

Project 1:

The STL and You

A quick intro to the STL to give you tools to get started with stacks and queues, without writing your own!

Use a deque instead!

Speed up your output!

DO NOT!!!

- Copy and paste code from a PDF and expect it to compile
 - PDF files sometimes use Unicode characters to make things like - look nice, but it isn't a “minus” sign
 - PDF files have hidden characters (called elisions) to make spacing look good
- Anything in here is short enough to retype

The vector<> Template

- You must `#include <vector>`
- Basically a variable-sized array
- Implemented as a container template
- You must specify the type at compile time
- The size can be specified at run time
- For example:
`vector<int> values;`

Adding to a Vector

- Starts empty with no room for values
- Use the `.push_back()` member function to add a value to the end
- Parameter to `.push_back()` must be same `<type>` as when vector was declared
- For example:
`values.push_back(15);`

Accessing Vector Elements

- The `vector<>` template overloads `operator[]()`
- When the vector is not empty, you can access it with `[0]`, `[1]`, etc.
- Loop through all values:

```
for (size_t i = 0; i < values.size(); ++i)  
    cout << values[i] << endl;
```

Important Note

- These are not the only data structures you will need for Project 1!
- This is intended to help you with the “Routing Scheme” portion, where you have to remove/add when searching from the current location
- See Project 1 specification for more details; search for “Routing Scheme”

STL Containers

- The STL containers are implemented as template classes
- There are many types available, but some of them are critical for Project 1
 - Stack
 - Queue
 - Deque (one deque can take the place of both a stack and a queue, saving code)
- Common/similar member functions

Common Member Functions

- The stack and queue containers use many of the same member functions

`void push(elem)` – add element to container

`void pop()` – remove the next element from the container

`bool empty()` – returns true/false

- The only difference is which end the `push()` operation affects

Different Member Functions

- The stack uses:
 - <T> top() – look at the “next” element (the top of the stack)
- The queue uses:
 - <T> front() – look at the “next” element (the front of the queue)

Using Stack/Queue in Project 1

- If you want to use stack and queue for the searching in Project 1, you *could* create one of each type
- Must use them inside a single function (which will be long, with duplicate code), or write two almost identical functions
 - Cannot make a template function, due to `.top()` versus `.front()`
- This is not the best way to proceed

The Deque Container

- The deque is pronounced “deck”
 - Prevents confusion with dequeue (dee-cue)
- It is a double-ended queue
- Basically instead of being restricted to pushing or popping at a single end, you can perform either operation at either end
`#include <deque>`

Deque Member Functions

- The deque provides the following:

```
void push_front(elem)
```

```
<T> front()
```

```
void pop_front()
```

```
void push_back(elem)
```

```
<T> back()
```

```
void pop_back()
```

```
bool empty()
```

Using a Deque in Project 1

- If you want to use a single data structure for searching in Project 1, use a deque
- This is the *search container* in the spec
- **Always** use `.push_back()`
- When you're supposed to use a stack, use `.back()` and `.pop_back()`
- For a queue, use `.front()` and `.pop_front()`

More Information

- More information on these STL data types can be found online
 - cppreference.com
 - cplusplus.com
- Look up their syntax, constructors, member functions, etc.

2D or 3D Data Structures

- Create a `**` or `***` (double or triple pointer)
 - Bad choice, too much work to do on your own
- Create a nested vector<>
 - Create the vector with the right size initially
 - Use the `.resize()` member function on each dimension before reading the file
- For any choice, exploit locality of reference
 - Use subscripts in this order:
`[level][row][col]`

Creating/Initializing a Vector

- Here is an example of creating and initializing a 1D vector, with 10 entries, all initialized to -1:

```
uint32_t size = 10;  
vector<int> oneDimArray(size, -1);
```

- Since 10 values already exist, read data directly into them using `[i]`, do NOT `.push_back()` more values

Creating then Resizing

- If instead you want to declare the vector then read the size, then change the size of the vector:

```
vector<int> oneDimArray;  
uint32_t size;  
cin >> size;  
oneDimArray.resize(size, -1);
```

Creating/Initializing a 2D Vector

- Here is an example of creating and initializing a 2D vector, all initialized to -1:

```
uint32_t rows;  
uint32_t cols;  
cin >> rows >> cols;  
vector<vector<int>> twoDimArray(rows, vector<int>(cols, -1));
```

- Each “row” is itself a `vector<int>`
- You can extend this upward to 3 dimensions!

Resizing Multiple Dimensions

- If you have a 2D vector:

```
uint32_t rows, cols;  
vector<vector<int>> twoDimArray;  
cin >> rows >> cols;  
twoDimArray.resize(rows, vector<int>(cols, -1));
```

- When you have a 3D vector, extend this syntax upward to three dimensions
- There's two items inside every set of ()
 - The number of elements
 - What each element is

About Data Structures

- Be willing to make different types of data for different purposes
- Don't try to make one type of data that can be used for every purpose (the map, backtracing, and deque)
 - If you do this you'll have memory trouble
- Make different data types for different purposes as needed

Converting char To/From int

- You will probably find that you need to perform conversions
- You can add and subtract integers and characters, and convert!
- For example, character to number:
`level = static_cast<uint32_t>(square - '0');`
- Or number to character:
`square = static_cast<char>('0' + level);`

Speeding up Input/Output

- C++ cin and cout can be slow, but there are several ways to speed it up:
 - DO turn off synchronization of C/C++ I/O
 - DO use `'\n'`
 - DON'T use string streams
 - This has **NO** real time benefit when using the latest version of g++, and it wastes memory
 - DON'T produce a string object containing all your output (no speed gain, wastes memory)

Synchronized I/O

- What if you used both `printf()` (from C) and `cout` (C++) in the same program?
 - Would the output order always be the same?
 - What if you were reading input?
- To insure consistency, by default, C++ I/O is synchronized with C-style I/O
- Since you're likely only using one method, turning off synchronization saves time

Turning off Synchronized I/O

- Add the following line of code in your program, as the first line of `main()`
- It should appear before ANY I/O is done!

```
ios_base::sync_with_stdio(false);
```


Warning!

- If you turn off synchronized I/O, and then use `valgrind`, it will report potential memory leaks
 - Appears as around 122KB that is “still reachable”
- The simplest way to get accurate feedback from `valgrind` is to:
 1. Comment out the call to `sync_with_stdio()`
 2. Recompile
 3. Run `valgrind`
 4. **Uncomment** the `sync/false` line (don't forget this)
 5. Proceed to edit/compile/submit/etc.

'\n' versus endl

- Whenever the endl object is sent to a stream, after displaying a newline it also causes that stream to “flush”
 - Same as calling stream.flush()
- Causes output to be written to the hard drive RIGHT NOW
 - Doing this after every line takes up time
- Using '\n' does not flush

Finding the Path

- Once you reach the goal, you have to display the path that found it
 - Either as part of the map, or in list mode
- The map, stack/queue/deque do not have this information
- You have to save it separately!

Backtracing the Path

- You can't start at the beginning and work your way to the end
 - Remember, the Start might have had 4 possible places to go
- Think about it this way: when you're at the goal, how did you get here?
 - Since each location is visited ONCE, there is exactly ONE location “before” this one

Backtracing Example

- When you're at the goal, how did you get here? Where were you when the goal was *discovered* (added to the stack/queue/deque)?
 - Every location must remember the “previous” location
- If you're using queue-based routing, the H was reached from the west
- With stack-based routing, the H was reached from the south

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