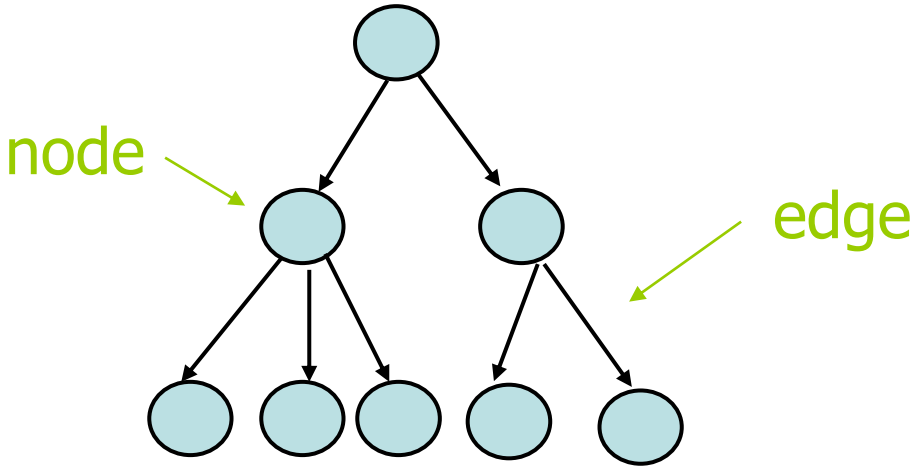
Artificial Intelligence

Tutorial 0

Trees

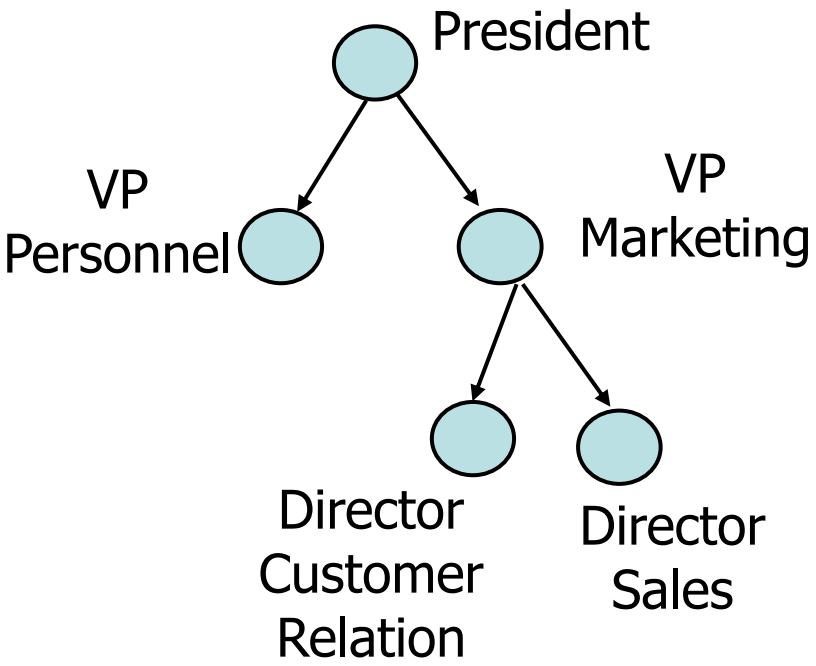
What is a tree?

- Trees are structures used to represent hierarchical relationship
- Each tree consists of nodes and edges
- Each node represents an object
- Each edge represents the relationship between two nodes.

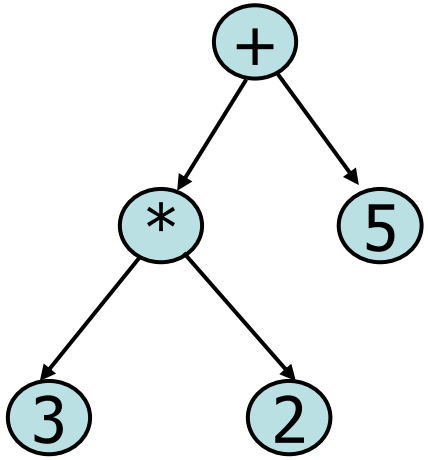


Some applications of Trees

Organization Chart



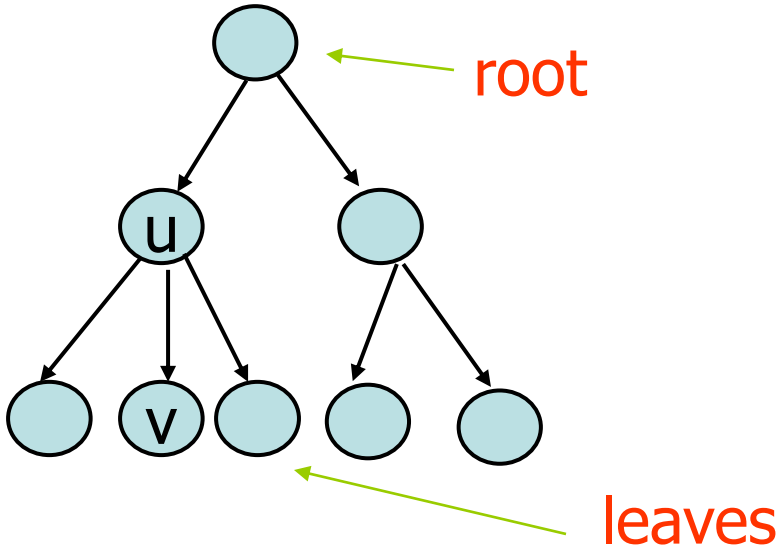
Expression Tree



Terminology I

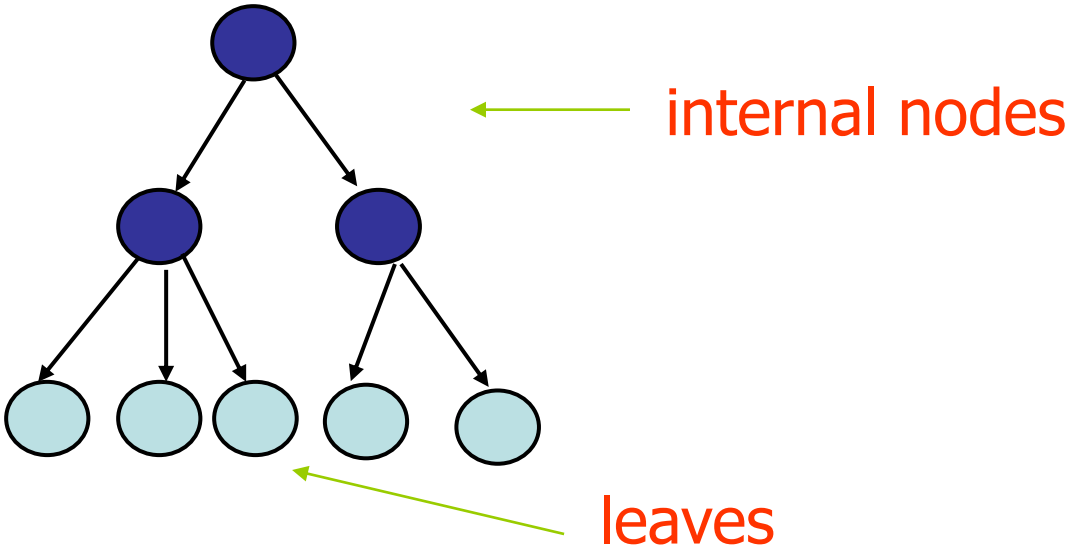
- For any two nodes u and v, if there is an edge pointing from u to v, u is called the parent of v while v is called the child of u. Such edge is denoted as (u, v).
- In a tree, there is exactly one node without parent, which is called the root. The nodes without children are called leaves.

u: parent of v
v: child of u



Terminology II

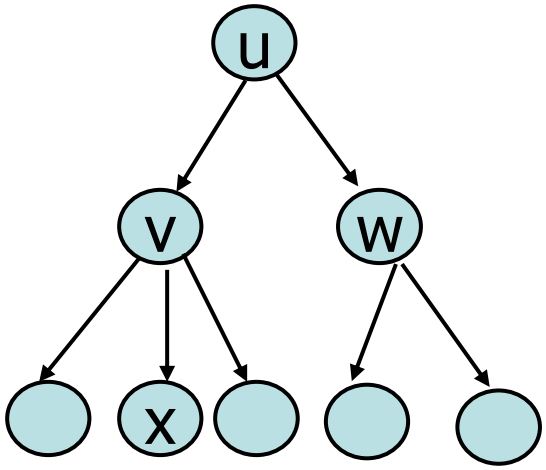
- In a tree, the nodes without children are called leaves. Otherwise, they are called internal nodes.



Terminology III

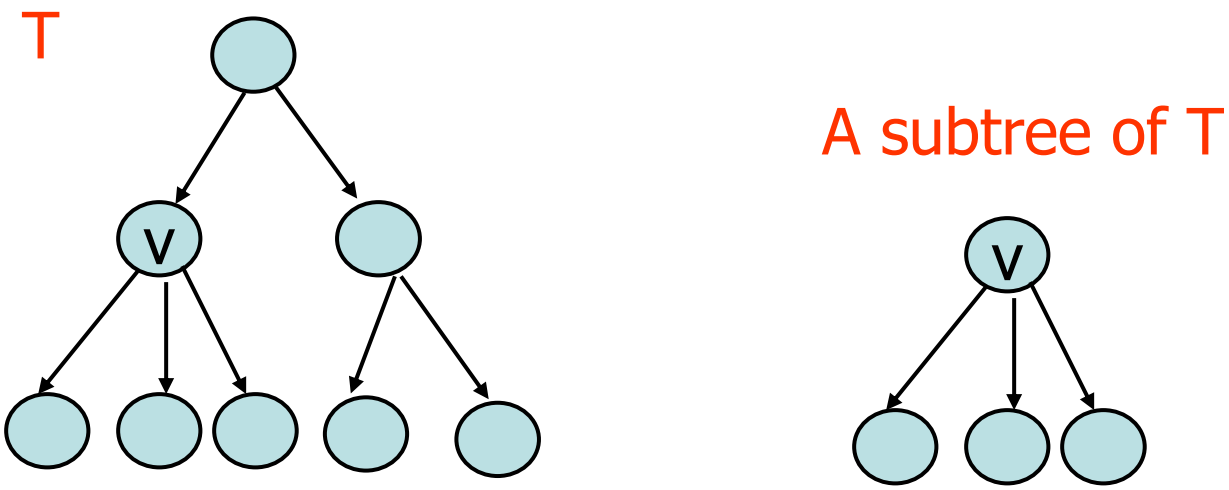
- If two nodes have the same parent, they are siblings.
- A node u is an ancestor of v if u is parent of v or parent of parent of v or …
- A node v is a descendent of u if v is child of v or child of child of v or …

v and w are siblings
u and v are ancestors of x
v and x are descendents of u



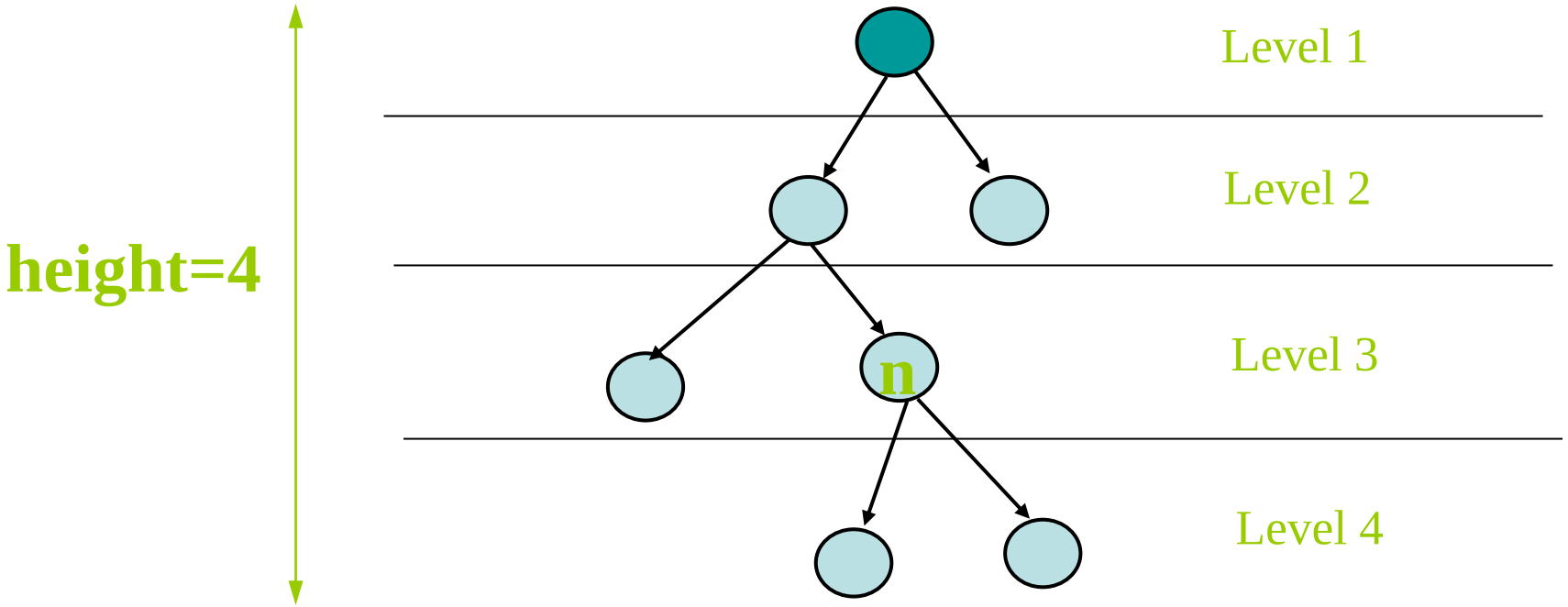
Terminology IV

- A subtree is any node together with all its descendants.



Terminology V

- Level of a node n: number of nodes on the path from root to node n
- Height of a tree: maximum level among all of its node



Tree Traversal

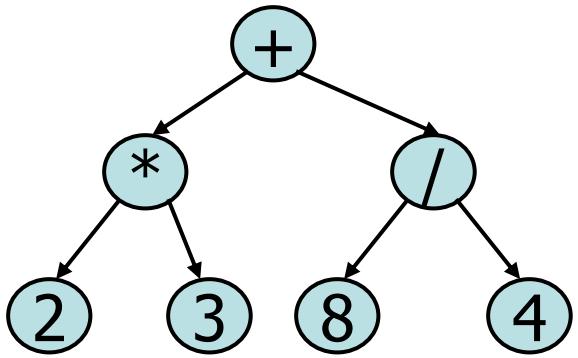
- Given a binary tree, we may like to do some operations on all nodes in a binary tree. For example, we may want to double the value in every node in a binary tree.
- To do this, we need a traversal algorithm which visits every node in the binary tree.

Ways to traverse a tree

- There are three main ways to traverse a tree:
  - Pre-order:
    - (1) visit node, (2) recursively visit left subtree, (3) recursively visit right subtree
  - In-order:
    - (1) recursively visit left subtree, (2) visit node, (3) recursively right subtree
  - Post-order:
    - (1) recursively visit left subtree, (2) recursively visit right subtree, (3) visit node
  - Level-order:
    - Traverse the nodes level by level
- In different situations, we use different traversal algorithm.

Examples for expression tree

- By pre-order, (prefix)
  + * 2 3 / 8 4
- By in-order, (infix)
  2 * 3 + 8 / 4
- By post-order, (postfix)
  2 3 * 8 4 / +
- By level-order,
  + * / 2 3 8 4



- Note 1: Infix is what we read!
- Note 2: Postfix expression can be computed efficiently using stack

Preorder, Postorder and Inorder

- Preorder traversal
  - node, left, right
  - prefix expression
    - ++a*bc*+*defg

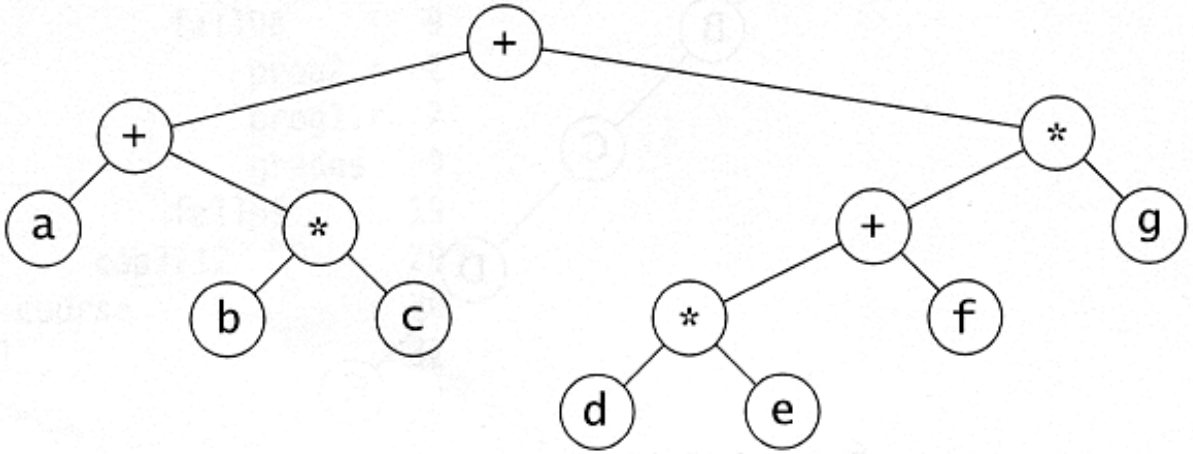


Figure 4.14 Expression tree for (a + b * c) + ((d * e + f) * g)

Preorder, Postorder and Inorder

- Postorder traversal
  - left, right, node
  - postfix expression
    - abc*+de*f+g*+
- Inorder traversa
  - left, node, right.
  - infix expression
    - a+b*c+d*e+f*g

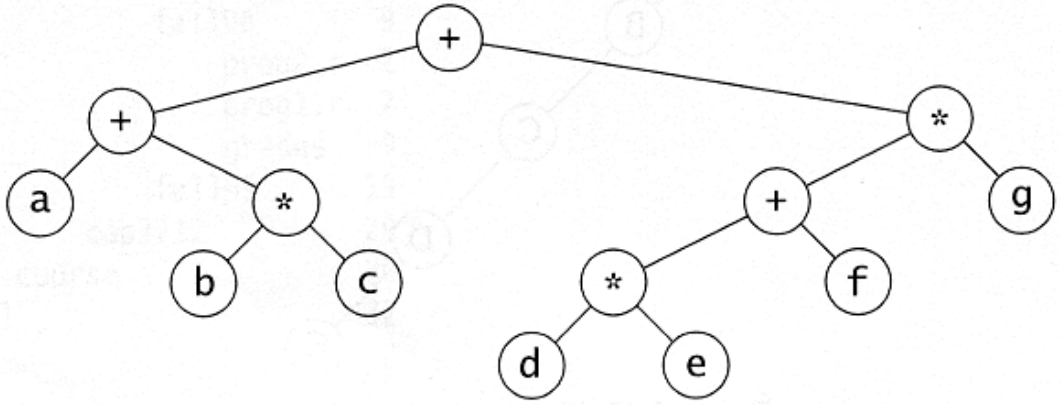


Figure 4.14 Expression tree for (a + b * c) + ((d * e + f) * g)

Pre-order example

Pre-order(a); →

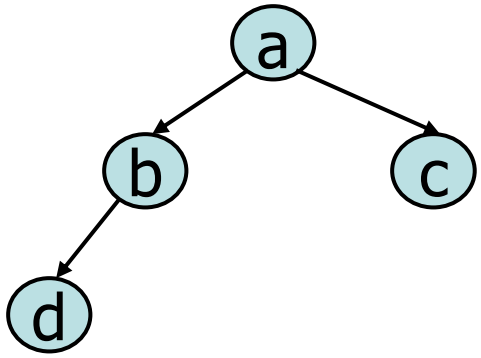
Print a;
Pre-order(b);
Pre-order(c);

Print b;
Pre-order(d);
Pre-order(null);

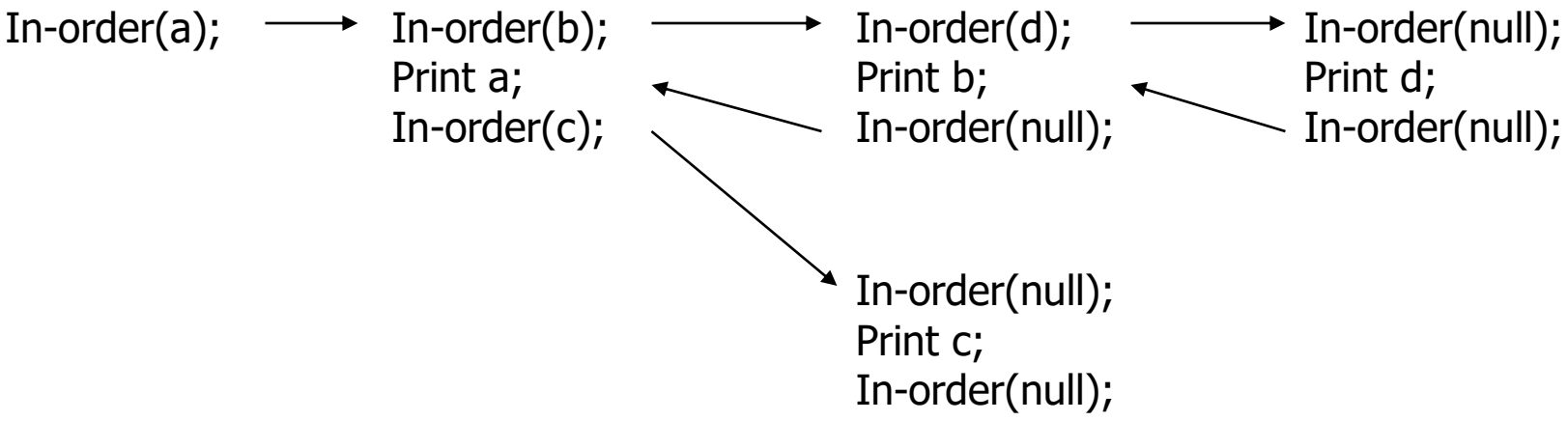
Print d;
Pre-order(null);
Pre-order(null);

Print c;
Pre-order(null);
Pre-order(null);

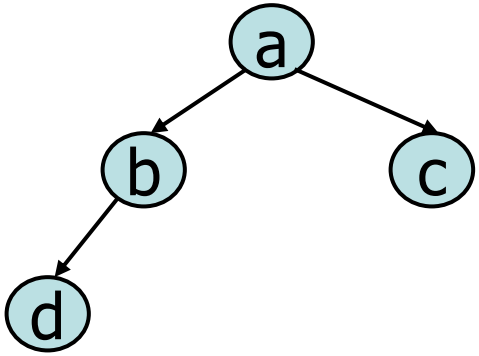
a b d c



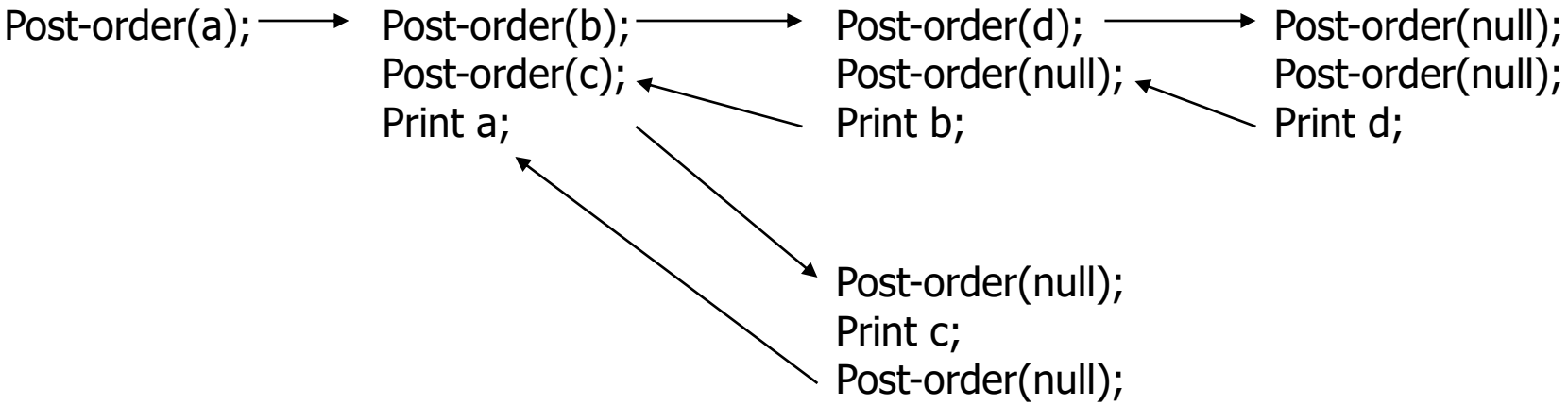
In-order example



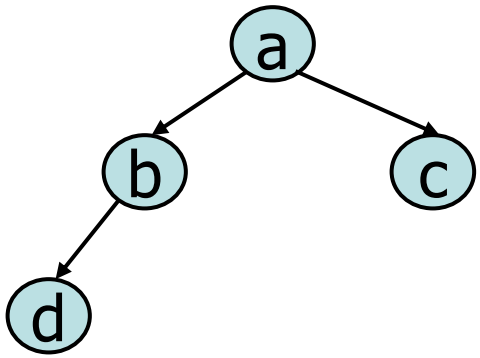
d b a c



Post-order example



d b c a

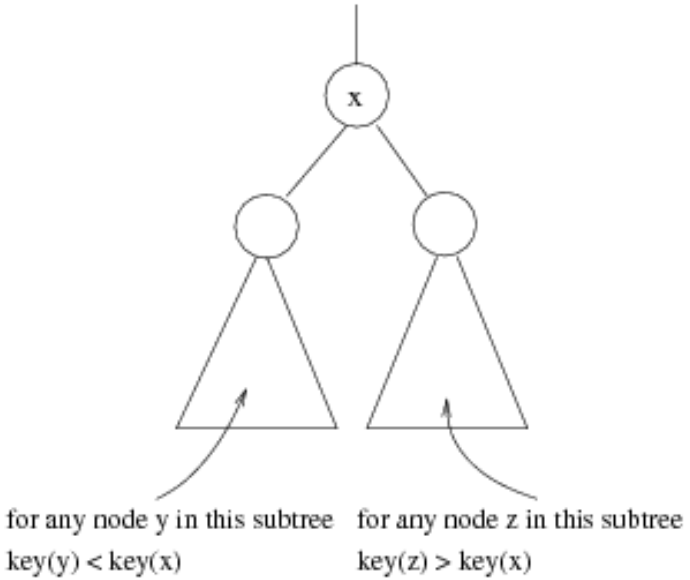


Binary Search Trees

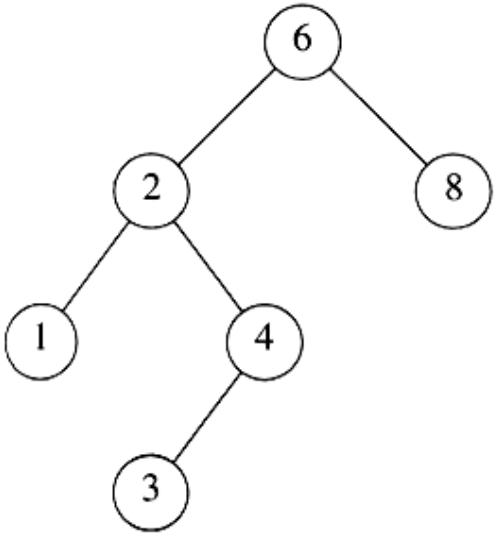
- Stores keys in the nodes in a way so that searching, insertion and deletion can be done efficiently.

Binary search tree property

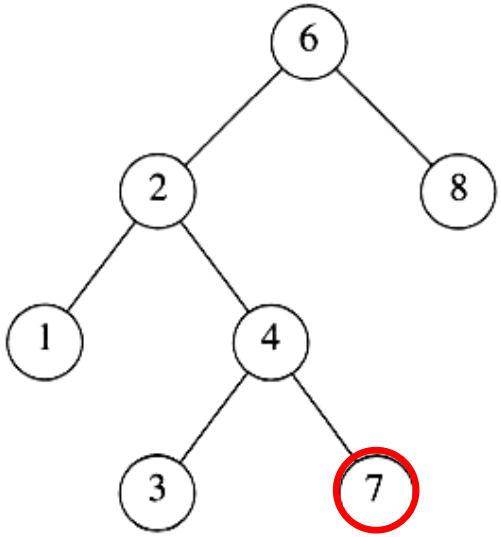
- For every node X, all the keys in its left subtree are smaller than the key value in X, and all the keys in its right subtree are larger than the key value in X



Binary Search Trees



A binary search tree

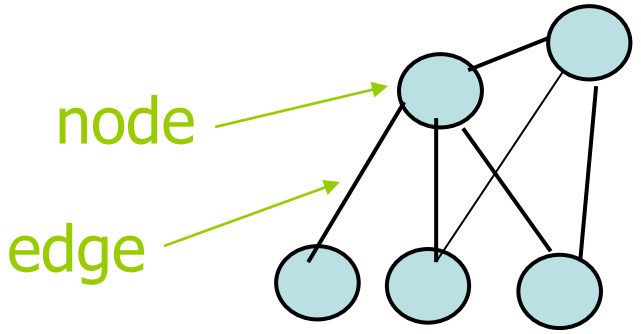


Not a binary search tree

Graphs

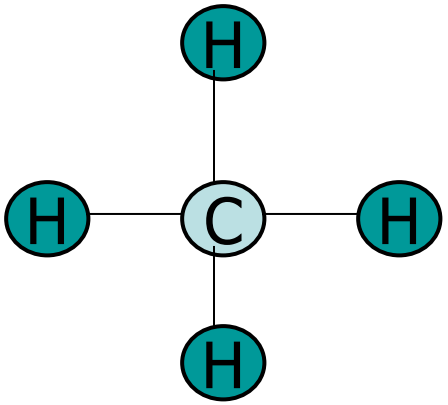
What is a graph?

- Graphs represent the relationships among data items
- A graph G consists of
  - a set V of nodes (vertices)
  - a set E of edges: each edge connects two nodes
- Each node represents an item
- Each edge represents the relationship between two items

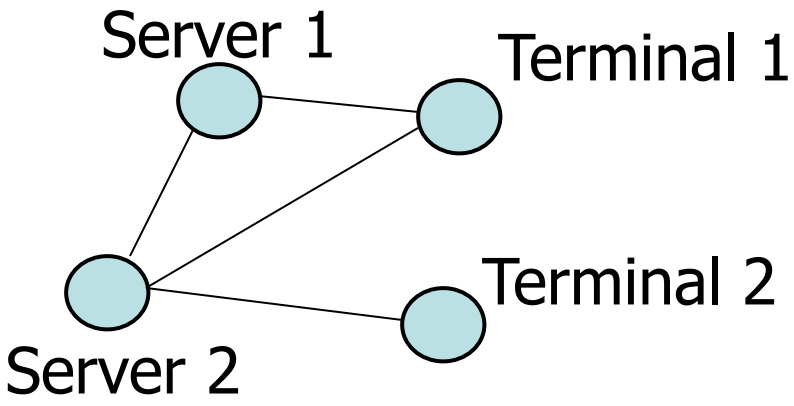


Examples of graphs

Molecular Structure



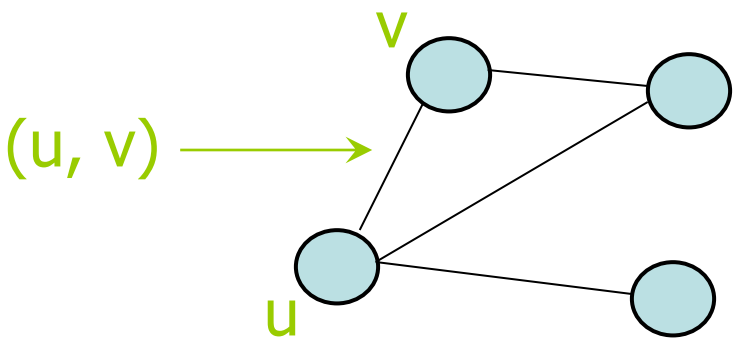
Computer Network



Other examples: electrical and communication networks, airline routes, flow chart, graphs for planning projects

Formal Definition of graph

- The set of nodes is denoted as V
- For any nodes u and v, if u and v are connected by an edge, such edge is denoted as (u, v)



- The set of edges is denoted as E
- A graph G is defined as a pair (V, E)