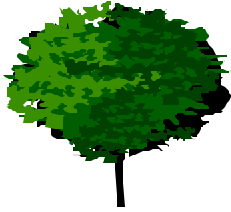


Trees



Trees Joyce Kilmer

I think that I shall never see
A poem lovely as a tree.
A tree whose hungry mouth is prest
Against the earth's sweet flowing breast:
A tree that looks at God all day,
And lifts her leafy arms to pray:
A tree that may in Summer wear
A nest of robins in her hair:
Upon whose bosom snow has lain;
Who intimately lives with rain.
Poems are made by fools like me,
But only God can make a tree.

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Trees (for CS-folks)



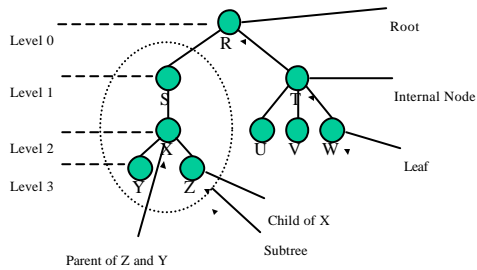
- A tree is defined as follows:
 - A tree T is either empty or it is a finite set of one or more nodes such that there is a specially designated node $r \in T$ (called the root of T) and $T - \{r\}$ can be partitioned into zero, one or more disjoint subsets T_1, T_2, \dots, T_n , each of which is itself a tree (called a subtree of T)

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Tree Anatomy



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Tree Terms

Term	Definition
Node	An element in a tree; contains one piece of information
Child	The immediate descendent of a node
Parent	The immediate ancestor of a node
Sibling	A node sharing the same parent as another node
Root	The topmost node in the tree; has no parent
Leaf	A node which has children
Level	All nodes which are the same distance from the root
Depth	How many levels there are in the tree
Complete	All parents have a full complement of children
Balanced	All subtrees of a node have similar depths.

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Tree Facts

- Each node, except the root, has exactly one parent
- Once a link from a parent to a child is followed, it is not possible to get back to the parent by following more links (i.e., there are no cycles in the tree)
- The children of a node are, themselves, trees (called subtrees)

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Binary Tree

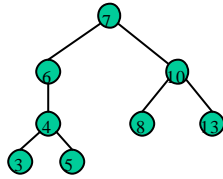
- A binary tree
 - Is a finite set of nodes that is either empty or consists of a root and at most two disjoint binary trees called the *left* and *right* subtrees

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Binary Tree



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Tree Traversals

- One of the most common operations performed on trees, are a *tree traversals*
- A traversal starts at the root of the tree and visits every node in the tree exactly once
 - visit means to process the data in the node
- Traversals are either *depth-first* or *breadth-first*

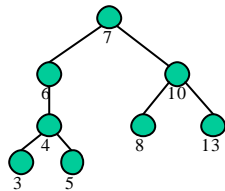
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Breadth First Traversals

- All the nodes in one level are visited
- Followed by the nodes the at next level
- Beginning at the root
- For the sample tree
 - 7, 6, 10, 4, 8, 13, 3, 5



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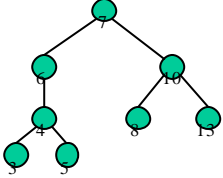
Depth-First Traversals

- There are 8 different depth-first traversals
 - VLR (pre-order traversal)
 - VRL
 - LVR (in-order traversal)
 - RVL
 - RLV
 - LRV (post-order traversal)

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Pre-order Traversal

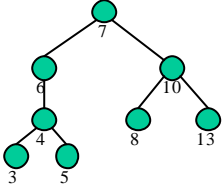
- Visit the node
- Do a pre-order traversal of the left subtree
- Finish with a pre-order traversal of the right subtree
- For the sample tree
 - 7, 6, 4, 3, 5, 10, 8, 13



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In-order Traversal

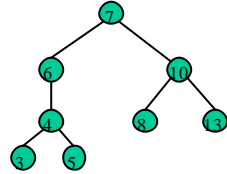
- Do an in-order traversal of the left subtree
- Visit the node
- Finish with an in-order traversal of the right subtree
- For the sample tree
 - 3, 4, 5, 6, 7, 10, 8, 13



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Post-order Traversal

- Do a post-order traversal of the left subtree
- Followed by a post-order traversal of the right subtree
- Visit the node
- For the sample tree
 - 13, 8, 10, 5, 3, 4, 6, 7



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Binary Search Tree

- A binary search tree, is a binary tree, with the following property
 - from any parent node, all the nodes in the parent's left subtree have values which are less than or equal to that in the parent
 - all the values in any parent node's right subtree are greater than that in the parent

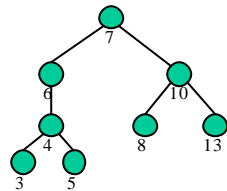
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Searching a Binary Tree

- Begin at the root
- Until the value is found OR we fall off the tree
 - if the value in the node is what we are looking for
 - stop we are done
 - otherwise
 - if the value is less
 - » look left
 - » otherwise look right
- $\log_2 N$ for balanced trees



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Building a Binary Tree

- Begin at the root
 - if the new value == value in node stop
 - if the new value < value in node
 - if there is a left child
 - insert value into left subtree
 - otherwise create a left subtree with the new value
 - if the new value > value in node
 - if there is a right child
 - insert value into right subtree
 - otherwise create a right subtree with the new value

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Try it!!

- Build binary search trees for the following input sequences
 - 7, 4, 2, 6, 1, 3, 5, 7
 - 7, 1, 2, 3, 4, 5, 6, 7
 - 7, 4, 2, 1, 7, 3, 6, 5
 - 1, 2, 3, 4, 5, 6, 7, 8
 - 8, 7, 6, 5, 4, 3, 2, 1

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