The Standard Template Library

...

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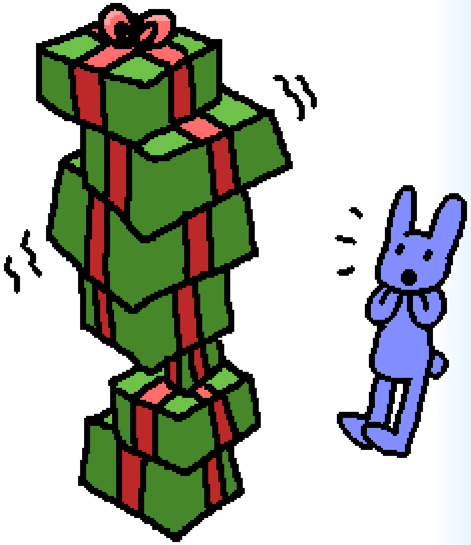
Topics:

- The Standard Template Library
- Vectors
- Lists
- Stacks
- Queues
- Maps

Introduction

C++ has some data structures already pre-built and available within the standard library that we can use to get familiar a bit with how these structures work.

Before we get into the details of *implementing* these data structures, it might be useful to see how they can actually be used first...



Introduction

Wait, if data structures already exist, why are we going to spend all semester learning how to write ‘em?!

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Wait, if data structures already exist, why are we going to spend all semester learning how to write 'em?!

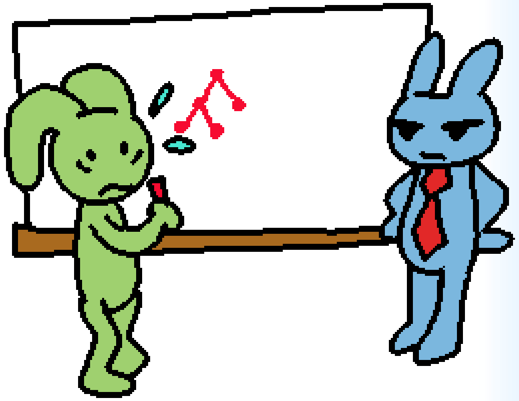
- Well… learning about data structures & algorithm analysis is a big part of computer science.
- You also need to know the inner-workings of these structures, so that when you're implementing solutions, you can choose the best structure for your particular problem – it isn't one size fits all!

Introduction

Wait, if data structures already exist, why are we going to spend all semester learning how to write 'em?!

- You might need to create your own data structures down the line, or customize an existing one!

- You'll be asked about them during job interviews. Interviewers <u>love</u> asking about data structures.



Introduction

So let's see how some of these structures work by utilizing the structures available in the Standard Template Library.

In particular...

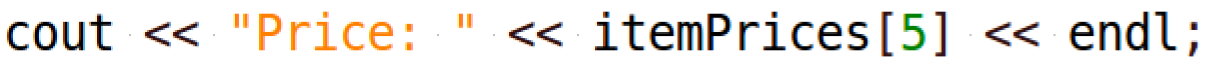
- **STL Vector**
- **STL List**
- **STL Stack**
- **STL Queue**
- **STL Map**

STL Vector

STL Vector

In some ways, vector objects are similar to arrays, which you may have used in previous classes.

You can access specific items of the vector with the subscript operator, [ ]

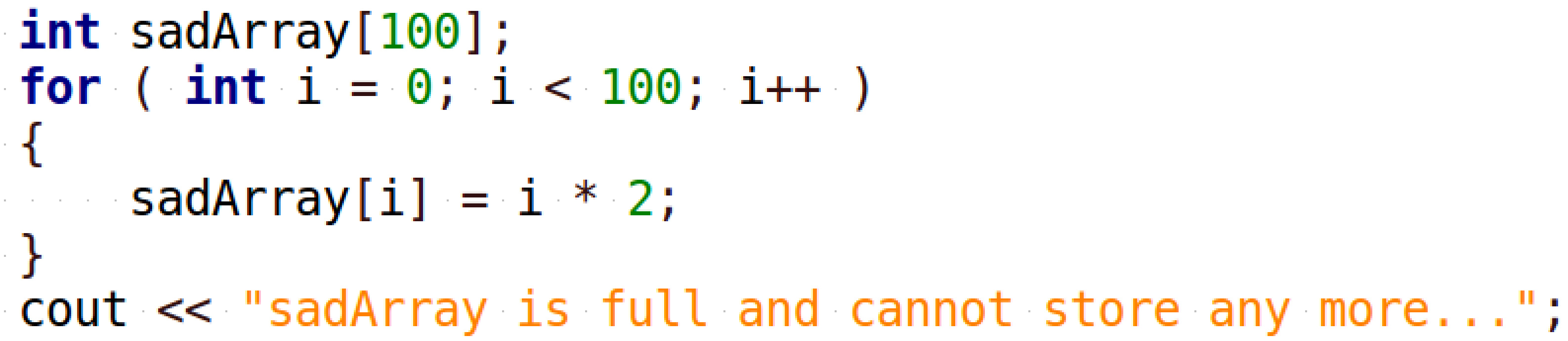


```
cout << "Price: " << itemPrices[5] << endl;
```

STL Vector

A perk of the vector object is that it handles resizing on its own.

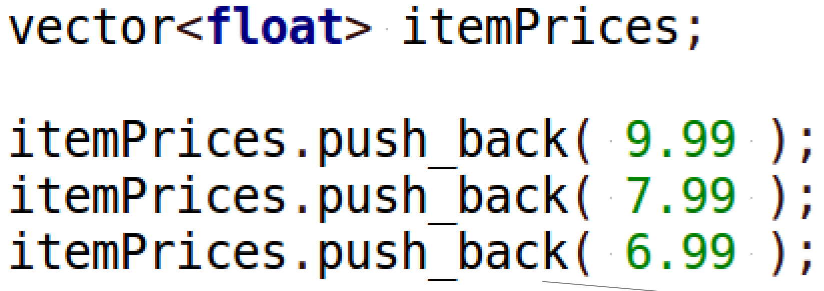
Recall that with a static array, we had to know what its size was at <u>compile time,</u> and it <u>couldn’t be resized!</u>



```cpp
int sadArray[100];
for ( int i = 0; i < 100; i++ )
{
    sadArray[i] = i * 2;
}
cout << "sadArray is full and cannot store any more...";
```

STL Vector

With a STL vector, it handles resizing on its own (behind-the-scenes!), so we don’t have to worry about it – we can just keep adding items on to it!



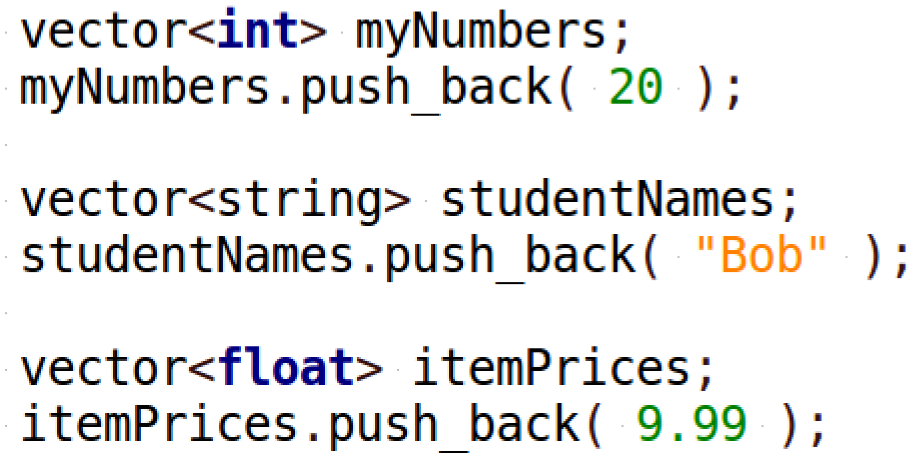
```
vector<float> itemPrices;

itemPrices.push_back( 9.99 );
itemPrices.push_back( 7.99 );
itemPrices.push_back( 6.99 );
```

Now we’re the “other programmer”, and we don’t really care how it’s implemented, we just care that it works!

The vector’s **push_back** function is how we add items into the “array”.

STL Vector

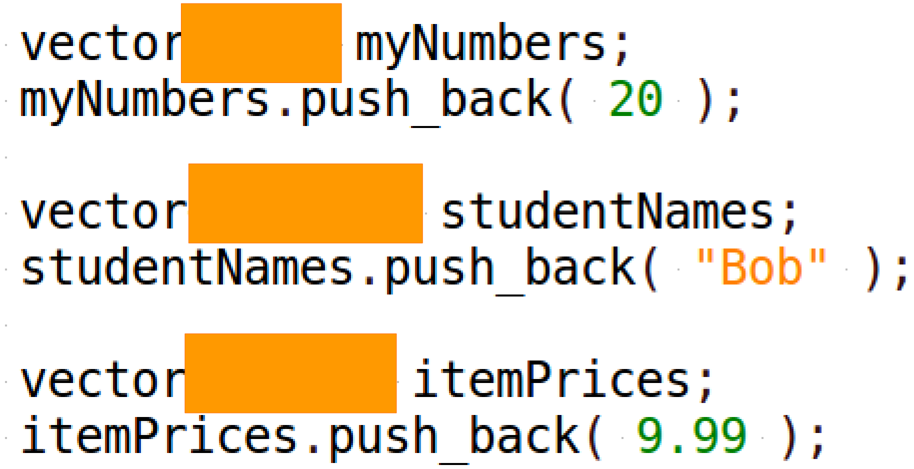
A Vector can store any data-type.



```
vector<int> myNumbers;
myNumbers.push_back( 20 );

vector<string> studentNames;
studentNames.push_back( "Bob" );

vector<float> itemPrices;
itemPrices.push_back( 9.99 );
```

STL Vector

A Vector can store any data-type.



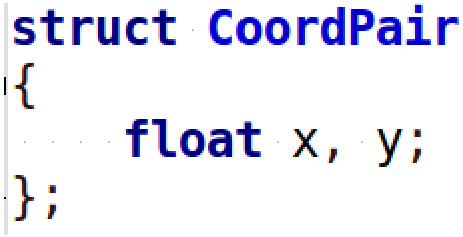
```
vector[redacted] myNumbers;
myNumbers.push_back( 20 );

vector[redacted] studentNames;
studentNames.push_back( "Bob" );

vector[redacted] itemPrices;
itemPrices.push_back( 9.99 );
```

The `<int>`, `<string>`, and `<float>` bits of code are because vector has been implemented as a **template**.

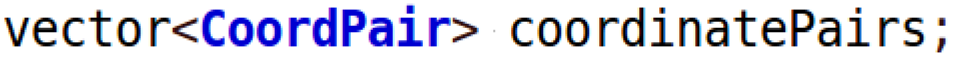
If you haven't covered templates before, or don't quite remember how they work, don't worry – we will go over them more later on.

STL Vector

A Vector can store any data-type.



```
struct CoordPair
{
    float x, y;
};
```



```
vector<CoordPair> coordinatePairs;
```

If we write a **struct** or a **class**, a vector can even store those!

STL Vector

Some handy functions of a vector are...

- **push_back**
  Insert an item at the end of the vector
- **size**
  Returns the amount of items in the vector
- **empty**
  Returns whether the vector is empty or not (size == 0?)
- **operator[]**
  Access an item in the vector at any index
- **clear**
  Clears out all the elements of the vector.

STL Vector

Let’s try it out!

STL List

STL List

Lists also store a linear series of data, but they’re a little different from vectors.

For one, you cannot *randomly access data* with the subscript operator [ ].

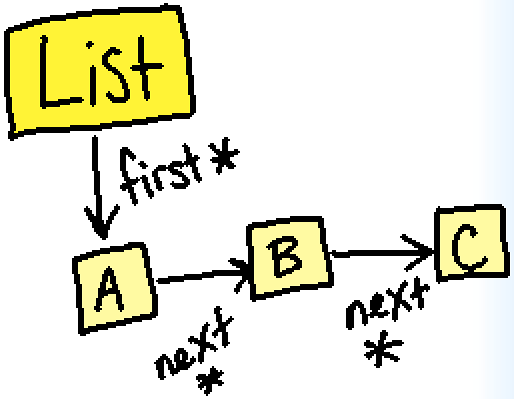
Generally, to step through a list, you have to start at the beginning and keep stepping through, one at a time.

The STL List does contain a sort() function and reverse() function, though!

STL List

We cannot *randomly* access data in a List because it isn't implemented with an <u>array</u>, like <u>vector</u> is.

STL Lists use <u>pointers</u>. The list keeps track of what its <u>starting element</u> is, and each element points to the next element in the list.



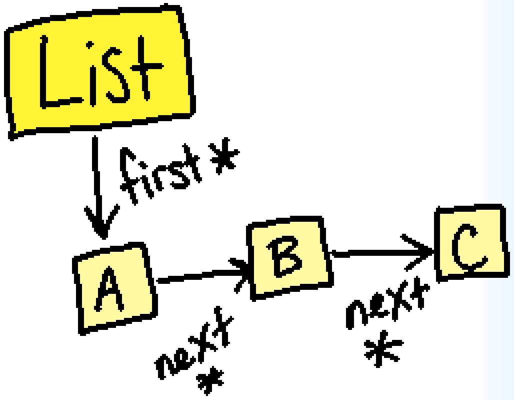
Therefore, unlike an array, the elements are not in contiguous memory slots.

(This is why it's important to stay familiar with pointers for this class!)

STL List

We will discuss the pointer and memory aspect of lists later on, once we're implementing linked lists.

For now...
onto the STL List functionality!



STL List

- **push_back**
  Insert an item at the end of the list
- **size**
  Returns the amount of items in the list
- **empty**
  Returns whether the list is empty or not (size == 0?)
- **clear**
  Clears out all the elements of the list.
- **sort**
  Sorts the elements of the list
- **reverse**
  Reverses the order of elements in the list.

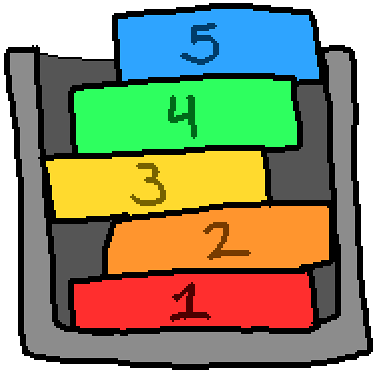
STL List

Let’s try it out!

STL Stack

STL Stack

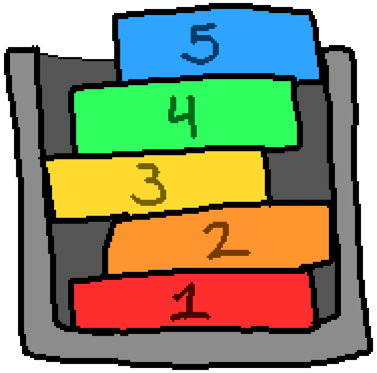
A Stack is a type of data structure that is linear, like a list or vector is, but it also restricts access to the internal data.



The main characteristic of a stack is that it is a First In Last Out (or) Last In First Out structure.

STL Stack

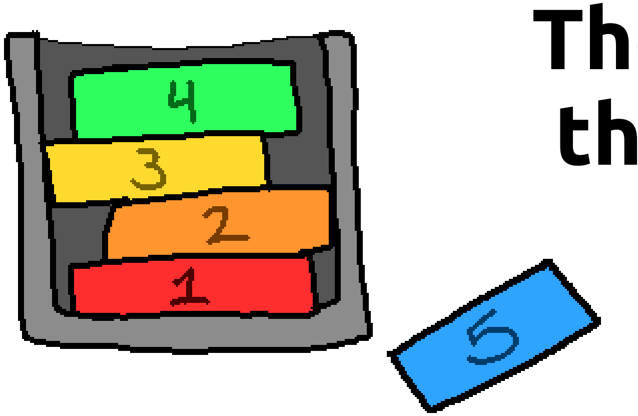
At any time, you're only able to access one item from the stack – the top-most item.



And, as items are pushed onto the stack, the older items are on the bottom, and the newer items are on the top.

STL Stack

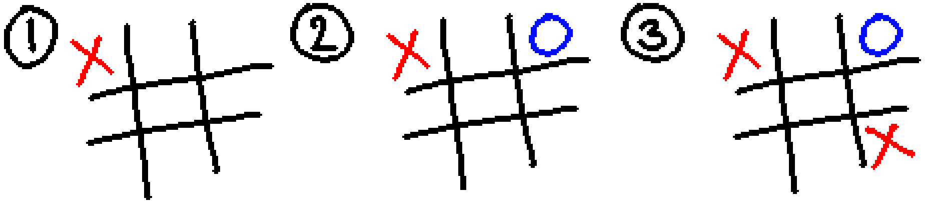
As you remove items from the stack, you pull the newest item that was added to the stack.



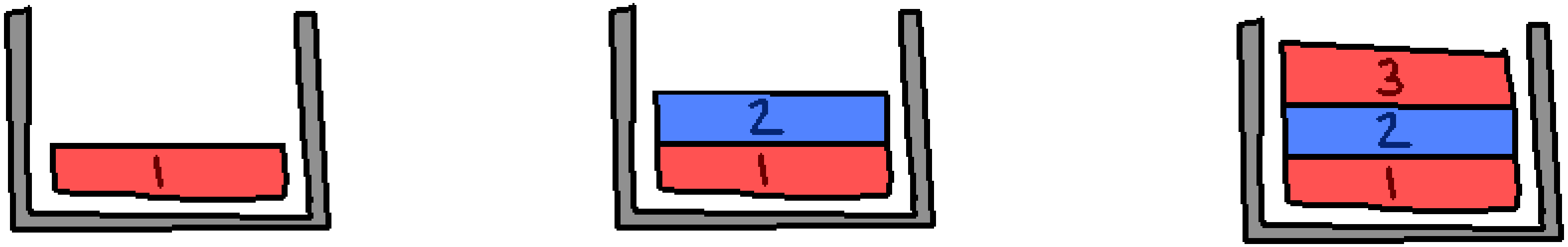
The first item on the stack is the last one to be removed.

STL Stack

One example of using a Stack is to keep track of moves in a game of tic-tac-toe

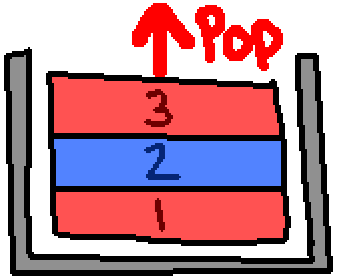


Every time a move is made, we could push the game board's current state onto a stack…

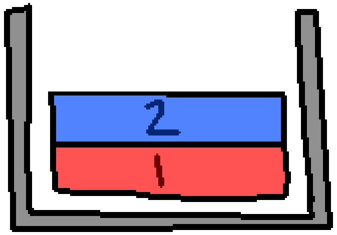


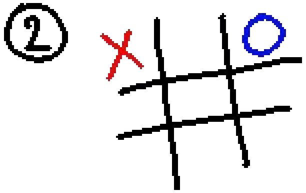
STL Stack

Then if we want to undo a turn, we can pop the most recent state off the stack



And the game board reverts to the state before.





STL Stack

Some handy functions of a stack are...

- **push**
  Pushes an item to the top of the stack.

- **pop**
  Removes an item from the top of the stack.

- **top**
  Returns the item that is at the top of the stack.

- **size**
  Returns the amount of items in the stack.

- **empty**
  Returns whether the stack is empty or not.

STL Stack

Let’s try it out!

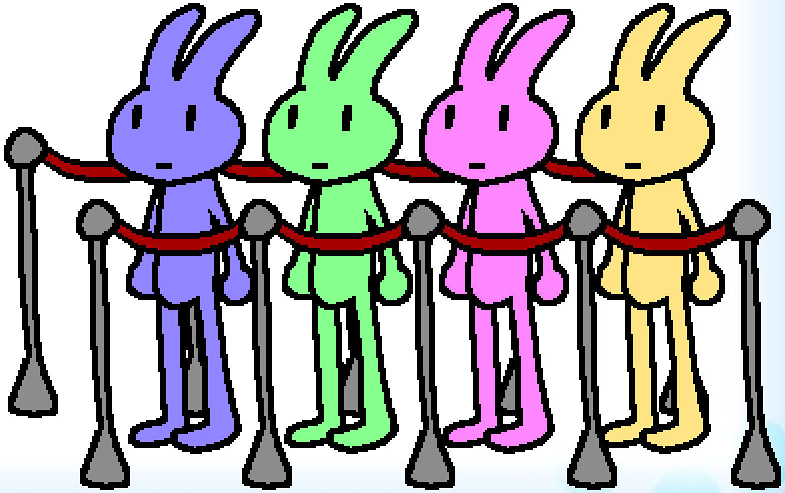
STL Queue

STL Queue

A queue is another kind of restricted-access data structure.

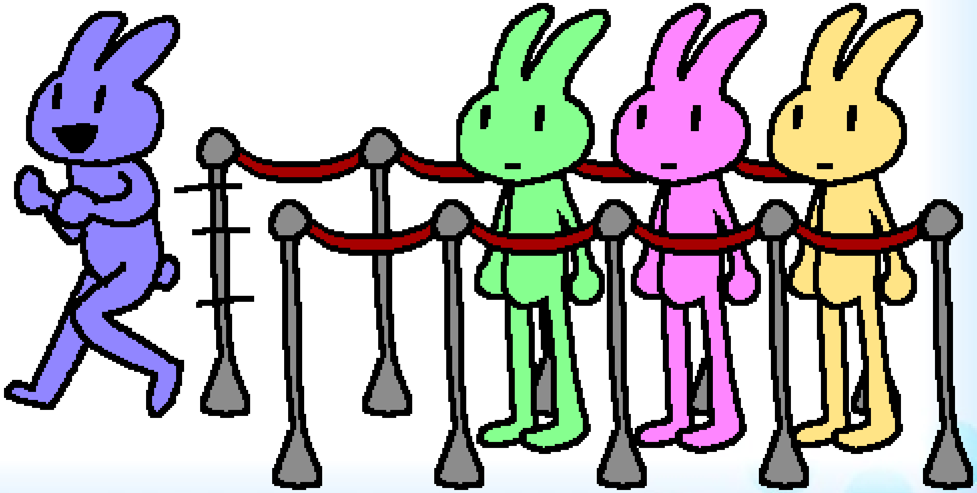
Like a stack, you can only access one item of the queue at a time.

However, a queue is First In First Out structure



STL Queue

The first item that enters the queue, who sits at the front of the line, is the first one to get removed, just like in a grocery-store line.



STL Queue

And when a new item is added to the queue, it enters at the end (or <u>back</u>) of the queue.

STL Queue

Some handy functions of a queue are...

- **push**
  Pushes an item to the back of the queue.

- **pop**
  Removes an item from the front of the queue.

- **front**
  Returns the item that is at the front of the queue.

- **size**
  Returns the amount of items in the queue.

- **empty**
  Returns whether the queue is empty or not.

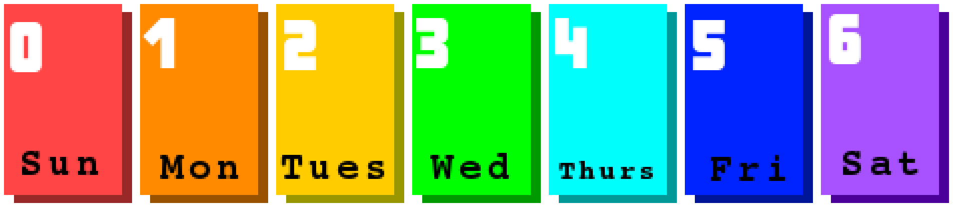
STL Queue

Let’s try it out!

STL Map

STL Map

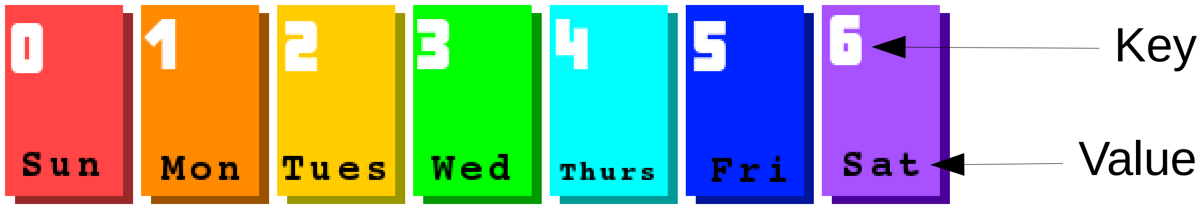
When we’re using a plain-old array, we have a series of elements in order, starting at 0, going until (size – 1).



7 items in the array
=
Index 0 through 6 is valid

STL Map

A value of 0, 1, 2, 3, 4, 5, or 6, which specifies an element's position, is known as an index, but we can also think of it like a "key", which helps us locate the value we want



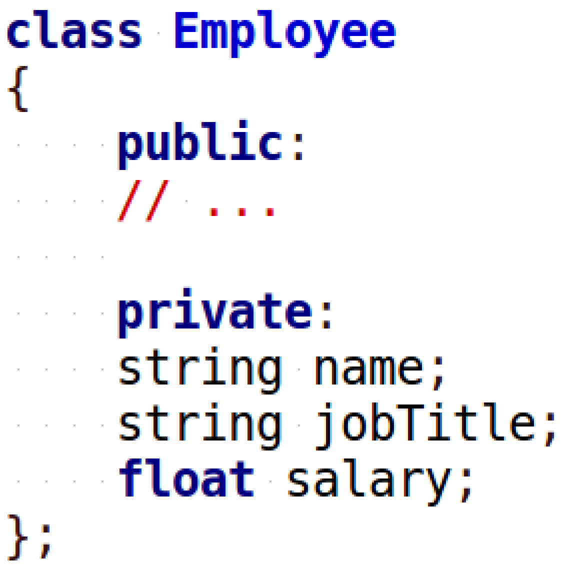
STL Map

But with a data structure like a <u>map</u>, our keys don't have to just be integers, and they don't have to be array indices.

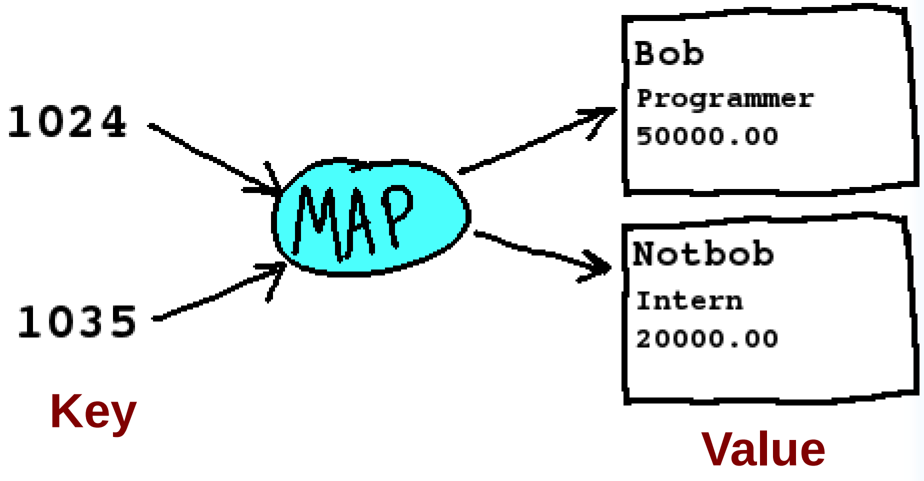
**The key can be <u>any data type</u>,
and it can point to a value of <u>any data type as well</u>.**

STL Map

For example, think of an employee ID, that points to an employee object in a program...

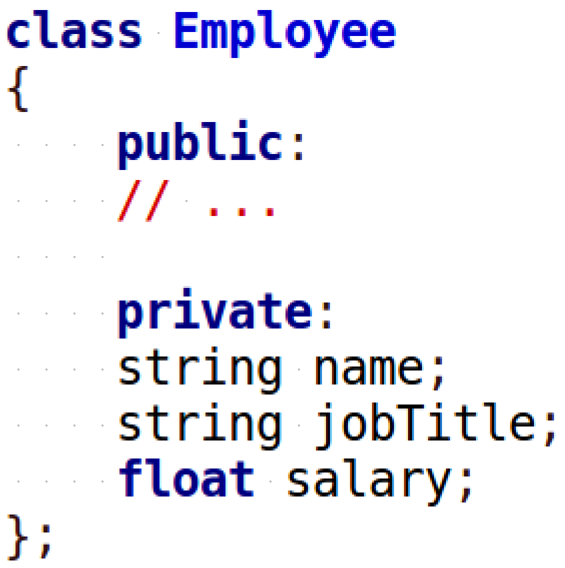


```
class Employee
{
    public:
    // ...

    private:
    string name;
    string jobTitle;
    float salary;
};
```

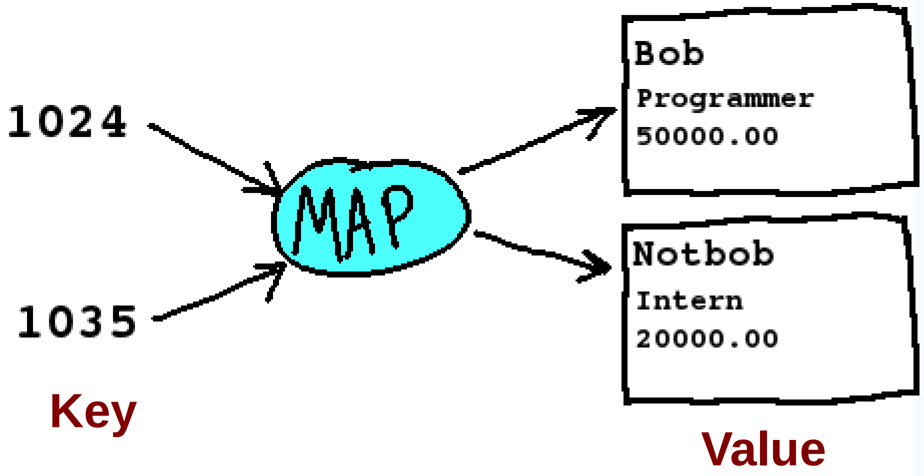


STL Map

Maps are built in a special way so that we can access elements <u>by key</u>, and it will access it quickly – search algorithm not required.



```
class Employee
{
    public:
    // ...

    private:
    string name;
    string jobTitle;
    float salary;
};
```



STL Map

Some handy functions of a map are...

- **operator[]**
  Access an element of the map, using a key
- **insert**
  Insert a new key-value pair into the map
- **empty**
  Returns whether the map is empty or not
- **size**
  Get the amount of elements in the map

STL Map

Let’s try it out!

CPlusPlus.com

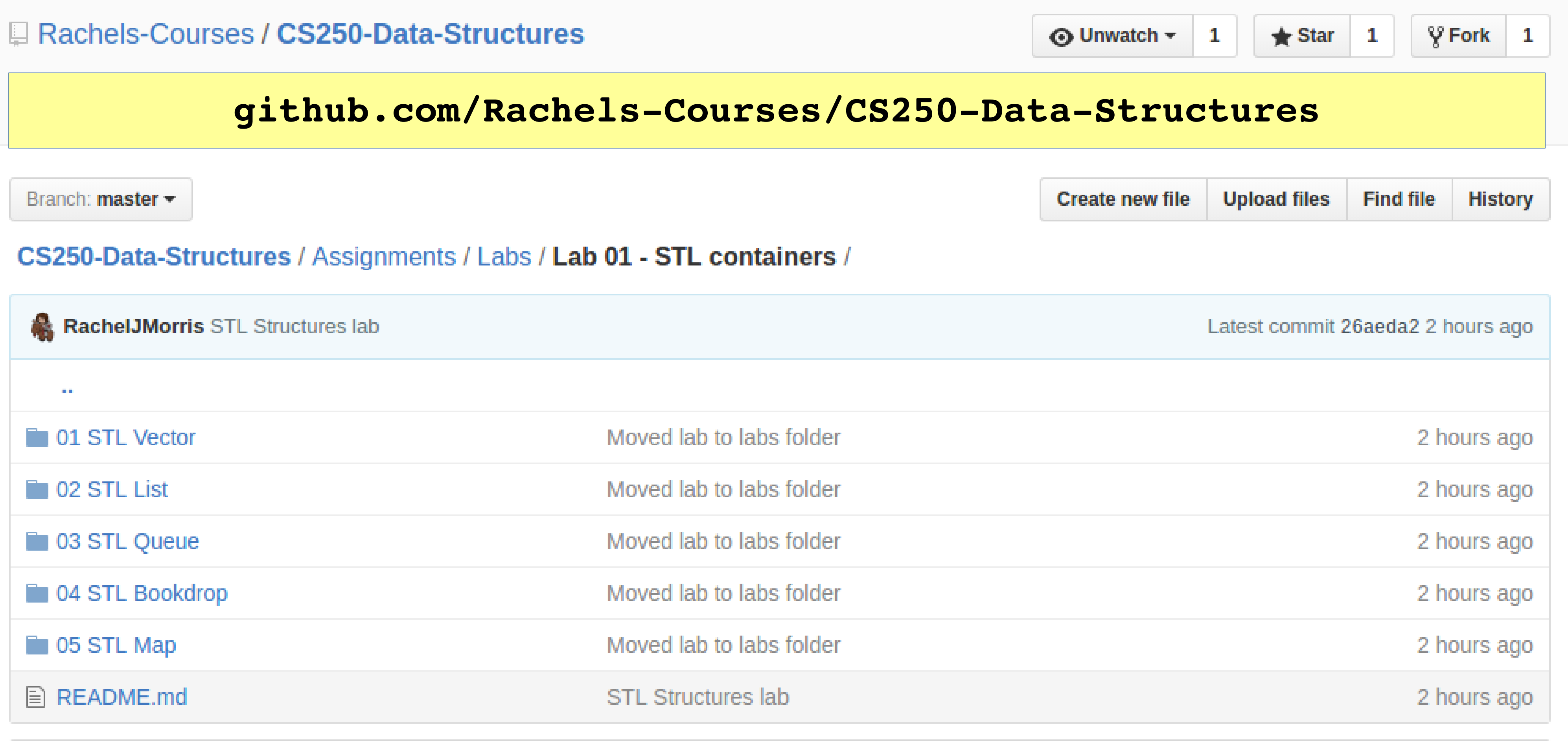
A really handy page for C++ documentation is CplusPlus.com

If you look up stuff from the C++ standard library, you will find objects included in the library, functions that those objects have, and example code.

http://www.cplusplus.com/

Practice

Make sure to check out the course GitHub for example code and practice projects.



Rachels-Courses / **CS250-Data-Structures**

github.com/Rachels-Courses/CS250-Data-Structures

CS250-Data-Structures / Assignments / Labs / **Lab 01 - STL containers** /

RachelJMorris STL Structures lab — Latest commit 26aeda2 2 hours ago

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01 STL Vector	Moved lab to labs folder	2 hours ago
02 STL List	Moved lab to labs folder	2 hours ago
03 STL Queue	Moved lab to labs folder	2 hours ago
04 STL Bookdrop	Moved lab to labs folder	2 hours ago
05 STL Map	Moved lab to labs folder	2 hours ago
README.md	STL Structures lab	2 hours ago