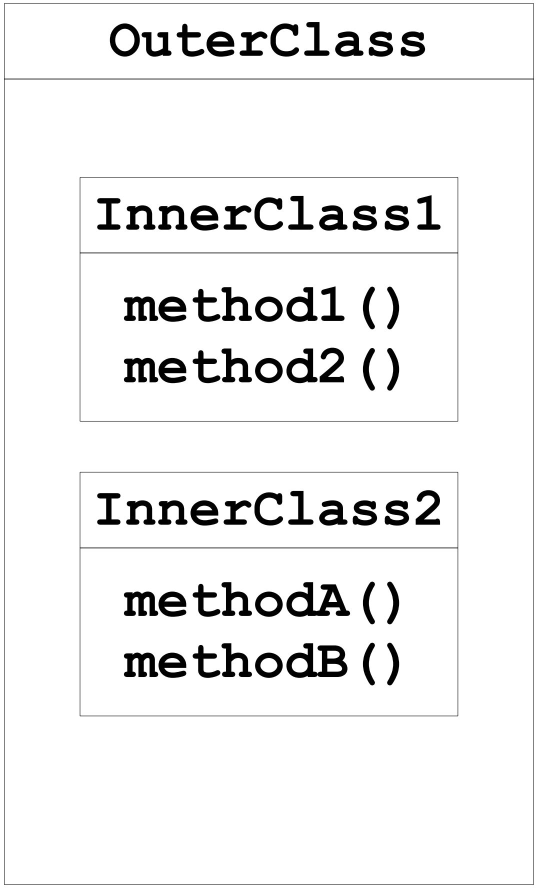
Inner Classes and Nested Interfaces

- The basics of inner classes
- The *state design pattern* revisited
- Accessing data in the outer classes
- A callback mechanism
  - implemented with interfaces and inner classes
- Nesting interfaces
- Creating instances of inner classes
- Anonymous inner classes
- The template design pattern
- Summary

What is an Inner Class?

- Main idea: Nest a class within another class
- Class names can be hidden
- More than hiding and organization
  - Call-back mechanism.
  - Can access members of enclosing object.
- Fundamental new language feature
  - added in Java 1.1
- Used a lot in JFC/Swing (GUI programming)



Inner Classes, Example

```
public class Parcel1 {  // [Source: bruceeckel.com]
  class Contents {
    private int i = 11;
    public int value() { return i; }
  }
  class Destination {
    private String label;
    Destination(String whereTo) {
      label = whereTo;
    }
    String readLabel() { return label; }
  }
  public void ship(String dest) {
    Contents c = new Contents();
    Destination d = new Destination(dest);
    System.out.println(d.readLabel());
  }
  public static void main(String[] args) {
    Parcel1 p = new Parcel1();
    p.ship("Tanzania");
  }
}
```

Interfaces and Inner Classes

- An outer class will often have a method that returns a reference to an inner class.

```
// [Source: bruceeckel.com]
public interface Contents {
   int value();
}

public interface Destination {
   String readLabel();
}
```

Interfaces and Inner Classes, cont

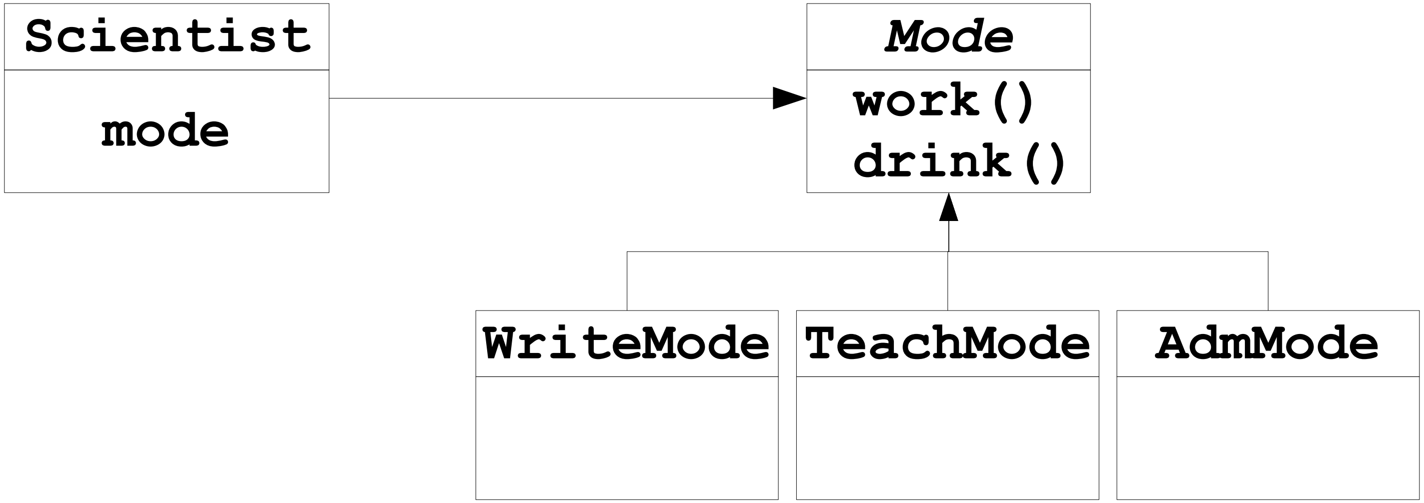
```java
public class Parcel3 { // [Source: bruceeckel.com]
  private class PContents implements Contents {
    private int i = 11;
    public int value() { return i; }
  }

  protected class PDestination implements Destination {
    private String label;
    private PDestination(String whereTo) {
      label = whereTo;
    }
    public String readLabel() { return label; }
  }

  public Destination dest(String s) {
    return new PDestination(s);
  }
  public Contents cont() {
    return new PContents();
  }
}
```

Interfaces and Inner Classes, cont

```
 // [Source: bruceeckel.com]
class Test {
  public static void main(String[] args) {

    Parcel3 p = new Parcel3();
    Contents c = p.cont();
    Destination d = p.dest("Tanzania");

    // Illegal -- can't access private class:
    //! Parcel3.PContents pc = p.new PContents();
  }

}
```

The State Design Pattern Revisited

- A scientist does three very different things (modes)
  - Writes paper (and drinks coffee)
  - Teaches classes (and drinks water)
  - Administration (and drinks tea)
- The implementation of each is assumed to be very complex
- Must be able to dynamically change between these modes



Implementation of State Design Pattern

```
public class Scientist{

   private interface Mode{
      void work();
      void drink();
   }

   private class WriteMode implements Mode{
      public void work() { System.out.println("write"); }
      public void drink(){ System.out.println("coffee");}
   }

   protected class TeachMode implements Mode{
      public void work() { System.out.println("teach");}
      public void drink(){ System.out.println("water");}
   }

   //snip
}
```

Implementation of State Design Pattern, cont.

```
public class Scientist{ // nothing has changed here
   //snip
   private Mode mode;
   public Scientist(){
      mode = new WriteMode(); /* default mode */
   }

   // what scientist does
   public void doing() { mode.work();}
   public void drink() { mode.drink();}

   // change mode methods
   public void setWrite()          { mode = new WriteMode();}
   public void setTeach()          { mode = new TeachMode();}
   public void setAdministrate() { mode = new AdmMode();}

   public static void main(String[] args){
      Scientist einstein = new Scientist();
      einstein.doing(); einstein.setTeach();
      einstein.doing();
   }
}
```

Evaluation of State Design Pattern

- Can change modes dynamically
  - Main purpose!
- Different modes are isolated in separate classes
  - Complexity is reduced (nice side-effect)
- Client of the **`Scientist`** class can see the **`Mode`** class (and its subclasses).
  - This may unnecessarily confuse these clients. (FIXED)
- **`Scientist`** class *cannot* change mode added after it has been compiled, e.g., **`SleepMode`**. (CANNOT BE FIXED)
- Can make instances of **`Mode`** class. This should be prevented. (FIXED)
- The *state design pattern*
  - Nice design!

Why Inner Classes?

- Each inner class can independently inherit from other classes
  - outer class inherits from one class
  - inner class inherits from another class
- The only way to get “multiple implementation inheritance”.
  - Reuse code from more than one superclass
- Makes design more modular
- Reduces complexity
  - By encapsulation/information hiding

- Use with caution
  - Make reduce reuse (very bad feature)
  - Make sure inner classes not useful outside enclosing class!

Access to Outer Data

```
public interface Diplomat{
   /** Attend a meeting */
   void attendMeeting();
   /** Talk nicely */
   void talkNice();
}
public class Embassy{
   private String[] secrets = new String[100];
   private int counter = 0;

   private class Agent implements Diplomat {
      public void attendMeeting() {
         System.out.println("Be nice");
      }
      public void talkNice() {
         System.out.println("Talk nice");
      }
      protected void tellSecrets(){
         System.out.println("Tell a secret");
         secrets[counter++] = new String("A new secret");
      }
   }
```

Callback Mechanism

```
public class Embassy{
   // snip

   public class Secretary implements Diplomat {
      public void attendMeeting() {
         System.out.println("Secretary.attendMeeting()");
      }
      // snip
   }


   boolean sendAgent = true;
   // send out diplomats some are secret agents (call-back)
   public Diplomat sendDiplomat(){
      if (sendAgent){
         sendAgent = false; return new Agent();
      }
      else {
         sendAgent = true; return new Secretary();
      }
   }
```

Callback Mechanism, cont

```
public class Embassy{
   // snip
   // get reports back from diplomats
   public void getReport(Diplomat dip){
      if (dip instanceof Agent) {
         ((Agent)dip).tellSecrets();
      }
      else {dip.talkNice();}
   }

   public static void main(String[] args){
      Diplomat[] dips = new Diplomat[10];
      Embassy cccp = new Embassy();
      for(int i = 0; i < 10; i++){
         dips[i] = cccp.sendDiplomat();
      }
      for(int j = 0; j < 10; j++){
         cccp.getReport(dips[j]);
      }
   }
}
```

What is Wrong?

```
// file S.java
public class S {
   public class S {
   }
}
```

```
// file T.java
public class T {
}

public class S {
}
```

```
// file T.java
public class T{
}

class S{
}
```

```
// file T.java
public class T{
}

private class S{
}
```

```
// file A.java
public abstract class A {
   private abstract class AI {
   }
}

class B {
   public class BI extends A.AI{
   }
}
```

Nesting Interfaces

- Interfaces can be nested however public rule still apply!

```
public interface NestedInterface{
   private interface A{   /* not allowed compile error */
      int ADATA = 1;
      int a();
   }
   protected interface B{ /* not allowed compile error */
      int BDATA = 2;
      int b();
   }
   interface C{               /* default public */
      int CDATA = 3;
      int c();
   }
   public interface D{        /* explicit public */
      int DDATA = 4;
      int d();
   }
   int outer();               /* method on outer interface */
}
```

Nesting Interfaces, cont

- Private and protected interfaces possible in classes

```
public class NestedInterfacesInClass{
   private interface A{
      int ADATA = 1;
      int a();
   }
   protected interface B{
      int BDATA = 2;
      int b();
   }
   interface C{         /* package access */
      int CDATA = 3;
      int c();
   }
   public interface D{
      int DDATA = 4;
      int d();
   }
}
```

Creating Instances of Inner Classes

- Cannot create inner classes without an instance of outer class

```
public class A{
   public A(){ System.out.println("A");   }
   public class BB {
      public BB(){ System.out.println("BB");}
      public class CCC{
      public CCC(){ System.out.println("CCC");  }
      }
   }

   public static void main(String[] args){
      A a          = new A();       // known syntax
      A.BB bb      = a.new BB();    // weird syntax
      A.BB.CCC ccc = bb.new CCC();  // ditto
   }
}
```

Anonymous Inner Classes, Example

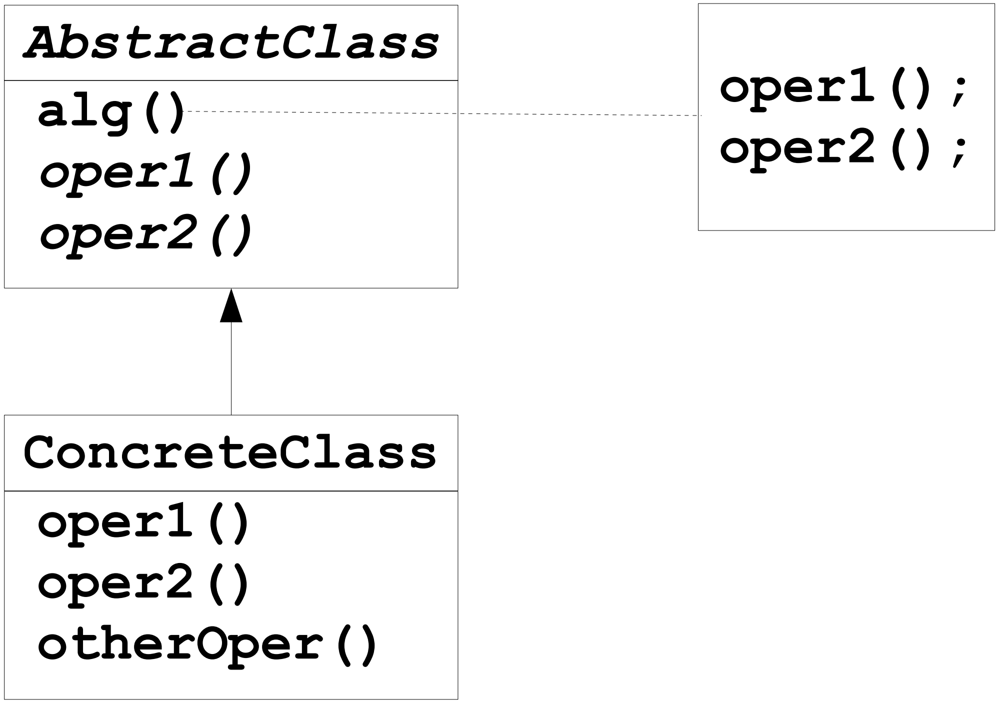
- When a class in only needed in one place.
- Convenient shorthand.
- Works for both interfaces and classes.

```
// [source: bruceeckel.com]
public interface Contents {
   int value();
}

public class Parcel6 {
  public Contents cont() {
    return new Contents() {
      private int i = 11;
      public int value() { return i; }
    };
  }
  public static void main(String[] args) {
    Parcel6 p = new Parcel6();
    Contents c = p.cont();
  }
}
```

note the semicolon

The Template Design Pattern

- Intent: Define the skeleton for an algorithm in an operation, deferring some steps to subclasses [GOF pp. 325].
- Well-suited to be implemented using inner classes (+ interfaces)
- Used extensively in many frameworks, e.g., Swing
  - "Factoring out common code"



The Template Design Pattern, cont

- A student participates in many events during a day, as examples
  - wakes up
  - eats breakfast
  - does math homework
  - goes to bed
- Each event always consists of three ordered steps
  - Prepare
  - Do the actual event
  - Clean up

```
// interface for modeling an event
public interface Event{
   void open();
   void doStuff();
   void close();
}
```

The Template Design Pattern, cont

- Build the abstract class and make use of the **Event** interface

```
public abstract class Controller {
   private Event[] events;
   private int counter;
   public Controller(){ // constructor on abstract class
      events = new Event[100];
      counter = 0;
   }
   /** Adds an event */
   public final void add(Event e){events[counter++] = e;}

   /** final to make sure not overridden in subclass */
   public final void run(){
      for(int i = 0; i <= counter - 1; i++){
         Event e = events[i];
         e.open();
         e.doStuff();
         e.close();
      }
   }
}
```

The Template Design Pattern, cont

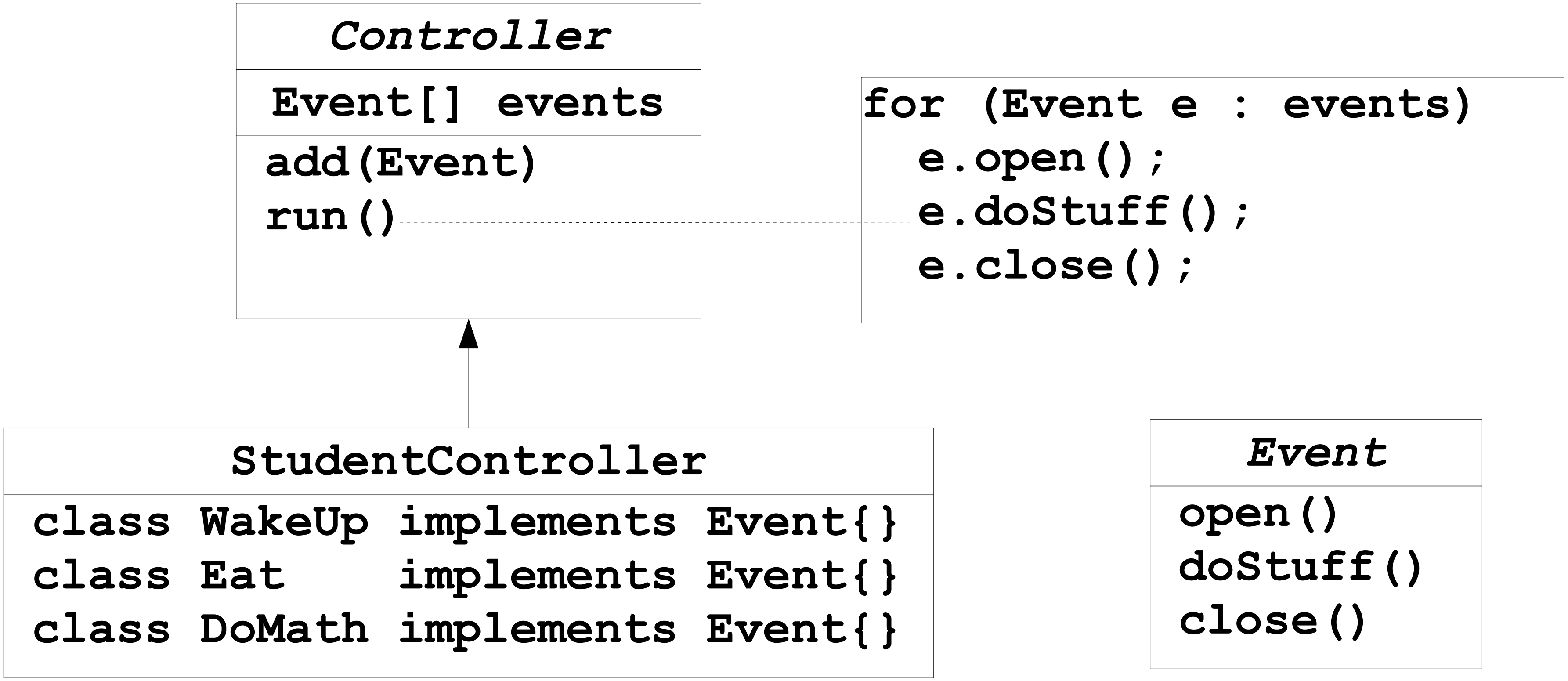
```
public class StudentController extends Controller{

   public StudentController(){
      super(); // calls constructor on abstract class!
   }

   public class DoMath implements Event{
     public void open() { System.out.println("open math book");}
     public void doStuff() { System.out.println("read");}
     public void close() { System.out.println("close math book");
   }

   public class WakeUp implements Event{
     public void open() { System.out.println("open eyes");}
     public void doStuff() { System.out.println("leave bed");}
     public void close() { System.out.println("turn-on light");}
   }

   // similar implementations of Sleep and Eat classes
}
```

The Template Design Pattern, cont

```
public class StudentController extends Controller{
   public static void main(String[] args){
      StudentController sc = new StudentController();

      // the events for one day for a single student
      sc.add(sc.new WakeUp());
      sc.add(sc.new Eat());
      sc.add(sc.new DoMath());
      sc.add(sc.new GoToSleep());
      sc.run(); // activate template method
   }
}
```

The Template Design Pattern, cont.

- **`run`** method is final, i.e., cannot be redefined
- All methods used in **`run`** are defined in **`Event`** interface
- **`Event`** interface implemented by inner classes.



Controller

```
Event[] events
```

```
add(Event)
run()
```

```
for (Event e : events)
  e.open();
  e.doStuff();
  e.close();
```

StudentController

```
class WakeUp implements Event{}
class Eat    implements Event{}
class DoMath implements Event{}
```

Event

```
open()
doStuff()
close()
```

Summary

- There can be more than one Java class in a single file
  - 0..1 public class and 0..n inner classes
- Nested classes used to make the internals of class more readable
- Very many details for related to inner classes
- All four access modifiers can be used on
  - inner classes
  - inner interfaces
- Anonymous inner classes
  - Do not have to invent a name for a class you only need one off
- Template design pattern shows usage of
  - interfaces
  - inner classes
- Use inner classes with caution
  - May prevent reuse of your nicely created classes