CSE 331
Software Design & Implementation

Hal Perkins

Autumn 2012

Java Graphics & GUIs

The plan

Today: introduction to Java graphics and Swing/AWT class libraries

Then: event-driven programming and user interaction

None of this is comprehensive – only an overview and guide to what you should expect to be out there.

Credits: material ~~stolen~~ adapted from many places; including slides and materials by Ernst, Hotan, Mercer, Notkin, Perkins, Stepp; Regis, Sun/Oracle docs, Horstmann, Wikipedia, undoubtedly others

References

Useful start: Sun/Oracle Java tutorials

http://docs.oracle.com/javase/tutorial/ui/index.html

http://docs.oracle.com/javase/tutorial/uiswing/index.html

Mike Hoton's slides/sample code from CSE 331 Sp12 (lectures 23, 24 with more extensive widget examples)

Decent book: *Core Java* vol. I by Horstmann & Cornell (but if you've got another favorite, that's good too)

Why study GUIs?

It's how the world works!!

Classic example of using inheritance to organize large class libraries

Work with a ~~large~~ huge API – and learn how (not) to deal with all of it

Many core design patterns show up here: callbacks, listeners, event-driven programs

It's cool!! It's fun!!!!

What not to do…

There’s way too much to know all of it

Don’t memorize – look things up as you need them

Focus on the main ideas, fundamental concepts

Don’t get bogged down implementing eye candy

The (more detailed) plan

Organization of the AWT/Swing library

Graphics and drawing

- Repaint callbacks, layout managers, etc.

Handling user events

Building GUI applications

- MVC, user events, updates, &c

A very short history (1)

Graphical user interfaces have existed in Java since the beginning

Original Java GUI: AWT (Abstract Window Toolkit)

- Limited set of user interface elements (widgets)
- Mapped Java UI to host system UI widgets
- Lowest common denominator
- “Write once, debug everywhere”

A very short history (2)

Swing: Newer GUI library, introduced with Java 2 (1998)

Basic idea: underlying system only provides a blank window. Swing draws all UI components directly; doesn't use underlying system widgets

Not a total replacement for AWT. Swing is implemented on top of core AWT classes and both still coexist.

Use Swing, but deal with AWT when you must

GUI terminology

window: A first-class citizen of the graphical desktop

Also called a top-level container

examples: frame, dialog box, applet

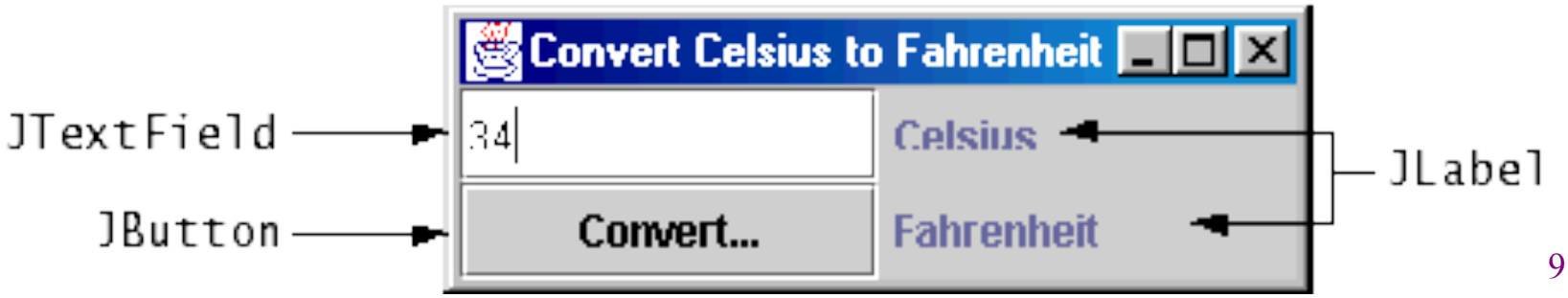
component: A GUI widget that resides in a window

Also called controls in many other languages

examples: button, text box, label

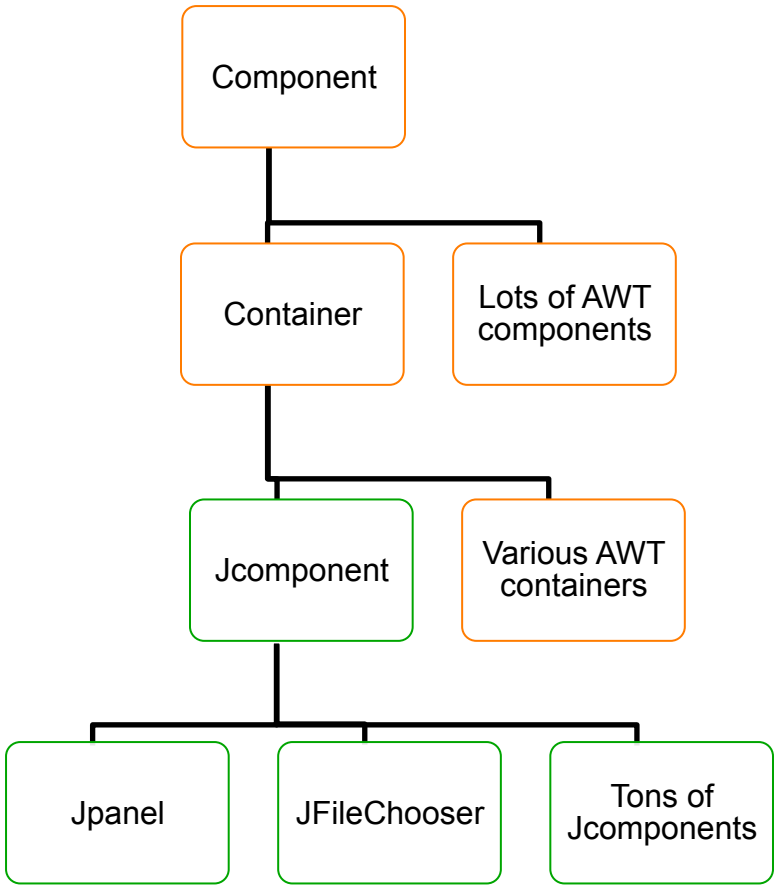
container: A logical grouping for storing components

examples: panel, box



Component & container classes

- Every GUI-related class descends from Component, which contains dozens of basic methods and fields
- "Atomic" components: labels, text fields, buttons, check boxes, icons, menu items…
- Many components are Containers – things like panels that can hold nested subcomponents



Swing/AWT inheritance hierarchy

```
Component   (AWT)
    Window
        Frame
            JFrame   (Swing)
            JDialog
    Container
        Jcomponent  (Swing)
            JButton          JColorChooser
            JFileChooser
            JComboBox        JLabel          JList
            JMenuBar         JOptionPane     JPanel
            JPopupMenu       JProgressBar    JScrollbar
            JScrollPane      JSlider         JSpinner
            JSplitPane       JTabbedPane     JTable
            JToolbar         JTree           JTextArea
            JTextField       ...
```

Component properties

Zillions. Each has a **`get`** (or **`is`**) accessor and **`set`** modifier. Ex: **`getColor`**, **`setFont`**, **`isVisible`**, …

name	type	description
background	`Color`	background color behind component
border	`Border`	border line around component
enabled	`boolean`	whether it can be interacted with
focusable	`boolean`	whether key text can be typed on it
font	`Font`	font used for text in component
foreground	`Color`	foreground color of component
height, width	`int`	component's current size in pixels
visible	`boolean`	whether component can be seen
tooltip text	`String`	text shown when hovering mouse
size, minimum / maximum / preferred size	`Dimension`	various sizes, size limits, or desired sizes that the component may take

Types of containers

- Top-level containers: JFrame, JDialog, …
  - Often correspond to OS windows
  - Can be used by themselves, but usually as a host for other components
  - Live at top of UI hierarchy, not nested in anything else
- Mid-level containers: panels, scroll panes, tool bars
  - Sometimes contain other containers, sometimes not
  - JPanel is a general-purpose component for drawing or hosting other UI elements (buttons, etc.)
- Specialized containers: menus, list boxes, …
- Technically, all J-components are containers

JFrame – top-level window

Graphical window on the screen

Typically holds (hosts) other components

Common methods:

- **`JFrame(String`** *title*`)` – constructor, title optional
- **`setDefaultCloseOperation(int`** *what*`)` – what to on window close. **`JFrame.EXIT_ON_CLOSE`** terminates application when window closed.
- **`setSize(int`** *width*`, int`** *height*`)` – set size
- **`add(Component`** *c*`)` – add component to window
- **`setVisible(boolean`** *v*`)` – make window visible or not

Example

SimpleFrameMain.java

JPanel – a general-purpose container

Commonly used as a place for graphics, or to hold a collection of button, labels, etc.

Needs to be added to a window or other container

```
frame.add(new Jpanel(…))
```

`JPanel`s can be nested to any depth

Many methods/fields in common with **`JFrame`** (since both inherit from Component)

Advice: can't find a method/field? Check the superclass(es)

Some new methods. Particularly useful:

`setPreferredSize(Dimension` *d*`)`

Layout managers

What if we add several components to a container? How are they postioned relative to each other?

Answer: each container has a layout manger. Kinds:

- **`FlowLayout`** (left to right, top to bottom) – default for **`JPanel`**
- **`BorderLayout`** (“center”, “north”, “south”, “east”, “west”) – default for **`JFrame`**
- **`GridLayout`** (regular 2-D grid)
- others... (some are incredibly complex)

The first two should be good enough for now….

pack()

Once all the components are added to their containers, do this to make the window visible

```
pack();
setVisible(true);
```

`pack()` figures out the sizes of all components and calls the layout manager to set locations in the container (recursively as needed)

If your window doesn't look right, you may have forgotten **`pack()`**

Example

SimpleLayoutMain.java

Graphics and drawing

So far so good – and very boring…

What if we want to actually draw something? A map, an image, a path, …?

Answer: Override method **`paintComponent`**

- Components like **`JLabel`** provide a suitable **`paintComponent`**that (in **`JLabel`**'s case) draws the label text
- Other components typically inherit an empty **`paintComponent`** and can use it for drawing.

Example

SimplePaintMain.java

Graphics methods

Many methods to draw various lines, shapes, etc., …

Can also draw images (pictures, etc.). Load the image file into an **`Image`** object and use **`g.drawImage(…)`**:

- In the program (*not* in **`paintComponent`**):

```
Image pic =
    Toolkit.getDefaultToolkit()
           .getImage(image path);
```

- Then in **`paintComponent`**:

```
g.drawImage(pic, ...);
```

Graphics vs Graphics2D

Class **`Graphics`** was part of the original Java AWT

- Has a procedural interface: **`g.drawRect(…)`**, **`g.fillOval(…)`**

Swing introduced **`Graphics2D`**

- Added a object interface – create instances of **`Shape`** like **`Line2D`**, **`Rectangle2D`**, etc., and add these to the **`Graphics2D`** object

Parameter to paintComponent is always **`Graphics2D`**. Can always cast it to that class. **`Graphics2D`** supports both sets of graphics methods.

- Use whichever you like for CSE 331

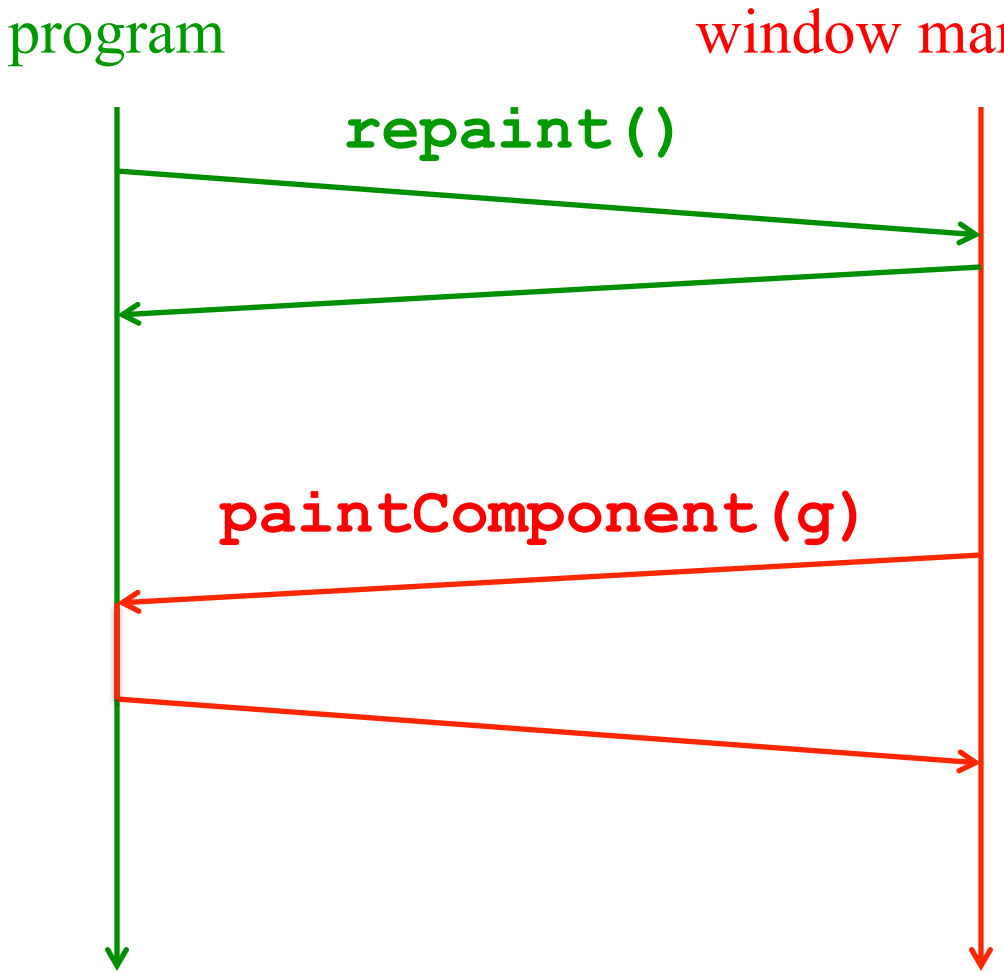
So who calls paintComponent? And when??

- Answer: the window manager calls **`paintComponent`** *whenever it wants!!!*
  - When the window is first made visible, and whenever after that it is needed
- Corollary: **`paintComponent`** must **always** be ready to repaint – regardless of what else is going on
  - You have no control over when or how often – must store enough information to repaint on demand
- If you want to redraw a window, call **`repaint()`**
  - Tells the window manager to schedule repainting
  - Window manager will call **`paintComponent`** when it decides to redraw (soon, but maybe not right away)

Example

FaceMain.java

How repainting happens



It's worse than it looks!

Your program and the window manager are running concurrently:

- Program thread
- User Interface thread

Do not attempt to mess around – follow the rules and nobody gets hurt!

Rules for painting – Obey!

- Always override **`paintComponent(g)`** if you want to draw on a component
- Always call **`super.paintComponent(g)`** first
- ***NEVER*** call **`paintComponent`** yourself. That means **ABSOLUTELY POSITIVELY NEVER!!!**
- Always paint the entire picture, from scratch
- Use **`paintComponent`**'s **`Graphics`** parameter to do all the drawing. ***ONLY*** use it for that. Don't copy it, try to replace it, or mess with it. It is quick to anger.
- **DON'T** create new **`Graphics`** or **`Graphics2D`** objects

- Fine print: Once you are a certified™ wizard, you may find reasons to do things differently, but you aren't there yet.

What's next – and not

Major topic next time is how to handle user interactions

- We already know the core idea – it's a big-time application of the observer pattern

Beyond that you're on your own to explore all the wonderful widgets in Swing/AWT. Have fun!!!

- (But don't sink huge amounts of time into eye candy)