Trees

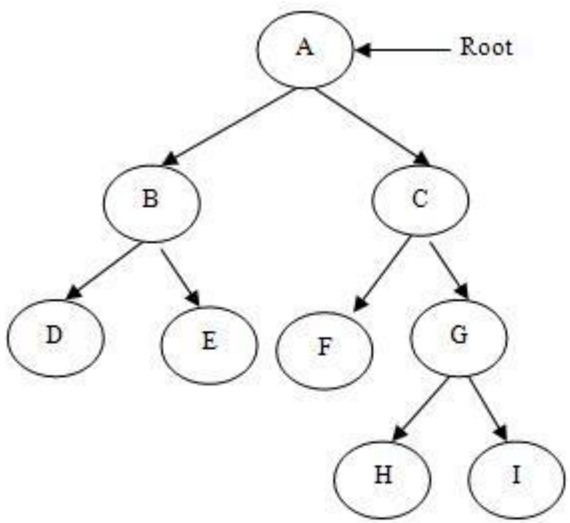
Until now, we have dealt with linear data structures such as:

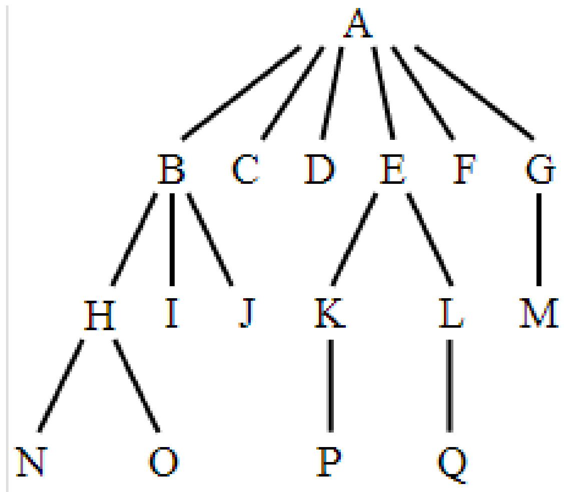
- arrays
- linked lists
- stacks
- queues

A tree is:

- a nonlinear data structure where members may have multiple successors
- a data structure made up of nodes.

Trees





Tree Terminology

- **root** – unique starting node
- **degree** – number of subtrees of the node
- **parent** – predecessor of a node
- **child** – successor of a node
- **leaf** – a node with no children
- **siblings** – two nodes with the same parent
- **ancestors** – let A be an arbitrary node of a tree. If A is the root node, then A has no ancestors; otherwise, the parent of A and all ancestors of A's parent are ancestors of A

- What kind of definition is ancestor?

Tree Terminology

- **descendants** – let B be an arbitrary node of a tree. If B is a leaf node, then B has no descendants; otherwise, each child of B and all descendants of each child of B are descendants of B.
- **subtree** – an arbitrary node in the tree and all descendants of that node
- **level** – the root node is level 0 and every other node in the tree is at level n where n is the number of nodes in the path from the root node to the node in question
- **height of a node** – # of edges on longest path between that node and a leaf
- **height of tree** – height of the root node
- **depth of a node** - # of edges from root node to the node

Identify Tree Attributes

For the given tree, identify:

a) root

b) parent of E

c) children of A

d) leaf nodes

e) any two siblings

f) ancestors of F

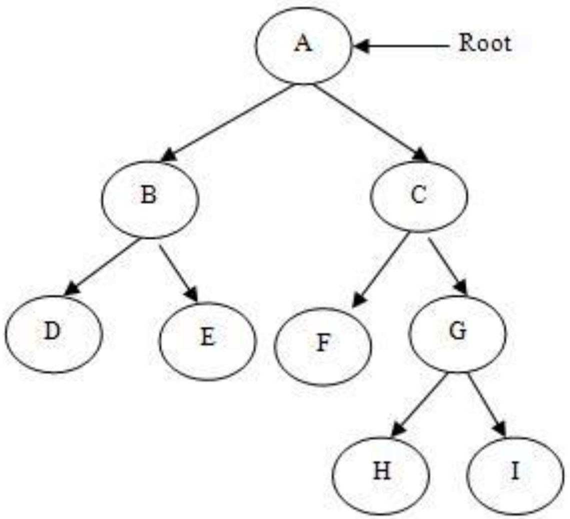
g) descendants of C

h) level of D

I) depth of the tree

j) height of C

k) depth of C



General Tree

- Characteristics of any tree:
  - There is a specifically designated node called the root, in this case 1 if not otherwise specified
  - The remaining nodes are grouped into n>=0 disjoint sets T_0, T_1, ... T_n where each set is a tree

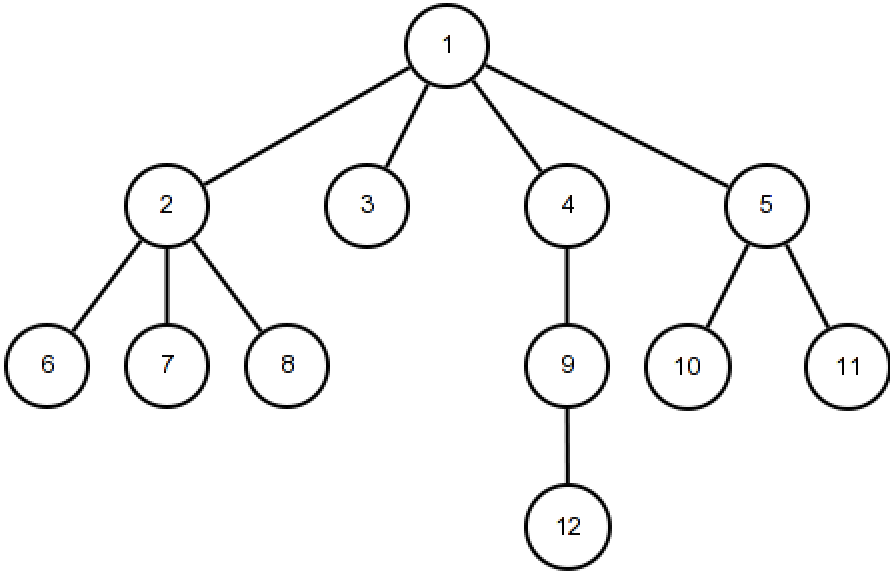


Figure 1: A simple tree.

Binary Tree

- Characteristics of a binary tree:
  - A binary tree is an example of a general tree
  - Each parent can have at most two children
  - A binary tree can be empty
  - If a binary tree has two children, the child on the left is the ″left child″ and the one on the right is the ″right child″

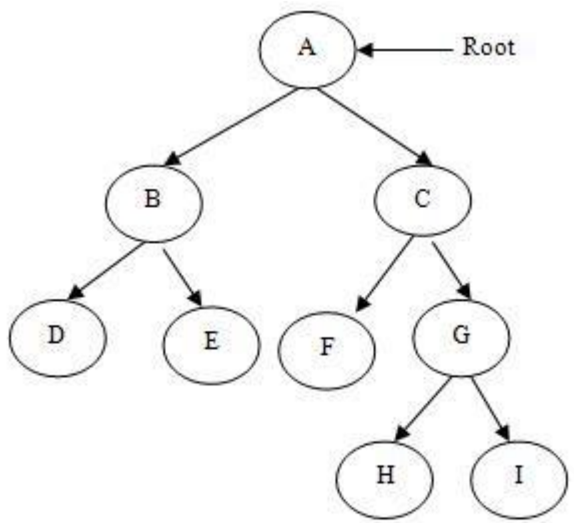
- Note: The left child is the root of the left subtree and the right child is the root of the right subtree

Some Binary Tree Operations

- Before defining the Binary Tree ADT, let's work a few problems.
- Write the appropriate data structure definitions for a binary tree.
- We can define three traversal methods for a binary tree:
  - inorder: Left, Visit, Right (LVR)
  - preorder: Visit, Left, Right (VLR)
  - postorder: Left, Right, Visit (LRV)

Identify

- For the following binary tree, identify the inorder, preorder, and postorder traversals.



Binary Search Tree (BST)

- Consider an arbitrary node in a tree called A.
- All values in the left subtree are less than the value in A.
- All values in the right subtree are greater than the value in A.

Create BST

- Create a BST for the following strings assuming lexicographic (dictionary or alphabetical) ordering (e.g. : apr < jan):

- jan, feb, mar, apr, may, jun, jul, aug, sep, oct, nov, dec

Traversals

- If visiting a node means printing the contents of the node, show each of the following traversals of the newly created BST.

- preorder
- inorder
- postorder

BST Functions

- Write an algorithm for bstInsert.
- What is the worst case computing complexity of your algorithm? Why?
- Write the C function bstInsert.

BST Functions

- Write a C function bstFindLevel that returns the level of a node in a BST.

- Write a C function btFindLevel that returns the level of a node in a binary tree.