
CSE 331

Software Design & Implementation

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GUI Event-Driven Programming

(Based on slides by Mike Ernst, David Notkin, Hal Perkins)

The plan

- User events and callbacks
 - Event objects
 - Event listeners
 - Registering listeners to handle events
- Anonymous inner classes
- Proper interaction between UI and program threads

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Event-driven programming

Many applications are *event-driven* GUI programs:

- Program initializes itself on startup then enters an *event loop*

- Abstractly:

```
do {  
    e = getNextEvent();  
    process event e;  
} while (e != quit);
```

Contrast with application- or algorithm-driven control where program expects input data in a particular order

- Typical of large non-GUI applications like web crawling, payroll, data simulation, ...

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Kinds of GUI events

Typical *events* handled by a GUI program:

- Mouse move/drag/click, button press, button release
- Keyboard: key press or release, sometimes with modifiers like shift/control/alt/etc.
- Finger tap or drag on a touchscreen
- Joystick, drawing tablet, other device inputs
- Window resize/minimize/restore/close
- Network activity or file I/O (start, done, error)
- Timer interrupt (including animations)

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Events in Java AWT/Swing

Many (most?) of the GUI widgets can generate events (button clicks, menu picks, key press, etc.)

Handled using the Observer Pattern:

- Objects wishing to handle events register as observers with the objects that generates them
- When an event happens, appropriate method in each observer is called
- As expected, multiple observers can watch for and be notified of an event generated by an object

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Event objects

A Java GUI event is represented by an *event object*

- Superclass is **AWTEvent**
- Some subclasses:
 - ActionEvent** – GUI-button press
 - KeyEvent** – keyboard
 - MouseEvent** – mouse move/drag/click/button

Event objects contain information about the event

- UI object that triggered the event
- Other information depending on event. Examples:
 - ActionEvent** – text string from a button
 - MouseEvent** – mouse coordinates

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Event listeners

Event listeners must implement the proper interface: **KeyListener**, **ActionListener**, **MouseListener** (buttons), **MouseMotionListener** (move/drag), ...

- Or extend the appropriate library *abstract class* that provides empty implementations of the *interface* methods

When an event occurs, the appropriate method specified in the interface is called: **actionPerformed**, **keyPressed**, **mouseClicked**, **mouseDragged**, ...

An event object is passed as a parameter to the event listener method

Example: button

Create a **JButton** and add it to a window

Create an object that implements **ActionListener**
– (containing an **actionPerformed** method)

Add the listener object to the button's listeners

ButtonDemo1.java

Which button is which?

Q: A single button listener object often handles several buttons. How to tell which button generated the event?

A: an **ActionEvent** has a **getActionEvent** method that returns (for a button) the "action command" string

- Default is the button name (text), but usually better to set it to some string that will remain the same inside the program code even if the UI is changed or translated. See button example.

Similar mechanisms to decode other events

Listener classes

ButtonDemo1.java defines a class that is used only once to create a listener for a single button

- Could have been a top-level class, but in this example it was an inner class since it wasn't needed elsewhere
- But why a full-scale class when all we want is to create a method to be called after a button click?
 - Alas, no lambdas (function closures) until Java 8

A more convenient shortcut: *anonymous inner classes*

Anonymous inner classes

Idea: **define** a **new class** directly in the **new expression** that creates an object of the (new) anonymous inner class

- Specify the superclass to be extended or interface to be implemented
- Override or implement methods needed in the anonymous class instance
- Can have methods, fields, etc., but not constructors
- But if it starts to get complex, use an ordinary class for clarity (nested inner class if appropriate)

Alas, ghastly syntax ahead

Example

The diagram shows the following code snippet with annotations:

```
button.addActionListener(new ActionListener() {  
    public void actionPerformed(ActionEvent e) {  
        model.doSomething();  
    }  
});
```

Annotations:

- Method call parameter list**: points to `button.addActionListener`
- new expression to create class instance**: points to `new`
- Class or interface being extended/implemented (can include constructor parameters)**: points to `ActionListener`
- Implementation of method for this anonymous class**: points to the `public void actionPerformed` block
- Brackets surrounding new class definition**: points to the curly braces `{ }` of the anonymous class

Example

ButtonDemo2.java

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Program thread and UI thread

Recall that the program and user interface are running in separate, concurrent threads

All UI actions happen in the UI thread – *including the callbacks* like `actionListener` or `paintComponent`, etc. defined in your code

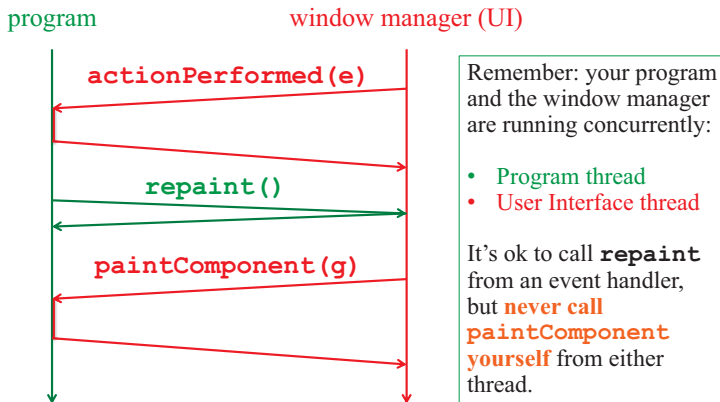
After event handling and related work, call `repaint()` if `paintComponent()` needs to run. **Don't** try to draw anything from inside the event handler itself (as in **you must not do this!!!**)

Remember that `paintComponent` must be able to do its job by reading data that is available whenever the window manager calls it

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Event handling and repainting



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Working in the UI thread

Event handlers should not do a lot of work

- If the event handler does a lot of computing, the user interface will appear to freeze up
 - (Why?)
- If there's lots to do, the event handler should set a bit that the program thread will notice: Do the heavy work back in the program thread.
 - (Don't worry – finding a path for campus maps should be fast enough to do in the UI thread)

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Synchronization issues?

Yes, there can be synchronization problems

- (cf. CSE332, CSE451, ...)

Not usually an issue in well-behaved programs, but can happen

Some advice:

- Keep event handling short
- Call `repaint` when data is ready, not when partially updated
- Don't update data in the UI and program threads at the same time (particularly for complex data)
- **Never** call `paintComponent` directly
 - (Have we mentioned you should never call `paintComponent`? And don't create a new `Graphics` object either.)

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Larger example – bouncing balls

A hand-crafted MVC application. Origin is somewhere back in the CSE142/3 mists. Illustrates how some swing GUI components can be put to use.

Disclaimers:

- Not the very best design
- Unlikely to be directly appropriate for your project
- Use it for ideas and inspiration, and feel free to steal small bits if they *really* fit

Enjoy!

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