Nested Classes
(or “How to impress during your next job interview...”)

Introduction

- So far, all our class declarations have been outermost in a .java file
  - Inside a package, which can be inside another package, etc
  - Called *top-level classes*
- Java also permits class declarations to appear within *smaller scopes*
- Recall?
  - The members of a class include: fields, methods, and *other classes*
Nested Classes

- A class declared within something else (i.e., not at package level) is called a nested class.
- 4 kinds of nested classes:
  1. Static nested classes
     - Static members of an enclosing class
  2. Inner classes
     - Nonstatic members of an enclosing class
  3. Local classes (or local inner classes)
     - Declared inside a method, like a local variable
  4. Anonymous classes (or anonymous inner classes)
     - Declared/used at same time, nameless

Role: Helper Classes

- Sometimes a class, H, is needed by exactly one other class, C:
  - H bundles state into 1 object for C to use
  - H implements an interface that C needs to instantiate
- Example:
  ```java
class SlowSetOfChar extends AbstractSet<Character> {
    private . . . //fields representing set
    public Iterator<Character> iterator () {
      //problem: can not instantiate interface
      return new Iterator<Character>();
      //ok: class that implements Iterator<Character>
      return new MySlowIteratorOfChar();
    }
}
```
- Key point: clients of SlowSetOfChar do not need to know about MySlowIteratorOfChar class!
Example: Transcript

/**
 * @mathmodel t : sequence of <<Q,C,W,G>>
 * @convention (exists k : dateList.length = k,
 * courseList.length = k,
 * creditList = k,
 * gradeList.length = k)
 */
public class Transcript {
    private ArrayList<Quarter> dateList;
    private ArrayList<CourseNumber> courseList;
    private ArrayList<Integer> creditList;
    private ArrayList<Grade> gradeList;
    . . .
    public addEntry(Course c, Offering t, Grade g) {
        //extend all 4 lists by extracting info from c/t/g
        . . .
    }
}

Solution 1: Transcript

/**
 * @mathmodel t : sequence of <<Q,C,W,G>>
 */
public class Transcript {
    private ArrayList<TranscriptLine> transcriptList;
    . . .
    public addEntry(Course c, Offering t, Grade g) {
        //extend list by extracting info from c/t/g
        TranscriptLine entry = new TranscriptLine();
        . . .
    }
}

class TranscriptLine { //one more top-level class
    Quarter Q;
    Course C;
    int W;
    Grade G;
}
Solution 2: Transcript

```java
/**
 * @mathmodel t : sequence of <<Q,C,W,G>>
 */
public class Transcript {
    class TranscriptLine {  //inner class
        Quarter Q;
        Course C;
        int W;
        Grade G;
    }

    private ArrayList<TranscriptLine> transcriptList;
    ...
    public addEntry(Course c, Offering t, Grade g) {
        //extend list by extracting info from c/t/g
        TranscriptLine entry = new TranscriptLine();
        ...
    }
}
```

Visibility

- Two choices for top level classes:
  - Public, or package-private (ie default)
- Inner classes are like any other member:
  - Public, package-private, protected, or private
- Regardless of inner class’s visibility:
  - Inner class can access outer’s `private` members!
  - Outer class can access inner’s `private` members!
- Can be static
  - Makes it a static nested class
Solution 3: Transcript

```java
public class Transcript {
    private class TranscriptLine {
        //private inner class
        private Quarter Q;  //same visibility as public
        private Course C;
        private int W;
        private Grade G;
    }

    private ArrayList<TranscriptLine> transcriptList;
    . . .
    public addEntry(Course c, Offering t, Grade g) {
        //extend list by extracting info from c/t/g
        TranscriptLine entry = new TranscriptLine();
        entry.G = new Grade(g);
        . . .
    }
}
```

Instantiation and Access

- Typically, an inner class is private
  - Instantiate in outer class with new()
    Inner innerObject = new Inner();
  - Outer’s access of Inner: use reference
    innerObject.innerMethod();
  - Inner’s access of Outer: use (qualified) this
    g(); //Inner’s g if it exists, else Outer’s
    this.g(); //same as above
    Outer.this.g(); //Outer’s g

- Inner classes can also be public
  - Can be instantiated/used outside of Outer
    Outer outerObject = new Outer();
    Outer.Inner innerObject = outerObject.new Inner();
    innerObject.innerMethod();
Inner Class vs Static Nested Class

- Instances of an *inner class* are always associated with a (*one*) instance of their outer class
  - Called “enclosing instance”
  - Thus, instance of outer class must be created first
- Instances of *static nested classes* are not associated with any instances of their outer class
  - Thus, can only access static members of outer class

Good Practice: Use Static Nested

- Prefer static nested classes over inner classes
- Bad rule: considering when static nested *must* be used
  - If nested class will itself have static members
  - If nested class must be accessed from outer’s static methods
- Better rule: Use inner classes only if
  - Nested class needs access to *instance members* of outer class
- Otherwise, use static nested classes
  - Degenerate case: Nested class has no methods
  - Common case: Nested class methods use only arguments and nested class’s fields
  - Note: There are instances of a static nested class!
- Clients of outer access static nested through class name
  ```java
  public class Animal {
    public static class Migration { . . . }
  }
  Animal.Migration x = new Animal.Migration();
  ```
Solution 4: Transcript

```java
public class Transcript {
    private static class TranscriptLine { //static nested
        private Quarter Q;
        private Course C;
        private int W;
        private Grade G;
    }

    private ArrayList<TranscriptLine> transcriptList;
    ...
    public addEntry(Course c, Offering t, Grade g) {
        //extend list by extracting info from c/t/g
        TranscriptLine entry = new TranscriptLine();
        ...
    }
}
```

Role: Event Handlers

- Recall roles for H and C
  - H bundles state into 1 object for C to use
  - H implements an interface that C needs to instantiate
- Common example of #2: Event handlers
  - More general description: “call-backs”
- Recall Swing components and listeners
  - Event handlers implement an interface
    ```java
    interface ActionListener {
        void actionPerformed (ActionEvent e);
    }
    ```
  - Component has a method for registering a listener
    ```java
    public abstract class AbstractButton {
        void addActionListener (ActionListener l)
    }
    ```
Example: ActionListener

```java
public class SimpleWindow extends JFrame {
    public SimpleWindow() {
        Button test = new Button();
        BHandler handler = new BHandler();
        test.addActionListener(handler);
        setVisible(true);
    }

    private static class BHandler implements ActionListener {
        public void actionPerformed(ActionEvent event) {
            JOptionPane.showMessageDialog(null, "You pressed: " + event.getActionCommand());
        }
    }
}
```
Anonymous Classes

- Simultaneous declaration and use
  - Occur within an expression
  - Usually an argument in a method call
    ```java
test.addActionListener(/*here*/);
```

- Anonymous class has no class name
  - Can not use as declared type
    ```java
AnonClass anObject = new AnonClass();
```
  - Instead, use some other (named) type, and have anonymous class subtype it
    ```java
SomeInterface anObject = new AnonClass();
```
  - Replace constructor name with declaration
    ```java
SomeInterface anObject = new SomeInterface() {
  public void methodName() {
    ...
}
};
```

- Result is either
  - Compact clean code, or
  - Dense impenetrable code

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Anonymous ActionListener

```java
public class SimpleWindow extends JFrame {
  public SimpleWindow() {
    Button test = new Button();
    //anonymous class
    test.addActionListener(new ActionListener() {
      public void actionPerformed(ActionEvent event) {
        JOptionPane.showMessageDialog(null, "You pressed: " + event.getActionCommand());
      }
    });
    setVisible(true);
  }

  //no need for an inner class!
}
```
Example of Anonymous Class

- In java.util:
  ```java
default class Arrays {
    public static <T> void sort (T[] a, Comparator<T> c) {
      . . .
    }
}

interface Comparator<T> {
  int compare (T o1, T o2);
}
```

- In client code somewhere:
  ```java
  Arrays.<String>sort (args, new Comparator<String>() {
    public int compare (String s1, String s2) {
      return s1.length() - s2.length();
    }
  });
  ```

Compilation

- Source (.java) --> byte code (.class)
  - Example:
    ```bash
    $ javac Classname.java
    ```
  - Produces:
    ```bash
    Classname.class
    ```

- If class Outer contains a nested class, Nested, two class files are produced
  - Example:
    ```bash
    $ javac Outer.java
    ```
  - Produces:
    ```bash
    Outer.class  Outer$Inner.class
    ```
Good Practice: Use Sparingly

- Proper use makes code smaller and cleaner
- Improper use makes code hard to understand
- Stick with basic patterns:
  - Bundling state (static nested)
  - Adaptors (inner)
  - Event handlers (inner or anonymous)
    - ie Call-backs (inner or anonymous)
    - ie Single-method interface implementations (inner or anonymous)
  - Avoid local classes altogether (very rare)

Summary

- Four kinds of nested classes
  - Static nested, inner, local, anonymous
- Mutual access of private members
- Static vs inner:
  - Inner have enclosing instance
- Anonymous classes declared & used at same time
- Use: helper class used by 1 other class
  - Bundle state
  - Instantiate interface
- Commonly encountered “interface instantiation”
  - Event handlers (Swing)
  - Thread creation
  - Iteration