DATA STRUCTURE AND ALGORITHMS

By

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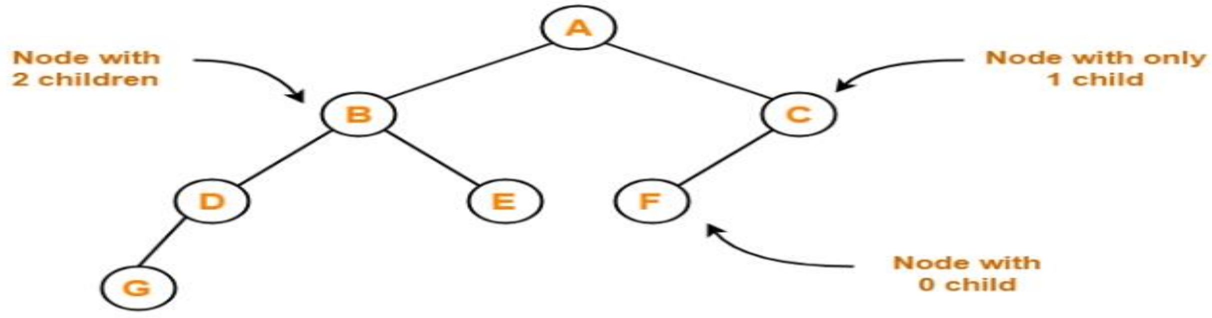
UNIT II
TREES

BINARY TREE

Binary tree is a special tree data structure in which each node can have at most 2 children.

Thus, in a binary tree,Each node has either 0 child or 1 child or 2 children.

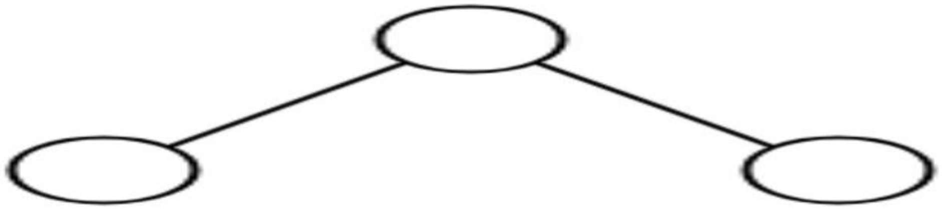


Binary Tree Example

Types of Binary Tree

Unlabeled Binary Tree-

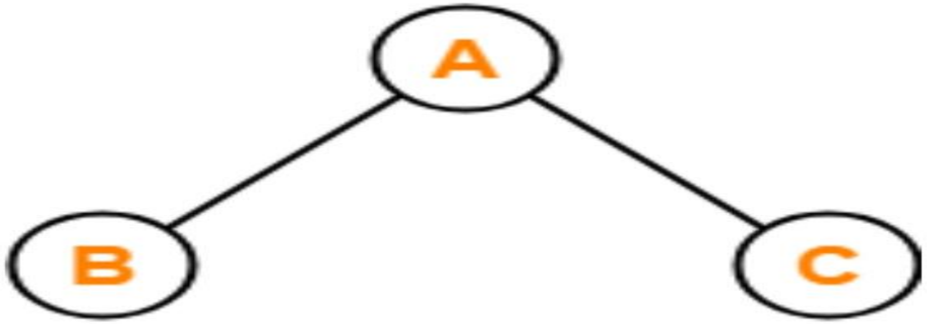
A binary tree is unlabeled if its nodes are not assigned any label.



Unlabeled Binary Tree

Labeled Binary Tree–

- A binary tree is labeled if all its nodes are assigned a label.



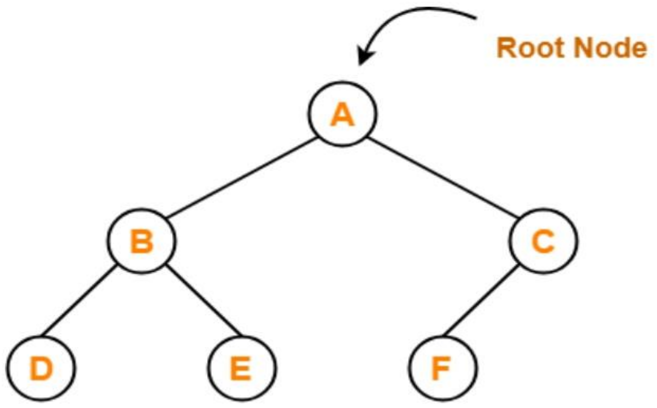
Labeled Binary Tree

Types of Binary Tree

1. Rooted Binary Tree
2. Full / Strictly Binary Tree
3. Complete / Perfect Binary Tree
4. Almost Complete Binary Tree
5. Skewed Binary Tree

1. Rooted Binary Tree-

- A **rooted binary tree** is a binary tree that satisfies the following 2 properties-
- It has a root node.
- Each node has at most 2 children.

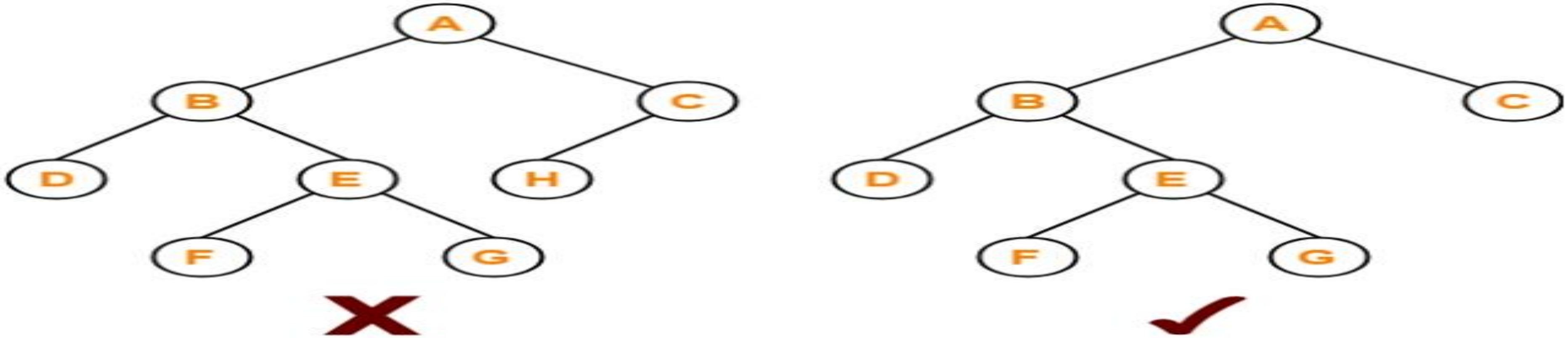


Rooted Binary Tree

2 . Full / Strictly Binary Tree–

- A binary tree in which every node has either 0 or 2 children is called as a **Full binary tree**.
- Full binary tree is also called as **Strictly binary tree**.

Example-

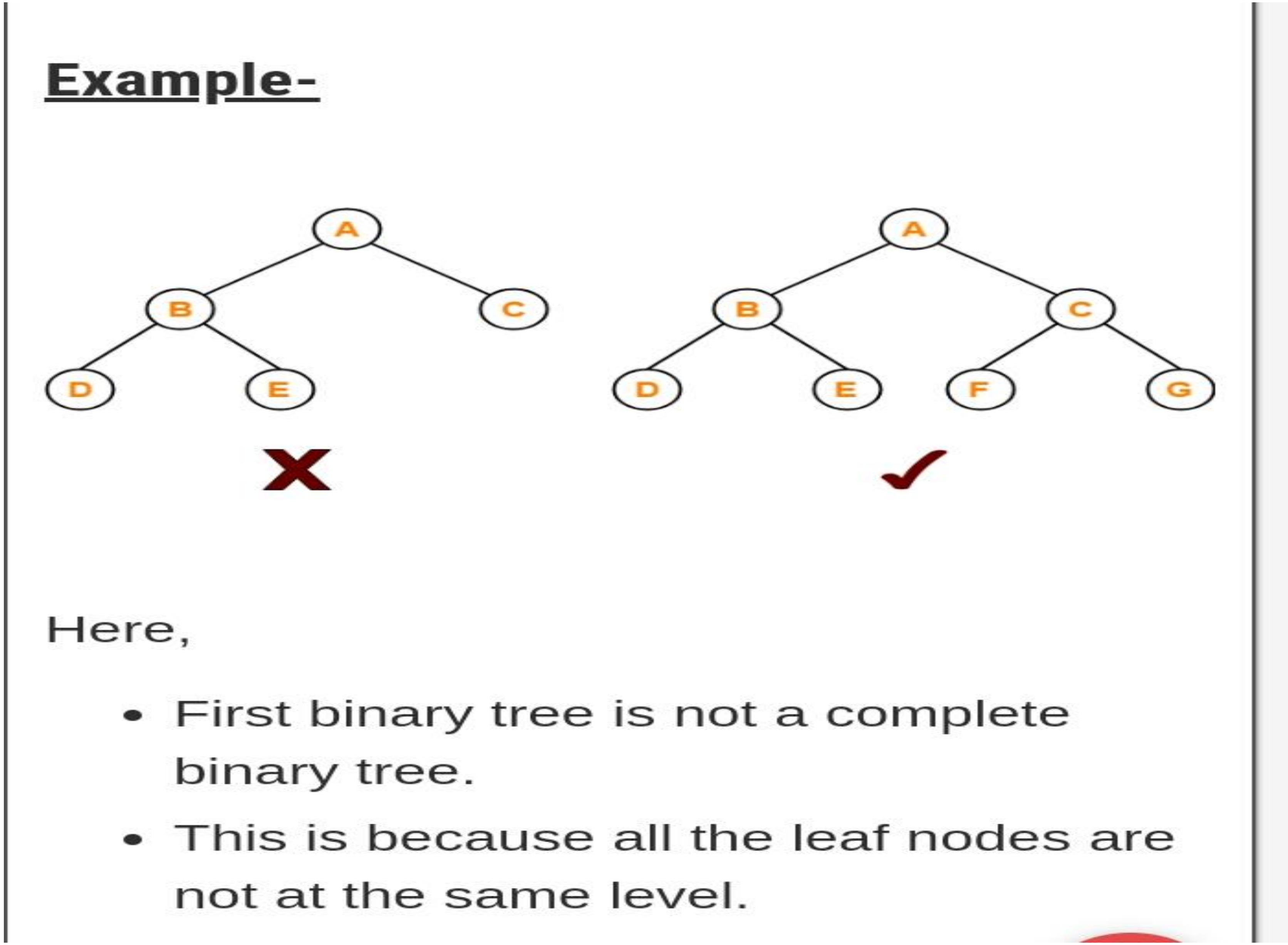


Here,

- First binary tree is not a full binary tree.
- This is because node C has only 1 child.

3. Complete / Perfect Binary Tree

- A **complete binary tree** is a binary tree that satisfies the following 2 properties-
- Every internal node has exactly 2 children.
- All the leaf nodes are at the same level.
- Complete binary tree is also called as **Perfect binary tree**.



Example-

Here,

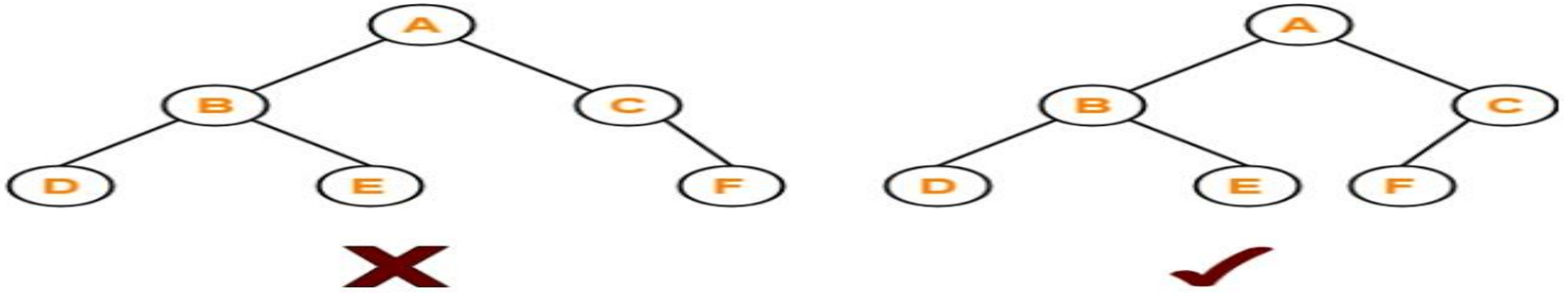
- First binary tree is not a complete binary tree.
- This is because all the leaf nodes are not at the same level.

4. Almost Complete Binary Tree–

An **almost complete binary tree** is a binary tree that satisfies the following 2 properties-

- All the levels are completely filled except possibly the last level.
- The last level must be strictly filled from left to right.

Example-



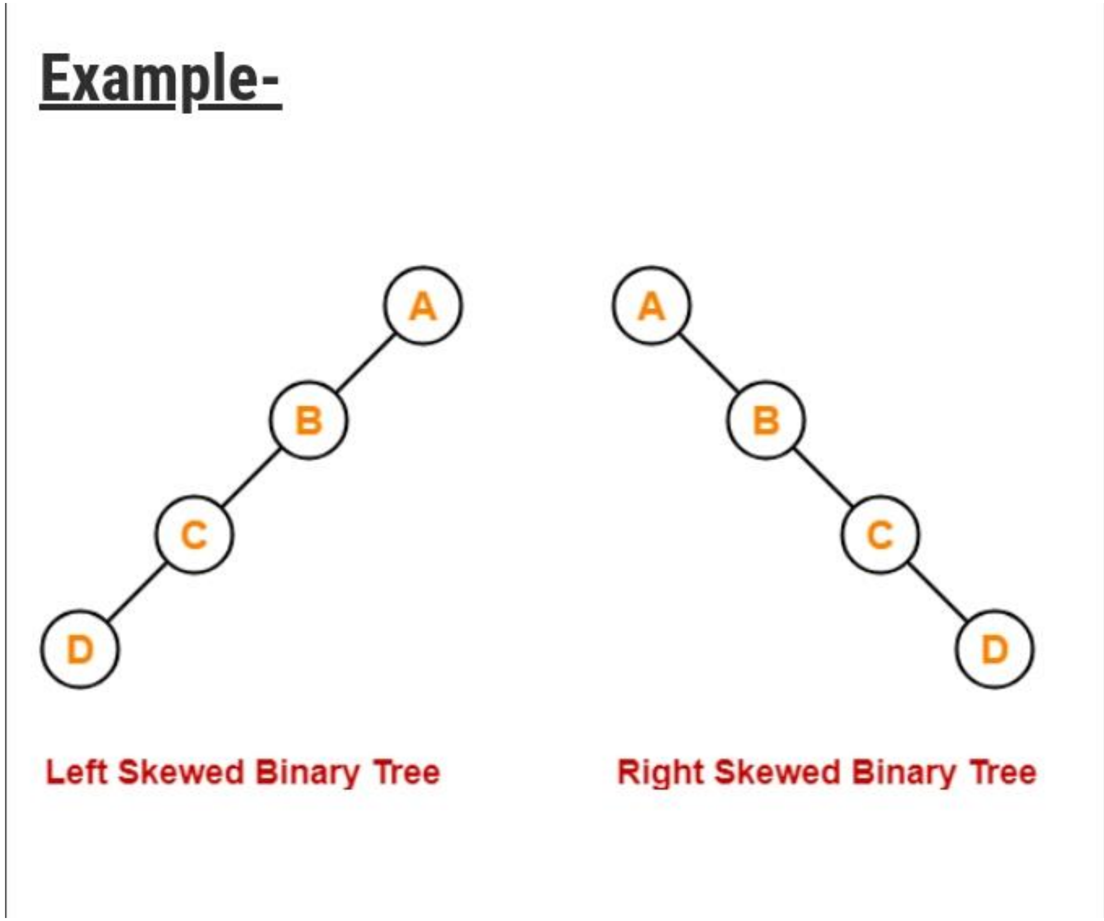
Here,
First binary tree is not an almost complete binary tree.
This is because the last level is not filled from left to right.

5. Skewed Binary Tree

- A **skewed binary tree** is a binary tree that satisfies the following 2 properties-
- All the nodes except one node has one and only one child.
- The remaining node has no child.

OR

- A **skewed binary tree** is a binary tree of n nodes such that its depth is (n-1).



Example-

Left Skewed Binary Tree

Right Skewed Binary Tree

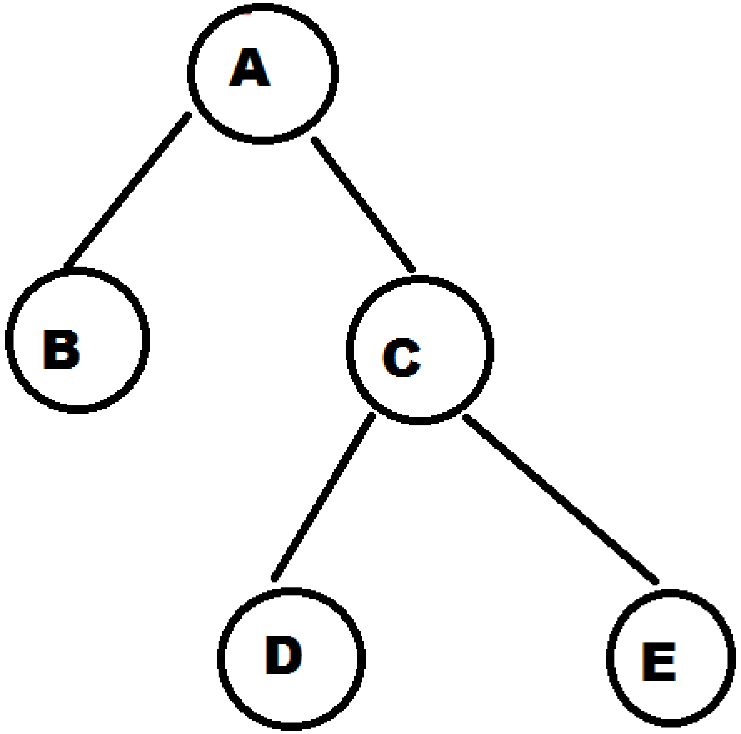
Binary Tree representation

There are two types of representation of a binary tree:

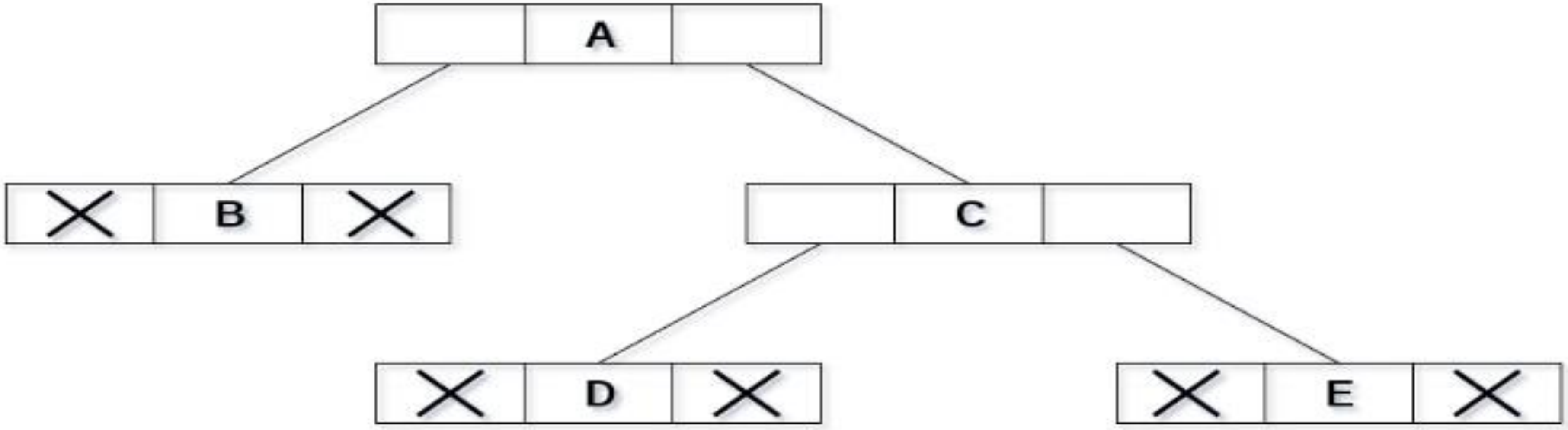
1. Linked Representation

- In this representation, the binary tree is stored in the memory, in the form of a linked list where nodes are linked together by inheriting parent child relationship like a tree.

For this binary tree



Linked Representation is

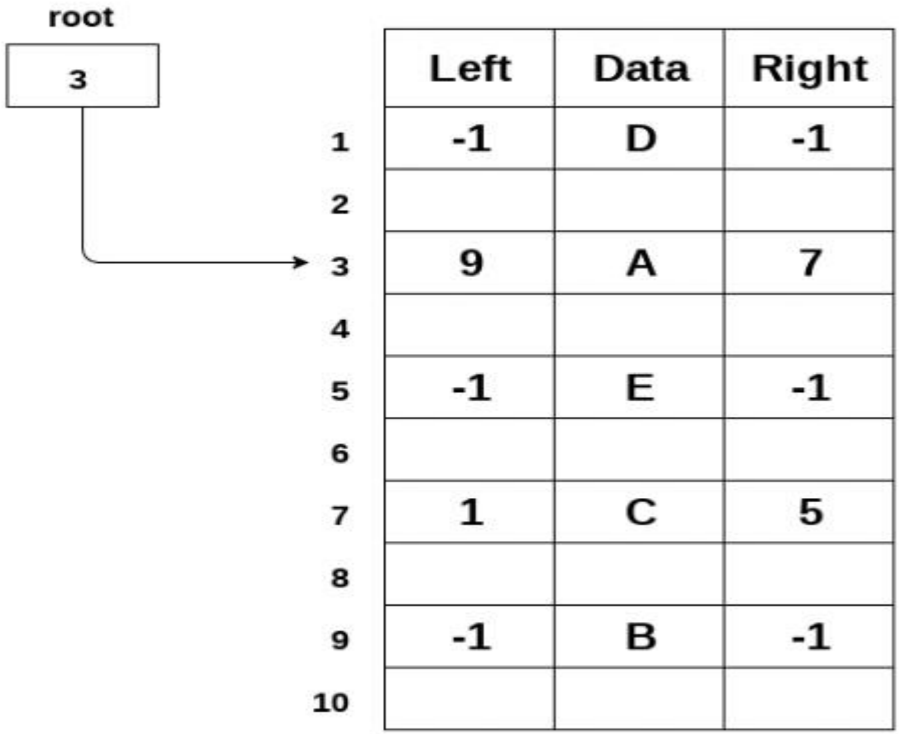


In the above figure, a tree is seen as the collection of nodes where each node contains three parts :

- left pointer,
- data element and
- right pointer.
- Left pointer stores the address of the left child while the right pointer stores the address of the right child.
- The leaf node contains **null** in its left and right pointers.

The following image shows about how the memory will be allocated for the binary tree by using linked representation.

- There is a special pointer maintained in the memory which points to the root node of the tree.
- Every node in the tree contains the address of its left and right child.
- Leaf node contains null in its left and right pointers.



root

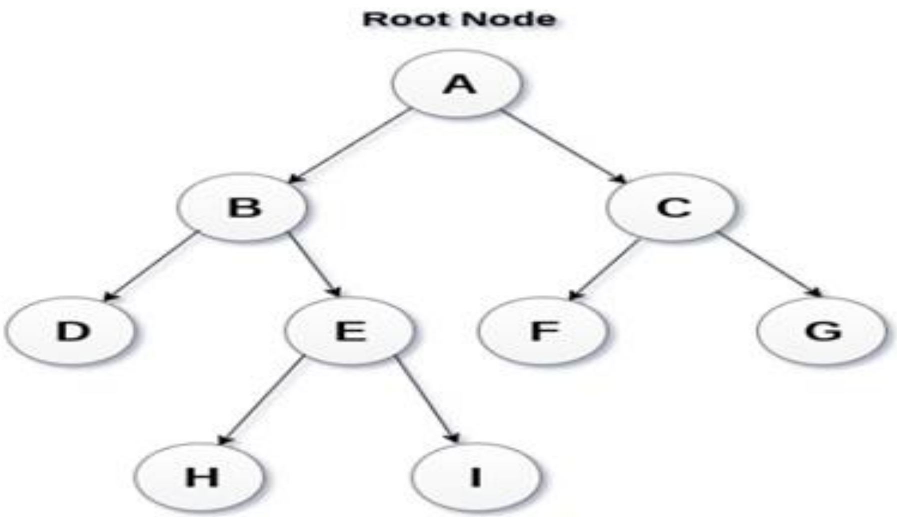
3

	Left	Data	Right
1	-1	D	-1
2			
3	9	A	7
4			
5	-1	E	-1
6			
7	1	C	5
8			
9	-1	B	-1
10			

Memory Allocation of Binary Tree using linked Representation

2.Sequential Representation

- This is the simplest memory allocation technique to store the tree elements.
- But it is an inefficient technique since it requires a lot of space to store the tree elements.
- A binary tree is shown in the following figure along with its memory allocation.



A	B	C	D	E	F	G			H	I
1	2	3	4	5	6	7	8	9	10	11

Sequential Representation of Binary Tree

2.Sequential Representation

- In this representation, an array is used to store the tree elements. Size of the array will be equal to the number of nodes present in the tree.
- The root node of the tree will be present at the 1st index of the array.
- If a node is stored at ith index then its left and right children will be stored at 2i and 2i+1 location.
- If the 1st index of the array i.e. tree[1] is 0, it means that the tree is empty.

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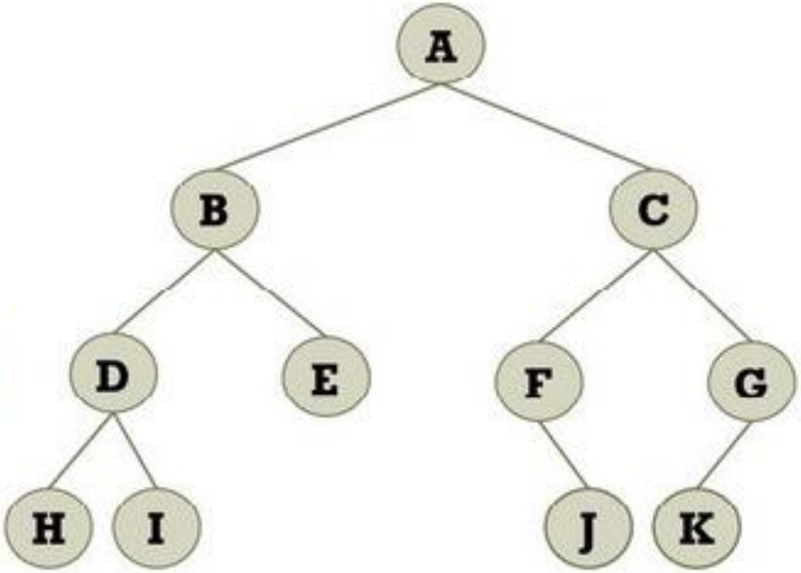
BINARY TREE TRAVERSAL

Binary Tree Traversal

Tree Traversal refers to the process of visiting each node in a tree data structure exactly once.

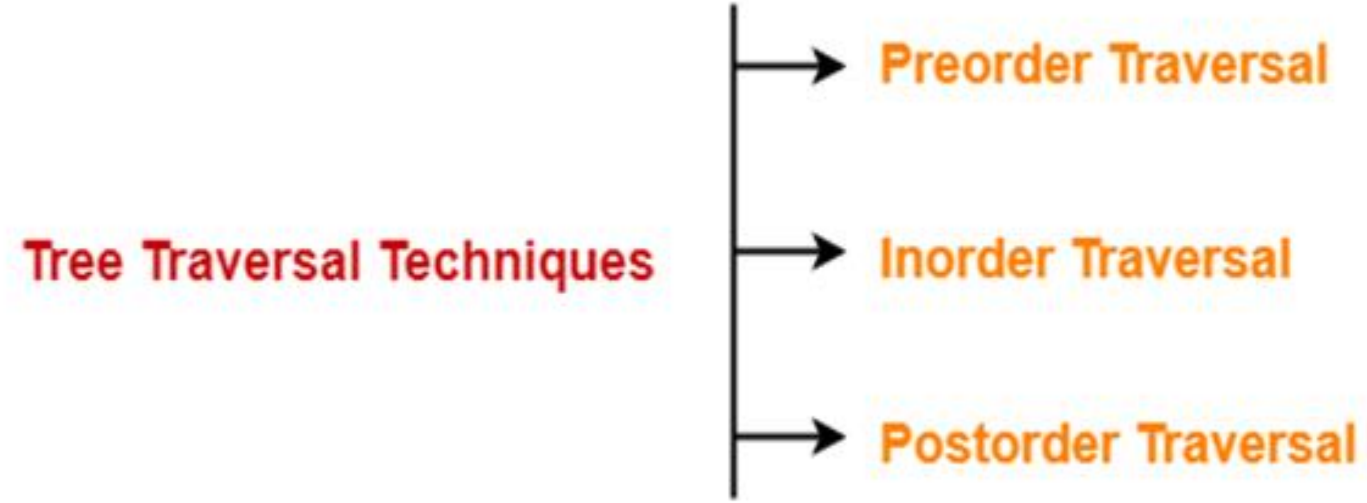
Traversal of Binary Tree

- Traversal
  - The process of visiting each node in a tree
- Why the traversal necessary?
  - Checking whether insertions/deletions work well.
  - Searching a specific node.
- How to visit all nodes once?



Binary Tree Traversal

Various tree traversal methods are-



Tree Traversal Techniques

- Preorder Traversal
- Inorder Traversal
- Postorder Traversal

1. Preorder Traversal

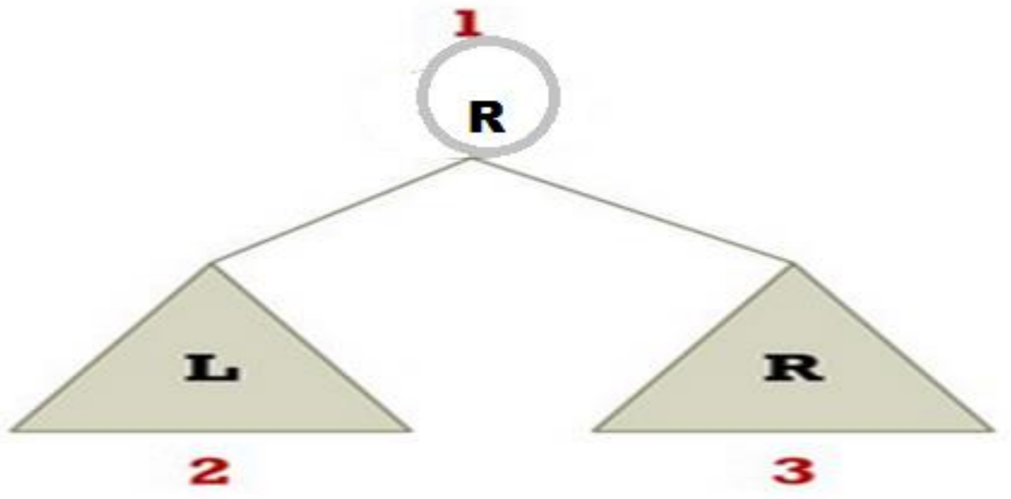
Algorithm-

1. Visit the root node.
2. Visit all the nodes in the left subtree.
3. Visit all the nodes in the right subtree

Root → Left → Right

Always remember for preorder

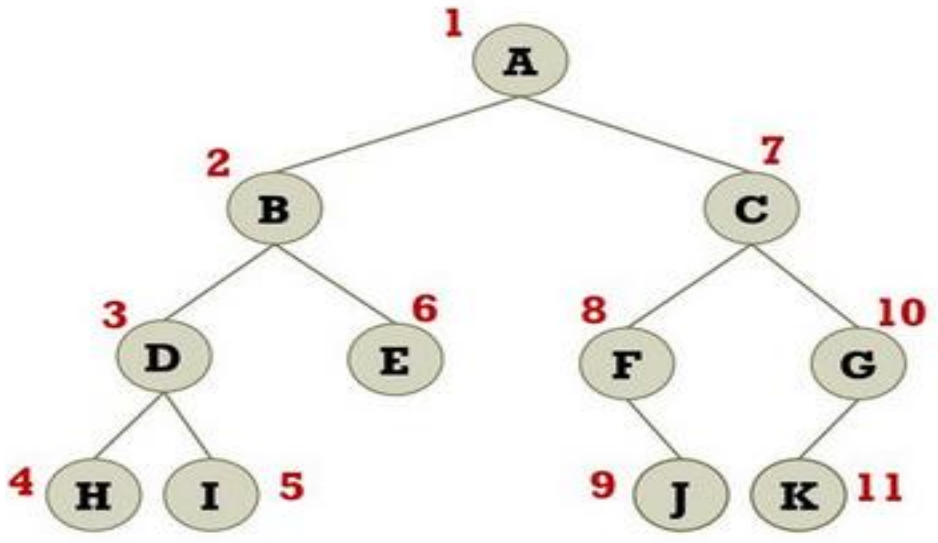
Root → Left → Right **or** **DATA--> LEFT --> RIGHT**

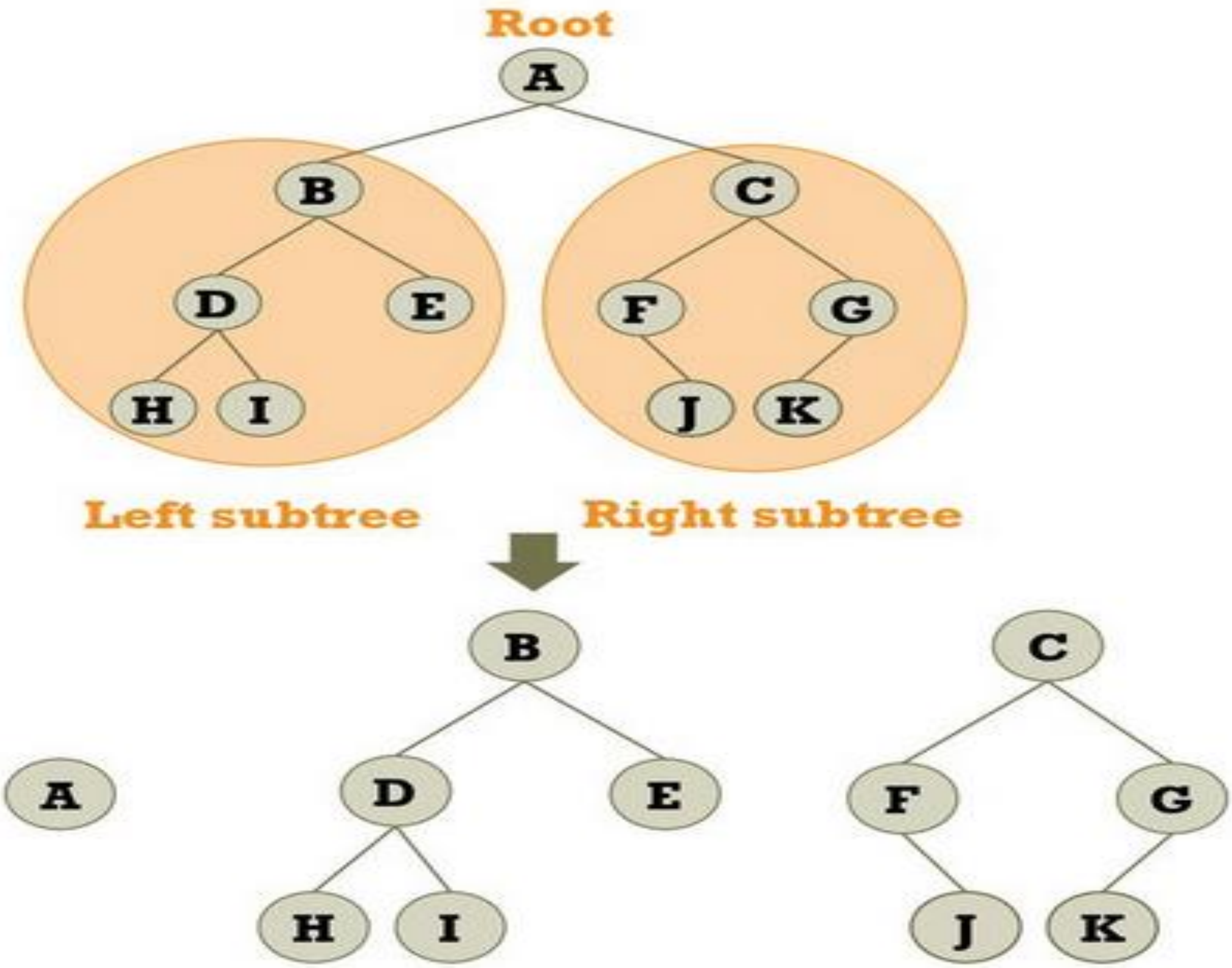


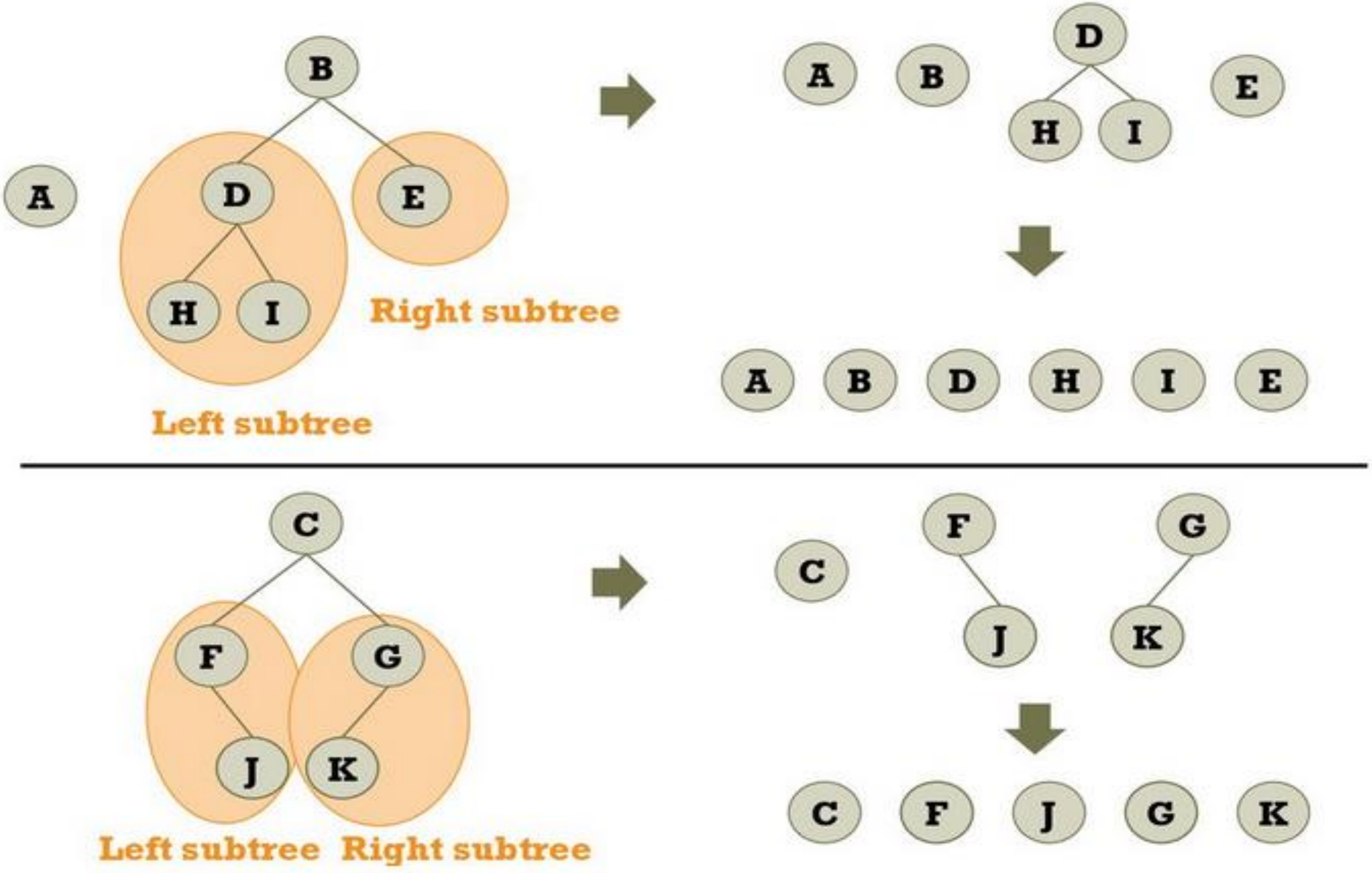
1. Preorder Traversal

Example

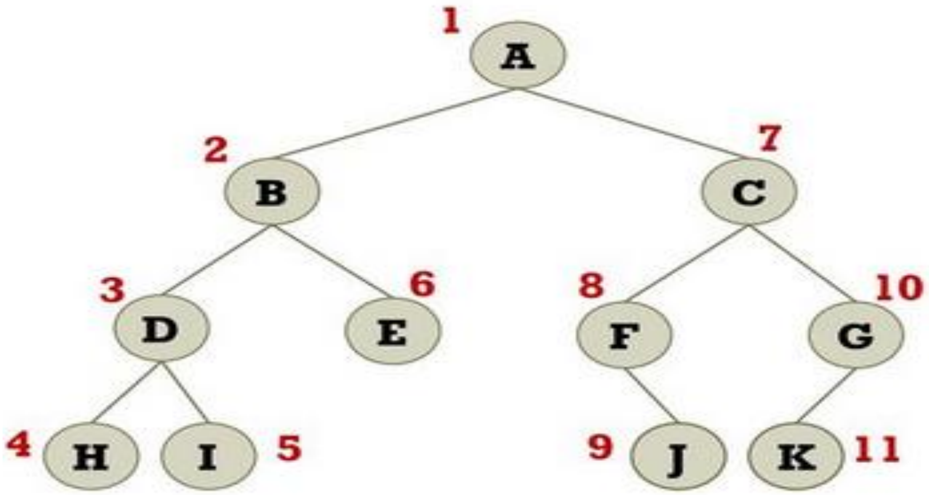
Consider the following example




Root
A
B
C
D
E
F
G
H
I
J
K
Left subtree
Right subtree
B
C
A
D
E
F
G
H
I
J
K

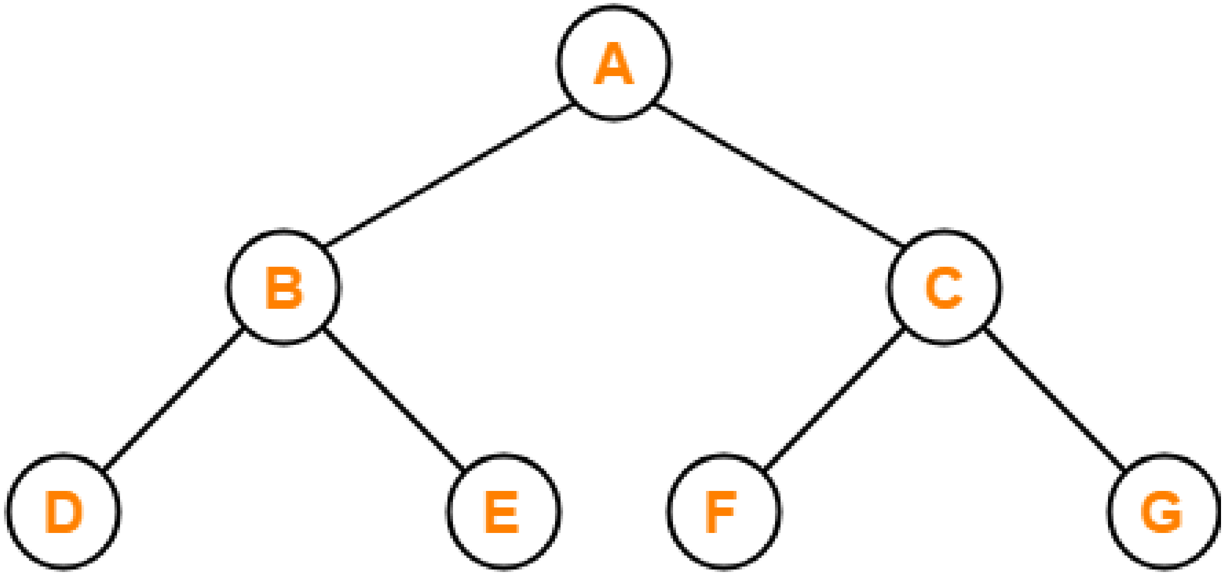

B
A
D
E
H
I
Right subtree
Left subtree
A B D E H I
A B D H I E
C
F
G
J
K
Left subtree
Right subtree
C F G J K
C F J G K

1. Preorder Traversal



A B D H I E C F J G K

1. Preorder Traversal

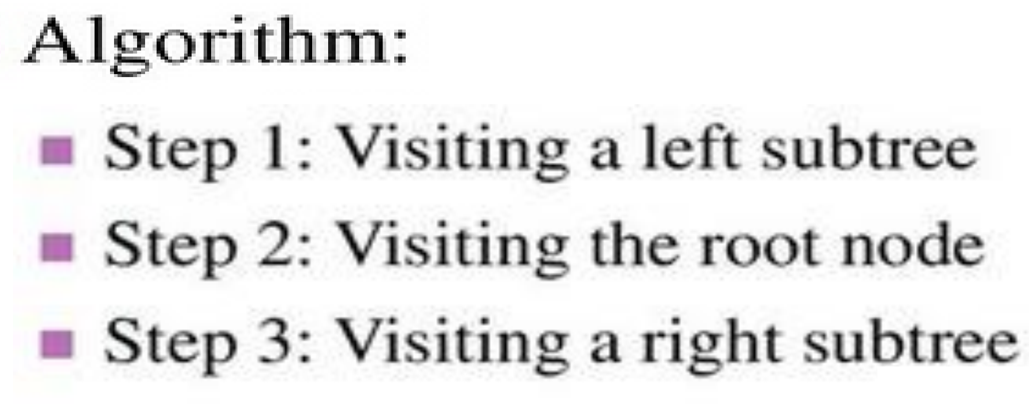


Preorder Traversal : A , B , D , E , C , F , G

Applications Of Preorder

- Preorder traversal is used to get prefix expression of an expression tree.
- Preorder traversal is used to create a copy of the tree.

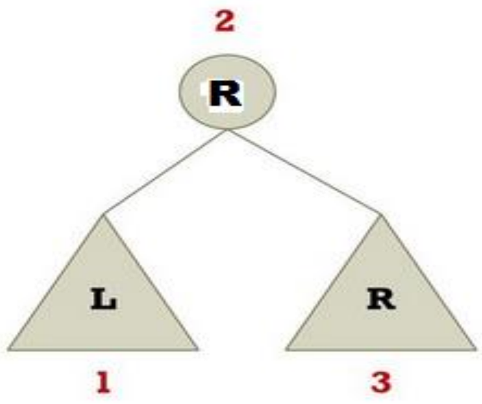
2. Inorder Traversal



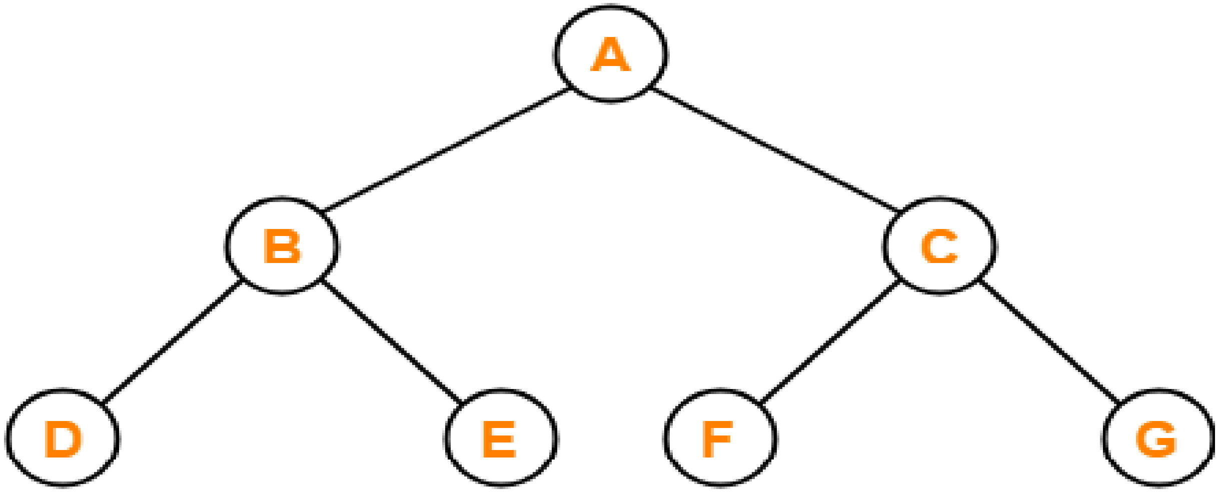
Algorithm:

- Step 1: Visiting a left subtree
- Step 2: Visiting the root node
- Step 3: Visiting a right subtree

Left → Root → Right



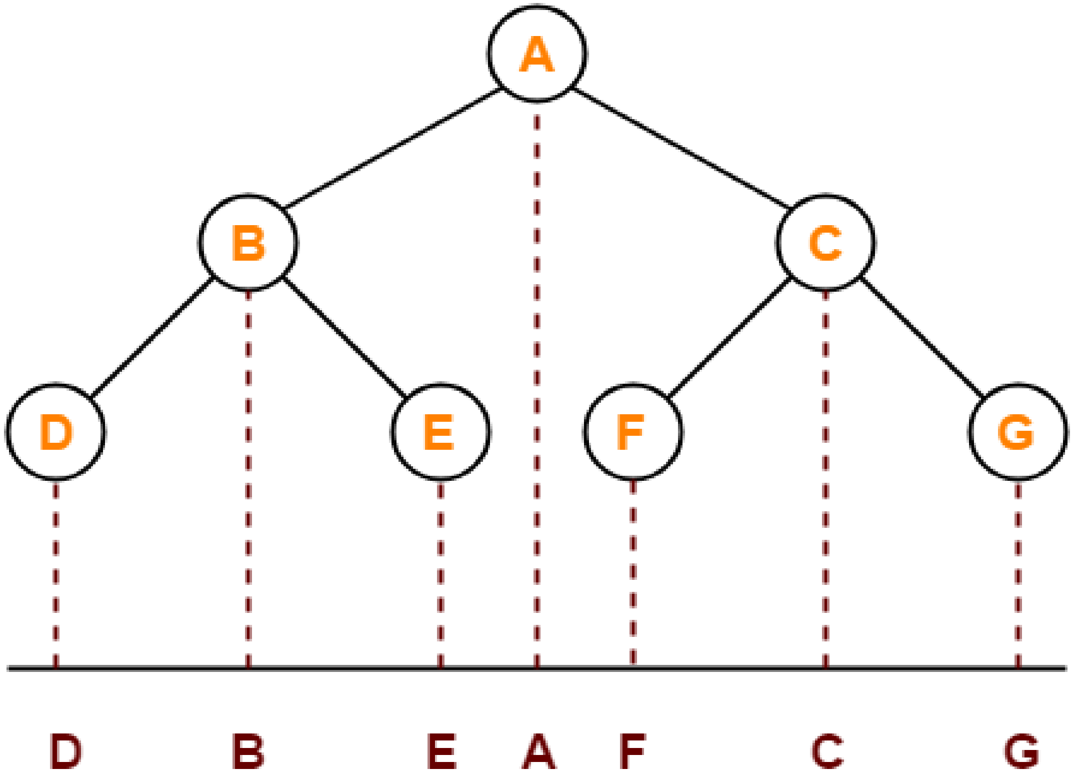
Consider the following example-



Inorder Traversal : D , B , E , A , F , C , G

Inorder Traversal Shortcut

Keep a plane mirror horizontally at the bottom of the tree and take the projection of all the nodes.

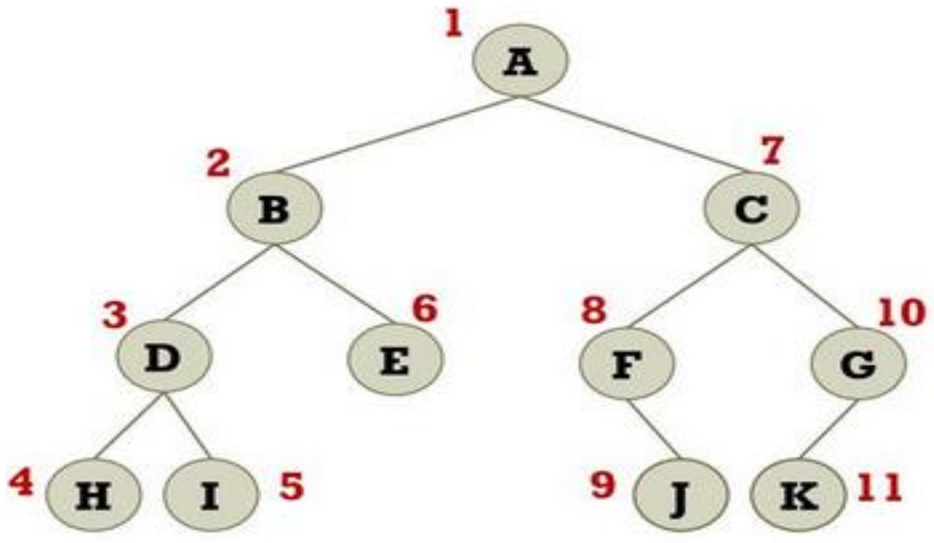


Inorder Traversal : D , B , E , A , F , C , G

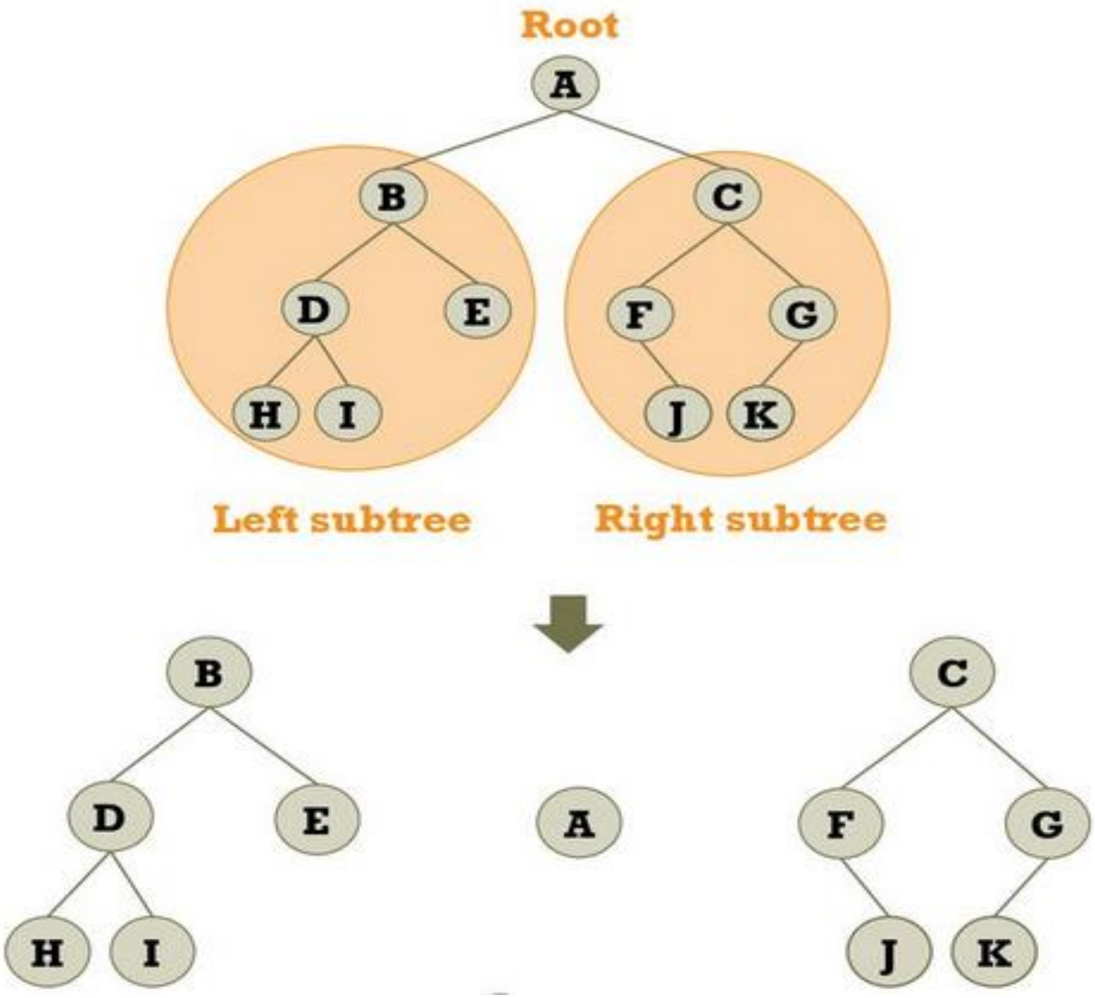
2. Inorder Traversal

Example

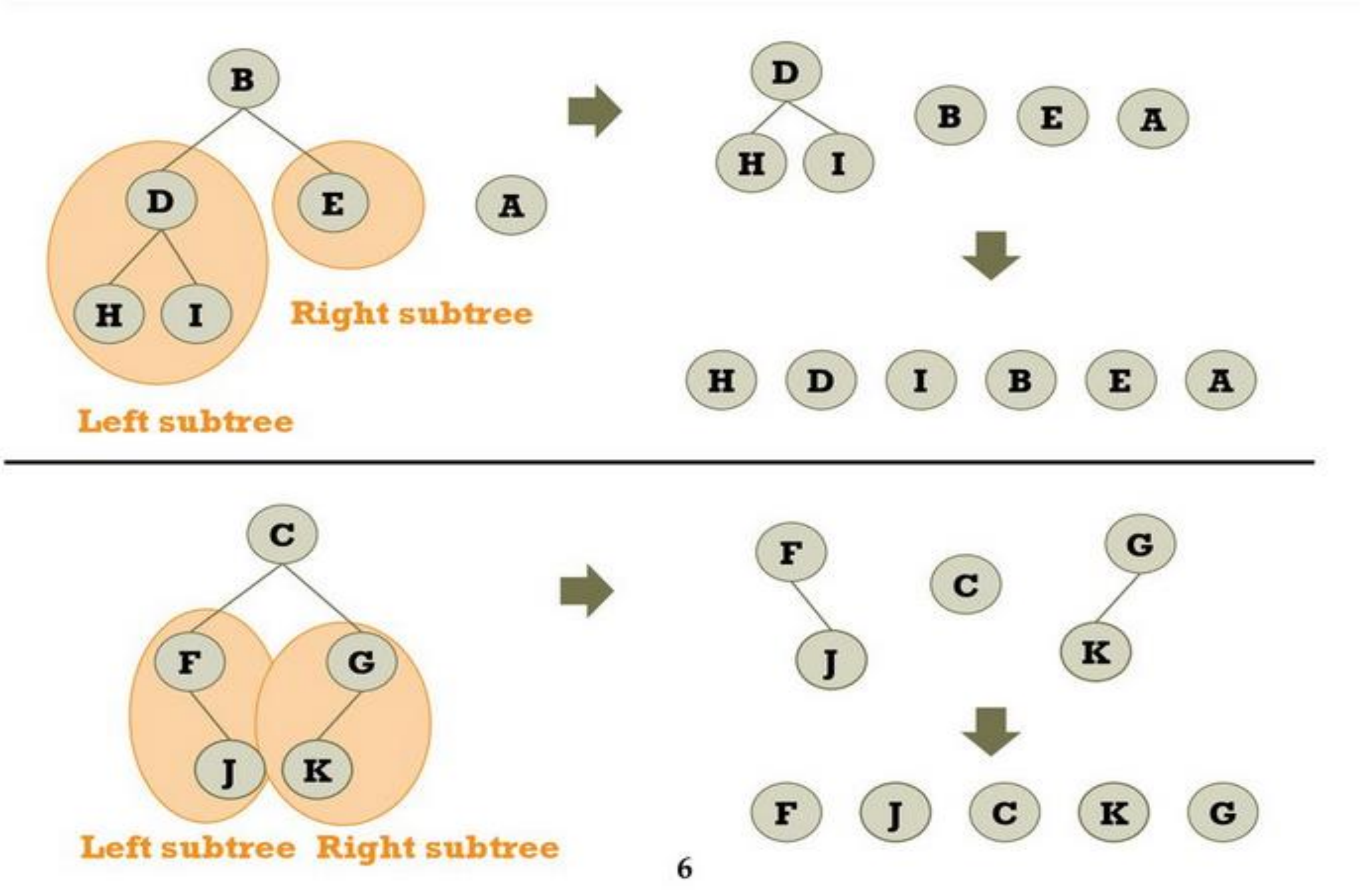
Consider the following example



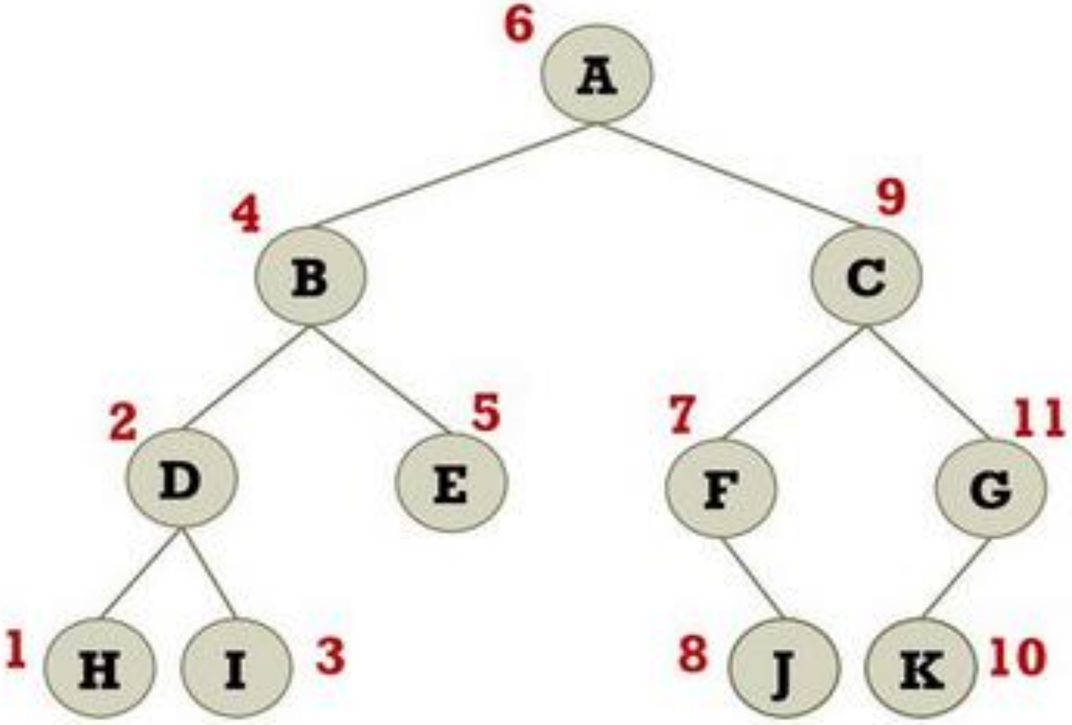
2. Inorder Traversal



2. Inorder Traversal



SO THE INORDER TRAVERSAL FOR GIVEN TREE IS

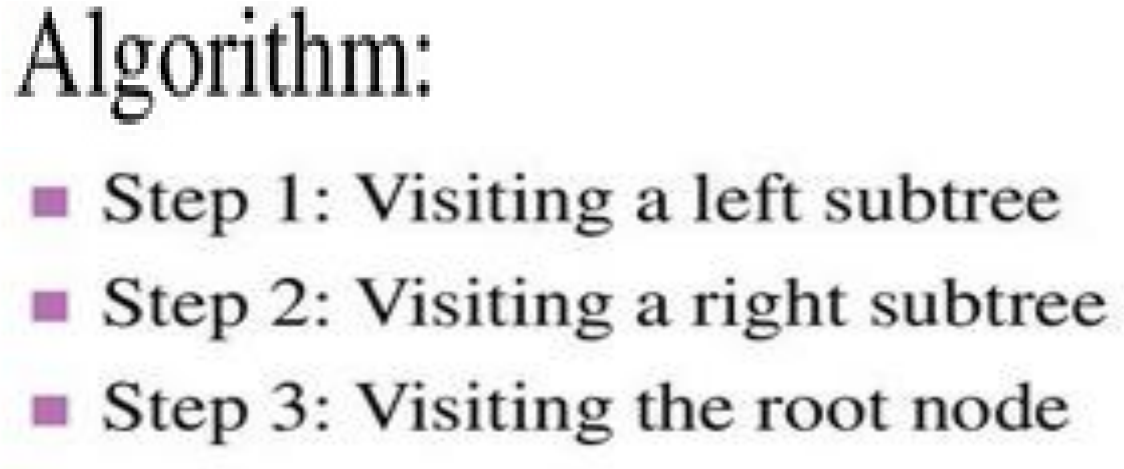


H D I B E A F J C K G

Applications Of Inorder

- Inorder traversal is used to get infix expression of an expression tree.

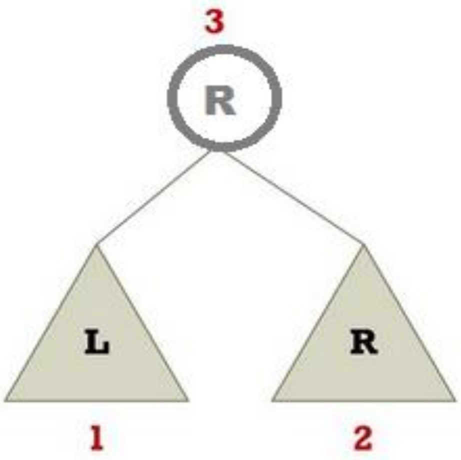
3. Postorder Traversal



Algorithm:

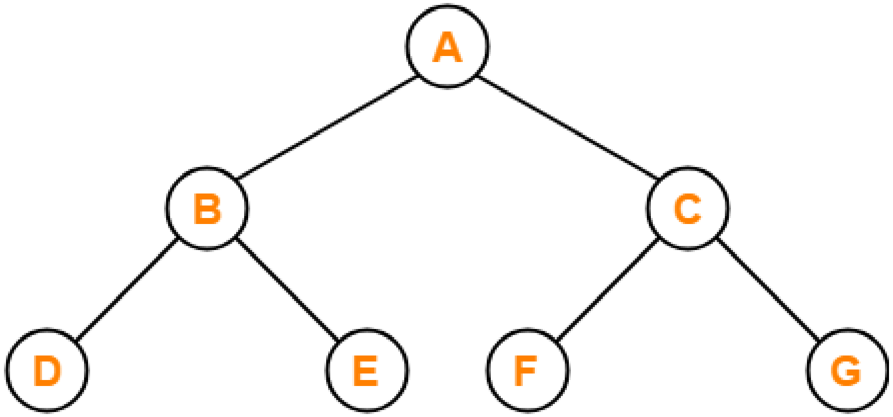
- Step 1: Visiting a left subtree
- Step 2: Visiting a right subtree
- Step 3: Visiting the root node

Left → Right → Root



3. Postorder Traversal

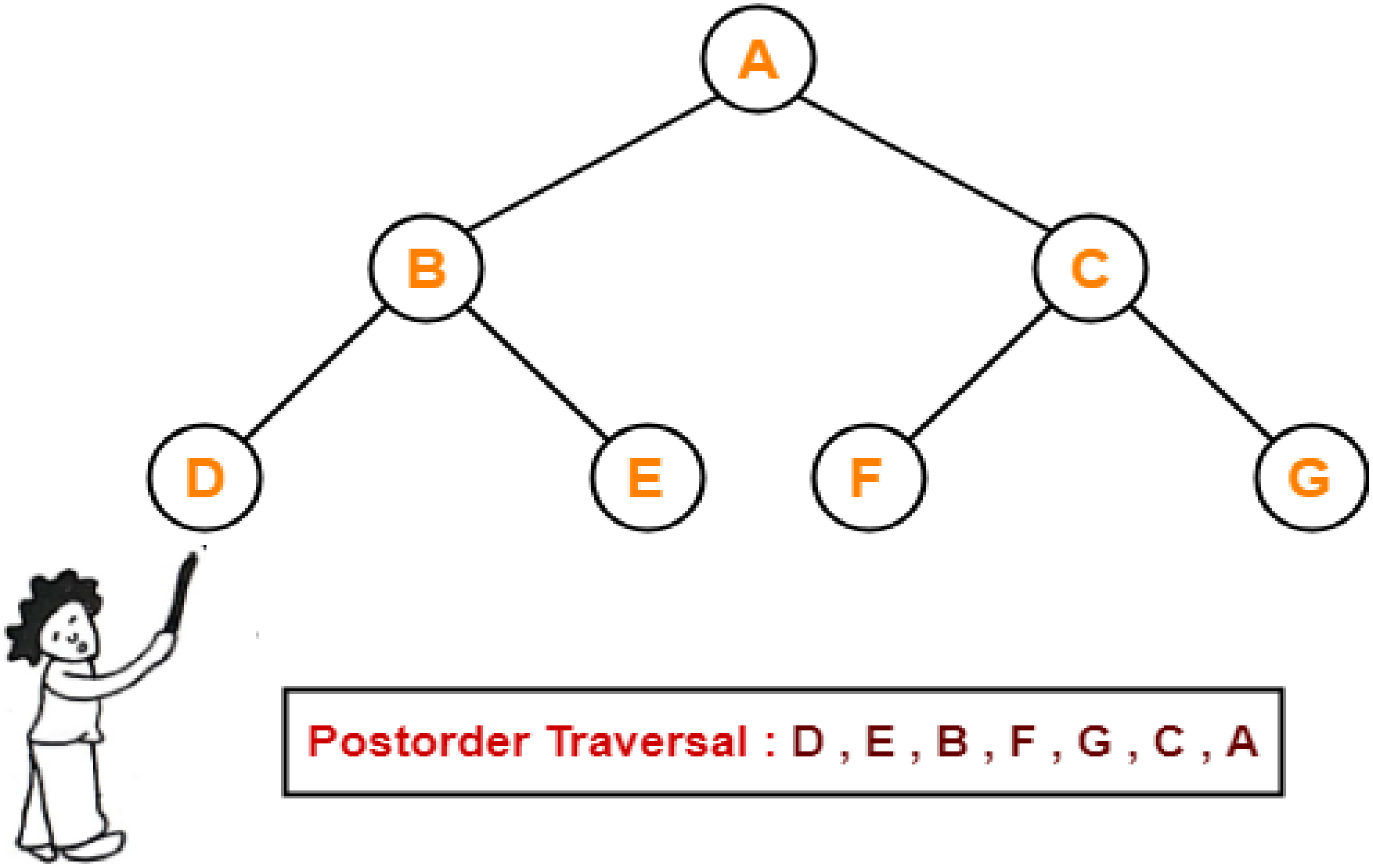
Consider the following example-



Postorder Traversal : D , E , B , F , G , C , A

Postorder Traversal Shortcut

Pluck all the leftmost leaf nodes one by one.



Postorder Traversal : D , E , B , F , G , C , A