Big picture recap…

• via the services of the RasterImage class
• our app asks the window manager for a window
• the constructor creates and places a blank “canvas” inside this window
• this canvas has an associated Graphics2D object, which we can access via getGraphics2D()
• via the services of the Graphics2D class
• we use the services of this class to modify the current settings
• we use the services of this component to perform drawing of shape primitives and text

The VM and the window manager coordinate with one another in order to do the drawing.

Shooter Games…

• Shooting is a basic behaviour that is a defining characteristic of shooter games
• We will employ encapsulation:
  • encapsulate the shooter
  • encapsulate the projectile
  • encapsulate the target
• Shooting entails:
  • waiting for user input
  • rendering the trajectory over a sequence of frames
  • collision behaviours

Frame Drawing…

• We need functionality to implement repeated frame drawing
• frames need to be drawn whether the user is performing actions or not
• we need a service that will dispatch events repeatedly, each of which signals “draw new frame”
Suspension of Disbelief

- Humans will suspend judgment about the implausibility of a narrative in order to engage with the material
  - this alternative is that human does not suspend judgment, disengages and rejects premise of the material
- Video games require suspension of disbelief
  - game mechanics are unrealistic (by design or by technological limitation)
- Designs seek to support suspension of disbelief and try to remove aspects that interfere with suspension of disbelief
  - uncanny valley interferes with suspension of disbelief
  - high motion interferes with suspension of disbelief

Motion Perception

- High motion:
  - when moving images do not blur or strobe even when tracked closely by the eye
  - is the characteristic of video or film footage displayed possessing a sufficiently high frame rate
  - how do a succession of still images give the illusion of a motion?
  - why do we not see the “blanks” in between successive still images?

Motion Perception

- we don’t see the “blanks” in between successive still images because of persistence of vision
  - the afterimage persists on the retina for a small period of time (like 40 msec)
  - fireworks leave what we perceive to be trails of light; there is no trail, it is a creation of the mind, which retains a perception of the light stimulus for a fraction of a second longer
Motion Perception

- how do a succession of still images give the illusion of a motion?
  - apparent motion: when an object is perceived as moving when, in fact, a series of stationary images is being presented
    - this is the “beta movement” percept
  - illusory “object”: something is perceived, but it is an illusion
    - our brains fill in the gap with something
    - the phi phenomena
  - the two percepts are often confused and conflated

Frame Rate

- The speed at which frames are drawn is called the frame rate
  - TV: 60 fps
  - Movies: 24 fps
  - The Hobbit 3D experiment: 48 fps
  - Lower threshold: 10-12 fps, phi phenomenon
  - Upper threshold: ~66 fps

How can we implement frames?

- let’s start with a simple example
- we want to animate a dot moving in a diagonal
- start with the dot at the origin:

```
private final int DIA = 10;
Point p = new Point(0, 0);
```

for each frame, draw the dot at the current anchor point
```
Ellipse2D.Double dot = new Ellipse2D.Double(p.x, p.y, DIA, DIA);
```

also update the anchor point (for the next frame)
```
p = new Point(p.x + 1, p.y + 1);
```

Separation of Concerns

there are two tasks here:
1. triggering the new frame
2. specifying what is to be drawn on the frame

We want to delegate each of these tasks to different services
How can we implement frames?

- We will have two “players” here
  - Dude#1: says when it is time to redraw
  - Dude#2: says what happens to the drawing surface when it is time to draw a frame

How we implement frames

- Dude #2: says what happens to the drawing surface when it is time to draw a frame for each frame, draw the dot at the current anchor point
  
  ```java
  Ellipse2D.Double dot = new Ellipse2D.Double(p.x, p.y, DIA, DIA);
  graphics.draw(dot);
  theCanvas.repaint();
  update the anchor point (for the next frame)
  p = new Point(p.x + 1, p.y + 1);
  ```

How we implement frames

- Dude#1: says when it is time to redraw
  - we need to define the inter-frame interval (x msec)
  - we need to launch a thread for Dude#1 so he can start running his process
    - every x msec Dude#1 will announce it is time for a new frame
  - we need to set up Dude#2 to listen to Dude#1

How we implement frames

- we need to set up Dude#2 to listen to Dude#1
  - Dude#2 is the observer, Dude#1 is the observee
  - Dude#1 can make announcements till the cows come home; if no one is listening, nothing will happen
  - it’s like broadcasting a radio station; the listening public has to tune their radio to the right station
How to set things up…

1. Identify the **observee** component
   - this is the component that is dispatching events that you care about

2. Create an **observer** component
   - this will be a component that is capable of “listening” to those types of events
   - this is like “tuning” to the station

3. Use the services of the **observee** to tell it that it has an **observer**

---

The **Observee** component

```java
public class Observee

    public static void main(String[] args)
    {
        // Observee component code
    }
```

**Constructor Summary**

<table>
<thead>
<tr>
<th>Constructor and Description</th>
</tr>
</thead>
</table>
| public static void main(String[] args)

---

How we implement frames

- **Dude**: says when it is time to redraw
  - dude is encapsulated by the **observee** class definition
  - we specify the number of frames per second
  - services the class provides:
    - derives the inter-frame interval (msec)
    - instantiates a **Timer** object, which in turn launches a new thread
    - constructor of a **Timer** object requires a listener
      - the thread fires events at the specified inter-frame interval

---

The **Observer** component

```java
public class Observer

    public static void main(String[] args)
    {
        // Observer component code
    }
```

**Constructor Summary**

<table>
<thead>
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</tr>
</tbody>
</table>
How we implement frames

- Dude #2: says what happens to the drawing surface when it is time to draw a frame
  - dude#2 is encapsulated by the Observer class definition
  - services the class provides:
    - sets up the RasterImage, initializes values
    - implements an actionPerformed(ActionEvent) method
    - the body of the actionPerformed(ActionEvent) method is invoked each time an event is dispatched by this object’s observee
  - the body of the actionPerformed(ActionEvent) specifies each frame to be drawn

What services does the ActionEvent class provide?

- Events are objects that encapsulate some sort of “happening”
- Examples include:
  - the user did something
    - e.g., performed a mouse or keyboard action
  - the window manager did something
    - e.g., opened a window, shifted focus

- ActionEvent provides the most basic services to represent any sort of action with respect to any sort of component within a window

Interfaces

- Examine the API for the Observer class, notice the following
  - public class Observer
    extends java.lang.Object
    implements java.awt.event.ActionListener
  - the implements keyword is important
  - it signals that objects of type Observer can be treated as though they are of the type ActionListener
  - constructor creates objects that have two types, both at the same time!!!
  - review code example L09_Ex2

Event vs Exception

- Events are sorta like Exceptions
- Exceptions
  - encapsulate some sort of happening
  - The term exception is shorthand for the phrase “exceptional event.”
  - can be thrown/caught
- Events
  - encapsulate some sort of happening
  - many different types of happenings (mouse events, keyboard events, window events, etc, etc)
  - cannot be thrown/caught
  - instead, are passed as parameters to methods
Event vs Exception

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  - can be thrown/caught
  - Exception classes are defined in a hierarchy

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Attributes of ActionEvent objects

- Objects of type ActionEvent have the following attributes:
  - which component was the source of the event (e.g., which keyboard button, which GUI element, etc)
  - when the event was triggered (the timestamp)
  - the command that is associated with the event
  - for instance an on-screen button may be labeled "beep", and the associated command would be "play beep"
  - which modifiers were used (e.g., alt, control, shift keys)

Java's Event Class Hierarchy

A subset of Java's Event Class Hierarchy is shown here

See Java API for full hierarchy

Are Attributes Even that Important?

- sometimes the client doesn't care about an ActionEvent's attributes
  - A client may only care that an action event occurred, as opposed to any of the details about the event that occurred
  - For instance, dude #1 uses ActionEvent to encapsulate "it is time to advance the frame"
  - dude #2 receives those events and reacts; dude #2 doesn't care much about the who/what/when
The actionPerformed(ActionEvent) method

- review code example L09_Ex3

The Event Dispatching Thread

- code example L09_Ex3 can drive our animation, but it is not a correct implementation
- why not? because all event-handling code should be executed on the event dispatching thread, not the initial thread.

Threads & Concurrency

- We take it for granted that our systems can do more than one thing at a time.
  - e.g., continue to work in a word processor, while other applications download files, manage the print queue, and stream audio.
  - e.g., word processor is always be ready to respond to keyboard and mouse events, no matter how busy it is reformatting text or updating the display.
- Software that can do such things is known as concurrent software.
GUI Apps

- Typically have at least two threads
  - the main thread
    - the thread that executes the initial application code
  - the event dispatching thread
    - the thread that executes the code the responds to events
  - (optional) additional worker/background threads
    - the thread(s) that execute code the performs time-consuming tasks
      - perform calculations
      - perform read/write to the file system
      - managing network connections
      - etc...

source: Concurrency Lesson, The Java™ Tutorials

Tasks

- slow down the projectile to have a slower trajectory
- make the projectile expire before it reaches the edge of the screen
- make the projectile wrap around the screen
- introduce random movement

GUI Apps

- What services does the Timer constructor provide?
  - instantiate a Timer object
  - takes the second parameter (an ActionListener) and sets it up so that it is listening for any events that the Timer object may be dispatching
  - launches code the recurrently dispatches events
    - this code runs on the event dispatching thread
  - In L09_Ex3, our action listener object is launched on the main thread
    - this means that event handling is taking place on the main thread, not the event dispatching thread
    - in the next version of our code base, this problem will be fixed.