CS24 Week 3 Lecture 1

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Overview

- Some minor C++ points
- ADT Review
- Object-oriented Programming
- C++
  - Classes
  - Constructors
  - Destructors
  - More minor Points (if time)

Key Minor Points

`const`

Motivation

- A lot of bugs are rooted in unexpected state changes
  - Something unexpectedly changes a variable's value
  - A "read-only" operation wasn't read-only
- We would like a way to guarantee that state cannot change

Example

What is pointed to is constant	The pointer itself is constant

```
void foo(const char* const s) {
  s[0] = 'a'; // disallowed
  s = NULL; // disallowed
}
```

References

Motivation

- Pointers allow us to indirectly refer to data, which is very powerful
- ...but it's also very error-prone
- We want something in between

References

- These "reference" some other data directly
- References are indirect, but they behave as if they were direct
- Unlike pointers, references are not a distinct kind of data that lives in memory (more restricted)
    - Trying to get the address of a reference gets the address of what it references

References Example 1

```
void swapPointers(int* x, int* y) {
  int temp = *x;
  *x = *y;
  *y = temp;
}

void swapRef(int& x, int& y) {
  int temp = x;
  x = y;
  y = temp;
}
```

References Example 2

```
struct point {
  int x;
  int y;
};

void swap(struct point& p) {
  int temp = p.x;
  p.x = p.y;
  p.y = temp;
}

int addedPoint(const struct point& p) {
  return p.x + p.y;
}
```

ADT Review

- What is the application level?
- What is the logical/abstract level?
- What is the implementation level?

Object-Oriented Programming (OOP)

Observation

- Life is filled with nouns (people, cars, table, projector...)
- These different nouns interact with each other (speak, accelerate, place object on, turn on)
- Often have a concept of internal state (thinking, speed, weight, bulb health)

Observation

- Code can often be modeled in the exact same way

Relationship to OOP

- Nouns - *objects*
- Creating an object - *constructors*
- Which interactions are possible - *methods*
- Performing an interaction - *method calls*
- Internal state - `private` *state*, or *encapsulation*

Constructors

```
Car makeCar(int color);
```

Constructors

```
Car makeCar(int color);
```

Constructing an object

```
Car c = makeCar(GREEN);
```

`c`: `Car` **object**

Constructors

```
makeCar(int color);
```

Methods

```
void  accelerateTo(double mph);
void brake();
double getSpeed();
```

`c:Car` **object**

Constructors

```
makeCar(int color);
```

Methods

```
void  accelerateTo(double mph);
void brake();
double getSpeed();
```

Method call:

```
c.accelerateTo(15.5);
```

`c:Car` **object**

Constructors

`makeCar(int color);`

Methods

```
void  accelerateTo(double mph);
void brake();
double getSpeed();
```

Private State:

`double speed = 15.5;`

`c:Car` **object**

Recall the Rectangle

- Width, height, finding area and perimeter
- What does the constructor look like?
- What sort of methods does it have?
- What kind of internal/private state does it have?

OOP for ADTs

- OOP is great for modeling ADTs. Why?
  - Hint: why was C a suboptimal choice?

OOP for ADTs

- OOP is great for modeling ADTs. Why?
  - Methods good for defining interfaces (logical level)
  - Private state/encapsulation good for hiding implementation details
- C doesn't always make encapsulation easy

OOP in C++

Objects

- In order to make an object, we first need to define a `class`
- A class behaves like a sort of template for making objects
- With the previous example, we would need a `Car` class

Classes

- Hold the constructors, methods, and private state of the objects we want to make
- To make an object, we call a class' constructor to get an *instance* of a class
- Class instances are synonymous with objects

`Car` Class Example

`Rectangle` Class Example

Creating Class Instances

- Can be made either on the stack or the heap
  - On the stack: `Car c(speed);`
  - On the heap: `Car* c = new Car(speed);`
- Both of these examples call the same constructor
- For the heap, can free with: `delete c;`

Constructors in C++

Constructors

- C++ lets us define multiple constructors for a class
- Each can be used to make a class instance

Default Constructor

Default Constructor

- A constructor of special mention is the *nullary*, AKA *default* constructor
  - Takes no arguments
- Used when creating an array of objects on the stack: `Car c[20];`
  - Why?

Default Constructor

- A constructor of special mention is the *nullary*, AKA *default* constructor
  - Takes no arguments
- Used when creating an array of objects on the stack: `Car c[20];`
  - Why? - how would you pass the arguments if it weren't this way?

Default Constructor

- What happens?

```
class Foo {
  private:
    int x;
};
...
Foo f;
```

Default Constructor

- All OK - the compiler generates a *default constructor* for you

```
class Foo {
  private:
    int x;
};
...
Foo f;
```

Default Constructor

- What happens?

```
class Foo {
  private:
    int x;
};
...
Foo f; f.x;
```

Default Constructor

- Undefined - `f.x` can be set, but not accessed

```
class Foo {
  private:
    int x;
};
...
Foo f; f.x;
```

Default Constructor

- What happens?

```
class Foo {
  public:
    Foo(int y);
  private:
    int x;
};
...
Foo f;
```

Default Constructor

- Compile-time error: compiler cannot generate a default constructor

```
class Foo {
  public:
    Foo(int y);
  private:
    int x;
};
...
Foo f;
```

Copy Constructor

Copy Constructor

- Used in contexts where we need to copy an object
  - Declarations with initialization
  - Function calls

```
Car(const Car& other);
```

Copy Constructor

- What happens?

```
class Foo {
  public:
    Foo(int y);
  private:
    int x;
};
...
Foo a(1);
Foo b = a; // copy constructor
```

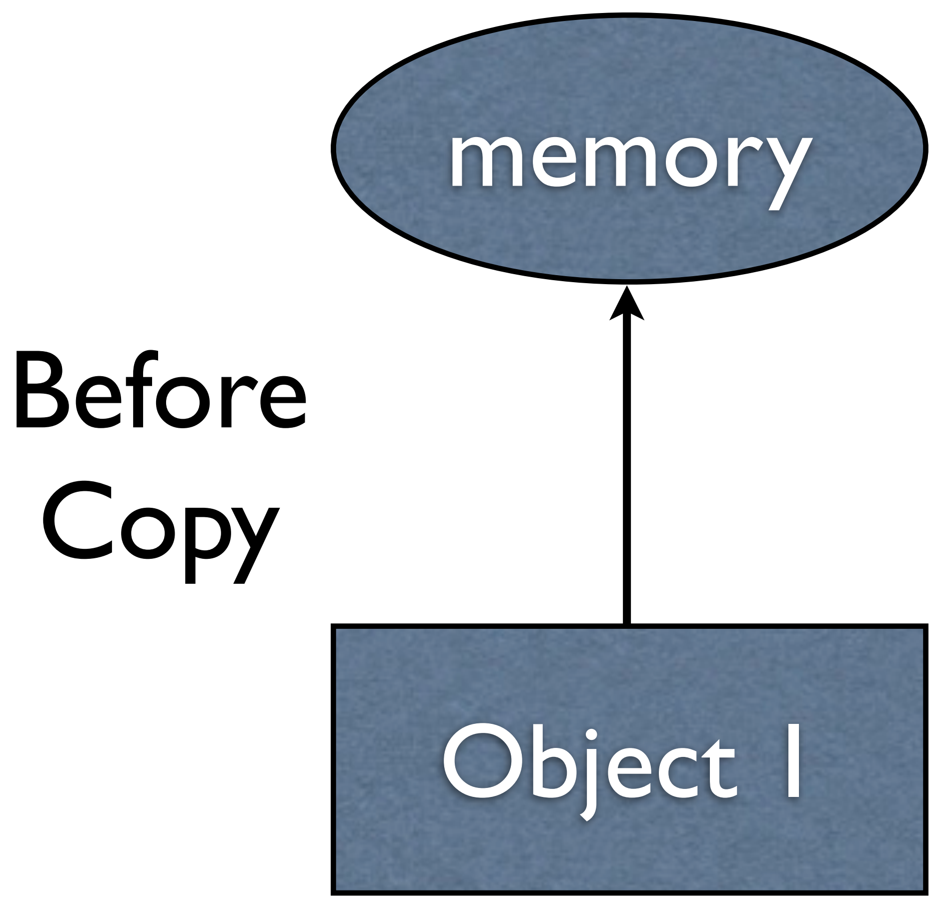
Copy Constructor

- All ok - the compiler generates a default copy constructor that copies everything

```
class Foo {
   public:
      Foo(int y);
   private:
      int x;
};
...
Foo a(1);
Foo b = a; // copy constructor
```

Default Copy Constructor

- Caveat: the copy performed is a *shallow* copy



Default Copy Constructor

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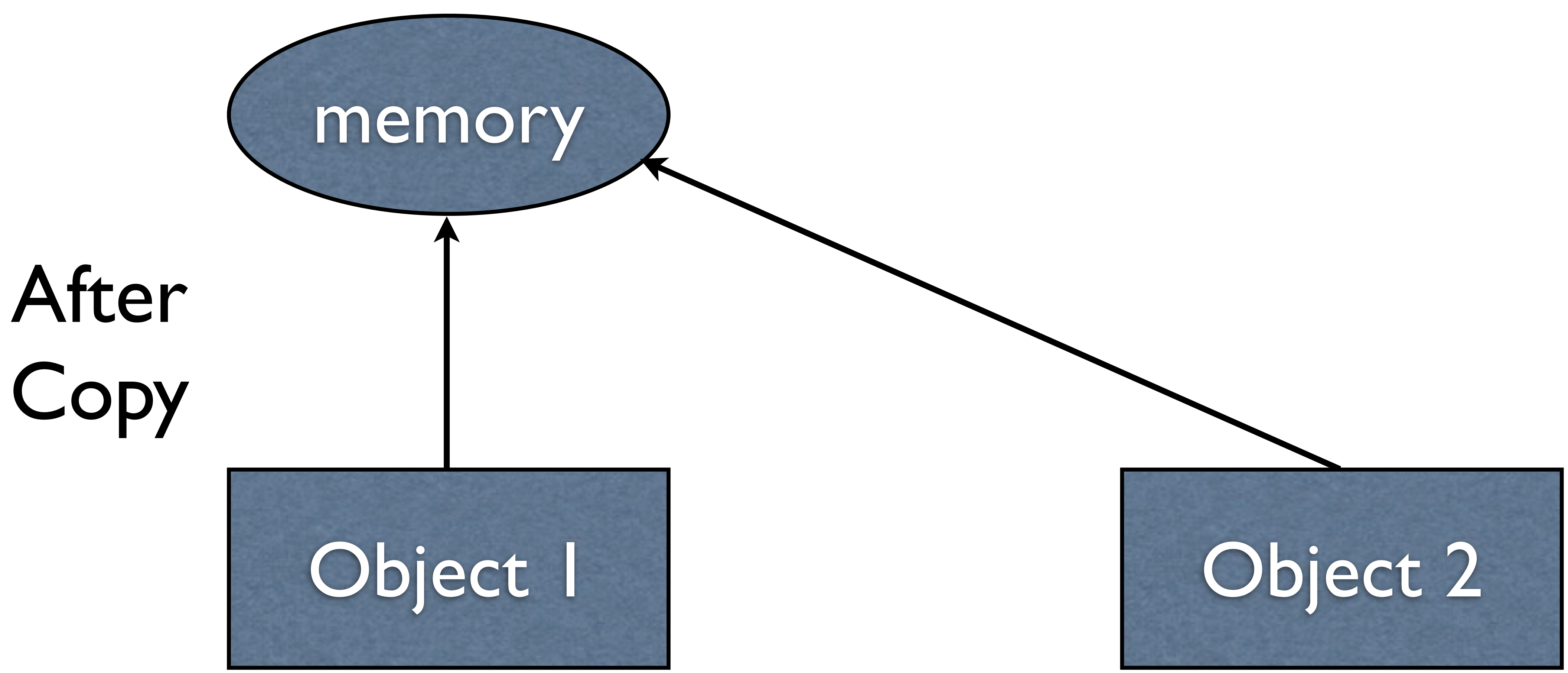
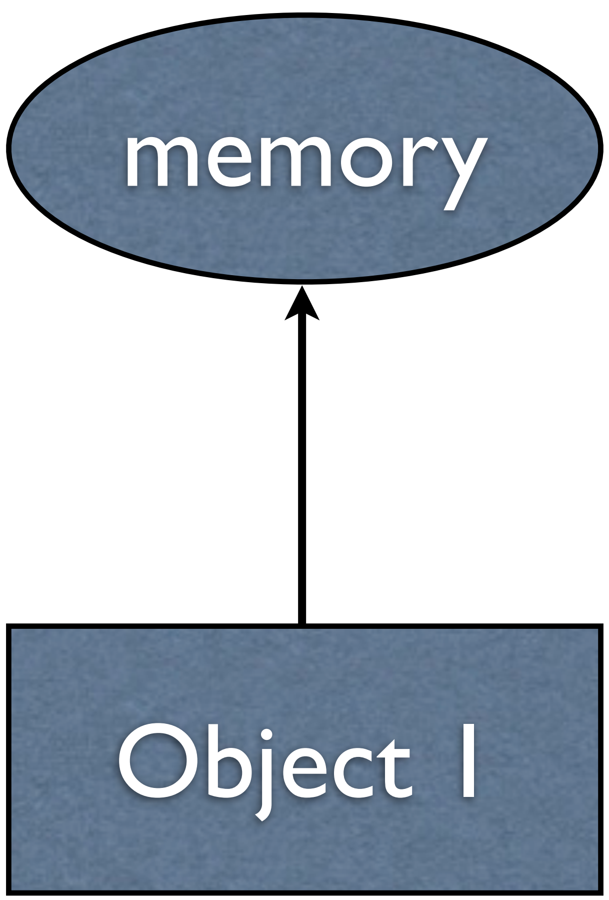


Default Copy Constructor

- If you want a *deep copy*, you must do it yourself with your own copy constructor

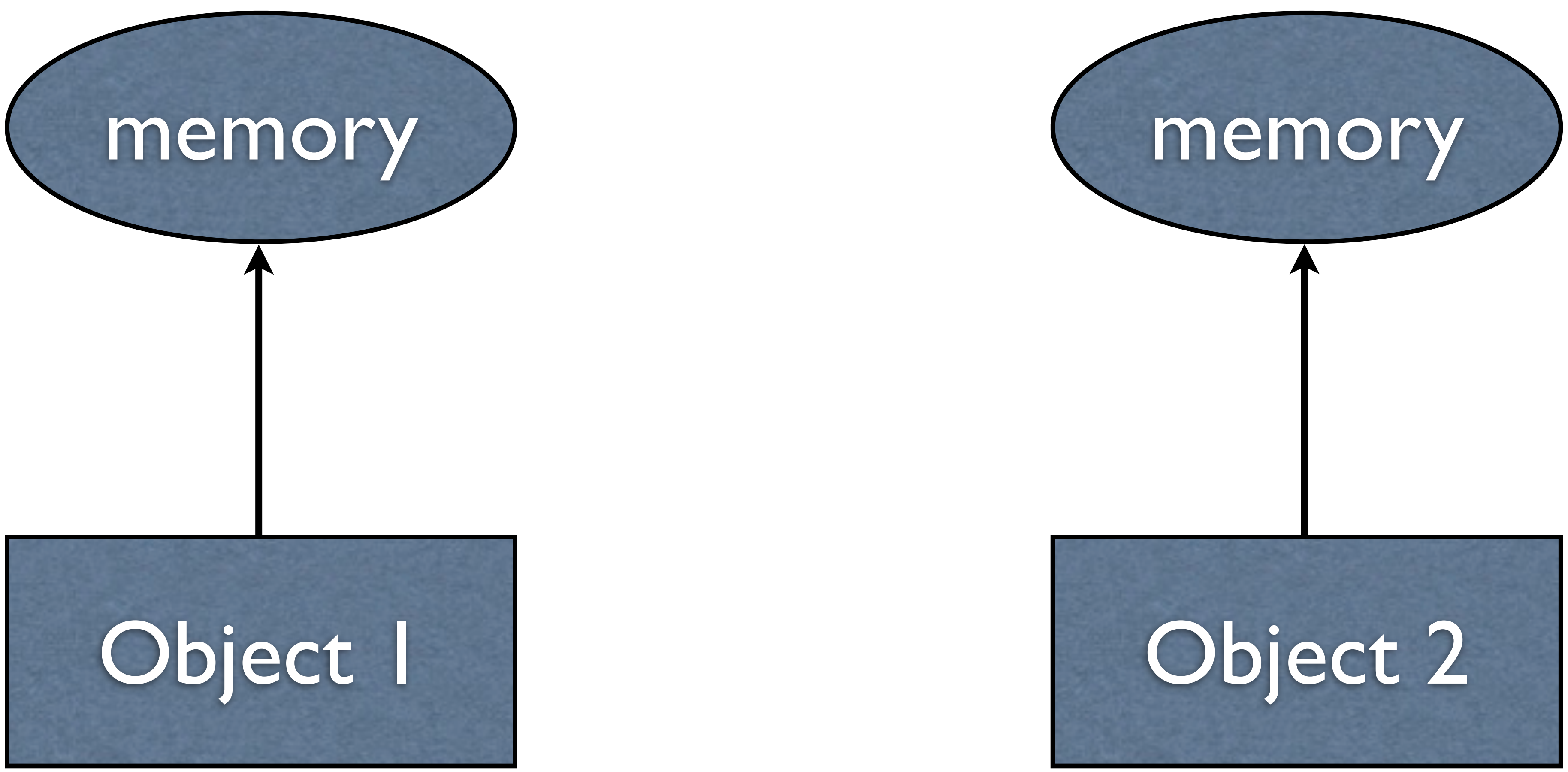
Before Copy



Default Copy Constructor

- If you want a *deep copy*, you must do it yourself with your own copy constructor

After Copy



Destructors

Destructors

- Optionally, you can define a destructor for a class: `Car::~Car() {}`
- Destructors are called during deallocation
  - When is this for something on the stack?
  - When is this for something on the heap?

Destructors

- Optionally, you can define a destructor for a class: `Car::~Car() {}`
- Destructors are called during deallocation
  - When is this for something on the stack?
    - Return from scope that introduced it
  - When is this for something on the heap?
    - When `delete` is called on it

Destructors

- Useful for objects which dynamically allocate memory internally
  - Why?

Destructors

- Useful for objects which dynamically allocate memory internally
  - Why? - Allows for memory to be deallocated in synchronization with the object being deallocated

More Minor Points

#include

`#include`

- No longer correct to put `.h` after the filename for **system-provided** files
- Still expected for your own files

```
// provided by system:
#include <iostream>

// provided by you:
#include “myfile.h”
```

Namespaces

Motivation

- Every name (variable, function, `struct`) in C lives in the some distinct *namespace*
- Means we cannot define two variables with the same name at the same scope
  - Global variable pain

Namespaces

- A way for the programmer to define custom namespaces
- In this class, you won't be defining your own, but you will be using existing ones
  - Most notable: `std` for the standard library

Namespaces

- Need to fully specify the name of something
- For example, `endl` is defined in namespace `std`, so to use it we must say:
  - `std::endl`

Namespaces

- Repeatedly typing out the namespace can be annoying, so we can instead say:
  - `using std::endl;`
- ...and then later simply say `endl` everywhere we would have said `std::endl`

Namespaces

- Sometimes we want everything from a namespace. For that, we can say:
  - `using namespace std;`
  - ...to put everything in the std namespace in scope (no more need to prepend `std::` to everything)

Terminal I/O

Terminal I/O

- Terminal input and output are modeled as *streams* that can be read from and written to
  - `cin`: input stream
  - `cout`: output stream
  - `cerr`: error stream (often synonymous with the output stream)

Reading and Writing

- Can be done using >> and <<, respectively

```
#include <iostream>

using namespace std;

int main() {
  int x;
  cin >> x;
  cout << "Saw: " << x << endl;
  return 0;
}
```