CSE 331
Software Design & Implementation

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Java Graphics and GUIs

(Based on slides by Mike Ernst, Dan Grossman, David Notkin, Hal Perkins, Zach Tatlock)

Review: how to create a GUI

1. Create a JFrame (window)

2. Add components to it
   – organize them on the screen using a layout manager

3. Add handlers on the components
   – one for each event you want to respond to

`JPanel` – a general-purpose container

In addition to all the uses we saw in lecture:

- Commonly used as a place for graphics

A particularly useful method:

- **`setPreferredSize(Dimension`** *d***`)`**
- you may want to call this when using JPanel as a canvas
    - (don’t usually want to otherwise)

Graphics and drawing

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 like **`JPanel`** typically inherit an empty **`paintComponent`** and can override it to draw things

Note: As we'll see, *we override* **`paintComponent`** but *we don't* call it

Example

`SimplePaintMain.java`

Graphics methods

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

Can also draw images (pictures, etc.):

- In the program (***not*** in **`paintComponent`**):
  - Use AWT's "Toolkit" to load an image:

```
Image pic =
    Toolkit.getDefaultToolkit()
        .getImage(file-name (with 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`** (extends **`Graphics`**)

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

Actual parameter to **`paintComponent`** is always a **`Graphics2D`**

- Can always cast this parameter from **`Graphics`** to **`Graphics2D`**
- **`Graphics2D`** supports both sets of graphics methods
- Use whichever you like for CSE 331

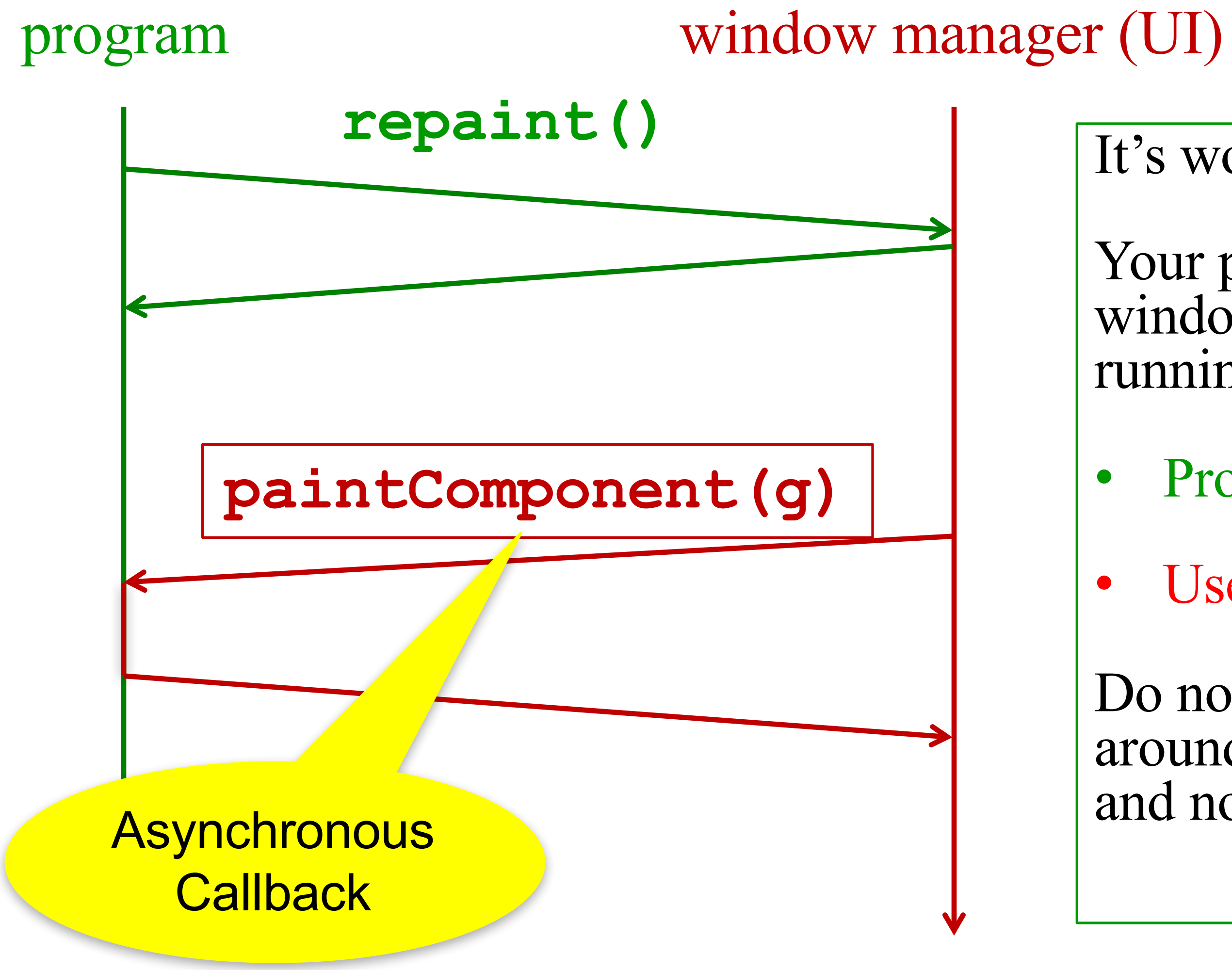
So who calls **`paintComponent`**? And when??

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

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!

Crucial rules for painting

- Always override **`paintComponent(g)`** if you want to draw on a component
- Always call **`super.paintComponent(g)`** first
- ***NEVER, EVER, EVER*** call **`paintComponent`** yourself
- 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 that requires deeper understanding of the GUI library's structure and specification

What’s next – and not

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)

Reminder: UI thread

Recall that sometimes the program has additional threads, e.g.:

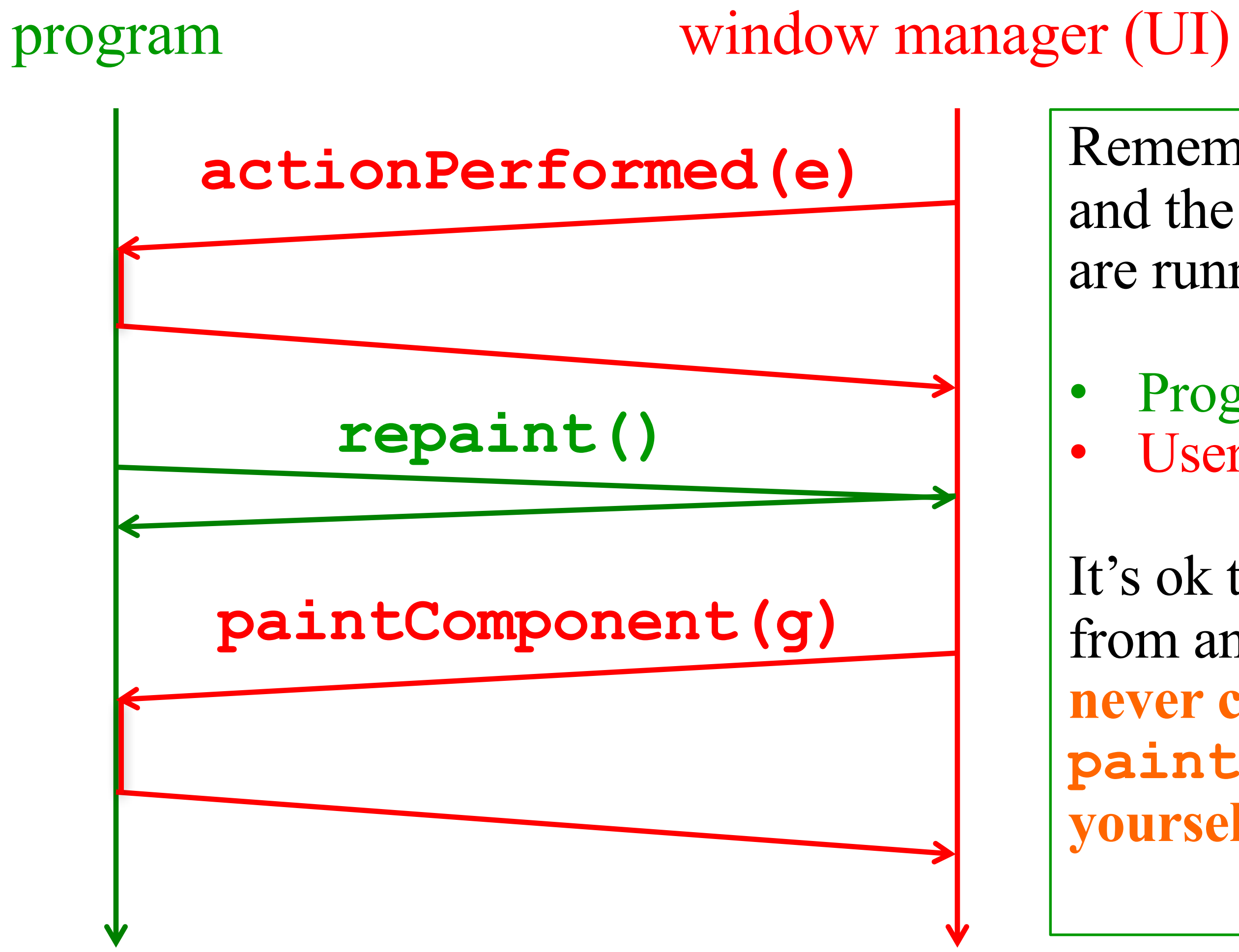
- one thread is waiting for network data ("the network thread")
- another thread is displaying the UI ("the UI thread")

All UI actions happen in the UI thread – *including 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 whenever the window manager calls it – so any data it needs to render must be prepared in advance

Event handling and repainting



Remember: your program and the window manager are running concurrently:

- Program thread
- User Interface thread

It's ok to call **`repaint`** from an event handler, but **never call `paintComponent` yourself** from either thread.

Synchronization issues?

Yes, there can be synchronization problems

- (cf. CSE332, CSE451, CSE452, …)

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

Advice:

- Keep event handling short
- Call **`repaint`** when data is ready, not when only 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 ever call **`paintComponent`**? And don't create a new **`Graphics`** object either.)

If you are building industrial-strength UIs, learn more about threads and Swing and how to avoid potential problems (Swing tutorial, …)

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 (maybe not even particularly good)
- 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!