TREES

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- Definition
- Basic Terminology
- Binary Trees
- Representation using Array & Linked List

Definition

- Tree is a non-linear data structure which organizes data in a hierarchical structure and this is a recursive definition.

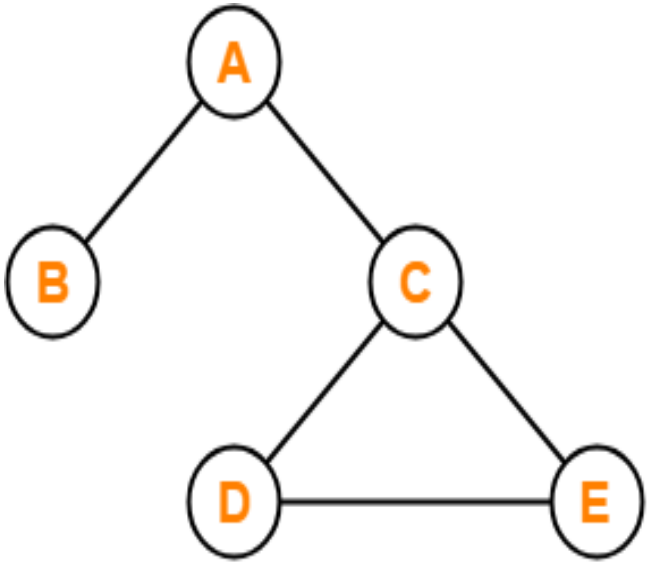
OR

- A tree is a connected graph without any circuits.

OR

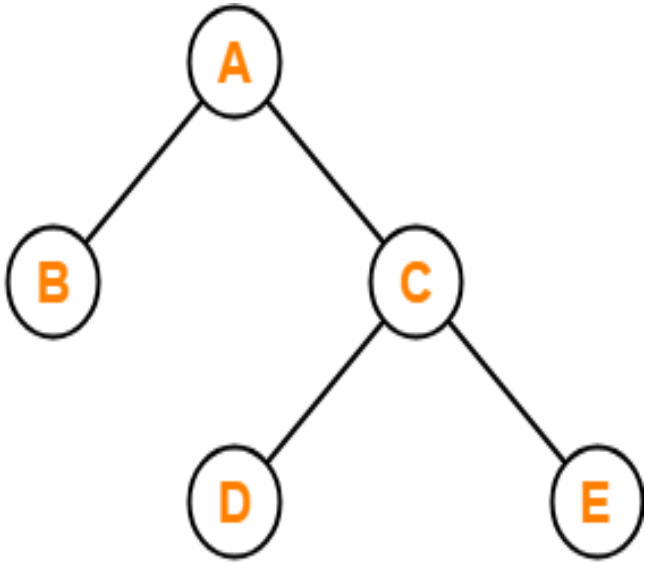
- If in a graph, there is one and only one path between every pair of vertices, then graph is called as a tree.

- **Example-**



✗

This graph is not a Tree



✓

This graph is a Tree

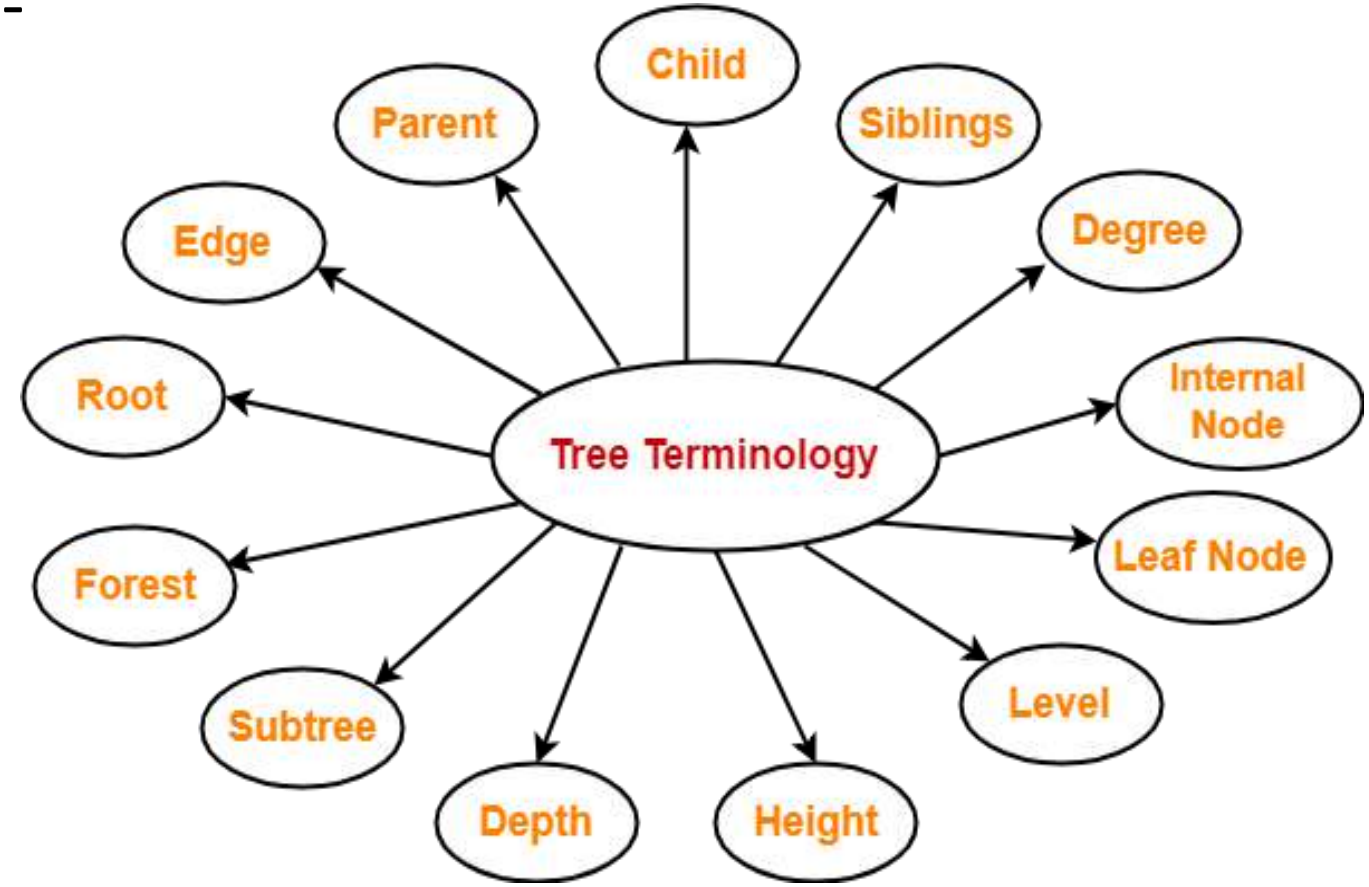
Properties

The important properties of tree data structure are:

- There is one and only one path between every pair of vertices in a tree.
- A tree with n vertices has exactly (n-1) edges.
- A graph is a tree if and only if it is minimally connected.
- Any connected graph with n vertices and (n-1) edges is a tree.

Basic Terminology

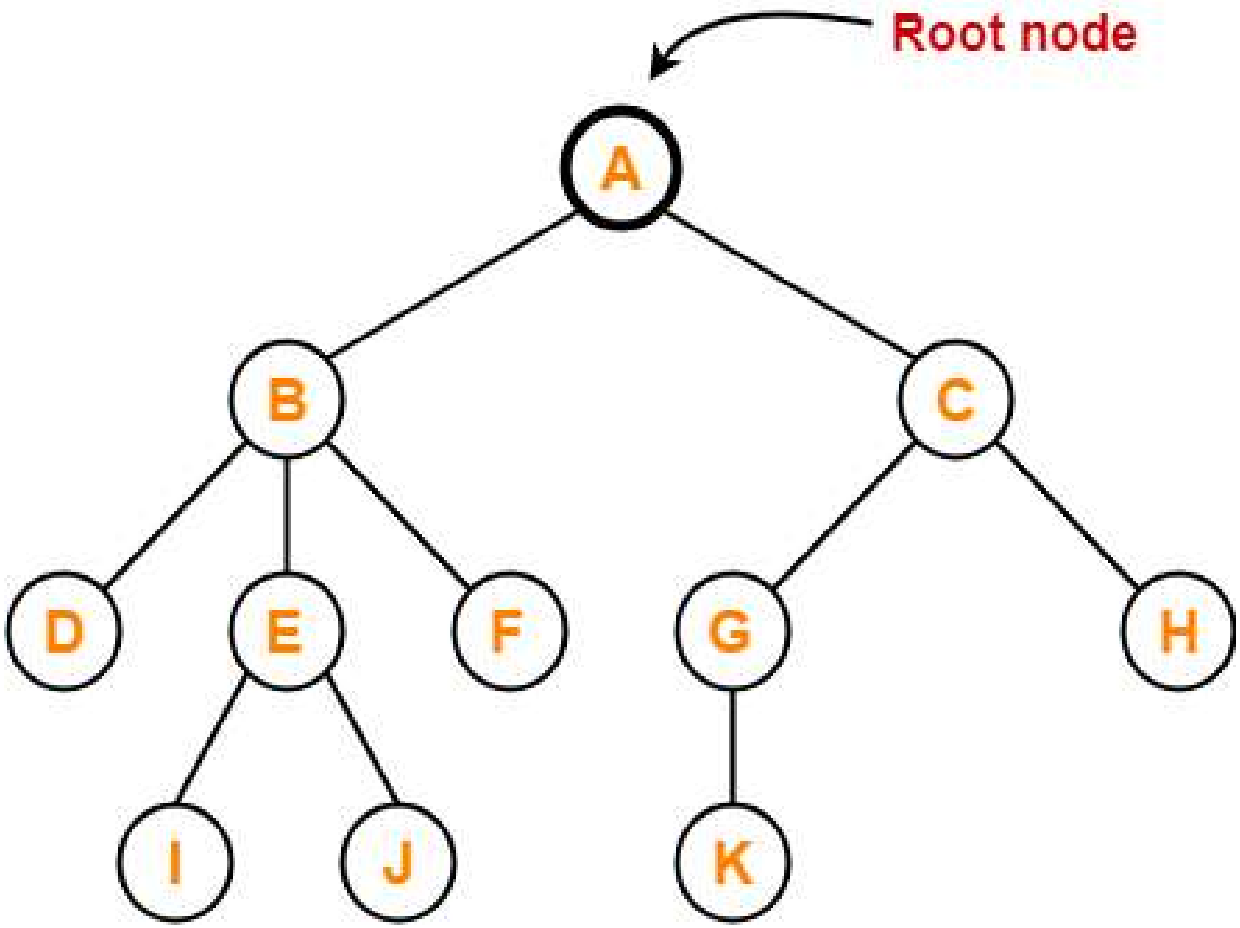
- The important terms related to tree data structure are-



1. Root-

- The first node from where the tree originates is called as a **root node**.
- In any tree, there must be only one root node.
- We can never have multiple root nodes in a tree data structure.

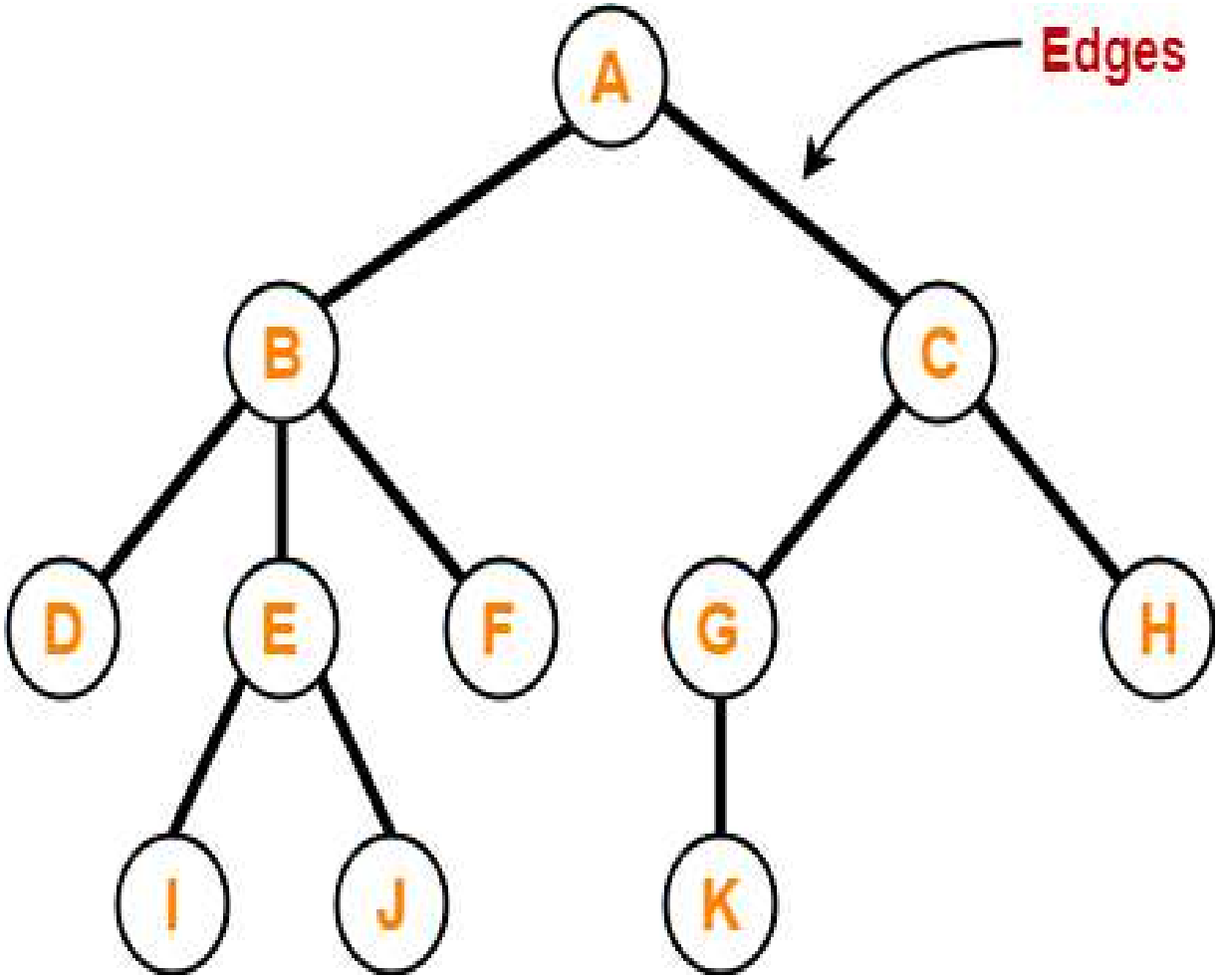
Example



2. Edge-

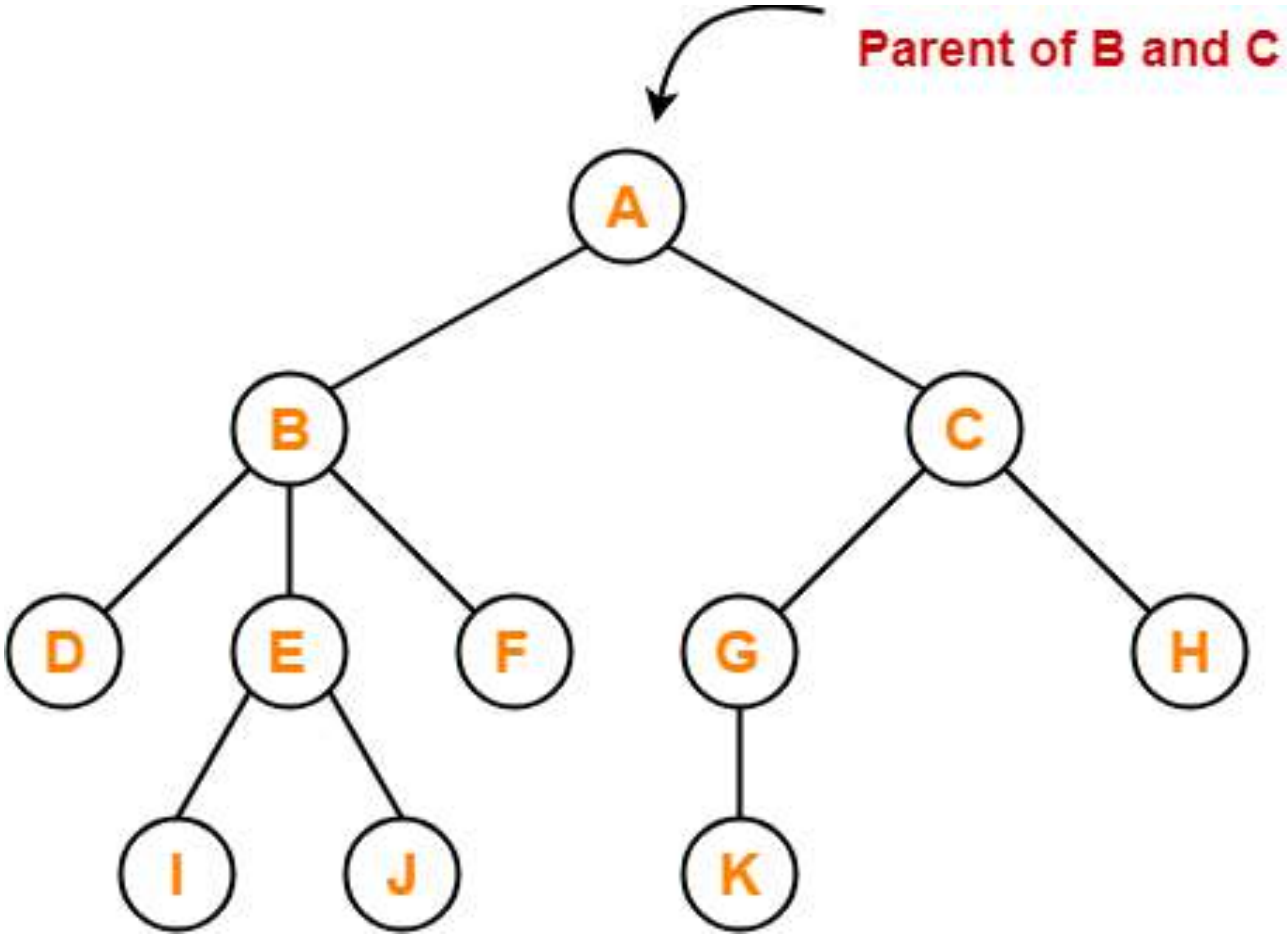
- The connecting link between any two nodes is called as an **edge**.
- In a tree with n number of nodes, there are exactly (n-1) number of edges.

Example



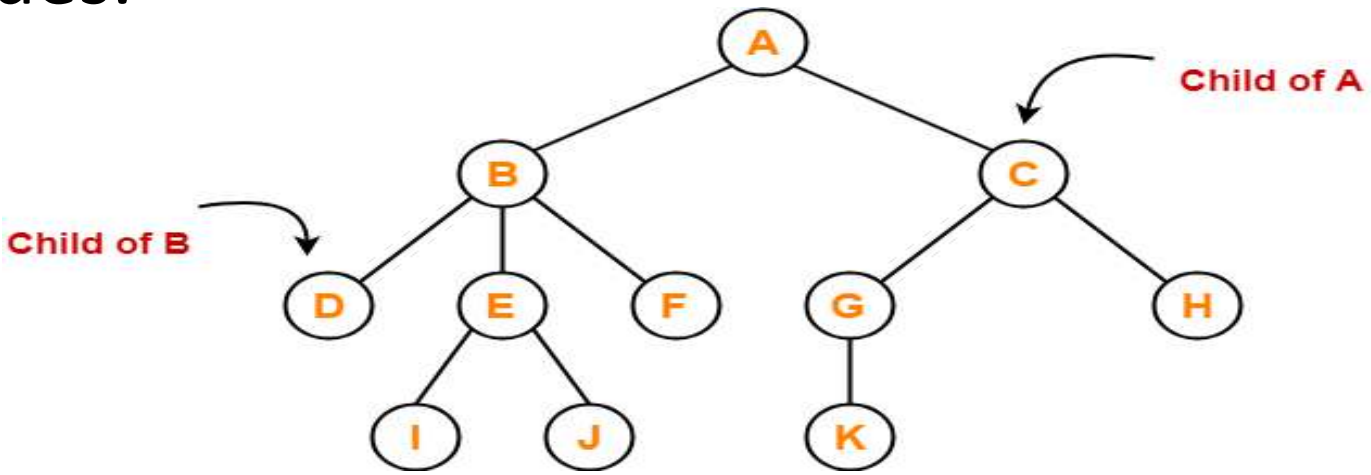
- **3. Parent-**
- The node which has a branch from it to any other node is called as a **parent node**.
- In other words, the node which has one or more children is called as a parent node.
- In a tree, a parent node can have any number of child nodes.

Example



- Here, Node A is the parent of nodes B and C
- Node B is the parent of nodes D, E and F
- Node C is the parent of nodes G and H
- Node E is the parent of nodes I and J
- Node G is the parent of node K

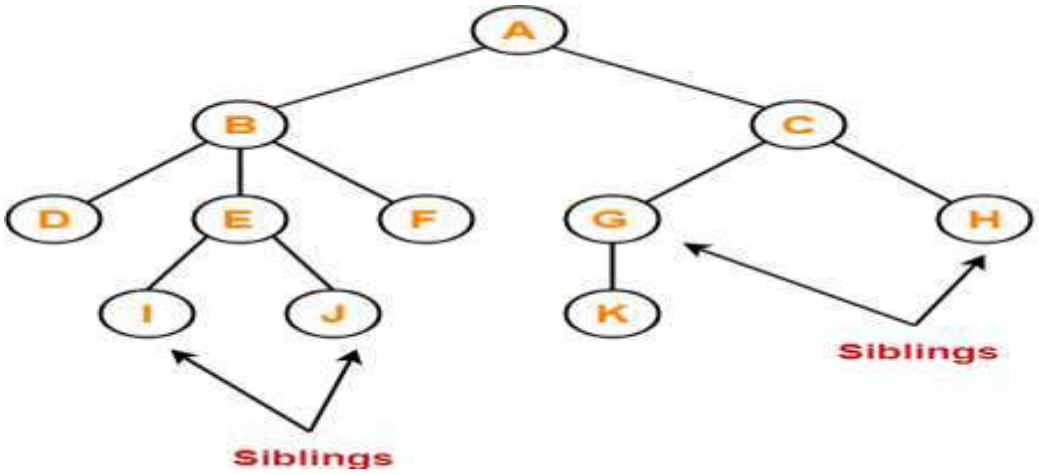
- **4. Child-**
- The node which is a descendant of some node is called as a **child node**.
- All the nodes except root node are child nodes.



Here,

- Nodes B and C are the children of node A
- Nodes D, E and F are the children of node B
- Nodes G and H are the children of node C
- Nodes I and J are the children of node E
- Node K is the child of node G

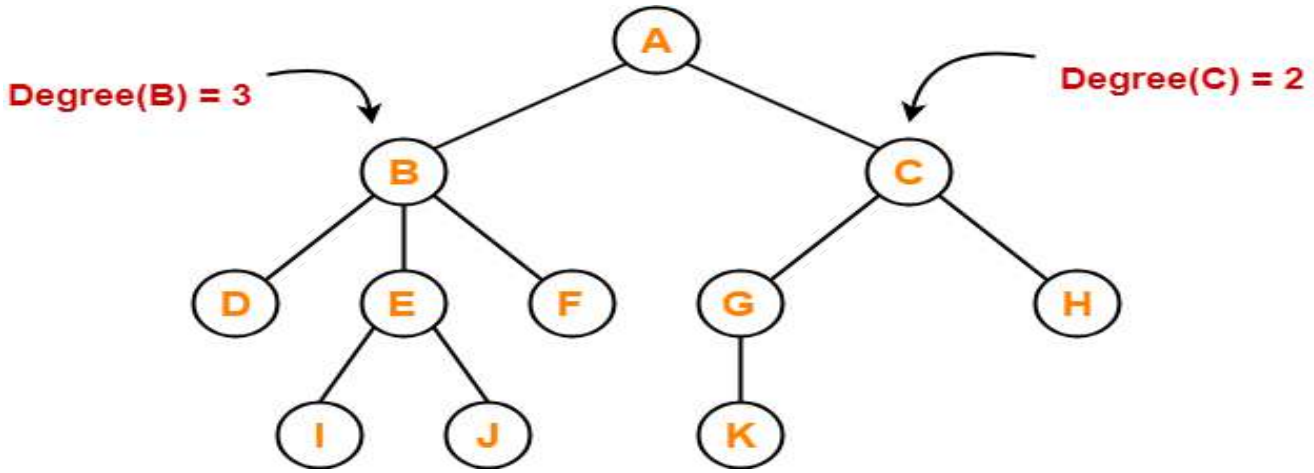
- **5. Siblings-**
- Nodes which belong to the same parent are called as **siblings**.
- In other words, nodes with the same parent are sibling nodes.



Here,

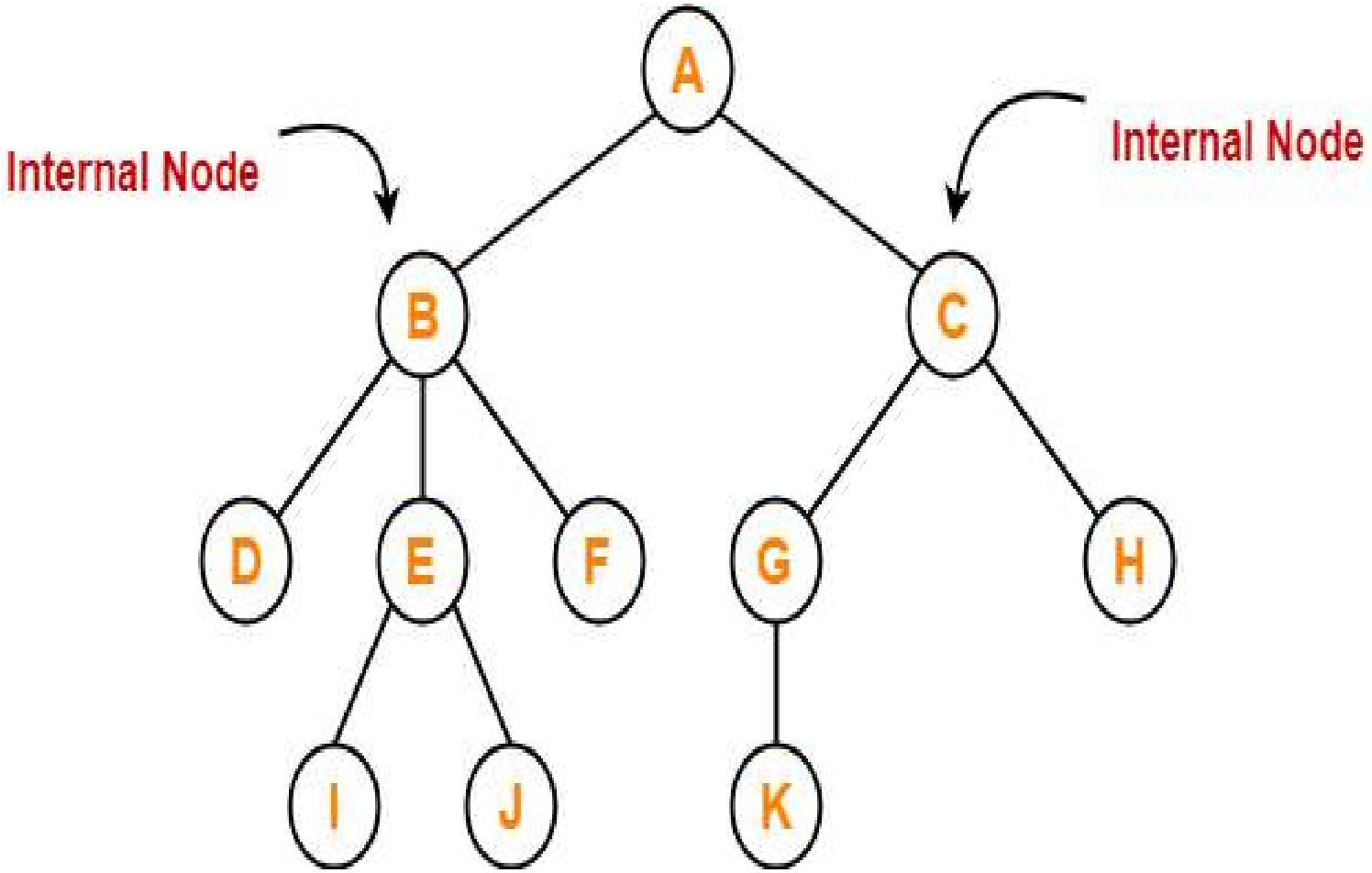
- Nodes B and C are siblings
- Nodes D, E and F are siblings
- Nodes G and H are siblings
- Nodes I and J are siblings

- **6. Degree-**
- **Degree of a node** is the total number of children of that node.
- **Degree of a tree** is the highest degree of a node among all the nodes in the tree.

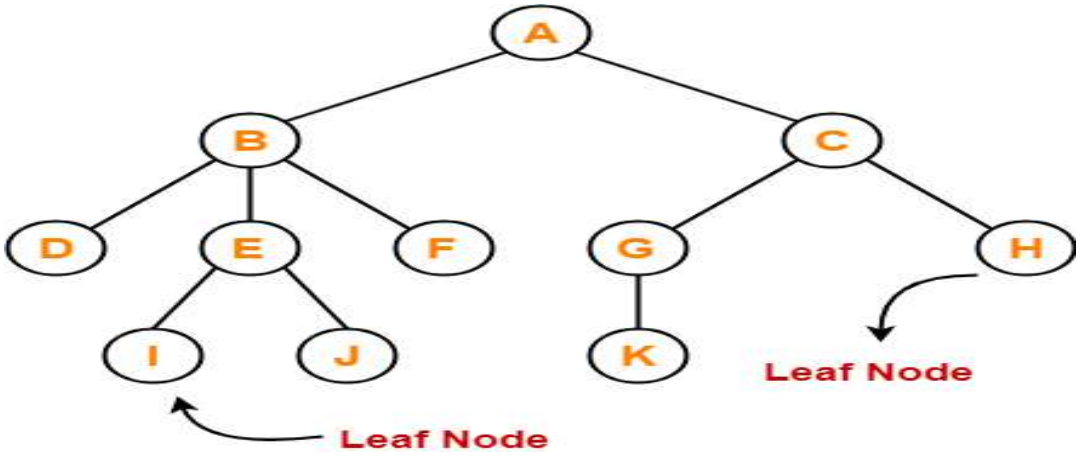


- Here,
- Degree of node A = 2
- Degree of node B = 3
- Degree of node C = 2
- Degree of node D = 0
- Degree of node E = 2
- Degree of node F = 0
- Degree of node G = 1
- Degree of node H = 0
- Degree of node I = 0
- Degree of node J = 0
- Degree of node K = 0

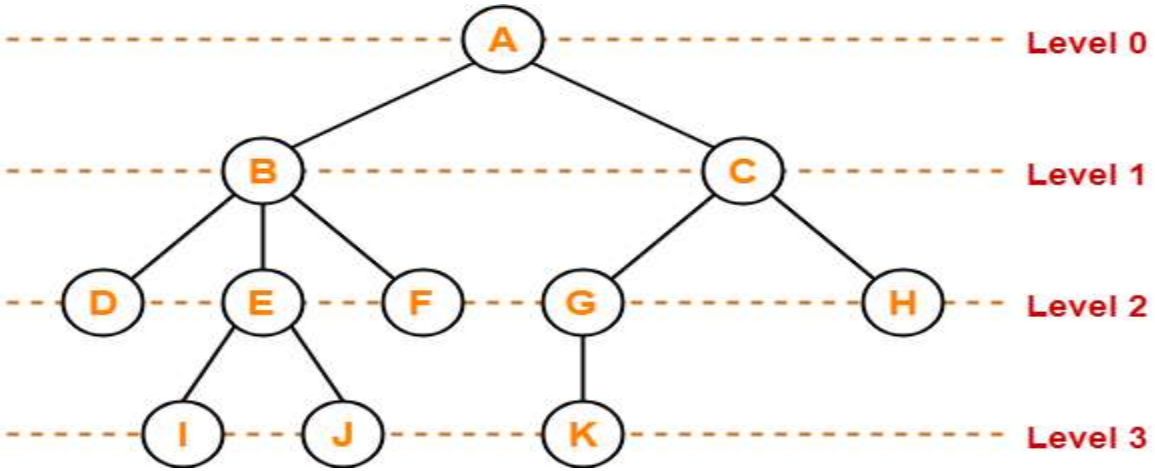
- **7. Internal Node-**
- The node which has at least one child is called as an **internal node**.
- Internal nodes are also called as **non-terminal nodes**.
- Every non-leaf node is an internal node.


Internal Node
Internal Node
A
B
C
D
E
F
G
H
I
J
K

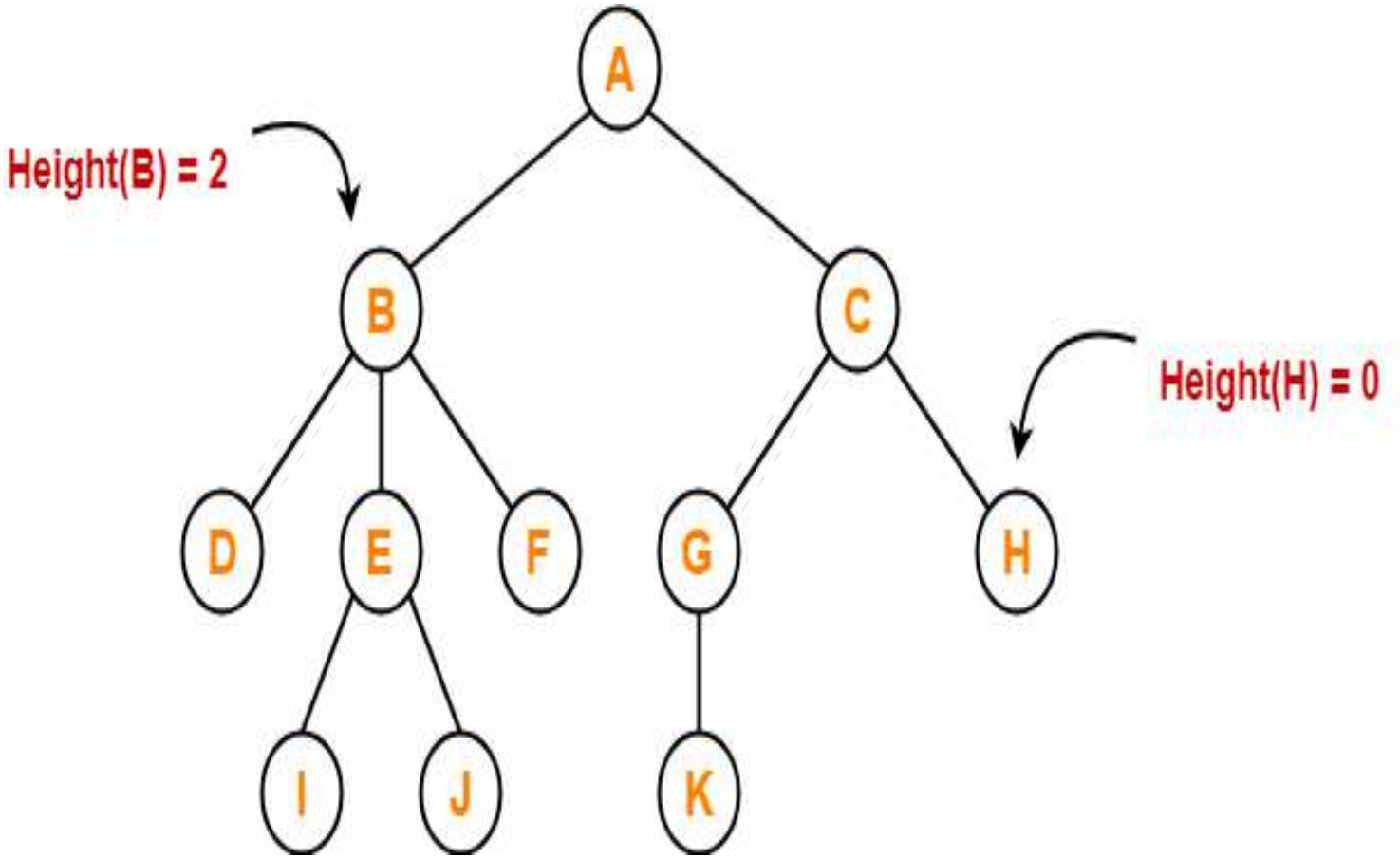
- **8. Leaf Node-**
- The node which does not have any child is called as a **leaf node**.
- Leaf nodes are also called as **external nodes** or **terminal nodes**.



- **9. Level-**
- In a tree, each step from top to bottom is called as **level of a tree**.
- The level count starts with 0 and increments by 1 at each level or step.

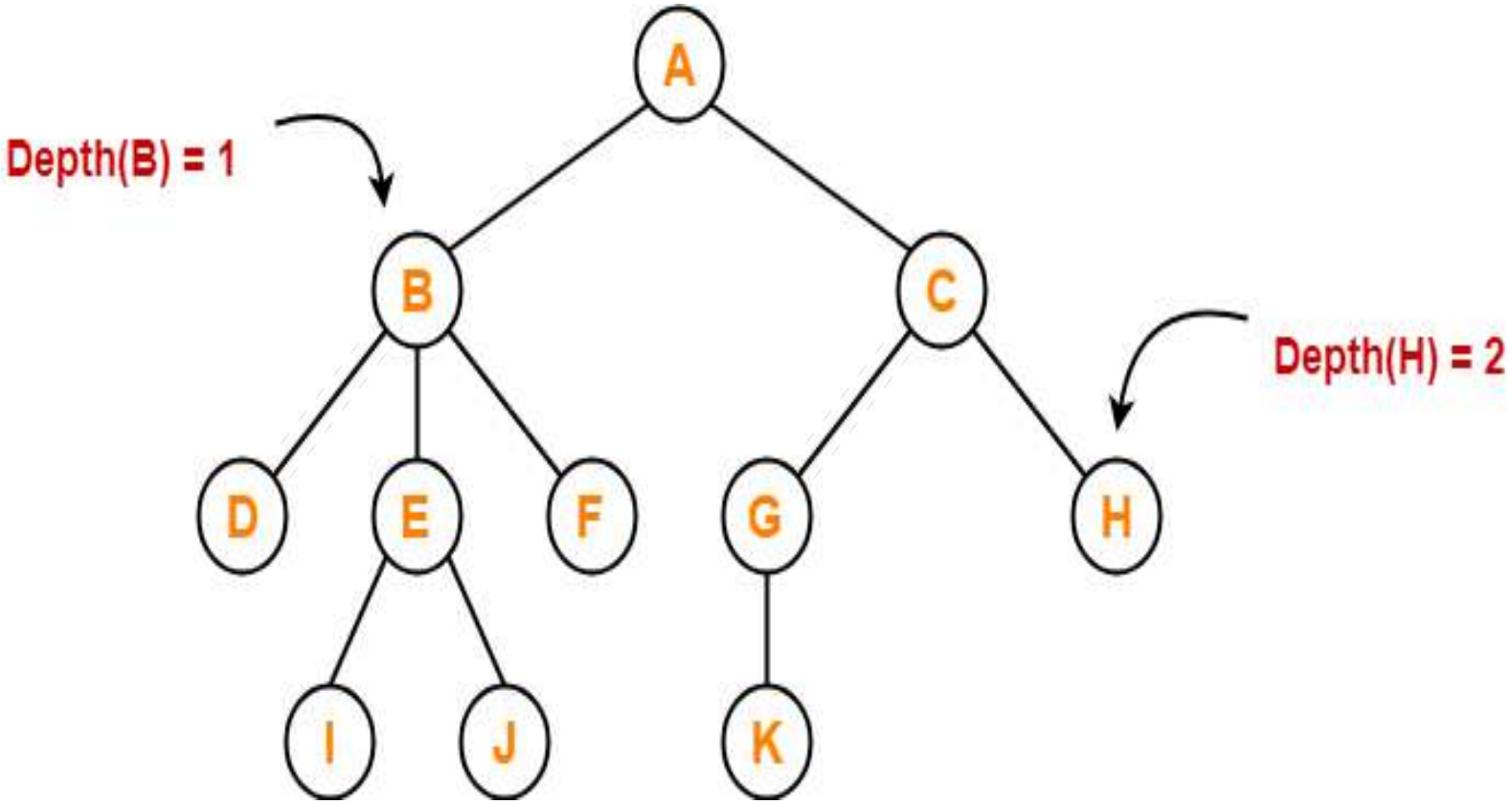


- **10. Height-**
- Total number of edges that lies on the longest path from any leaf node to a particular node is called as **height of that node**.
- **Height of a tree** is the height of root node.
- Height of all leaf nodes = 0


Height(B) = 2
Height(H) = 0
A
B
C
D
E
F
G
H
I
J
K

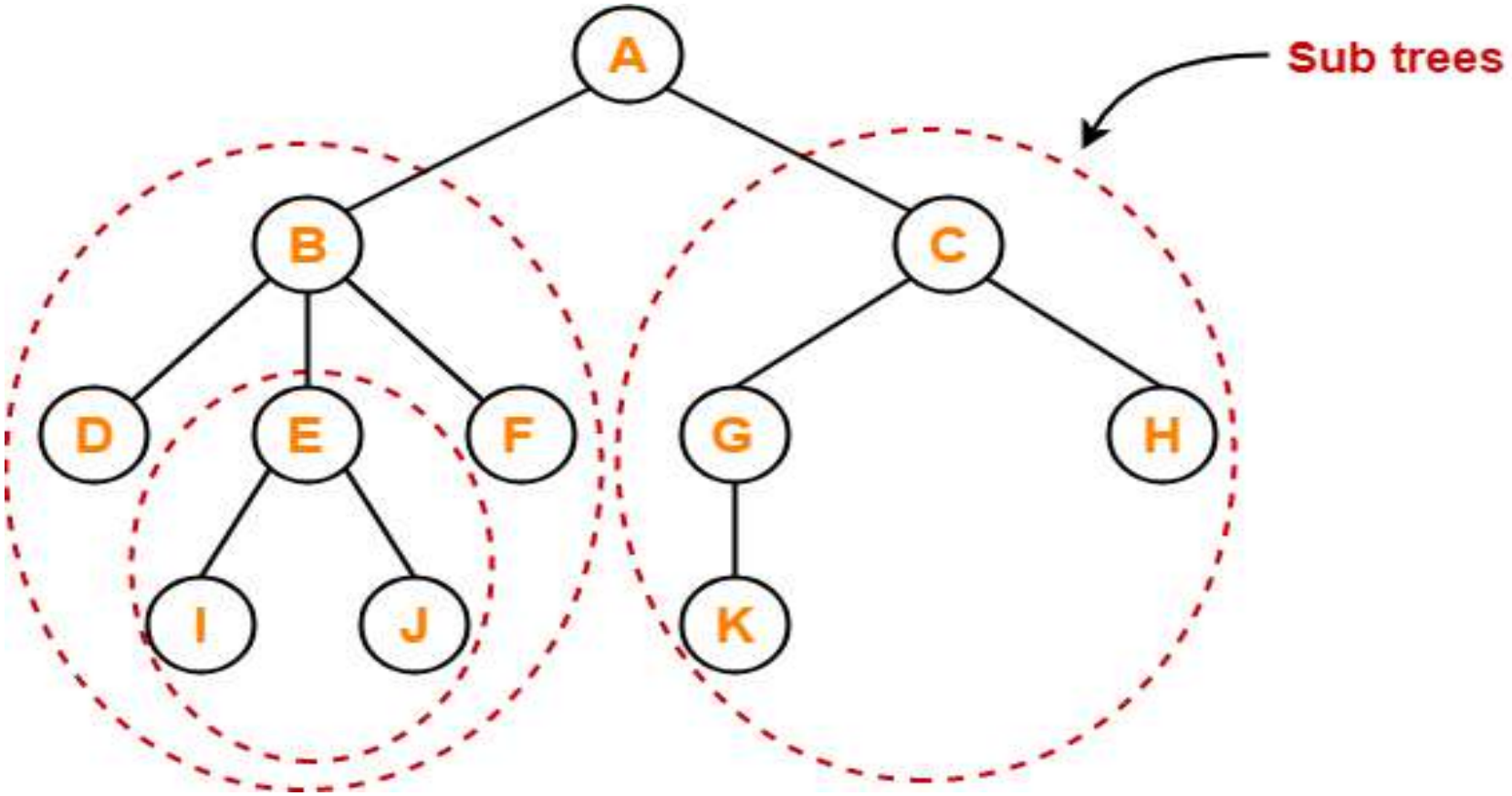
- Here,
- Height of node A = 3
- Height of node B = 2
- Height of node C = 2
- Height of node D = 0
- Height of node E = 1
- Height of node F = 0
- Height of node G = 1
- Height of node H = 0
- Height of node I = 0
- Height of node J = 0
- Height of node K = 0

- **11. Depth-**
- Total number of edges from root node to a particular node is called as **depth of that node**.
- **Depth of a tree** is the total number of edges from root node to a leaf node in the longest path.
- Depth of the root node = 0
- The terms “level” and “depth” are used interchangeably.

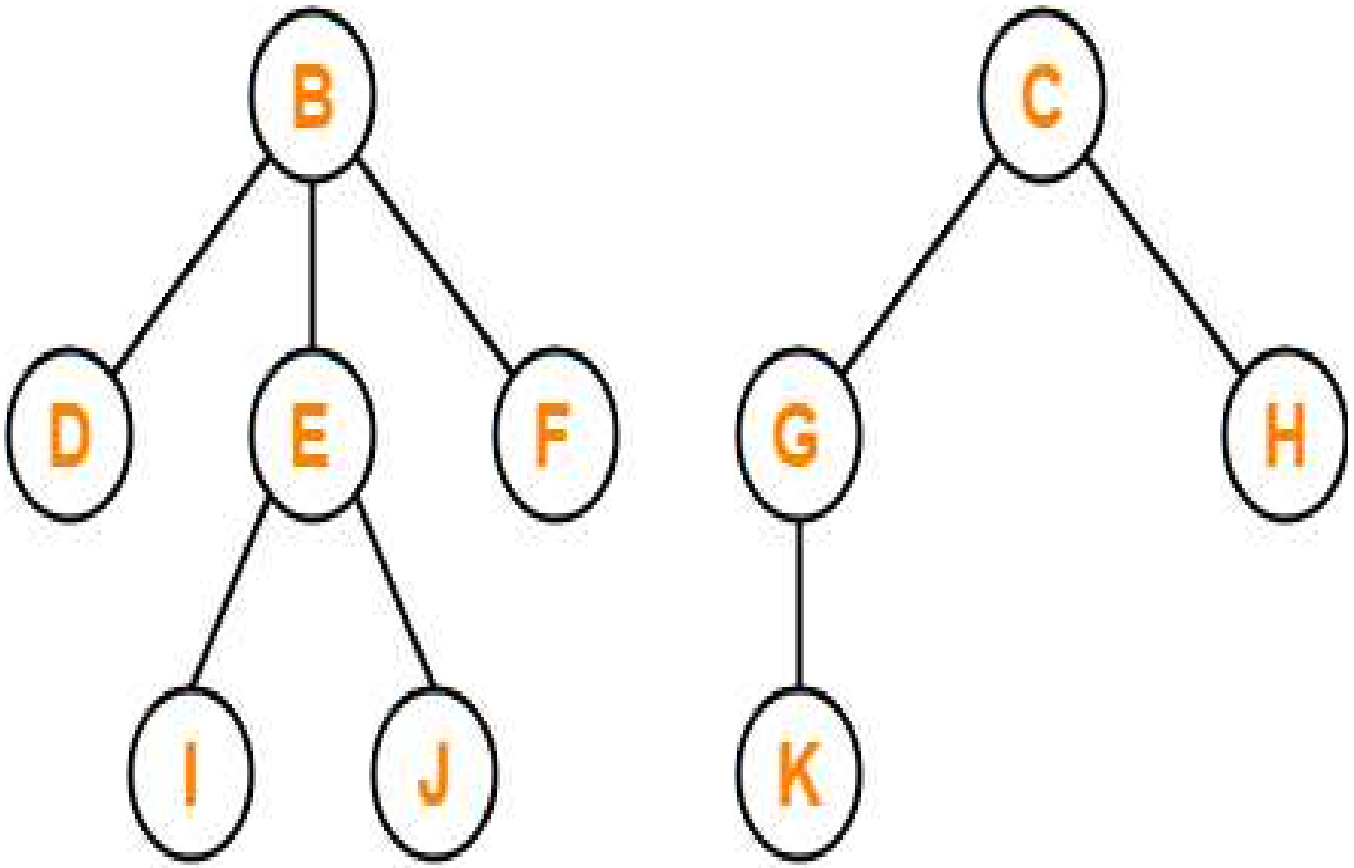

Depth(B) = 1
Depth(H) = 2
A
B
C
D
E
F
G
H
I
J
K

- Here,
- Depth of node A = 0
- Depth of node B = 1
- Depth of node C = 1
- Depth of node D = 2
- Depth of node E = 2
- Depth of node F = 2
- Depth of node G = 2
- Depth of node H = 2
- Depth of node I = 3
- Depth of node J = 3
- Depth of node K = 3

- **12. Subtree-**
- In a tree, each child from a node forms a **subtree** recursively.
- Every child node forms a subtree on its parent node.


A
B
C
D
E
F
G
H
I
J
K
Sub trees

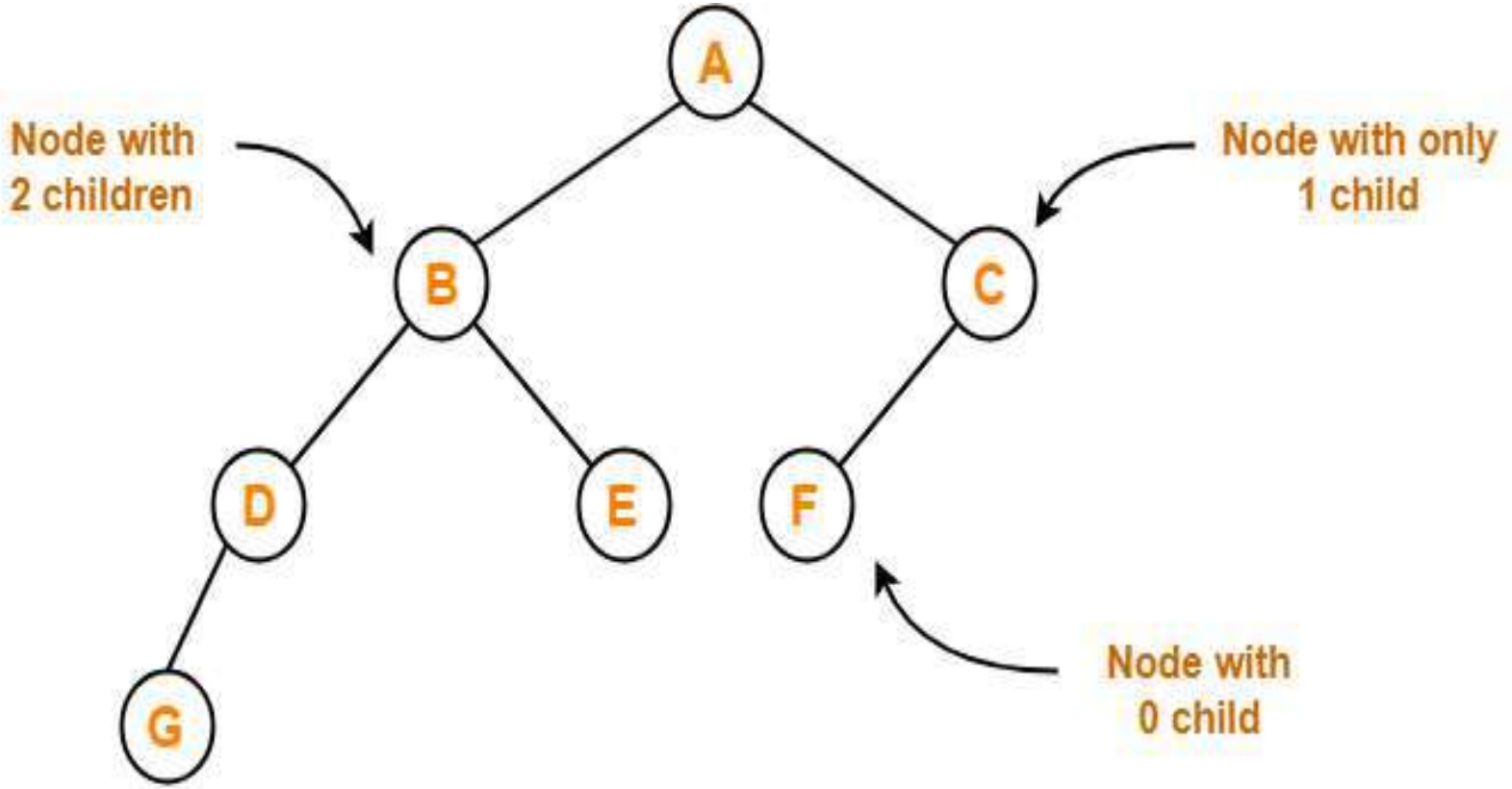
13. Forest-



Forest

Binary Tree

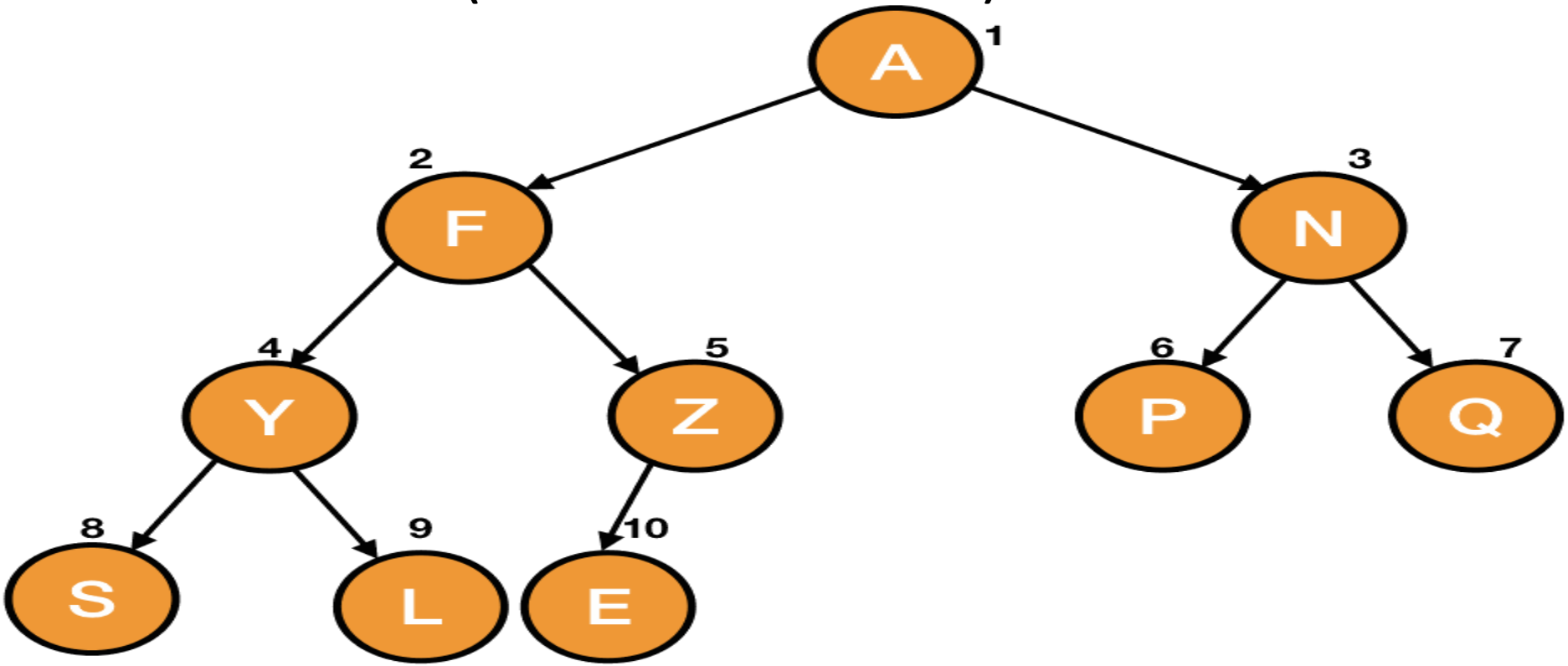
- Binary tree is a special tree data structure in which each node can have at most 2 children.
- Thus, in a binary tree,
- Each node has either 0 child or 1 child or 2 children.



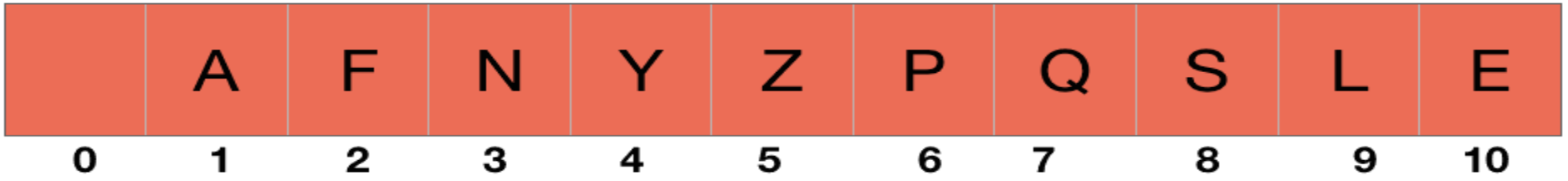
Binary Tree Example

Representation using Array & Linked List

- We start by numbering the nodes of the tree from 1 to n(number of nodes).



- As you can see, we have numbered from top to bottom and left to right for the same level. Now, these numbers represent the indices of an array (starting from 1) as shown in the picture given below.



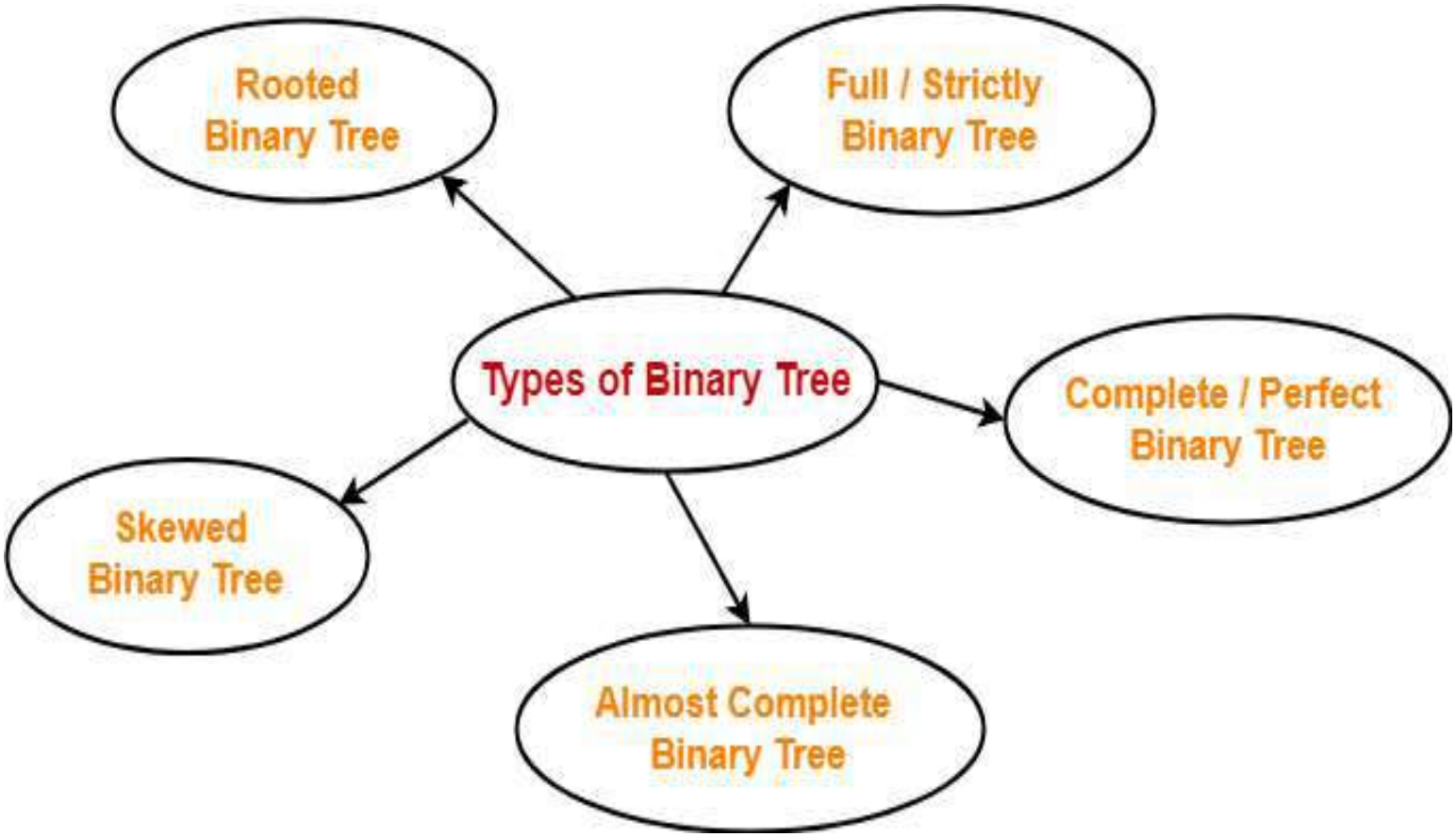
Array Representation of Binary Tree

Using Linked List

- Array representation is good for complete binary tree, but it is wasteful for many other binary trees. The representation suffers from insertion and deletion of node from themiddle of the tree, as it requires the moment of potentially many nodes to reflect thechange in level number of this node. To overcome this difficulty we represent thebinary tree in linked representation.

- In linked representation each node in a binary has three fields, the left child field denoted as LeftChild, data field denoted as data and the right child field denoted asRightChild. If any sub-tree is empty then the corresponding pointer’s LeftChild andRightChild will store a NULL value. If the tree itself is empty the root pointer will store a NULL value.

Binary Tree: Types



THANK YOU