DATA STRUCTURES & ALGORITHMS

Trees

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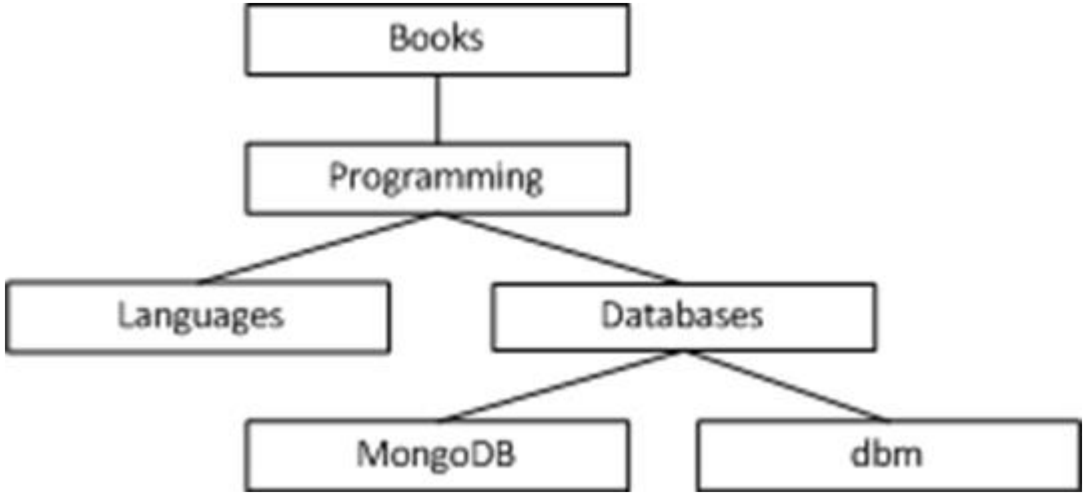
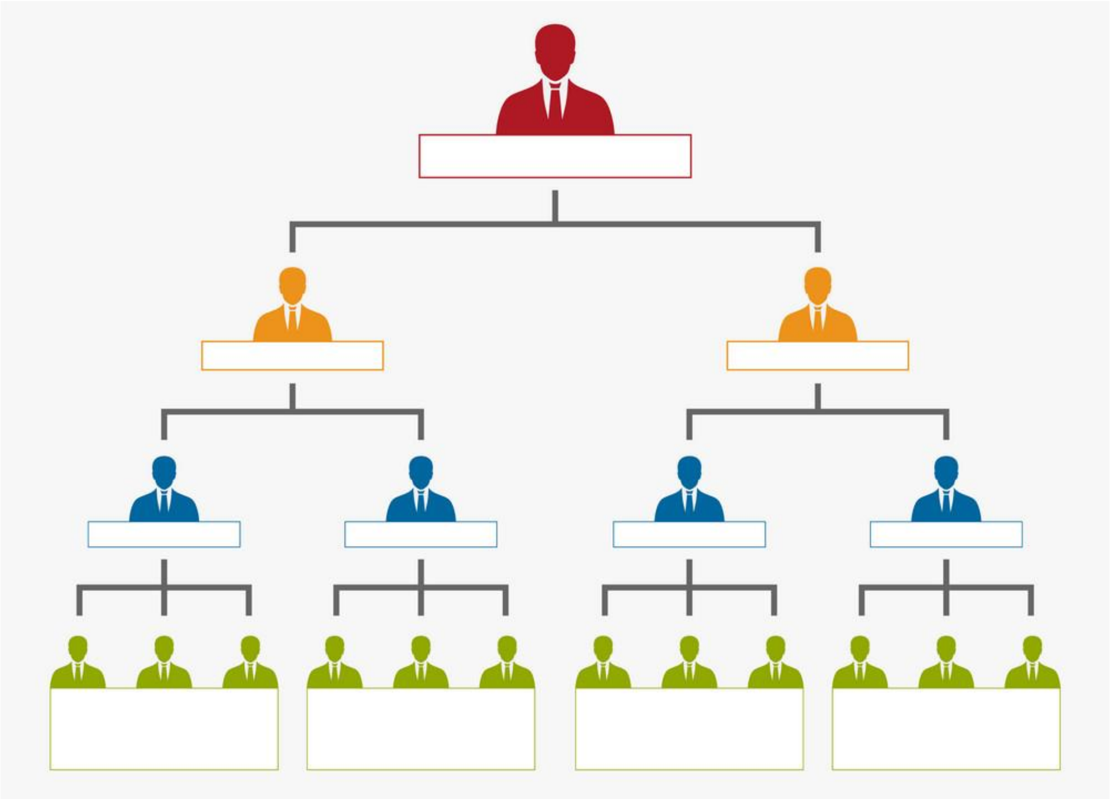
Trees



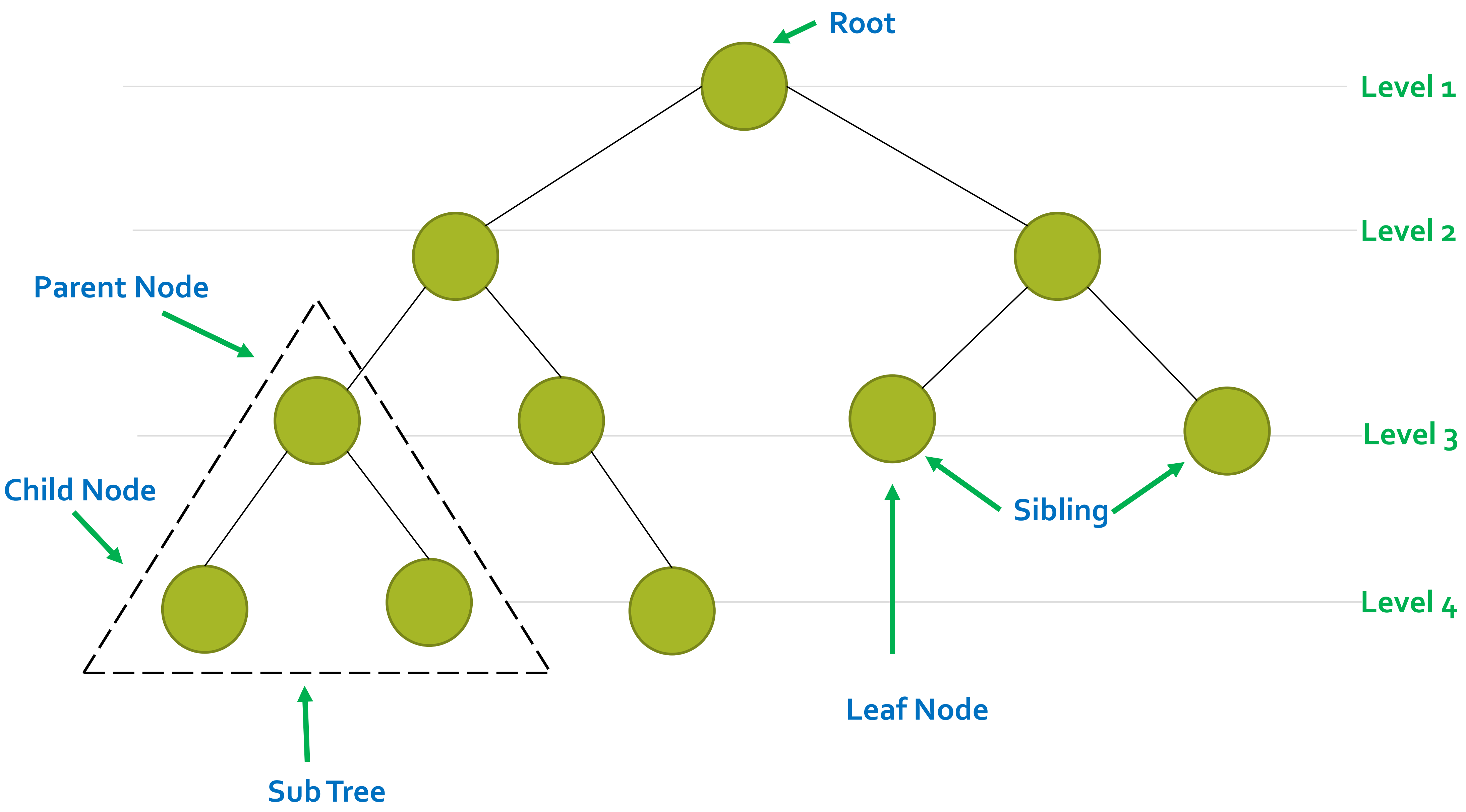


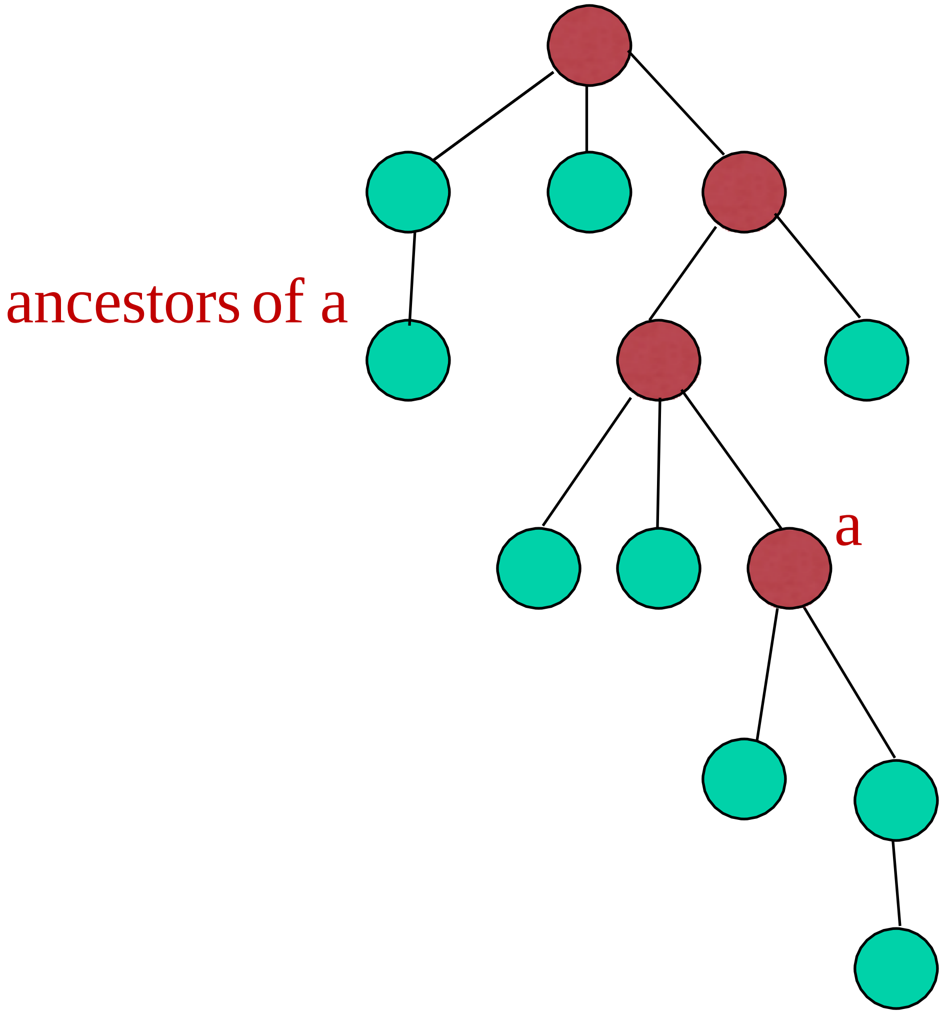
Key Terms

- **Root** – Node at the top of the tree
- **Path** - sequence of nodes along the edges of a tree
- **Predecessor** – node that is above certain node.
- **Successor** – node that is below certain node.
- **Ancestor** – all nodes that is before certain node and in the same path.
- **Descendant** – All nodes that is after certain node and in the same path.
- **Parent** – predecessor that is one level above certain node.
- **Child** – node below a given node .
- **Sibling** – nodes that have same parent.
- **Leaf** – node which have no child.

Key Terms

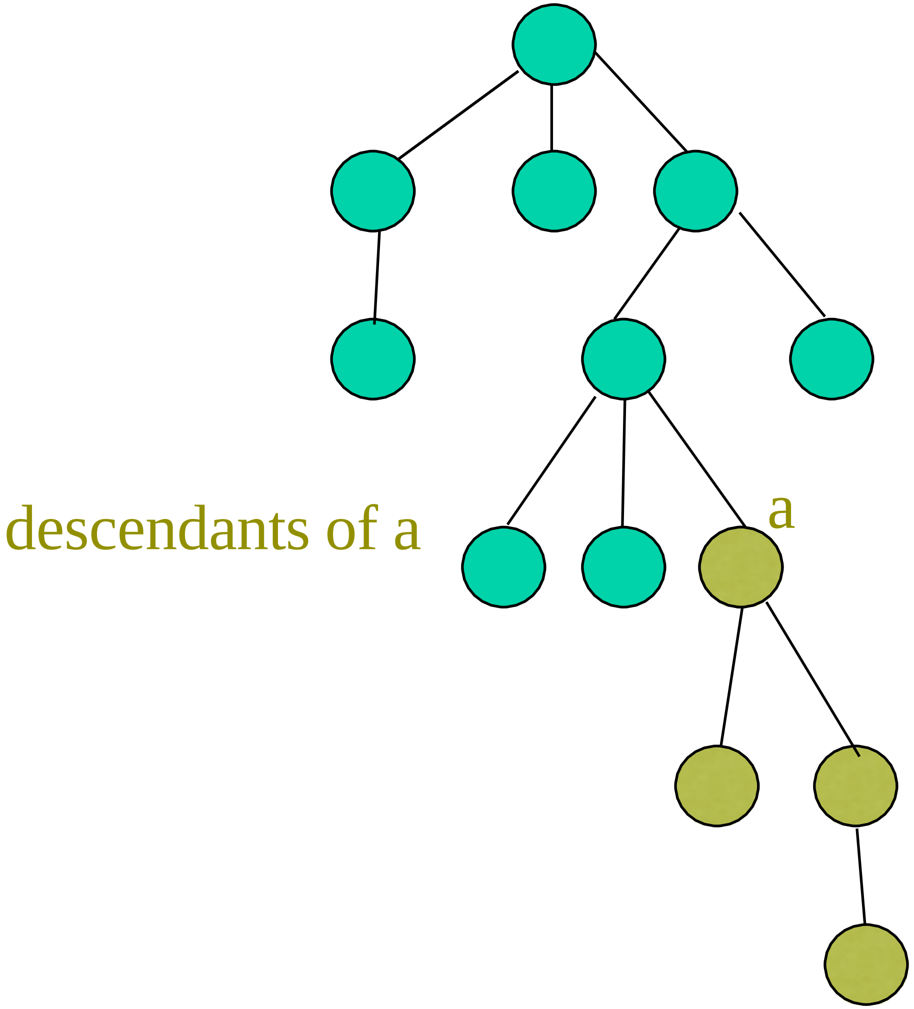
- **Degree of a node** – number of child of that node.
- **Degree of a tree** – maximum degree of nodes in a given tree.
- **Height of a node** – maximum path length from that node to a leaf node.
- **Height of a tree** – distance of the root to leaf.
- **Levels** – represents the generation of a node. If root node is at level 0, then its next child node is at level 1
- **Depth of a tree** – maximum level of any leaf in the tree.


Root
Level 1
Level 2
Parent Node
Level 3
Child Node
Sibling
Level 4
Leaf Node
Sub Tree



ancestors of a

a



descendants of a

a

Characteristics of trees

- Non-linear data structure
- Combines advantages of an ordered array
- Searching as fast as in ordered array
- Insertion and deletion as fast as in linked list

Applications

- Directory structure of a file store.
- Structure of an arithmetic expressions.
- Used in almost every high bandwidth router for storing router tables.
- Used in almost every 3 D video game to determine what objects need to be rendered.
- Used in compression algorithms, such as those used by the .jpeg and .mp3 file formats.

Binary trees

A binary tree is a tree such that

- every node has at most 2 children
- each node is labeled as being either a left child or a right child

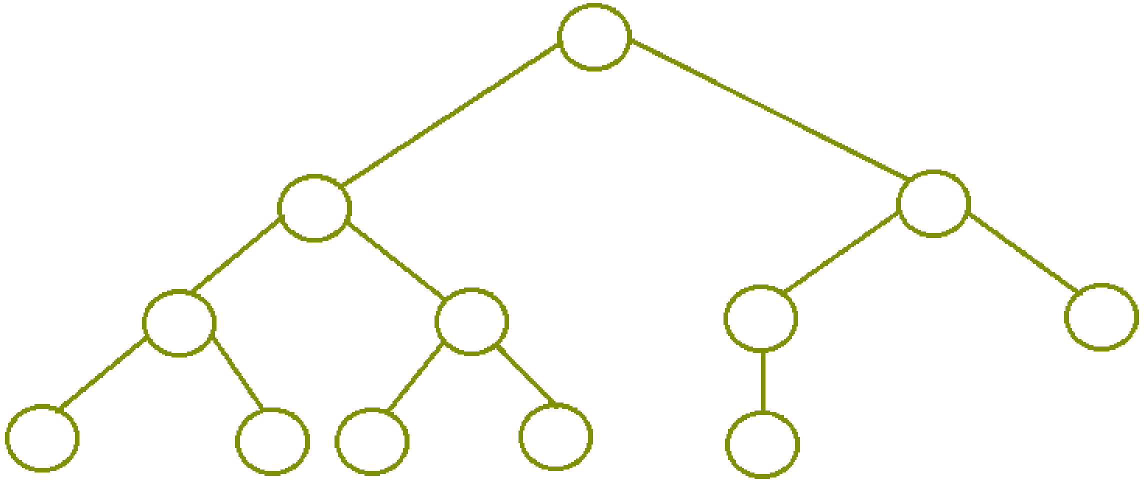
Properties of Binary Tree

- Maximum degree of one node is 2.
- Maximum number of node each level is $2^{(N-1)}$
- Maximum node until level N is 2^{N} - 1.

Types of Binary Tree

Complete binary tree

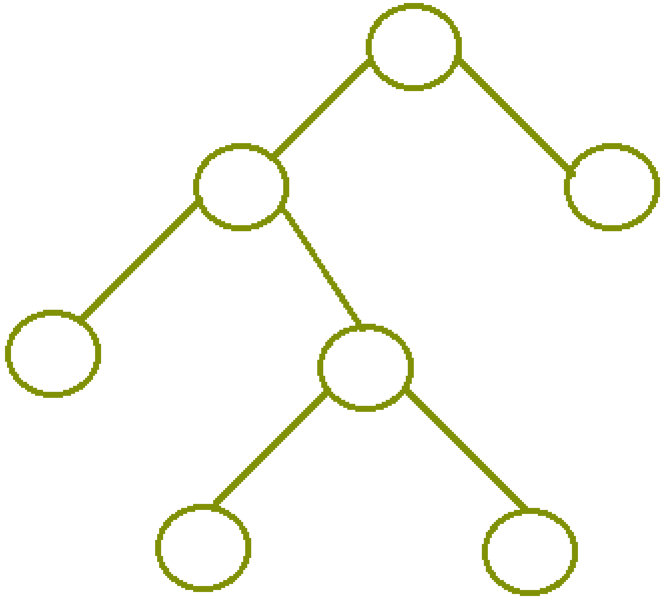
It is a binary tree in which every level, except possibly the last, is completely filled, and all nodes are as far left as possible.



Types of Binary Tree

Full/ Strict binary tree

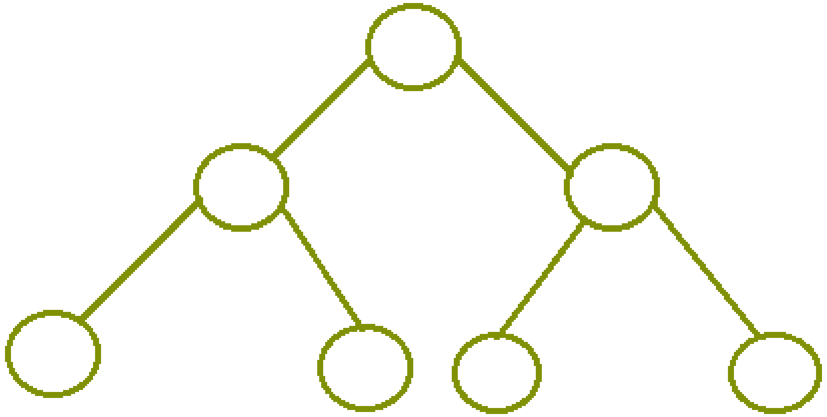
It is a tree in which every node in the tree has either 0 or 2 children.



Types of Binary Tree

Perfect binary tree

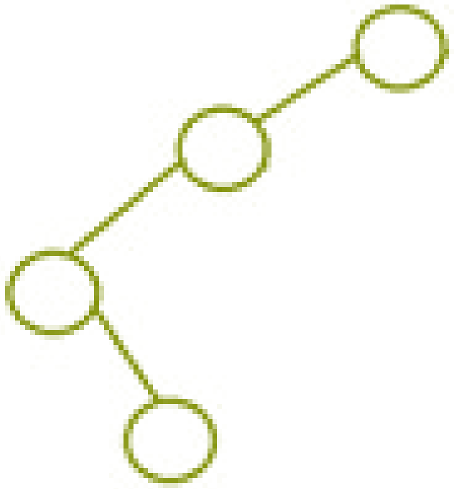
It is a binary tree in which all interior nodes have two children and all leaves have the same depth or same level.



Types of Binary Tree

Degenerate Binary Tree

A binary tree is said to be a degenerate binary tree or pathological binary tree if every internal node has only a single child.

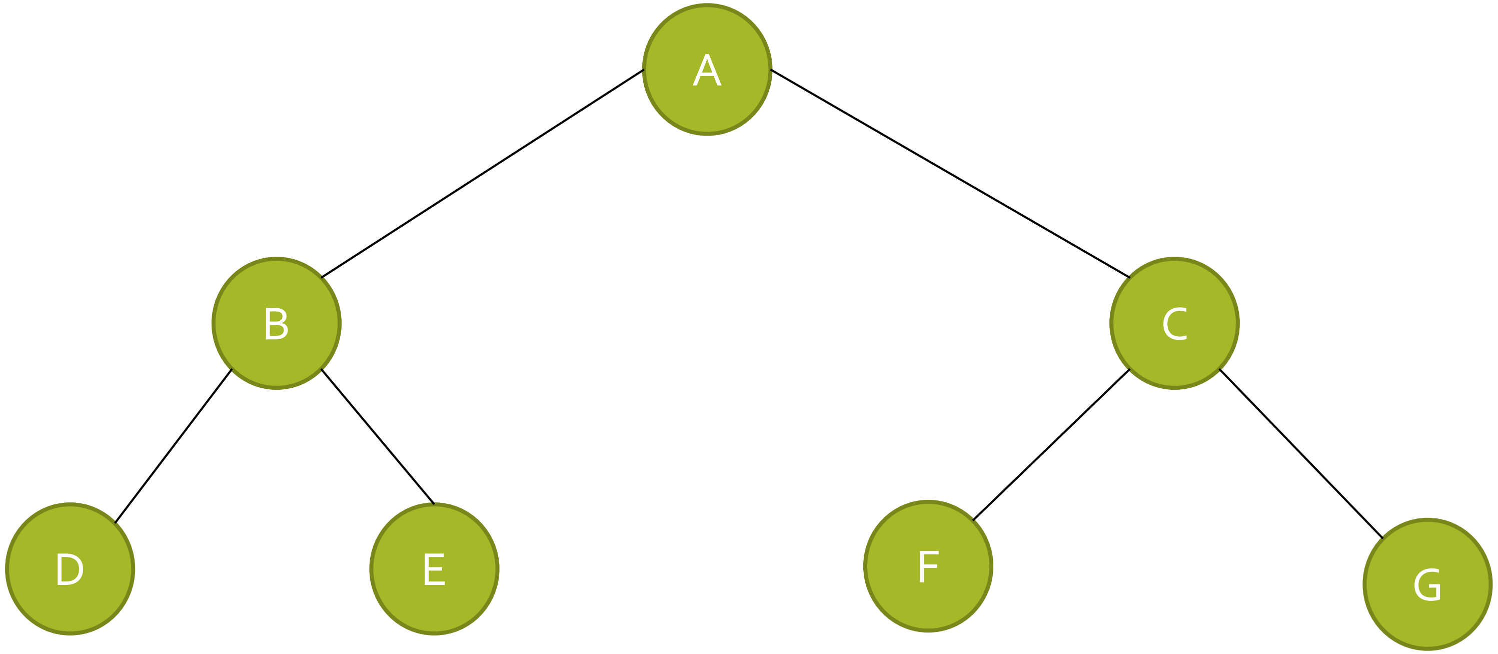


Tree Traversal

Process to visit all the nodes of a tree and may print their values too.

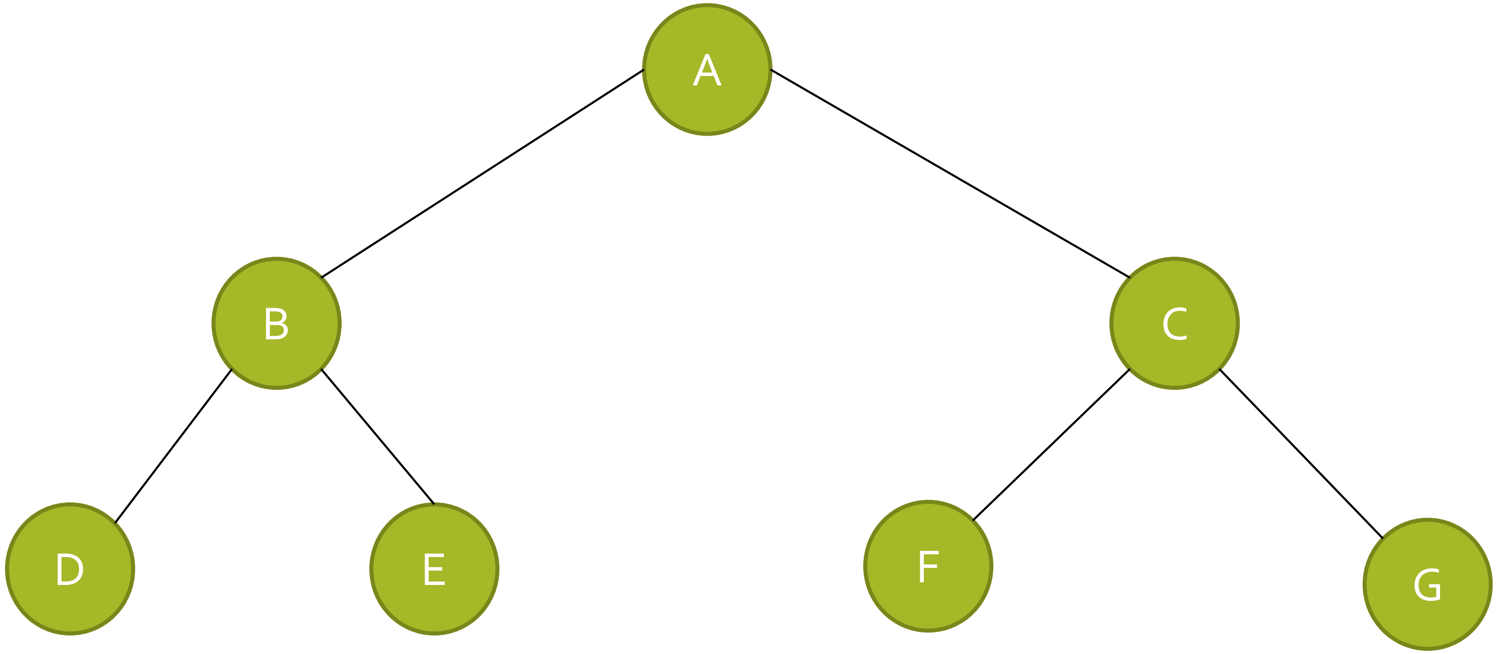
- Depth First
  - ✓ In order traversal
    - ✓ Left – Root - Right
  - ✓ Pre order traversal
    - ✓ Root – Left - Right
  - ✓ Post order traversal
    - ✓ Left - Right - Root
- Breath First/Level order

Pre Order



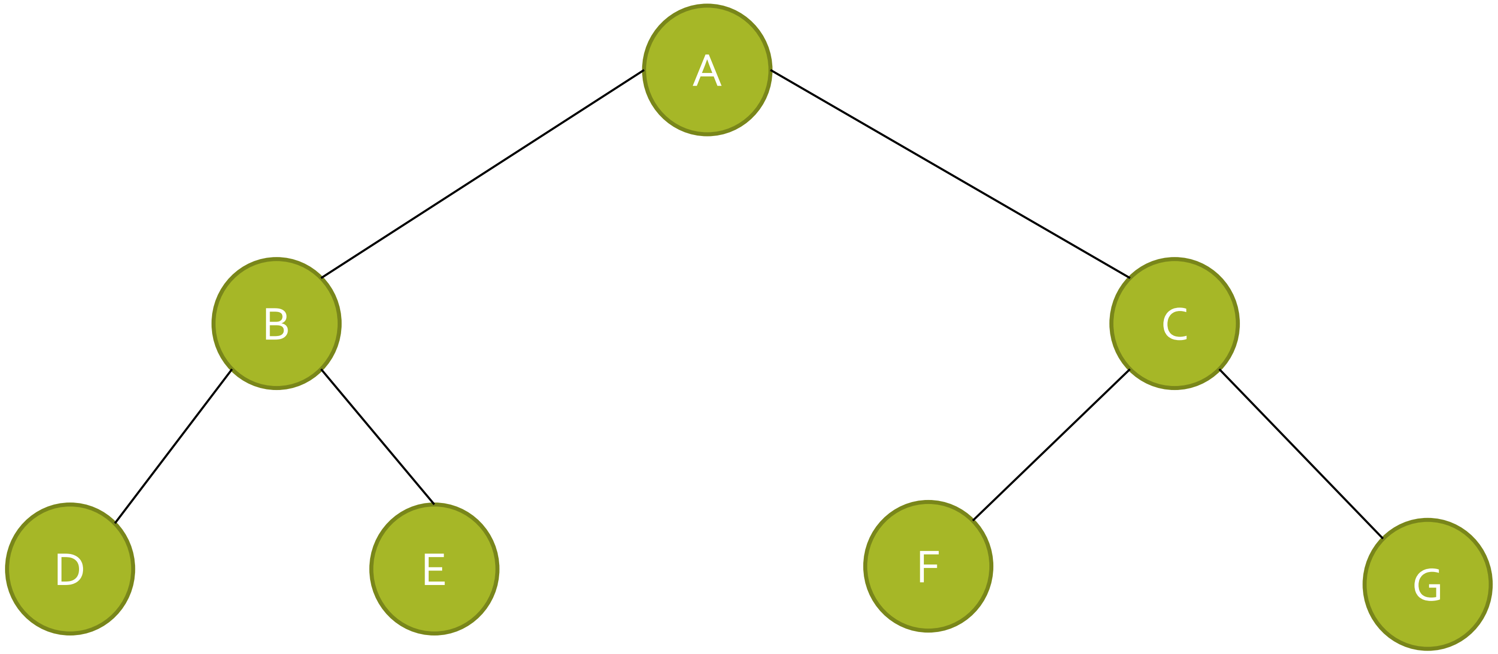
A → B → D → E → C → F → G

In Order



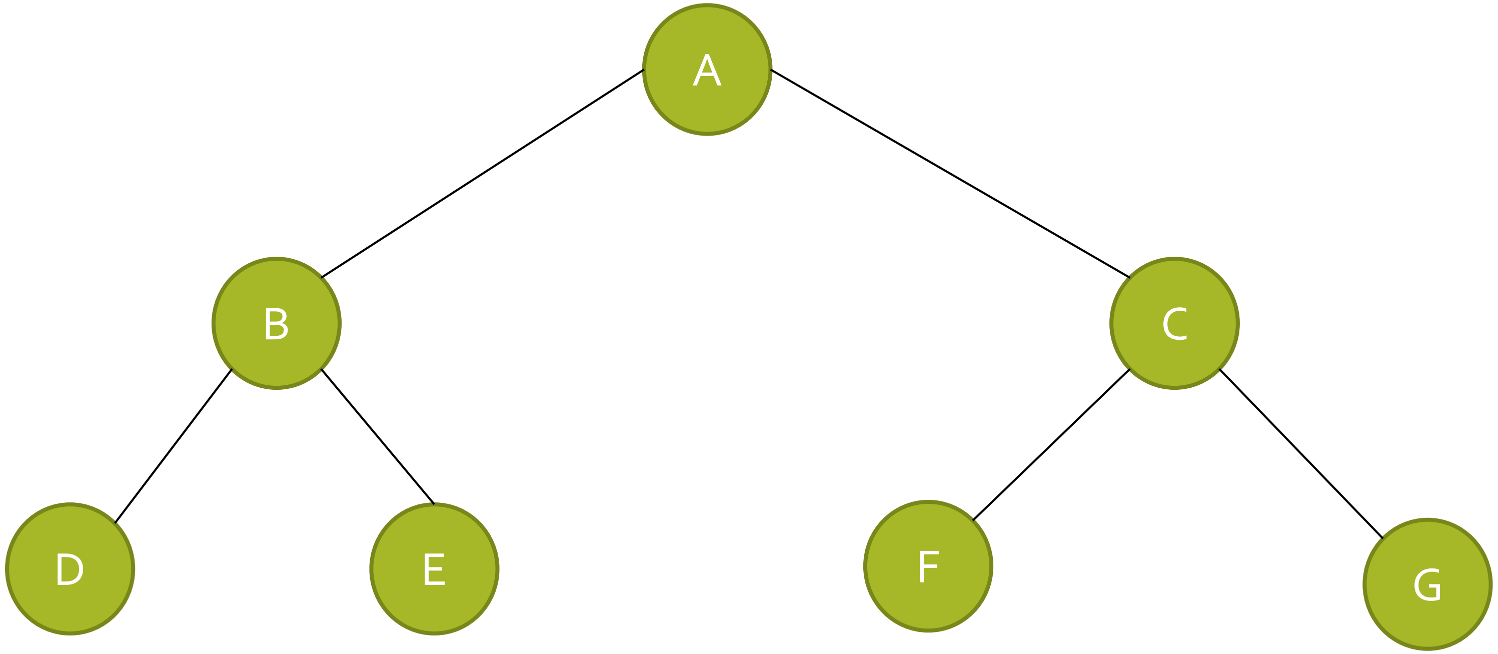
D → B → E → A → F → C → G

Post Order



D → E → B → F → G → C → A

Breath First/ Level Order



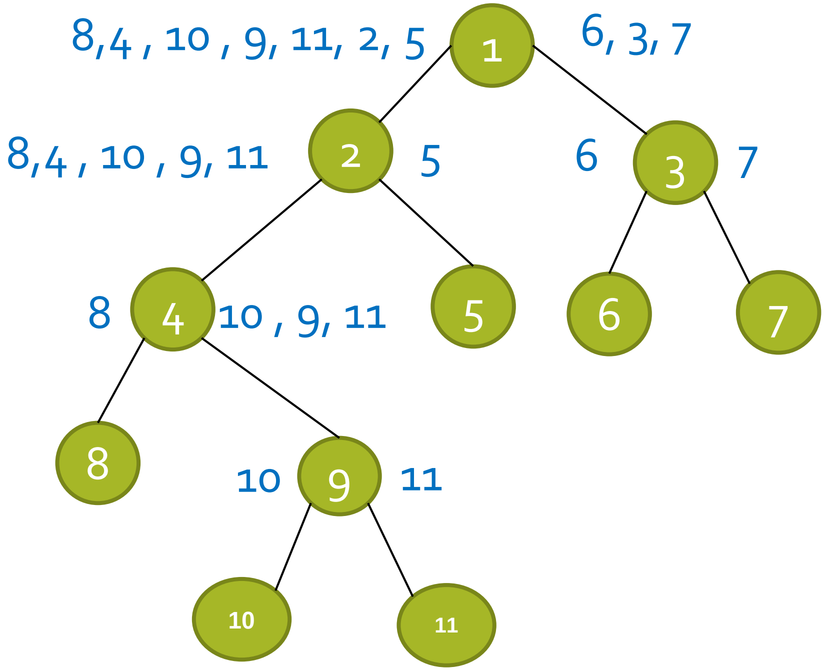
A → B → C → D → E → F → G

Example: Construct Binary tree using preorder and inorder traversals

```
Preorder: 1, 2 , 4, 8, 9, 10, 11, 5, 3, 6, 7
Inorder:  8, 4, 10, 9, 11, 2, 5, 1, 6, 3, 7
```

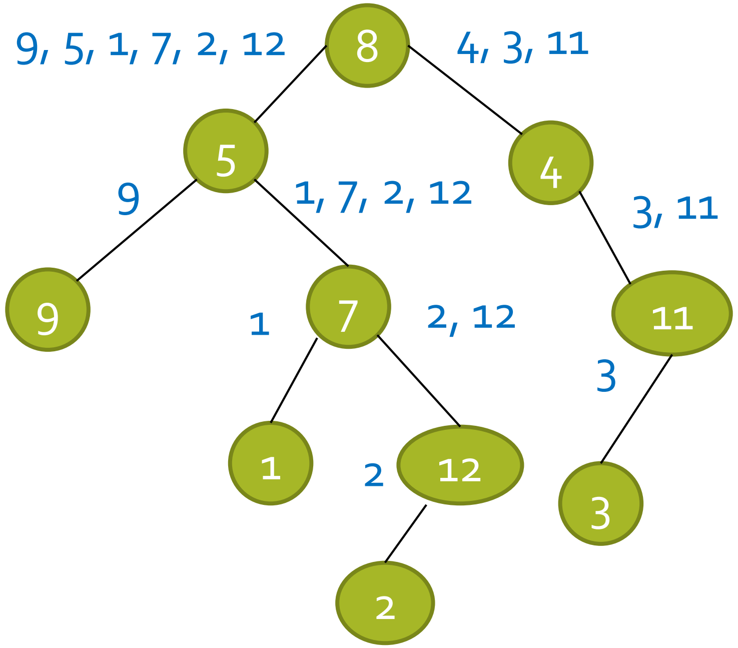
Root – Left - Right

Left – Root - Right



Example: Construct Binary tree using postorder and inorder traversals

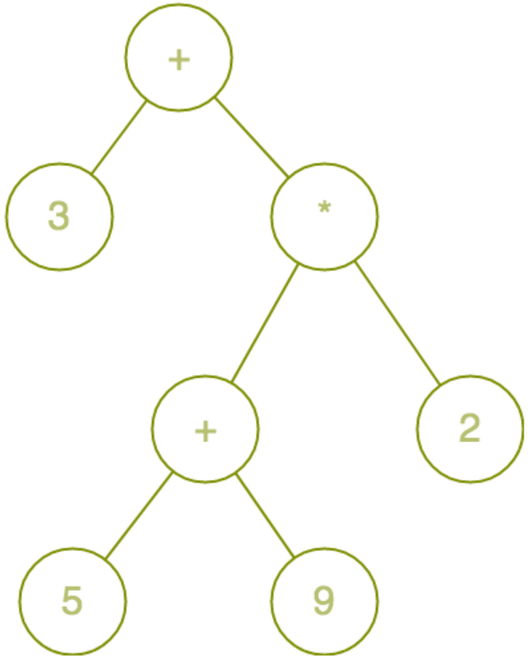
```
Postorder: 9, 1, 2, 12, 7, 5, 3, 11, 4, 8 Left - Right - Root
Inorder:   9, 5, 1, 7, 2, 12, 8, 4, 3, 11 Left – Root - Right
```



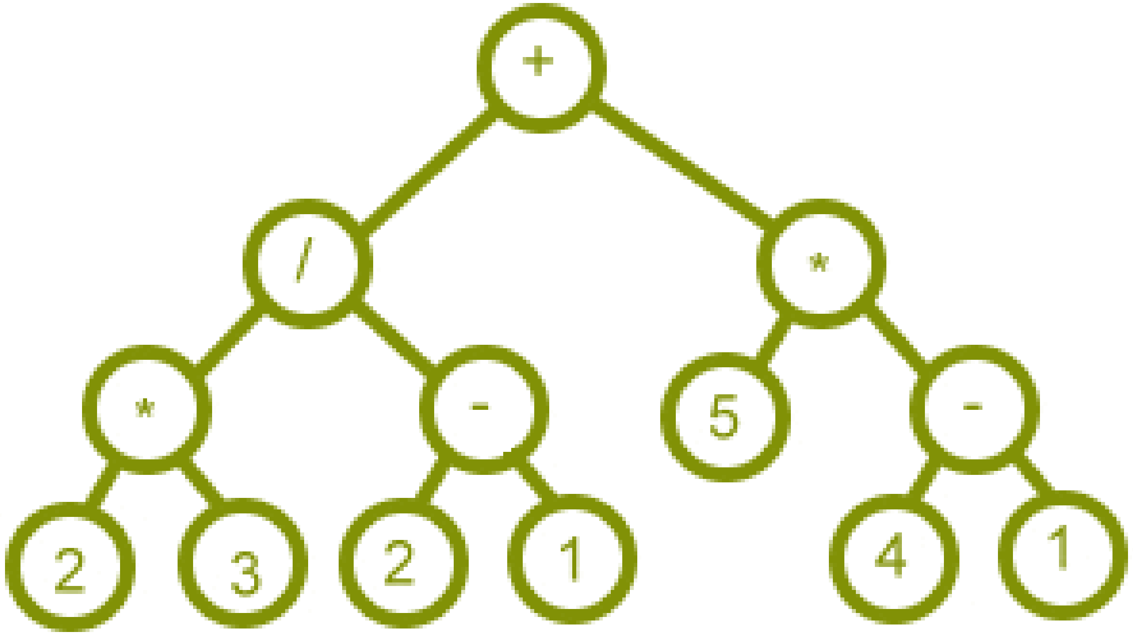
Expression Trees

Expression Tree is a special kind of binary tree which is used to represent expressions with the following properties:

- Each leaf is an operand.
- The root and internal nodes are operators.
- Subtrees are subexpressions with the root being an operator.



Expression Trees



Expression tree for 2*3/(2-1)+5*(4-1)