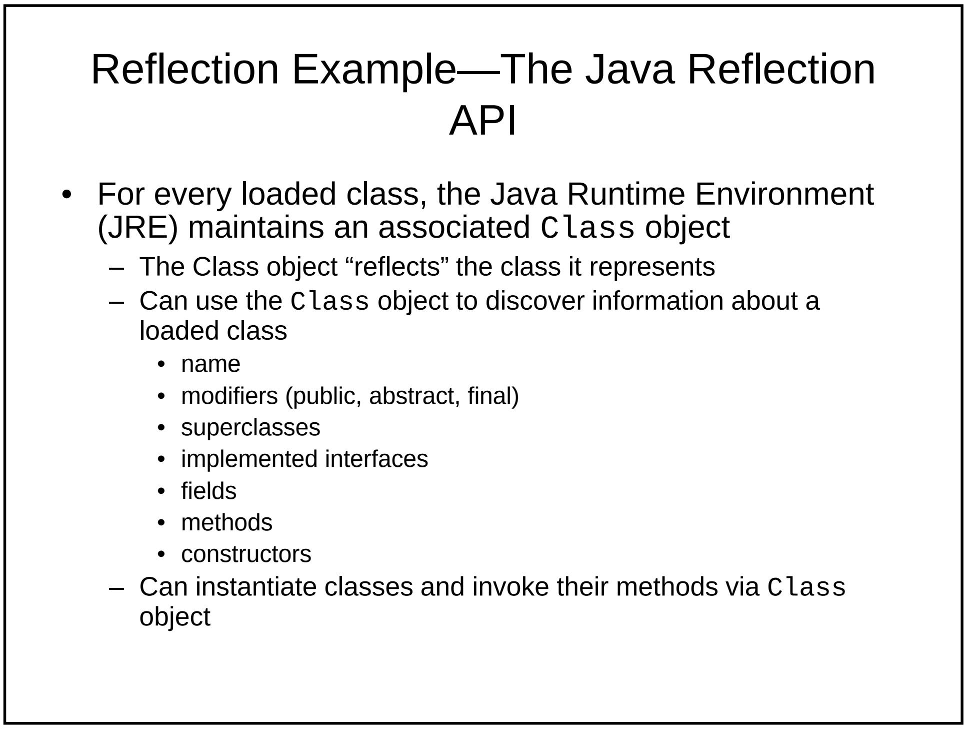
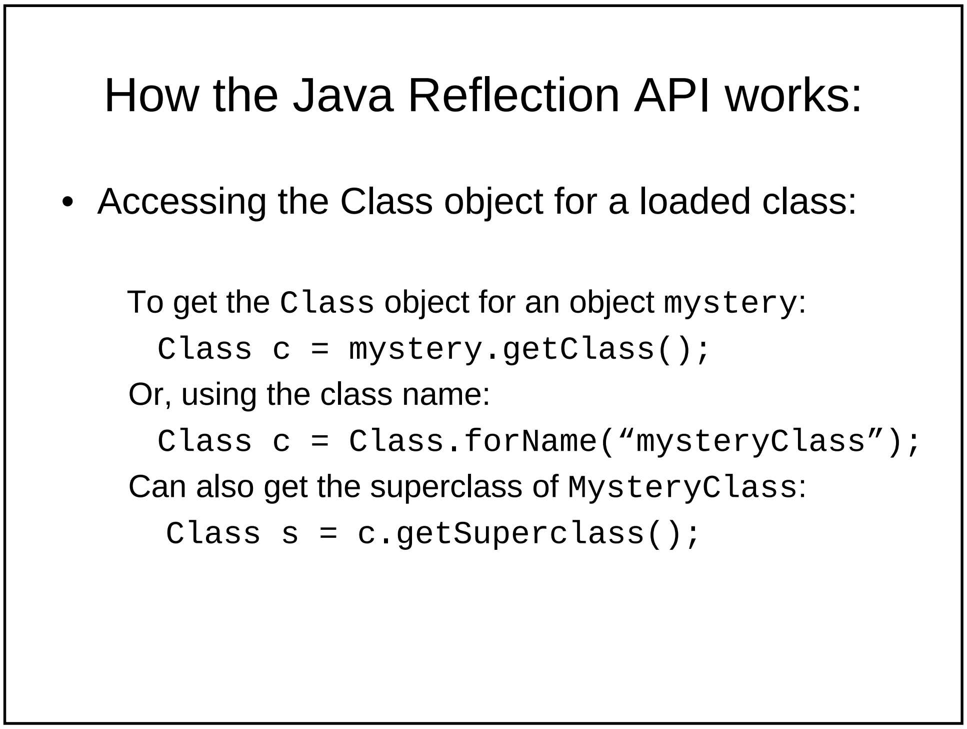


Reflection Example—The Java Reflection API

- For every loaded class, the Java Runtime Environment (JRE) maintains an associated `Class` object
  - The Class object “reflects” the class it represents
  - Can use the `Class` object to discover information about a loaded class
    - name
    - modifiers (public, abstract, final)
    - superclasses
    - implemented interfaces
    - fields
    - methods
    - constructors
  - Can instantiate classes and invoke their methods via `Class` object



How the Java Reflection API works:

- Accessing the Class object for a loaded class:

To get the `Class` object for an object `mystery`:

```
Class c = mystery.getClass();
```

Or, using the class name:

```
Class c = Class.forName(“mysteryClass”);
```

Can also get the superclass of `MysteryClass`:

```
Class s = c.getSuperclass();
```

Java Reflection--Continued

Introspecting (examining) a class via its `Class` object:

Getting the class name:

```
Class c = mysteryObject.getClass();
String s = c.getName();
```

Discovering the interfaces implemented by a class:

```
Class[] interfaces = c.getInterfaces();
```

Discovering the fields of a class:

```
Field[] fields = c.getFields();
```

Discovering the methods of a class:

```
Method[] methods = c.getMethods();
```

Example Code:

```
static void showMethods(Object o) {
   Class c = o.getClass();
   Method[] theMethods = c.getMethods();
   for (int i = 0; i < theMethods.length; i++) {
       String methodString = theMethods[i].getName();
       System.out.println("Name: " + methodString);
       String returnString =
            theMethods[i].getReturnType().getName();
       System.out.println(" Return Type: " + returnString);
       Class[] parameterTypes = theMethods[i].getParameterTypes();
      System.out.print(" Parameter Types:");
      for (int k = 0; k < parameterTypes.length; k ++) {
         String parameterString = parameterTypes[k].getName();
         System.out.print(" " + parameterString);
       }
     System.out.println();
     }
 }
```

Example--Continued

Output for a call: of the form:

```
Polygon P = new Polygon();
showMethods(p);
```

```
Name: equals
   Return Type: boolean
   Parameter Types: java.lang.Object
Name: getClass
   Return Type: java.lang.Class
   Parameter Types:
Name: intersects
   Return Type: boolean
   Parameter Types: double double double double
 .
 .
 .
```

Additional Features of Java Reflection

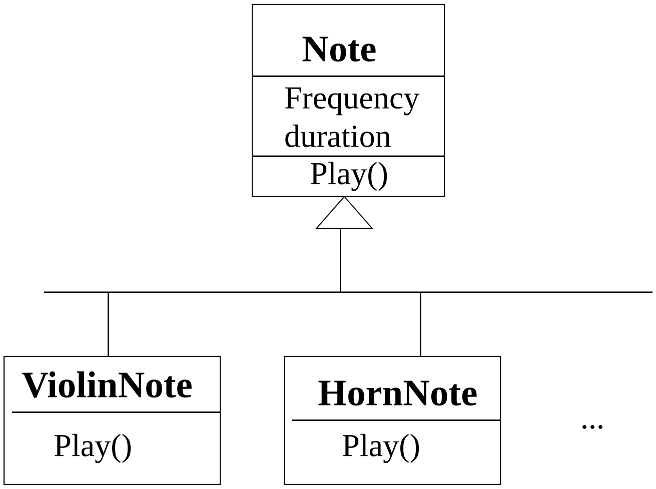
- Can obtain constructors for a class
- Can instantiate objects and invoke methods via information obtained from the reflection API.

A Java Reflection Example

Illustrates Four Issues:

1) Runtime type Information (RTTI)
2) Introspection
3) Invoking Method Objects
4) Dynamic Instantiation

Java RTTI Example



Note

Frequency
duration

Play()

ViolinNote

Play()

HornNote

Play()

...

RTTI Example--Continued

HornNote and ViolinNote are subclasses of Note that override the inherited play() method:

```
class HornNote extends Note {
   public void play() {
      System.out.println("Playing a horn note");
   }
}
class ViolinNote extends Note {
   public void play() {
      System.out.println("Playing a violin note");
   }
}
```

JAVA RTTI Example--Continued

Now consider the following test code:

```
Note note;
 note = new HornNote();
Class c = note.getClass();
System.out.println("class of note = " + c.getName());
note = new ViolinNote();
c = note.getClass();
 System.out.println("now class of note = " + c.getName());
```

The output produced would be:

```
class of note = HornNote
 now class of note = ViolinNote
```

JAVA RTTI Example--Continued

We could also reassign c to reference any super class of ViolinNote:

```
c = c.getSuperclass();
System.out.println("base class of note = " + c.getName());
c = c.getSuperclass();
System.out.println("base of base class of note = " + c.getName());
```

Here is the output produced:

```
base class of note = Note
base of base class of note = java.lang.Object
```

Introspection Example

We can also find out about the methods and fields of a class. Assume that c still references an object of the ViolinNote class. Then the following loop prints out the names of all of the ViolinClass methods:

```
Method methods[] = c.getMethods();
for(int i = 0; i < methods.length; i++)
  System.out.println(methods[i].getName());
```

Here is the output produced:

```
main  hashCode wait wait wait getClass equals  toString
notify notifyAll play
```

Note: we could also find out parameter lists, exception lists, return types, etc.

Introspection example continued

To print the names of the ViolinNote fields as well as their current values in the particular ViolinNote object referenced by note:

```
Field fields[] = c.getFields();
try {
   for(int i = 0; i < fields.length; i++) {
      System.out.print(fields[i].getName() + " = ");
      System.out.println(fields[i].getInt(note));
   }
} catch(Exception e) {
      // handle e
}
```

Here is the output produced:

```
frequency = 60
duration = 300
```

Non-public fields aren't printed.

Example--Invoking Method Objects

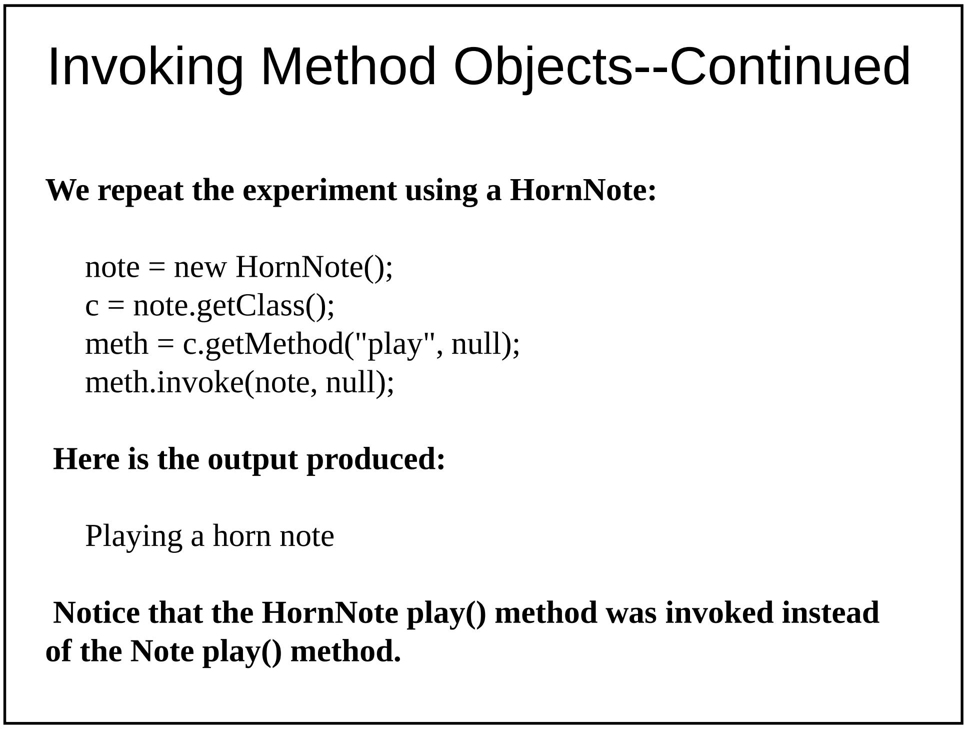
We can ask a Method object to invoke the method it represents. (Of course we must provide it with the implicit and explicit arguments.)

For example, let's create a generic Note object, then call its play() method using reflection:

```
note = new Note();
c = note.getClass();
Method meth = c.getMethod("play", null);
meth.invoke(note, null);
```

Here is the the output produced:

```
Playing a generic note
```



Invoking Method Objects--Continued

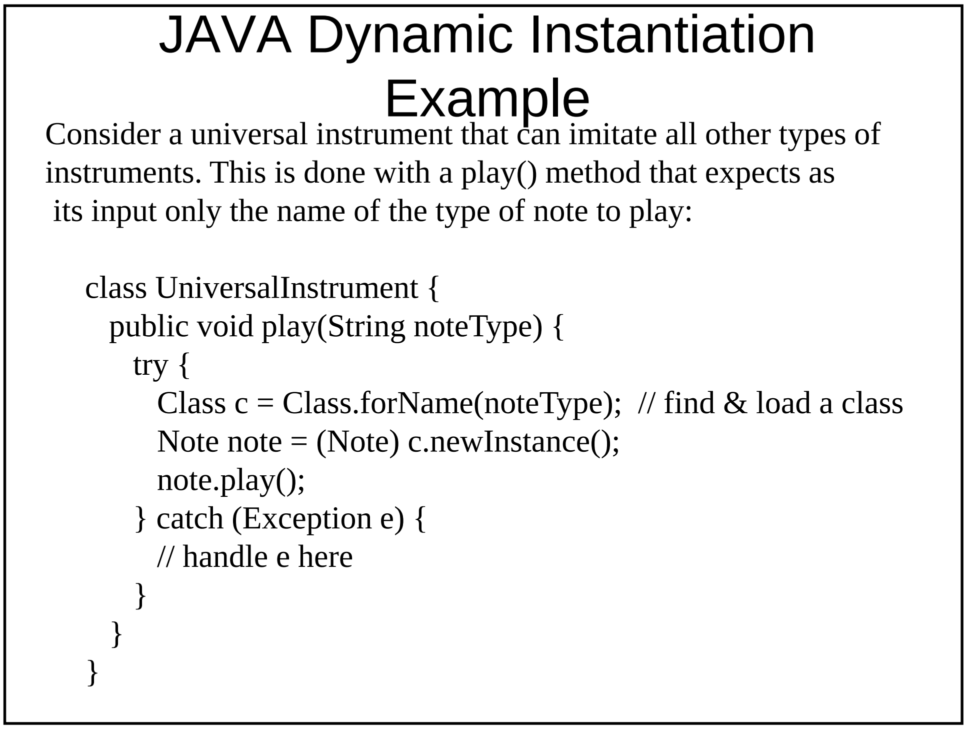
We repeat the experiment using a HornNote:

```
note = new HornNote();
c = note.getClass();
meth = c.getMethod("play", null);
meth.invoke(note, null);
```

Here is the output produced:

```
Playing a horn note
```

Notice that the HornNote play() method was invoked instead of the Note play() method.



JAVA Dynamic Instantiation Example

Consider a universal instrument that can imitate all other types of instruments. This is done with a play() method that expects as its input only the name of the type of note to play:

```
class UniversalInstrument {
  public void play(String noteType) {
    try {
      Class c = Class.forName(noteType);  // find & load a class
      Note note = (Note) c.newInstance();
      note.play();
    } catch (Exception e) {
      // handle e here
    }
  }
}
```

Dynamic Instantiation Example--continued

After creating a universal instrument, our test driver calls the play() method twice. The first time the string "ViolinNote" is the argument. The second time the string "HornNote" is the argument:

```
UniversalInstrument inst = new UniversalInstrument();
String noteType;
noteType = "ViolinNote";
inst.play(noteType);
noteType = "HornNote";
inst.play(noteType);
```

Here is the output produced:

```
Playing a violin note
Playing a horn note
```

Dynamic Instantiation Example--Continued

Of course if we wanted to create and play a HornNote followed by a ViolinNote, why not simply do it directly:

```
note = new HornNote();
note.play();
note = new ViolinNote();
note.play();
```

To see why, suppose instead of hardwiring the "ViolinNote" and "HornNote" strings into our test program, we allow the user to specify the strings:

```
System.out.print("enter a type of note: ");
noteType = MyTools.stdin.readLine();
inst.play(noteType);
```

We don't know what the user will enter, so we don't know what type of notes to make.

Dynamic Class Loading

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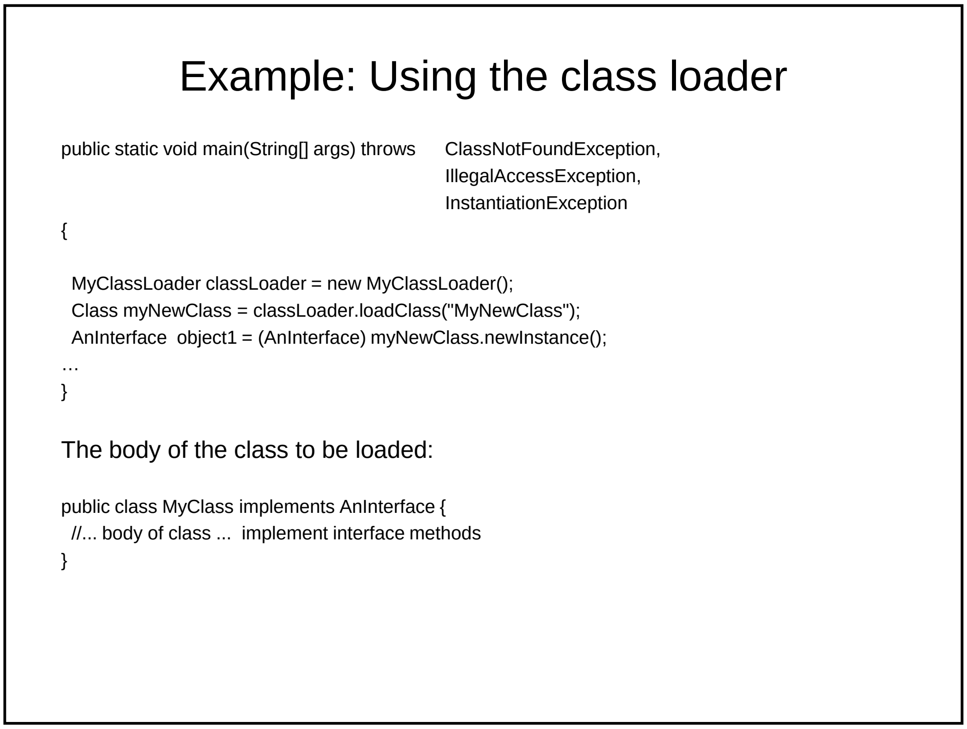
Software Engineering Languages and Tools

Class Loader Example

```
public class MyClassLoader extends ClassLoader{
  public Class loadClass(String name) throws ClassNotFoundException {
    try {
      String url = "file:C:/data/projects/dcl_example/classes/" + name;
      URL myUrl = new URL(url);
      URLConnection connection = myUrl.openConnection();
      InputStream input = connection.getInputStream();
      ByteArrayOutputStream buffer = new ByteArrayOutputStream();
      int data = input.read();
      while(data != -1){
        buffer.write(data);
        data = input.read();
      }
      input.close();
      byte[] classData = buffer.toByteArray();
      return defineClass(“MyNewClass", classData, 0, classData.length);
    } catch (MalformedURLException e) {
        e.printStackTrace();
    } catch (IOException e) {
        e.printStackTrace();
    } return null;
  }
}
```



Example: Using the class loader

```
public static void main(String[] args) throws     ClassNotFoundException,
                                                   IllegalAccessException,
                                                   InstantiationException
{

  MyClassLoader classLoader = new MyClassLoader();
  Class myNewClass = classLoader.loadClass("MyNewClass");
  AnInterface  object1 = (AnInterface) myNewClass.newInstance();
…
}
```

The body of the class to be loaded:

```
public class MyClass implements AnInterface {
  //... body of class ...  implement interface methods
}
```