Swing

Threads

Overview

- event dispatching and GUI painting
  - **single** thread (*event-dispatching thread*)
  - ensures sequential event processing
    - each event is processed after the previous one is finished
    - events do not interrupt painting
- SwingUtilities.invokeLater(Runnable doRun)
- SwingUtilities.invokeAndWait(Runnable doRun)
- SwingUtilities.isEventDispatchingThread()
  - tests whether the current thread is *event-dispatching thread*
- event processing
  - must finish quickly!
  - for long ones → move it to a special thread

SwingWorker<T, V>

- for lengthy GUI-interaction tasks
- part of JDK since 6
  - for older JDK must be downloaded separately

- abstract class
  - necessary to implement the method
    protected abstract T doInBackground()
    - performs the lengthy task
  - the method execute() launches a new thread and runs the doInBackground() method in it

SwingWorker<T, V>

```
public void actionPerformed(ActionEvent e) {
   ...
   final SwingWorker<Object, Object> worker =
                              new SwingWorker<Object, Object>(){
     public Object doInBackground() {
        ...
        return someValue;
     }
   };
   worker.execute();
   ...
}
```

- doInBackground() returns a value
  - can be obtained by the method get()
    - it blocks until doInBackground() terminates
- metoda done()
  - called after doInBackground() terminates
  - run in the event-dispatching thread **(!)**

SwingWorker<T, V>

- type parameters
  - T
    - the type of the worker's returning value
  - V
    - the type for intermediate results
    - protected void publish(V... chunks)
      - **„sends“** data
      - called from doInBackground()
    - protected void process(List<V> chunks)
      - processes the published data
      - intended for overriding
      - run in the event-dispatching thread **(!)**
- worker's state
  - public SwingWorker.StateValue getState()
    - values PENDING, STARTED, DONE

SwingWorker<T, V>

- current progress
  - int getProgress()
  - void setProgress(int progress)
    - not set automatically
    - has to be called explicitly from doInBackground()
      - but it is not necessary
- addPropertyChangeListener(PropertyChangeListener listener)
  - a listener for state and progress changes
- canceling the worker
  - the metoda cancel()
    - doInBackground() must cooperate using the method *isCancel();*

Swing Timer

- the class javax.swing.Timer
  - planning a task for future (repeated) execution
- it is timer for cooperation with GUI
  - intended for tasks that manipulate GUI – there is a special thread that cooperates with the event-dispatching thread
  - "regular" Timer should not be used for GUI manipulations
- creation
  - Timer(int delay, ActionListener listener)
- **Action listener** – its method is run in the event-dispatching thread **(!)**
- methods
  - start(), stop()
  - setRepeats(boolean b) – by default true

Swing

Own painting

Overview

- redefining the following method of GUI components
  `public void paintComponent(java.awt.Graphics g)`

- Graphics
  - raphics2D
  - offers methods for painting
  - usually an instance of the child Graphics2D

```
class MyPanel extends JPanel {

  public void paintComponent(Graphics g) {
    super.paintComponent(g);
    g.drawString("This is my custom Panel!",10,20);
  }
}
```

Overview

- can be redefined for any component
  - typically JPanel is used
    - e.g. for games
  - but other component can be used too
    - e.g. buttons
  - JComponent can be extended directly too
- the method **`paintComponent()`** is called automatically if needed
- explicit repainting request by calling **`repaint()`**
  - does not call **`paintComponent()`** directly but
  - puts a repaint request to a queue of events
    - several subsequent requests → single painting

Overview

- repaint() exists in several variants
  - without parameters
    - repainting a complete component
  - with parameters
    - repainting a given rectangle only
- note
  - painting is taken (and modified) from AWT
  - in AWT – own painting via the methods paint() and update()
    - default implementation – update() calls paint()
  - in Swing – from paint(), paintComponent() is called
    - plus the methods paintBorder() and paintChildren()
      - typically no need to override

Swing

Images

Overview

- the core class (from AWT)
  java.awt.Image
- assumption (from JDK 1.0) – images are loaded over the network
- obtaining an image
  - an applet
    - the method getImage()
  - an application
    - Toolkit.getDefaultToolkit().getImage()
- drawing
  - g.drawImage() // Graphics g;

- supports GIF, PNG, JPG

Example

```
import javax.swing.*;
import java.awt.*;
public class ShowImage extends JApplet {
  private Image im;
  public void init()  {
    im = getImage( getDocumentBase(), "ball.gif");
  }
  public void paint(Graphics g)  {
    g.drawImage(im, 0, 0, this);
  }
}
```

- an issue
  - getImage() does not load the image, just allocates memory
  - the image is loaded in drawImage() during drawing

Drawing

- Graphics.drawImage(Image img, int x, int y, ImageObserver observer)
  - ImageObserver
    - monitors loading the image
    - periodically calls imageUpdate()
      - by default it calls repaint()
    - JApplet and JFrame implements ImageObserver
- MediaTracker class
  - “pre-loading” images

```
public void init() {
   im = getImage(getDocumentBase(), "ball.gif");
   MediaTracker tracker = new MediaTracker(this);
   tracker.addImage(im, 0);
   try {
     tracker.waitForID(0);
   } catch (InterruptedException e)  {
     System.out.println("Download Error");
   }
}
```

ImageIcon

- merge of Image and ImageTracker
  im = new ImageIcon(getDocumentBase()+"ball.gif").getImage();
- can be used for any image
  - not only icons (small images)
- typical usage in applications
  im = new ImageIcon(getClass().getResource("ball.gif")).getImage();

Java 2D API

- added in latter versions
- extension of graphic operations
- the core class
  java.awt.Graphics2D
  - extends java.awt.Graphics
  - the method paintComponent() still has “only” the type Graphics
    => must be explicitly casted
    - can be done in fact always
  - in active painting (will be later)
    - the return value of getGraphics() can be also cast to Graphics2D
  - offers more operations than Graphics
  - easier to use

BufferedImage

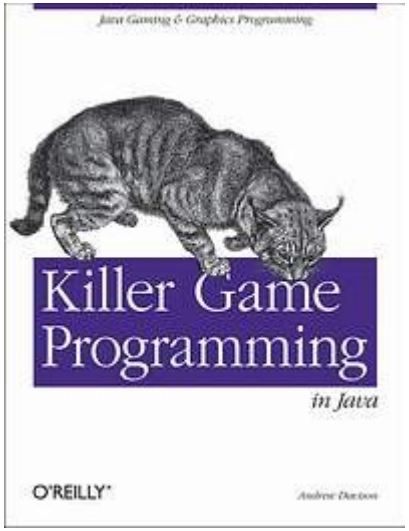
- extends Image
  - the package java.awt.image
- easy access to data of images
- automated conversion to *managed imaged*, which allow for usage of HW acceleration
- loading via javax.imageio.ImageIO.read()
  - should be faster than ImageIcon
- operations with BufferedImage
  - classes implementing java.awt.image.BufferedImageOp
  - transformations
    - AffineTransformOp, ColorConvertOp,...

Swing

Drawing in games

Overview

- examples taken from the book
  A. Dawison: ***Killer Game Programming in Java***
  - the book can be downloaded at
    http://fivedots.coe.psu.ac.th/~ad/jg/
    - not a final version of the book
    - also there are some additional chapters
  - the book exists in Czech also
    - Programování dokonalých her v Javě



Example 1


```
public class GamePanel extends JPanel implements Runnable {
  private static final int PWIDTH = 500;
  private static final int PHEIGHT = 400;
  private Thread animator;
  private boolean running = false;
  private boolean gameOver = false;
        :
  public GamePanel()  {
    setBackground(Color.white);
    setPreferredSize( new Dimension(PWIDTH, PHEIGHT));
    ...
  }
  public void addNotify()  {
    super.addNotify();
    startGame();
  }
  private void startGame()  {
    if (animator == null || !running) {
      animator = new Thread(this);
      animator.start();
    }
  }
```

Example 1 2/2

```
...
public void stopGame() { running = false;    }

public void run() {
  running = true;
  while(running) {
    gameUpdate();
    gameRender();
    repaint();
    try {
      Thread.sleep(20);
    } catch(InterruptedException ex) {}
  }
  System.exit(0);
}
private void gameUpdate() {
  if (!gameOver)
    ...
}
...
}
```

Example 1 Rendering

- usage of „double buffering“
  - drawing to an off-screen buffer
  - copying the buffer to the screen

```
private Graphics dbg;
private Image dbImage = null;
     :
private void gameRender() {
  if (dbImage == null){
    dbImage = createImage(PWIDTH, PHEIGHT);
    if (dbImage == null) {
      System.out.println("dbImage is null");
      return;
    } else
      dbg = dbImage.getGraphics();
  }
  dbg.setColor(Color.white);
  dbg.fillRect (0, 0, PWIDTH, PHEIGHT);
    ...
    ...
    if (gameOver)
      gameOverMessage(dbg);
} // end of gameRender()
private void
gameOverMessage(Graphics g) {
  g.drawString(msg, x, y);
}
```

Example 1 Rendering

- copying the buffer in paintComponent()

```
public void paintComponent(Graphics g) {
  super.paintComponent(g);
  if (dbImage != null) {
    g.drawImage(dbImage, 0, 0, null);
  }
}
```

Example 1 Input

- adding reactions to user input

```
public GamePanel() {
  setBackground(Color.white);
  setPreferredSize( new Dimension(PWIDTH, PHEIGHT));

  setFocusable(true);
  requestFocus();
  readyForTermination();
  ...
  addMouseListener( new MouseAdapter() {
    public void mousePressed(MouseEvent e) {
      testPress(e.getX(), e.getY()); }
  });
}
```

Example 1 Input

```
private void readyForTermination()  {
    addKeyListener( new KeyAdapter() {
     public void keyPressed(KeyEvent e)  {
       int keyCode = e.getKeyCode();
       if ((keyCode == KeyEvent.VK_ESCAPE) ||
           (keyCode == KeyEvent.VK_Q) ||
           (keyCode == KeyEvent.VK_END) ||
           ((keyCode == KeyEvent.VK_C) && e.isControlDown()) ) {
         running = false;
       }
     }
   });
}

private void testPress(int x, int y) {
  if (!gameOver) {
    ...
  }
}
```

Example 1 Issues

- the variables `running` and `gameOver` must be `volatile`
  - there are several threads – each of them can can a local copy of the variables (because of performance)
  - if they are `volatile`, they cannot be in a local copy
- `repaint()` only request for repainting
  - no guarantee when executed; its execution time cannot be obtained
  - amount of time for `sleep()` cannot be estimated
  - `sleep` is necessary
    - releasing CPU
    - `repaint()` can be executed

Example 2

- active rendering

```
public void run() {
  running = true;
  while(running) {
    gameUpdate();
    gameRender();
    paintScreen();
    try {
      Thread.sleep(20);
    } catch(InterruptedException ex){}
  }
  System.exit(0);
}
```

```
private void paintScreen() {
  Graphics g;
  try {
    g = this.getGraphics();
    if ((g != null) && (dbImage != null))
      g.drawImage(dbImage, 0, 0, null);
    g.dispose();
    Toolkit.getDefaultToolkit().sync();
  } catch (Exception e)  {
    System.out.
        println("Graphics context error: " + e);
  }
}
```

Example 3

- painting fully controlled
  => can be measured
  => time for sleep() can be set based on requested FPS

```
public void run() {
  long beforeTime, timeDiff, sleepTime;
  beforeTime = System.currentTimeMillis();
  running = true;
  while(running) {
    gameUpdate();
    gameRender();
    paintScreen();
    timeDiff = System.currentTimeMillis() - beforeTime;
    sleepTime = period - timeDiff;
    if (sleepTime <= 0)
      sleepTime = 5;
    try {
      Thread.sleep(sleepTime);
    } catch(InterruptedException ex){}
    beforeTime = System.currentTimeMillis();
  }
  System.exit(0);
}
```

Example 3

- the period variable contains requested FPS in milliseconds
  - example FPS 100
    1000/100 = 10 ms

- possible problems
  - imprecise timer
  - different precision on different platforms
- better to use System.nanoTime()
- further possibilities for enhancements
  - counting imprecision of the timer
  - separation of rendering period and game state update period

Full-Screen Exclusive Mode

- since JDK 1.4
- direct access to video RAM
  - bypasses most of Swing and AWT
- the class VolatileImage
  - accelerated images
  - no need to use directly
    - Swing decides when possible

Full-Screen Exclusive Mode

```
private GraphicsDevice gd;
private Graphics gScr;
private BufferStrategy bufferStrategy;
    :
private void initFullScreen() {
  GraphicsEnvironment ge =
     GraphicsEnvironment.getLocalGraphicsEnvironment();
  gd = ge.getDefaultScreenDevice();
  setUndecorated(true);
  setIgnoreRepaint(true);
  setResizable(false);
  if (!gd.isFullScreenSupported()) {
    System.out.println("Full-screen exclusive mode not supported");
    System.exit(0);
  }
  gd.setFullScreenWindow(this);
  // setDisplayMode(800, 600, 8);
  // setDisplayMode(1280, 1024, 32);
  }
```

Full-Screen Exclusive Mode

- page flipping
  - drawing to several buffers
  - no copying
  - only switching of video RAM pointer
- setting a number of buffers

```
try {
  EventQueue.invokeAndWait( new Runnable() {
    public void run()
    { createBufferStrategy(NUM_BUFFERS); }
  });
} catch (Exception e) {
  System.exit(0);
}
try {
  Thread.sleep(500);
}  catch(InterruptedException ex) {}
bufferStrategy = getBufferStrategy();
```

Full-Screen Exclusive Mode

```
private void screenUpdate() {
  try {
    gScr = bufferStrategy.getDrawGraphics();
    gameRender(gScr);
    gScr.dispose();
    if (!bufferStrategy.contentsLost())
      bufferStrategy.show();
    else
      System.out.println("Contents Lost");
  } catch (Exception e)  {
    e.printStackTrace();
    running = false;
  }
}
```

```
private void gameRender(Graphics gScr) {
  gScr.setColor(Color.white);
  gScr.fillRect (0, 0, pWidth, pHeight);
  …
}
```

Full-Screen Exclusive Mode

- end

```
private void restoreScreen() {
  Window w = gd.getFullScreenWindow();
  if (w != null)
    w.dispose();
  gd.setFullScreenWindow(null);
}
```

Others...

- JOGL
  - http://jogamp.org/jogl/
  - usage of OpenGL
- ...

GUI

System integration for desktop applications

java.awt.Desktop

- system integration for desktop applications
- **`static boolean isDesktopSupported()`**
  - whether the desktop integration is supported
- **`static Desktop getDesktop()`**
  - returns an instance of the desktop
- **`boolean isSupported(Desktop.Action action)`**
  - what is supported
  - Desktop.Action
    - enum

Desktop.Actions

- APP_ABOUT
- APP_EVENT_FOREGROUND
- APP_EVENT_HIDDEN
- APP_EVENT_REOPENED
- APP_EVENT_SCREEN_SLEEP
- APP_EVENT_SYSTEM_SLEEP
- APP_EVENT_USER_SESSION
- APP_HELP_VIEWER
- APP_MENU_BAR
- APP_OPEN_FILE
- APP_OPEN_URI
- APP_PREFERENCES
- APP_PRINT_FILE
- APP_QUIT_HANDLER
- APP_QUIT_STRATEGY
- APP_REQUEST_FOREGROUND
- APP_SUDDEN_TERMINATION
- BROWSE
- BROWSE_FILE_DIR
- EDIT
- MAIL
- MOVE_TO_TRASH
- OPEN
- PRINT

java.awt.Desktop

- methods corresponds with values in Desktop.Action
-
- **`void browse(URI uri)`**
  - opens an uri in the default browser
- **`void edit(File file)`**
  - opens the file in the default editor for the given file type
- **`void mail(URI mailtoURI)`**
  - opens the default mail client
- **`void open(File file)`**
  - opens the file in the default program for the given file type
- **`void print(File file)`**
  - prints file
- ...

java.awt.SystemTray

- represents the system “tray”
- example

```
TrayIcon trayIcon = null;
if (SystemTray.isSupported()) {
  SystemTray tray = SystemTray.getSystemTray();
  Image image = ...
  ActionListener listener = new ActionListener() {
    public void actionPerformed(ActionEvent e) {
      ...
    }
  };
  PopupMenu popup = new PopupMenu();
  popup.add(...);
  trayIcon = new TrayIcon(image, "Tray Demo", popup);
  trayIcon.addActionListener(listener);
  tray.add(trayIcon);
}
```

java.awt.SystemTray

- right-click on the icon
  - shows menu
- left-click
  - generates the action event
- a single application can add any number of icons
- methods
  - **`static boolean isSupported()`**
  - **`void add(TrayIcon icon)`**
  - **`void remove(TrayIcon icon)`**
    - removes the icon from the tray
      - when the application terminates the icons are moved automatically
  - **`TrayIcon[] getTrayIcons()`**
    - returns all tray icons of the application