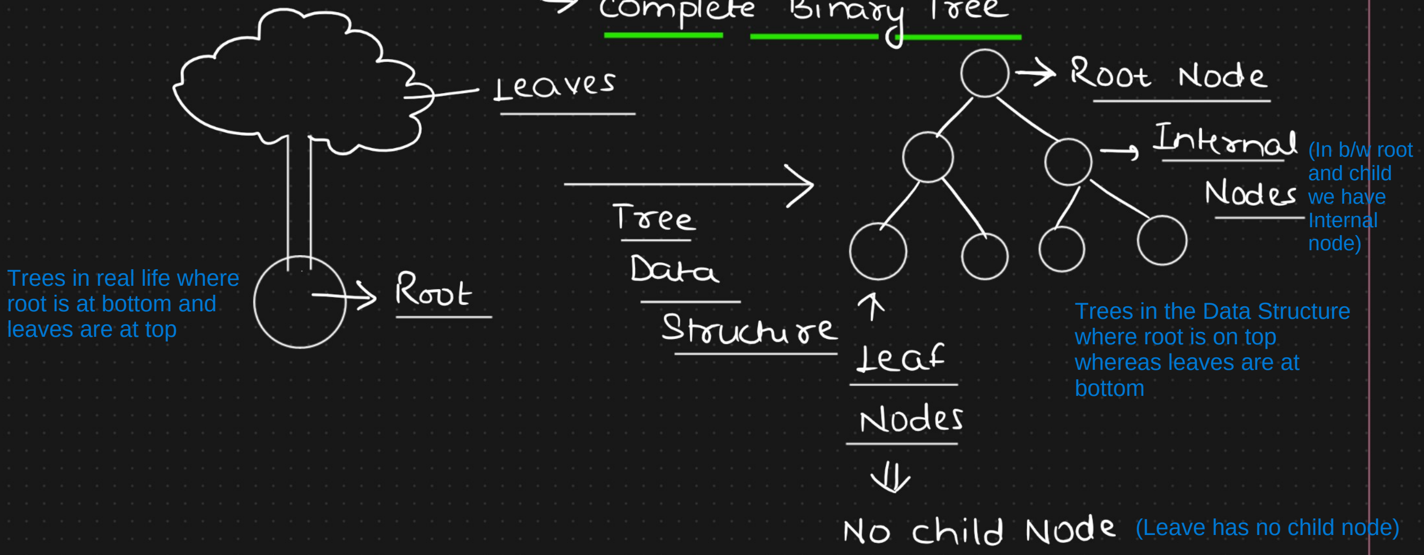
Heap Data Structure

↳ Complete Binary Tree



Trees in real life where root is at bottom and leaves are at top

(In b/w root and child we have Internal node)

Trees in the Data Structure where root is on top whereas leaves are at bottom

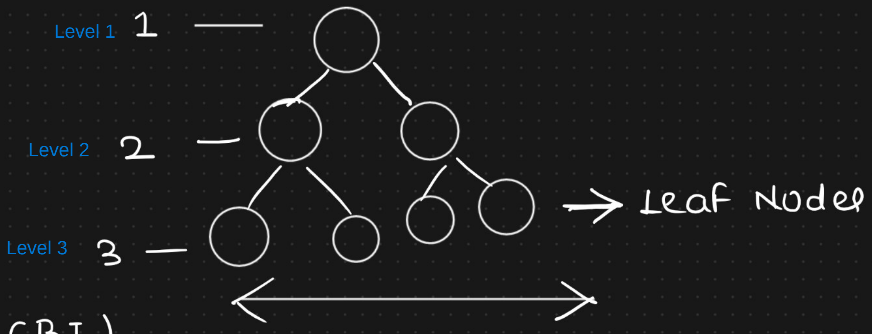
(Leave has no child node)

★ Binary Tree → # child Nodes → 0, 1, 2

↳ Atmost the node → 2 child nodes

Almost the node has 2 child nodes

★ Full Binary Tree → Every node has 2 child nodes apart from the leaf nodes.



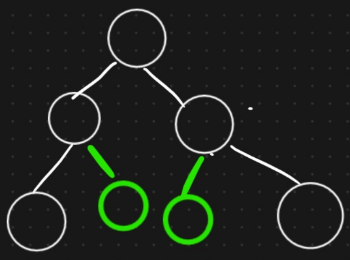
(CBT)

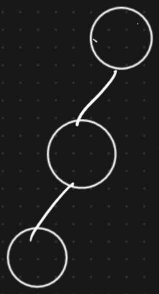
★ Complete binary tree → 1) After completion of first level, then only move towards filling of next level.

2) After completion of left side node, then only go for the completion of right side node.

CBT provides more flexibility as compared to the full binary tree since there is no such restriction on having 2 child nodes (except leaf node) in case of CBT that is imposed in Full Binary Tree.

Not CBT ←



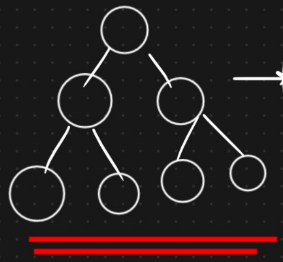


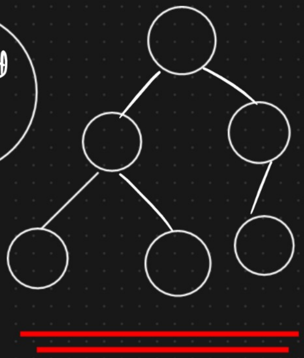
→ Not CBT

full Binary Tree

↑

Valid CBT





→ valid CBT

↓

Almost complete Binary Tree

★ Almost complete Binary Tree

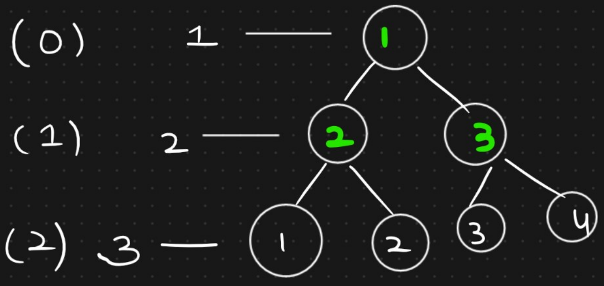
↳ always node → single child at the leaf node

$$\boxed{CBT = FBT + ACBT}$$

↓

flexible

Complete binary tree is flexible as both Full Binary tree and the Almost complete binary tree can be represented in the form CBT.



nodes

↑

n = 7 , k = 3

↓

Levels

Levels are indexed means if we are provided with 3 levels then it will be represented as 0th level, 1st level and 2nd level.

Leaf Node = 4

Non-Leaf Node = 3

Properties of Full Binary Tree (Complete Binary Tree)

1. $\boxed{n = 2^k - 1} = 2^3 - 1$

Relationship b/w number of nodes and the number of levels

$$n = 7$$

$$n = 2^k - 1$$

$$2^k = n + 1$$

$$\boxed{\underline{k} = \log_2 (n+1)}$$

# Levels

$$n = 63$$

$$k = \log_2 (63+1)$$

$$k = \log_2 64$$

$$k = \log_2 2^6$$

$$k = 6 \cancel{\log_2 2}$$

$$k = 6$$

2. $\left\lceil n/2 \right\rceil$ = Number of Leaf Nodes

This is the Upper Bound or Ceil division where n represents the number of nodes

$\left\lceil 7/2 \right\rceil = 4 =$ # Leaf Nodes

$\left\lfloor n/2 \right\rfloor$ = Number of non-leaf Nodes

This is the Lower Bound or Floor division where n represents the number of nodes

$\left\lfloor 7/2 \right\rfloor = 3 =$ # Non-Leaf Nodes

To summarize Heap Data structure is the Complete Binary Tree