CS1007: Object Oriented Design and Programming in Java

Lecture #17

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Outline

- Objects and types
- Understanding what is happening in the background
- Understanding the program

- Reading: 7-7.4

Announcements

- Posted last class notes
- Code from the book:
  - Check the resource webpage
- Homework 3 will be released this weekend

Understanding variables

- To understand what is going on with variables in any programming language, need to understand
- Which types are support
- Which values can be assigned to them

Java view of Types

- Primitive types:
- Class types
- Interface types
- Array types
- The null type
- Note:
  - void is not a type

Values

- value of primitive type
- reference to object of class type
- reference to array
- null
- Note: Can't have value of interface type

Array types

- Although arrays can be thought of as a collection of types, it actually is its own type

Example of inheritance

- Interface java.awt.Shape
  - Represents a two dimentional shape
- Some implementations:
  - Rectangle
  - Polygon

- So I can say:

```
Shape shapeobj;
Rectangle rec = new Rectangle();
Polygon poly = new Polygon();
shapeobj = rec;

System.out.println("shape is now: " +
  shapeobj);
```

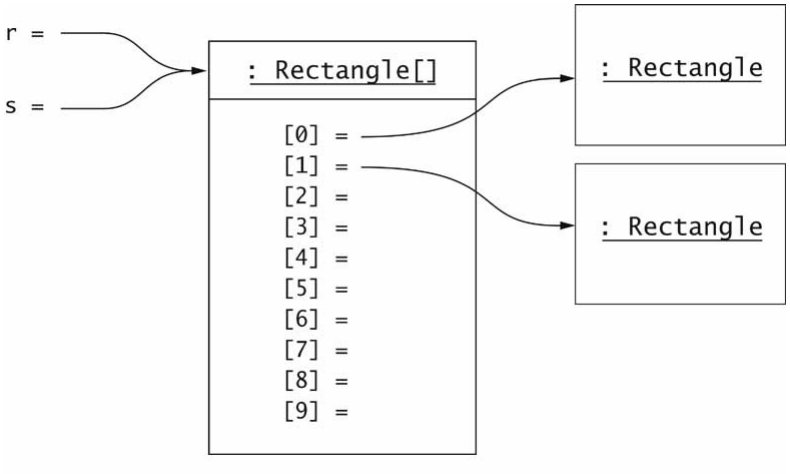
Careful

```
Rectangle[] r = new Rectangle[10];
Shape[] s = r;
```

- This assignment will compile fine

```
s[0] = new Polygon();
```

- But Throws an ArrayStoreException at runtime



Why primitives

- If java is so object oriented
- How do primitives fit in?

Upgrading

- Can always upgrade a primitive to an equivalent class:
- Integer i = new Integer(5);
- Why would you want to upgrade to object?
- Should be aware of memory overhead

Wrapping

- Primitive types aren't classes
- Use wrappers when objects are expected
- Wrapper for each type:

```
Integer Short Long Byte
Character Float Double Boolean
```

Before java 1.5

```
Integer A = new Integer(5);
…
Int x = A.intValue();
```

Boxing

- Auto-boxing and auto-unboxing
- `Integer X = 5;`

```
ArrayList<Integer> numbers = new
  ArrayList<Integer>();
numbers.add(13);
int n = numbers.get(0);
```

In between types

- Enum is a type with a preset number of values
- Great for keeping track of states
- enum types are classes; can add methods, fields, constructors
- Enum API

Enumerated

```
enum Size { SMALL, MEDIUM, LARGE
  }
```

- Typical use:

```
Size imageSize = Size.MEDIUM;
if (imageSize == Size.SMALL) . .
```

- Safer than integer constants

```
public static final int SMALL = 1;
public static final int MEDIUM = 2;
public static final int LARGE = 3;
```

Typesafe Enumeration

- enum equivalent to class with fixed number of instances

```
public class Size
{
   private Size() {  }
   public static final Size SMALL = new Size();
   public static final Size MEDIUM = new Size();
   public static final Size LARGE = new Size();
}
```

Object testing

- Many methods will return an Object object.
- Object Obj = ????
- How do we figure out what we are dealing with?

Type Inquiry

- Test whether e is a Shape:

```
if (e instanceof Shape) ...
```

- Good idea before doing a cast:

```
Shape s = (Shape) e;
```

- Remember: we don't know exact type of e
- WHY??
- Note:
  - If e is null, test returns false (no exception)

Confusion

- If Object class isn’t confusing enough
- There is also a type of class called :
- Class

Plain old class

- getClass method gets class of any object
- Returns object of type **Class**
- Class object describes a type

```
Object e = new Rectangle();
Class c = e.getClass();
System.out.println(c.getName()); //
  prints java.awt.Rectangle
```

- .class suffix yields Class object:

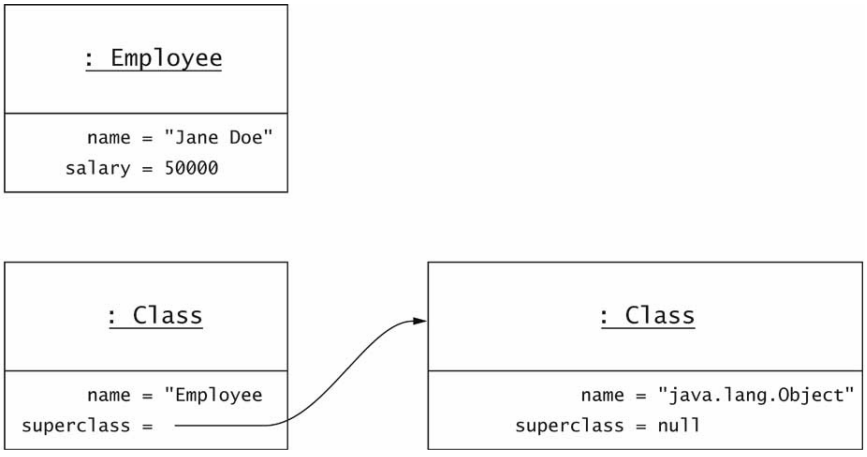
```
Class c = Rectangle.class;
```

- Class is not exactly a class since also works for primitives
  int.class
  void.class
  Shape.class

- Use Class.forName method to yields a Class object:

```
Class c =
  Class.forName("java.awt.Rectang
  le");
```

An Employee Object vs. the Employee.class Object



Checking Type

- Test whether e is a Rectangle:

if (e.getClass() == Rectangle.class) . . .

- Why can we use the ==

- A unique Class object for every class
- Test fails for subclasses
- Use instanceof to test for subtypes:
  - if (e instanceof Rectangle) . . .

Array Types

- Can apply getClass to an array
- Returned object describes an array type

```
double[] a = new double[10];
Class c = a.getClass();
if (c.isArray())
   System.out.println(c.getComponentType());
```

- getName produces strange names for array types

```
[Z for boolean[]
[D for double[])
[[java.lang.String; for String[][]
```

SUPERclass

- All classes extend Object
- Most useful methods:
  - String toString()
  - boolean equals(Object otherObject)
  - Object clone()
  - int hashCode()

toString

- Returns a string representation of the object
- Useful for debugging
- Example: Rectangle.toString returns something like

```
java.awt.Rectangle[x=5,y=10,width=20,
  height=30]
```

- toString used by concatenation operator
- aString + anObject

means

aString + anObject.toString()

Default

- `Object.toString()`
  - Prints class name and object address System.out.println(System.out) yields

java.io.PrintStream@d2460bf

- Implementor of PrintStream didn't override toString:

Overriding toString

- Format all fields:

```
public class Employee
{
   public String toString()
   {
      return getClass().getName()
         + "[name=" + name
         + ",salary=" + salary
         + "]";
   }
   ...
}
```

- Typical string:

Employee[name=Harry Hacker,salary=35000]

Subclass toString

- Format superclass first

```
public class Manager extends Employee
{
   public String toString()
   {
      return super.toString()
         + "[department=" + department +
  "]";
   }
   ...
}
```

- Typical string

Manager[name=Dolly Dollar,salary=100000][department=Finance]

Equals()

- equals tests for equal contents
- Used in many standard library methods
- Example: ArrayList.indexOf
  - Will trigger a equals call on your object in the array
- Unique to your class implimentation

```
/**
   Searches for the first occurrence of the given argument,
   testing for equality using the equals method.
   @param elem an object.
   @return the index of the first occurrence
   of the argument in this list; returns -1 if
   the object is not found.
*/
public int indexOf(Object elem)
{
   if (elem == null)
   {
      for (int i = 0; i < size; i++)
         if (elementData[i] == null) return i;
   }
   else
   {
      for (int i = 0; i < size; i++)
         if (elem.equals(elementData[i])) return i;
   }
   return -1;
}
```

Object.equals

- Object.equals tests for identity:

```
public class Object
{
   public boolean equals(Object obj)
   {
      return this == obj;
   }
   ...
}
```

- Override equals if you don't want to inherit that behavior

Requirements Rules

1. reflexive: x.equals(x)
2. symmetric: x.equals(y) if and only if y.equals(x)
3. transitive: if x.equals(y) and y.equals(z), then x.equals(z)
4. x.equals(null) must return false

Employee.equals

- What does it mean ?

Overriding equals

- Notion of equality depends on class, YOU need to define this
- Example: compare all fields

```
public class Employee
{
   public boolean equals(Object otherObject)
      // not complete yet
   {
      Employee other = (Employee)otherObject;
      return name.equals(other.name)
         && salary == other.salary;
   }
   ...
}
```

- Must cast the Object parameter to subclass
- Can use == for primitive types, equals for object fields

Rules?

- What rules are being violated ?

fixing

- Add test for null:

```
if (otherObject == null) return
  false
```

- What happens if otherObject not an Employee ?

- Common error: use of instanceof

```
if (!(otherObject instanceof
  Employee)) return false;
```

- Which type of classes is this valid for?

- Violates symmetry: Suppose e, m have same name, salary

e.equals(m) is true (because m instanceof Employee)

m.equals(e) is false (because e isn't an instance of Manager)

- Remedy: Test for class equality

```
if (getClass() != otherObject.getClass())
  return false;
```

Best practice

- Start with these three tests:

```
public boolean equals(Object otherObject)
{
   if (this == otherObject) return true;
   if (otherObject == null) return false;
   if (getClass() != otherObject.getClass())
  return false;
   ...
}
```

- First test is an optimization

Equals in subclass

- Call equals on superclass

```
public class Manager
{
   public boolean equals(Object otherObject)
   {
      Manager other = (Manager)otherObject;
      return super.equals(other)
         &&
  department.equals(other.department);
   }
}
```

Not always straight forward

- Two **sets** are equal if they have the same elements in some order

```
public boolean equals(Object o)
{
   if (o == this) return true;
   if (!(o instanceof Set)) return false;
   Collection c = (Collection) o;
   if (c.size() != size()) return false;
   return containsAll(c);
}
```

Hashing

- Goal want to quickly locate elements
- Need to use .equals() method to know if I've located what I'm looking for

Next time

- Read 7.4-7.7
- Check for homework 3 tomorrow