Algorithms and Data Structures for Data Science

Trees 1

CS 277
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Department of Computer Science

Informal Early Feedback

Form available on Moodle (along with lab surveys)

Feedback form open until October 13th

If >50% class participates, everyone gets 10 bonus points

Learning Objectives

Formally define the tree data structure

Explore properties of trees and the specifics of binary trees

Implement and understand traversals and search on trees

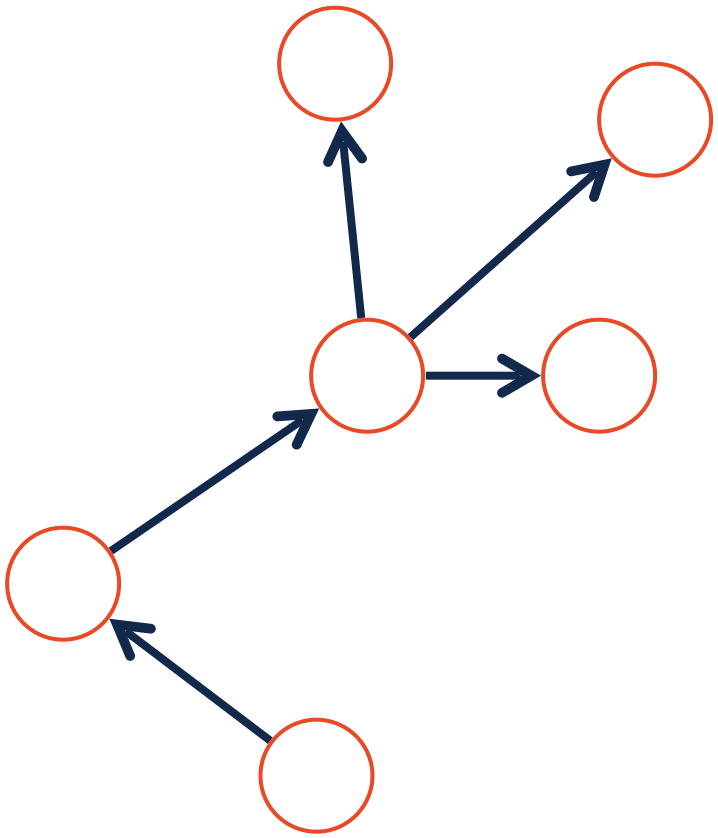
Trees

A non-linear data structure defined recursively as a collection of nodes where each node contains a value and zero or more connected nodes.

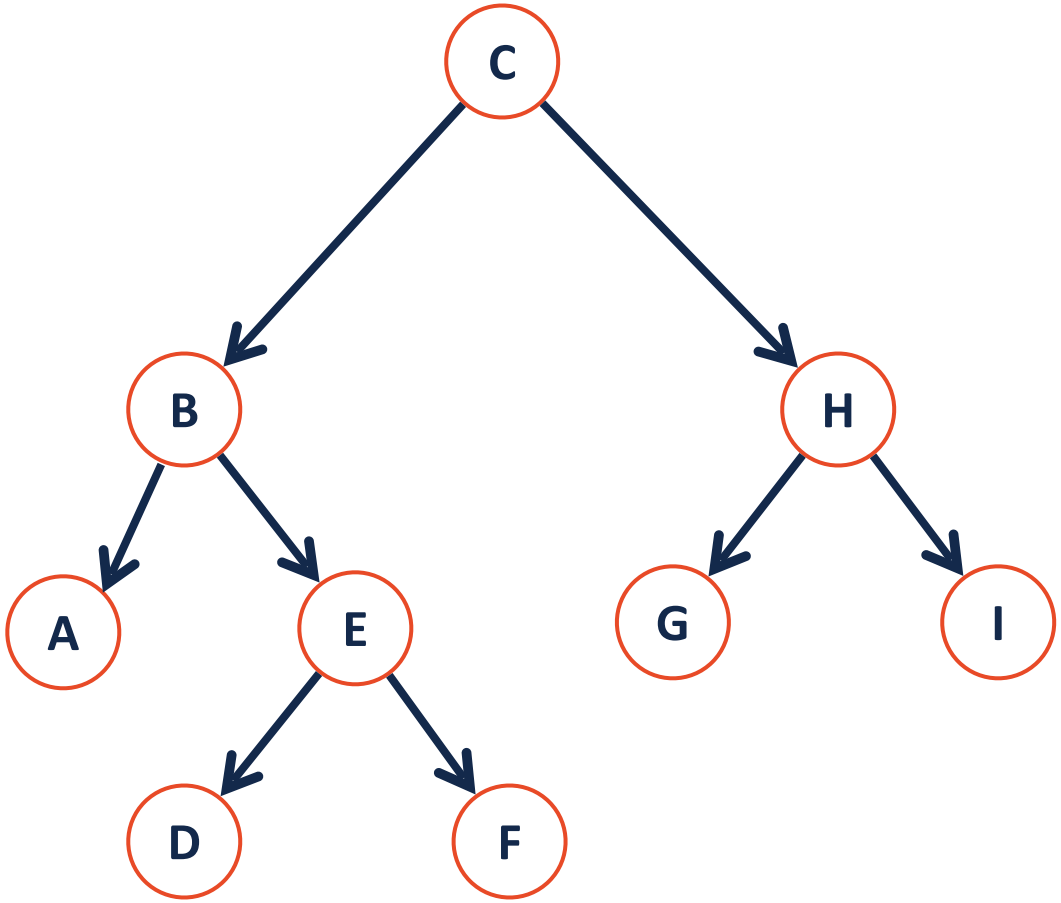
(In CS 277) a tree is also:

1) Acyclic

2) Rooted



Tree Terminology

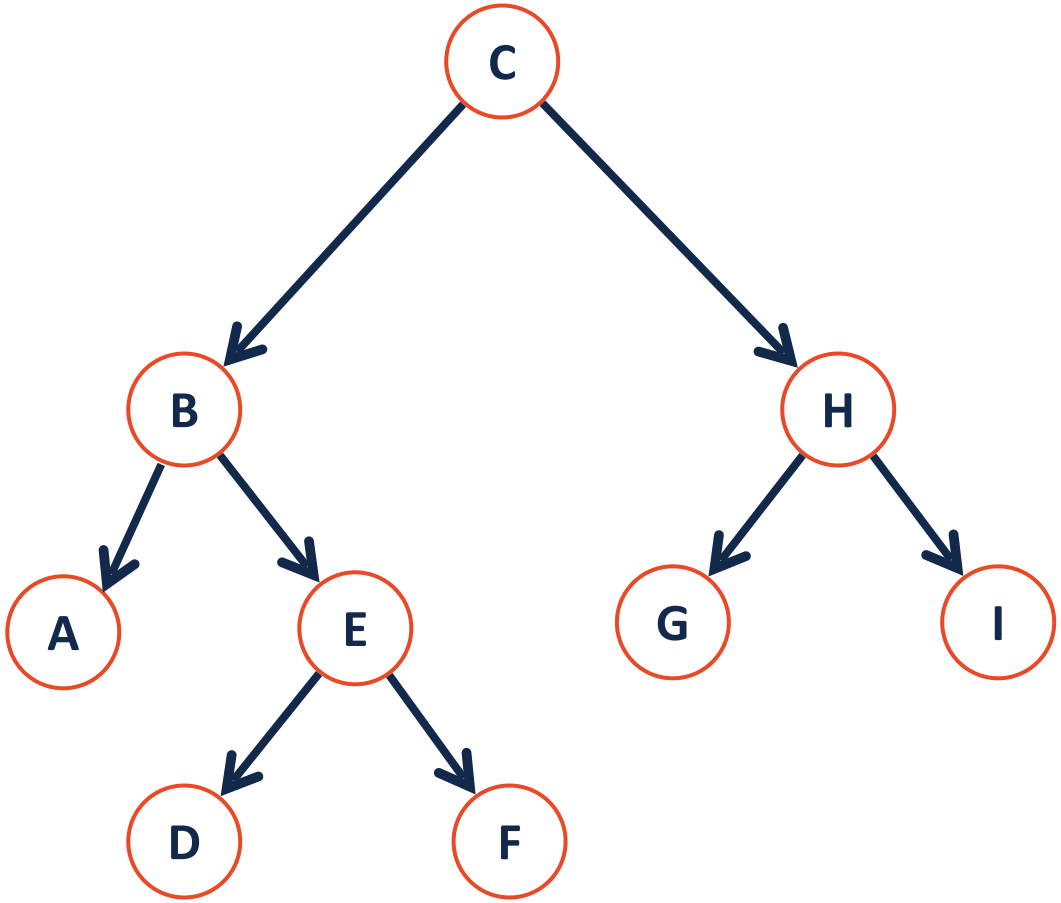


Node: The vertex of a tree

Edge: The [theoretical] connecting path between nodes

Path: A list of the edges (or nodes) traversed to go from node `start` to node `end`

Tree Terminology



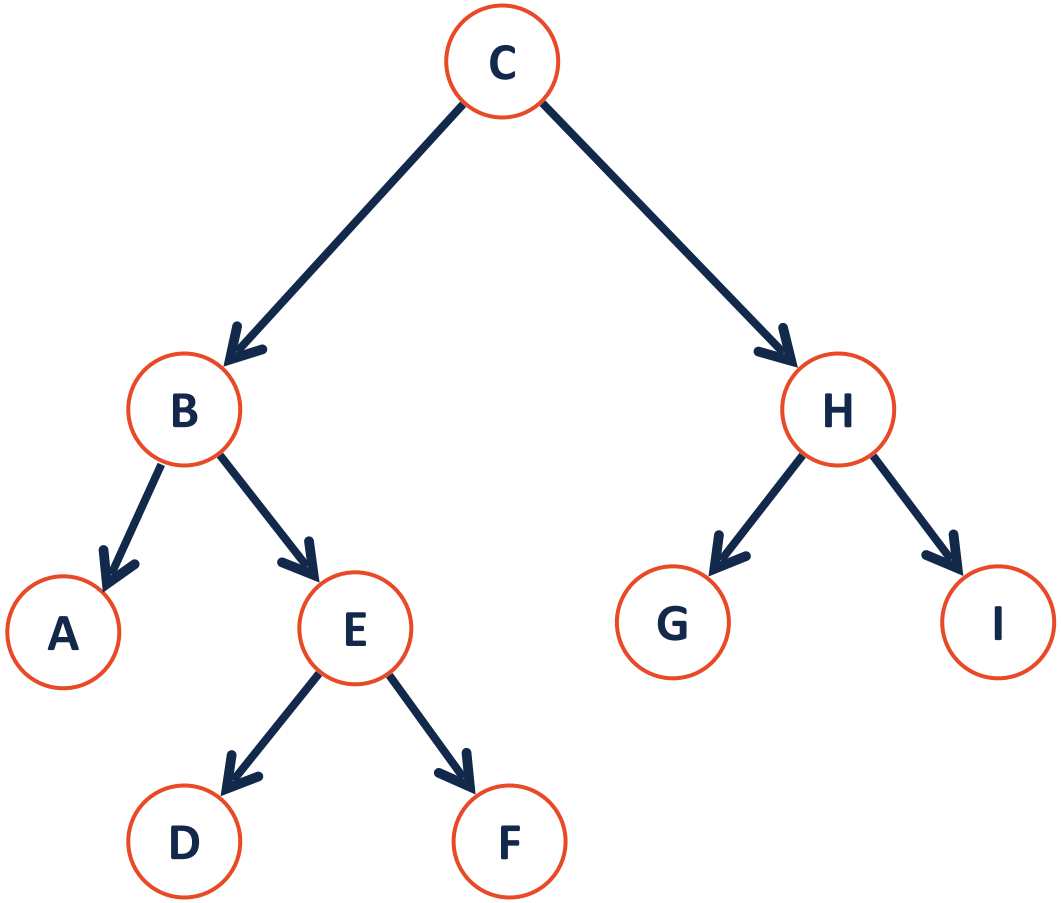
Parent: The precursor node to the current node is the 'parent'

Child: The nodes linked by the current node are it's 'children'

Neighbor: Parent or child

Degree: The number of children for a given node

Tree Terminology



Root: The start of a tree (the only node with no parent).

Leaf: The terminating nodes of a tree (have no children)

Internal: A node with at least one child

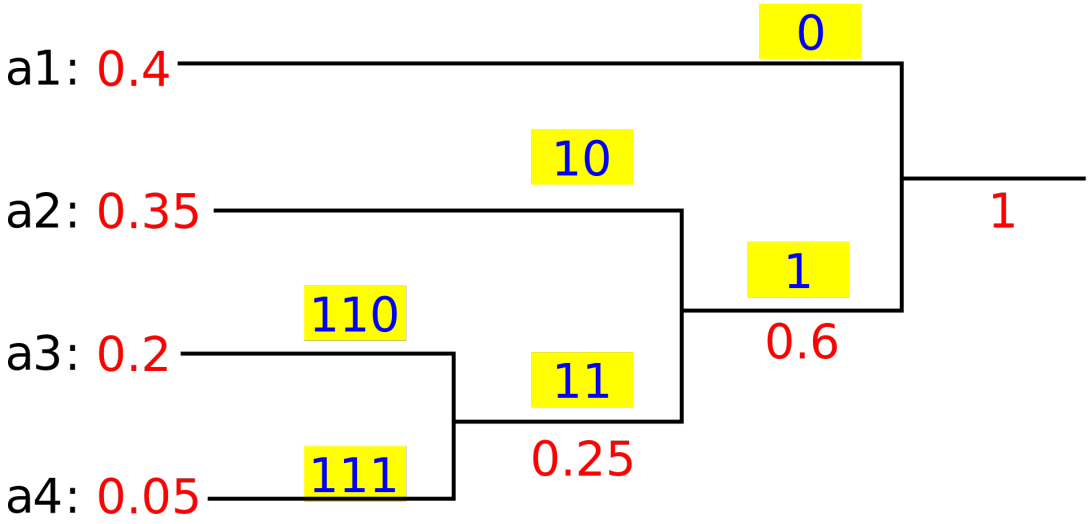
Tree ADT

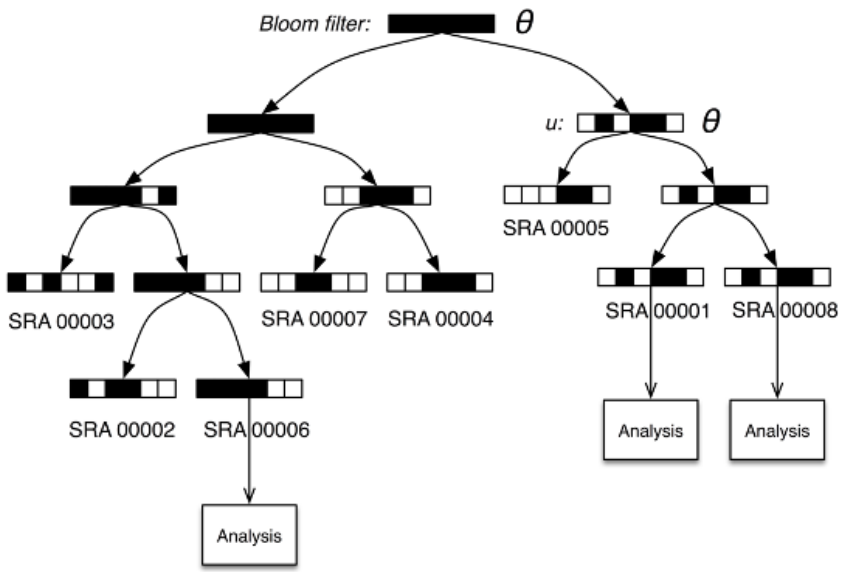
Insert: Add an object into tree

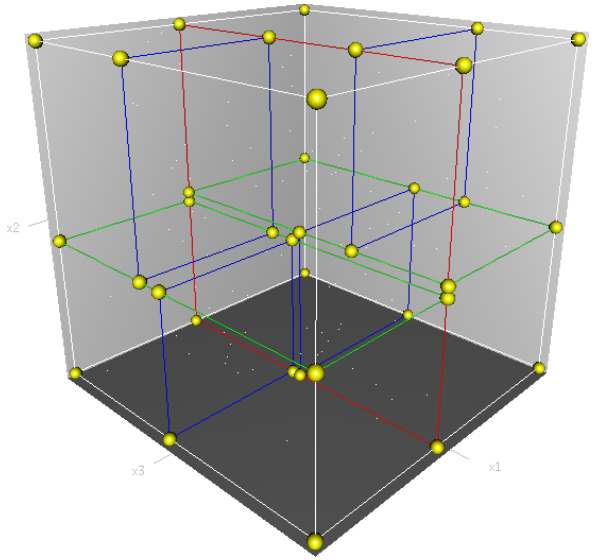
Remove: Remove a specific object from tree

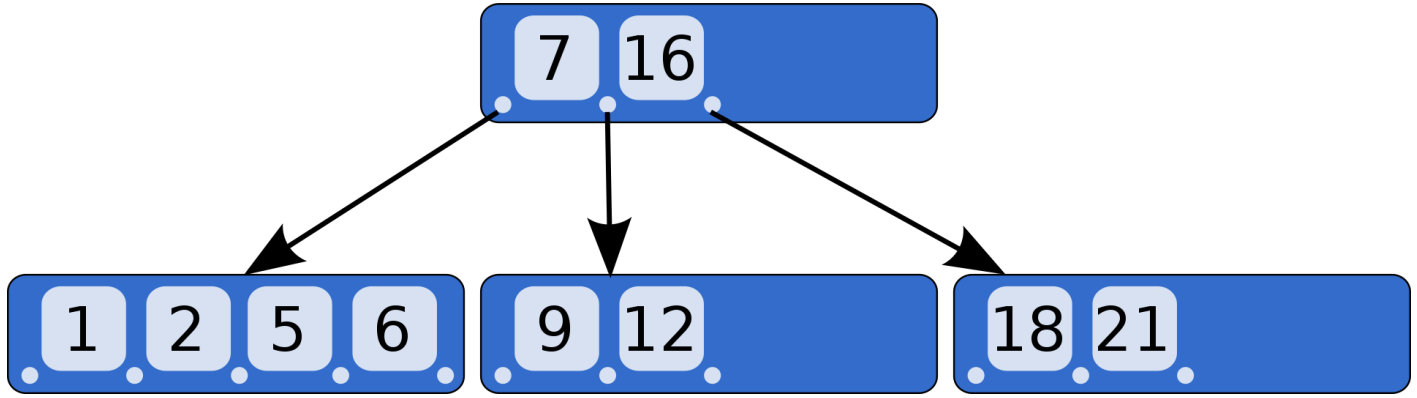
Traverse: Visit every node in tree (all objects)

There are many *types* of trees









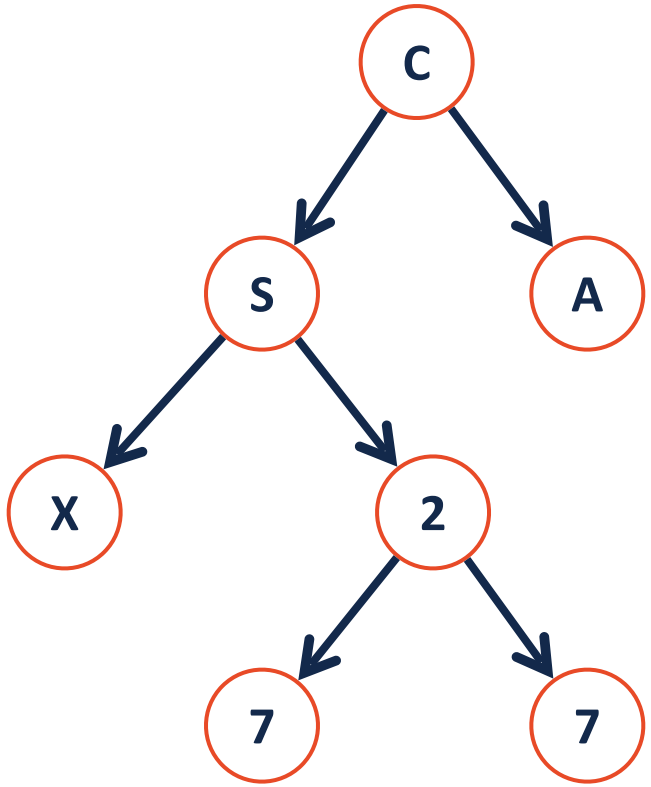
Binary Tree

A **binary tree** is a tree T such that:

$$T = None$$

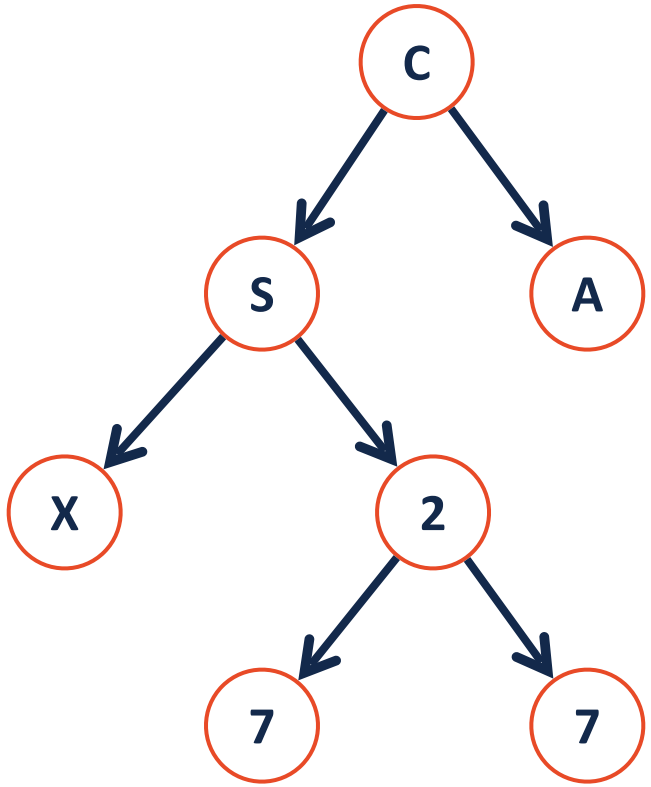
or

$$T = treeNode(val, T_L, T_R)$$



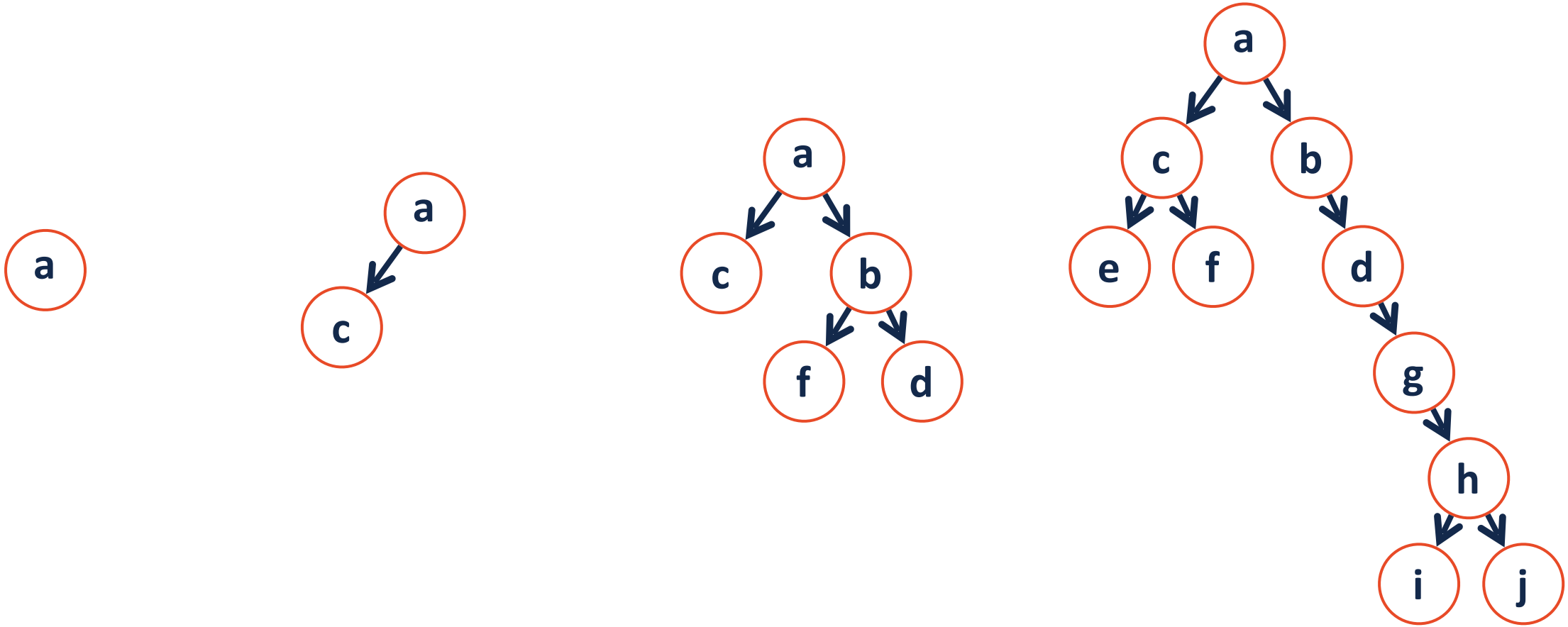
Binary Tree

```
class treeNode:
    def __init__(self, val, ______, ______):

        self.val = val


        ______________________


        ______________________


class binaryTree:
    def __init__(self, root=None):
        self.root = root
```



Tree Terminology

Height: the length of the longest path from the root to a leaf



Tree Height

`T.height() =`

Base Case:

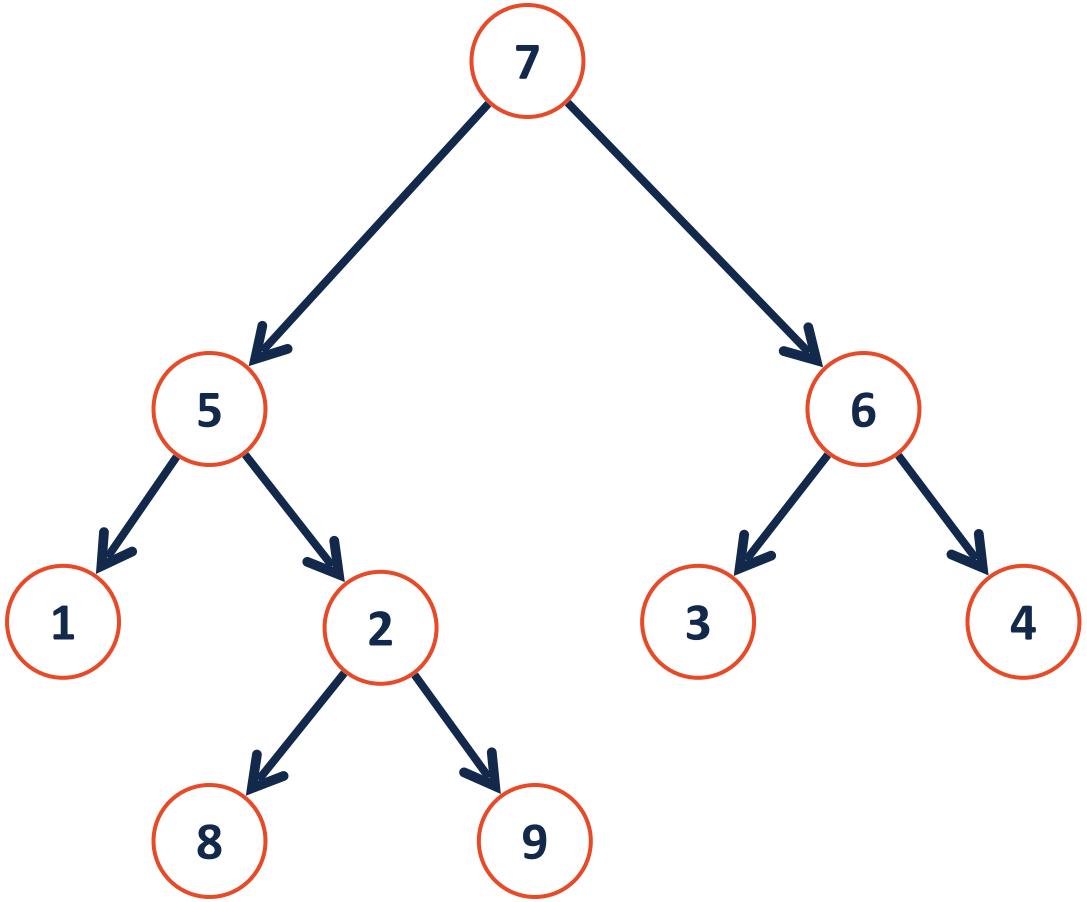
Recursive Step:

Combining:

Defining a tree

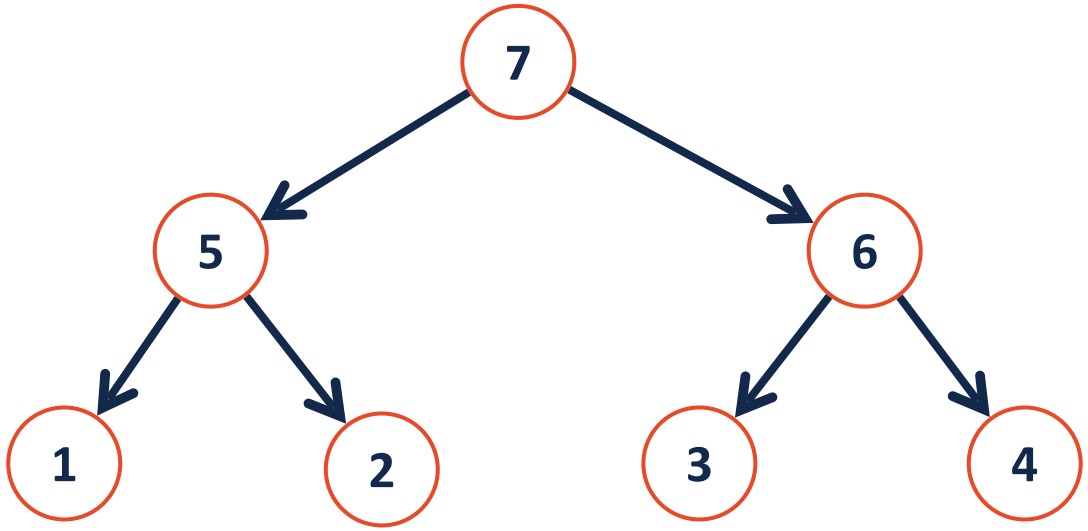
```
tn1 = treeNode(1)

tn2 = treeNode(2)

tn3 = treeNode(3)

tn4 = treeNode(4)

tn5 = treeNode(5, tn1, tn2)

tn6 = treeNode(6, tn3, tn4)

tn7 = treeNode(7, tn5, tn6)
```

Tree Traversals



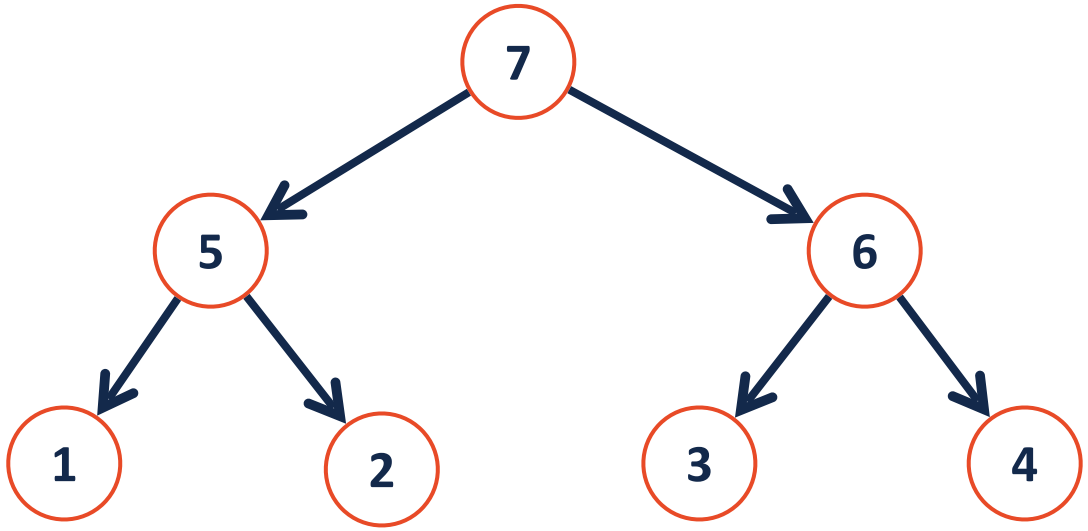
Pre-Order Traversal

```
class binaryTree:

    def preorderTraversal(self):
        self.preorderHelper(self.root)

    def preorderHelper(self, node):
```



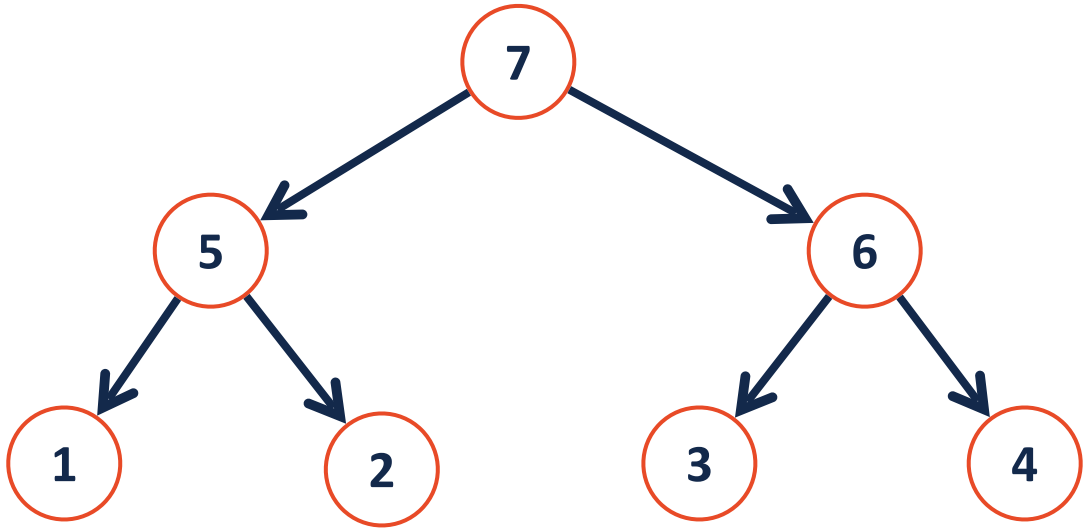
Post-Order Traversal

```
class binaryTree:

    def postorderTraversal(self):
        self.postorderHelper(self.root)

    def postorderHelper(self, node):
```

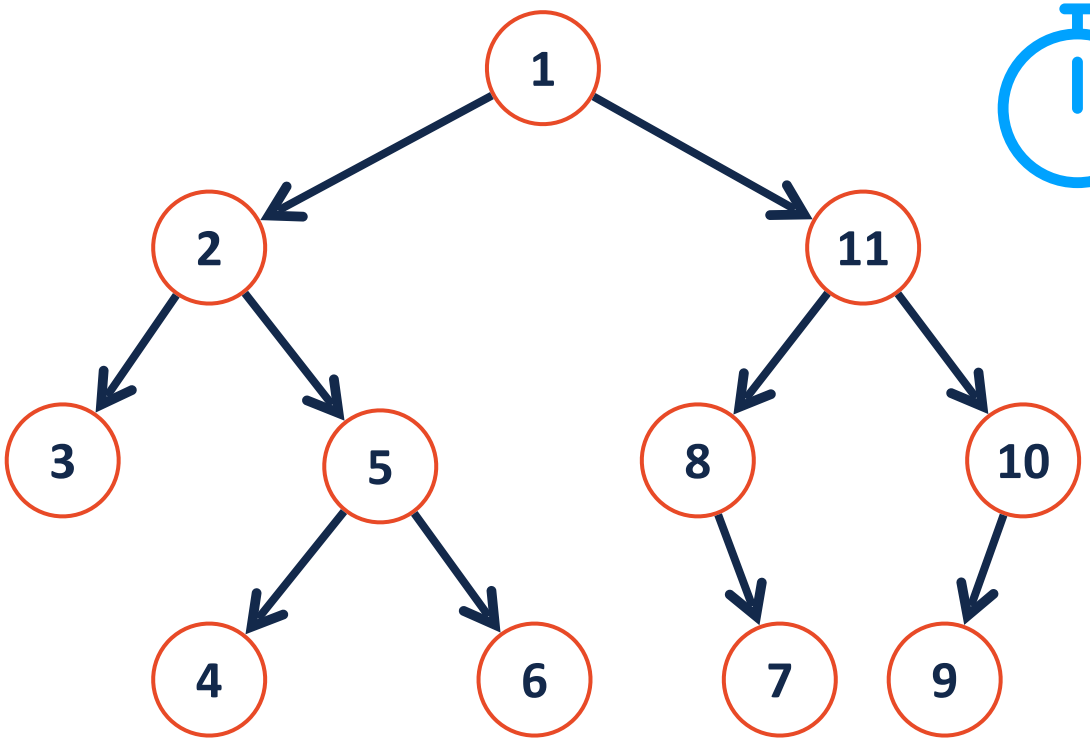


In-Order Traversal

```
class binaryTree:

    def inorderTraversal(self):
        self.inorderHelper(self.root)

    def inorderHelper(self, node):
```



Tree Traversals



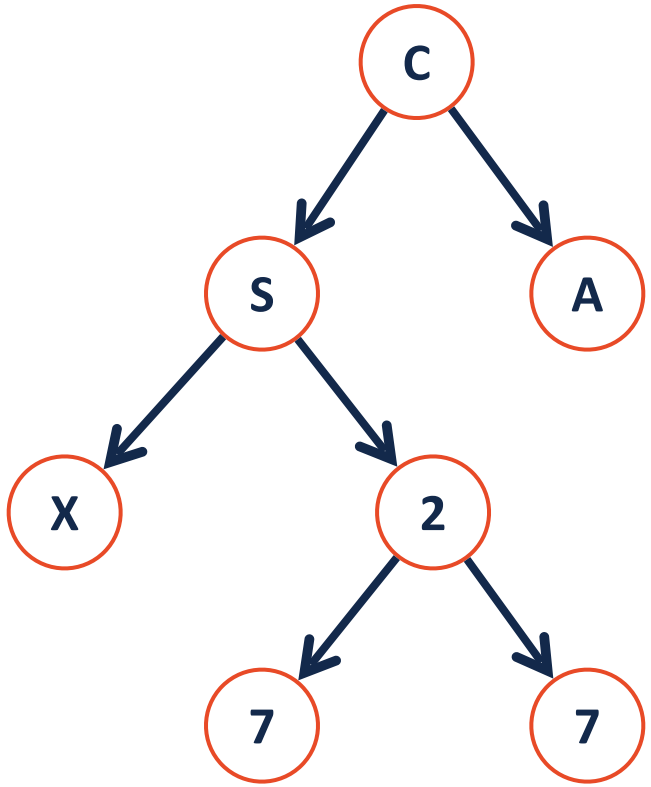
Pre-order:

In-order:

Post-order:

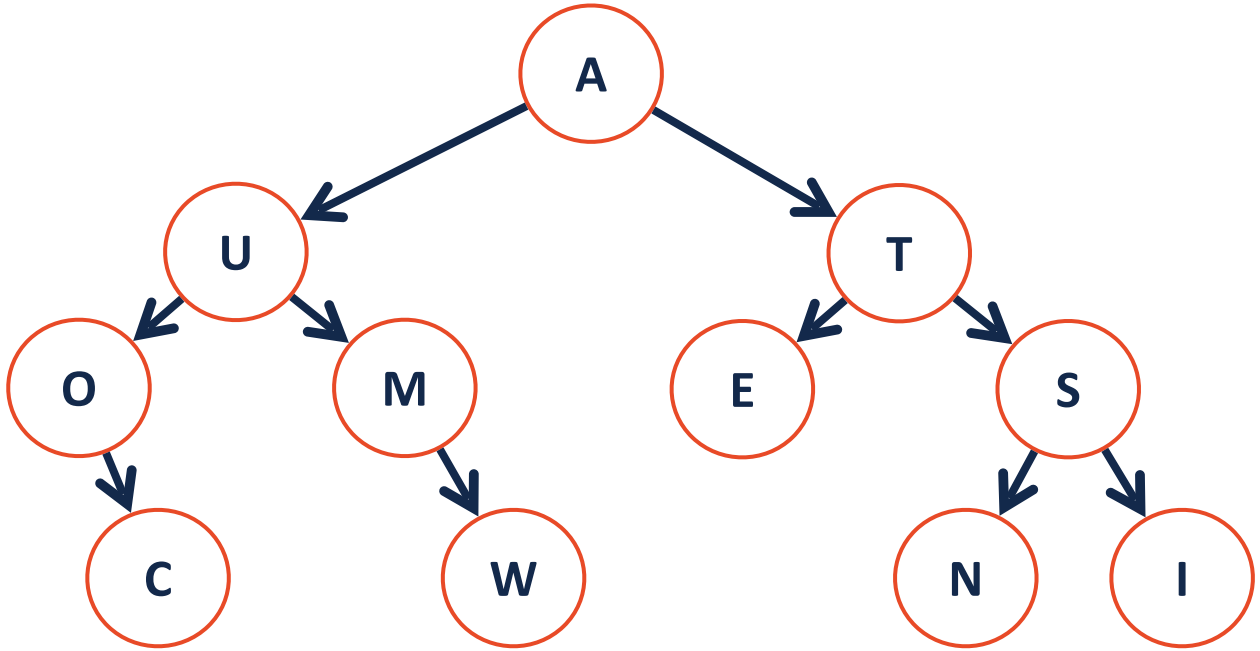
Tree Traversals

Pre-order: Ideal for copying trees



Post-order: Ideal for deleting trees

Search Running Times on a Binary Tree



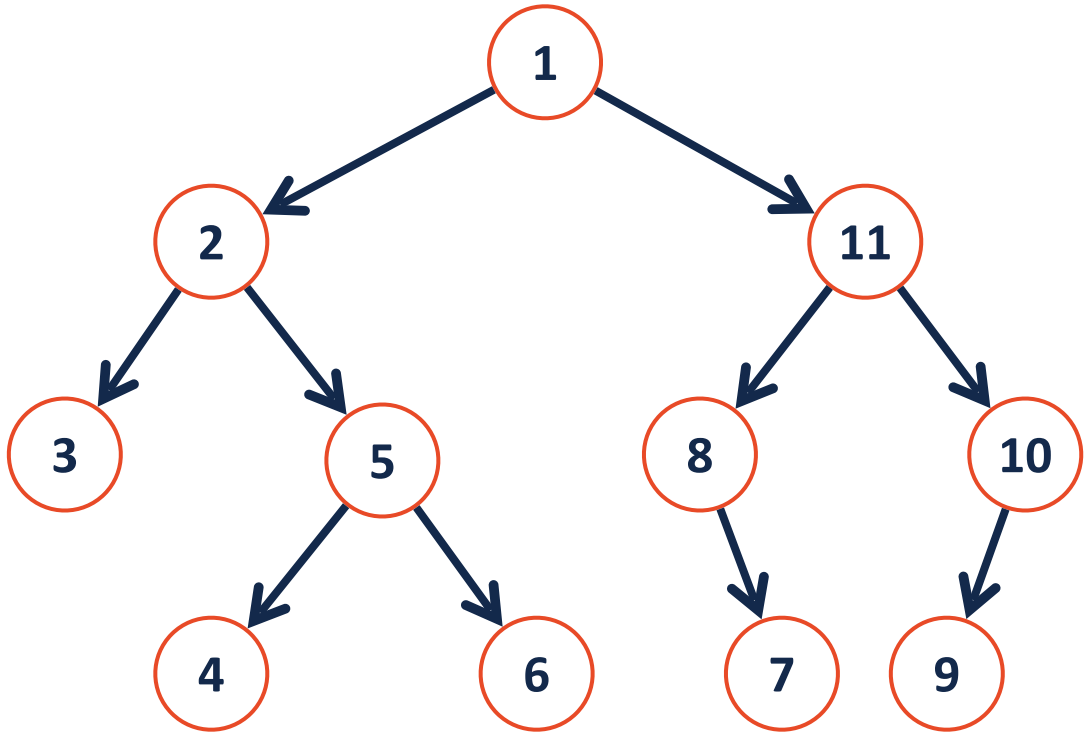
Traversal vs Search

Traversal:

Search:

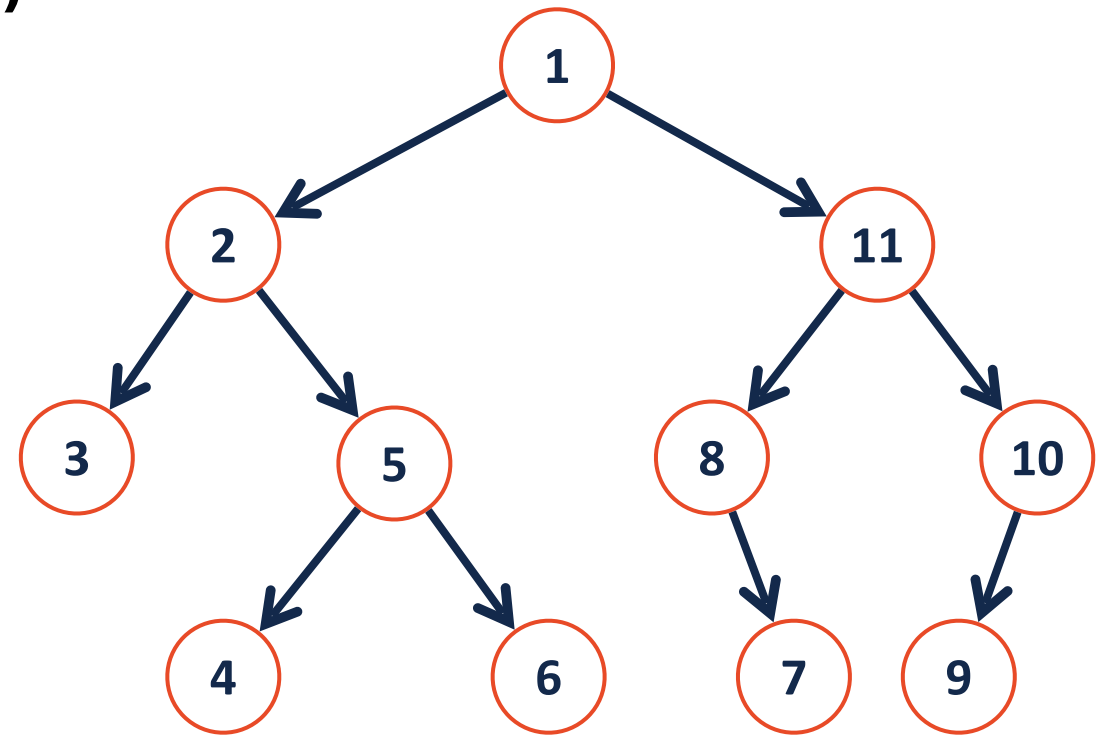
Search: Breadth First vs. Depth First

Strategy: Depth First Search (DFS)

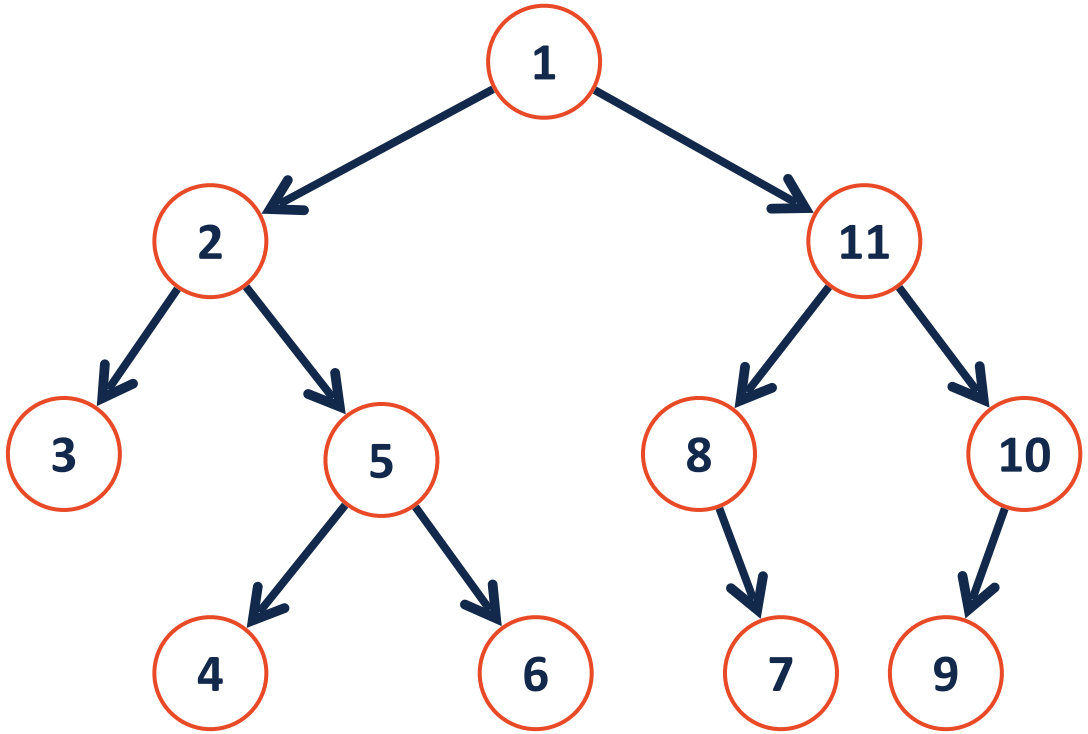


Search: Breadth First vs. Depth First

Strategy: Breadth First Search (BFS)



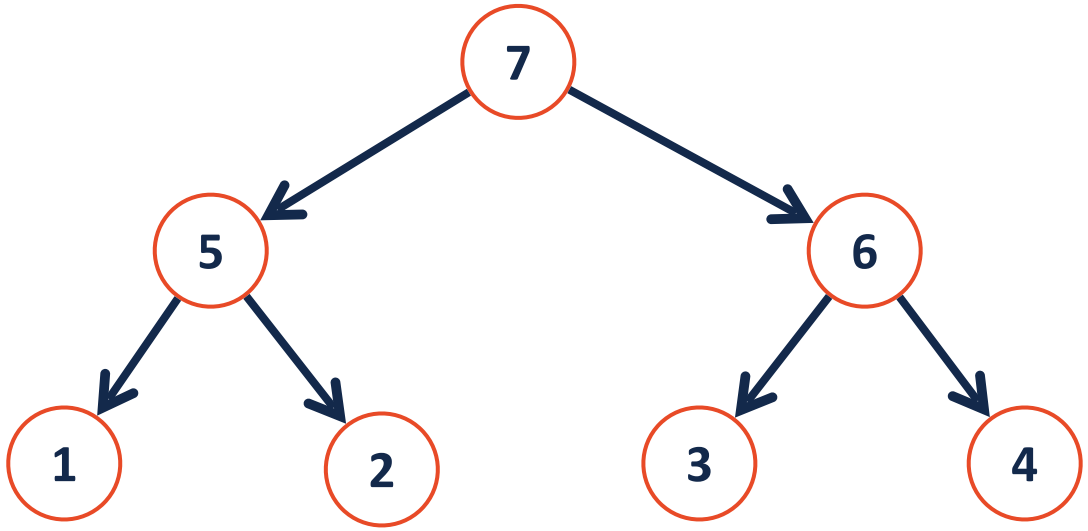
Level-Order Traversal



Level-order:

Level-Order Traversal

```
class binaryTree:

    def levelorderTraversal(self):
```



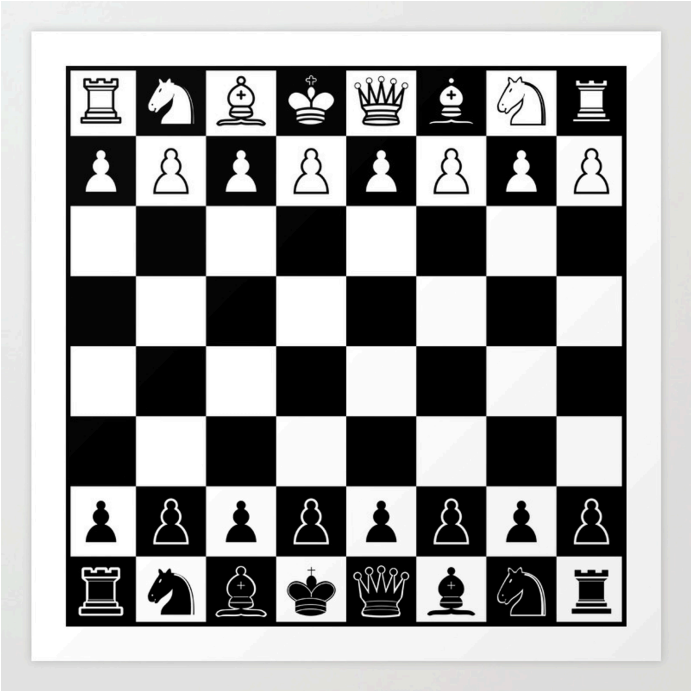
Search: Breadth First vs. Depth First

Strategy: Breadth First Search (BFS)

Strategy: Depth First Search (DFS)

What search algorithm is best?

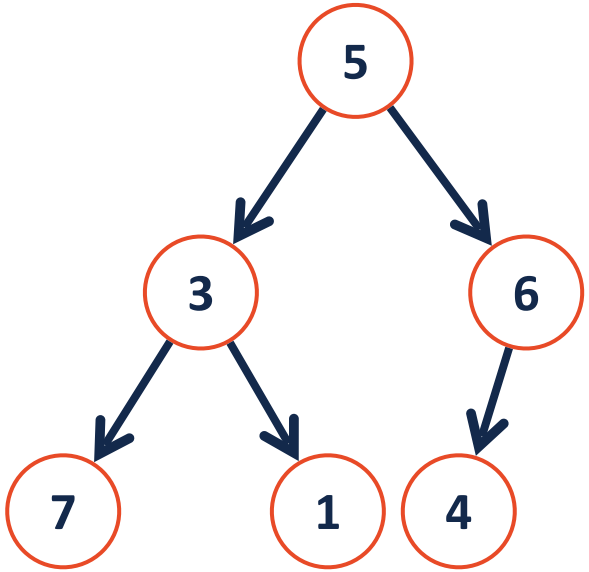
The average 'branch factor' for a game of chess is ~31. If you were searching a decision tree for chess, which search algorithm would you use?

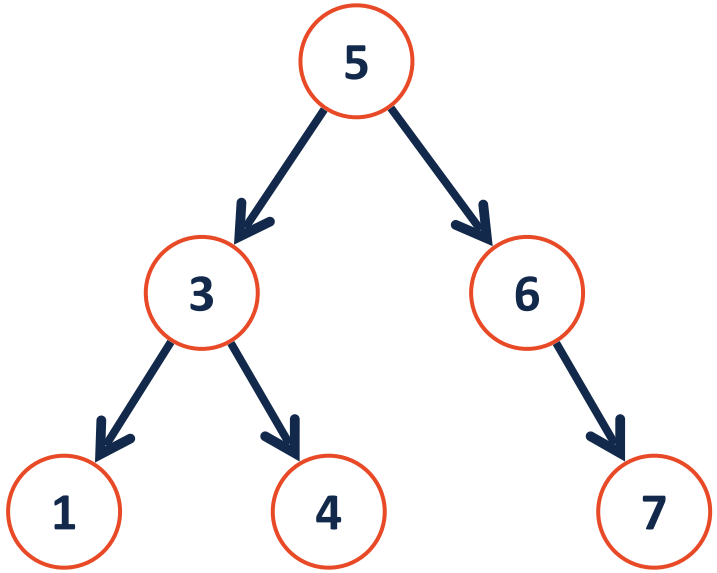


Improved search on a binary tree

5	3	6	7	1	4

1	3	4	5	6	7





Binary Search Tree (BST)

A **BST** is a binary tree $T = treeNode(val, T_L, T_r)$ such that:

$$\forall n \in T_L,\ n.val < T.val$$

$$\forall n \in T_R,\ n.val > T.val$$