Introduction To Object-Oriented Programming

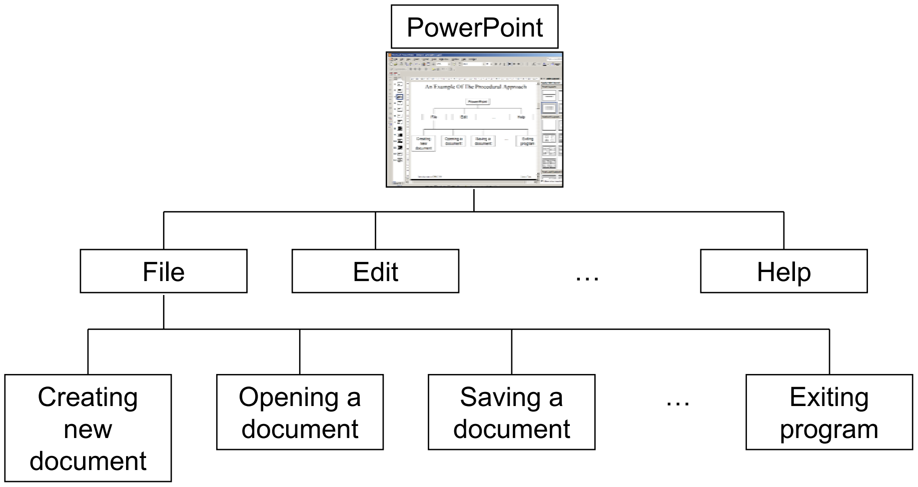
This section includes introductions to fundamental object-oriented principles such as information hiding, overloading, relationships between classes as well the object-oriented approach to design.

Reminder: What You Know

- There are different paradigms (approaches) to implementing computer programs.
- There are several different paradigms but the two you have been introduced to thus far:
  - Procedural
  - Object-Oriented.

An Example Of The Procedural Approach

•Break down the program by what it does (described with *actions/verbs*)



An Example Of The Object-Oriented Approach

•Break down the program into ‘physical’ components (*nouns*)

Dungeon Master

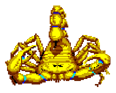
Monsters	
•Scorpion	•Mummy
•Ghost	•Screamer
•Knight	•Dragon

Weapons	
•Broadsword	•Rapier
•Longbow	•Mace

Example Objects: Monsters From Dungeon Master[1]

- Dragon

- Scorpion



- Couatl

1 Dungeon Master © FTL

Ways Of Describing A Monster

What information can be used to describe the dragon? (Attributes)

What can the dragon do? (Behaviors)

Monsters: Attributes

•Represents information about the monster:

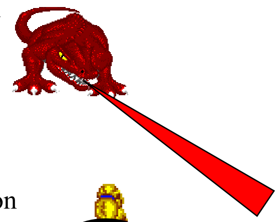
- Name
- Damage it inflicts
- Damage it can sustain
- Speed

:

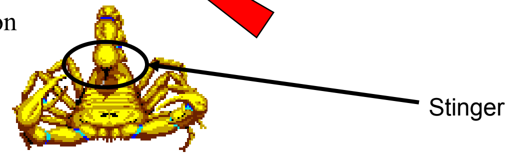
Monsters: Behaviours

- Represents what each monster can do (verb part):

- Dragon

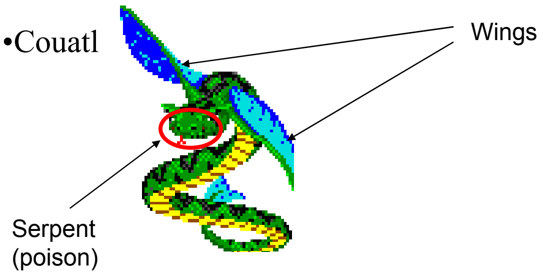


- Scorpion



Monsters: Operations

•Couatl



Working With Objects In Java

I. Define the class
II. Create an instance of the class (instantiate an object)
III. Using the different parts of an object (data and methods)

I) Defining A Java Class

Format:

```
public class <name of class>
{
    instance fields/attributes
    instance methods
}
```

Example:

```
public class Person
{
    // Define instance fields
    // Define instance methods
}
```

James Tam

Defining A Java Class (2)

Format of instance fields:

```
<access modifier>1  <type of the field> <name of the field>;
```

•**Example of defining instance fields**:

```
public class Person
{
    private int age;
}
```

1) Can be public or private but typically instance fields are private

2) Valid return types include the simple types (e.g., int, char etc.), predefined classes (e.g., String) or new classes that you have defined in your program. A method that returns nothing has a return type of "void".

James Tam

Defining A Java Class (3)

Format of instance methods:

```
<access modifier>¹ <return type²> <method name> (<p1 type> <p1
  name>…)
  {
        <Body of the method>
  }
```

Example of an instance method:

```
public class Person
{
    public void fun (int num)
    {
        System.out.println (num);
    }
}
```

1) Can be public or private but typically instance methods are public

2) Valid return types include the simple types (e.g., int, char etc.), predefined classes (e.g., String) or new classes that you have defined in your program. A method that returns nothing has return type of "void".

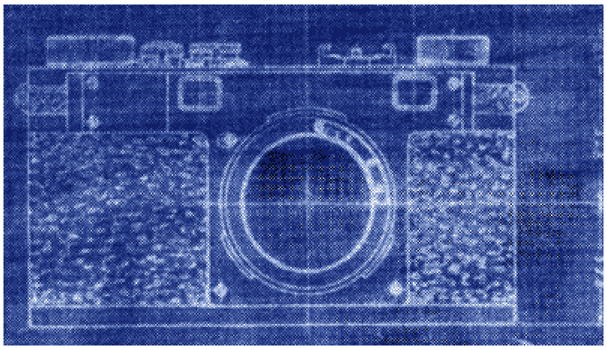
Defining A Java Class (4)

Example (complete class definition):

```
public class Person
{
    private int age;
    public void setAge (int anAge)
    {
        age = anAge;
    }
    public int getAge ()
    {
        return age;
    }
}
```

A Class Is Like A Blueprint

- It indicates the format for what an example of the class should look like (methods and attributes).
- Similar to a definition of composite types which bundle data e.g., C struct, (except methods can be specified).
- No memory is allocated.



II) Creating/Instantiating Instances Of A Class

Format:

```
<class name> <instance name> = new <class name> ();
```

Example:

```
Person jim = new Person();
```

- Note: 'jim' is not an object of type 'Person' but a reference to an object of type 'Person' (more on this later).

An Instance Is An Actual Example Of A Class

- Instantiation is when an actual example/instance of a class is created.

Declaring A Reference Vs. Instantiating An Instance

- Declaring a reference to a 'Person'

```
Person jim;
```

- Instantiating/creating an instance of a 'Person'

```
jim = new Person ();
```

III) Using The Parts Of A Class

Format:

<instance name>.<attribute name>;

<instance name>.<method name>(*<p1 name>*, *<p2 name>…*);

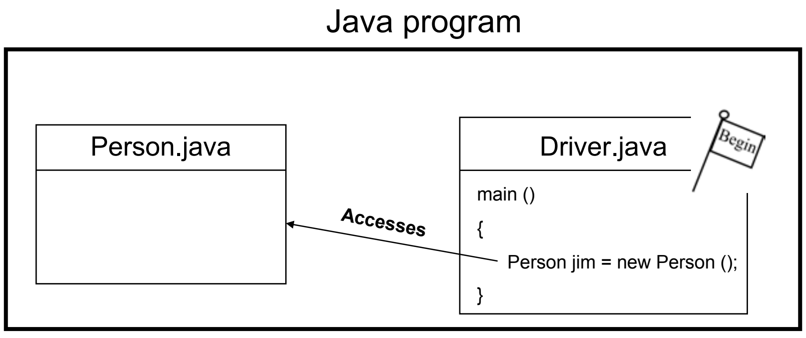
Example:

```
int anAge = 27;
Person jim = new Person ();
jim.setAge(anAge);
System.out.println(jim.getAge());
```

Note: In order to use the dot-operator "." the instance field or method cannot have a private level of access

Laying Out Your Program

- The program must contain a 'Driver' class (or equivalent).
- The driver class is the place where the program starts running (**it contains the main method**).
- Instances of other classes can be created and used here.
- For now you should have all the classes for a particular program reside in the same directory or folder.



Laying Out Your Program

•The code for each class should reside in its own separate file.

Person.java

```
class Person
{
    :    :
}
```

Driver.java

```
class Driver
{
    :    :
}
```

Putting It Altogether: First Object-Oriented Example

•Example (The complete example can be found in the directory /home/233/examples/introductionOO/firstExample

```
public class Driver
{
   public static void main (String [] args)
   {
        int anAge = 27;
        Person jim = new Person ();
        jim.setAge(anAge);
        System.out.println("Jim's current age is..." + jim.getAge());
   }
}
```

Putting It Altogether: First Object-Oriented Example (2)

```
public class Person
{
   private int age;
   public void setAge (int anAge)
   {
       age = anAge;
   }
   public int getAge ()
   {
       return age;
   }
}
```

Compilation With Multiple Classes

- In the previous example there were two classes: 'Driver' and 'Person'.
- One way (safest) to compile the program would entail compiling each source code (dot-Java) file:
  - javac Driver.java
  - javac Person.java
- However in this program a method of the Driver class contains a reference to an instance of class Person.

```
public static void main (String [] args)
{
    Person jim = new Person ();
}
```

- The Java compiler can detect that this dependency exists.

Compilation With Multiple Classes (2)

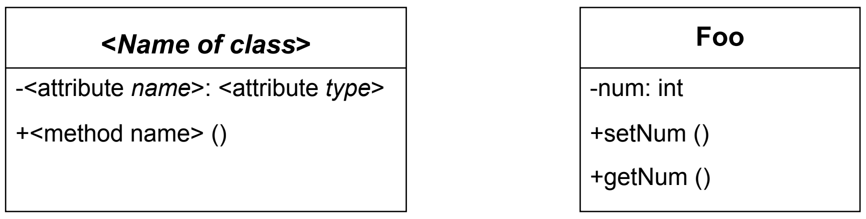
- The effect *in this example* is that when the Driver class is compiled, the code in class Person *may* also be compiled.
  - Typing: "java Driver.java" produces a "Driver.class" file (or produces an updated compiled version if a byte code file already exists).
  - If there is no "Person.class" file then one will be created.
  - If there already exists a "Person.class" file then an updated version will *not* be created (unless you explicitly compile the corresponding source code file).
- Moral of the story: when making changes to multiple source code (dot-Java files) make sure that you compile each individual file or at least remove existing byte code (dot-class) files prior to compilation.

Points To Keep In Mind About The Driver Class

- Contains the only main method of the whole program (where execution begins)
- Do not instantiate instances of the Driver[1]
- For now avoid:
  - Defining instance fields / attributes for the Driver[1]
  - Defining methods for the Driver (other than the main method)[1]

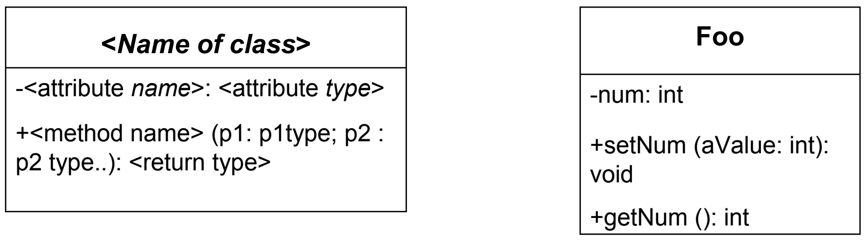
1 Details will be provided later in this course

UML[1] Representation Of A Class



1 UML = Unified Modeling Language

Class Diagrams With Increased Details


<Name of class>
-<attribute name>: <attribute type>
+<method name> (p1: p1type; p2 : p2 type..): <return type>
Foo
-num: int
+setNum (aValue: int): void
+getNum (): int

2 UML = Unified Modeling Language

Attributes Vs. Local Variables

- Class attributes (variables or constants)
  - Declared inside the body of a class definition but outside the body of any class methods.

```
class Foo
{
    private int num;
}
```

  - Typically there is a separate attribute for each instance of a class and it lasts for the life of the object.

- Local variables and constants
  - Declared within the body of a class' method.
  - Last for the life of the method

```
class Foo
{
    public void aMethod () { char ch; }
}
```

James Tam

Examples Of An Attribute

```
public class Person
{
    private int age;
    public void setAge (int newAge)
    {
        int aLocal;
        age = newAge;
    }
        :
}
            :
 main (String [] args)
 {
      Person jim = new Person ();
      Person joe = new Person ();
 }
```

"age": Declared within the definition of a class

James Tam

Examples Of An Attribute

```
public class Person
{
    private int age;
    public void setAge (int anAge)
    {
         int aLocal;
         age = anAge;
    }
         :
}
              :
 main (String [] args)
 {
       Person jim = new Person ();
       Person joe = new Person ();
 }
```

But declared outside of the body of a method

Example Of A Local Variable

```
public class Person
{
    private int age;
    public void setAge (int anAge)
    {
         int aLocal;
         age = anAge;
     }
              :
}
              :
 main (String [] args)
 {
       Person jim = new Person ();
       Person joe = new Person ();
       jim.setAge (5);
       joe.setAge (10);
 }
```

"aLocal": Declared inside the body of a method

Scope Of Local Variables

- Enter into scope
  - Just after declaration
- Exit out of scope
  - When the corresponding enclosing brace is encountered

```
public class Bar
{
                  public void aMethod ()
                  {
                      int num1 = 2;
                      if (num1 % 2 == 0)
                      {
                          int num2;
                          num2 = 2;
                      }
                  }
```

$\left.\begin{array}{l} \text{int num1 = 2;} \\ \text{if (num1 \% 2 == 0)} \\ \{ \\ \quad \text{int num2;} \\ \quad \text{num2 = 2;} \end{array}\right\}$ Scope of num1

Scope Of Local Variables

- Enter into scope
  - Just after declaration
- Exit out of scope
  - When the proper enclosing brace is encountered

```
public class Bar
{
                  public void aMethod ()
                  {
                      int num1 = 2;
                      if (num1 % 2 == 0)
                      {
                          int num2;
                          num2 = 2;
                      }
                  }
```

Scope of num2 $\left[\begin{array}{l} \text{int num2;} \\ \text{num2 = 2;} \end{array}\right.$

Scope Of Attributes

```
public class Bar
{
            private int num1;
                        :             :
            public void methodOne ()
            {
                num1 = 1;
                num2 = 2;
            }
            public void methodTwo ()
            {
                num1 = 10;
                num2 = 20;
                methodOne ();
            }
                        :             :
            private int num2;
}
```

Scope of num1 & num2

Scope Of Attributes

```
public class Bar
{
            private int num1;
                        :             :
            public void methodOne ()
            {
                num1 = 1;
                num2 = 2;
            }
            public void methodTwo ()
            {
                num1 = 10;
                num2 = 20;
                methodOne ();
            }
                        :             :
            private int num2;
}
```

Scope of methodOne and methodTwo

Referring To Attributes And Methods Outside Of A Class: An Example

```
public class Bar
{
    public void aMethod ()
    {
        System.out.println("Calling aMethod of class Bar");
    }
}
```

Scope of aMethod

James Tam

Referring To Attributes And Methods Outside Of A Class: An Example

```
public class Bar
{
    public void aMethod ()
    {
        System.out.println("Calling aMethod of class Bar");
    }
}

public class Driver
{
    public static void main (String [] args)
    {
        Bar b1 = new Bar ();
        Bar b2 = new Bar ();
        b1.aMethod();
    }
}
```

Outside the scope (dot operator is needed)

James Tam

Referring To Attributes And Methods Inside Of A Class: An Example

```
public class Foo
{
      private int num;
      public Foo () { num = 0; }
      public void methodOne () { methodTwo(); }
      public void methodTwo () { .. }
             :            :            :
}
  :          :
   main ()
   {
       Foo f1 = new Foo ();
       Foo f2 = new Foo ();
       f1.methodOne();
    }
```

Call is inside the scope (no instance name or 'dot' needed

Call is outside the scope (instance name and 'dot' IS needed

James Tam

Referring To The Attributes And Methods Of A Class: Recap

1. Outside the methods of the class you must use the dot-operator as well as indicating what instance that you are referring to.

   e.g., f1.method();

2. Inside the methods of the class there is no need to use the dot-operator nor is there a need for an instance name.

   e.g.,

```
public class Foo
{
  public void m1 () { m2(); }
  public void m2 () { .. }
}
```

James Tam

Shadowing

~~One form of shadowing occurs when a variable local to the method of a class has the same name as an attribute of that class.~~

- ~~Be careful of accidentally doing this because the wrong identifier could be accessed.~~

NO!

```
public class Sheep
{
    private String name;
    public Sheep (String aName)
    {
        String name;
        name = aName;
    }
```

Shadowing

Scope Rules:

1. Look for a local identifier (variable or constant)
2. Look for an attribute

```
public class Foo
{
    // Attributes
    public void method ()
    {
        // Local variables

        num = 1;
    }
}
```

Second: Look for an attribute by that name

First: Look for a local identifier by that name

A reference to an identifier

Encapsulation

- The ability bundle information (attributes) and behavior (methods) into a single entity.
- In Java this is done through a class definition.
- Other languages: C (“struct”), C++/Python (“class”), Pascal (“record”).

Information Hiding

- An important part of Object-Oriented programming and takes advantage of encapsulation.
- Protects the inner-workings (data) of a class.

- Only allow access to the core of an object in a controlled fashion (use the *public* parts to access the *private* sections).

Illustrating The Need For Information Hiding: An Example

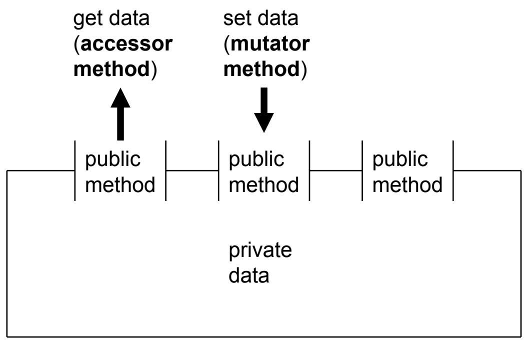
- •Creating a new monster: “The Critter”
- •Attribute: Height (must be 60” – 72”)

Illustrating The Need For Information Hiding: An Example

- •Creating a new monster: “The Critter”
- •Attribute: Height (must be 60” – 72”)

Public And Private Parts Of A Class

• The public methods can be used to do things such as access or change the instance fields of the class



Public And Private Parts Of A Class (2)

• Types of methods that utilize the instance fields:

1) **Accessor methods**: a 'get' method
   - Used to determine the current value of a field
   - Example:

```
public int getNum ()
{
    return num;
}
```

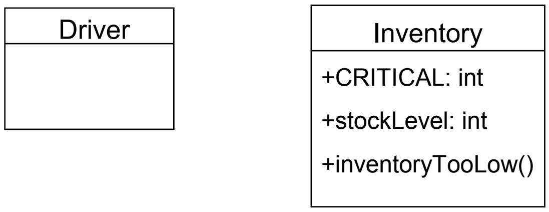
2) **Mutator methods**: a 'set' method
   - Used to set a field to a new value
   - Example:

```
public void setNum (int aValue)
{
    num = aValue;
}
```

How Does Hiding Information Protect The Class?

- Protects the inner-workings (data) of a class
  - e.g., range checking for inventory levels (0 – 100)

- The complete example can be found in the directory /home/233/examples/introductionOO/secondExample



The Inventory Class

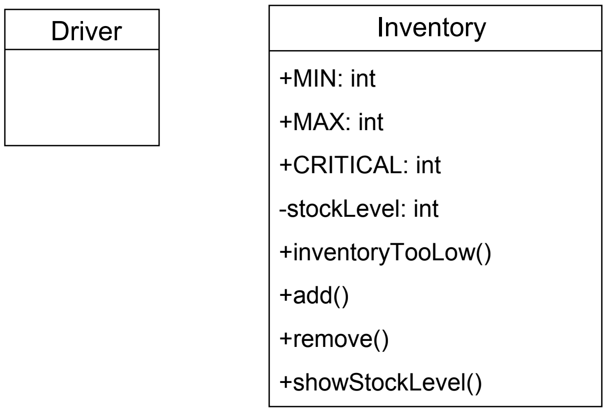
```
public class Inventory
{

   public final int CRITICAL = 10;
   public int stockLevel;
   public boolean inventoryTooLow ()
   {
        if (stockLevel < CRITICAL)
            return true;
       else
            return false;
   }
}
```

The Driver Class

```
public class Driver
{
    public static void main (String [] args)
    {
        Inventory chinook = new Inventory ();
        chinook.stockLevel = 10;
        System.out.println ("Stock: " + chinook.stockLevel);
        chinook.stockLevel = chinook.stockLevel + 10;
        System.out.println ("Stock: " + chinook.stockLevel);
        chinook.stockLevel = chinook.stockLevel + 100;
        System.out.println ("Stock: " + chinook.stockLevel);
        chinook.stockLevel = chinook.stockLevel - 1000;
        System.out.println ("Stock: " + chinook.stockLevel);
    }
}
```

Utilizing Information Hiding: An Example

•The complete example can be found in the directory /home/233/examples/introductionOO/thirdExample



The Inventory Class

```
public class Inventory
{
    public final int CRITICAL = 10;
    public final int MIN = 0;
    public final int MAX = 100;
    private int stockLevel = 0;

    // Method definitions
    public boolean inventoryTooLow ()
    {
        if (stockLevel < CRITICAL)
            return true;
        else
            return false;
    }
```

The Inventory Class (2)

```
    public void add (int amount)
    {
        int temp;
        temp = stockLevel + amount;
        if (temp > MAX)
        {
            System.out.println();
            System.out.print("Adding " + amount + " item will cause stock ");
            System.out.println("to become greater than " + MAX + " units
               (overstock)");
        }
        else
        {
            stockLevel = temp;
        }
    } // End of method add
```

The Inventory Class (3)

```
    public void remove (int amount)
    {
        int temp;
        temp = stockLevel - amount;
        if (temp < MIN)
        {
            System.out.print("Removing " + amount + " item will cause stock ");
            System.out.println("to become less than " + MIN + " units
              (understock)");
        }
        else
        {
            stockLevel = temp;
        }
    }

    public String showStockLevel () { return("Inventory: " + stockLevel); }
}
```

The Driver Class

```
public class Driver
{
    public static void main (String [] args)
    {
        Inventory chinook = new Inventory ();
        chinook.add (10);
        System.out.println(chinook.showStockLevel ());
        chinook.add (10);
        System.out.println(chinook.showStockLevel ());
        chinook.add (100);
        System.out.println(chinook.showStockLevel ());
        chinook.remove (21);
        System.out.println(chinook.showStockLevel ());
        // JT: The statement below won't work and for good reason!
        // chinook.stockLevel = -999;
    }
}
```

Information Hiding

VERSION I: BAD!!! ☹

```
public class Inventory
{

    public final int CRITICAL = 10;
    public int stockLevel;
            :           :

}


:           :
chinook.stockLevel = <value!!!>
```

Allowing direct access to the attributes of an object by other programmers is dangerous!!!

VERSION II: BETTER! :D

```
public class Inventory
{
    public final int CRITICAL = 10;
    public final int MIN = 0;
    public final int MAX = 100;
    private int stockLevel = 0;
            :           :
    // mutator and accessors
}
:           :
chinook.add (<value>);
```

Only allow access to privates attributes via public mutators and accessors

James Tam

Method Overloading

- Same method name but the type, number or order of the parameters is different (method signature).
- Used for methods that implement similar but not identical tasks.
- Method overloading is regarded as good coding style.
- Example:

```
System.out.println(int)
System.out.println(double)
    etc.
```

For more details on class System see:

- http://java.sun.com/j2se/1.5.0/docs/api/java/io/PrintStream.html

James Tam

Method Overloading (2)

- Things to avoid when overloading methods
  1. Distinguishing methods solely by the order of the parameters.
  2. Overloading methods but having an identical implementation.

Method Signatures And Program Design

- Unless there is a compelling reason do not change the signature of your methods!

Before:

```
Class Foo
{
    void fun ()
    {

    }
}
```

After:

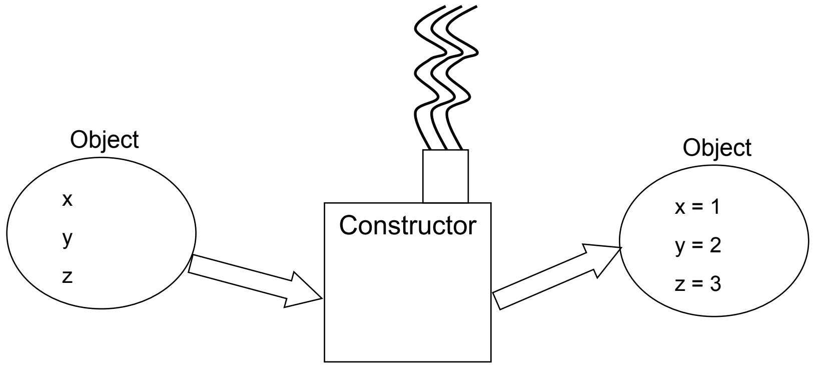
```
Class Foo
{
    void fun (int num)
    {

    }
}
```

```
public static void main ()
{
    Foo f = new Foo ();
    f.fun ()
}
```

This change has broken me! ☹

Creating Objects With The Constructor

- A method that is used to initialize the attributes of an object as the objects are instantiated (created).
- The constructor is automatically invoked whenever an instance of the class is created.



Creating Objects With The Constructor (2)

- If no constructor is specified then the **default constructor** is called
  - e.g., Sheep jim = new Sheep();

The call to 'new' calls the default constructor (if no constructor method has been explicitly defined in the class) as an instance of the class is instantiated.

Writing Your Own Constructor

Format (Note: *Constructors have no return type*):

```
public <class name> (<parameters>)
{
     // Statements to initialize the fields of the object
}
```

Example:

```
 public Sheep ()
{
    System.out.println("Creating \"No name\" sheep");
    name = "No name";
}
```

Overloading The Constructor

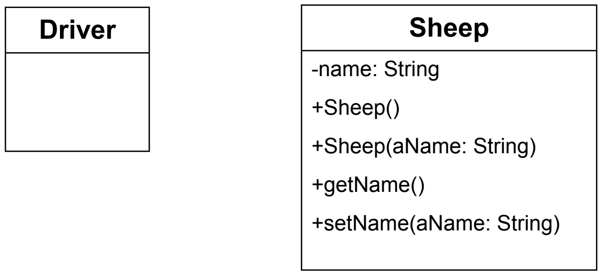
•Similar to other methods, constructors can also be overloaded

•Each version is distinguished by the number, type and order of the parameters

```
public Sheep ()
public Sheep (String aName)
```

Constructors: An Example

•The complete example can be found in the directory /home/233/examples/introductionOO/fourthExample



The Sheep Class

```
public class Sheep
{
   private String name;

   public Sheep ()
   {
      System.out.println("Creating \"No name\" sheep");
      setName("No name");
   }

   public Sheep (String aName)
   {
      System.out.println("Creating the sheep called " + aName);
      setName(aName);
   }
```

The Sheep Class (2)

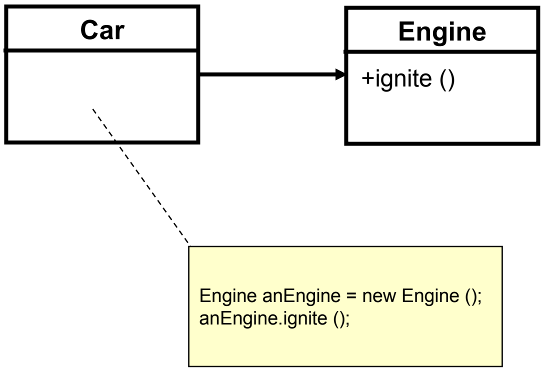
```
    public String getName ()
    {
        return name;
    }

    public void setName (String aName)
    {
        name = aName;
    }
}
```

The Driver Class

```
public class Driver
{
    public static void main (String [] args)
    {
        Sheep nellie;
        Sheep jim;
        System.out.println();
        System.out.println("Creating flock...");
        nellie = new Sheep ("Nellie");
        jim = new Sheep();
        jim.setName("Jim");
        System.out.println("Displaying updated flock");
        System.out.println("   " + nellie.getName());
        System.out.println("   " + jim.getName());
        System.out.println();
    }
}
```

Association Relations Between Classes

•A relation between classes allows messages to be sent (objects of one class can call the methods of another class).



```
Engine anEngine = new Engine ();
anEngine.ignite ();
```

Associations Between Classes

•One type of association relationship is a 'has-a' relation (also known as "aggregation").

- E.g. 1, A car <has-a> engine.
- E.g. 2, A lecture <has-a> student.

•Typically this type of relationship exists between classes when a class is an attribute of another class.

```
public class Car
{
        private Engine anEngine;
        private Lights headLights;
        public start ()
        {
           anEngine.ignite ();
           headLights.turnOn ();
        }
}
```

```
public class Engine
{
        public boolean ignite () { .. }
}

public class Lights
{
        private boolean isOn;
        public void turnOn () { isOn =
        true;}
}
```

Directed Associations

- Unidirectional
  - The association only goes in one direction.
  - You can only navigate from one class to the other (but not the other way around).
  - e.g., You can go from an instance of Car to Lights but not from Lights to Car, or you can go from an instance of Car to Engine but not from Engine to Car (previous slide).

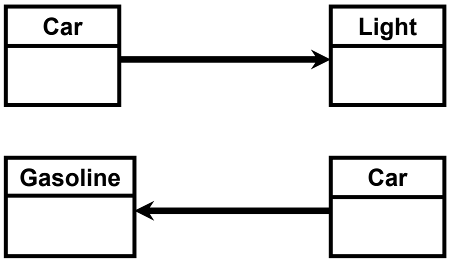
Directed Associations (2)

- Bidirectional
  - The association goes in both directions
  - You can navigate from either class to the other
  - e.g.,

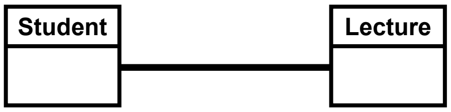
```
public class Student
{
    private Lecture [] lectureList = new Lecture [5];
                            :
}

public class Lecture
{
        private Student [] classList = new Student [250];
                            :
 }
```

UML Representation Of Associations

Unidirectional associations



Bidirectional associations

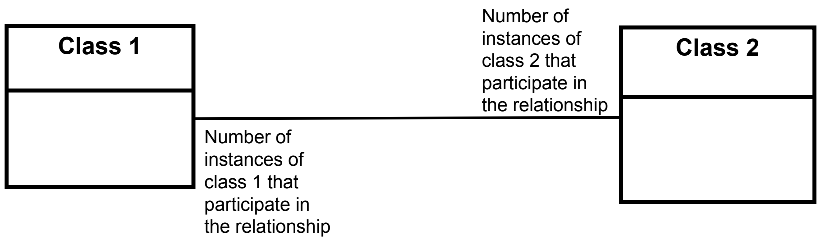


Multiplicity

- It indicates the number of instances that participate in a relationship
- Also known as cardinality

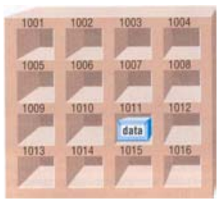
Multiplicity	**Description**
1	Exactly one instance
n	Exactly "n" instances
n..m	Any number of instances in the inclusive range from "n" to "m"
*	Any number of instances possible

Multiplicity In UML Class Diagrams

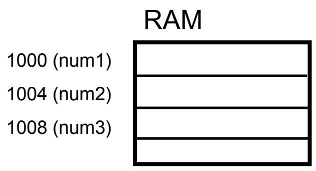

Class 1
Class 2
Number of instances of class 2 that participate in the relationship
Number of instances of class 1 that participate in the relationship

Review/New Topic: Hardware

- Computer memory: RAM (*R*andom *A*ccess *M*emory).
- Consists of a number slots that can each store information.



- Normally locations in memory are not accessed via the numeric addresses but instead through variable names.



Picture from Computers in your future by Pfaffenberger B

Variables: Storing Data Vs. Address

- What you have seen so far are variables that store data.
  - Simple types: integers, real numbers, Booleans etc.
  - Composite types: arrays, strings etc.
- Other types of variables (e.g., Java variables which appear to be objects) hold addresses of variables.

```
Foo aFoo;
aFoo = new Foo ();
```

  - The variable 'aFoo' is a reference to an object (contains the address of an object so it *refers* to an object).
  - Dynamic memory allocation: objects are created/instantiated only as needed.
- De-referencing: using an address to indirectly access data.
- Most times when you access instance variables in Java you directly access the object through the address of that object but knowing that an address is involved is important!

Variables: Storing Data Vs. Address (2)

- Even with high-level languages like Java, there *will* be times that programs will be working with the numeric address rather than the variable that the address is referring to.

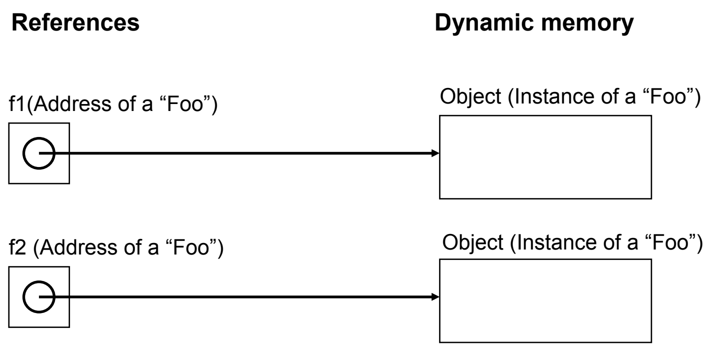
De-Referencing: Java Example

```
Foo f1 = new Foo ();
Foo f2 = new Foo ();

f1 = f2;
```

Exactly what is being copied here?

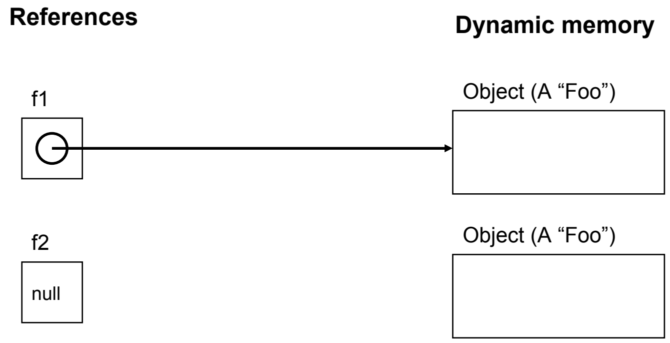
Automatic Garbage Collection Of Java References

•Dynamically allocated memory is automatically freed up when it is no longer referenced



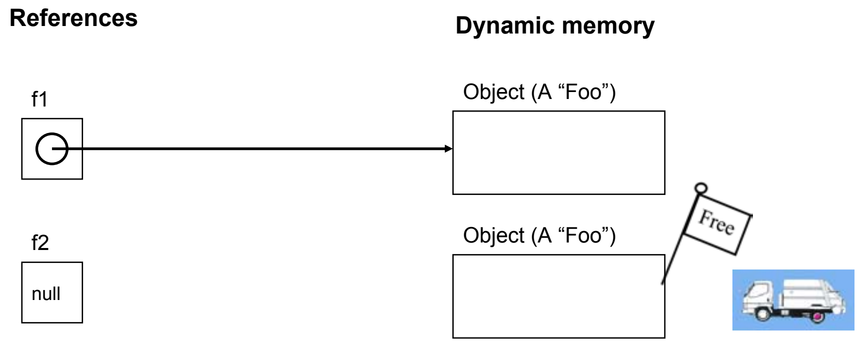
Automatic Garbage Collection Of Java References (2)

•Dynamically allocated memory is automatically freed up when it is no longer referenced e.g., f2 = null;



Automatic Garbage Collection Of Java References (2)

•Dynamically allocated memory is automatically freed up when it is no longer referenced e.g., f2 = null; (a null reference means that the reference refers to nothing, it doesn't contain an address).



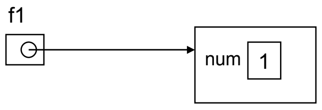
Caution: Not All Languages Provide Automatic Garbage Collection!

- Some languages do not provide automatic garbage collection (e.g., C, C++, Pascal).
- In this case dynamically allocated memory must be manually freed up by the programmer.
- Memory leak: memory that has been dynamically allocated but has not been freed up after it's no longer needed.
  - Memory leaks are a sign of poor programming style and can result in significant slowdowns.

The Finalize Method

- Example sequence:

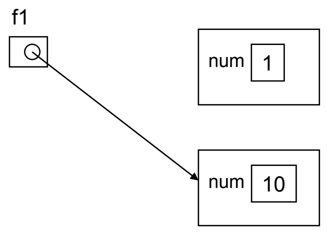
```
public class Foo
{
        int num;
        public Foo () { num = 1; }
        public Foo (int newValue) { num = newValue; }
          :       :          :
}
        :         :
Foo f1 = new Foo ();
```



The Finalize Method

•Example sequence:

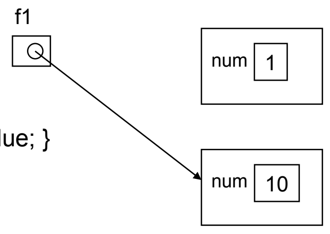
```
public class Foo
{
          int num;
          public Foo () { num = 1; }
          public Foo (int aValue) { num = aValue; }
            :       :          :
}
          :         :
Foo f1 = new Foo ();
f1 = new Foo (10);
```



The Finalize Method

•Example sequence:

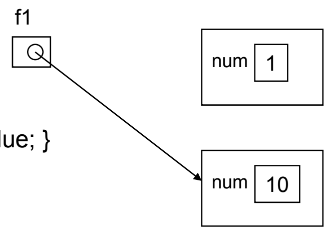
```
public class Foo
{
          int num;
          public Foo () { num = 1; }
          public Foo (int newValue) { num = newValue; }
            :       :          :
}
          :         :
Foo f1 = new Foo ();
f1 = new Foo (10);
```



The Finalize Method

•Example sequence:

```
public class Foo
{
        int num;
        public Foo () { num = 1; }
        public Foo (int newValue) { num = newValue; }
          :      :          :
}
        :         :
Foo f1 = new Foo ();
f1 = new Foo (10);
```

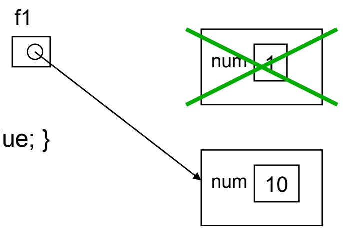


f1.finalize()

The Finalize Method

•Example sequence:

```
public class Foo
{
        int num;
        public Foo () { num = 1; }
        public Foo (int newValue) { num = newValue; }
          :      :          :
}
        :         :
Foo f1 = new Foo ();
f1 = new Foo (10);
```



f1.finalize()

The Finalize Method

- The Java interpreter tracks what memory has been dynamically allocated.
- It also tracks when memory is no longer referenced.
- When the system isn't busy, the Automatic Garbage Collector is invoked.
- If an object has a finalize method then it is invoked:
  - The finalize is a method written by the programmer to free up non-memory resources e.g., closing and deleting temporary files created by the program, closing network connections.
  - This method takes no arguments and returns no values.
  - Dynamic memory is **NOT** freed up by this method.
- After the finalize method finishes execution, the dynamic memory is freed up by the Automatic Garbage Collector.

Common Errors When Using References

- Forgetting to initialize the reference
- Using a null reference

Error: Forgetting To Initialize The Reference

```
Foo f;
f.setNum(10);
```

Compilation error!

```
> javac Driver.java
Driver.java:14: variable f might not have been initialized
        f.setNum(10);
        ^
1 error
```

Error: Using Null References

```
Foo f = null;
f.setNum(10);
```

Run-time error!

```
> java Driver
Exception in thread "main" java.lang.NullPointerException
        at Driver.main(Driver.java:14)
```

Self Reference: This Reference

•From every (non-static) method of an object there exists a reference to the object (called the "this" reference)

e.g.,

```
Foo f1 = new Foo ();
Foo f2 = new Foo ();
f1.setNum(10);

public class Foo
{
    private int num;
    public void setNum (int num)
   {
        num = num;
   }
        :              :
 }
```

Self Reference: This Reference

•From every (non-static) method of an object there exists a reference to the object (called the "this" reference)

e.g.,

```
Foo f1 = new Foo ();
Foo f2 = new Foo ();
f1.setNum(10);

public class Foo
{
    private int num;
    public void setNum (int num)
    {
        this.num = num;
    }
    :    :
}
```

Because of the 'this' reference, attributes of an object are always in scope when executing that object's methods.

This ()

- It's an invocation to the constructor of a class.
- It can be used when constructors have been overloaded.
- Example:

```
public class Foo
{
    private int num1;
    private int num2;
    public Foo ()
    {
        num1 = 0;
        num2 = 0;
    }
    public Foo (int n1)
    {
        this ();
        num1 = n1;
    }
}
```

After This Section You Should Now Know

- How to define classes, instantiate objects and access different part of an object
- What is the difference between a class, a reference and an object
- How to represent a class using class diagrams (attributes, methods and access permissions) and the relationships between classes
- Scoping rules for attributes, methods and locals
- What is encapsulation and how is it done
- What is information hiding, how is it done and why is it important to write programs that follow this principle
- What are accessor and mutator methods and how they can be used in conjunction with information hiding

After This Section You Should Now Know (2)

- What is method overloading and why is this regarded as good style
- What is a constructor and how is it used
- What is an association, how do directed and non-directed associations differ, how to represent associations and multiplicity in UML
- What is multiplicity and what are kinds of multiplicity relationships exist