CSCI 200: Foundational Programming Concepts & Design Lecture 41

Trees & Graphs

Previously in CSCI 200

- BFS and DFS -- $\mathrm{O}(n^2)$
  - Same pseudocode except for Queue or Stack implementation
    - Explore neighbors recursively via iterative implementation
  - Reach same conclusion, potentially at varying speeds
  - “Graph” algorithms to discover paths between connected nodes

On Tap For Today

- Trees
- Graphs
- Practice

On Tap For Today

- Trees
- Graphs
- Practice

Data Structure Operations

Operation		Array	Doubly-Linked List
Element Access		O(1)	O(n)
Traversal	Forwards	O(n)	O(n)
	Backwards		
Add	Front	O(n)	O(1)
	Middle		O(n)
	Back		O(1)
Delete	Front	O(n)	O(1)
	Middle		O(n)
	Back		O(1)
Search		O(n)	O(n)
Min / Max		O(n)	O(n)
Memory		n*sizeof(T) contiguous	n*(sizeof(T)+16) fragmented

Algorithm Complexities

Algorithm	Worst Case	Best Case	Average Case
Selection Sort	O(n^2)	O(n^2)	O(n^2)
Insertion Sort	O(n^2)	O(n)	O(n^2)
Bubble Sort	O(n^2)	O(n)	O(n^2)
Merge Sort	O($n \log n$)	O($n \log n$)	O($n \log n$)

Algorithm	Worst Case	Best Case	Average Case
Linear Search	O(n)	O(1)	O(n)
Binary Search	O($\log n$)	O(1)	O($\log n$)

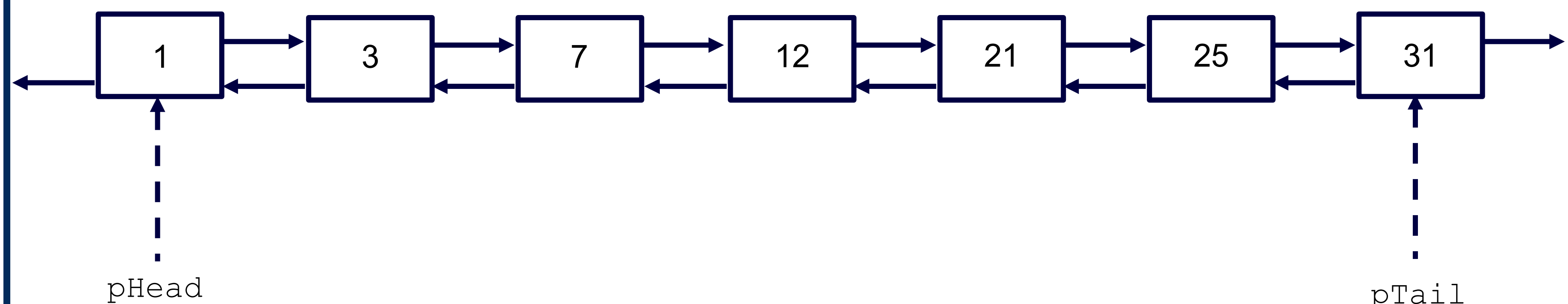
Data Structure Operations

Operation		Array	Doubly-Linked List
Element Access		O(1)	O(*n*)
Traversal	Forwards	O(*n*)	O(*n*)
	Backwards		
Add	Front	O(*n*)	O(1)
	Middle		O(*n*)
	Back		O(1)
Delete	Front	O(*n*)	O(1)
	Middle		O(*n*)
	Back		O(1)
Sort		O(*n log n*)	O(*n log n*)
Search	Linear	O(*n*)	O(*n*)
	Binary		
Min / Max	Unsorted	O(*n*)	O(*n*)
	Sorted	O(1)	O(1)
Memory		n*sizeof(T) contiguous	n*(sizeof(T)+16) fragmented

Data Structure Operations

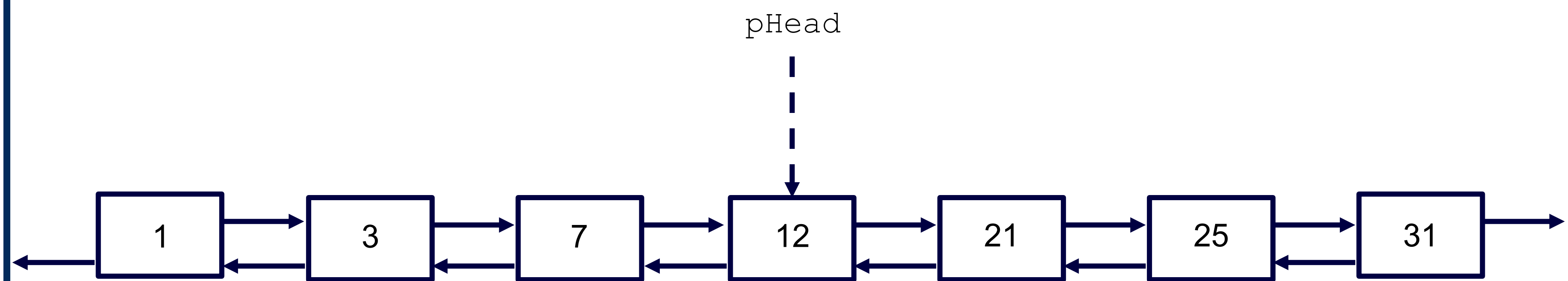
Operation		Array	Doubly-Linked List
Element Access		O(1)	O(*n*)
Traversal	Forwards	O(*n*)	O(*n*)
	Backwards		
Add	Front	O(*n*)	O(1)
	Middle		O(*n*)
	Back		O(1)
Delete	Front	O(*n*)	O(1)
	Middle		O(*n*)
	Back		O(1)
Sort		O(*n log n*)	O(*n log n*)
Search	Linear	O(*n*)	O(*n*)
	Binary	O(*log n*)	O(*n log n*)
Min / Max	Unsorted	O(*n*)	O(*n*)
	Sorted	O(1)	O(1)
Memory		n*sizeof(T) contiguous	n*(sizeof(T)+16) fragmented

Doubly Linked List



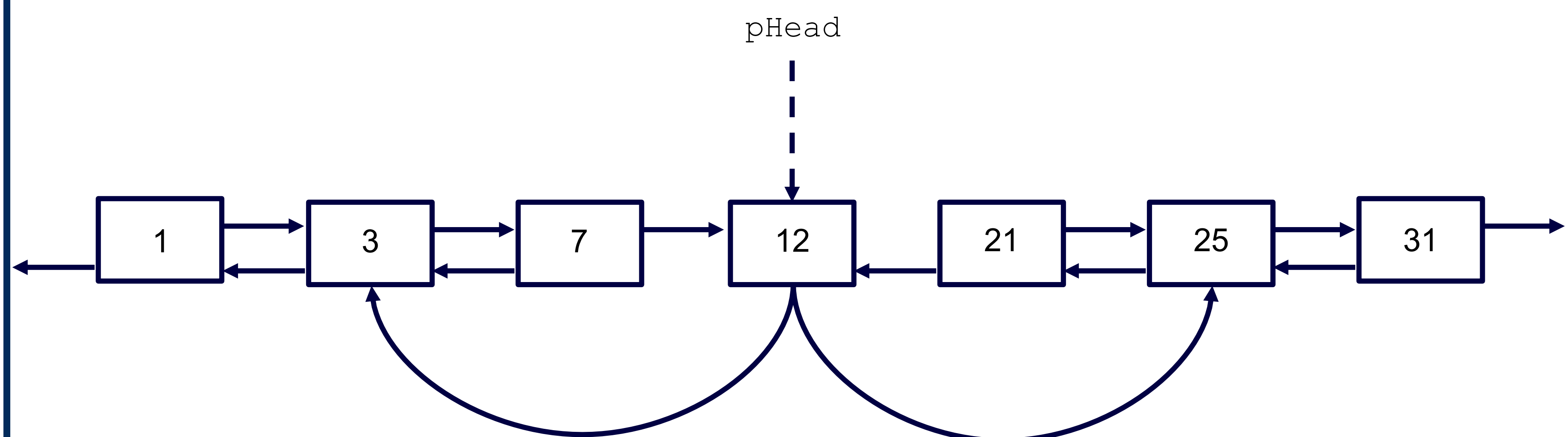
Doubly Linked List

- Point to midpoint



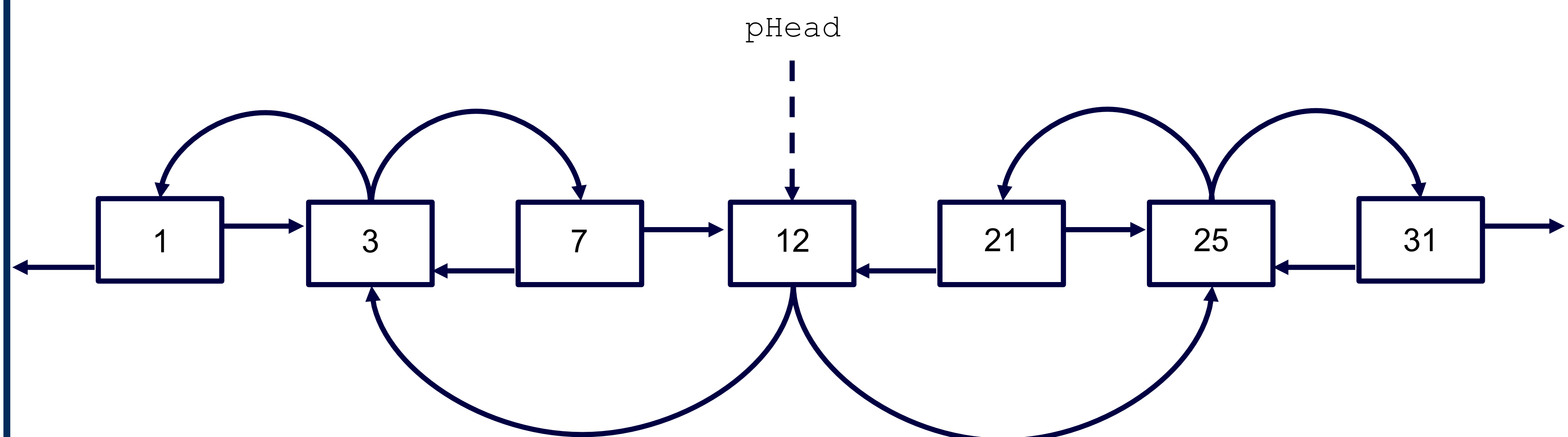
Doubly Linked List

- Point to midpoint
  - Have that point to midpoints



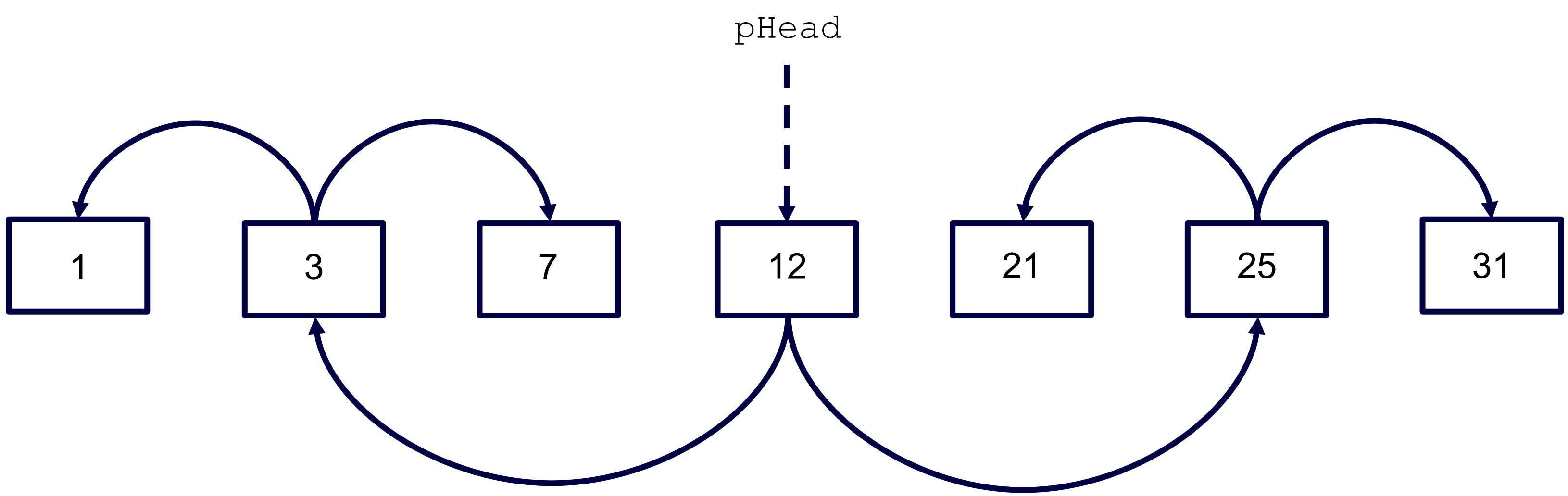
Doubly Linked List

- Point to midpoint
  - Have that point to midpoints
    - And so on

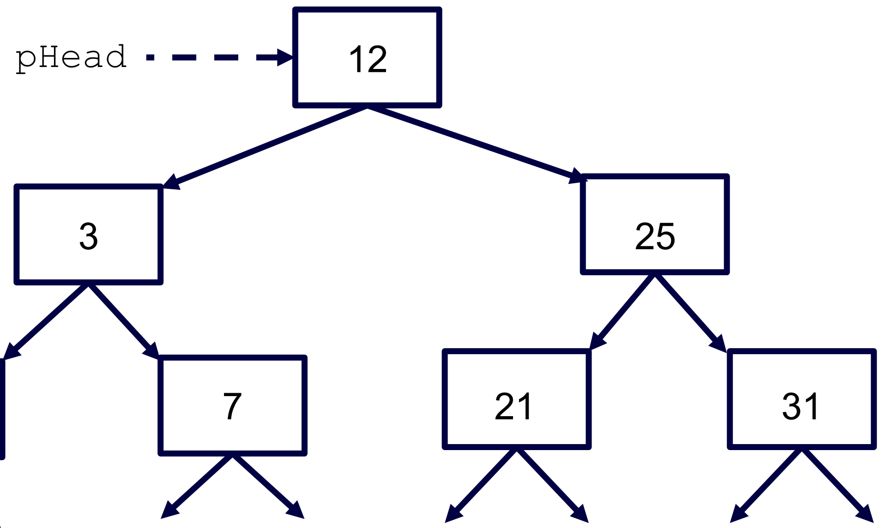


Doubly Linked List

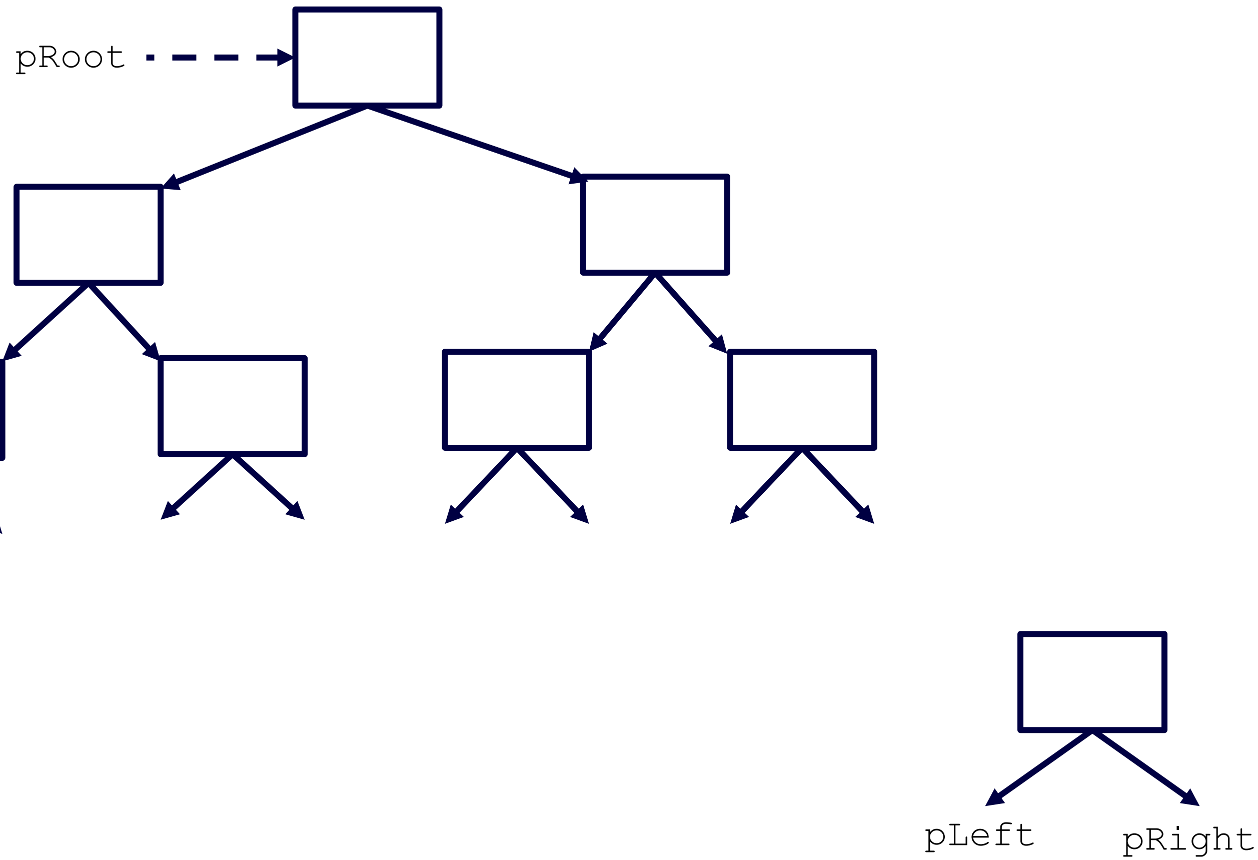
- Cost of “Binary Search”?



Doubly Linked List

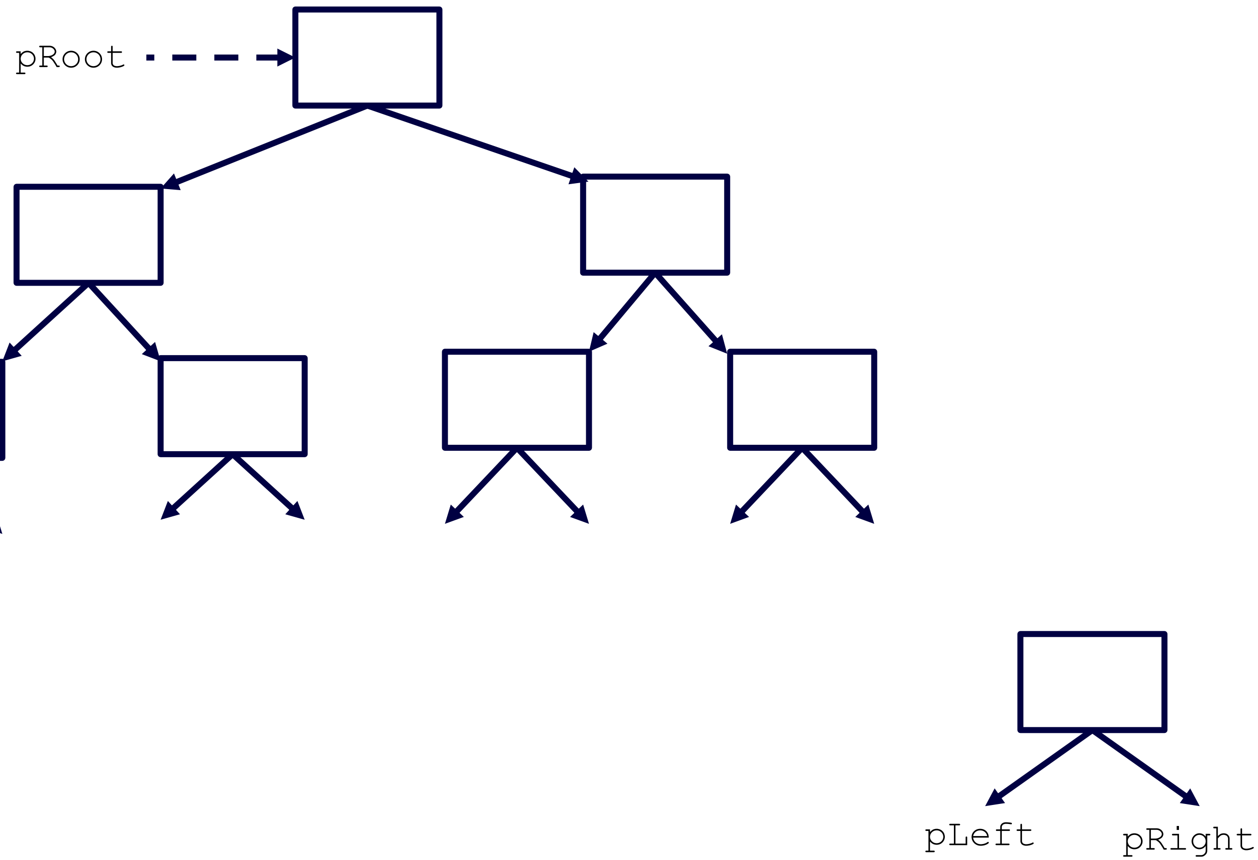


Binary Tree

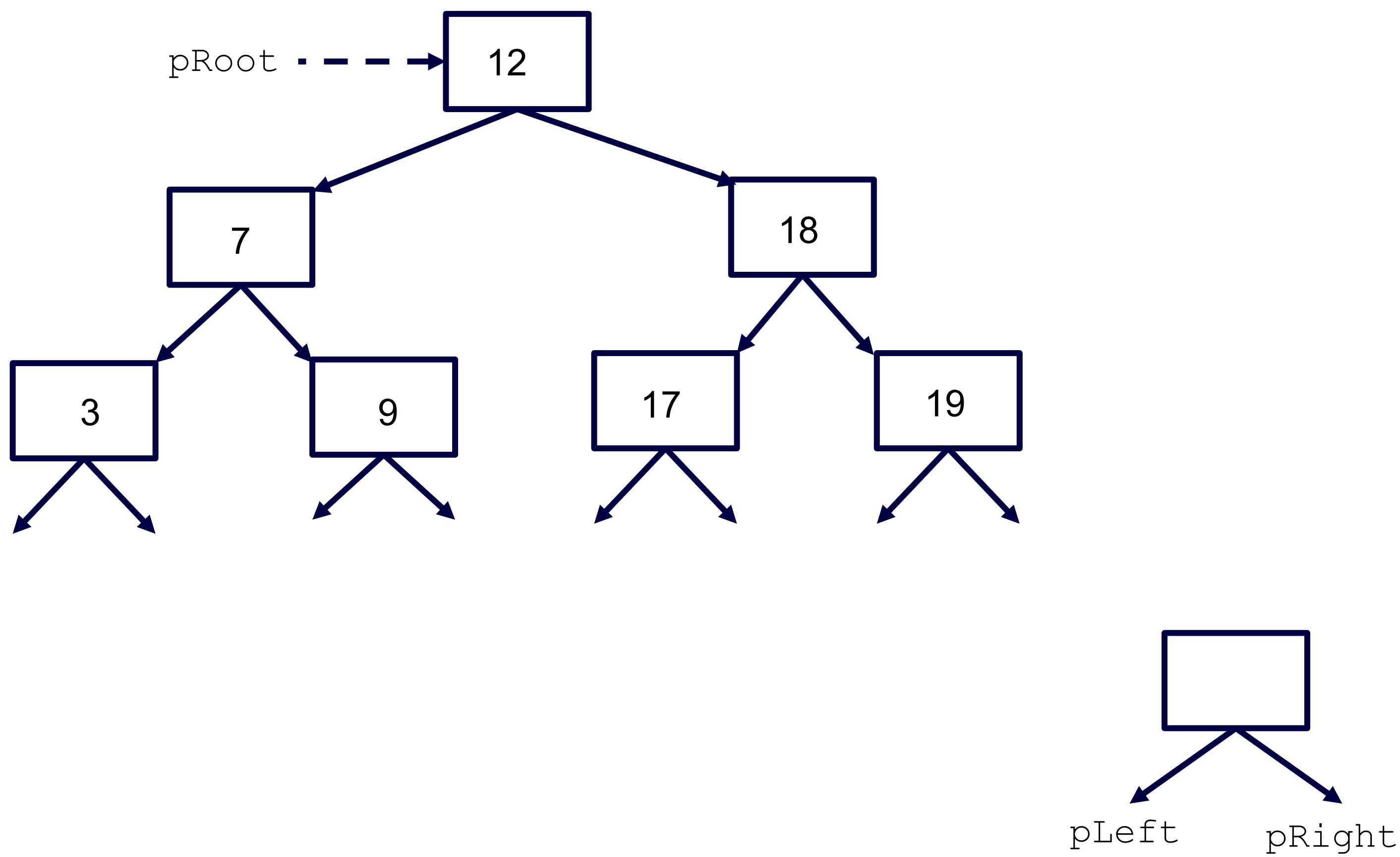


Binary Tree

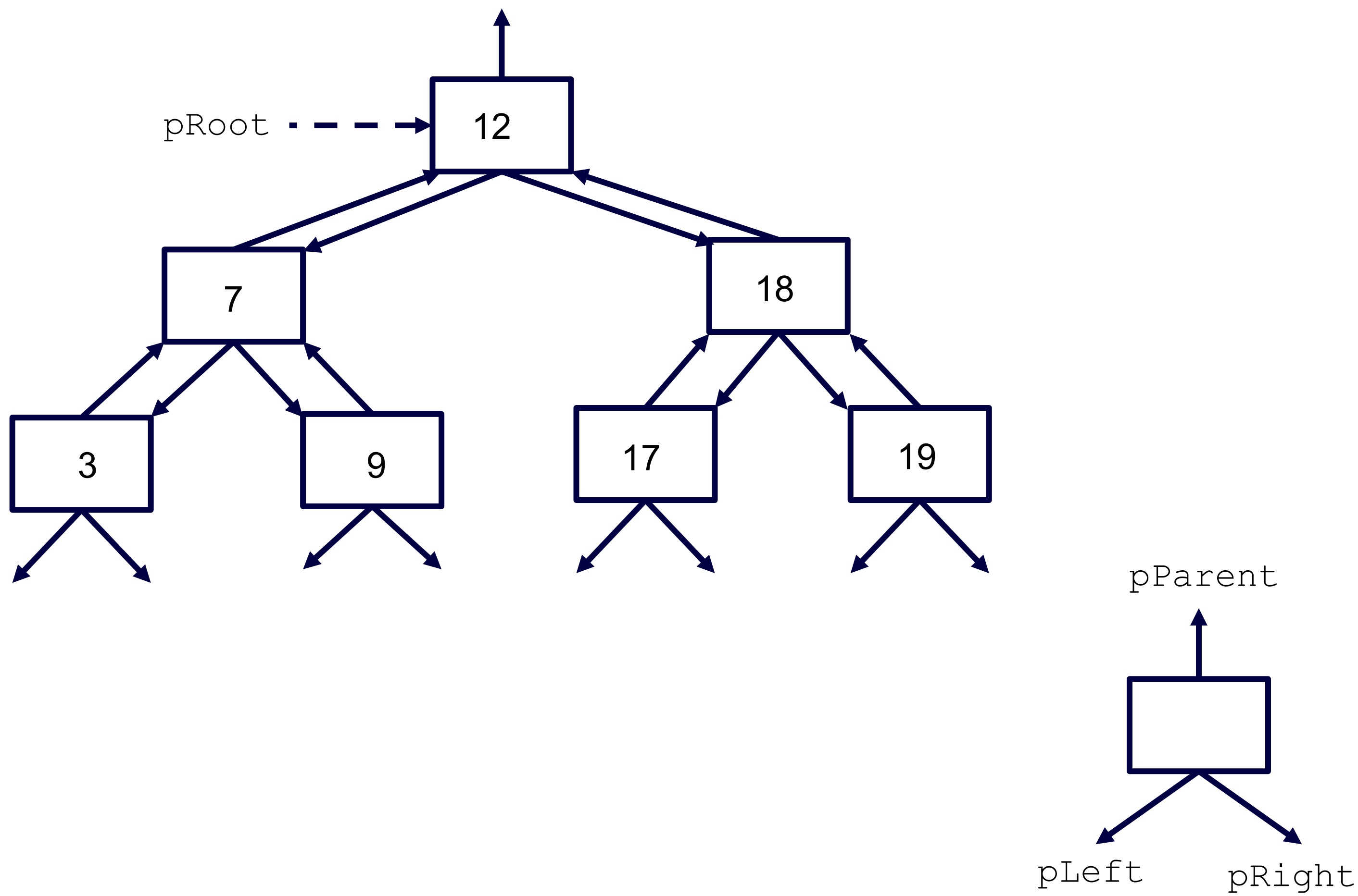
- When adding – apply insertion sort



Binary Search Tree

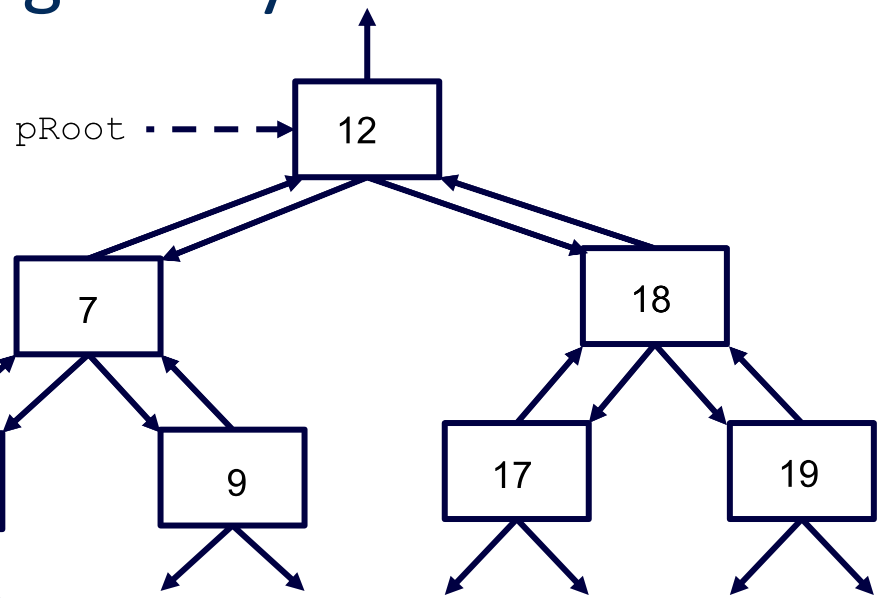


Binary Search Tree

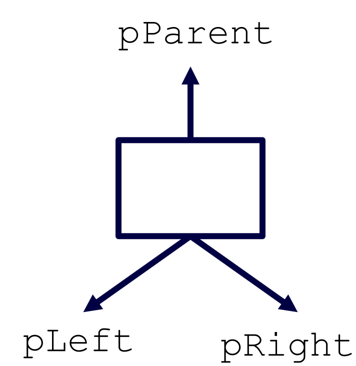


Binary Search Tree

- When adding – may need to rebalance



- <u>**Note: For AXC - not doing a self-balancing tree**</u>



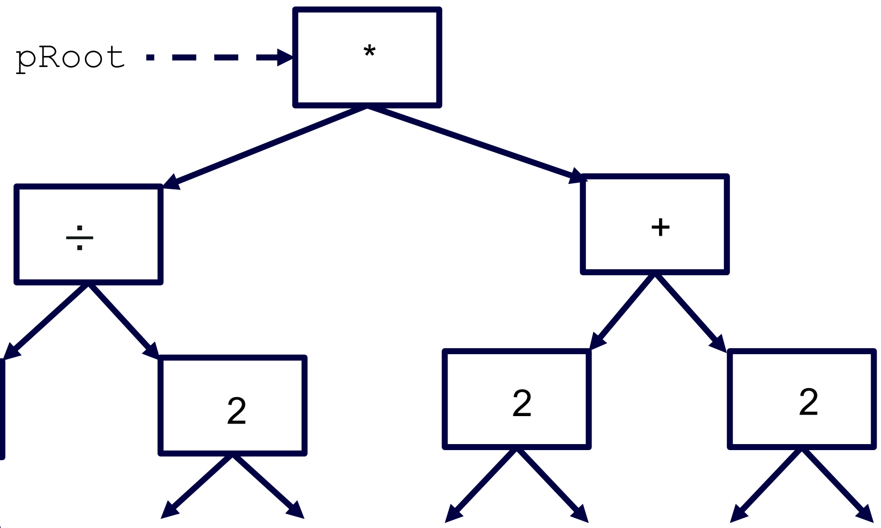
Tree Traversal

-

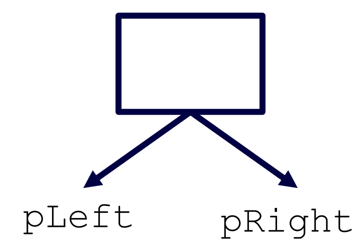
- Solve: $8 \div 2(2+2)$
  - BODMAS / PEMDAS

Tree Traversal

- Infix
- Prefix
- Postfix



- Solve: 8÷2(2+2)
  - BODMAS / PEMDAS



Data Structure Operations

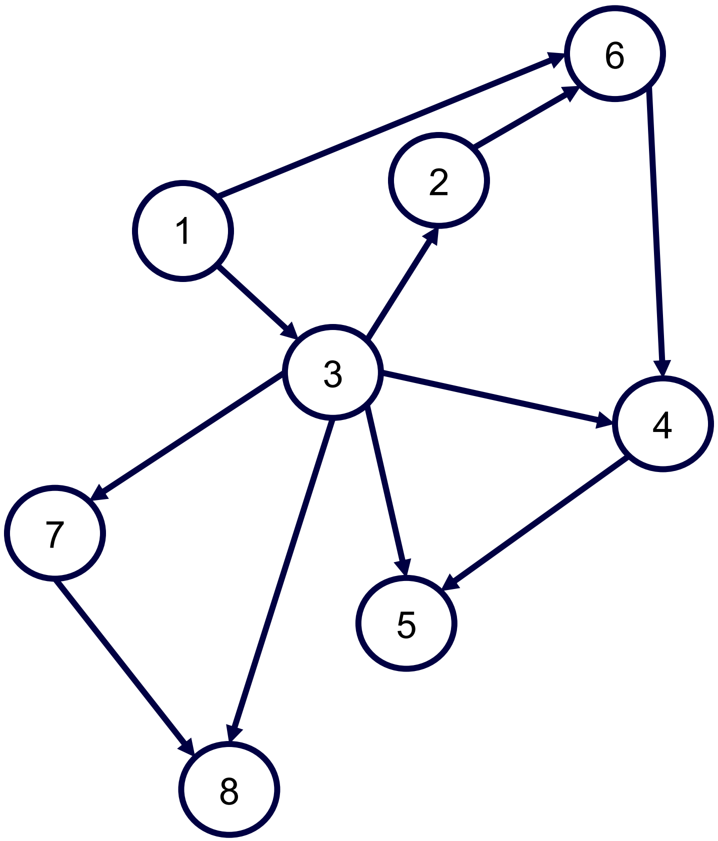
Operation		Array	Doubly-Linked List	Balanced BST
Element Access		O(1)	O(*n*)	O(*log n*)
Traversal	Forwards	O(*n*)	O(*n*)	O(*n*)
	Backwards			
Add	Front	O(*n*)	O(1)	O(*log n*)
	Middle		O(*n*)	
	Back		O(1)	
Delete	Front	O(*n*)	O(1)	O(*log n*)
	Middle		O(*n*)	
	Back		O(1)	
Sort		O(*n log n*)	O(*n log n*)	*N/A*
Search	Linear	O(*n*)	O(*n*)	*N/A*
	Binary	O(*log n*)	O(*n log n*)	O(*log n*)
Min / Max	Unsorted	O(*n*)	O(*n*)	O(*log n*)
	Sorted	O(1)	O(1)	
Memory		n*sizeof(T) contiguous	n*(sizeof(T)+16) fragmented	n*(sizeof(T)+16) fragmented

On Tap For Today

- Trees
- Graphs
- Practice

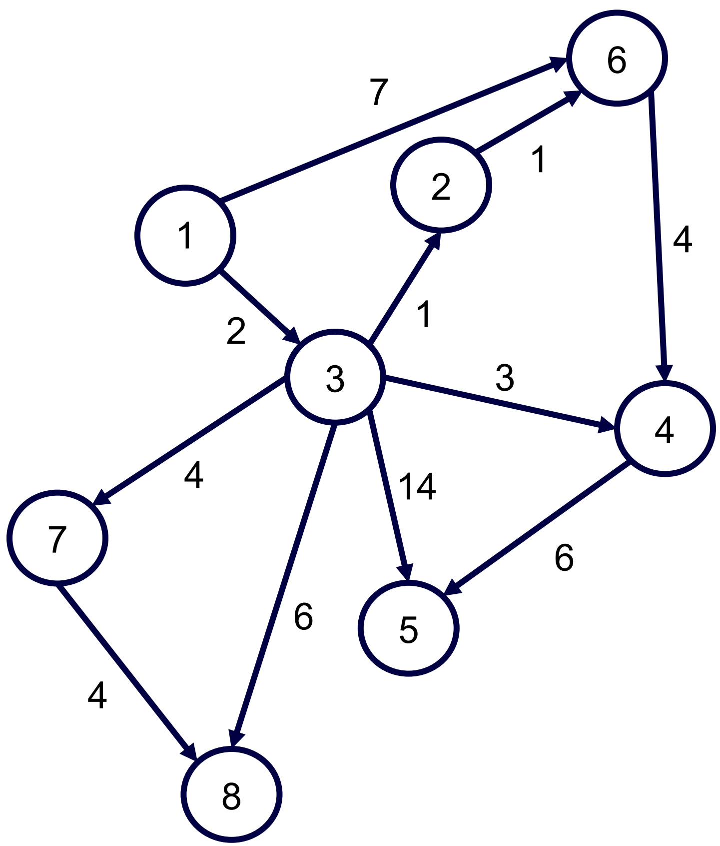
Nodes with *n* Pointers

- Directed Acyclic Graph (DAG)



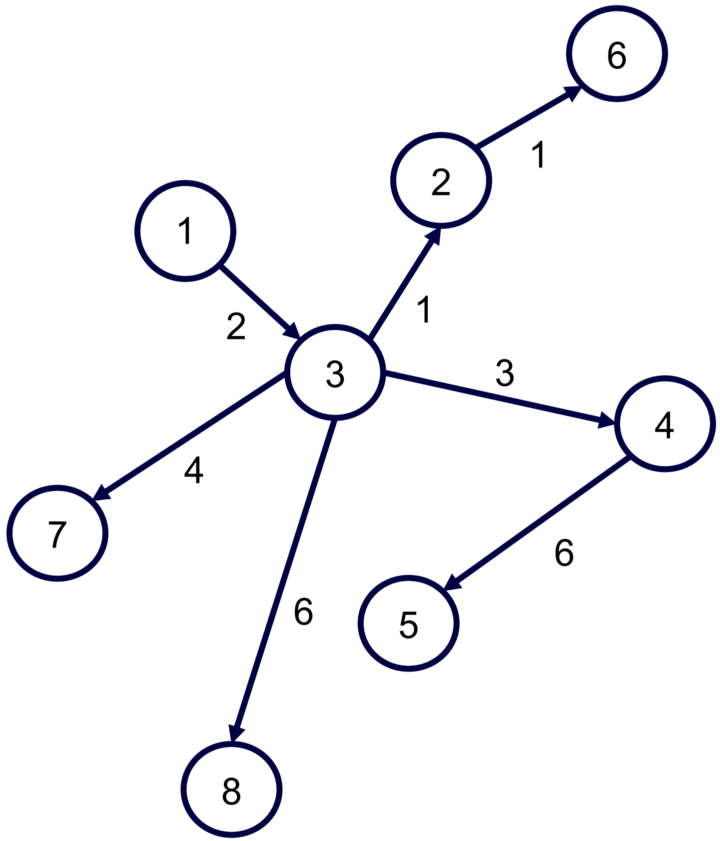
Nodes with *n* Pointers

- Weighted Directed Acyclic Graph



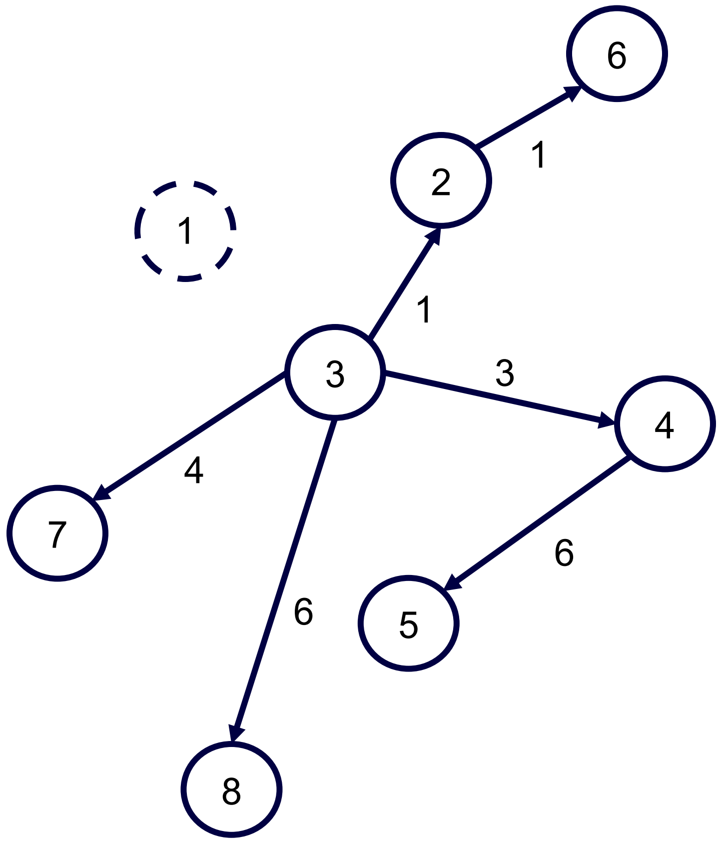
Nodes with *n* Pointers

- Shortest Path Tree from 1 to ? (Djikstra's)



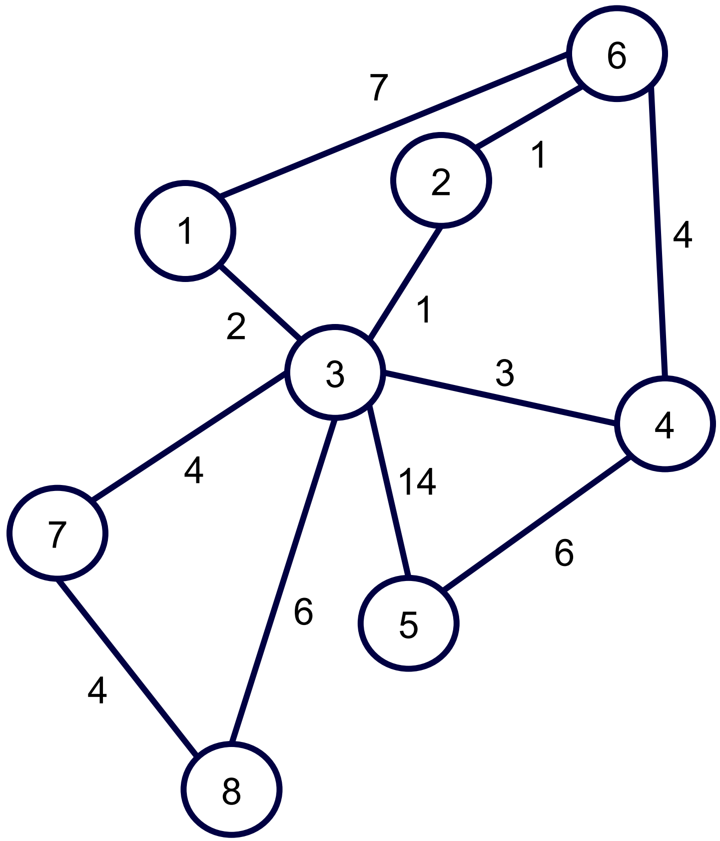
Nodes with *n* Pointers

- Shortest Path Tree from 3 to ? (Djikstra's)



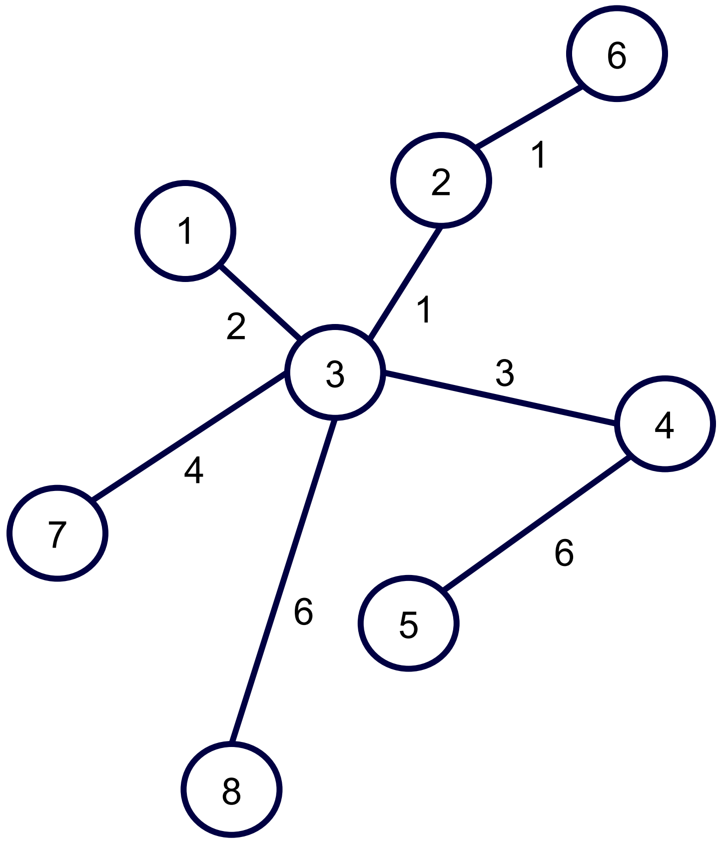
Nodes with *n* Pointers

- Weighted Undirected Graph



Nodes with *n* Pointers

- Minimum Spanning Tree



On Tap For Today

- Trees
- Graphs
- Practice

To Do For Next Time

- Rest of semester
  - W 12/06: Exam Review
  - R 12/07: Set6, SetXP, Final Project due
  - M 12/11: Final Exam

List Quiz

- Make Canvas Full Screen
- Access Code:
- 12 Minutes