Data Structures

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AGENDA

01

Introduction
Give a little to get a little (data that is)

02

Course Rules
The "Structure" of our course

03

Getting Started with Repl.IT
I promise it will work this time, mostly……

AGENDA

Introduction

Hey everyone, I’m Basil.

I’m a Software Architect/Lead from Slalom.
I’ve been building software on multiple platforms (web, mobile, desktop, cloud) for 15 years

When I’m not working, I love playing sports and video games

I’m a big fan of pecan pie

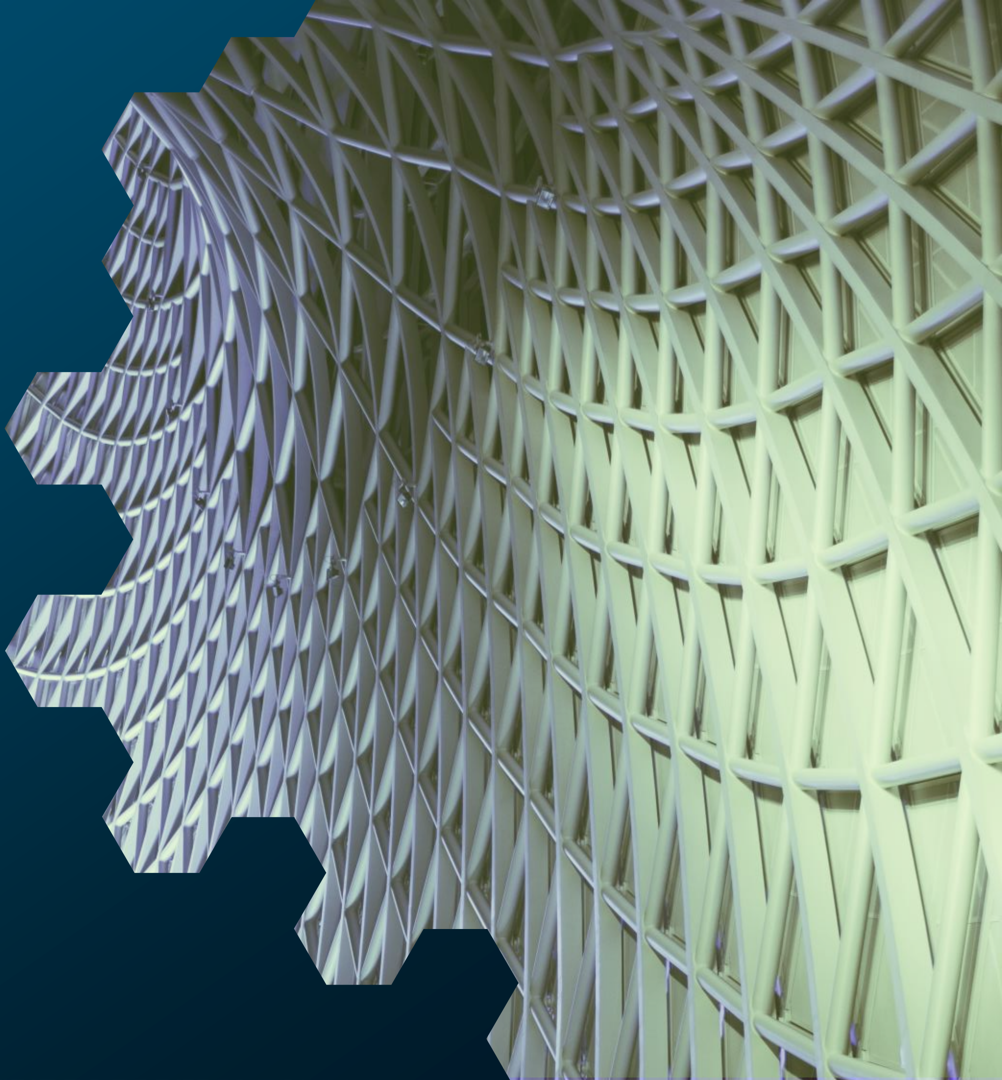
Tell me about you

Hey everyone, who are you?

Professional Background

What do you do for fun besides coding?

What is your favorite dessert?



COURSE RULES

PARTICIPATE!

You will all get so much more from this experience if you participate. Try to contribute to all of the discussions.

ASK QUESTIONS

Though it might sound like it when I talk, I don't just want to listen to my voice all day. Ask questions and share experiences whenever you want.

NO CODING NEEDED

There are coding problems in this course, but you don't need to have coding experience to participate. You can follow along with me.

SAY YES TO JS

All coding examples are in JavaScript, though the principles apply to all programming languages

GETTING STARTED WITH GITHUB AND REPL.IT

https://github.com/budoudoh/data-structures

All of the coding problems in this course course can be found here. Once you navigate to GitHub, click on the “run on repl.it” button to work on the code there. Each team will have their own space that they can work on the coding examples in.

LET’S GET STARTED

WHAT IS A DATA STRUCTURE

- Software is all about data!
- Data Structures are memory/program constructs that allow us to organize data so that it can be used effectively
- Modern software processes massive amounts of data, so it's important that we choose carefully when we're loading data into structures.

DATA STRUCTURE FUCTIONS

LOAD

Data must be loaded into the data structure to be used. Individual elements can be loaded ad-hoc as well.

ACCESS

Once the data is present, the application will need to periodically access individual and/or multiple data elements.

SEARCH

With multi-dimensional data sets, applications will often have to search for data elements that have certain properties.

DELETE

Once a data element is no longer valid or useful, I may need to be removed from the data structure without compromising the rest of the data.

BIG-O: MORE COMPLEX THAN IT SOUNDS

- Data Structures are judged by how efficient they can perform the functions from the last slide in two dimensions: **Space and Time**
- **Big-O** notation is a measure of complexity (or performance) of a data structure or algorithm and how it performs in Space (memory usage) and Time (CPU usage)
- Big-O describes the average and worst-case performance of a data structure based on how many data elements are held in that structure (usually described as “N” number of elements)
- **Time** is the most important complexity measure for data structures, as space complexity collapses down to the number of elements as the data structure and its number of elements get larger.
- Big-O measures are important to remember for interviews!

IMPORTANT BIG-O MEASURES

CONSTANT TIME

The best performance possible for a data structure

$O(1)$

LOGARITHMIC TIME

Very efficient performance, usually based on sorted input

$O(\log n)$

LINEAR TIME

Not great performance, but sometimes it’s the best you can do

$O(n)$

QUADRATIC TIME

Horrible performance for a data structure, usually only found in sorting algorithms, which is the next class

$O(n^2)$

Guess that Big-O!

	A	
$O(1)$		$O(\log n)$
$O(n^2)$		$O(n)$

	B	
$O(n)$		$O(\log n)$
$O(n^2)$		$O(1)$

	C	
$O(\log n)$		$O(1)$
$O(n)$		$O(n^2)$

	D	
$O(1)$		$O(n^2)$
$O(\log n)$		$O(n)$

DATA STRUCTURE TYPES

01

LINEAR DATA STRUCTURES

Data is collected in parsed in a linear fashion

02

NON-LINEAR/HIERARCHICAL DATA STRUCTURES

Data is collected and parsed in a hierarchical or non-linear fashion

LINEAR DATA STRUCTURES

LINEAR DATA STRUCTURES

ARRAYS
An oldie but goodie

LINKED LISTS
Sometimes all you need is to know where you are and what's next

STACKS
Works for more than just large sums of money

QUEUES
Just like at the DMV, except quicker. Much quicker……

HASH MAPS
This map won't take you forever to find your destination

ARRAYS

An oldie but goodie

ARRAYS – A VISUAL

ARRAYS - FACT SHEET

An array is a collection of data elements, each of which identified and retrieved by an array index.

LOAD

- Command – Create new then copy
- Complexity – O(n)

ACCESS

- Command – Array[index]
- Complexity – O(1)

SEARCH

- Command – foreach() then compare
- Complexity – O(n)

DELETE

- Command – Create then copy
- Complexity – O(n)

BEST USE CASES

- Static dataset
- Pre-counted dataset

ARRAYS – Guess that Big-O!

```
function hasDessert(desserts, dessert){
    for(let i = 0; i < desserts.length; i++){
        if(desserts[i] === dessert)
            return true
    }

    return false;
}
```

A: O(1)   B: O(log n)   C: O(n)   D: O(n^2)

LINKED LIST

Sometimes all you need is
to know where you are
and what's next

LINKED LIST – A VISUAL

LINKED LIST - FACT SHEET

A linked list is a collection of nodes, where each node is made up of a data elements and a pointer to the next node in the list.

LOAD

- Command – Get the tail, change the pointer
- Complexity – O(1)

ACCESS

- Command – Get the head, iterate
- Complexity – O(n)

SEARCH

- Command – Get the head, iterate
- Complexity – O(n)

DELETE

- Command – Remove the pointer
- Complexity – O(1)

BEST USE CASES

- Dynamic dataset
- Iterative use cases

LINKED LIST – Guess that Big-O!

```
function getItemFromDessertList(desserts, itemNumber){
    let count = 0;
    let dessert = desserts.first();
    while(count < itemNumber && dessert != null){
        dessert = dessert.next();
        count++;
    }

    return dessert;
}
```

A: $O(1)$ B: $O(\log n)$ C: $O(n)$ D: $O(n^2)$

STACKS

Works for more than just large sums of money

STACKS- A VISUAL

STACKS - FACT SHEET

A stack is a collection of data elements where each element that is added as well as removed to/from the collection is added to the front of the collection (LIFO).

LOAD

- Command – push to the top of the stack
- Complexity – O(1)

SEARCH

- Command – pop from stack, iterate
- Complexity – O(n)

BEST USE CASES

- Dynamic dataset
- Iterative use cases
- Single use data structures
- Recursion use cases
- Depth-First Search

ACCESS

- Command – pop or peek off the top of stack
- Complexity – O(n)

DELETE

- Command – Pop from stack
- Complexity – O(1)

STACKS – Guess that Big-O!

```
function gimmeADessertNow(desserts){
    let ok_heres_your_dessert = desserts.pop();
    return ok_heres_your_dessert;
}
```

A: O(1)   B: O(log n)   C: O(n)   D: O(n^2)

QUEUE

Just like at the DMV, except quicker. Much quicker……

QUEUES- A VISUAL

QUEUE - FACT SHEET

A queue is a collection of data elements where each element that is added to the back of the collection and removed from the front of the collection (FIFO).

LOAD

- Command – enqueue in the back of the queue
- Complexity – O(1)

ACCESS

- Command – dequeue from the front of the queue
- Complexity – O(n)

SEARCH

- Command – dequeue from the front of the queue, iterate
- Complexity – O(n)

DELETE

- Command – Dequeue from stack
- Complexity – O(1)

BEST USE CASES

- Dynamic dataset
- Iterative use cases
- Single use data structures
- Breadth-First Search

QUEUE – Guess that Big-O!

```
function addDessertToOrder(desserts, dessert){
    if(dessert == null)
        return desserts;
    if(!dessert.wasOrdered)
        return desserts;
    if(dessert.price > 8.99)
        return desserts;

    desserts.enqueue(dessert);
    return desserts;
}
```

A: $O(1)$ B: $O(\log n)$ C: $O(n)$ D: $O(n^2)$

HASHMAP

This map won't take you forever to find your destination

HASHMAP- A VISUAL

HASHMAP - FACT SHEET

A hash map is a collection of data elements where an index for each element can be calculated from a unique key using a hashing function.

LOAD

- Command – insert into hash map
- Complexity – O(1)

SEARCH

- Command – Get from map based on key
- Complexity – O(1)

BEST USE CASES

- Dynamic dataset
- Single Lookup use cases

ACCESS

- Command – get from map based on key
- Complexity – O(1)

DELETE

- Command – Remove from
- Complexity – O(1)

HASHMAP - Guess that Big-O!

```
function findMyfavoriteDessert(desserts, favorite){
    let favorite_dessert = desserts[favorite];
    return favorite_dessert;
}
```

A: $O(1)$ B: $O(\log n)$ C: $O(n)$ D: $O(n^2)$

LINEAR DATA STRUCTURES REVIEW

ARRAYS

- Static, fully counted data
- Great for storage and iteration

LINKED LISTS

- Dynamic, ad-hoc data
- Great for storage and iteration

STACKS

- Dynamic, ad-hoc data
- LIFO
- Great for recursion and DFS

QUEUES

- Dynamic, ad-hoc data
- FIFO
- Great for BFS

HASH MAPS

- Dynamic, ad-hoc data
- Great for efficient lookup tables

BREAKOUT TIME!

1. We're going to divide the class up into groups.
2. Each group will go to https://github.com/budoudoh/data-structures/blob/master/LinearProblem.md to find the problem they are solving. Then click the repl.it link there for your team to get to the problem.
3. Once you're in repl.it, select "Node.JS" as the language for the project, then click "Done".
4. Navigate to the "linear" folder. There you will find the problem your team was assigned. The instructions for the problem will be written in the comments at the top of the problem.
5. Each team should designate one person to be the scribe: this person will write code while everyone else helps to think through the problem.
6. You have 20 minutes to solve the problem. Remember, you should be using one of the data structures we just learned about to solve this problem based on which structure is best suited for the solution.
7. Once your time is up, each team will be given 2 minutes to explain their solution as well as the logic and reasoning that lead them to solution.

GO!

NON-LINEAR DATA STRUCTURES

NON-LINEAR DATA STRUCTURES

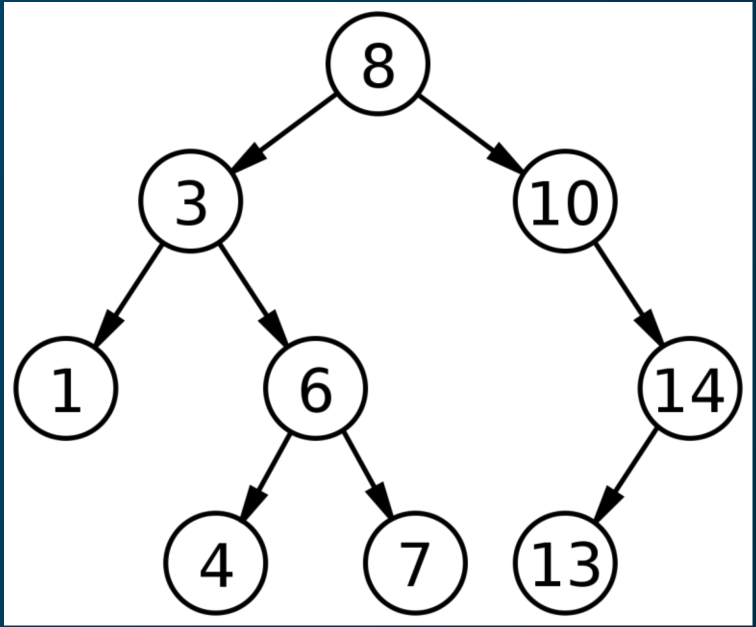
TREES
Think about the children

GRAPHS
Networking and relationships

TREES

Think about the children

TREES- A VISUAL



TREE - FACT SHEET

A tree is a collection of data elements where data is structured as a hierarchy, with data elements serving as parent nodes and child nodes for each other. A Binary Search Tree is a special tree variant where each parent has at most two nodes, each node is themselves a Binary Search Tree, and the value of the left node is always less than the value of the right node.

LOAD

- Command – insert into tree
- Complexity – O(log n)

SEARCH

- Command – traverse tree
- Complexity – O(log n)

BEST USE CASES

- Dynamic dataset
- Single Lookup use cases
- Hierarchical data

ACCESS

- Command – traverse tree
- Complexity – O(log n)

DELETE

- Command – Remove from tree
- Complexity – O(log n)

TREE – Guess that Big-O!

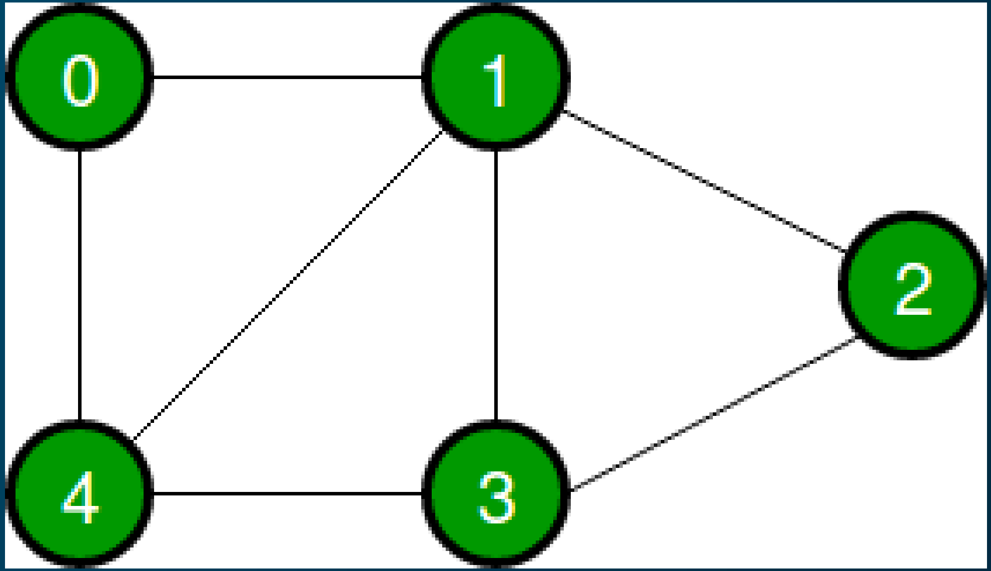
```
function howManyDessertsAreBetter(dessertBTS, currentDessert){
    let score = 0;
    if(dessertBTS == null)
        return score;

    if(dessertBTS.getDessert().getScore() > currentDessert.getScore())
        score = 1;

    if(score == 1)
        return score +
                howManyDessertsAreBetter(dessertBTS.getLeft(), currentDessert) +
                howManyDessertsAreBetter(dessertBTS.getRight(), currentDessert);
    else
        return howManyDessertsAreBetter(dessertBTS.getRight(), currentDessert)
}
```

A: O(1)   B: O(log n)   C: O(n)   D: $O(n^2)$

GRAPHS

Networking and relationships

GRAPHS- A VISUAL



GRAPH - FACT SHEET

A graph is a collection of data elements that are structured in relation to each other, with the data serving as vertices and the relationship serving as edges.

LOAD

- Command – insert node or vertex into graph
- Complexity – O(1)

SEARCH

- Command – query graph
- Complexity – O(n)

BEST USE CASES

- Dynamic dataset
- Relational Data

ACCESS

- Command – query graph
- Complexity – O(n)

DELETE

- Command – Remove from graph
- Complexity – O(1)

GRAPH – Guess that Big-O!

```
function howManyFriendsLikeDessert(friendGraph, me, dessert){
    let friends = friendGraph.getEdges(me);
    let count = 0;
    for(let i = 0; i < friends.length; i++){
        let friend = friends[i];
        if(friend.favorite_dessert == dessert){
            count++
        }
    }

    return count;

}
```

A: O(1) B: O(log n) C: O(n) D: O(n^2)

NON-LINEAR DATA STRUCTURES REVIEW

TREES

- Dynamic, hierarchical data
- Great for performing operations in logarithmic time

GRAPHS

- Dynamic, relational data
- Great for mapping relationships between data elements

BREAKOUT TIME!

1. We're going to divide the class up into groups.
2. Each group will go to https://github.com/budoudoh/data-structures/blob/master/NonLinearProblem.md to find the problem they are solving. Then click the repl.it link there for your team to get to the problem.
3. Once you're in repl.it, select "Node.JS" as the language for the project, then click "Done".
4. Navigate to the "non-linear" folder. There you will find the problem your team was assigned. The instructions for the problem will be written in the comments at the top of the problem.
5. Each team should designate one person to be the scribe: this person will write code while everyone else helps to think through the problem.
6. You have 20 minutes to solve the problem. Remember, you should be using one of the data structures we just learned about to solve this problem based on which structure is best suited for the solution.
7. Once your time is up, each team will be given 2 minutes to explain their solution as well as the logic and reasoning that lead them to solution.

GO!

TAKEAWAYS

O(n)

Remember the concept of Big-O and the different time complexities for each data structure type

Use the best data structure for the job you're doing. Arrays aren't always the answer

Graphs and trees are great for mapping relationships between elements

THANKS

All today’s code and this presentation are available on github @ https://github.com/budoudoh/data-structures