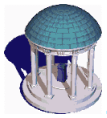


The University of North Carolina at Chapel Hill

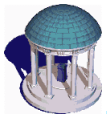
COMP 144 Programming Language Concepts

Spring 2002

Lecture 25: Run-Time Type Identification and Introspection

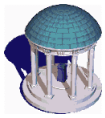
Felix Hernandez-Campos

March 22



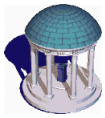
RTTI and Introspection

- *Run-time type identification* make it possible to determine the type of an object
  - E.g. given a pointer to a base class, determine the derived class of the pointed object
  - The type (class) must be known at compile time
- *Introspection* makes general class information available at run-time
  - The type (class) does not have to be known at compile time
  - This is very useful in component architectures and visual programming
  - E.g. list the attributes of an object



RTTI and Introspection

- RTTI and introspection are powerful programming language features
  - They enables some powerful design techniques
  - We will discuss them in the context of Java
- This discussion will follow Chapter 11 in *Thinking in Java* by Bruce Eckel
  - http://www.codeguru.com/java/tij/tij0119.shtml
  - By the way, this is an excellent book freely available on-line



The need for RTTI
Polymorphism Example

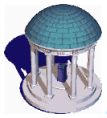
```
//: Shapes.java
package c11;
import java.util.*;
interface Shape {
  void draw();
}
class Circle implements Shape {
  public void draw() {
    System.out.println("Circle.draw()");
  }
}
class Square implements Shape {
  public void draw() {
    System.out.println("Square.draw()");
  }
}
```

Upcasting (Type Safe in Java)

```
class Triangle implements Shape {
  public void draw() {
   System.out.println("Triangle.draw()");
  }
}
public class Shapes {
  public static void main(String[] args) {
    Vector s = new Vector();
    s.addElement(new Circle());
    s.addElement(new Square());
    s.addElement(new Triangle());
    Enumeration e = s.elements();
    while(e.hasMoreElements())
      ((Shape)e.nextElement()).draw();
  }
}
```

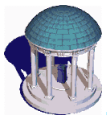
Poly-morphism

What if you want to known the exact type at run-time?



The Class Object

- Type information is available at run-time in Java
- There is a *Class object* for each class in the program
  - It stores class information
- Class objects are loaded in memory the first time they are needed
  - A Java program is not completely loaded before it begin!
- The class **`Class`** provides a number of useful methods for RTTI
  - http://java.sun.com/j2se/1.3/docs/api/java/lang/Class.html



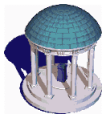
Example

```
class Candy {
  static {
    System.out.println("Loading Candy");
  }
}
class Gum {
  static {
    System.out.println("Loading Gum");
  }
}
class Cookie {
  static {
    System.out.println("Loading
Cookie");
  }
}
```

Executed at Load Time

```
public class SweetShop {
  public static void main(String[] args) {
    System.out.println("inside main");
    new Candy();
    System.out.println("After creating
Candy");
    try {
      Class.forName("Gum");
    } catch(ClassNotFoundException e) {
      e.printStackTrace();
    }
    System.out.println( "After
Class.forName(\"Gum\")");
    new Cookie();
    System.out.println("After creating
Cookie");
  }
}
```

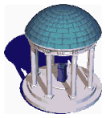
Returns a reference to class Gum



Example

- Output
  - JVM-1

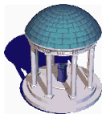
```
inside main
Loading Candy
After creating Candy
Loading Gum
After Class.forName("Gum")
Loading Cookie
After creating Cookie
```

Example

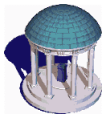
- Output
  - JVM-2

```
Loading Candy
Loading Cookie
inside main
After creating Candy
Loading Gum
After Class.forName("Gum")
After creating Cookie
```



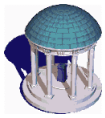
The Class Object

- Class literals also provide a reference to the Class object
  - *E.g.* `Gum.class`
- Each object of a primitive wrapper class has a standard field called TYPE that also provides a reference to the Class object
  - http://java.sun.com/j2se/1.3/docs/api/java/lang/Boolean.html



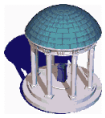
RTTI

- The type of a object can be determined using the **`instanceof`** keyword
  - See PetCount.java
  - It can be rewritten using Class literal, see PetCount2.java
  - Notice that an object of a derived class is an instance of the its base classes (*i.e.* any predecessor in the inheritance hierarchy)
- RTTI is very useful when reusing classes without extending them
- **`Class.isInstance()`** also implements the **`instanceof`** functionality



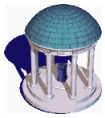
Introspection

- *Introspection* makes general class information available at run-time
  - The type (class) does not have to be known at compile time
  - E.g. list the attributes of an object
- This is very useful in
  - Rapid Application Development (RAD)
    - » Visual approach to GUI development
    - » Requires information about component at run-time
  - Remote Method Invocation (RMI)
    - » Distributed objects



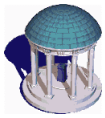
Reflection

- Java supports introspection through its reflection library
  - http://java.sun.com/j2se/1.3/docs/api/java/lang/reflect/package-summary.html
  - See classes Field (attributes), Method and Constructor
- Examples:
  - ShowMethods.java



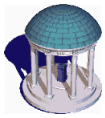
Python

- The Inspect module provides introspections mechanism
  - http://www.python.org/doc/current/lib/module-inspect.html
  - See:
    - » getmembers(object[, predicate])
    - » getsource(object)
    - » getclasstree(classes[, unique])
    - » getmro(cls)



Java Beans

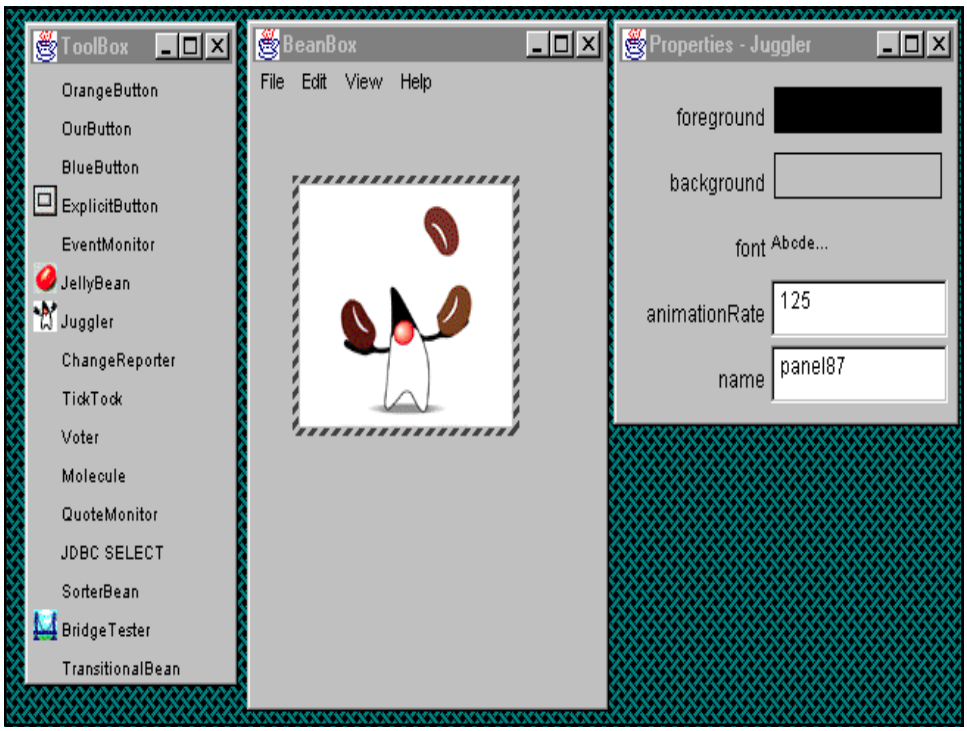
- Tutorial
  - http://java.sun.com/docs/books/tutorial/javabeans/index.html
- The JavaBeans API makes it possible to write ***component software*** in the Java programming language.
- **Components** are self-contained, reusable software units that can be ***visually composed*** into composite components, applets, applications, and servlets using visual application builder tools.
- JavaBean components are known as *Beans*.

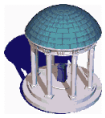


Demonstration

- BeanBox application

  The BeanBox is a simple tool you can use to test your Beans, and to learn how to visually manipulate their properties and events. The BeanBox is not a builder tool. You'll use the BeanBox to learn about Beans.





Reading Assignment

- Bruce Eckel *Thinking in Java*
  - Chapter 11, RTTI
    - » http://www.codeguru.com/java/tij/tij0119.shtml
- Java Beans
  - Tutorial
    - » http://java.sun.com/docs/books/tutorial/javabeans/index.html
  - Play with the BeanBox