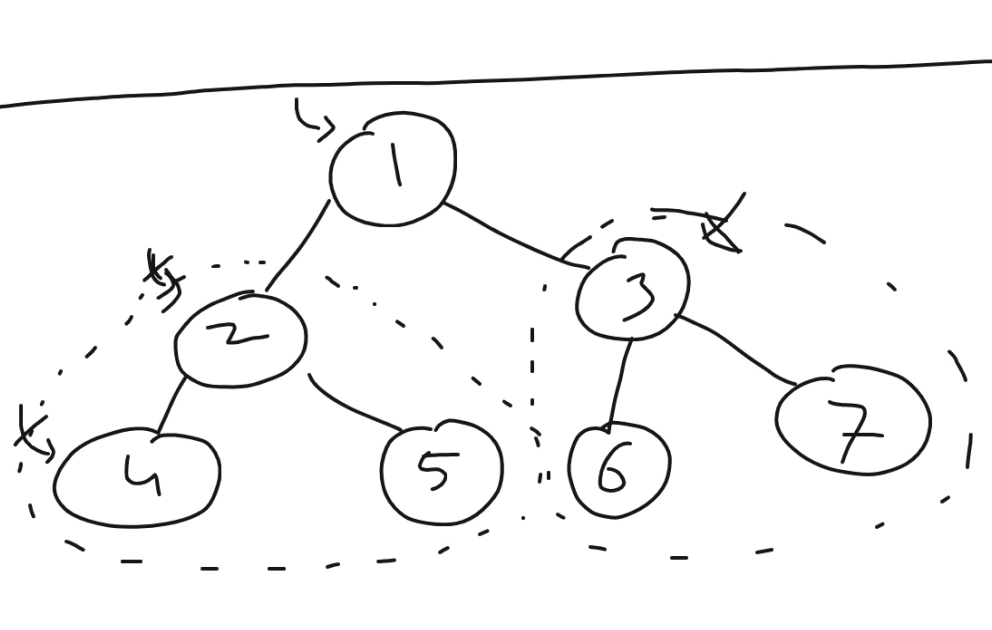
BINARY TREES

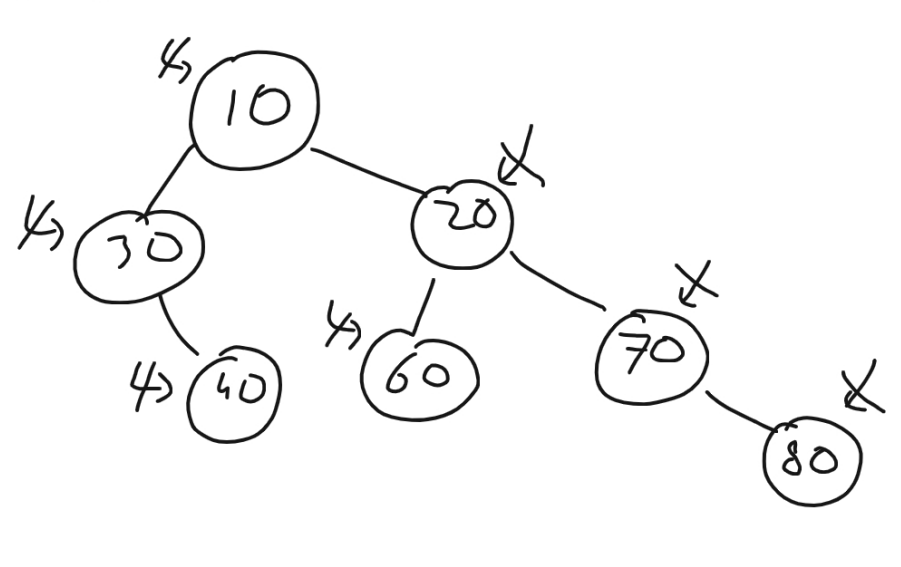
```
class TreeNode {
  public:
      int data;
      TreeNode* left;
      TreeNode* right;
};
```



Preorder Traversal:

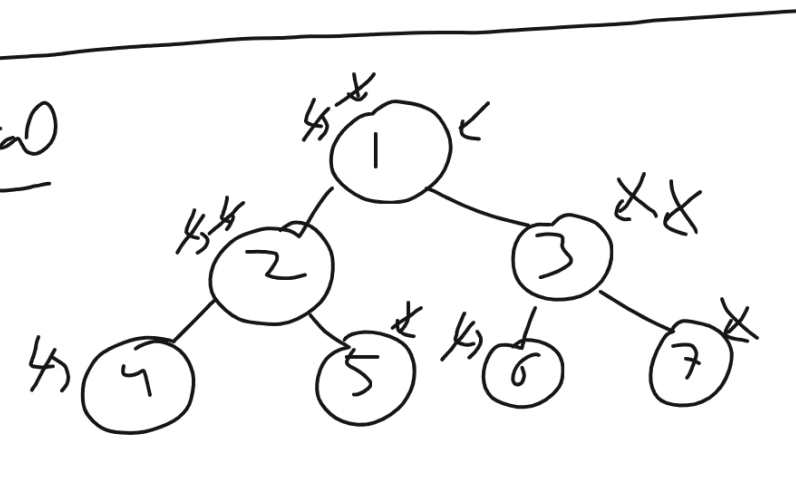
→ Process the current node
→ Recursively process the left subtree
→ Recursively process the right subtree

[1, 2, 4, 5, 3, 6, 7]


10
30
20
40
60
70
80

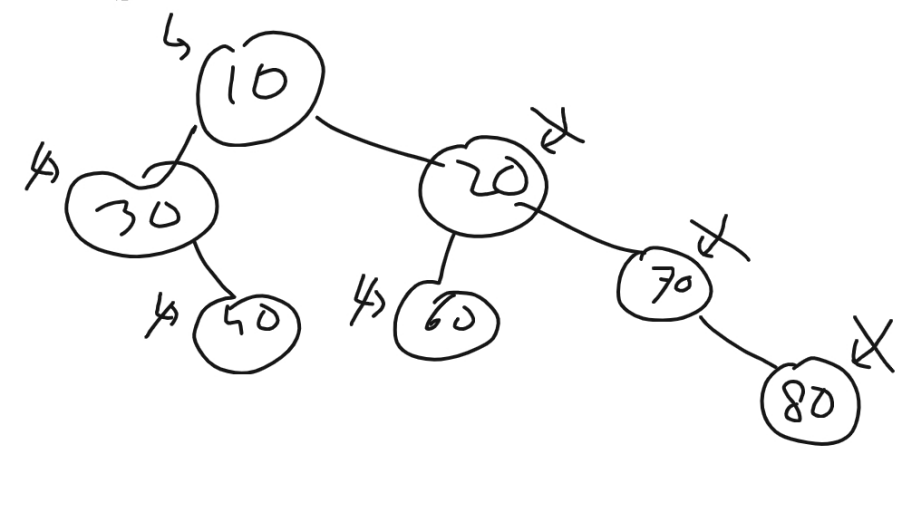
[10, 30, 40, 20, 60, 70, 80]

Post order Traversal



→ Recursively process the left subtree
→ Recursively process the right subtree
→ Process the current node.

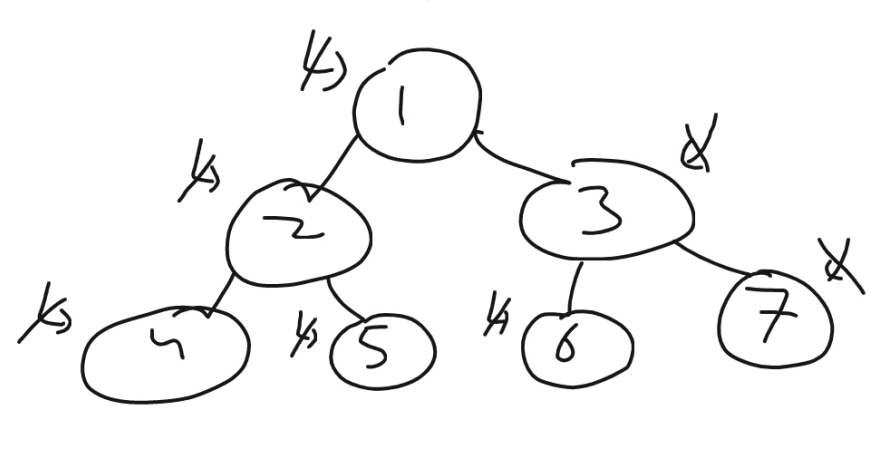
[4, 5, 2, 6, 7, 3, 1]


10
30
20
40
60
70
80

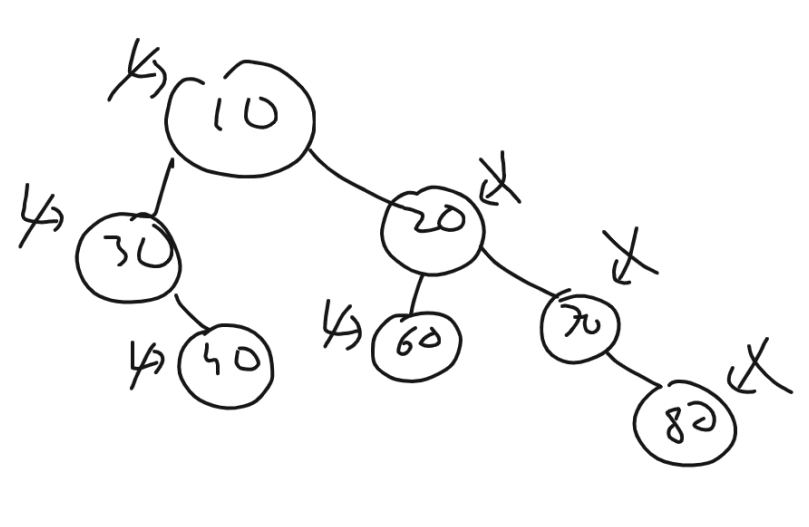
[40, 30, 60, 80, 70, 20, 10]

Inorder Traversal

→ Recursively process the left subtree
→ Process the current node
→ Recursively process the right subtree

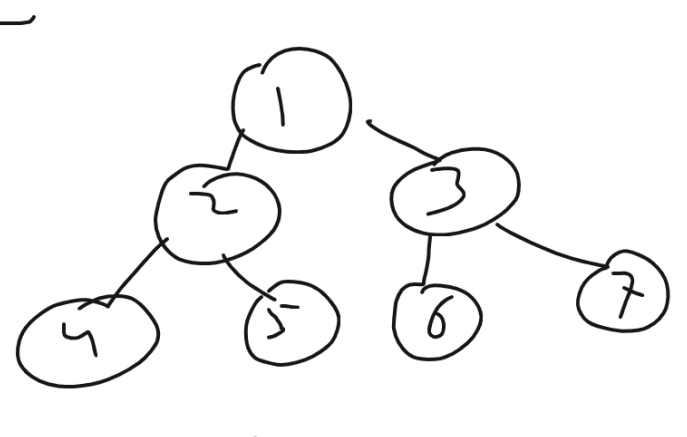


[4, 2, 5, 1, 6, 3, 7]

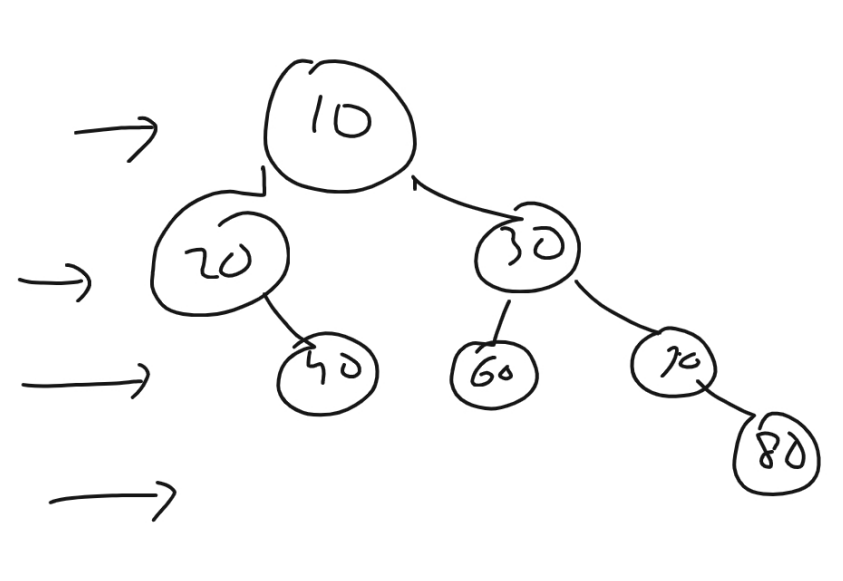

10
30
20
40
60
70
80

[30, 40, 10, 60, 20, 70, 80]

Level-order Traversal

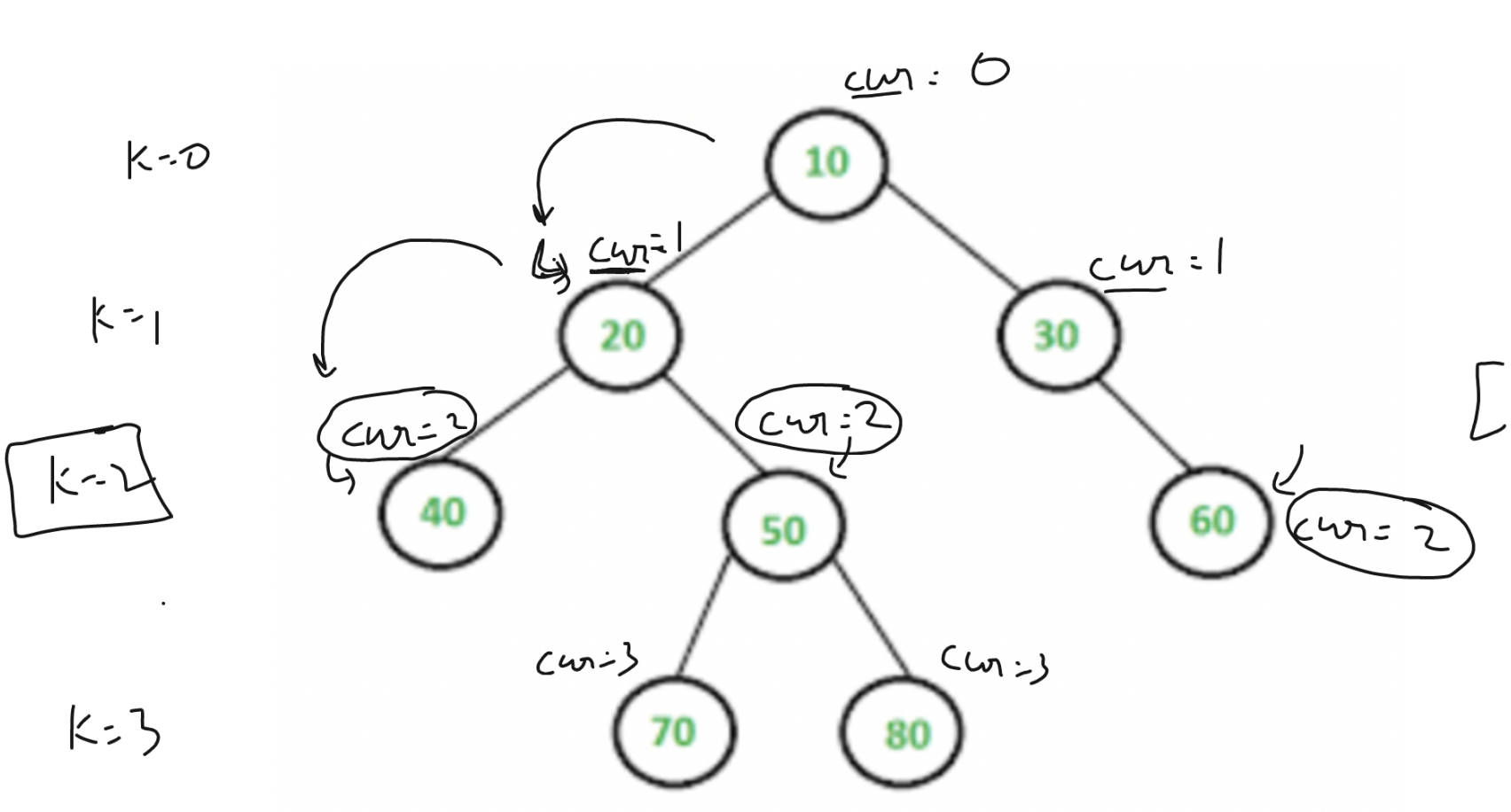


[1, 2, 3, 4, 5, 6, 7]


10
20
30
40
60
70
80

[10, 20, 30, 40, 60, 70, 80]

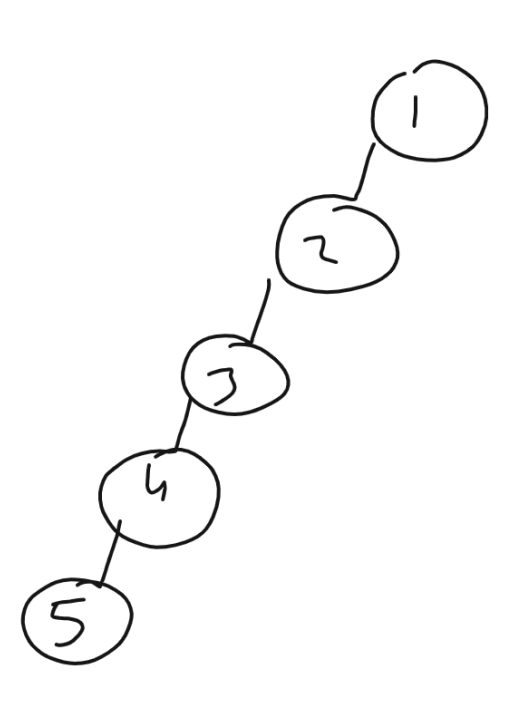
Write a function to print the k-th level of a Binary Tree from left to right.

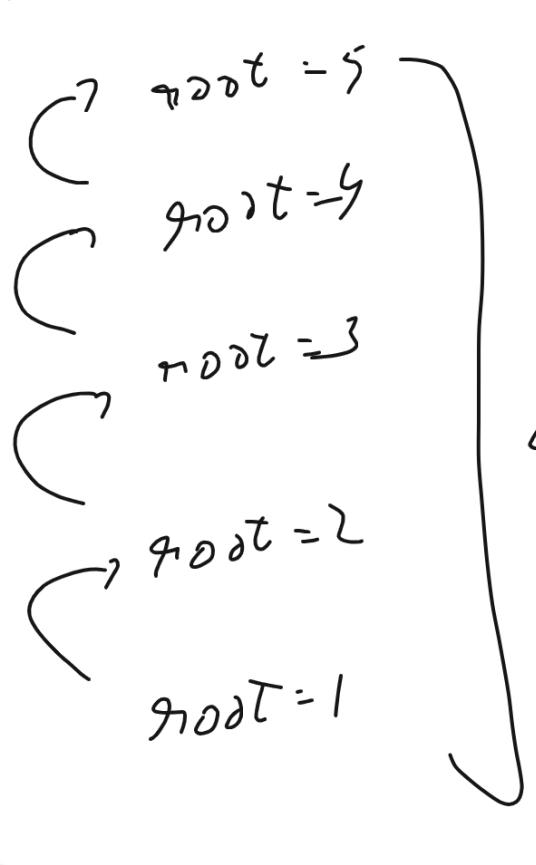

k=0
k=1
k=2
k=3
curr: 0
curr=1
curr=1
curr=2
curr=2
curr=2
curr=3
curr=3
10
20
30
40
50
60
70
80

curr

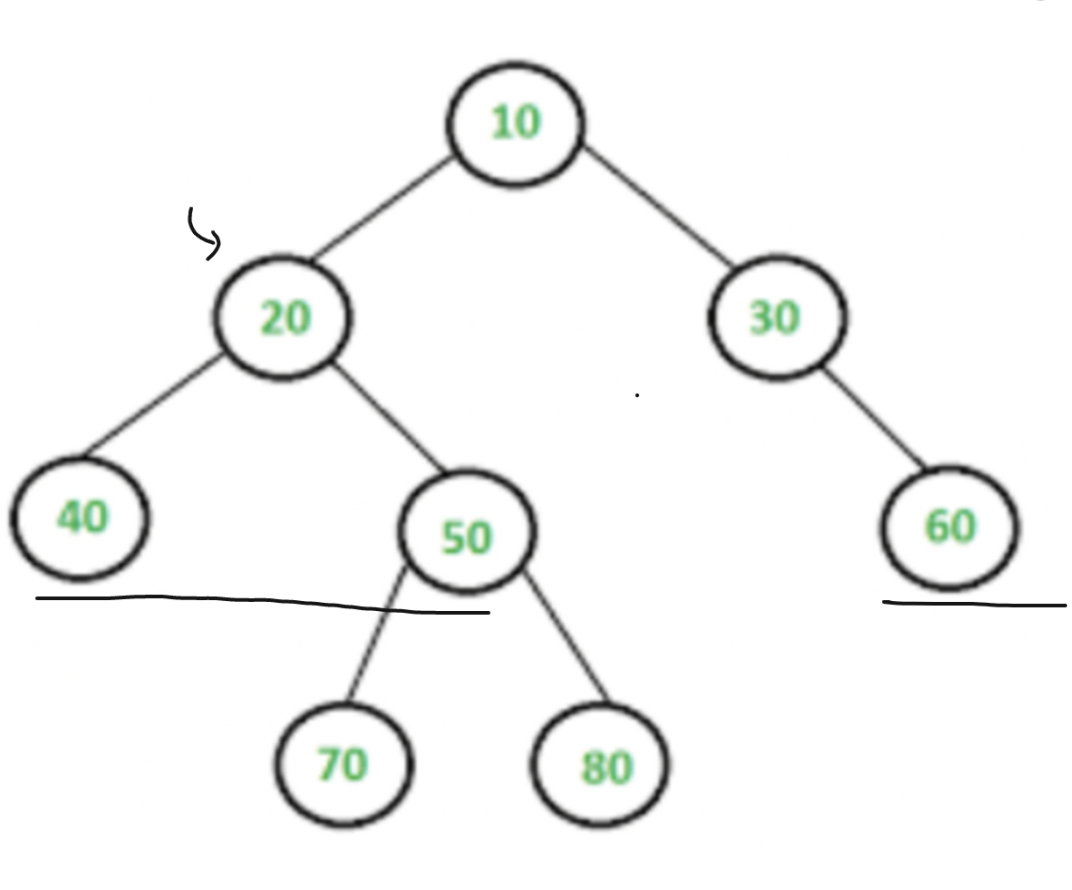
[40, 50, 60]

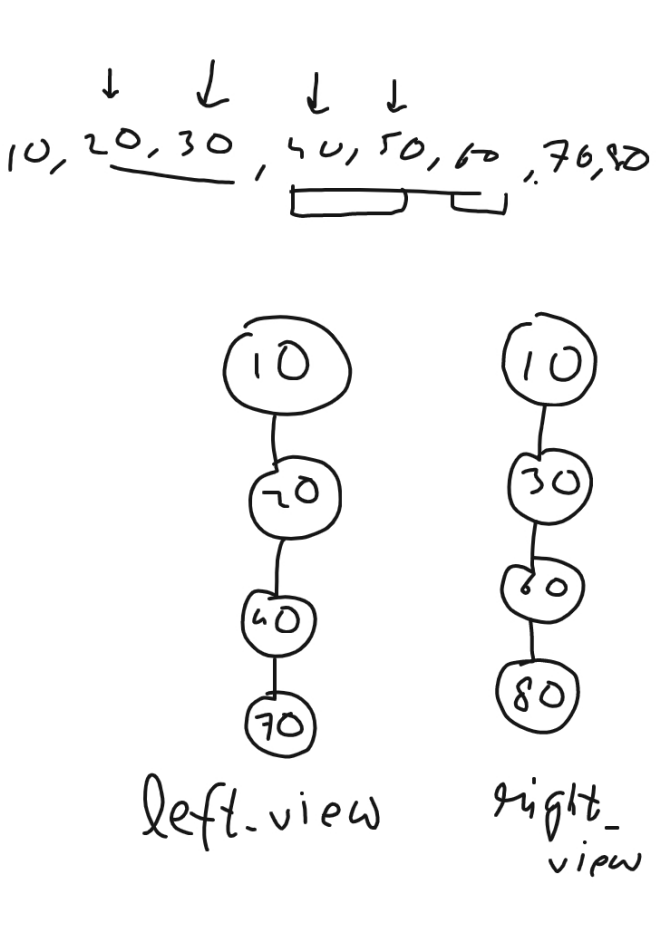
Preorder: [10, 20, 40, 50, 70, 80, 30, 60]




root = 5
root = 4
root = 3
root = 2
root = 1

O(n)


10
20
30
40
50
60
70
80


10, 20, 30, 40, 50, 60, 70, 80
10
20
40
70
left_view
10
30
60
80
right_view

~~10~~	~~20~~	~~30~~	~~40~~	~~50~~	~~60~~	~~70~~	~~80~~

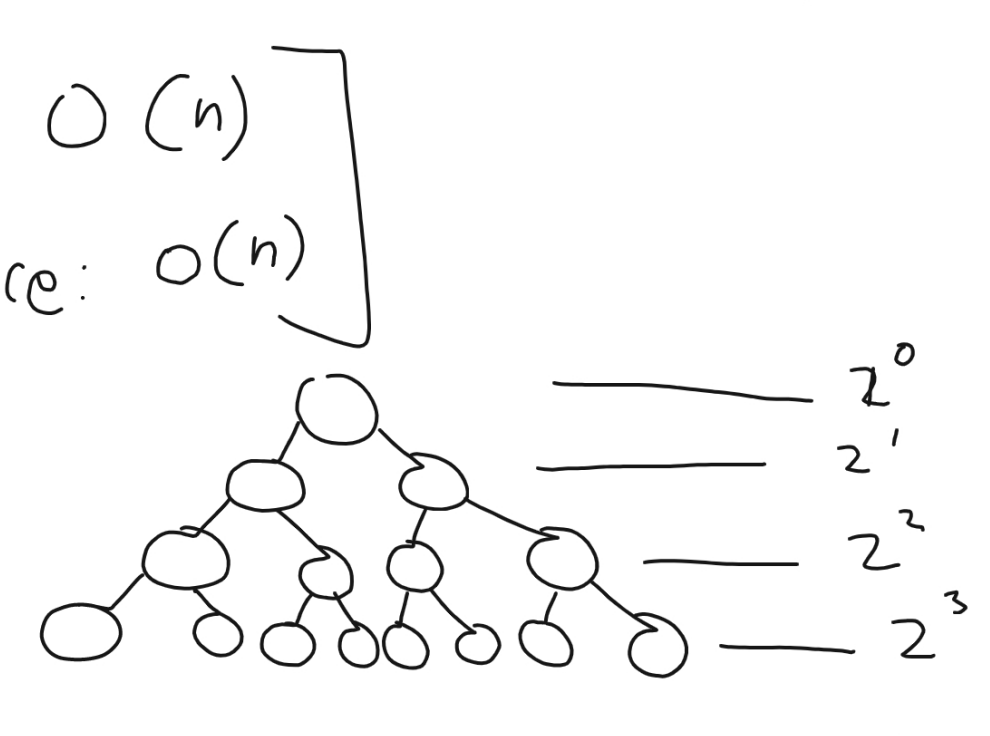
current = ~~10~~ ~~20~~ ~~30~~ ~~40~~ ~~50~~ ~~60~~ ~~70~~ 80

→ Pop-out the front element from the queue. Let it be 'current'.
→ Print current → data
→ Push the child nodes of 'current' into the queue.

Level-order Traversal:

[10, 20, 30, 40, 50, 60, 70, 80]

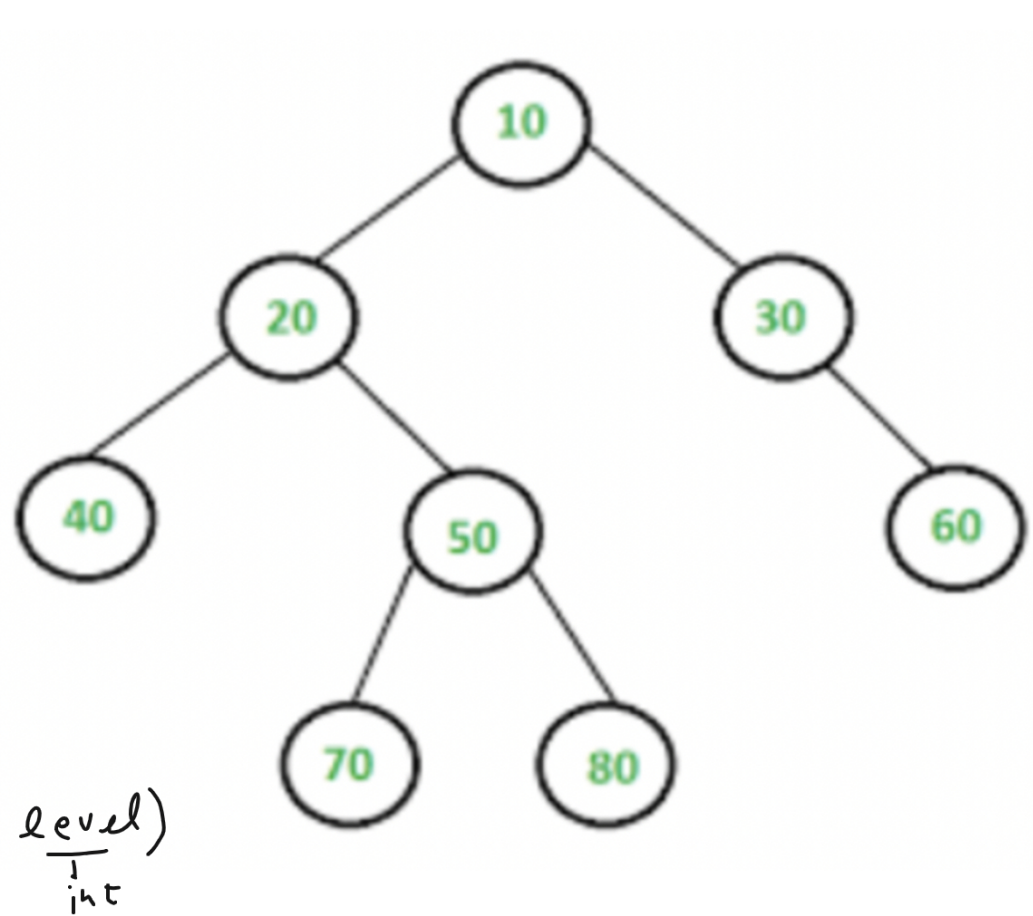
TC = O(n)
Aux. space: O(n)



15.

no. of nodes in the last level = $2^{(h-1)}$

Total no. of nodes: $\underbrace{2^0 + 2^1 + 2^2 + \dots + 2^{h-1}}_{\text{GP with } a=1,\ r=2,\ \text{no. of terms} = h} = \frac{1(2^h - 1)}{2-1} = 2^h - 1$


10
20
30
40
50
60
70
80

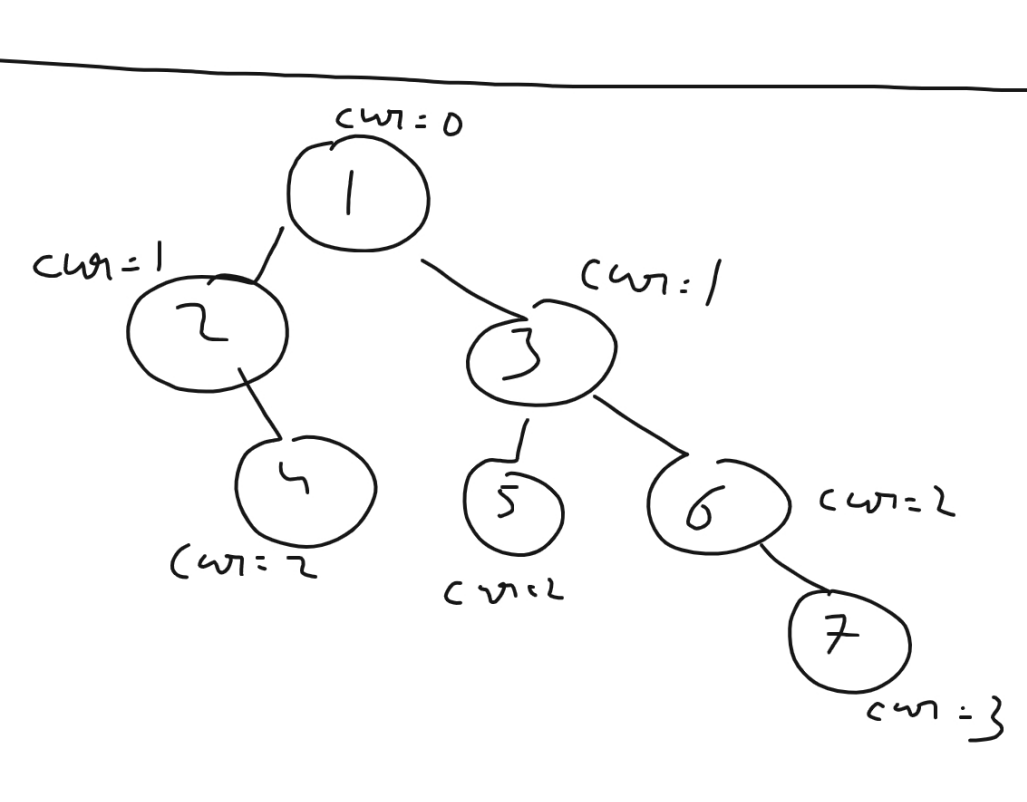
0 → ~~False~~ True
1 → ~~F~~ True
2 → ~~F~~ True
3 → ~~F~~ True

pair<TreeNode*, level>
int

~~10,0~~	~~20,1~~	~~30,1~~	~~40,2~~	~~50,2~~	~~60,2~~	~~70,3~~	~~80,3~~

current_node = ~~10~~ ~~20~~ ~~30~~ ~~40~~ ~~50~~ ~~60~~ ~~70~~ 80
current_level = ~~0~~ ~~1~~ ~~1~~ ~~2~~ ~~2~~ ~~2~~ ~~3~~ 3

[10, 20, 40, 70]

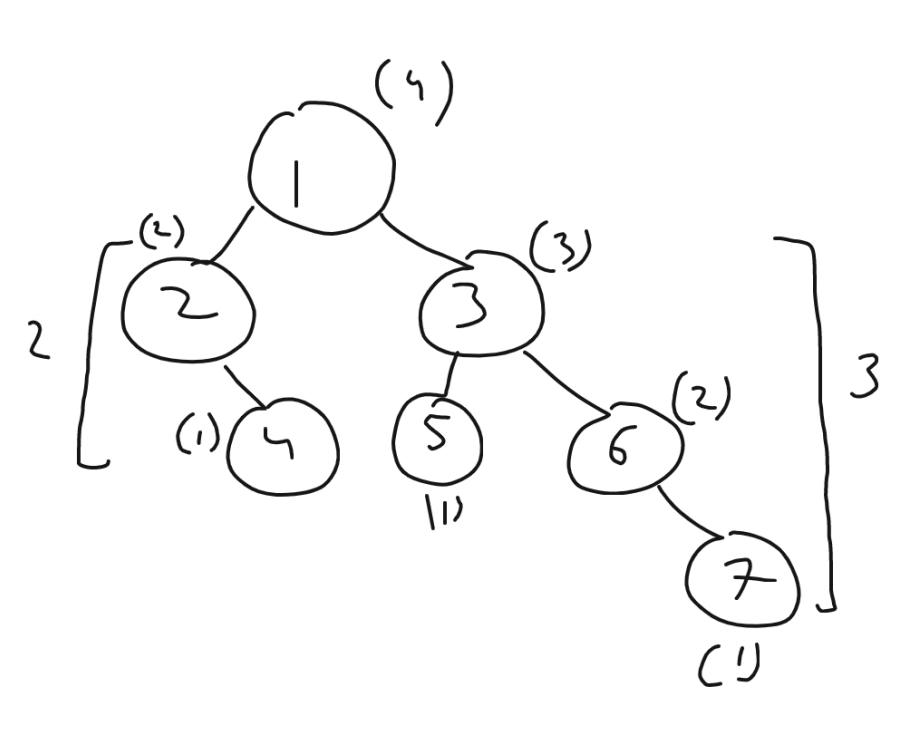

curr: 0
curr: 1
curr: 1
curr: 2
curr: 2
curr: 2
curr: 3
1
2
3
4
5
6
7

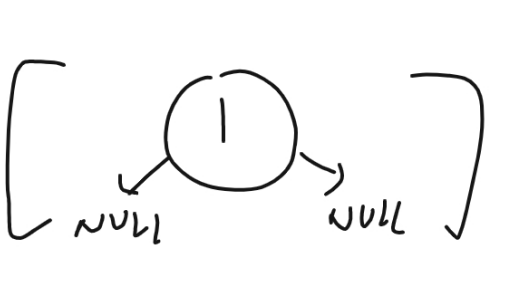
max_level = ~~0~~ ~~1~~ ~~2~~ 3

⇓

height: 3+1 = 4

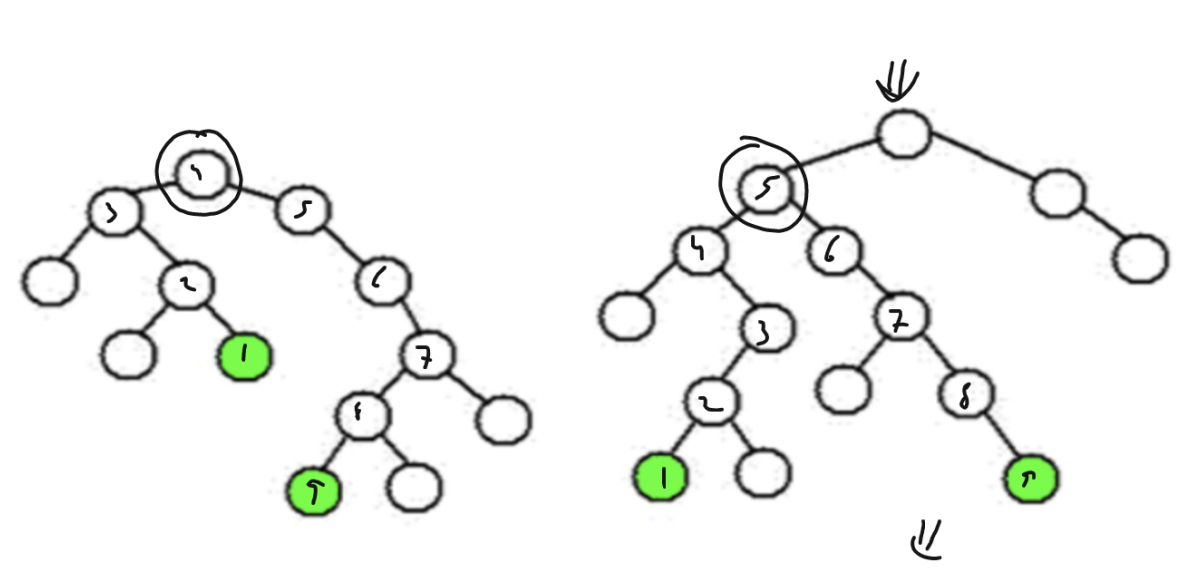
[height (root) = 1 + max (height (root → left), height (root → right))]


(4)
(2)
(3)
(1)
(1)
(2)
(1)
2
3
1
2
3
4
5
6
7



left_subtree.height = 0
right_subtree.height = 0
return 1 + max (0, 0) = 1

(4, 2, 5, 7, 6, 3, 1)



diam = 9

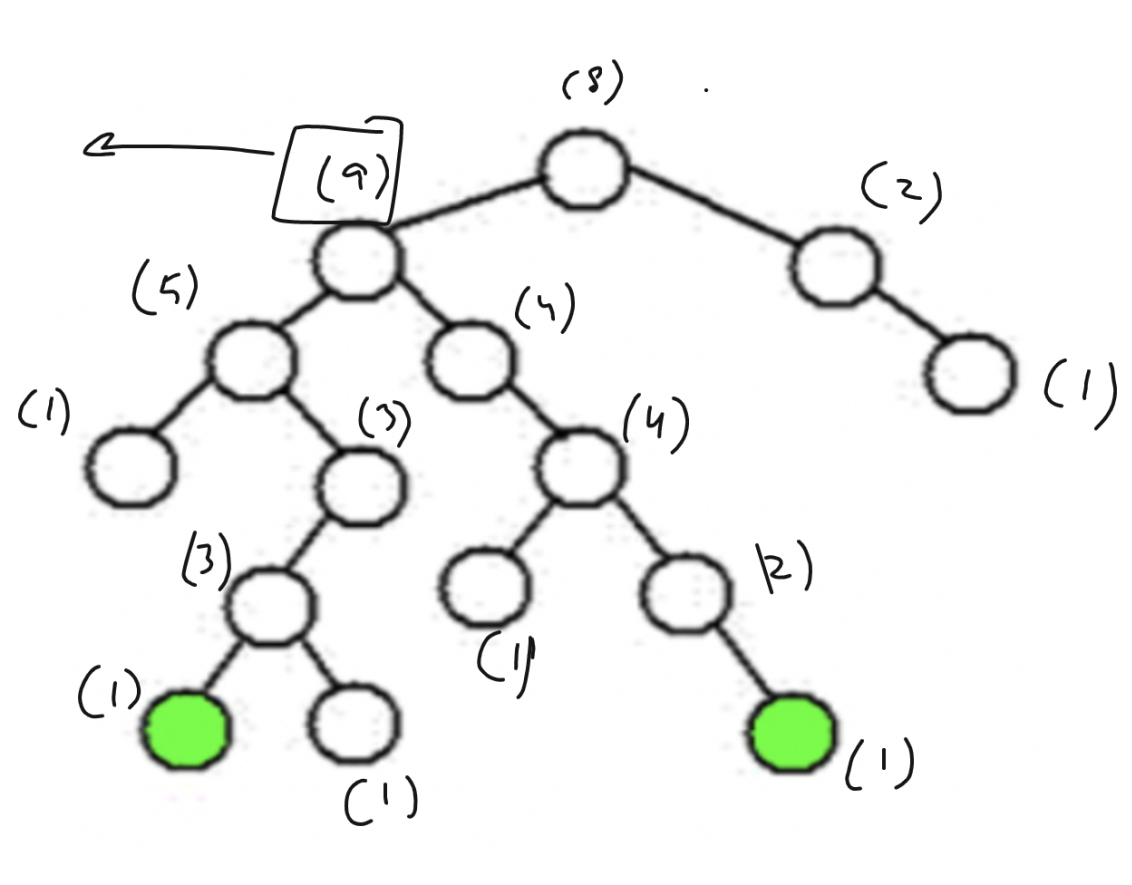
diam = 9

(LCA)

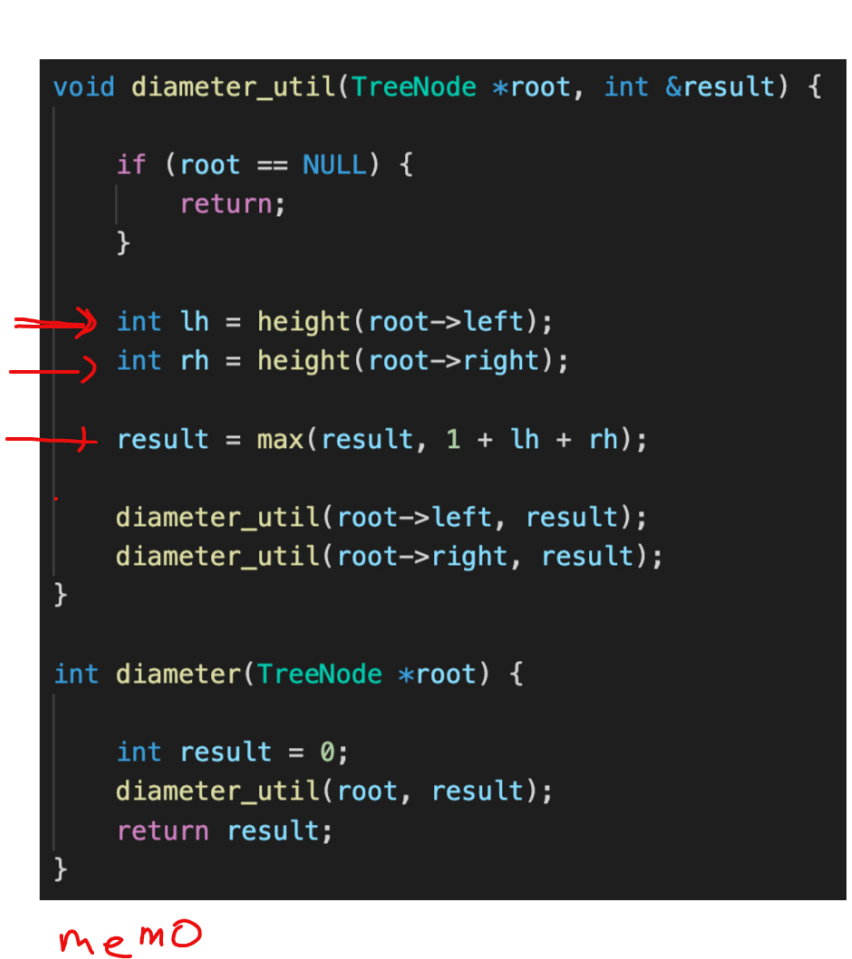
[Once we reach the lowest common ancestor of the two end nodes, the diam can be calculated as: (lh + rh + 1)]

⇒ One by one, assume the possibility of each node being the LCA of the two end nodes that gets us the diameter

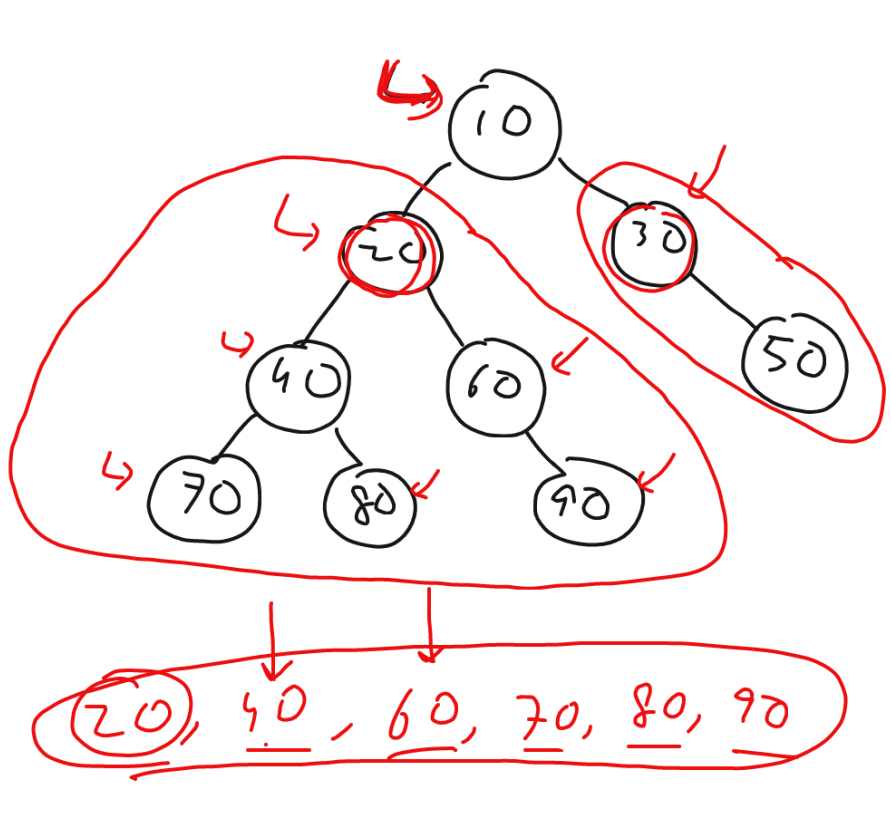
diam = 9


(9)
(8)
(5)
(4)
(2)
(1)
(3)
(4)
(1)
(3)
(2)
(1)
(1)
(1)
(1)

[lh + rh + 1]



```
void diameter_util(TreeNode *root, int &result) {

    if (root == NULL) {
        return;
    }

    int lh = height(root->left);
    int rh = height(root->right);

    result = max(result, 1 + lh + rh);

    diameter_util(root->left, result);
    diameter_util(root->right, result);
}

int diameter(TreeNode *root) {

    int result = 0;
    diameter_util(root, result);
    return result;
}
```


10
20
30
40
60
50
70
80
90

20, 40, 60, 70, 80, 90

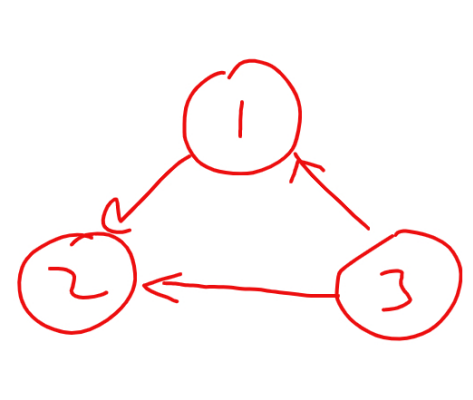
30, 50

⇒ 40, 70, 80

⇒ 60, 90

memo
20 → 3
40 → 2
70 → 1
80 → 1
60 → 2
90 → 1
30 → 2
50 → 1

$\underbrace{O(n)} + \underbrace{O(1) + O(1) + O(1) \dots}_{(n-1)\ \text{times}}$

$\boxed{(n-1)}$