Lecture 6

C++: Basics
So You Think You Know C++

- Most of you are experienced Java programmers
  - Both in 2110 and several upper-level courses
  - If you saw C++, was likely in a systems course

- Java was based on C++ syntax
  - Marketed as “C++ done right”
  - Similar with some important differences

- This Lecture: an overview of the differences
  - If you are a C++ expert, will be review
So You Think You Know C++

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- Java
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**This Lecture**: an overview of the differences
- If you are a C++ expert, will be review

All the sample code is online. Download and **play with it**.
### Comparing Hello World

#### Java

```java
/* Comments are single or multiline */

// Everything must be in a class
global class HelloWorld {

    // Application needs a main METHOD
global static void main(String arg[]) {
        System.out.println("Hello World");
    }
}
```

#### C++

```cpp
/* Comments are single or multiline */

// Nothing is imported by default
#include <stdio.h>

// Application needs a main FUNCTION
int main() {
    printf("Hello World");
    printf("\n");  // Must add newline
    // Must return something
    return 0;
}
```
## Comparing Hello World

<table>
<thead>
<tr>
<th>Java</th>
<th>C++</th>
</tr>
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<tbody>
<tr>
<td>/* Comments are single or multiline</td>
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</table>

### C++ Overview

- C-style console. In CUGL, use CULog instead.
Biggest Difference: **Compilation**

**Java Process**

Compiler

```
javac
```

Run the class file

Loads other classes as it needs them
Biggest Difference: **Compilation**

### C++ Process

- **Compiler**
  - CPP → c++ → OBJ

- **Linker**
  - OBJ + OBJ → c++ → EXE

**Run the executable**
All Handled by the IDE
All Handled by the IDE

Command line work requires a Makefile
# Makefile comment (Python style)

# Variables. In case we wanted to swap compilers
CC=c++

# Main application is first. If you type "make" by itself, you get this.
app: main.o helper.o
   $(CC) -o app main.o helper.o

# The object files (pre-linker). Type "make main.o" to get this.
main.o: main.cpp main.h helper.h
   $(CC) -c main.cpp

helper.o: helper.cpp helper.h
   $(CC) -c helper.cpp
# Makefile comment (Python style)

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Makefile Format

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Separation Requires Header Files

- Need `#include` for libs
- But linker adds the libs
- So what are we including?

**Function Prototypes**
- Declaration without body
- Like an interface in Java

- Prototypes go in .h files
- Also includes types, classes
- May have own `#includes`

```c++
/* stringfun.h
 * Recursive string funcs in CS 1110
 */

#ifndef _STRINGFUN_H_
define _STRINGFUN_H_

#include <string>

/* True if word a palindrome */
bool isPalindrome(string word);

/* True if palindrome ignore case */
bool isLoosePalindrome(string word);

#endif
```
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Prevents inclusion more than once (which is an error)
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#endif // _STRINGFUN_H
```

Type not built-in
Headers and Namespaces

- Headers are not packages!
  - Java import is very different
  - Packages prevent collisions
- C++ has **namespaces**
  - Define it in the header file
  - In-between curly braces
- Must add prefix when used
  - `stringfun::isPalindrome(..)`
  - *Even in implementation!*
- Unless have using command

```cpp
/* stringfun.h */

#ifndef _STRINGFUN_H_
#define _STRINGFUN_H_

#include <string>

namespace stringfun {

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}

#endif
```

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#include "stringfun.h"

/* True if word a palindrome */
bool stringfun::isPalindrome(string w) {
    if (s.size() < 2) {
        return true;
    }
    string sub = s.substr(1, s.size() - 2);
    return s[0] == s[s.size() - 1] &&
           stringfun::isPalindrome(sub);
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```
Headers and Namespaces

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```
# Pointers vs References

## Pointer
- Variable with a * modifier
- Stores a memory location
- Can modify as a parameter
- Must dereference to use
- Can allocate in heap

## Reference
- Variable with a & modifier
- Refers to another variable
- Can modify as a parameter
- No need to dereference
- Cannot allocate in heap

Java’s reference variables are a combination of the two
## Pointers vs References

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---

**Safer!**
Preferred if do not need heap
When Do We Need the Heap?

- To **return** a non-primitive
  - Return value is on the stack
  - Copied to stack of caller
  - Cannot copy if size variable

- Important for arrays, objects
  - But objects can cheat…

```c
int* makearray(int size) {
    // Array on the stack
    int result[size];
    // Initialize contents
    for(int ii = 0; ii < size; ii++) {
        result[ii] = ii;
    }
    return result; // BAD!
}
```

<table>
<thead>
<tr>
<th>address</th>
<th>value</th>
</tr>
</thead>
<tbody>
<tr>
<td>0x7ed508</td>
<td>???</td>
</tr>
<tr>
<td>0x7ed528</td>
<td>4</td>
</tr>
<tr>
<td>0x7ed548</td>
<td>0</td>
</tr>
<tr>
<td>0x7ed568</td>
<td>1</td>
</tr>
<tr>
<td>0x7ed588</td>
<td>2</td>
</tr>
<tr>
<td>0x7ed5a8</td>
<td>3</td>
</tr>
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Allocation and Deallocation

Not An Array

- Basic format:
  ```
  type* var = new type(params);
  ...
  delete var;
  ```

- Example:
  - `int* x = new int(4);`
  - `Point* p = new Point(1,2,3);`

- One you use the most

Arrays

- Basic format:
  ```
  type* var = new type[size];
  ...
  delete[] var; // Different
  ```

- Example:
  - `int* array = new int[5];`
  - `Point* p = new Point[7];`

- Forget `[]` == memory leak
Strings are a Big Problem

- Java string operations allocate to the heap

- \[ s = \text{"The point is ("} + x + \text{","} + y \text{")}" \]

- How do we manage these in C++?
  - For char*, we don’t. Operation + is illegal.
  - For string, we can use + but it comes at a cost

- **Idea**: Functions to remove string memory worries
  - Formatters like printf and CCLog for direct output
  - Stream buffers to cut down on extra allocations
Displaying Strings in C++

C-Style Formatters

- `printf(format, arg1, arg2, ...)`
  - Substitute into % slots
  - Value after % indicates type
- Examples:
  - `printf("x = %d", 3)`
  - `printf("String is %s", "abc")`
- Primarily used for output
  - Logging/debug (CCLog)
  - Very efficient for output

C++ Stream Buffers

- `strm << value << value << ...`
  - Easy to chain arguments
  - But exact formatting tricky
- Example:
  - `cout << "x = " << 3 << endl`
  - `stringstream s << "x = " << 3`
- Great if you need to `return`
  - More efficient than + op
  - Can concatenate non-strings
How Does Concatenation Work?

- String operations allocate
  - Each string needs memory
  - String ops are expensive
  - C++11 has optimized a lot
- Memory may be on **stack**
  - Almost never **new** strings
  - Return/parameters copied
  - Will see implications later
- What does this mean?
  - Simple operations are okay
  - Otherwise use stringstream

```cpp
void foo() {
    string a = "Hello"; // Stack
    string b("Hello"); // Stack
    // THIS is on the heap
    string c = new String("Hello");
    string d = a + " World"; // Stack
    string e = *c + " World"; // Stack
    // Copies to next frame in stack
    return e;
    // a, b, d, e are deleted
    // c is still in heap
}
```
Next Time: Classes and Closures