Introduction to Java (cs2514)

Lecture 11: Nested Classes

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Outline

- This lecture is about *nested classes.*
- We study the famous *observer design pattern:*
  - We have a *subject* and one or more *observers.*
  - The subject may be viewed as a newspaper.
  - The observers are subscribed to the newspaper.
  - The subscribed obervers are waiting for news from the subject.
  - The subject broadcasts news items to its subscribed observers.
    - Done by calling observer's `notify( )` method.
- The observer pattern is frequently used with GUIs.
  - The GUIs are ony to show how the observer pattern is used.
  - There won't be any questions about GUIs for the exam.

The Observer Design Pattern

- The *observer pattern* is a commonly used design pattern.
- It defines a one-to-many object dependency.
- The dependency ensures that the object's dependents are automatically updated when the object's state changes [Gamma et al. 2008].
- AKA Dependents, Publish-Subscribe [Freeman, and Freeman 2005, Pages 44–78], and Event-Listener.

The Observer Pattern (Continued)

The Source of the News: A Newspaper

- There is one `Subject`.
- There are zero or more `Observers`.
- An `Observer` can be attached to the `Subject`.
- An `Observer` can be detached from the `Subject`.
- If the `Subject`'s state changes it updates all its `Observers`.
  - This is done by calling each `Subject`'s `update( )` method.

The Observer Pattern (Continued)

Potential Readers

- There is one `Subject`.
- There are zero or more `Observers`.
- An `Observer` can be attached to the `Subject`.
- An `Observer` can be detached from the `Subject`.
- If the `Subject`'s state changes it updates all its `Observers`.
  - This is done by calling each `Subject`'s `update( )` method.

The Observer Pattern (Continued)

Subscribe as Reader to the Newspaper

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- There are zero or more `Observers`.
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- An `Observer` can be detached from the `Subject`.
- If the `Subject`'s state changes it updates all its `Observers`.
  - This is done by calling each `Subject`'s `update( )` method.

The Observer Pattern (Continued)

Unsubscribe as Reader to the Newspaper

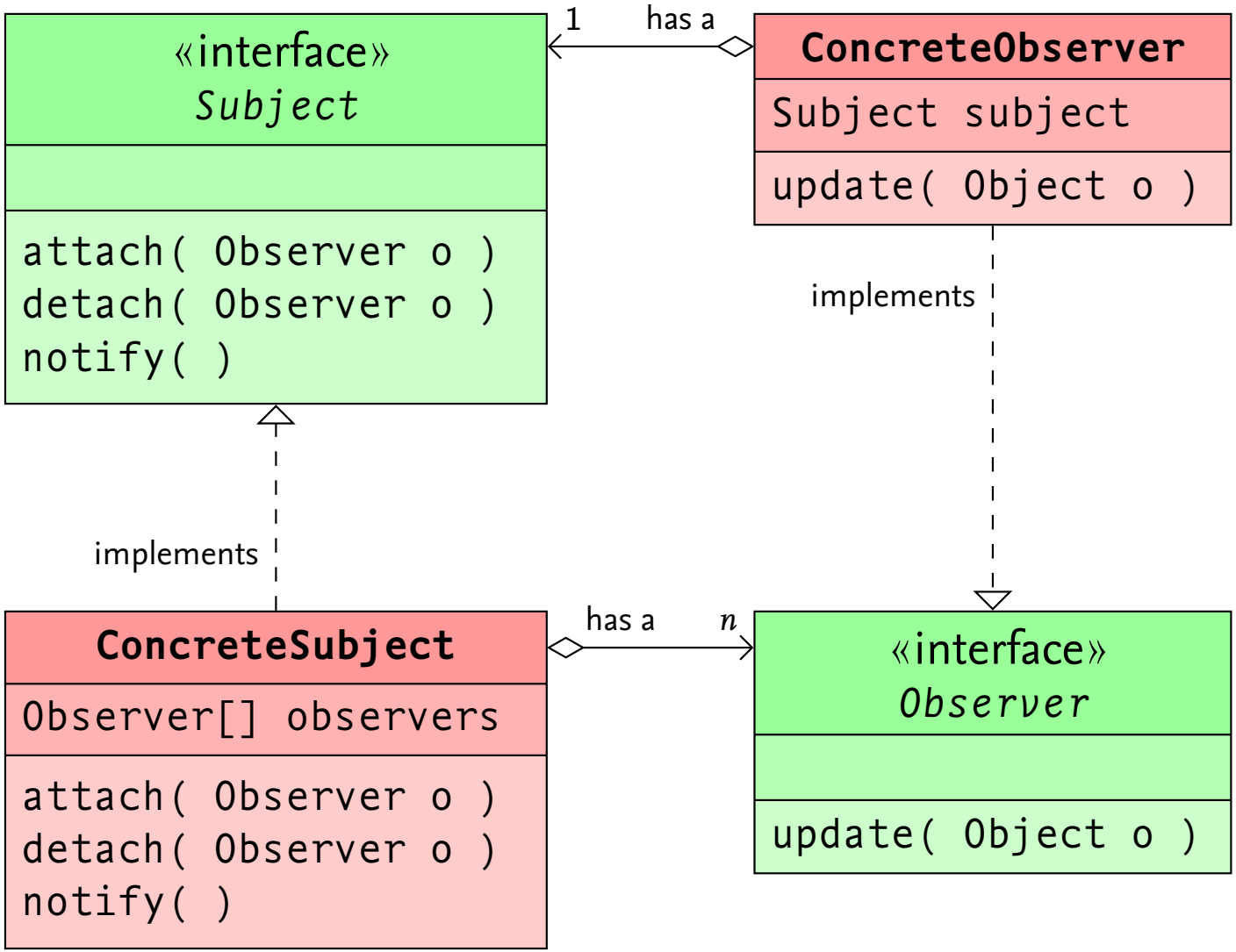
- There is one `Subject`.
- There are zero or more `Observers`.
- An `Observer` can be attached to the `Subject`.
- An `Observer` can be detached from the `Subject`.
- If the `Subject`'s state changes it updates all its `Observers`.
  - This is done by calling each `Subject`'s `update( )` method.

The Observer Pattern (Continued)

Inform the Readers about News

- There is one `Subject`.
- There are zero or more `Observers`.
- An `Observer` can be attached to the `Subject`.
- An `Observer` can be detached from the `Subject`.
- If the `Subject`'s state changes it updates all its `Observers`.
  - This is done by calling each `Subject`'s `update( )` method.

Class Diagram of the Observer Pattern



Case Study

- We have a newspaper and readers of the newspaper.
- The readers can subscribe and unsubscribe.
- The newspaper informs the subscribers about new newsitems.

Implementing the Interfaces

Java

```
public interface Subject {
    // Subscribe to this newspaper.
    public void attach( Observer subscriber );
    // Unsubscribe from this newspaper.
    public void detach( Observer subscriber );
    // Notify this newspaper of a news event.
    public void notify( String event );
}
```

Java

```
public interface Observer {
    // Inform this subscriber about a published event.
    public void update( String event );
}
```

Implementing the Interfaces

Java

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public interface Subject {
    // Subscribe to this newspaper.
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Implementing the Interfaces

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Implementing the Interfaces

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public interface Subject {
    // Subscribe to this newspaper.
    public void attach( Observer subscriber );
    // Unsubscribe from this newspaper.
    public void detach( Observer subscriber );
    // Notify this newspaper of a news event.
    public void notify( String event );
}
```

Java

```
public interface Observer {
    // Inform this subscriber about a published event.
    public void update( String event );
}
```

A Concrete Observer

Java

```
public class ConcreteObserver implements Observer {
    // The name of the subscriber.
    final String name;

    public ConcreteObserver( final String name ) {
        this.name = name;
    }

    // Inform this subscriber about a published event.
    @Override
    public void update( final String event ) {
        System.out.println( name + " reading: " + event );
    }

    @Override
    public String toString( ) {
        return name;
    }
}
```

A Concrete Subject

Java

```
public class ConcreteSubject implements Subject {

    // The name of this newspaper.
    private final String name;
    // The subscribers of this newspaper.
    private final ArrayList<Observer> subscribers;

    public ConcreteSubject( final String name ) {
        subscribers = new ArrayList<Observer>( );
        this.name = name;
    }

    @Override
    public String toString( ) {
        return name;
    }

    // omitted

}
```

A Concrete Subject (Continued)

Java

```
public class ConcreteSubject implements Subject {

    // omitted

    @Override // Subscribe a new customer.
    public void attach( final Observer subscriber ) {
        System.out.println( subscriber + " subscribed to " + this );
        subscribers.add( subscriber );
    }

    @Override // Unsubscribe an existing customer.
    public void detach( final Observer subscriber ) {
        System.out.println( subscriber + " unsubscribed from " + this );
        subscribers.remove( subscriber );
    }

    @Override // Inform this newspaper about hot news item.
    public void notify( final String news ) {
        // Inform all subscribers about the news item.
        System.out.println( this + " got news item: " + news );
        for( Observer subscriber : subscribers ) {
            subscriber.update( news );
        }
    }

}
```

The Main Class

Java

```
public class Main {
    public static void main( String[] args ) {
        final Subject eolas = new ConcreteSubject( "Eolas" );
        final Subject examiner = new ConcreteSubject( "Examiner" );

        final Observer john = new ConcreteObserver( "John" );
        final Observer jane = new ConcreteObserver( "Jane" );
        final Observer eoin = new ConcreteObserver( "Eoin" );

        examiner.attach( john );
        examiner.attach( eoin );
        examiner.attach( jane );
        eolas.attach( jane );

        eolas.notify( "Assignment 1 to be handed back next Monday." );
        examiner.notify( "Media still creating fake news." );

        examiner.detach( jane );

        examiner.notify( "No news today." );
    }
}
```

Sample Output

Unix Session

```
$
```

Sample Output

Unix Session

```
$ java Main
```

Sample Output

Unix Session

```
$ java Main
John subscribed to Examiner
Eoin subscribed to Examiner
Jane subscribed to Examiner
Jane subscribed to Eolas
Eolas got news item: Assignment 1 to be handed back next Monday.
Jane reading: Assignment 1 to be handed back next Monday.
Examiner got news item: Media still creating fake news.
John reading: Media still creating fake news.
Eoin reading: Media still creating fake news.
Jane reading: Media still creating fake news.
Jane unsubscribed from Examiner
Examiner got news item: Sorry folks: No news today.
John reading: Sorry folks: No news today.
Eoin reading: Sorry folks: No news today.
$
```

Windows

- Without a window you could not write a GUI application.
- In Java a window is represented as a JFrame object.
- The JFrame is where you put your window's *widgets* in.
- Possible widgets are
  - Buttons,
  - Checkboxes,
  - Sliders,
  - Dialogue boxes,
  - Text fields,
  - And so on.
- The appearance of a JFrame may differ from OS to OS.

Open that Window

- Create a `JFrame`.

Java

```
JFrame frame = new JFrame( ⟨title string⟩ );
```

- Set the `JFrame`'s closing operation.

Java

```
frame.setDefaultClosingOperation( JFrame.EXIT_ON_CLOSE );
```

- Make one or several widgets and add them to the `JFrame`.

Java

```
JButton button = new JButton( "Click me" );
frame.getContentPane( ).add( button );
```

- Give the `JFrame` a size and make it visible.

Java

```
frame.setSize( 300, 300 );
frame.setVisible( true );
```

A Full Program

Java

```
import javax.swing.*;

public class DummyButton {
    public static void main( String[] args ) {
        JFrame frame = new JFrame( "Our second Button" );
        JButton button = new JButton( "Click me" );
        frame.getContentPane( ).add( button );
        frame.setDefaultCloseOperation( JFrame.EXIT_ON_CLOSE );
        frame.setSize( 300, 300 );
        frame.setVisible( true );
    }
}
```

Our First Button

Our First Button

But ...

Our First Button

But ..., When We Click the Button

Our First Button

But ..., When We Click the Button, Nothing Happens:-(

Events

- It is quite obvious our button did nothing when we clicked it.
  - After all, we didn't tell it what to do.
  - Let alone, *how*, and *when*.
- The `JButton` class knows *when* its buttons are clicked:

  Event: Clicking the button generates a button event.
- To let the button do something *when* it's clicked we need:

  Listener: Listener to button events.
  Handler: Listener instance method that is called for each event.

Summary

1. The button event is activated when the button is clicked.
2. The button event triggers the button event listener.
3. The button event listener carries out the button event handler.

That Sounds Familiar: The Observer Pattern

- The `JButton` is the `Subject`.
- Clicking the `JButton` is a *user action*.
- The `JButton` turns the user action into a button event object.
  - It may be thought of as a call to `notify( event )`.
- The button event is broadcast to all button even listeners.
- The `Observers` are the button event listeners.
- Each `Observer` implements its button event handler.
  - Each event handler is a dedicated `update( )` method.
  - The call `update( event )` sends the event to the listener.
    - The button sends the event by calling `update( )`.
    - By doing things in `update( )`'s body, the listener responds.

Creating an Event Listener

- An event listener class implements an event listener interface.
  - Button event listeners implement the button listener interface,
  - Mouse event listeners implement the mouse listener interface,
  - And so on.
- Some interfaces have more than one `notify( )` method.
- For buttons you usually only want to know when it's clicked.
  - However, it is possible to distinguish between events pressing and releasing a button.
- The "click events" for `JButtons` are `ActionEvent` objects.
- So our listener must implement the `ActionListener` interface.
  - The method `actionPerformed( ActionEvent event )` in the interface is equivalent to the `Observer`'s `update( )` method.

Example

Java

```
import javax.swing.*;
import java.awt.event.*;
import java.awt.Color;

public class SimpleGUI implements ActionListener {
    private final JButton button;
    private boolean alert;

    public static void main( String[] args ) {
        JFrame frame = ⟨Create JFrame⟩
        SimpleGUI gui = new SimpleGUI( );
        ⟨Remaining JFrame-related statements.⟩
    }

    public SimpleGUI( ) {
        button = new JButton( "Click me" );
        button.addActionListener( this );
    }

    @Override
    public void actionPerformed( ActionEvent event ) {
        button.setText( alert ? "Alarm" : "No panic" );
        button.setBackground( alert ? Color.red : Color.green );
        alert = !alert;
    }
}
```

A Button with a Counter

Java

```
import javax.swing.*;
import java.awt.event.*;

public class CountingButton implements ActionListener {
    private int clicks;
    private final JButton button;

    public static void main( String[] args ) {
        JFrame frame = ⟨Create JFrame⟩
        SimpleGUI gui = new SimpleGUI( );
        ⟨Remaining JFrame-related statements.⟩
    }

    public CountingButton( ) {
        clicks = 0;
        button = new JButton( "Click me" );
        button.addActionListener( this );
    }

    @Override
    public void actionPerformed( ActionEvent event ) {
        String text = "# clicks = " + ++ clicks + ". Try again.";
        button.setText( text );
    }
}
```

Nested Classes

- Classes defined in other classes are called *nested classes.*
- There are two kinds of nested classes.
  - Static classes: these are called *static (nested) classes.*
  - Non-static classes: these are called *inner classes.*
- Both kinds of classes are part of the enclosing (defining) class.
- The enclosing class is also referred to as the *outer* class.
- The differences between the two kinds of classes are subtle.

Proper Inner Classes

- Defined at top level of its outer class.
- An inner class instance *depends on an instance of the outer class.*
  - The inner instance can see its outer instance's instance attributes.
  - Implicitly, the inner instance owns its outer instance's reference.
  - Inner classes cannot have class attributes and class methods.
- You may create inner class instances in two kinds of methods.
  1. **An instance method or constructor of the outer class.**
     - The new instance depends on the `this` of the method/constructor.
  2. **An instance method or constructor of the inner class.**
     - The new instance depends on the instance that the current inner class instance depends on.

Example: Inner Class

Java

```
public class Outer {
    private final int value;

    public void outerMethod( ) {
        Inner inner = new Inner( );
    }

    private class Inner {
        private Inner( ) {
            System.out.println( value );
        }
        ...
    }
}
```

Inner Class: Second Example

Java

```
import javax.swing.*;
import java.awt.event.*;
import java.awt.Color;

public class InnerClassExample {
    private final JButton button;
    private boolean alert;

    public static void main( String[] args ) {
        final InnerClassExample gui = new InnerClassExample( );
        gui.run( );
    }

    private InnerClassExample( ) {
        button = new JButton( "click me" );
        alert = false;
    }

    ...
}
```

Inner Class: Second Example (Continued)

Java

```
public class InnerClassExample {
    private final JButton button;
    private boolean alert;

    ...

    private void run( ) {
        JFrame frame = new JFrame( "Two Listeners" );
        final JPanel panel = new JPanel( );
        final Listener listener = new Listener( );
        frame.getContentPane( ).add( panel );
        panel.add( button );
        frame.setDefaultCloseOperation( JFrame.EXIT_ON_CLOSE );
        frame.setSize( 300, 100 );
        frame.setVisible( true );
    }

    ...
}
```

Inner Class: Second Example (Continued)

Java

```
public class InnerClassExample {
    private final JButton button;
    private boolean alert;

    ...

    private class Listener implements ActionListener {

        private Listener( ) {
            button.addActionListener( this );
        }

        @Override
        public void actionPerformed( ActionEvent event ) {
            button.setText( alert ? "Alarm" : "No panic" );
            button.setBackground( alert ? Color.red : Color.green );
            alert = !alert;
        }
    }
}
```

Several Inner Classes

- You can have several inner classes.
- Very useful for GUI applications.

  Main class Owns attributes that represent GUI state.

  Inner class instances Listen to the events.
  - Have access to the attributes.
  - Can modify them when an event occurs.

Third Inner Class Example

Java

```
public class EditorGUI {
    private final ButtonGroup fontStyleGroup;
    private final ButtonGroup sizeGroup;
    ...

    public EditorGUI( ) { ... }

    private class FontGroupListener implements ActionListener { ... }

    private class SizeGroupListener implements ActionListener { ... }

    ...
}
```

Local Classes

- `Java` also lets you define classes in methods.
- These classes are called *local* classes.
  - A local class defined in instance method is an inner class.
  - A local class defined in a class method is a `static` class.
- Local classes may have names or not.

  With name: These are called *local (inner) classes.*
  Without name: These are called *anonymous classes.*
- Only use them when classes are really short.
  - With long classes, you usually can't see the wood from the trees.

Example: Local Class

Java

```
public class Outer {
    public static void classMethod( ) {
        private class Inner {
            ...
        }
        final Inner inner = new Inner( );
        ...
    }
}
```

Static Classes

- A static class is defined at the top level of some other class.
- It has no access to outer class instance methods.
- It has no access to outer class instance attributes.

Static Classes

Java

```
import javax.swing.*;
import java.awt.event.*;
import java.awt.Color;

public class StaticDoubleListener {

    public static void main( String[] args ) {
        JFrame frame = new JFrame( "Two Listeners" );
        final JButton firstButton = new JButton( "first" );
        final JButton secondButton = new JButton( "second" );
        final JPanel panel = new JPanel( );
        final Listener first = new Listener( firstButton, secondButton );
        final Listener second = new Listener( secondButton, firstButton );
        frame.getContentPane( ).add( panel );
        panel.add( firstButton );
        panel.add( secondButton );
        frame.setDefaultCloseOperation( JFrame.EXIT_ON_CLOSE );
        frame.setSize( 300, 100 );
        frame.setVisible( true );
    }

    private static class Listener implements ActionListener {
        ...
    }
}
```

Static Classes

Java

```
private static class Listener implements ActionListener {
    private final JButton button;
    private boolean alert;

    private Listener( final JButton thisButton,
                      final JButton thatButton ) {
        button = thisButton;
        thatButton.addActionListener( this );
    }

    @Override
    public void actionPerformed( ActionEvent event ) {
        button.setText( alert ? "Alarm" : "No panic" );
        button.setBackground( alert ? Color.red : Color.green );
        alert = !alert;
    }
}
```

Anonymous Classes

- An anonymous class is a class without name.
- It extends a single class or implements a single interface.
- It combines class definition & instance creation.
  - It cannot have an explicit constructor.
  - Its body should override all necessary methods.

Example: Anonymous Class

Java

```
public class Matrimony {
    ...
    private static void unite( ) {
        final Man john = new Man( ) {
            @Override public void marry( final Woman wife ) { ... }
        };
        final Woman mary = new Woman( ) {
            @Override public void marry( final Man husband ) { ... }
        };
        john.marry( mary );
    }
}
```

Interfaces can be “Nested” Too

Java

```
public class Matrimony {
    ...

    private interface Unitable { }

    private interface Woman extends Unitable {
        public void marry( final Man husband );
    }

    private interface Man extends Unitable {
        public void marry( final Woman wife );
    }
}
```

Question Time

Questions Anybody?

For Friday

- Study the presentation;
- Re-implement the newspaper example from scratch;
- Read [Sierra, and Bates 2004, Chapter 12];
- Study [Bloch 2008, Item 30] if you have the book.

Acknowledgements

- This lecture corresponds to [Sierra, and Bates 2004].
- [Freeman, and Freeman 2005, Pages 44–78];
- Gamma et al. [2008].
- Some material is based on the `Oracle` tutorials.

Bibliography I

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About this Document

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