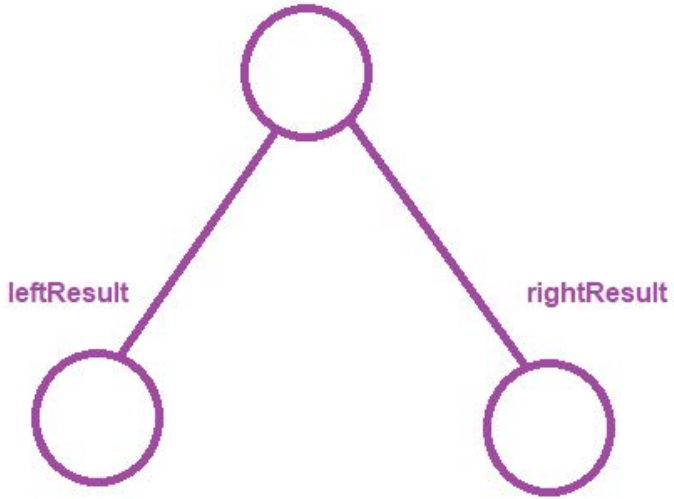
Left < Mid(root) < Right

if we do an inorder traversal, the results list is in acscending order!

1. recursive inorder traversal
2. iterative inorder traversal

Divide and Conquer

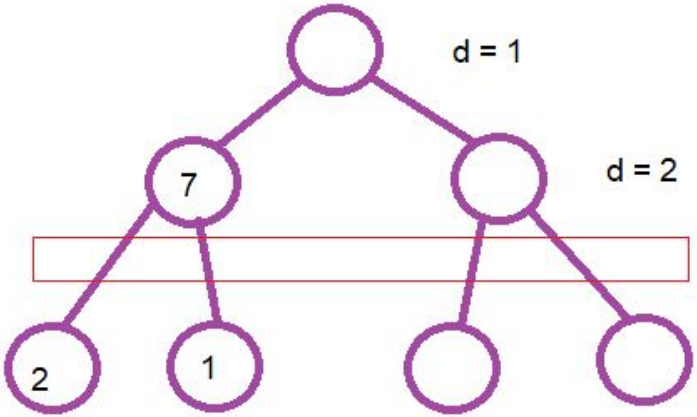
Divide and Conquer




```
private int dfs(TreeNode root) {
   if (root == null) {
      return 0;
   }
   final int leftVal = dfs(root.left);
   final int rightVal = dfs(root.right);
   sum += Math.abs(leftVal - rightVal);
   return leftVal + rightVal + root.val;
}
```

623. Add One Row to Tree

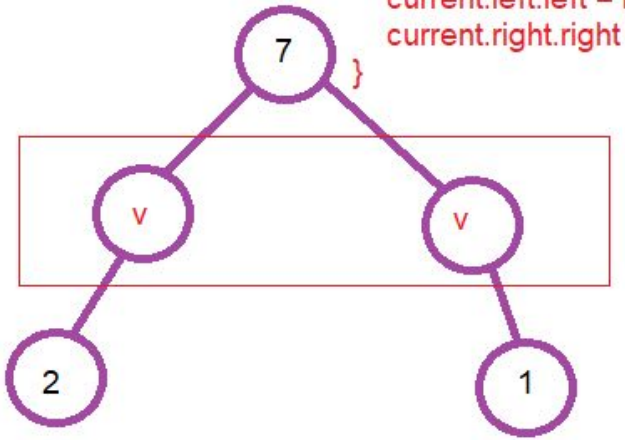
https://leetcode.com/problems/add-one-row-to-tree/



aim (d = 3)

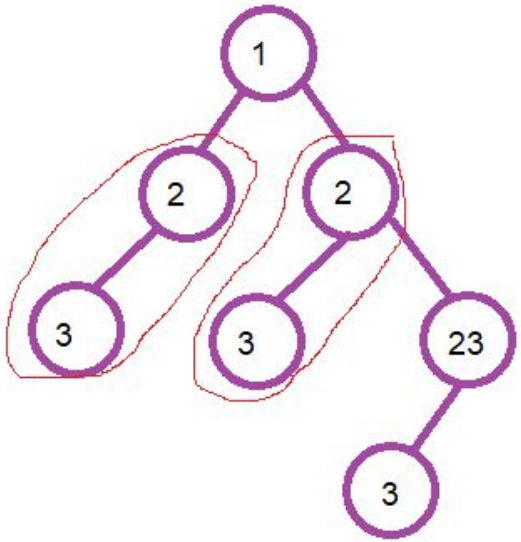
d = 3

```
// now in queue is the level we should handle
while (!queue.isEmpty()) {
    final TreeNode current = queue.poll();
    final TreeNode left = current.left;
    final TreeNode right = current.right;
    current.left = new TreeNode(v);
    current.right = new TreeNode(v);
    current.left.left = left;
    current.right.right = right;
}
```

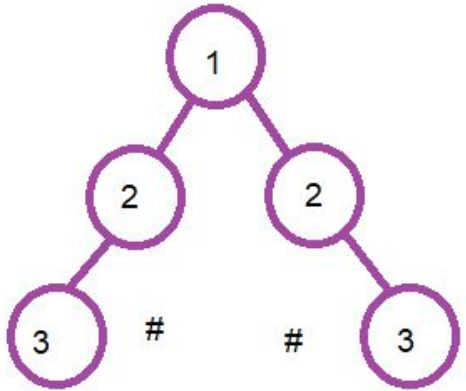


652. Find Duplicate Subtrees

https://leetcode.com/problems/find-duplicate-subtrees/



1,(2,3),(2,3),23,3



653. Two Sum IV - Input is a BST

https://leetcode.com/problems/two-sum-iv-input-is-a-bst/

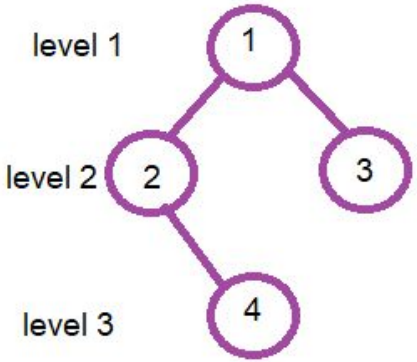
1. Two Sum : use HashMap to store value,index, O(N) S(N)

2. Two Sum sorted array : binary search! log(n) * log(n)

3. Two Sum BST: O(N) S(N)

655. Print Binary Tree

https://leetcode.com/problems/print-binary-tree/

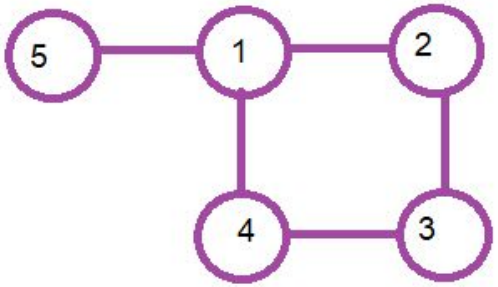


1	2	3	4	5	6	7
			1			
	2				3	
		4				

1. get the height of tree, 3
2. width is 1 << height, 8
3. the index of root node is width >> 1, 4
4. current distance is width >> 2, is 2
   so left node index is 4 -2 = 2
   so right node index is 4 +2 = 6
5. current distance >>= 1

684. Redundant Connection

https://leetcode.com/problems/redundant-connection/



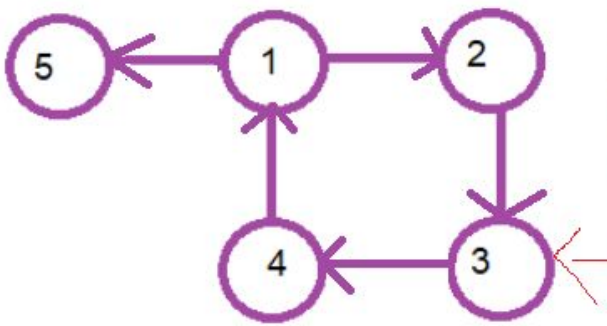
[1,2]
[2,3]
[3,4]
[1,4]
[1,5]

1. for each edge, add it to graph
2. if an edge is already in graph, and can connect, return it
3. use BFS or DFS to check the connection

```
for (edge in edges) {
    if (graph[edge[0]].isNotEmpty() && graph[edge[1]].isNotEmpty() && bfs(graph, edge[0], edge[1])) {
        return edge
    }
    graph[edge[0]].add(edge[1])
    graph[edge[1]].add(edge[0])
}
```

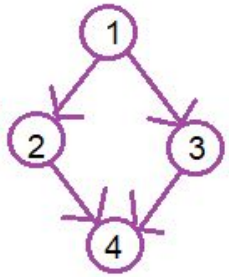
685. Redundant Connection II

https://leetcode.com/problems/redundant-connection-ii/



[1,5]
[1,2]
[2,3]
[3,4]
[4,1]

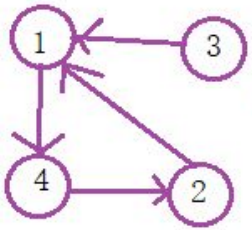
two cases of redundant connections:
1. one node has two parents
2. every node has one parent



[1,2]
[1,3]
[2,4]
[3,4]

orbit function
start from 1.
seen = [1,4,3,2]

return the last node that edge [0] [1] are both in seen,
which is [4,1]



[2,1]
[3,1]
[4,2]
[1,4]

remove [2,1]

DFS on tree

DFS == Recursion

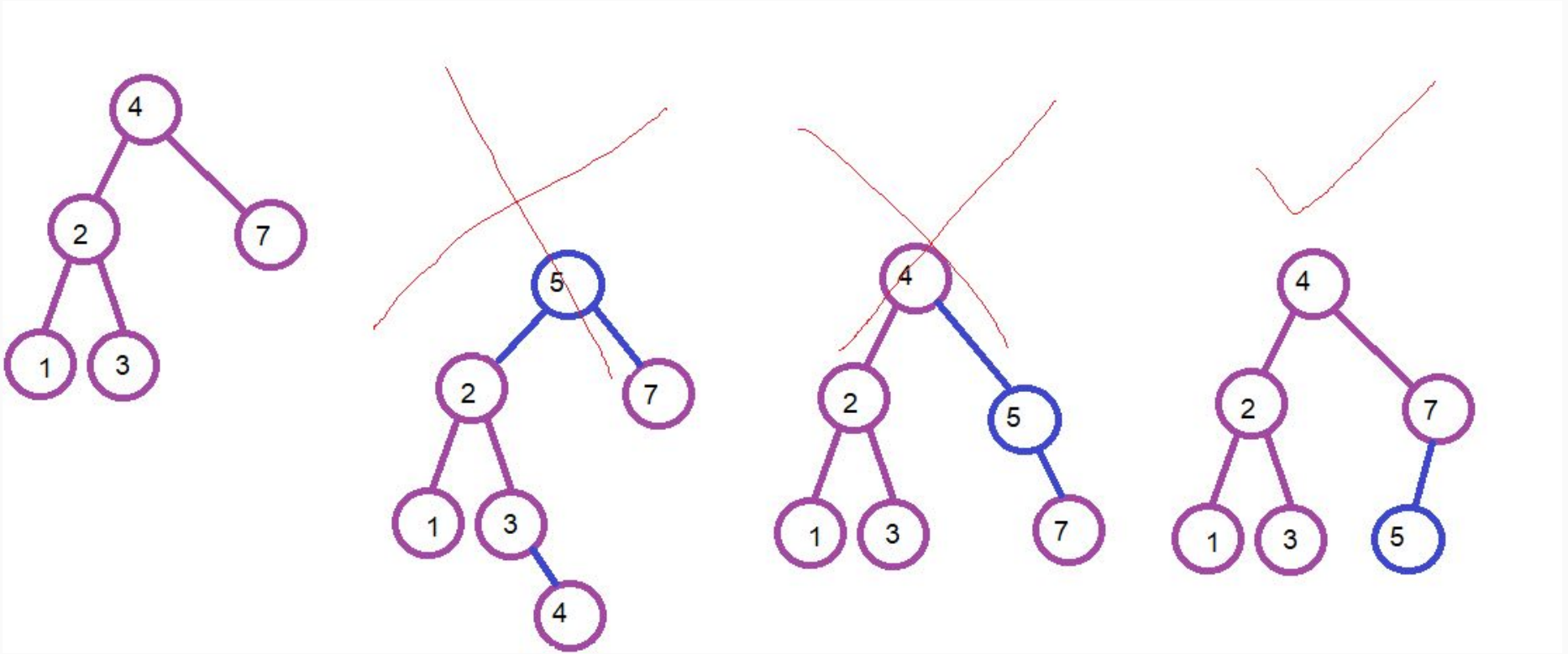
1. definition
2. end condition
3. call dfs

leftResult = dfs
rightResult = dfs

root.val ?

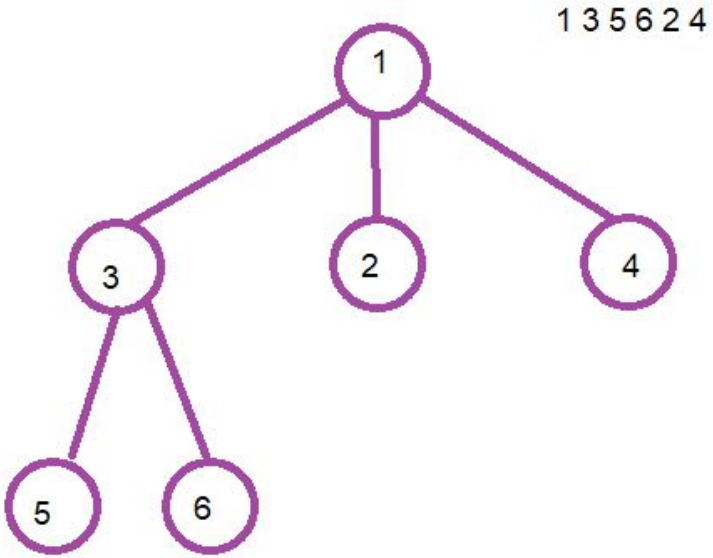
701. Insert into a Binary Search Tree

https://leetcode.com/problems/insert-into-a-binary-search-tree/



589. N-ary Tree Preorder Traversal & 590. N-ary Tree Postorder Traversal

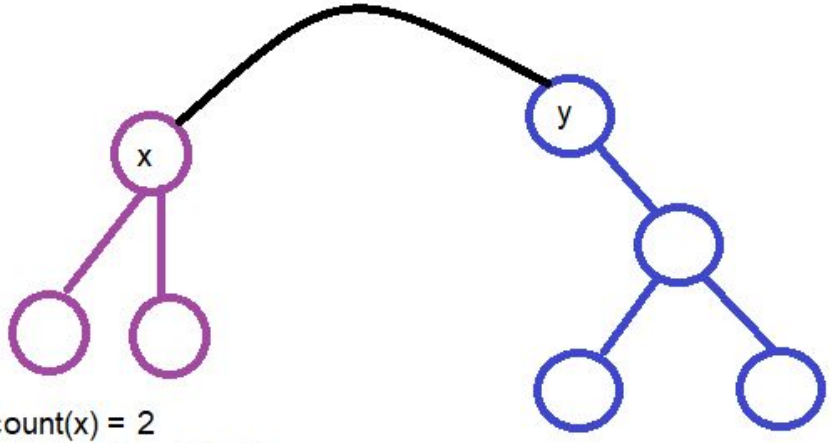
https://leetcode.com/problems/n-ary-tree-preorder-traversal/




```
public List<Integer> preorder(Node root) {
    final List<Integer> results = new LinkedList<>();
    if (root == null) {
        return results;
    }
    results.add(root.val);
    for (Node child : root.children) {
        results.addAll(preorder(child));
    }
    return results;
}
```

834. Sum of Distances in Tree

https://leetcode.com/problems/sum-of-distances-in-tree/



count(x) = 2
subTreeSum(x) = 2

count(y) = 4
subTreeSum(y) = 5

answer[x] = subTreeSum(x) + subTreeSum(y) + count(y) = 2 + 5 + 4 = 11
answer[y] = subTreeSum(y) + subTreeSum(x) + count(x) = 5 + 2 + 2 = 9
answer[x] - answer[y] = count(y) - count(x)

answer[x] = answer[y] + (N - count(x)) - count(x)

1. convert edges to graph
2. use post order traversal to calculate
   => count(?)
   => subTreeSum(?)

count(k) += all children
subTreeSum(k) = subTreeSum(children) +
count(children)

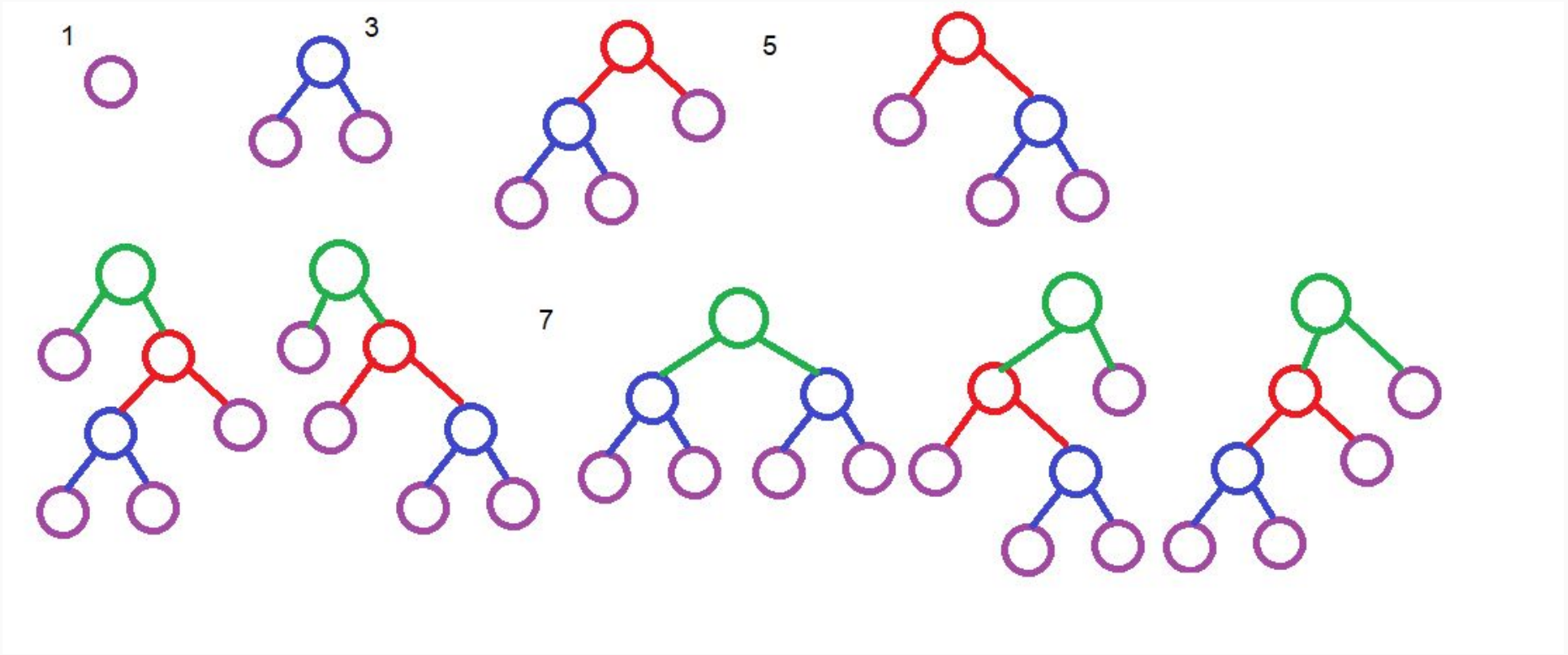
so we have the right answer for root

3. for each child, use preorder traversal

answer[child] = answer[Parent]
+ (N - count(child))
- count(child)

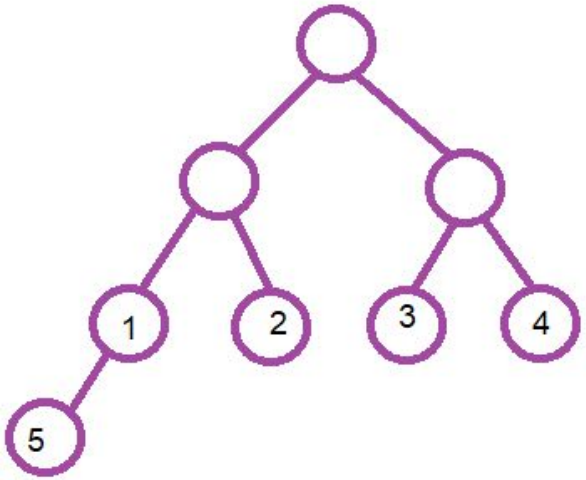
894. All Possible Full Binary Trees

https://leetcode.com/problems/all-possible-full-binary-trees/



919. Complete Binary Tree Inserter

https://leetcode.com/problems/complete-binary-tree-inserter/



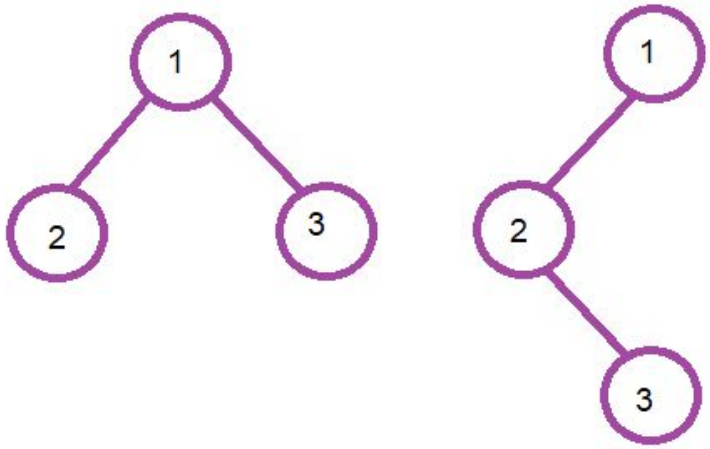
1. bfs to find uncompleted nodes (left == null || right == null)

2. add them into a queue

3. when insert, peek() a parent in queue, after add new node, if parent node is compeleted, queue.pop().

951. Flip Equivalent Binary Trees

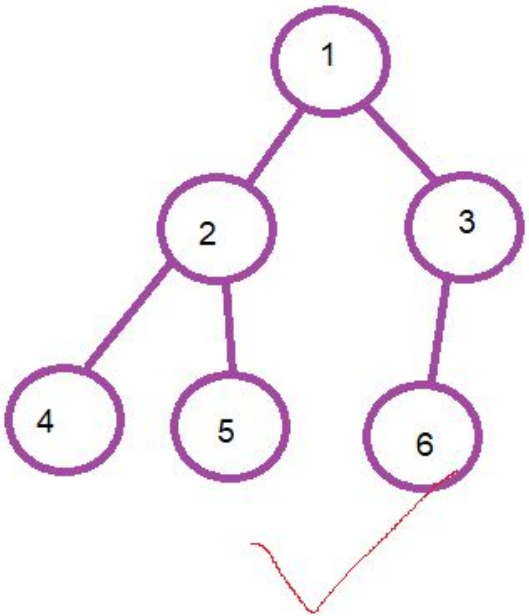
https://leetcode.com/problems/flip-equivalent-binary-trees/




```
private void traversal(TreeNode node, List<Integer> results) {
    if (node == null) {
        results.add(null);
        return;
    }
    results.add(node.val);
    final int left = node.left == null ? -1 : node.left.val;
    final int right = node.right == null ? -1 : node.right.val;
    if (left < right) {
        traversal(node.left, results);
        traversal(node.right, results);
    } else {
        traversal(node.right, results);
        traversal(node.left, results);
    }
}
```

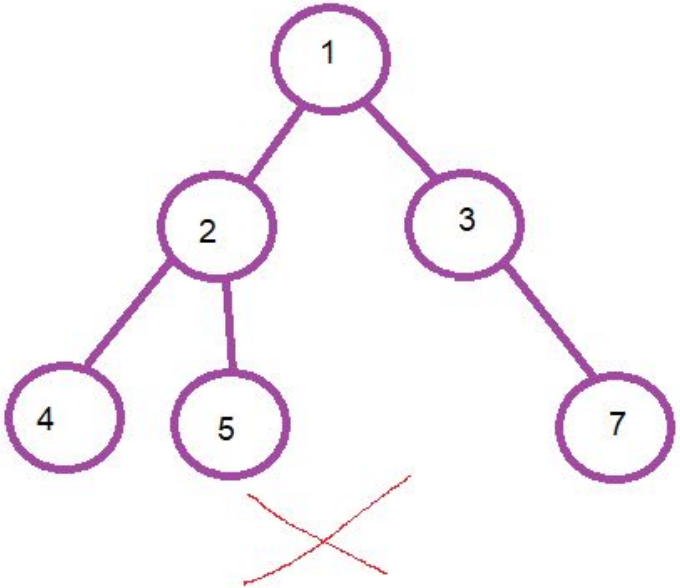
958. Check Completeness of a Binary Tree

https://leetcode.com/problems/check-completeness-of-a-binary-tree/



value = 2

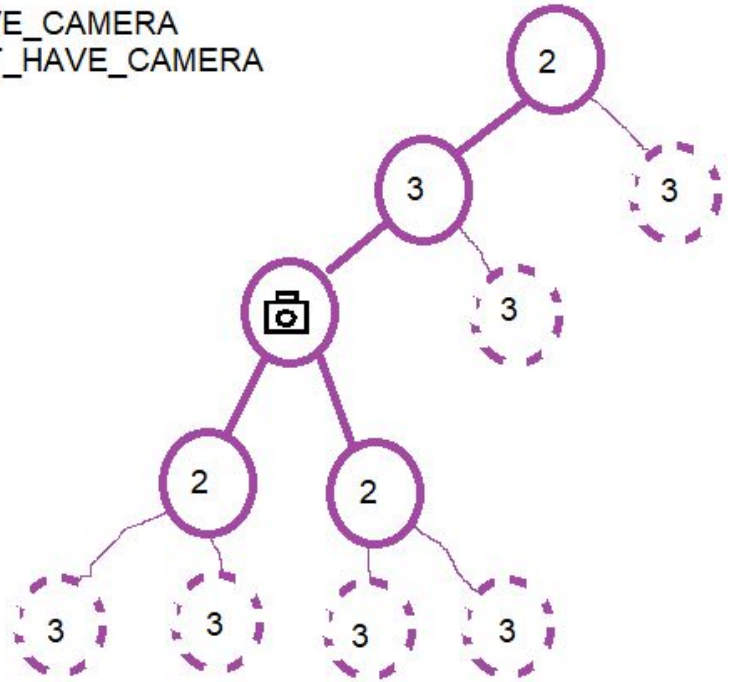
left = value * 2 = 4
right =value * 2 + 1 = 5



968. Binary Tree Cameras

https://leetcode.com/problems/binary-tree-cameras/

1. CAMERA
2. MUST_HAVE_CAMERA
3. MUST_NOT_HAVE_CAMERA



if node == null, 3

if one child is 2, then current is CAMERA

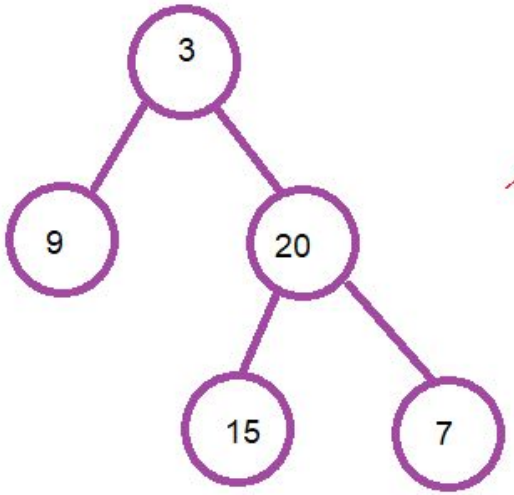
if one child is CAMERA, then current is 3

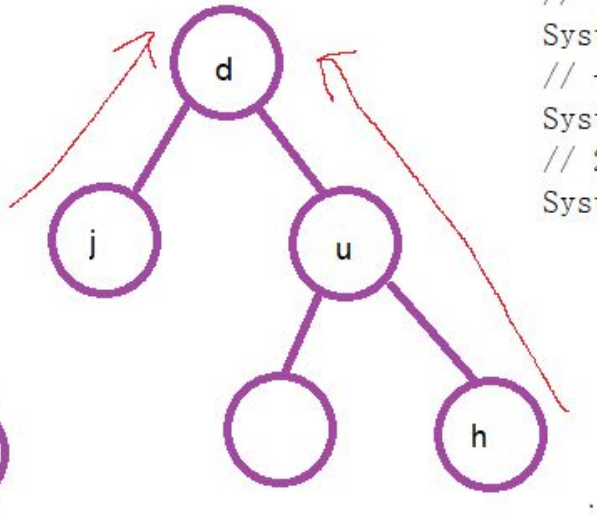
else (both children are 3), current is 2

notice that if root is type 2, result++

988. Smallest String Starting From Leaf

https://leetcode.com/problems/smallest-string-starting-from-leaf/

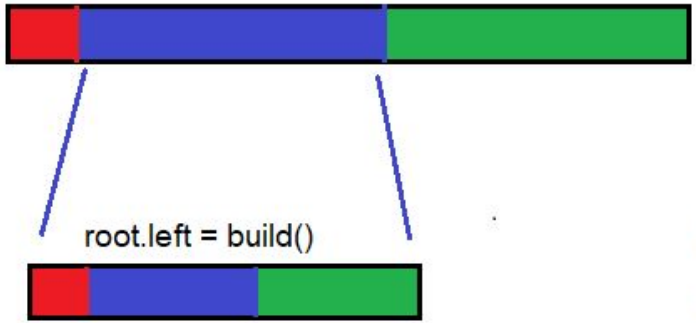





```
// -1
System.out.println(Integer.compare(0, 1));
// -1
System.out.println("ab".compareTo("abc"));
// 2
System.out.println("jd".compareTo("hud"));
```

1028. Recover a Tree From Preorder Traversal

https://leetcode.com/problems/recover-a-tree-from-preorder-traversal/



root, left, right

1 - 2 - - 3 - - 4 - 5 - - 6 - - 7

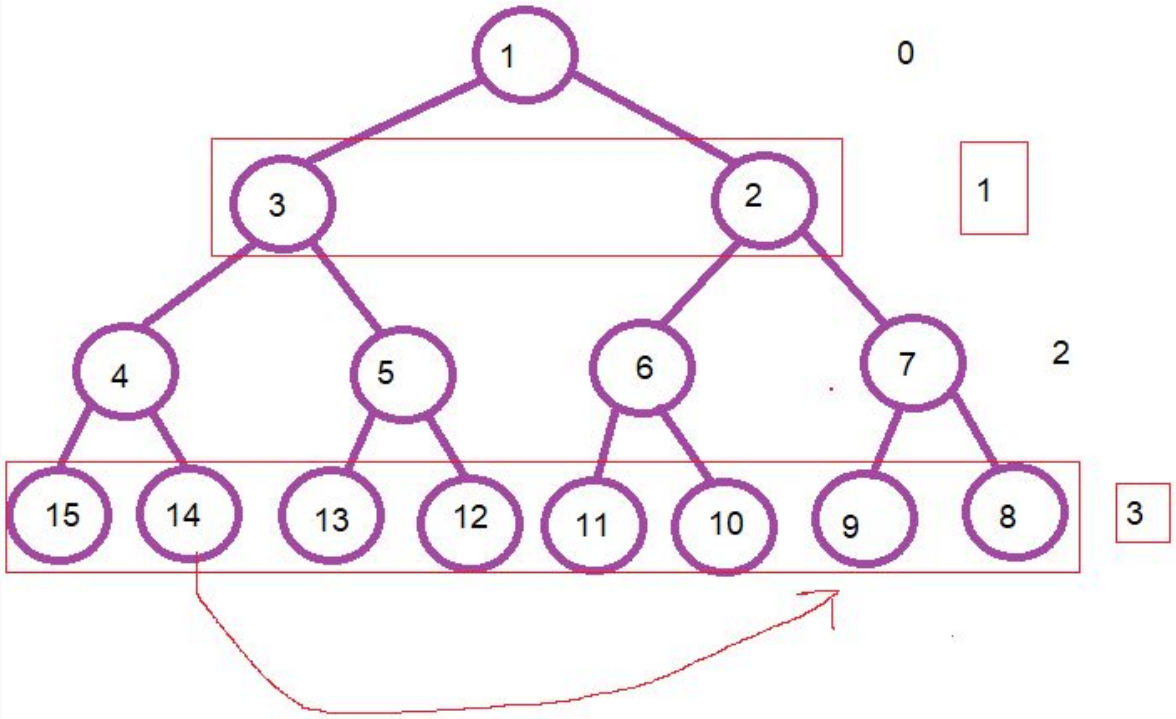
1. build tree from charArray

2. take care of chars to int, for example 405 - -, when parse the first integer, it's 405, NOT 4

3. the difficult is how to search the start point of right part and calculate the end of left part

1104. Path In Zigzag Labelled Binary Tree

https://leetcode.com/problems/path-in-zigzag-labelled-binary-tree/



1. calculate level

2. calculate the "true value"

3. add "zigzag" value into result list

level 3
trueVal = 9, zigzagVal = 14

level 2
trueVal = 4, zigzagVal = 4

level 1
trueVal = 2, zigzagVal = 3

level 0
1

1130. Minimum Cost Tree From Leaf Values

https://leetcode.com/problems/minimum-cost-tree-from-leaf-values/

[7 12 8 10]

we cant sort the given array!

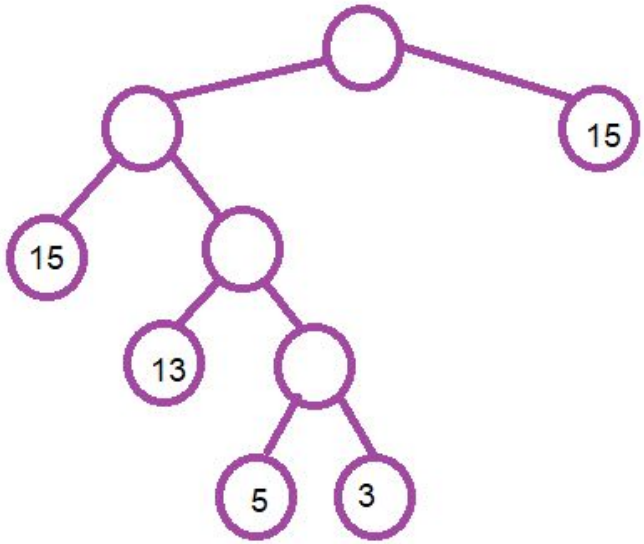
the leaf node should keep the same order.

~~[7 8 10 12]~~ ✗

idea: make sure always use smallest integers to get product.

[15, 13, 5, 3, 15]

3 * 5
+
5 * 13
+
13 * 15
+
15 * 15

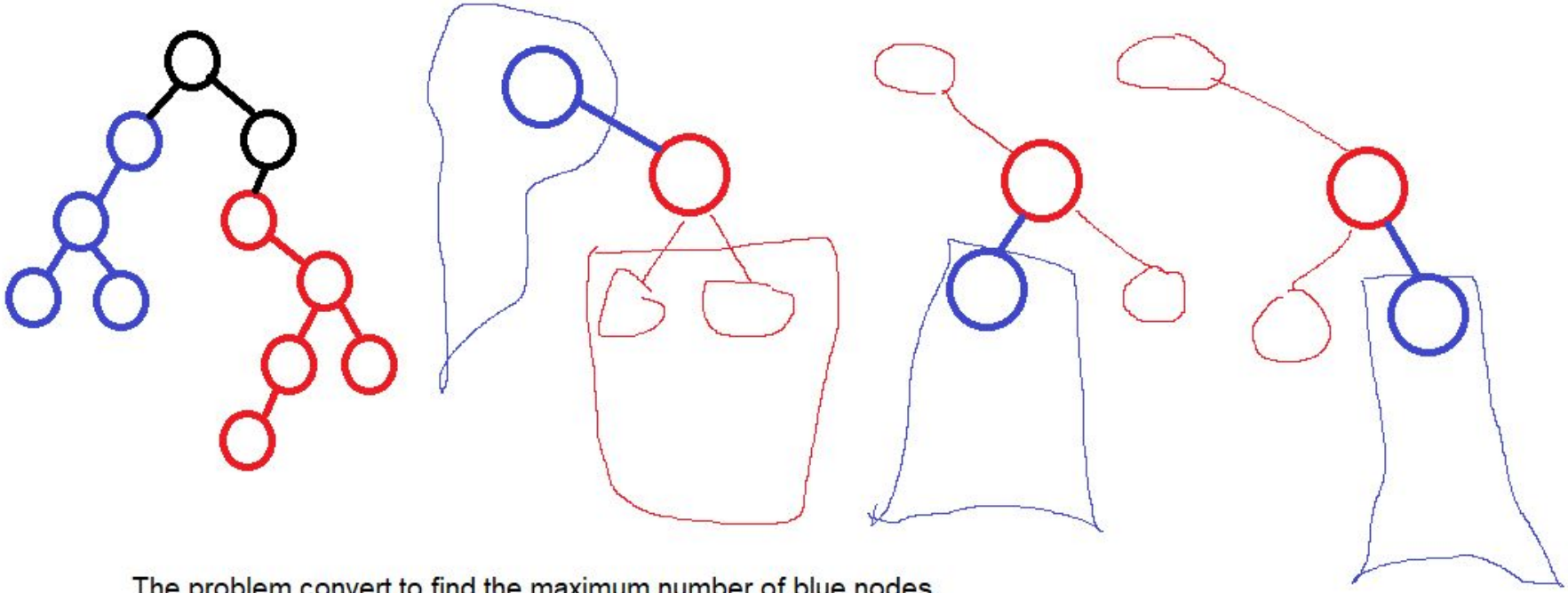


use stack, if currentVal >= stack.peek()

we should make sure stack.peek() multiply the smallest value
(current or previous value in stack)

1145. Binary Tree Coloring Game

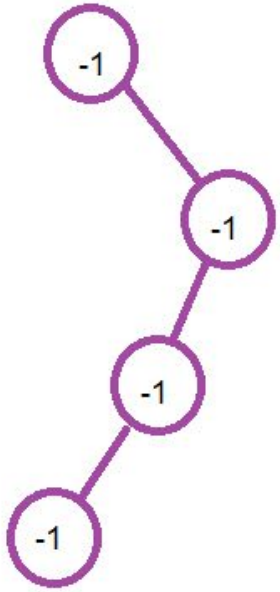
https://leetcode.com/problems/binary-tree-coloring-game/

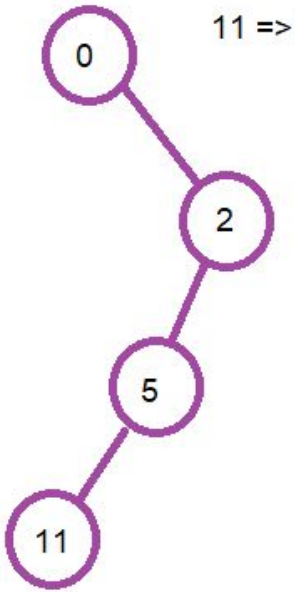


The problem convert to find the maximum number of blue nodes.

1261. Find Elements in a Contaminated Binary Tree

https://leetcode.com/problems/find-elements-in-a-contaminated-binary-tree/





11 => RIGHT, LEFT,LEFT

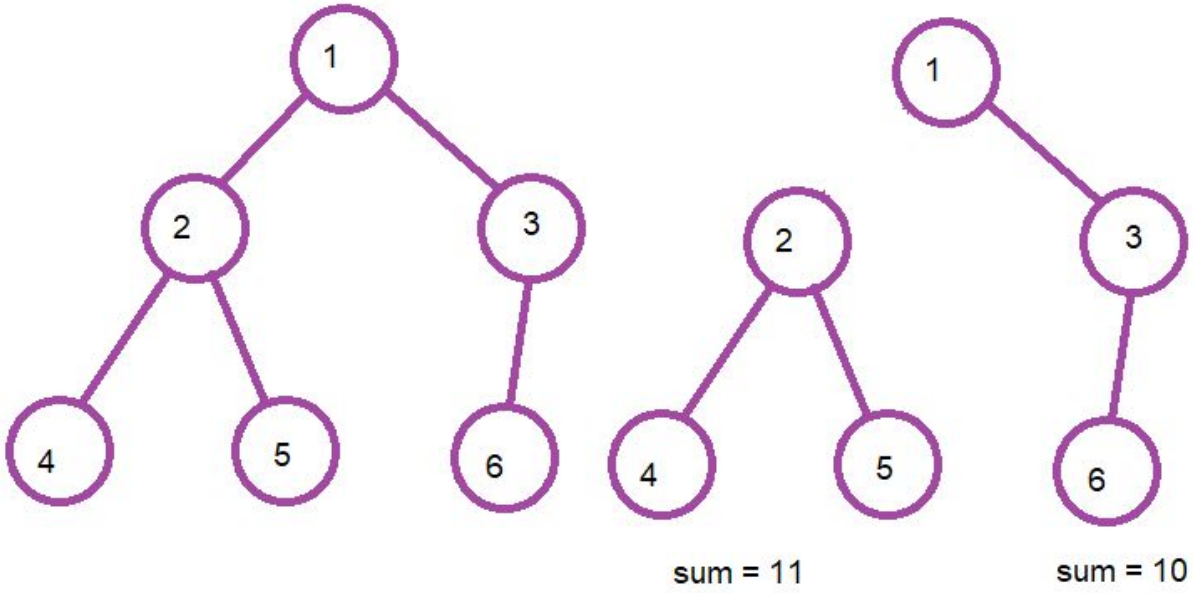
stack:
LEFT
LEFT
RIGHT

left = 2 * val + 1
right = 2 * val + 2

```
final Stack<Integer> stack

while (target > 0) {
    if (target % 2 == 0) {
        stack.push(RIGHT);
        target = (target - 2) >> 1;
    } else {
        stack.push(LEFT);
        target = (target - 1) >> 1;
    }
}
```

1339. Maximum Product of Splitted Binary Tree

https://leetcode.com/problems/maximum-product-of-splitted-binary-tree/

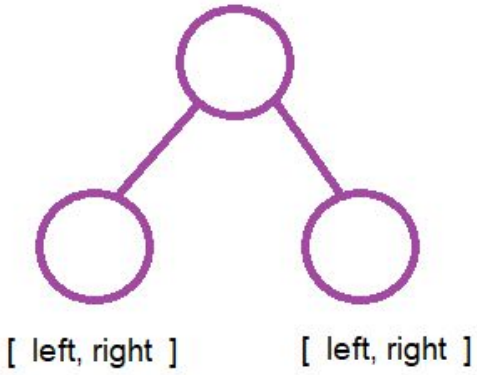


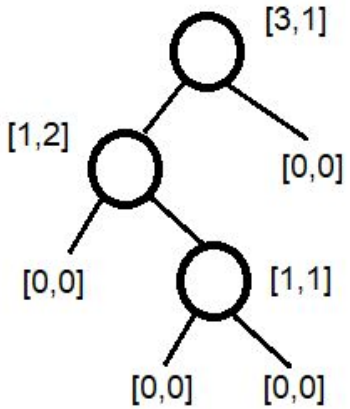
[1 2 3 4 5 6]

preSum
[1 3 6 10 15 21]
Sum - preSum
[0 18 15 11 6 0]

1372. Longest ZigZag Path in a Binary Tree

https://leetcode.com/problems/longest-zigzag-path-in-a-binary-tree/

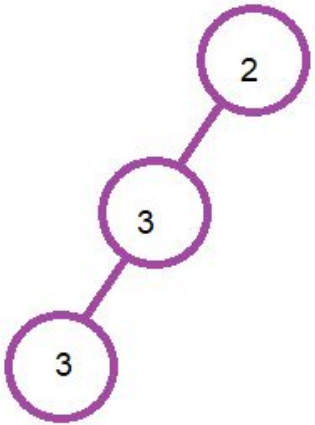





```
private int[] dfs(TreeNode root) {
    if (root == null) {
        return new int[]{0, 0};
    }
    final int[] leftResult = dfs(root.left);
    final int[] rightResult = dfs(root.right);

    final int leftMax = 1 + leftResult[1];
    final int rightMax = 1 + rightResult[0];

    max = Math.max(max, leftMax);
    max = Math.max(max, rightMax);

    return new int[]{leftMax, rightMax};
}
```

1457. Pseudo-Palindromic Paths in a Binary Tree

https://leetcode.com/problems/pseudo-palindromic-paths-in-a-binary-tree/



if there exists a pesudo-palindromic path, there must have at most one single int.

value = 2

mask = mask xor(^) (1<<(val-1))
= 0(00) ^ 2 (10)
= 2(10)

value = 3

mask = 2 (10) xor 4 (100)

= (6)110

value = 3

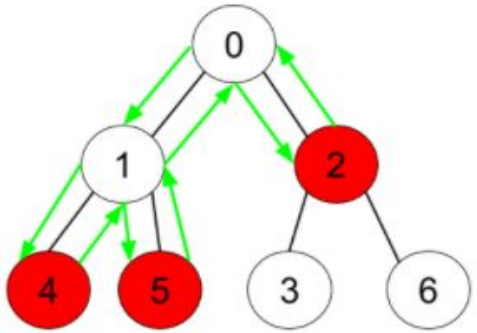
mask = 6 (110) xor 4(100) = 2 (010)

if(mask & (mask-1)){ ++result }

for mask, at most one bit could be 1
so for a given mask, and (mask-1) should have 0.

1443. Minimum Time to Collect All Apples in a Tree

https://leetcode.com/problems/minimum-time-to-collect-all-apples-in-a-tree/



1. build graph

2. dfs, result is time to clollect

Algorithm:

for each node, count its neighbors's time.

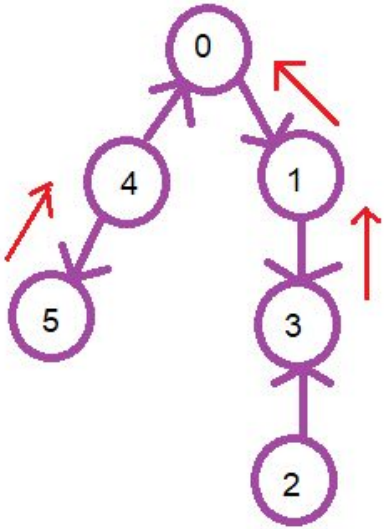
==> if node is "root", return result,

==> if node is "leaf" or result of neighbors is 0,
return 2 if hasApple or 0.

==> Others, return count + 2. (it means node is in path of collecting apples)

1466. Reorder Routes to Make All Paths Lead to the City Zero

https://leetcode.com/problems/reorder-routes-to-make-all-paths-lead-to-the-city-zero/



count how many vectors are inversed

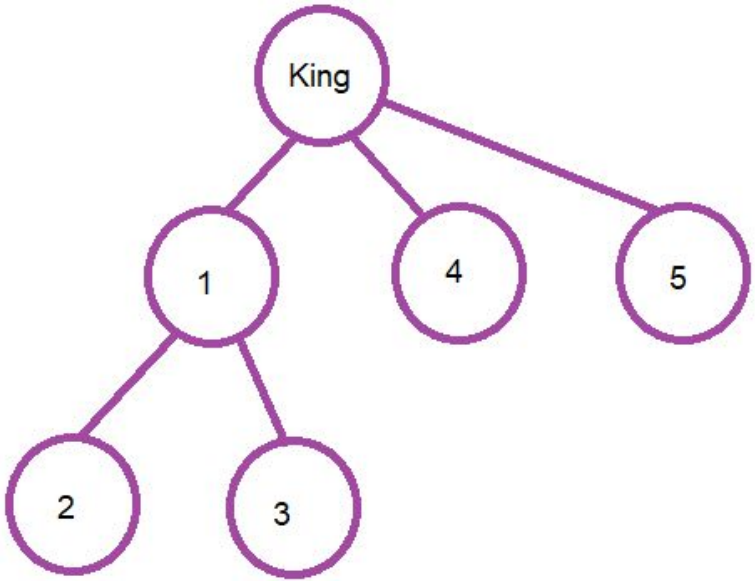
two ways:

a ==> 1. build graph, and record the original connections into a map
2. dfs travel from 0, if exists connect from child to parent, return 0 else 1

(advanced)
b ==> 1. build graph, orignial connect marked as [0] to [1],
inversed connection as [1] to -[0]
2. when travel from parent to child(neighbor), if [1] > 0, return 1 else 0

1600. Throne Inheritance

https://leetcode.com/problems/throne-inheritance/




```
private final Map<String, List<String>> graph = new HashMap<>();

private final HashSet<String> deaths = new HashSet<>();

public List<String> getInheritanceOrder() {
    final List<String> results = new LinkedList<>();
    dfs(king, results);
    return results;
}

private void dfs(String current, List<String> results) {
    if (!deaths.contains(current)) {
        results.add(current);
    }
    if (graph.containsKey(current)) {
        for (String child : graph.get(current)) {
            dfs(child, results);
        }
```

here:
preorder traversal