Trees Basics

Content

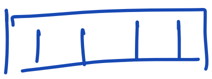
→ Trees introduction

→ Naming conventions

→ Tree traversal

→ Basic tree problems

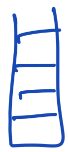
Linear DS



arrays

[] → [] → [] → null

LL



stack

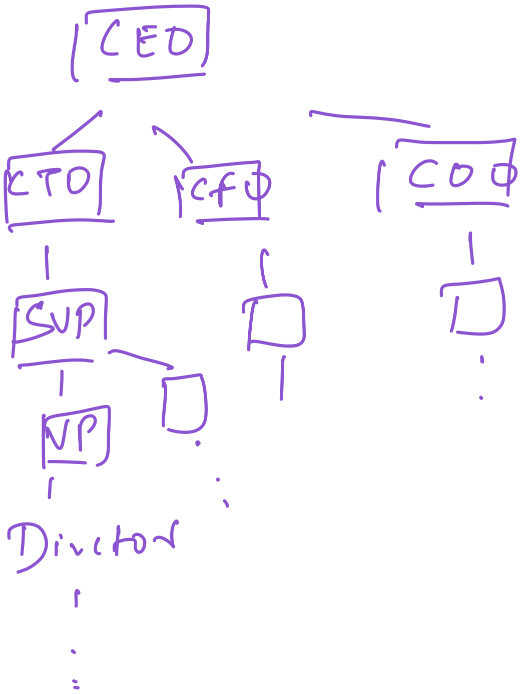
hashmap

Heirarchial Data

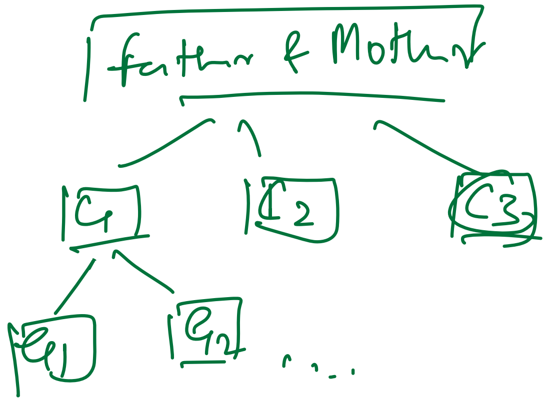
Folders & files

C:/
└ Desktop —— folderA
　　　　　└ folderB
　　　　　　⋮
└ Document
└ Music
⋮
⋮

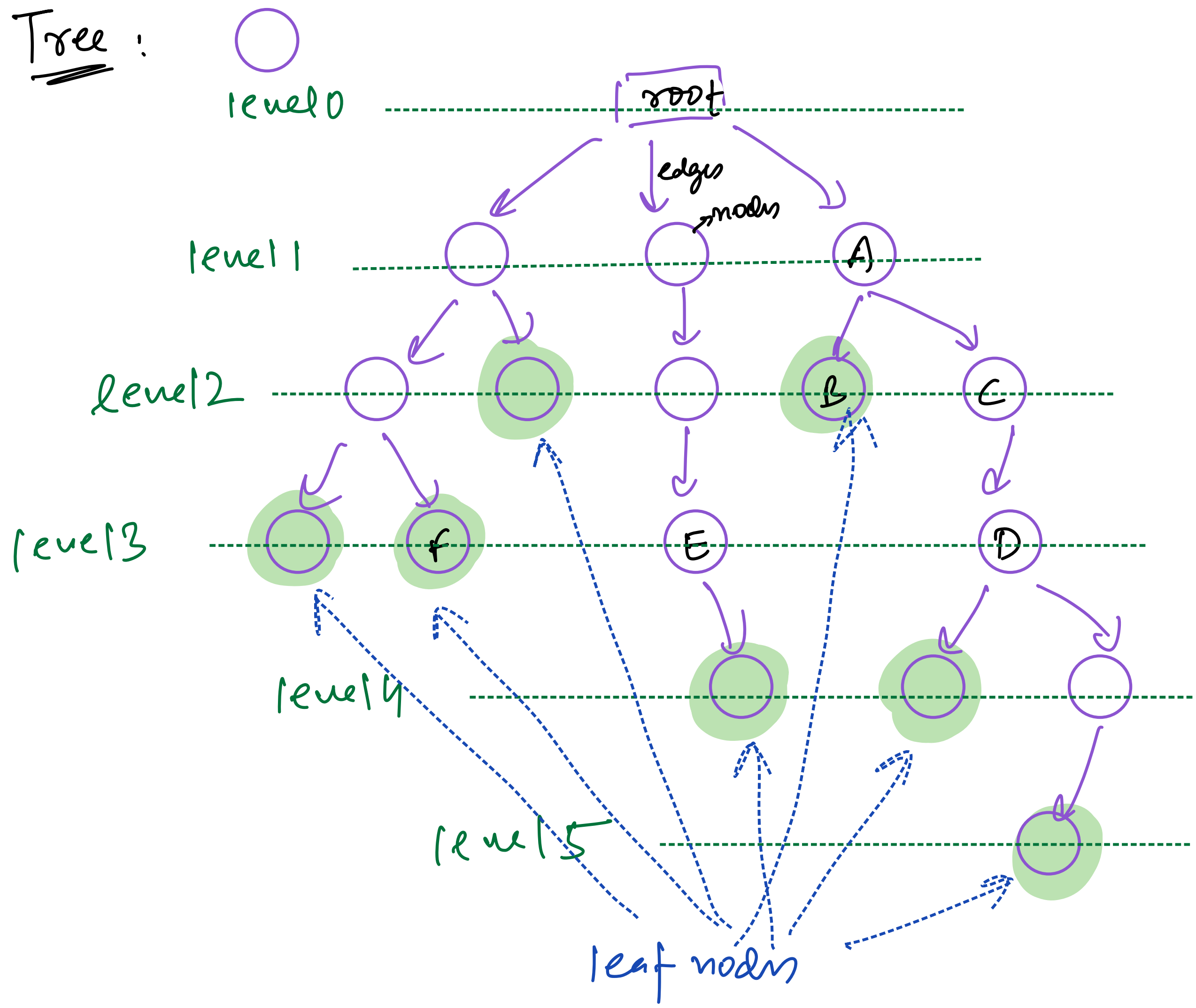
Company structure



Family tree



Tree :



Naming

A — B : A is a parent of B | B is child of A

A — D : A is ancestor of D | D is descendant of A

B – C : sibling nodes because they share the same parent.

D, E, F : nodes at the same level.

root : node without a parent

leaf nodes : nodes without children

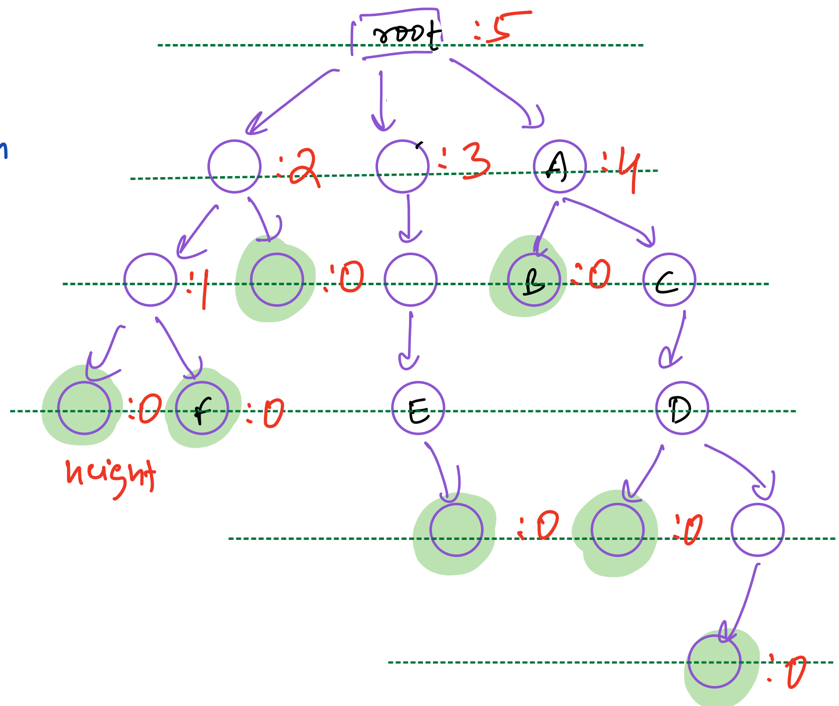
What is a tree?

1. tree can have only 1 root node
2. for every node, there is only one parent.

Height of a node

length of longest path from node to any of its descendent leaf node.

Note: path is calculated based on no. of edges



Observation 1 :

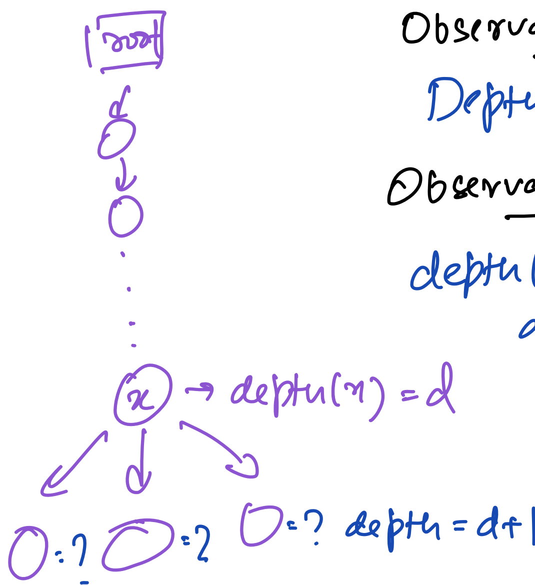
Height(node) = 1 + max(height of its child nodes)

Observation 2 :

Height(leaf node) = 0

Depth of a node

length of path from root to the node



Observation 1 :

Depth(root) = 0

Observation 2 :

depth(node) = depth(parent) + 1

Depth of node = level of node

Terminologies

Height (tree) = Height (root node)

Depth (tree) = ~~Depth (root node) = 0~~ ✗

max depth of any leaf node

OR

deepest leaf node

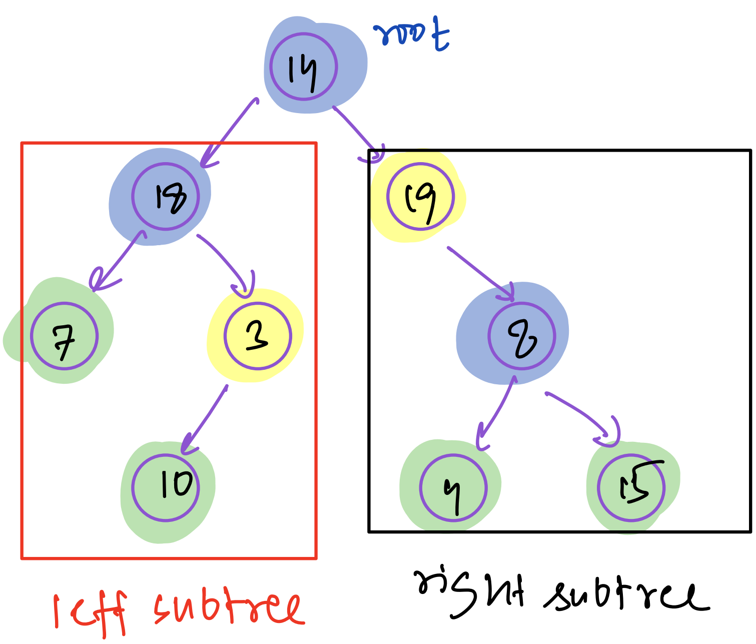
OR

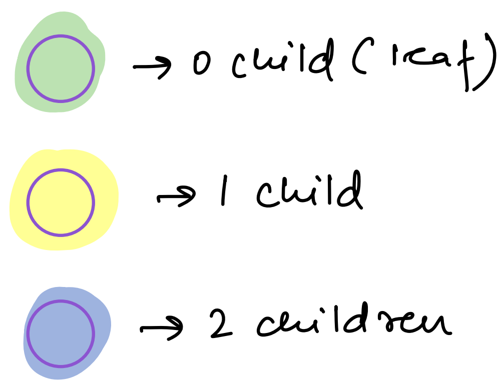
deepest node of the tree

Binary tree

Tree where every node can have at max 2 children.

0, 1, 2 ✓ ✓ ✓ , 3, 4, . . . ✗

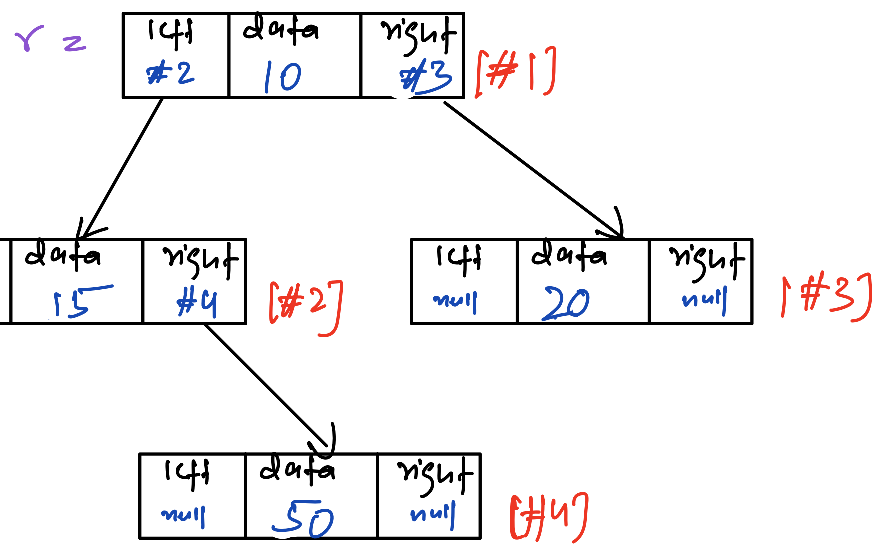




```
class Node {
    int data;
    Node left;  // obj reference which hold address of left child node
    Node right; // for right child node

    Node(int x) {
        data = x;
        left = null;
        right = null;
    }
}
```

```
Node r = new Node(10)
r.left = new Node(15)
r.right = new Node(20)
r.left.right = new Node(50)
```



<u>Observation</u> : Given a root node, we can traverse the entire tree.

Tree construction / insertion can be explained by serialization / de-serialization.

(learn in advance batch)

Note: for all tree problems, tree is already constructed. We are just given the root node.

Tree traversals

- → preorder
- → inorder
- → post order

- → level order
- → vertical level order

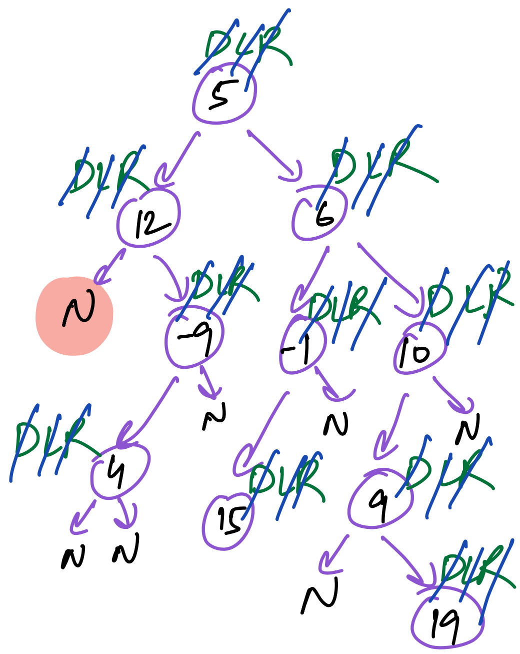
advance batch

Preorder: D L R (D → data, L → left, R → right)

Step 1: print (node data)

step 2: goto left subtree and print entire left subtree in preorder.

Step 3: goto right subtree and print entire right subtree in preorder.



output: 5 12 -9 4 6 -1 15 10 9 19

Pseudocode

```
void preOrder (Node r) {
1.  if (r == null) { return; }      → base condition
2.  print (r.data)                  ]
3.  preOrder (r.left)               ] → main logic
4.  preOrder (r.right)              ]
}
```

N = total no. of nodes in tree

TC : O(N)

SC : O(height of tree)
↳ max stack size

height = n-1

height <= N   height = O(N)

Preorder : 1 2 3 4

Inorder : 1 3 2 4

Postorder : 1 3 4 2

↳ TODO code

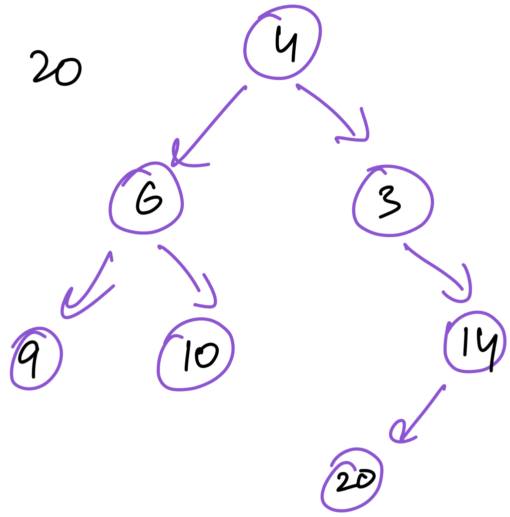
1 → base
2 → print
3 → goto left
4 → goto right

In all assignment questions, use recursion

DLR
preorder : 4 6 9 10 3 14 20

LDR
inorder : 9 6 10 4 3 20 14

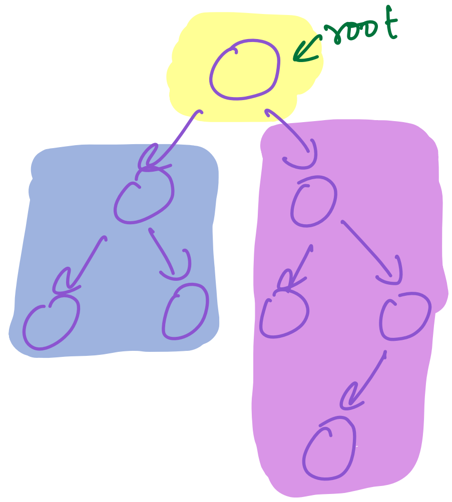
LRD
postorder : 9 10 6 20 14 3 4



Tree Problems

Solve with recursion.

1. Size (Node r) → total nodes
2. Sum (Node r) → total sum of all nodes
3. Height (Node r) → height of the node

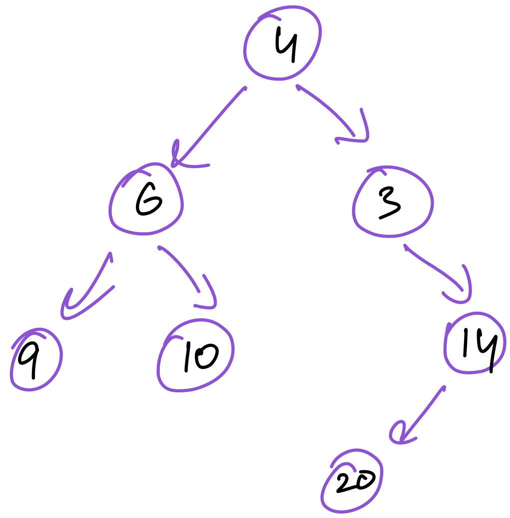


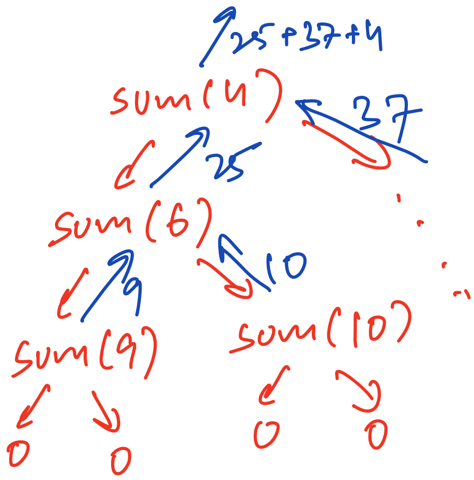
1. size(root) = size (LST) + size (RST) + 1

```
int size ( Node n) {
    if (n==null) { return 0 }
    l = size(n.left)
    r = size( n.right )
} return l+r+1
```

2. sum(root) = sum(LST) + sum(RST) + root.data

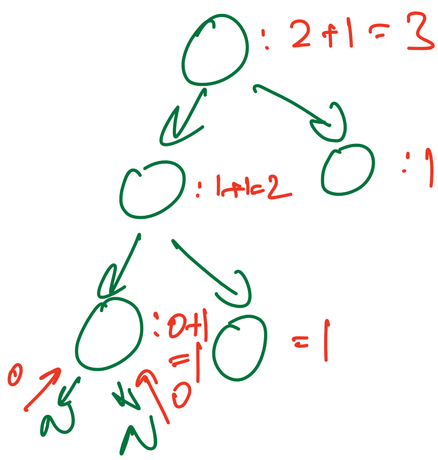
```
int sum ( Node n ) {
    if (n== null) { return 0 }
    l = sum( n.left)
    r = sum ( n. right)
    return  l + r + n.data
}
```

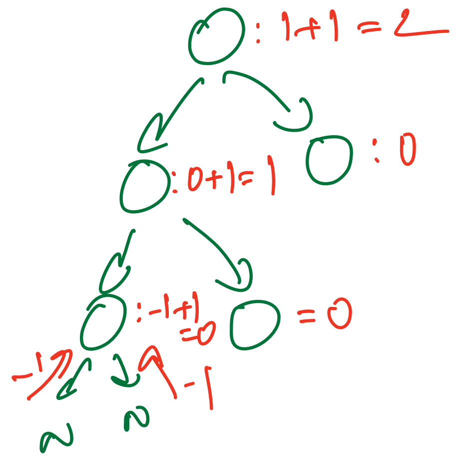




3. Height (root) = max(height of LST , height of RST) + 1

```
int height( Node n ) {
    if (n== null) { return ~~0~~ -1 }
    l = height(n.left)
    r = height( n.right)
    return  max( l, r) + 1
}
```





Doubt

0th → "0"
1st → "01"
2nd → "0110"
3rd → "01101001"
⋮ → $\underbrace{01101001}$10010110

$2^0 = 1$
$2^1 = 2$
$2^2 = 4$
$2^3 = 8$
⋮
$2^A : 2^{20} : 10^6$

A^{th}