Data Structures Notes

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> Hello Stranger! *These are notes made during the my #100daysofCode Challenge. Start date: 7th November 2022 (in-progress)*
> *The notes were written using Notion app and exported into a pdf.*

> *If you can't **explain it simply**, you don't **understand it well** enough.*
>
> *~ Albert Einstein*

Introduction

A `data structure (DS)` is a way of organizing data so that it can be used efficiently.

Data structures are helpful in:

1. Creating fast and powerful algorithms.
2. Managing and organizing data.
3. Making code cleaner and easier to understand.

Abstract Data Type vs Data Structure

Abstract data types are `analogous to modes of transportation` e.g. walking, train, biking, plane. `They are just ways of getting from one point to another.` When you choose a ***`specific mode of transportation like biking then that is considered a data structure.`***

An `abstract data type (ADT)` is referred to as an abstraction of a data structure which

Abstraction (ADT)	Implementation (DS)

provides only the interface to which a data structure must adhere to. The interface does not give specific details about how something should be implemented or in what programming language.

Abstraction (ADT)	Implementation (DS)
List	Dynamic Array, Linked List
Queue	Linked list based queue, Array based queue, Stack based queue,
Map	Tree Map, Hash Map / Hash Table
Vehicle	Golf cart, Smart car, Bicycle

Computational Complexity Analysis

This helps us understand the performance that the data structures are providing. i.e knowing the time and space an algorithm will need.

An algorithm that takes so much time to run even if it uses very little space is not effective. The same is when an algorithm uses all the bytes but runs fast is still not efficient.

This is how Big-O Notation was created.

Big-O Notation (Come back to this)

Big-O Notation gives an upper bound of the complexity in the worst case, helping to quantify performance as input size becomes arbitrary large. `In other words we are always looking for the worst case scenario of an algorithm when using Big-O in terms of time and space.`

Lets say you are looking for a number 8 in an unordered list of unique numbers, in terms of time, Big-O Notation tells us the time it will take to find 8, in the worst case; when 8 is the last in the list.

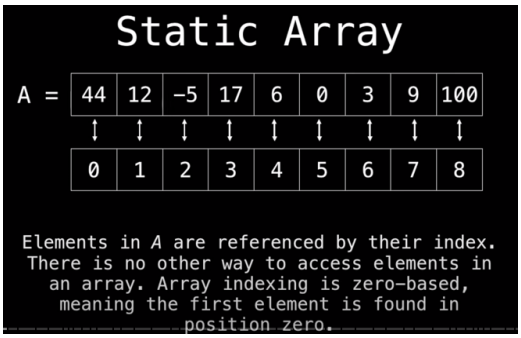
Static and Dynamic Arrays

Introduction to Arrays

Static Arrays

Static Arrays are arrays where the `size/length is specified when the array is created/allocated.` Because the length is fixed, this type of array is also

know as fixed-length arrays / fixed arrays.



Application of Static arrays

1. Temporary store objects
2. Lookup tables and inverse lookup tables due to its indexing.
3. Can be used to return multiple values from a table
4. Storing and accessing sequential data
5. Used by Input/Output routines as buffers
6. Used in dynamic programming to cache answers to sub-problems

Language	Defined Values	Fixed-Length with Undefined or Default Values
C++	`int values[] = {0, 1, 2};`	`int values[3];`
C#	`int[] values = {0, 1, 2};`	`int[] values = = new int[3];`
Java	`int[] values = {0, 1, 2};`	`int[] values = = new int[3];`
JavaScript	`var values = [0, 1, 2];`	`var values = new Array(3);`
Python	`values = [0, 1, 2]`	`values = [None] * 3`
Swift	`var values:[Int] = [0, 1, 2]`	`var values: [Int] = [Int](repeating: 0, count: 3)`

Complexity of Static Arrays

	Static Arrays	*Explanation*
Accessing	O(1)	It is constant because of indexing. You can find a particular value in an array.
Searching	O(n)	It takes linear time since you have to look through all the values in the array.
Insertion	N/A	Due to its fixed nature, no new values can be added to the array
Appending	N/A	Due to its fixed nature, no new values can be appended to the array
Deletion	N/A	Due to its fixed nature, no values can be deleted from the array

Dynamic Arrays

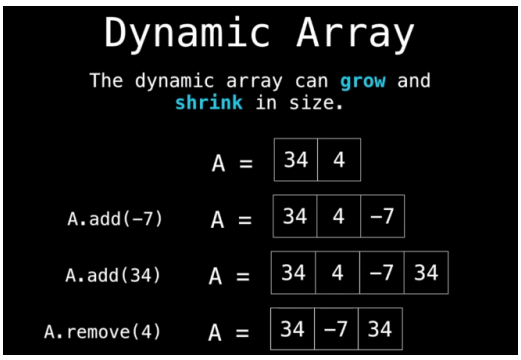
This is an array that allows individual elements to be added and / or removed

during runtime.

Language	Class	Add	Remove
C++	`#include <list>` `std::list`	`insert`	`erase`
C#	`System.Collections.Generic.List`	`Add`	`Remove`
Java	`java.util.ArrayList`	`add`	`remove`
JavaScript	`Array`	`push` , `splice`	`pop` , `splice`
Python	`List`	`append`	`remove`
Swift	`Array`	`append`	`remove`

Operation in Dynamic Arrays

This example below is in the Java language.

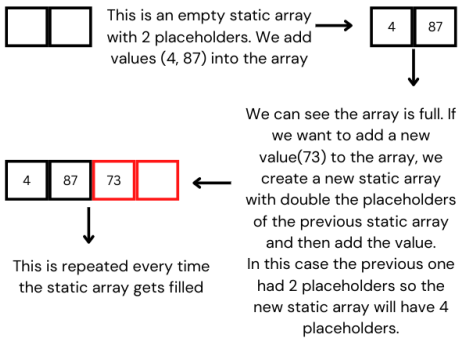


A dynamic array can be implemented using a static array. The following steps explains how this takes place.

1. Create a static array with an initial capacity
2. Add elements to the static array
3. If a new element is to be added but the static array is full, a new static array with double the capacity is created and copy the original elements in.

Complexity of Dynamic Arrays

	Dynamic Arrays	*Explanation*
Accessing	O(1)	It is constant because of indexing. You can find a particular value in an array.
Searching	O(n)	It takes linear time since you have to look through all the values in the array.
Insertion	O(n)	It is linear because you have to recopy and shift all the elements to the right when adding to an array
Appending	O(1)	It takes constant time because it does not take time to add a value at the end of an array.
Deletion	O(n)	It is linear because you have to recopy and shift all the elements when deleting from an array.


This is an empty static array with 2 placeholders. We add values (4, 87) into the array
4
87
We can see the array is full. If we want to add a new value(73) to the array, we create a new static array with double the placeholders of the previous static array and then add the value. In this case the previous one had 2 placeholders so the new static array will have 4 placeholders.
4
87
73
This is repeated every time the static array gets filled