Lecture 19: Intro to C++

Lecture Participation Poll #19

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Or
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HW4 late turn in locks today
Reminder: on Friday I gave everyone 3 more late days
Object Oriented Programming

▪ **Encapsulation**
  - discrete portions of code keep state and implementation private while providing public interfaces

▪ **Abstraction**
  - the high level interface is exposed to users without detailing underlying code

▪ **Inheritance**
  - classes can be derived from other classes allowing for shared code

▪ **Polymorphism**
  - subclasses implement methods of superclasses to allow for a consistent interface
Meet C++

▪ C++ is a general-purpose programming language created as an extension of the C programming language
  - Sometimes referred to “C with Classes”
  - Includes object-oriented, generic and functional features in addition to facilities for low-level memory manipulation
  - Designed with a bias towards system programming and embedded, resource-constrained software

▪ C is (roughly) a subset of C++, a C program can be compiled as a C++ program
  - You can still use printf – but bad style in ordinary C++ code
  - Can mix C and C++ idioms if needed to work with existing code, but avoid mixing if you can

▪ C++ makes it easy to hide a significant amount of complexity
  - It’s powerful, but really dangerous
  - Once you mix everything together (templates, operator overloading, method overloading, generics, multiple inheritance), it can get really hard to know what’s actually happening!

▪ C++ is considered a “middle level” language
  - can do both system programming and OOP
Features of C++

- Machine independent, but platform dependent
  - C++ executable is not platform-independent but they are machine independent
    - ie executable compiled on one windows machine can run on all windows machines but not on Linux machines
- rich library support
  - standard built in libraries have data structures and algorithms support
  - lots of 3rd party libraries
- Compiled language
  - does not include modern features like garbage collection, dynamic typing
  - makes C++ SUPER fast
- Pointer support and direct memory access
  - enables direct memory manipulation for low-level programming
- Object oriented
  - includes classes, objects, inheritance, polymorphism
  - namespaces allow for intelligent code grouping
- strongly typed
  - specific data types that are not interoperable
  - allows for both static and dynamic type checking
    - types checked at either compile or runtime
C++ Resources

- Best place to start: C++ Primer, Lippman, Lajoie, Moo, 5th edition
- Good Online Source: cplusplus.com
- Serious C++ programmers should read:
  - Effective C++, Meyers, 3rd Edition
    - Best practices for standard C++
  - Effective Modern C++, Meyers, O’Reilly
    - Additional “best practices” for C++11/C++14
Basic Differences between C and C++

- File names end with *.cc or *.cpp or *.cxx
  - Still use *.h for header files

- Use a different compiler: g++ instead of gcc

- C++ uses C preprocessor but libraries are different
  - #include <cstdlib>
  - basically the same as <stdlib.h>
Hello World

```c
#include <stdio.h> // for printf()
#include <stdlib.h> // for EXIT_SUCCESS

int main(int argc, char** argv) {
    printf("Hello, World!\n");
    return EXIT_SUCCESS;
}
```

```cpp
#include <iostream> // for cout, endl
#include <cstdlib> // for EXIT_SUCCESS

int main(int argc, char** argv) {
    std::cout << "Hello, World!" << std::endl;
    return EXIT_SUCCESS;
}
```
Hello World C++ iostream

helloworld.cc

```cpp
#include <iostream> // for cout, endl
#include <cstdlib> // for EXIT_SUCCESS

int main(int argc, char** argv) {
    std::cout << "Hello, World!" << std::endl;
    return EXIT_SUCCESS;
}
```

- **iostream** is part of the C++ standard library
  - **Note**: you don’t write “.h” when you include C++ standard library headers
    - But you do for local headers (e.g. `#include "ll.h"`)
  - **iostream** declares stream *object* instances in the “std” namespace
    - *e.g.* `std::cin, std::cout, std::cerr`
Hello World C++ cstdlib

helloworld.cc

```cpp
#include <iostream> // for cout, endl
#include <cstdlib> // for EXIT_SUCCESS

int main(int argc, char** argv) {
    std::cout << "Hello, World!" << std::endl;
    return EXIT_SUCCESS;
}
```

- **cstdlib** is the C standard library’s `stdlib.h`
- Nearly all C standard library functions are available to you
  - For C header `foo.h`, you should `#include <cfoo>`
We include it here for `EXIT_SUCCESS`, as usual
Hello World C++ std::cout

```cpp
#include <iostream>  // for cout, endl
#include <cstdlib>  // for EXIT_SUCCESS

int main(int argc, char** argv) {
    std::cout << "Hello, World!" << std::endl;
    return EXIT_SUCCESS;
}
```

- `std::cout` is the “cout” object instance declared by `iostream`, living within the “std” namespace
  - C++’s name for `stdout`
  - `std::cout` is an object of class `ostream`
  - Used to format and write output to the console
  - The entire standard library is in the namespace `std`

- Next, another member function on `std::cout` is invoked to handle `<<` with RHS `std::endl`
  - `std::endl` is a pointer to a “manipulator” function
    - This manipulator function writes newline (\n) to the `ostream` it is invoked on and then flushes the `ostream`'s buffer
This enforces that something is printed to the console at this point
Hello World C++ ostream

```cpp
#include <iostream>  // for cout, endl
#include <cstdlib>   // for EXIT_SUCCESS

int main(int argc, char** argv) {
    std::cout << "Hello, World!" << std::endl;
    return EXIT_SUCCESS;
}
```

- The `ostream` class’ member functions that handle `<<` return a reference to themselves
  - When `std::cout << "Hello, World!";` is evaluated:
    - A member function of the `std::cout` object is invoked
    - It buffers the string "Hello, World!" for the console
  And it returns a reference to `std::cout`

- `ostream` has many different methods to handle `<<`
  - The functions differ in the type of the right-hand side (RHS) of `<<`
  - e.g. if you do `std::cout << "foo";`, then C++ invokes `cout`’s function to handle `<<` with RHS `char*`
“<<” is an operator defined by the C++ language

- Defined in C as well: usually it bit-shifts integers (in C/C++)
- C++ allows classes and functions to overload operators!
  - Here, the \texttt{ostream} class overloads “<<”

- \textit{i.e.} it defines different \textbf{member functions} (methods) that are invoked when an \texttt{ostream} is the left-hand side of the \texttt{<<} operator

- Std library include a \texttt{cout} and a \texttt{cin} function
- Operators \texttt{>>} and \texttt{<<} act like shell redirection
- Operators \texttt{>>} and \texttt{<<} take left and right operands and return a stream
- use \texttt{namespace std} or
- use \texttt{std::cout} & \texttt{std::cin}

```cpp
using namespace std;

cout << "what is your name";
string name;

cin >> name;

cout << "when were you born?";
int year;

cin >> year;
```
Namespaces

- Groups code logically
- can reuse names for each namespace
- Disambiguate with :: syntax
- Can avoid using the prefix with
  - using namespace foo
  - doSomething(3)
- if you are using a namespace in a header, you must also use the namespace in the source code

```cpp
namespace foo {
    int doSomething(int x);
}
namespace bar {
    int doSomething(int x);
}
int main() {
    foo::doSomething(3);
    bar::doSomething(3);
}
```
Cout and Types

• C++ distinguishes between objects and primitive types
  • These include the familiar ones from C: `char, short, int, long, float, double, etc.`
  • C++ also defines `bool` as a primitive type (woo-hoo!)
    • Use it!

• `ostream` has many different methods to handle `<<`
  • The functions differ in the type of the right-hand side (RHS) of `<<`
    e.g. if you do `std::cout << "foo";`, then C++ invokes `cout`'s function to handle `<<` with RHS `char*`
```
#include <iostream>  // for cout, endl
#include <cstdlib>   // for EXIT_SUCCESS
#include <string>    // for string

using namespace std;

int main(int argc, char** argv) {
    string hello("Hello, World!");
    cout << hello << endl;
    return EXIT_SUCCESS;
}
```

C++’s standard library has a std::string class

- Include the string header to use it
  - Seems to be automatically included in iostream on CSE Linux environment (C++11) – but include it explicitly anyway if you use it
#include <iostream>  // for cout, endl
#include <cstdlib> // for EXIT_SUCCESS
#include <string>  // for string

using namespace std;

int main(int argc, char** argv) {
    string hello("Hello, World!");
    cout << hello << endl;
    return EXIT_SUCCESS;
}

- The `using` keyword introduces a namespace (or part of) into the current region
  - `using namespace std;` imports all names from `std::`
  - `using std::cout;` imports only `std::cout` (used as `cout`)

- Benefits of `using namespace std;`
  - We can now refer to `std::string` as `string`, `std::cout` as `cout`, and `std::endl` as `endl`
#include <iostream>  // for cout, endl
#include <cstdlib>     // for EXIT_SUCCESS
#include <string>      // for string

using namespace std;

int main(int argc, char** argv) {
    string hello("Hello, World!");
    cout << hello << endl;
    return EXIT_SUCCESS;
}

• Here we are instantiating a std::string object on the stack (an ordinary local variable)
  • Passing the C string "Hello, World!" to its constructor method hello is deallocated (and its destructor invoked) when main returns

• The C++ string library also overloads the << operator
  • Defines a function (not an object method) that is invoked when the left hand side is ostream and the right hand side is std::string

http://www.cplusplus.com/reference/string/string/operator<</
#include <iostream> // for cout, endl
#include <cstdlib> // for EXIT_SUCCESS
#include <string>   // for string

using namespace std;

int main(int argc, char** argv) {
    string hello("Hello");
    hello = hello + ", World!";
    cout << hello << endl;
    return EXIT_SUCCESS;
}

• This statement is complex!
  • First "+" creates a string that is the concatenation of hello’s current contents and ", World!"
  • Then "=" creates a copy of the concatenation to store in hello
  • Without the syntactic sugar:
    • hello.operator=(hello.operator+("", World!");

## String Concatenation
The string class overloads the "+" operator
• Creates and returns a new string that is the concatenation of the left and right

## String Assignment
The string class overloads the "=" operator
• Copies the right and replaces the string’s contents with it
New keyword indicating “this thing must not change”
used for global constants:
const int CURRENT_YEAR = 2021;
global constants look like global variables, but they are OK stylistically
Questions