the gamedesigninitiative at cornell university

Lecture 9

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

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  - Both in 2110 and several upper-level [illegible]ses
  - If you saw C++, was li[illegible]rse
- Java [illegible]
  - Ma[illegible]
  - Simi[illegible] some important differences
- **This Lecture**: an overview of the differences
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All the sample code is online.
Download and **play with it**.

Comparing Hello World

Java

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

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

  // Application needs a main METHOD
  public static void main(String arg[]){

    System.out.println("Hello World");

  }

}
```

C++

```
/*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

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C++

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#includ

// Appli                                  TION
int main(){

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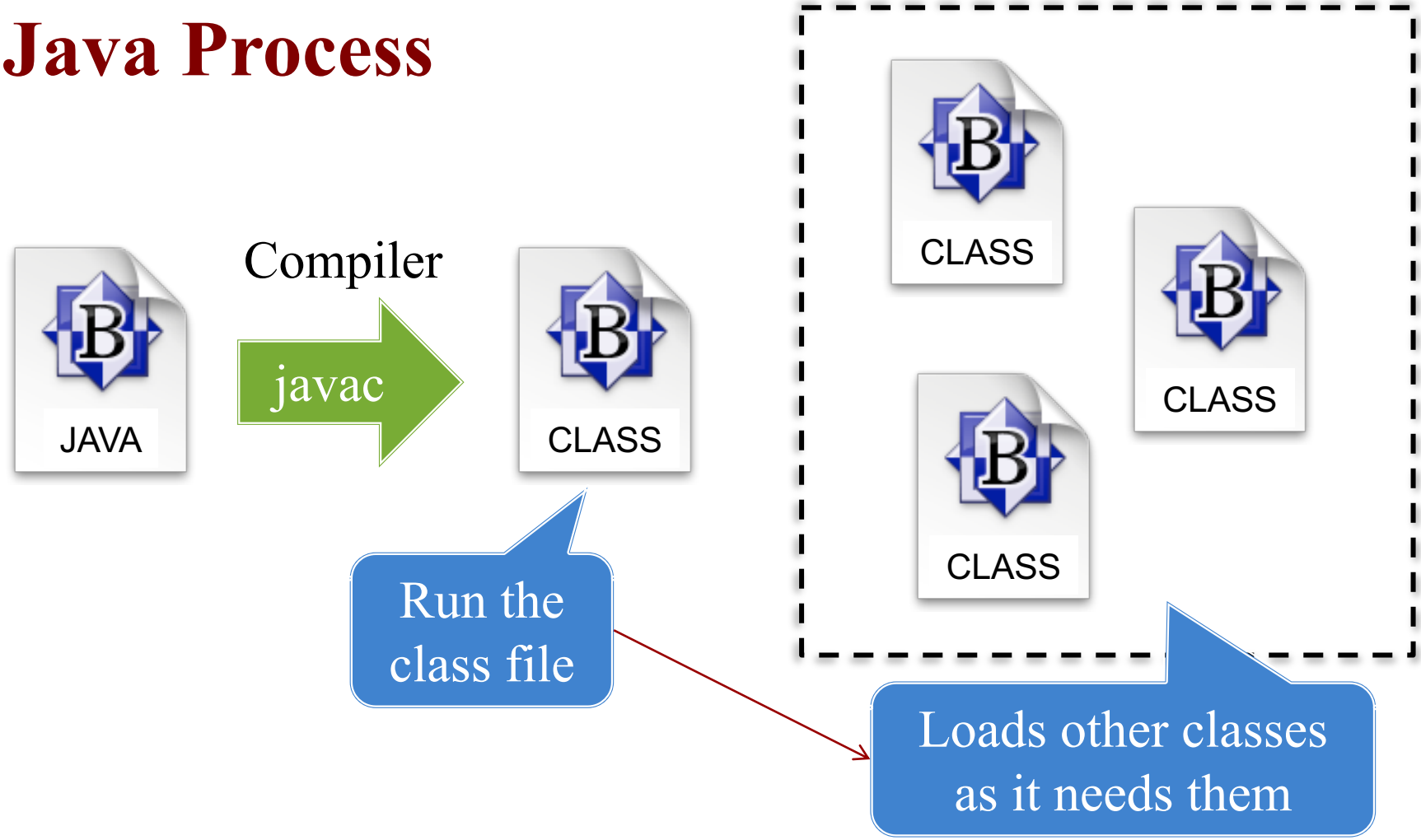
  // Must return something
  return 0;
}
```

C-style console.
In CUGL, use
CULog instead.

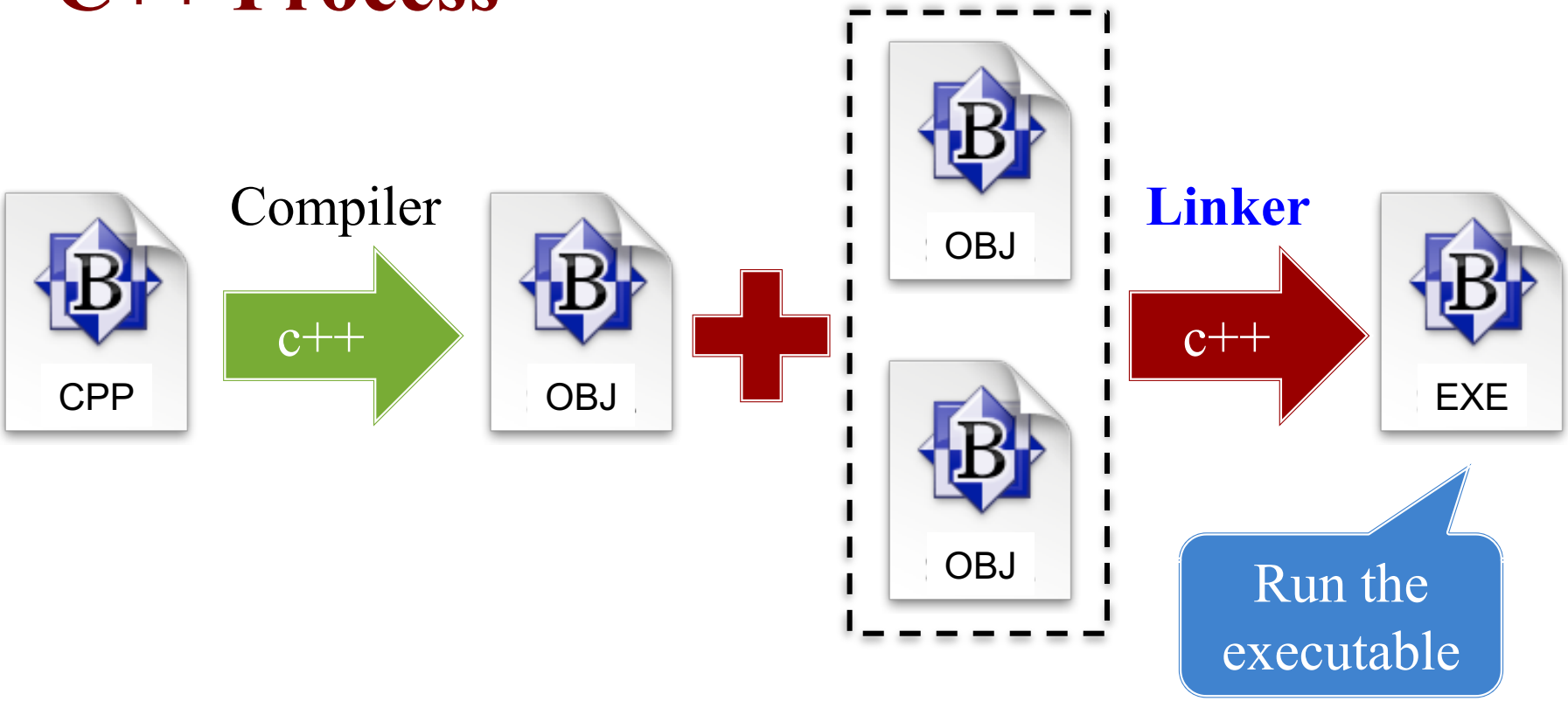
Biggest Difference: **Compilation**

Java Process

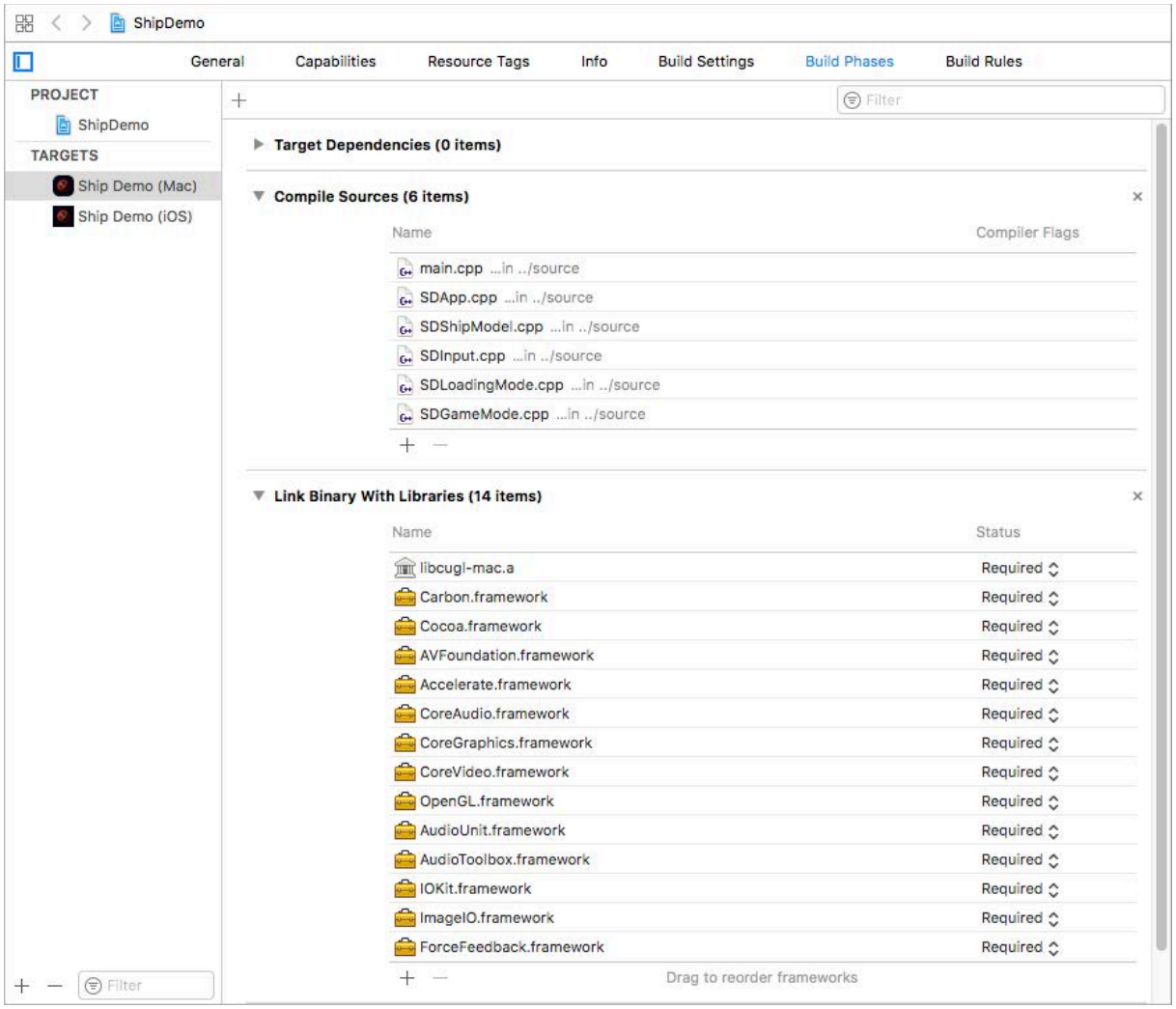


Biggest Difference: Compilation

C++ Process



All Handled by the IDE



All Handled by the IDE

ShipDemo

General | Capabilities | Resource Tags | Info | Build Settings | Build Phases | Build Rules

PROJECT
ShipDemo
TARGETS
Ship Demo (Mac)
Ship Demo (iOS)

Filter

Target Dependencies (0 items)

Compile Sources (6 items)

Name	Compiler Flags
main.cpp ...in ../source	
SDApp.cpp ...in ../source	
SDShipModel.cpp ...in ../source	
SDInput.cpp ...in ../source	
SDLoadingMode.cpp ...in ../source	
SDGameMode.cpp ...in ../source	

Link Binary With Libraries (14 items)

Name	Status
libcugl-mac.a	Required
Carbon.framework	Required
Cocoa.framework	Required
AVFoundation.framework	Required
Accelerate.framework	Required
CoreAudio.framework	Required
CoreGraphics.framework	Required
CoreVideo.framework	Required
	Required
	Required
	Required
	Required
	Required
	Required

Drag to reorder frameworks

Command line work requires a **Makefile**

Makefile Format

```
# 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 Format

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app: main.o helper.o
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# [illegible] linker). Type "make main.o" to get this.
ma[illegible] h helper.h
	$(CC) -c main.cpp

helper.o: helper.cpp helper.h
	$(CC) -c helper.cpp
```

Target

Dependencies

Do if target not there or older than dependencies

Evaluates variable

Makefile Format

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```

Linker step

Compiler step

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

```
/* 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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bool i

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```

Prevents inclusion more than once (which is an error)

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```

Type not built-in

Headers and Namepaces

- 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

```
/* stringfun.h */

#ifndef_STRINGFUN_H_
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#include <string>

namespace stringfun {

  /* True if word a palindrome */
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}

#endif
```

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```
/* stringfun.cpp */

#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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using namespace stringfun;

/* True if word a palindrome */
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{
  if (s.
     return true;
  }

  string s                          ze()-2);
  return s[0]  - s[s.size()-1] &&
     isPalindrome(sub);
}
```

Prefix here

Not here

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

Pointer

- Variable with a * modifier
- Stores a
- Can mo
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- 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

Safer!
Preferred if do not need heap

Java's reference variables are a combination of the two

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…

```
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!
}
```

0x7ed508	???
0x7ed528	4
0x7ed548	0
0x7ed568	1
0x7ed588	2
0x7ed5a8	3

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 = "The point is ("+x+","+y+")"`

    allocate

    allocate
- 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 `CULog` 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 (`CULog`)
  - 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

```
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