Data Structures
Binary Trees

COMP128 Data Structures

Midterm Feedback

- More flexible with in-class activities (time, teammates, etc.)
- Shorter lectures (and more coding examples)
- Exam 3 is take-home
- Preceptors’ office hours

Binary Trees

This presentation illustrates the simplest kind of trees:

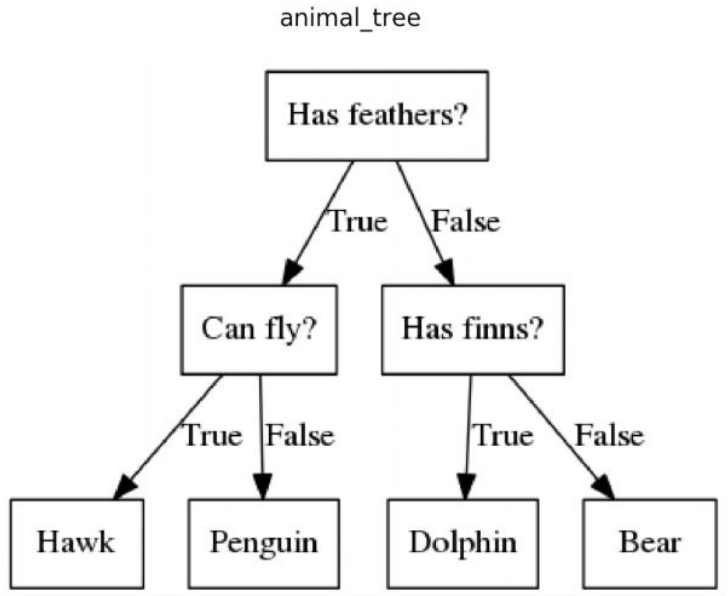
- Complete Binary Trees.
- Also Incomplete Binary Trees
- And representations for each

Binary Trees

- A binary tree has nodes, similar to nodes in a linked list structure.
- Data of one sort or another may be stored at each node.
- But it is the connections between the nodes which characterize a binary tree.

Why use trees?

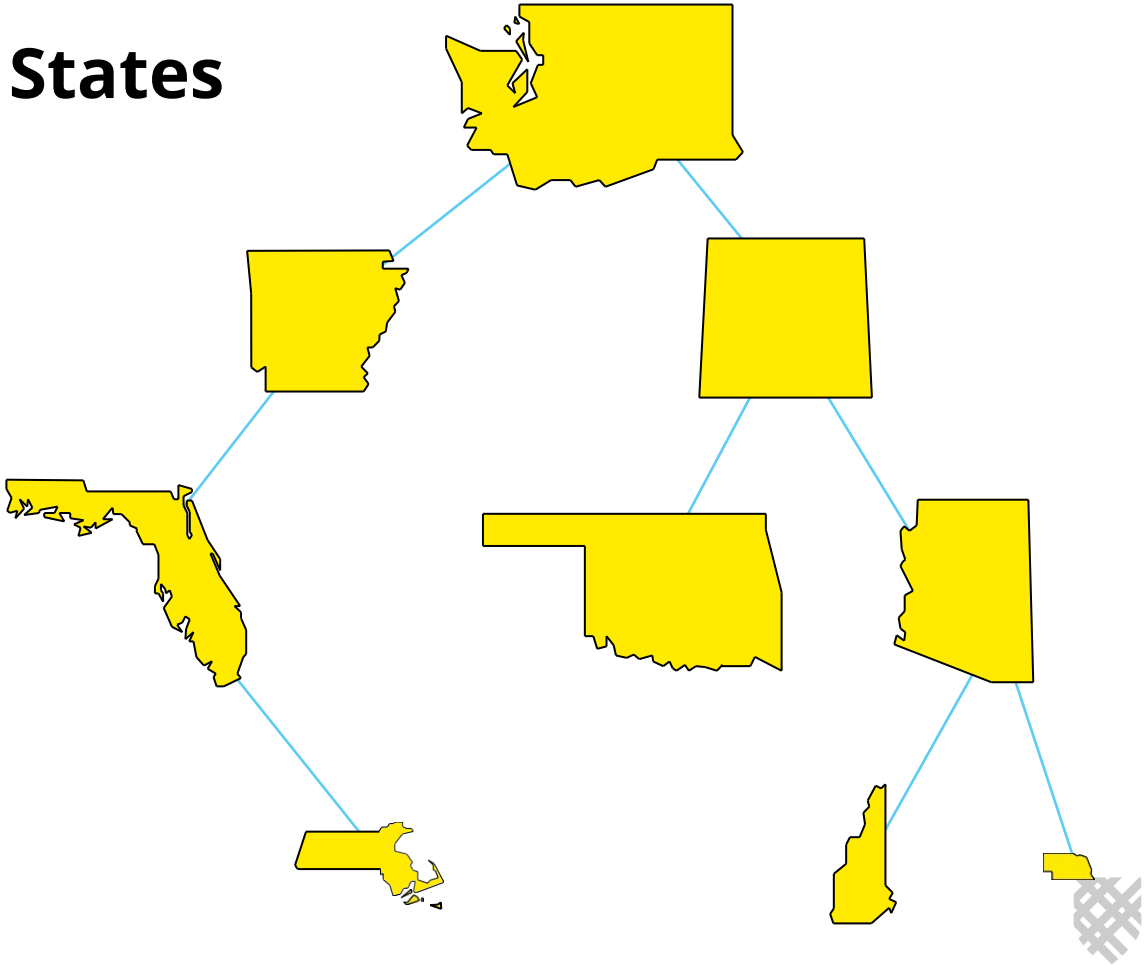
- Forms a hierarchy, e.g., file system
- Better time performance in search, compared to linear data structures
  - We will talk more about this in the class
- Other applications like spanning tree (in network design), or decision tree (in machine learning)



Source: mc.ai

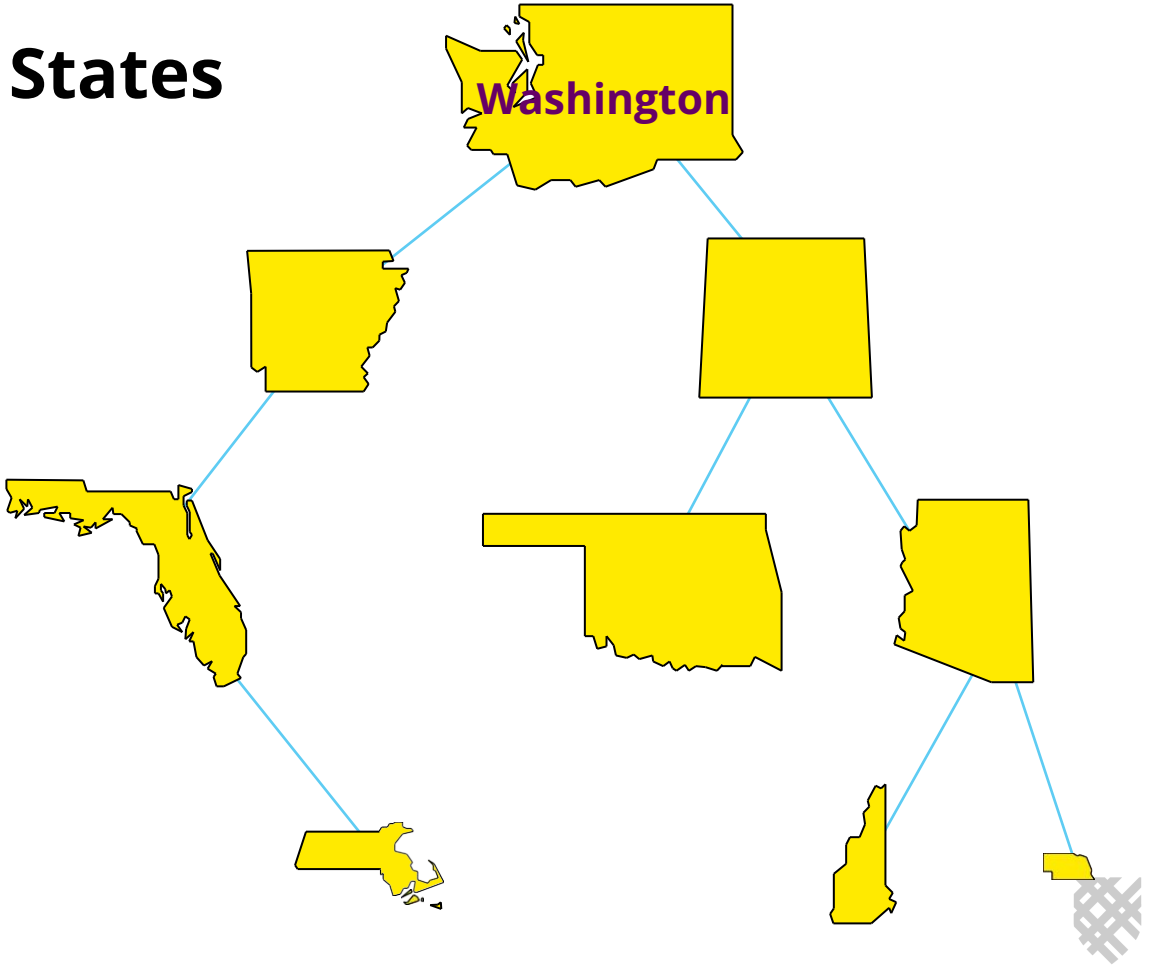
A Binary Tree of States

In this example, the data contained at each node is one of the 50 states.



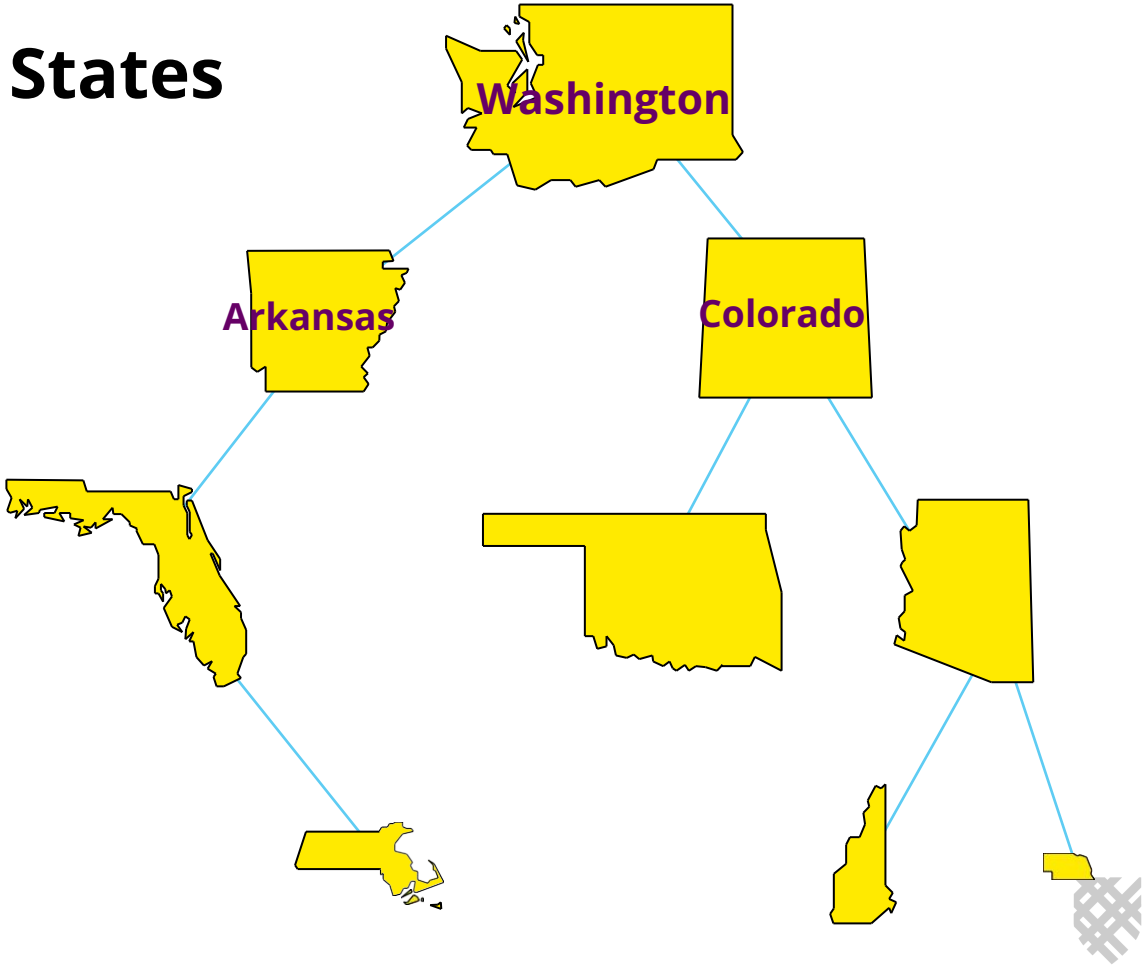
A Binary Tree of States

Each tree has a special node called its root, usually drawn at the top.



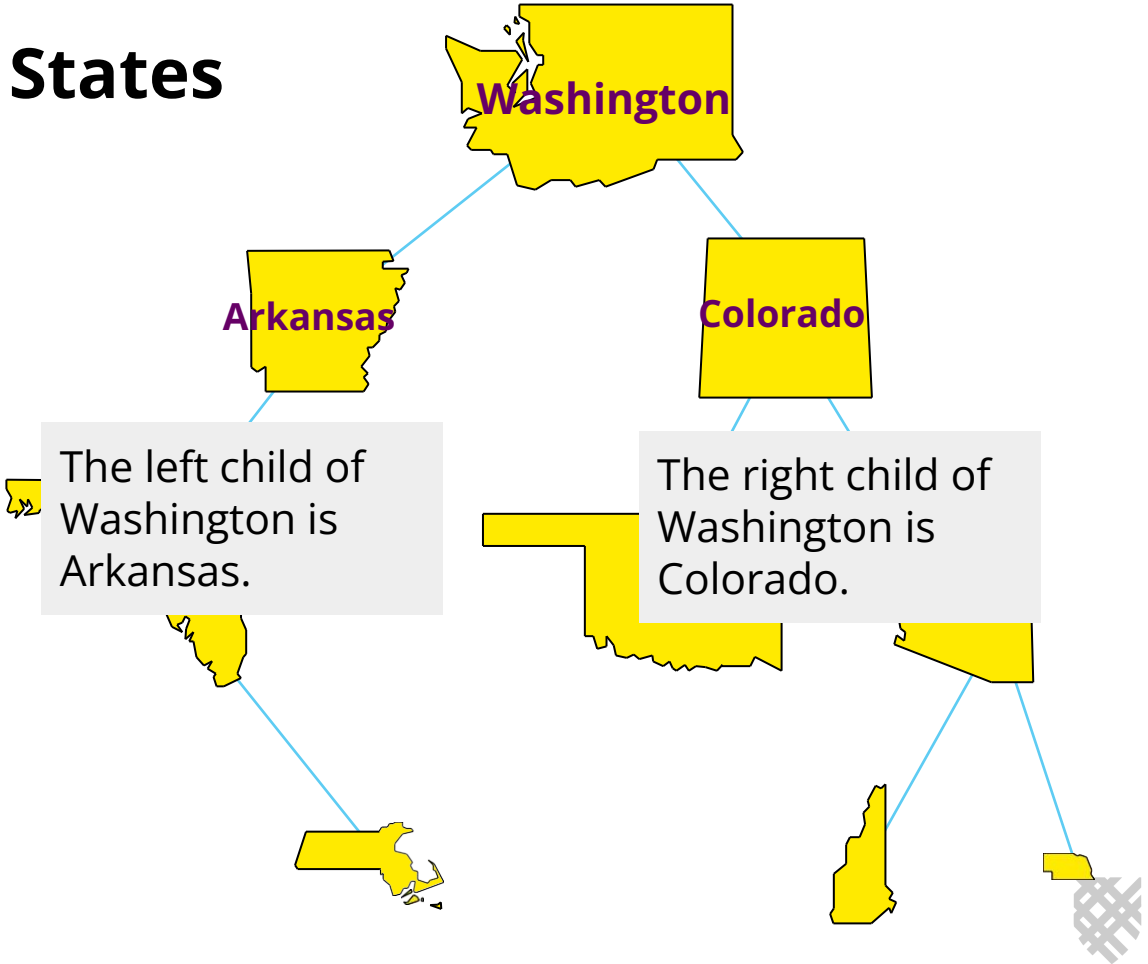
A Binary Tree of States

Each node is permitted to have **two links** to other nodes, called **the left child and the right child**.



A Binary Tree of States

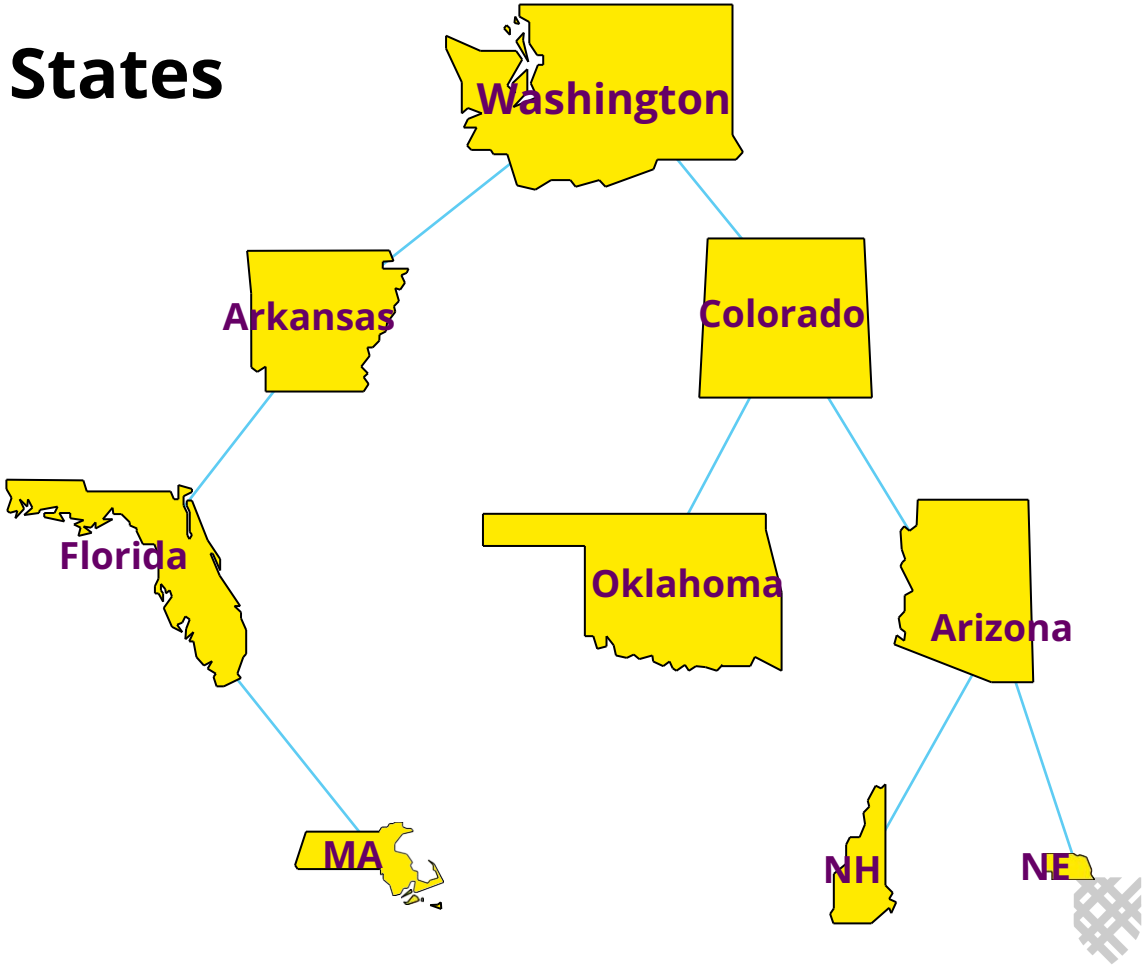
Children are usually drawn below a node.



A Binary Tree of States

Some nodes have only one child.

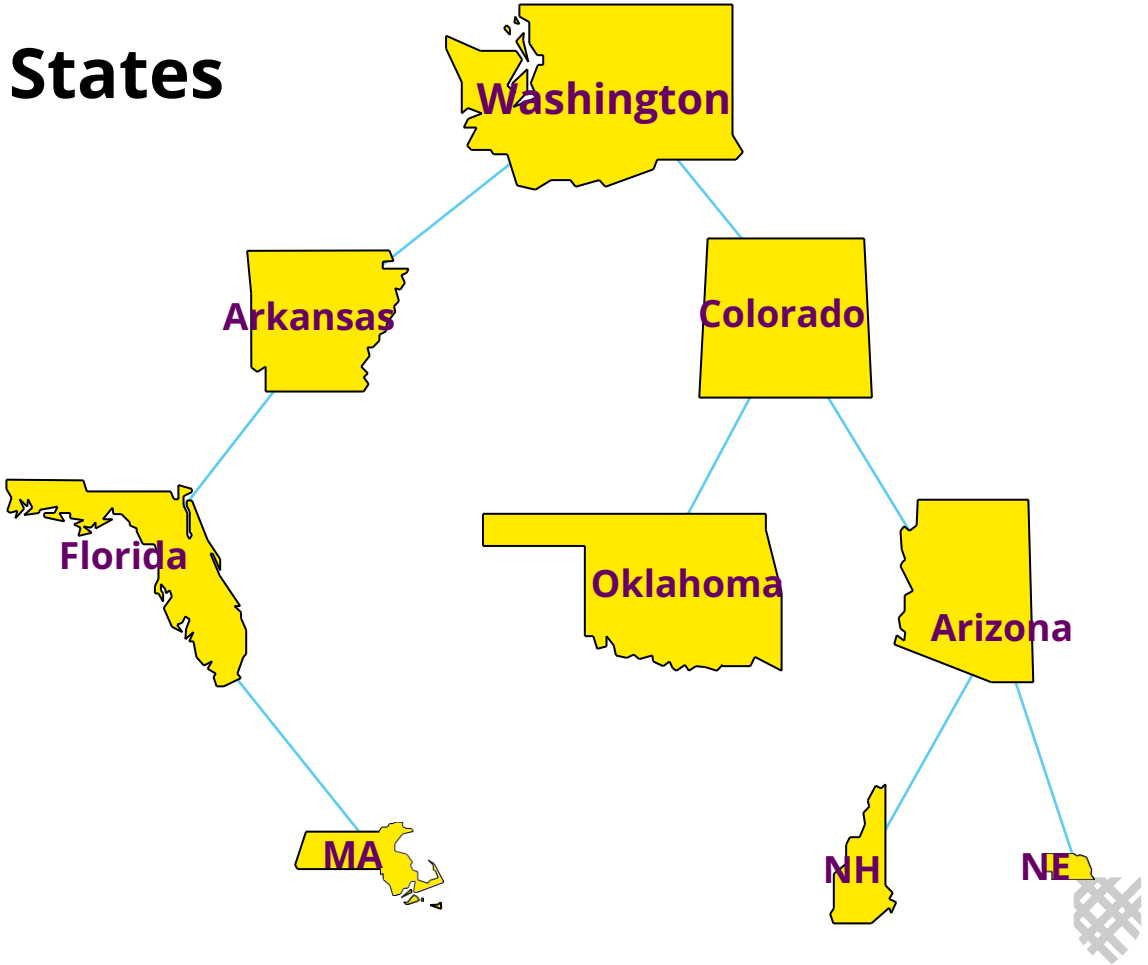
Arkansas has a left child, but no right child.



A Binary Tree of States

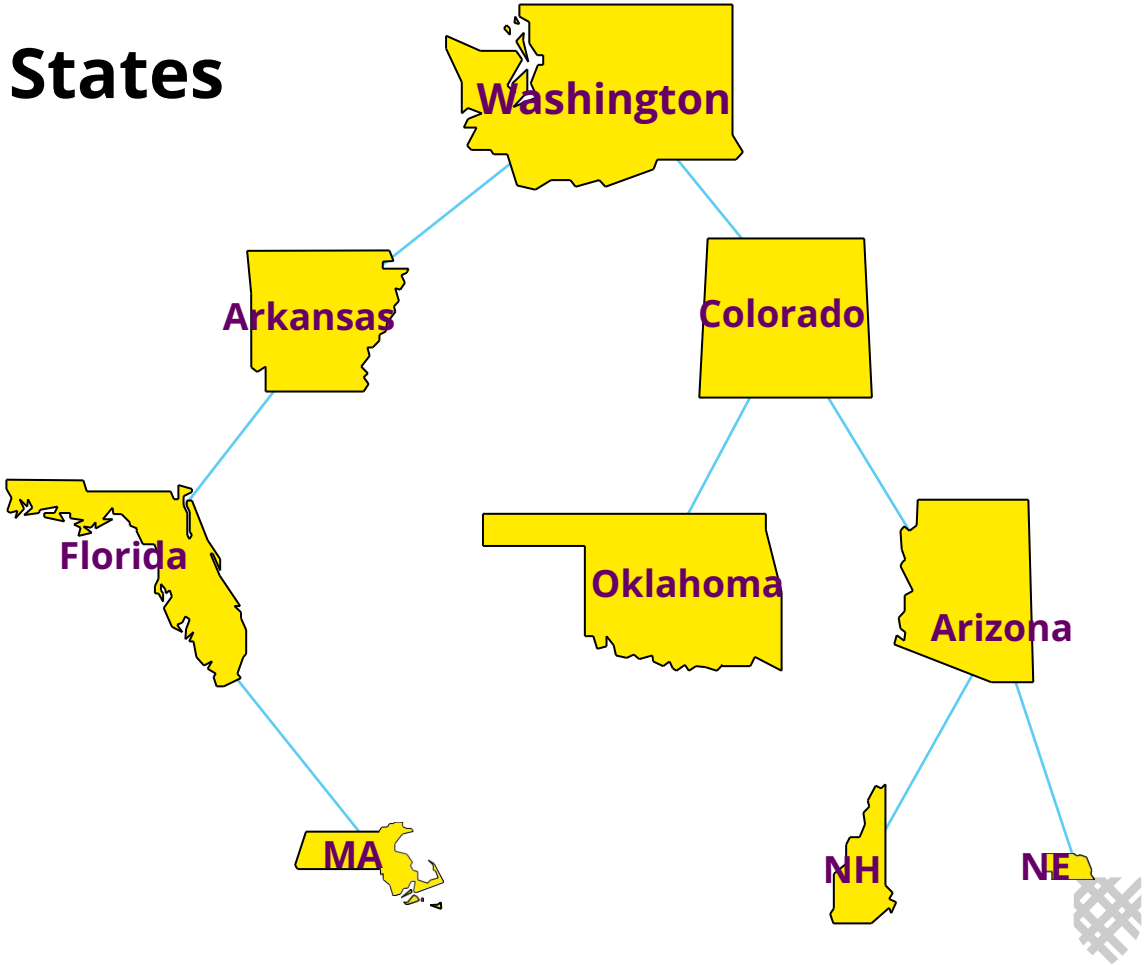
Some nodes have only one child.

Florida has only a right child.



A Binary Tree of States

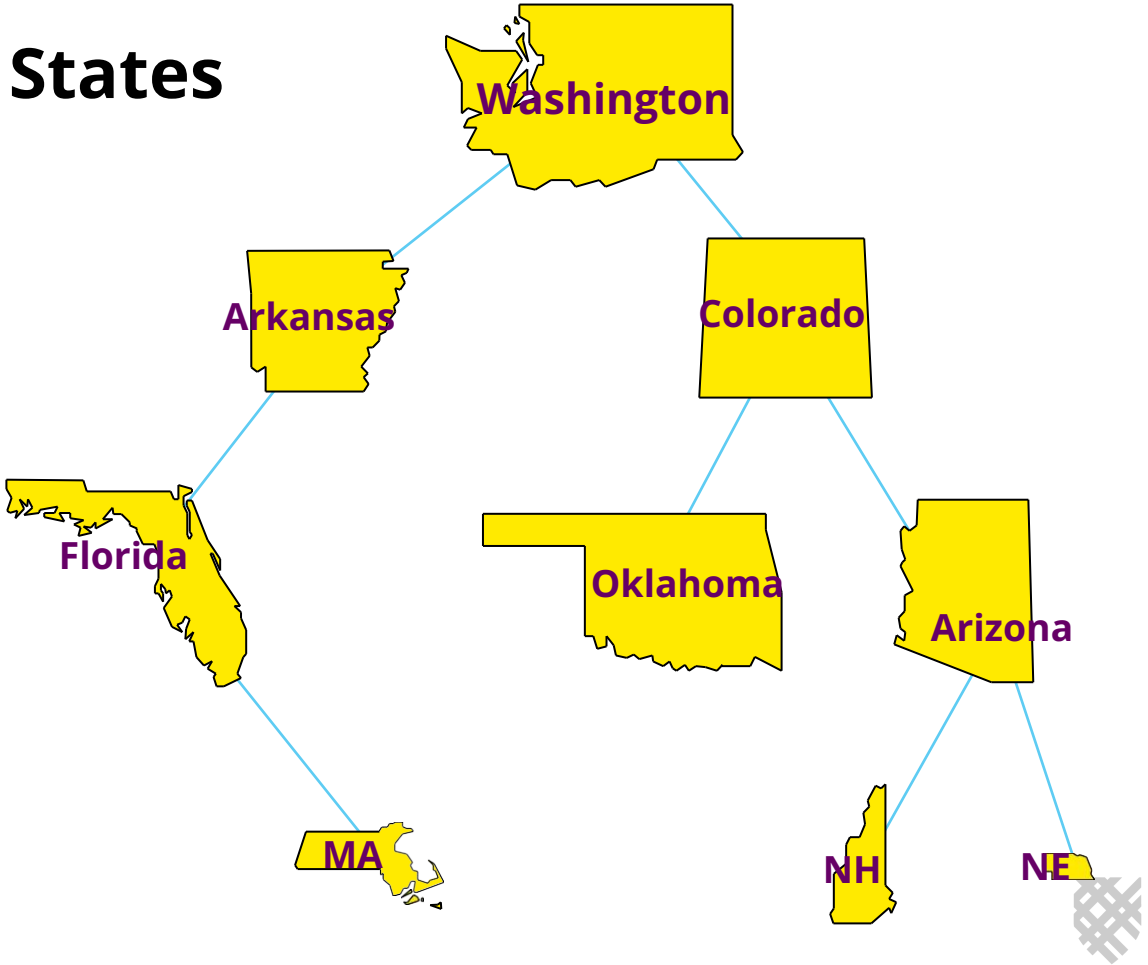
A node with no children is called a **leaf**.



A Binary Tree of States

Each node is called **the parent** of its children.

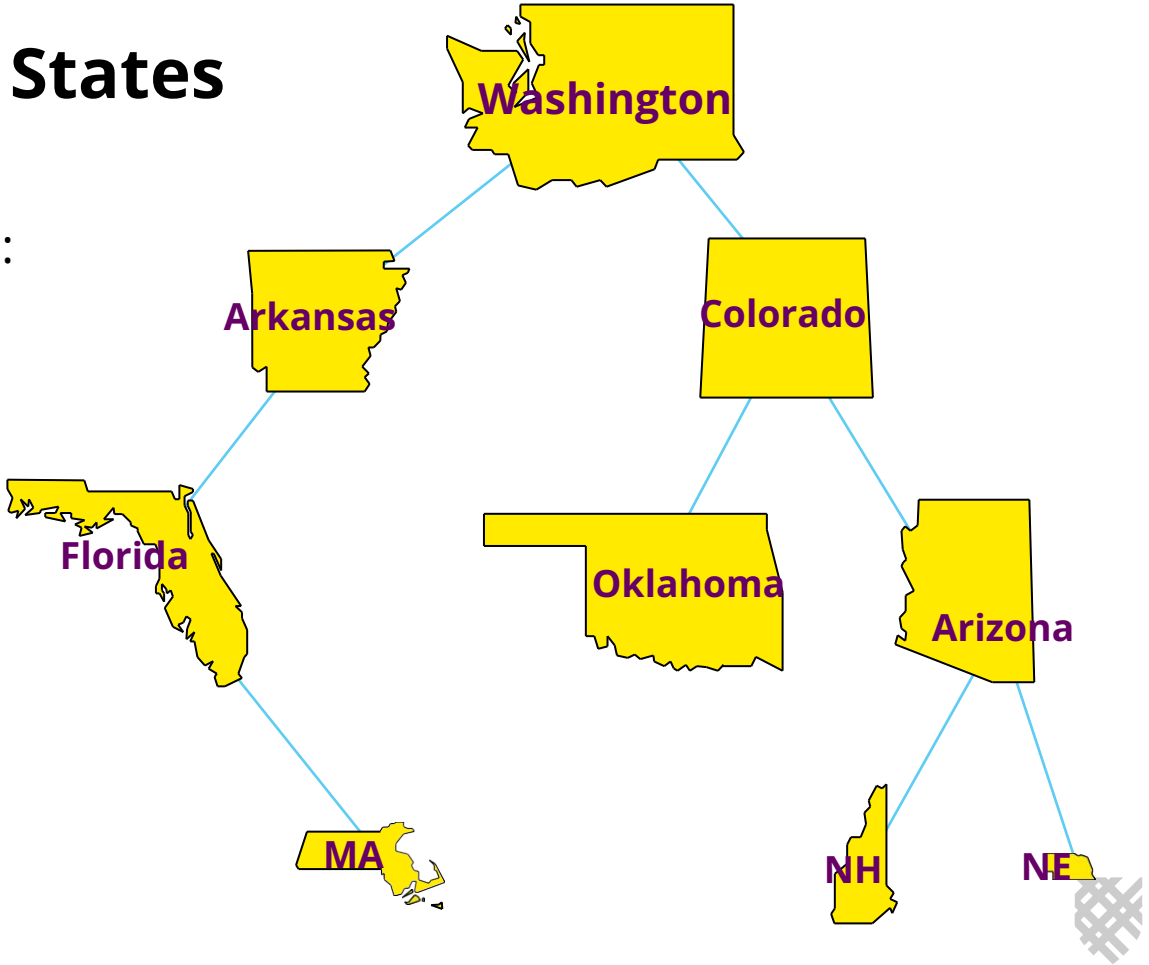
Washington is the parent of Arkansas and Colorado.



A Binary Tree of States

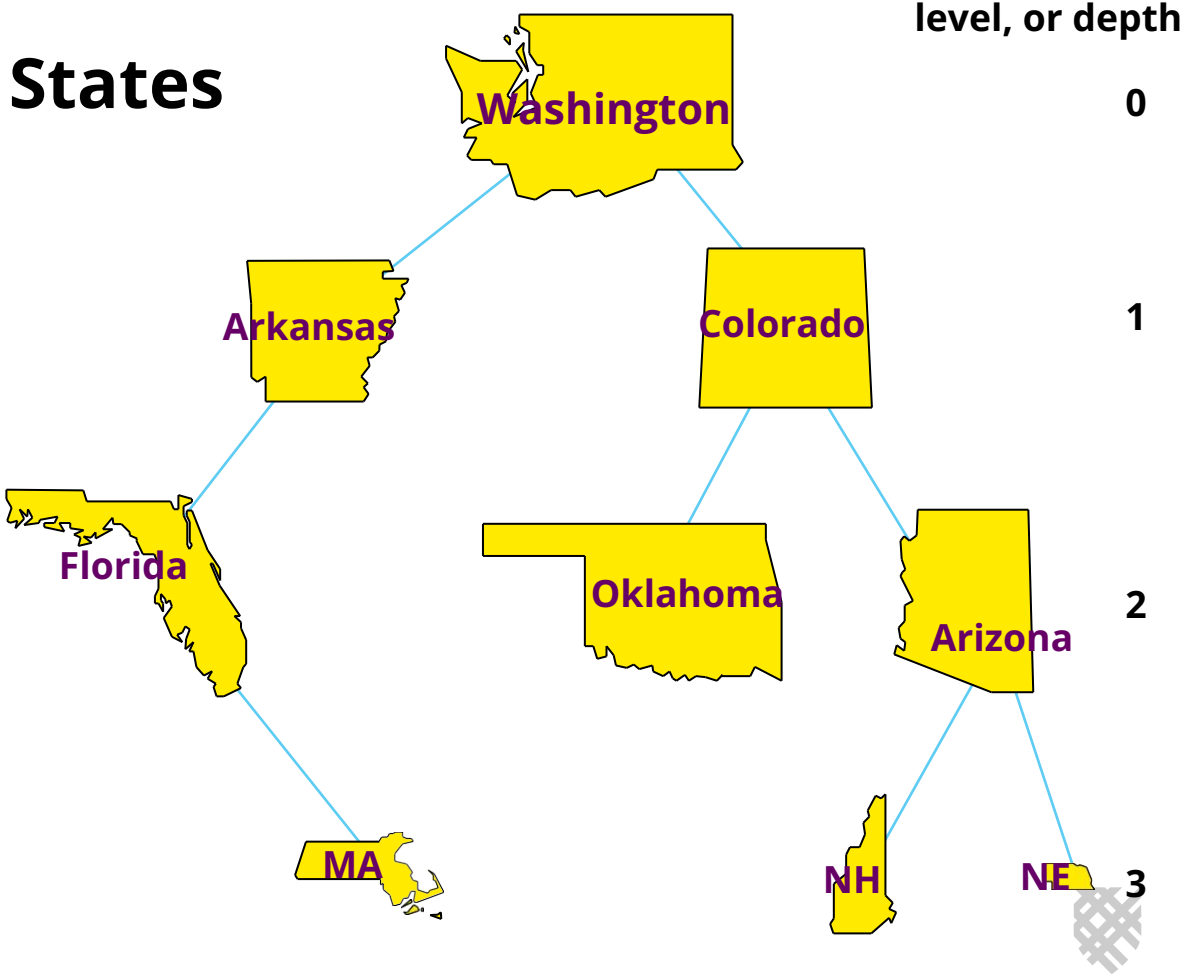
Two rules about parents:

- The root has no parent.
- Every other node has exactly one parent.



A Binary Tree of States

A node has a depth, or level.



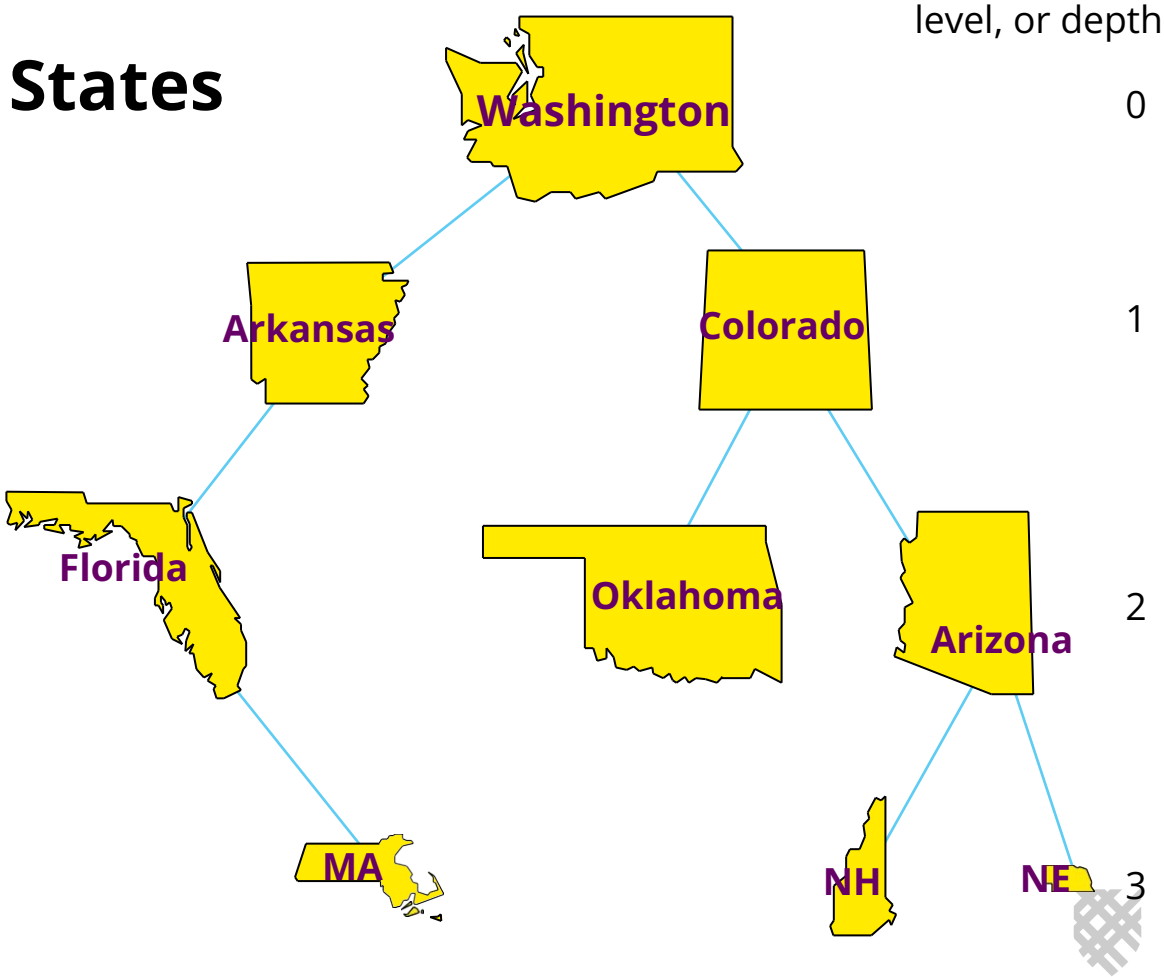
The depth of Florida is 2;

The depth of Washington is zero

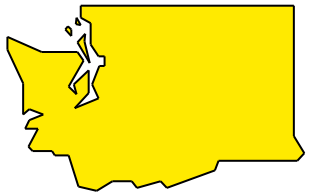
A Binary Tree of States

A tree has an overall maximum height, defined as longest path length.

What is the height of this tree?



Complete Binary Trees

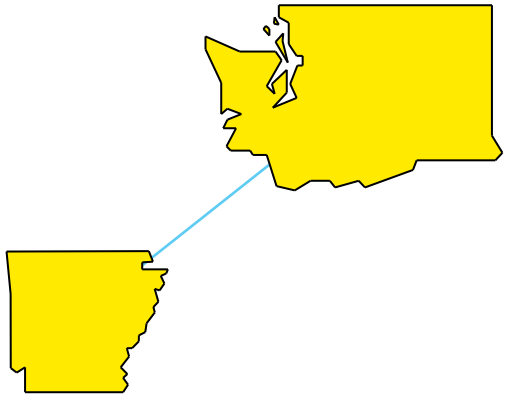


A complete binary tree is a special kind of binary tree which will be useful to us.

When a complete binary tree is built, its first node must be the root.

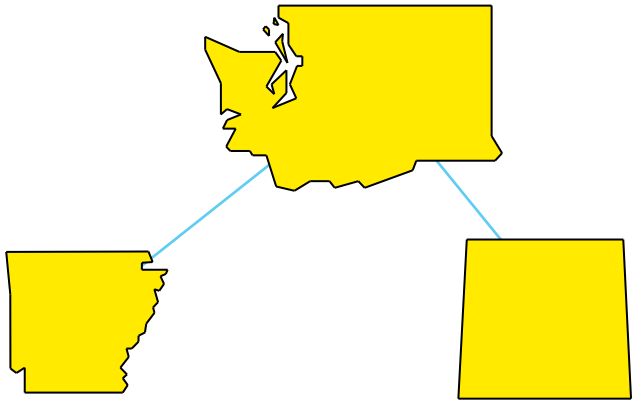
Complete Binary Trees

The second node of a complete binary tree is always the left child of the root...



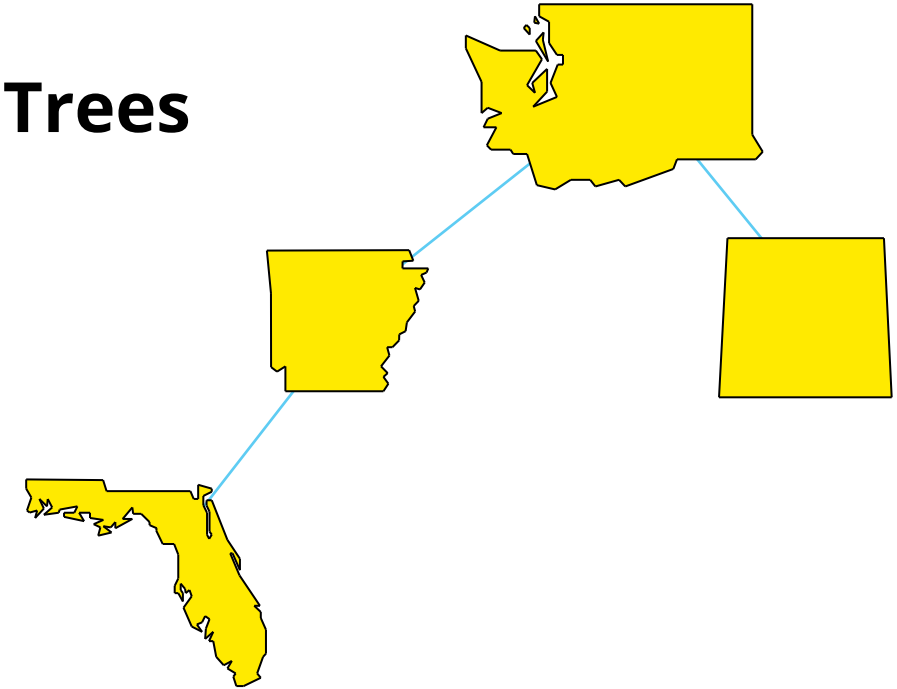
Complete Binary Trees

The second node of a complete binary tree is always the left child of the root...
... and the third node is always the right child of the root.



Complete Binary Trees

The next nodes must always fill the next level from left to right.



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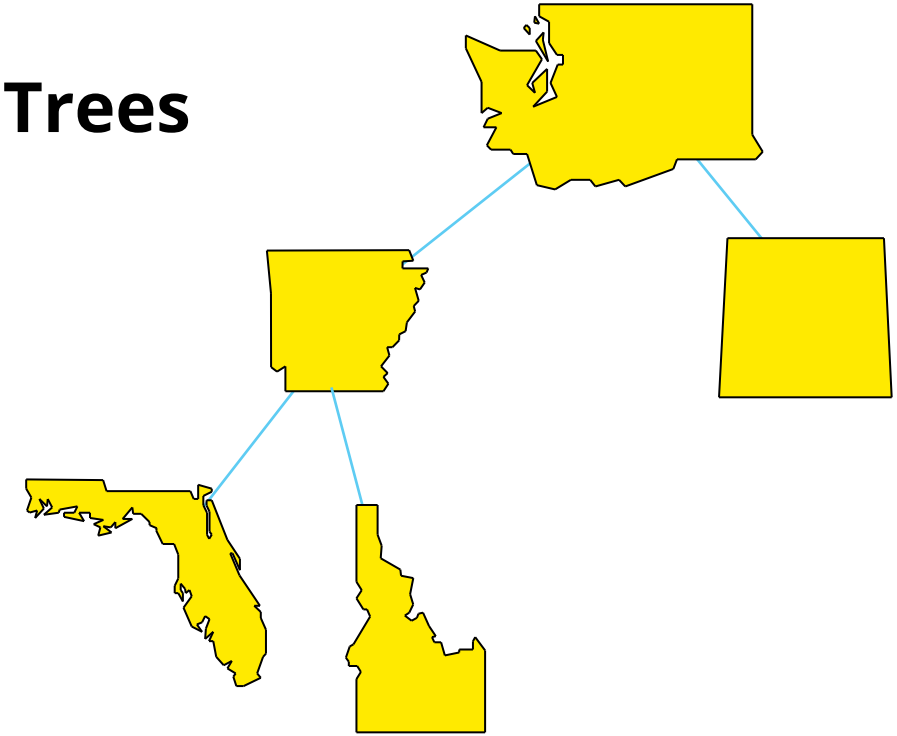

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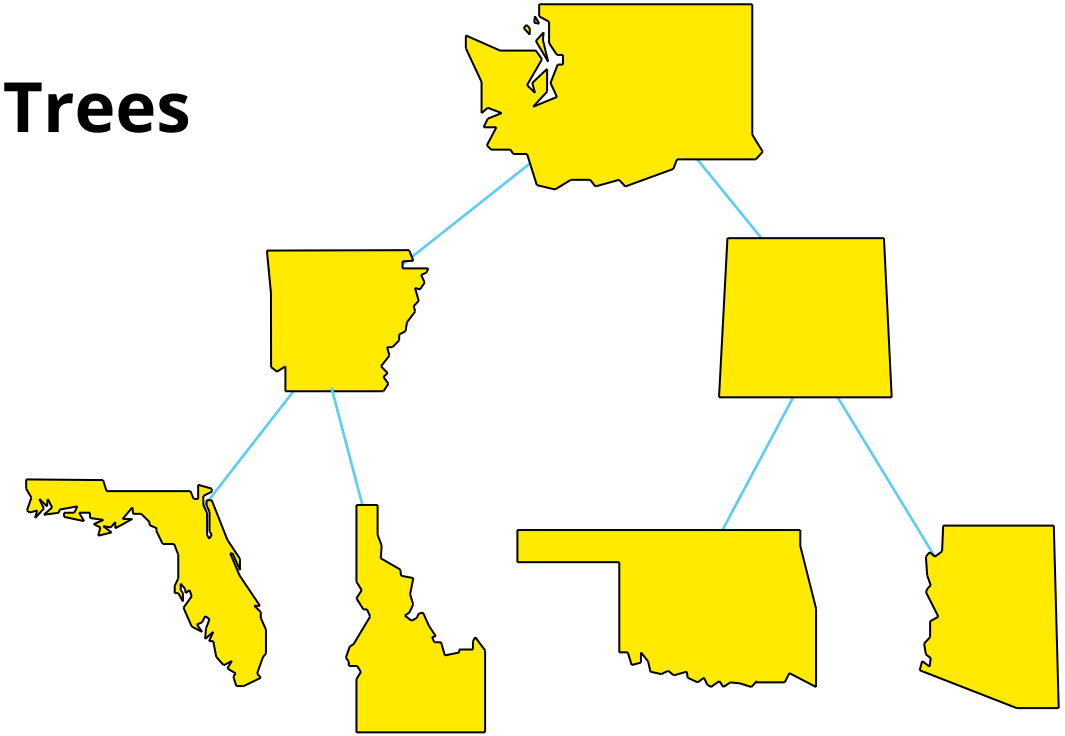

Complete Binary Trees

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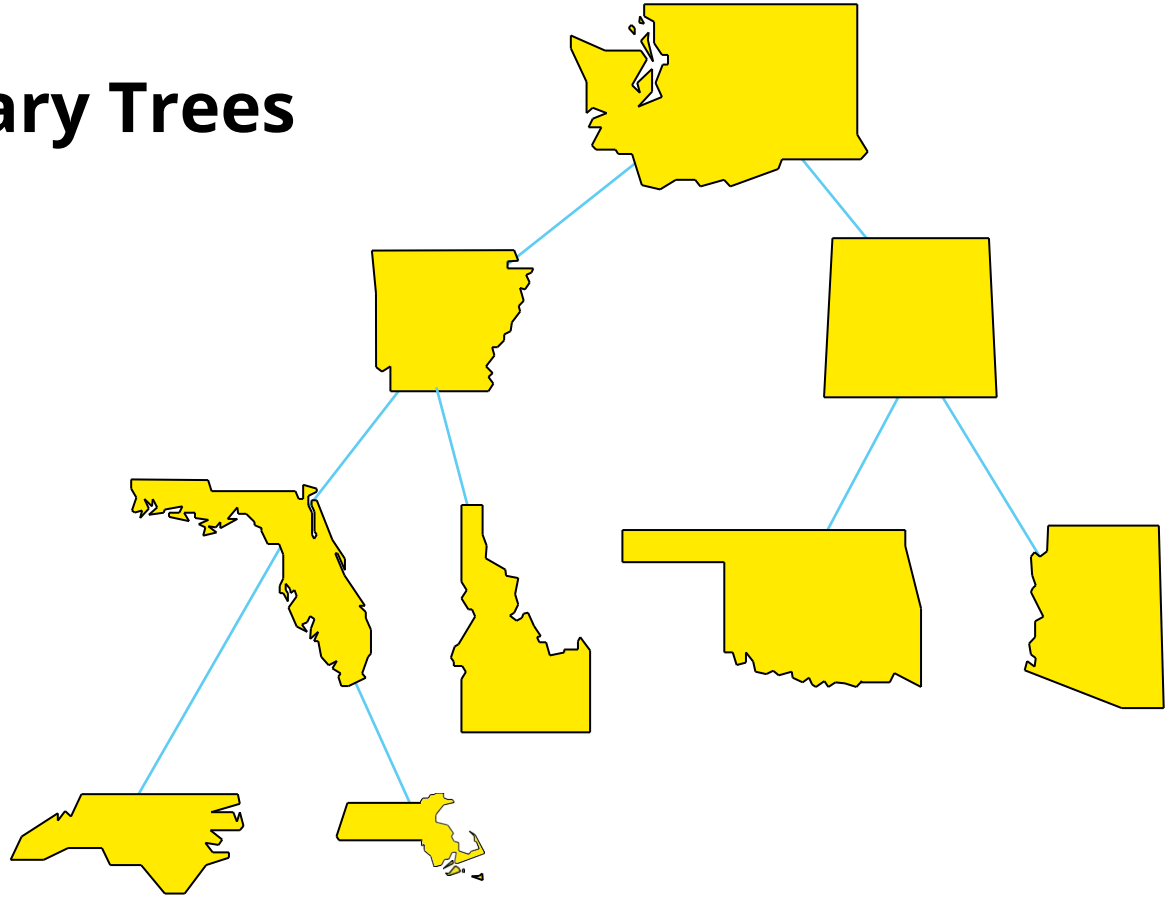
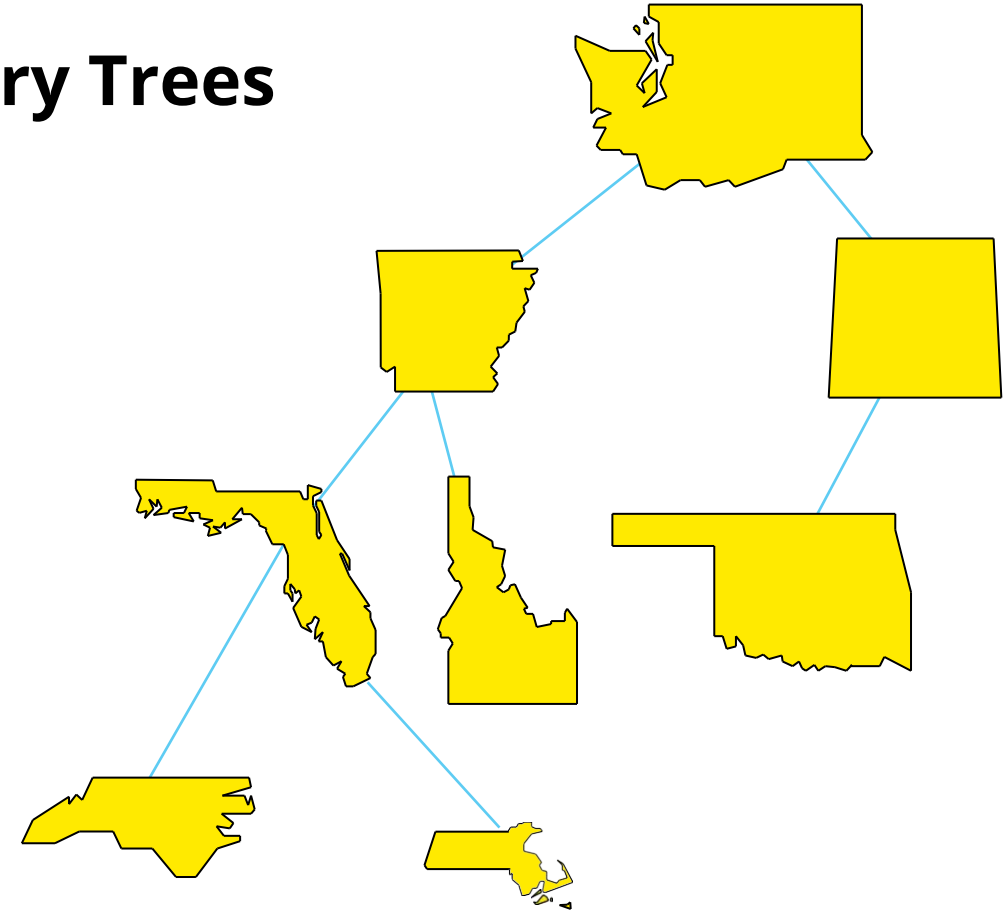


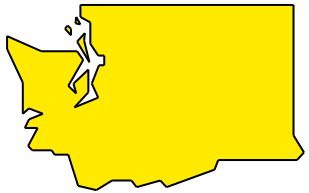
Complete Binary Trees

Is this complete?



Complete Binary Trees

Is this complete?

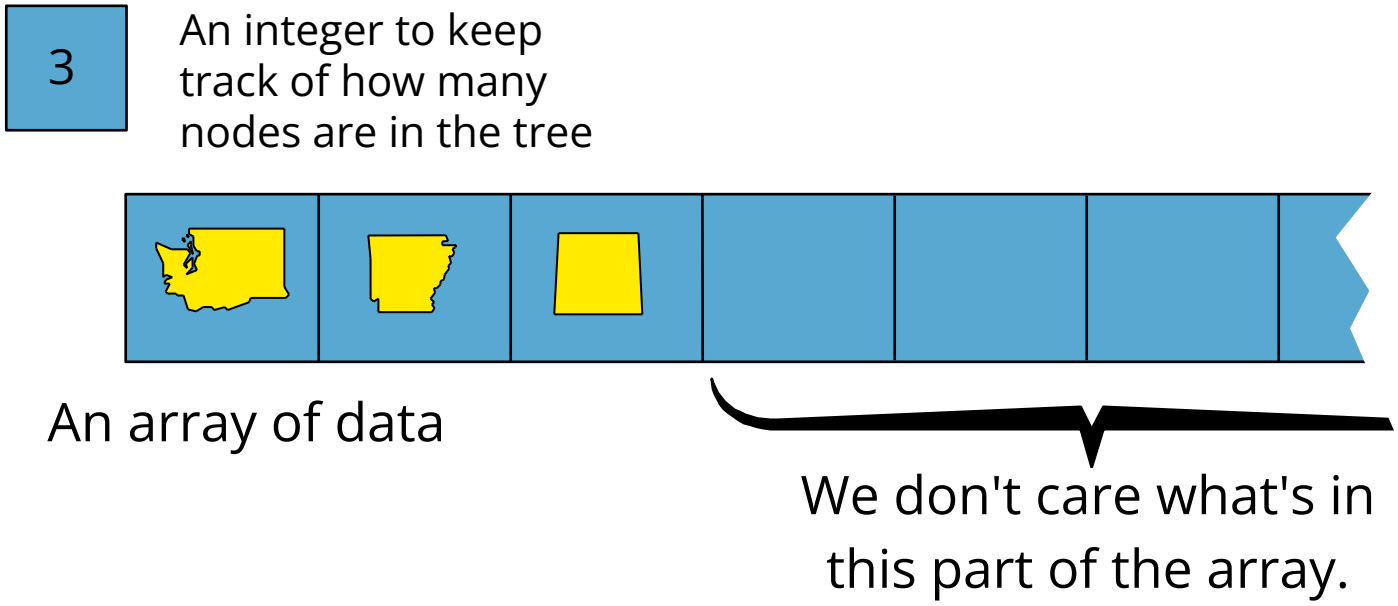


Complete Binary Trees

Is this complete?

Implementing a complete binary tree using an array

We will store the data from the nodes in a partially-filled array.



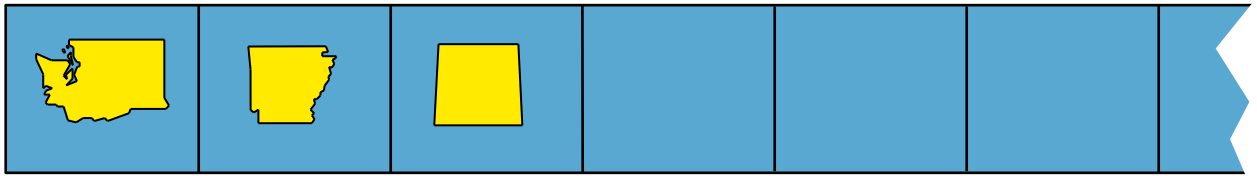
Implementing a complete binary tree using an array

We will store the data from the nodes in a partially-filled array.

3

An integer to keep track of how many nodes are in the tree

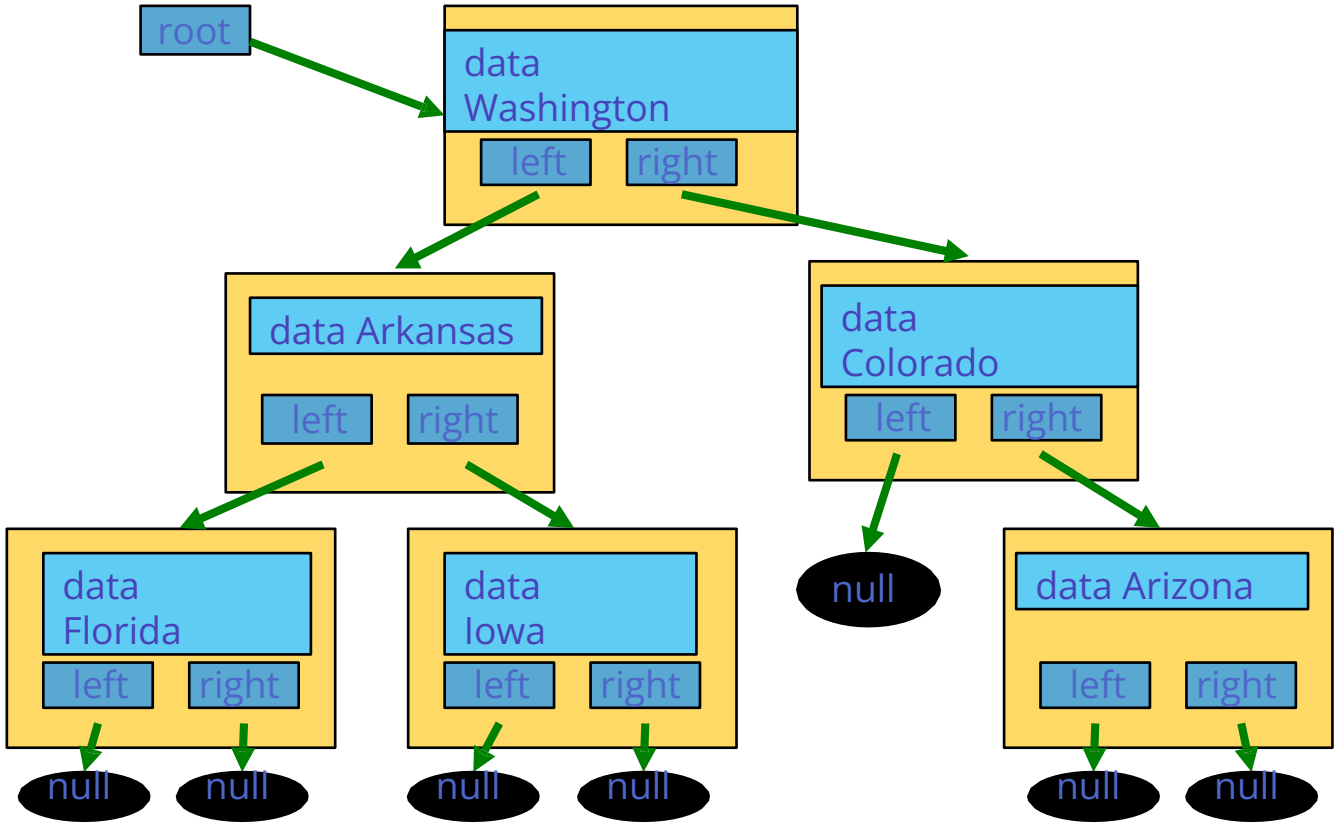
A single array is most useful for COMPLETE binary trees.
Why?



An array of data

We don't care what's in this part of the array.

Representing a binary tree with a class for Nodes



Summary

- Binary trees contain nodes.
- Each node may have a left child and a right child.
- If you start from any node and move upward, you will eventually reach the root.
- Every node except the root has one parent. The root has no parent.
- Complete binary trees require the nodes to fill in each level from left-to-right before starting the next level.

In-class Activity

Binary Tree Worksheet