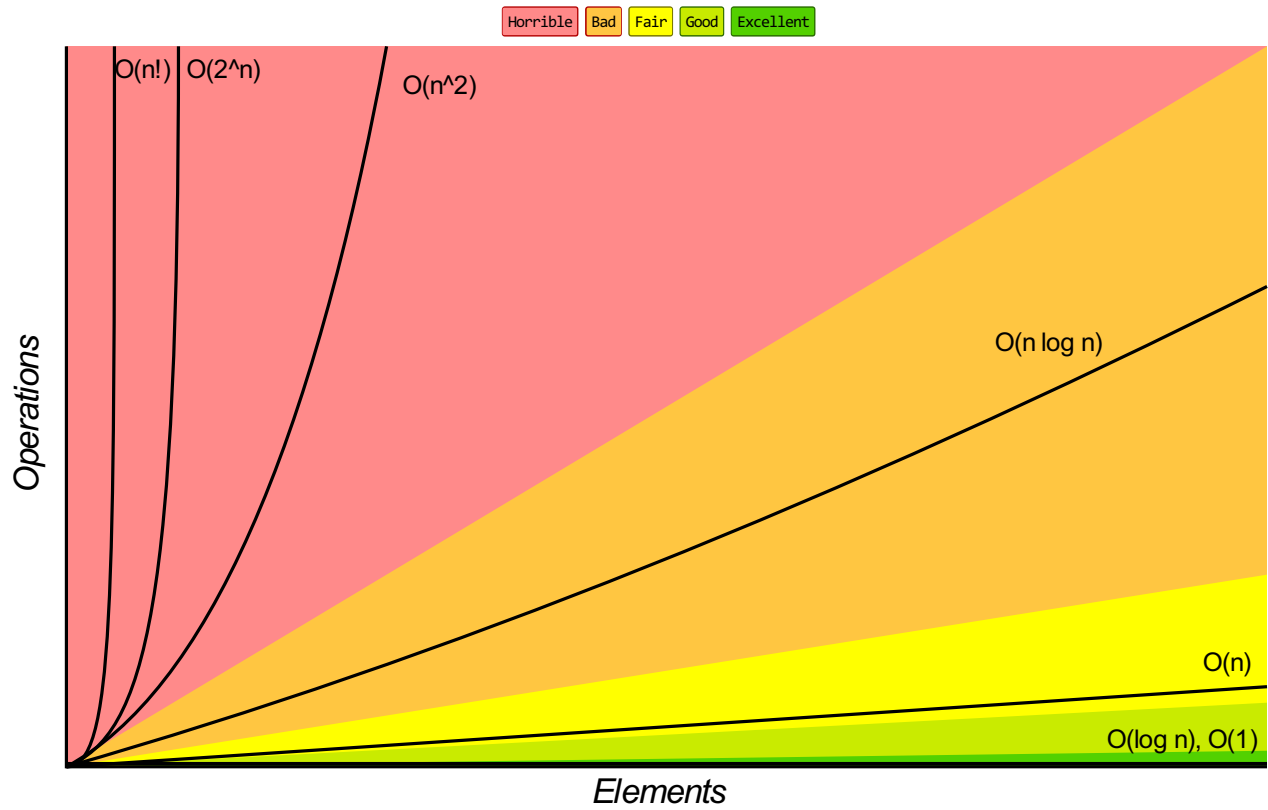


Know Thy Complexities!

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Big-O Complexity Chart



Common Data Structure Operations

Data Structure	Time Complexity								Space Complexity
	Average				Worst				Worst
	Access	Search	Insertion	Deletion	Access	Search	Insertion	Deletion	
Array	$\Theta(1)$	$\Theta(n)$	$\Theta(n)$	$\Theta(n)$	$\Theta(1)$	$\Theta(n)$	$\Theta(n)$	$\Theta(n)$	$\Theta(n)$
Stack	$\Theta(n)$	$\Theta(n)$	$\Theta(1)$	$\Theta(1)$	$\Theta(n)$	$\Theta(n)$	$\Theta(1)$	$\Theta(1)$	$\Theta(n)$
Queue	$\Theta(n)$	$\Theta(n)$	$\Theta(1)$	$\Theta(1)$	$\Theta(n)$	$\Theta(n)$	$\Theta(1)$	$\Theta(1)$	$\Theta(n)$
Singly-Linked List	$\Theta(n)$	$\Theta(n)$	$\Theta(1)$	$\Theta(1)$	$\Theta(n)$	$\Theta(n)$	$\Theta(1)$	$\Theta(1)$	$\Theta(n)$
Doubly-Linked List	$\Theta(n)$	$\Theta(n)$	$\Theta(1)$	$\Theta(1)$	$\Theta(n)$	$\Theta(n)$	$\Theta(1)$	$\Theta(1)$	$\Theta(n)$
Skip List	$\Theta(\log(n))$	$\Theta(\log(n))$	$\Theta(\log(n))$	$\Theta(\log(n))$	$\Theta(n)$	$\Theta(n)$	$\Theta(n)$	$\Theta(n)$	$\Theta(n \log(n))$
Hash Table	N/A	$\Theta(1)$	$\Theta(1)$	$\Theta(1)$	N/A	$\Theta(n)$	$\Theta(n)$	$\Theta(n)$	$\Theta(n)$
Binary Search Tree	$\Theta(\log(n))$	$\Theta(\log(n))$	$\Theta(\log(n))$	$\Theta(\log(n))$	$\Theta(n)$	$\Theta(n)$	$\Theta(n)$	$\Theta(n)$	$\Theta(n)$
Cartesian Tree	N/A	$\Theta(\log(n))$	$\Theta(\log(n))$	$\Theta(\log(n))$	N/A	$\Theta(n)$	$\Theta(n)$	$\Theta(n)$	$\Theta(n)$
B-Tree	$\Theta(\log(n))$	$\Theta(\log(n))$	$\Theta(\log(n))$	$\Theta(\log(n))$	$\Theta(\log(n))$	$\Theta(\log(n))$	$\Theta(\log(n))$	$\Theta(\log(n))$	$\Theta(n)$
Red-Black Tree	$\Theta(\log(n))$	$\Theta(\log(n))$	$\Theta(\log(n))$	$\Theta(\log(n))$	$\Theta(\log(n))$	$\Theta(\log(n))$	$\Theta(\log(n))$	$\Theta(\log(n))$	$\Theta(n)$
Splay Tree	N/A	$\Theta(\log(n))$	$\Theta(\log(n))$	$\Theta(\log(n))$	N/A	$\Theta(\log(n))$	$\Theta(\log(n))$	$\Theta(\log(n))$	$\Theta(n)$
AVL Tree	$\Theta(\log(n))$	$\Theta(\log(n))$	$\Theta(\log(n))$	$\Theta(\log(n))$	$\Theta(\log(n))$	$\Theta(\log(n))$	$\Theta(\log(n))$	$\Theta(\log(n))$	$\Theta(n)$
KD Tree	$\Theta(\log(n))$	$\Theta(\log(n))$	$\Theta(\log(n))$	$\Theta(\log(n))$	$\Theta(n)$	$\Theta(n)$	$\Theta(n)$	$\Theta(n)$	$\Theta(n)$

Array Sorting Algorithms

Algorithm	Time Complexity			Space Complexity
	Best	Average	Worst	Worst
Quicksort	$\Omega(n \log(n))$	$\Theta(n \log(n))$	$\Theta(n^2)$	$\Theta(\log(n))$
Mergesort	$\Omega(n \log(n))$	$\Theta(n \log(n))$	$\Theta(n \log(n))$	$\Theta(n)$
Timsort	$\Omega(n)$	$\Theta(n \log(n))$	$\Theta(n \log(n))$	$\Theta(n)$
Heapsort	$\Omega(n \log(n))$	$\Theta(n \log(n))$	$\Theta(n \log(n))$	$\Theta(1)$
Bubble Sort	$\Omega(n)$	$\Theta(n^2)$	$\Theta(n^2)$	$\Theta(1)$
Insertion Sort	$\Omega(n)$	$\Theta(n^2)$	$\Theta(n^2)$	$\Theta(1)$
Selection Sort	$\Omega(n^2)$	$\Theta(n^2)$	$\Theta(n^2)$	$\Theta(1)$
Tree Sort	$\Omega(n \log(n))$	$\Theta(n \log(n))$	$\Theta(n^2)$	$\Theta(n)$
Shell Sort	$\Omega(n \log(n))$	$\Theta(n(\log(n))^2)$	$\Theta(n(\log(n))^2)$	$\Theta(1)$
Bucket Sort	$\Omega(n+k)$	$\Theta(n+k)$	$\Theta(n^2)$	$\Theta(n)$
Radix Sort	$\Omega(nk)$	$\Theta(nk)$	$\Theta(nk)$	$\Theta(n+k)$
Counting Sort	$\Omega(n+k)$	$\Theta(n+k)$	$\Theta(n+k)$	$\Theta(k)$
Cubesort	$\Omega(n)$	$\Theta(n \log(n))$	$\Theta(n \log(n))$	$\Theta(n)$

Big O Reference

Big O Reference of common algorithms and data structures

Sorting

Algorithm	Time			Auxiliary Space
	Best	Average	Worst	Worst
Bubble sort	$O(n)$	$O(n^2)$	$O(n^2)$	$O(1)$
Insertion sort	$O(n)$	$O(n^2)$	$O(n^2)$	$O(1)$
Selection sort	$O(n^2)$	$O(n^2)$	$O(n^2)$	$O(1)$
Mergesort	$O(n \log(n))$	$O(n \log(n))$	$O(n \log(n))$	$O(n)$
Quicksort	$O(n \log(n))$	$O(n \log(n))$	$O(n^2)$	$O(\log(n))$
Heapsort	$O(n \log(n))$	$O(n \log(n))$	$O(n \log(n))$	$O(1)$
Shell Sort $(h=2^k-1)$	$O(n \log(n))$	$O(n^{1.25})$ conjectured	$O(n^{(3/2)})$	$O(1)$
Bucket sort	$O(n+k)$	$O(n+k)$	$O(n^2)$	$O(nk)$
Radix sort	$O(nk)$	$O(nk)$	$O(nk)$	$O(n+k)$

Searching

Algorithm	Data Structure	Time		Space
		Average	Worst	Worst
Depth First Search (DFS)	Graph of $ V $ vertices and $ E $ edges	-	$O(E + V)$	$O(V)$
Breadth First Search (BFS)	Graph of $ V $ vertices and $ E $ edges	-	$O(E + V)$	$O(V)$
Binary Search	Sorted array of n elements	$O(\log(n))$	$O(\log(n))$	$O(1)$
Linear (Brute force)	Array of n elements	$O(n)$	$O(n)$	$O(1)$
Shortest path by Dijkstra, Min-heap as priority queue	Graph of $ V $ vertices and $ E $ edges	$O((V + E) \log V)$	$O((V + E) \log V)$	$O(V)$
Shortest path by Dijkstra, unsorted array as priority queue	Graph of $ V $ vertices and $ E $ edges	$O(V ^2)$	$O(V ^2)$	$O(V)$
Shortest path by Bellman-Ford	Graph of $ V $ vertices and $ E $ edges	$O(V E)$	$O(V E)$	$O(V)$

Common Data Structures

[illegible]

Heaps

Heaps	Time						
	Heapify	Find Max	Extract Max	Increase Key	Insert	Delete	Merge
Linked List	-	$O(1)$	$O(1)$	$O(n)$	$O(n)$	$O(1)$	$O(m+n)$
Linked List (unsorted)	-	$O(n)$	$O(n)$	$O(1)$	$O(1)$	$O(1)$	$O(1)$
Binary Heap	$O(n)$	$O(1)$	$O(n \log(n))$	$O(n \log(n))$	$O(n \log(n))$	$O(n \log(n))$	$O(m+n)$
Binomial Heap	-	$O(n \log(n))$	$O(n \log(n))$	$O(n \log(n))$	$O(n \log(n))$	$O(n \log(n))$	$O(n \log(n))$
Fibonnaci Heap	-	$O(1)$	$O(\log(n))^*$	$O(1)^*$	$O(1)$	$O(\log(n))^*$	$O(1)$

Graphs

Node / Edge Management	Storage	Add Vertex	Add Edge	Remove Vertex	Remove Edge	Query
Adjacency List	$O(V + E)$	$O(1)$	$O(1)$	$O(V + E)$	$O(E)$	$O(V)$
Incidence List	$O(V + E)$	$O(1)$	$O(1)$	$O(E)$	$O(E)$	$O(E)$
Adjacency Matrix	$O(V ^2)$	$O(V ^2)$	$O(1)$	$O(V ^2)$	$O(1)$	$O(1)$
Incidence Matrix	$O(V \cdot E)$	$O(V \cdot E)$	$O(V \cdot E)$	$O(V \cdot E)$	$O(V \cdot E)$	$O(E)$