Programming user interface in Java
Overview

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- expected knowledge of Java (at least within the scope of NPRG013; better NPRG021)
  - ideally enroll to NPRG021 too

- 0/2 Z
  - “zápočet” – home project
Synopsis

- Swing
- JavaFX
- Servlets, JSP, JSF
- NetBeans platform
- Eclipse platform
- ...

- bring your laptops
GUI in the std library
Overview

- JDK1.0 – AWT
  - Abstract Window Toolkit
  - goal – the same good-looking GUI on all platforms
    - not very successful
    - many limitations (e.g. 4 fonts only)
    - hard to use it
      - "non-object-based" approach
- JDK1.1
  - new event model
    - object-based approach
- JDK1.2
  - new GUI – Swing
    - a part of JFC (Java Foundation Classes)
- JDK 8
  - JavaFX – new UI, exists since 2009 (had to be installed separately)
JAVA

Swing
Swing

- packages
  - javax.swing....
  - uses also classes from java.awt...
  - many classes extends classes from java.awt...

- AWT
  - also a part of JFC
  - still present
    - compatibility reasons
  - uses the event model

- fully implemented in Java
  - the same look-and-feel on all platforms
    - look-and-feel can be modified – adjusted to a platform

- support for 2D graphics, printing, drag-and-drop, localization, ...
import javax.swing.*;

public class HelloWorldSwing {
    private static void createAndShowGUI() {
        JFrame.setDefaultLookAndFeelDecorated(true);
        JFrame frame = new JFrame("HelloWorldSwing");
        frame.setDefaultCloseOperation(JFrame.EXIT_ON_CLOSE);
        JLabel label = new JLabel("Hello World");
        frame.getContentPane().add(label);
        frame.pack();
        frame.setVisible(true);
    }

    public static void main(String[] args) {
        javax.swing.SwingUtilities.invokeLater(new Runnable() {
            public void run() {
                createAndShowGUI();
            }
        });
    }
}
import javax.swing.*;

public class HelloWorldSwing {
    private static void createAndShowGUI() {
        JFrame.setDefaultLookAndFeelDecorated(true);
        JFrame frame = new JFrame("HelloWorldSwing");
        frame.setDefaultCloseOperation(JFrame.EXIT_ON_CLOSE);
        JLabel label = new JLabel("Hello World");
        frame.getContentPane().add(label);
        frame.pack();
        frame.setVisible(true);
    }

    public static void main(String[] args) {
        javax.swing.SwingUtilities.invokeLater(new Runnable() {
            public void run() {
                createAndShowGUI();
            }
        });
    }
}
### Layout

// example: cz.cuni.mff.java.gui.ButtonAndLabel
Container pane = frame.getContentPane();
pane.setLayout(new GridLayout(0, 1));

JButton button = new JButton("Click here");
pane.add(button);

JLabel label = new JLabel("Hello World");
pane.add(label);

- **layout**
  - defines size and placement of components in a container
  - defines changes of size and placement when container size is changed
  - implements the interface java.awt.LayoutManager
Panel and borders

// example: cz.cuni.mff.java.gui.ButtonAndLabel2
JPanel panel = new JPanel(new GridLayout(0, 1));
panel.setBorder(BorderFactory.createEmptyBorder(30, 30, 10, 30));
JButton button = new JButton("Click here");
panel.add(button);
JLabel label = new JLabel("Hello World");
panel.add(label);
...
frame.getContentPane().add(panel);

- panel
  - "lightweigth" container
  - container can be inserted to other containers
- border
  - how to paint borders of components (JComponent)
Look & Feel

// example: cz.cuni.mff.java.gui.ButtonAndLabel3
String lookAndFeel =
    UIManager.getCrossPlatformLookAndFeelClassName();
UIManager.setLookAndFeel(lookAndFeel);

• defines look and behavior of GUI
• L&F included in JDK
  – crossplatform (Metal) – the same GUI on all platforms
  – Windows – similar to the Windows GUI
  – system
    • on Unix – Metal
    • on Windows – Windows
  – Motif
  – GTK+ – since JDK 1.4.2
  – Nimbus – since JDK 6 u10

own ones can be created
Events

• GUI is controlled through events
  – e.g. click on a button → event
• event processing – listener
  – an object registers a listener → receives info about events
• many types of events (and of corresponding listeners)
  – e.g. button click, window closing, mouse move,...

public class ButtonAndLabel4 implements ActionListener {
    ...
    JButton button = new JButton("Click here");
    button.addActionListener(this);
    ...
    public void actionPerformed(ActionEvent e) {
        clicks++;
        label.setText("Hello World: "+ clicks);
    }
}
Events

- a single *listener* can be registered for multiple events

```java
public class TempConvert implements ActionListener {
    ...
    input = new JTextField();
    convertButton = new JButton("Convert");
    convertButton.addActionListener(this);
    input.addActionListener(this);
    ...
    public void actionPerformed(ActionEvent e) {
        int temp = (int)
            ((Double.parseDouble(input.getText())-32)*5/9);
        celLabel.setText(temp+" Celsius");
    }
}
```
Threads

- event processing and GUI painting
  - a **single** thread (event-dispatching thread)
  - ensures subsequent event processing
    - each event is processed after the previous one is finished
  - events do not interrupt painting
- `SwingUtilities.invokeLater(Runnable doRun)`
  - static method
  - runs code in `doRun.run()` using the event-processing thread
    - waits until all events are processed
  - the method ends immediately
    - does not wait till the code is run
  - used for GUI modifications
- `SwingUtilities.invokeAndWait(Runnable doRun)`
  - as `invokeLater()`, but ends after the code is run
Actions

• oddělení komponenty a její funkce
  – pro tlačítka, menu,....
  – stejná akce přiřazená k více komponentám

• Action
  – interface
  – lze nastavit
    • zobrazovaný text
    • ikonu
    • popis
    • klávesovou zkratku
    • action listener
    • ...

• AbstractAction
  – třída implementující interface Action
  – typicky se od ní dědí
Swing

Layouts
Overview

- the container feature
  - components of GUI are placed in a container (frame, dialog, panel, ...)
- determines size and placement of components in the container
- determines changes of size and placement when the size of the container is changed
- implements the interface `java.awtLayoutManager`
- `java.awt.Container`
  - `void setLayout(LayoutManager m)`
  - `LayoutManager getLayout()`
**BorderLayout**

- default layout for the *content pane*
- 5 regions - north, south, east, west, center

```
JPanel p = new JPanel();
p.setLayout(new BorderLayout());
p.add(new Button("Okay"), BorderLayout.SOUTH);
// following two lines are equivalent
p.add(new Button("Cancel"));
p.add(new Button("Cancel"), BorderLayout.CENTER);
```
BorderLayout

- relative determining the region
  - page start, page end, line start, line end
  - depends on ComponentOrientation
    - java.awt.Component
      - setComponentOrientation
      - getComponentOrientation
    - java.awt.ComponentOrientation
      - component orientation related to the used language
        - if ComponentOrientation.LEFT_TO_RIGHT, then it corresponds to north, south, west, east

<table>
<thead>
<tr>
<th></th>
<th>page start</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Isit</td>
<td>CENTER</td>
<td>Isit</td>
</tr>
<tr>
<td>na</td>
<td></td>
<td>na</td>
</tr>
<tr>
<td>t</td>
<td>page end</td>
<td>t</td>
</tr>
</tbody>
</table>
**BorderLayout**

- default – no gaps between components in the container
- the constructor
  - BorderLayout(int horizontalGap, int verticalGap)
- methods
  - void setVgap(int)
  - void setHgap(int)
FlowLayout

- default layout for JPanel
- arranges components in a directional flow
- if there is no space left in a row, then it starts new row

```java
contentPane.setLayout(new FlowLayout());

contentPane.add(new JButton("Button 1"));
contentPane.add(new JButton("Button 2"));
contentPane.add(new JButton("Button 3"));
contentPane.add(new JButton("Long-Named Button 4"));
contentPane.add(new JButton("5"));
```
FlowLayout

- constructors
  - FlowLayout()
  - FlowLayout(int alignment)
  - FlowLayout(int alignment, int horizontalGap, int verticalGap)
    - alignment – alignment of components
      - FlowLayout.LEADING
      - FlowLayout.CENTER
      - FlowLayout.TRAILING
      - depends on the ComponentOrientation
    - Gap – a gap between components
GridLayout

- arranges components in a table
- each component occupies a single cell in the table
- all cells have the same size
- necessary to specify number of columns and rows
  - GridLayout(int rows, int columns)
  - one of the sizes can be 0
    - both cannot
    - the size with 0 is calculated based on the number of inserted components
- ordering of components according to ComponentOrientation

```java
pane.setLayout(new GridLayout(0,2));

pane.add(new JButton("Button 1"));
pane.add(new JButton("Button 2"));
```
CardLayout

- allows several components (typically JPanels) occupy the same place
- only one component is visible at a time

```java
JPanel cards;
final static String PANEL1 = "Panel1";
final static String PANEL2 = "Panel2";

JPanel card1 = new JPanel();
...
JPanel card2 = new JPanel();
...
cards = new JPanel(new CardLayout());
cards.add(card1, PANEL1);
cards.add(card2, PANEL2);
```
CardLayout

- **switching visible components**
  
  ```java
  CardLayout cl = (CardLayout)(cards.getLayout());
  cl.show(cards, PANEL2);
  ```

- **other methods for switching**
  
  ```java
  void first(Container)
  void next(Container)
  void previous(Container)
  void last(Container)
  ```

- **JTabbedPane**
  
  - similar to CardLayout
  - it is not layout
  - it is a component
  - shows tabs
GridBagLayout

- most complex but most flexible layout
- arranges components in a table
- a single component can occupy several rows and/or columns
- rows and columns can have different sizes

- placing of components determined by GridBagConstraint

```java
JPanel pane = new JPanel(new GridBagLayout());
GridBagConstraints c = new GridBagConstraints();

// pro každou komponentu
//...vytvořit komponentu...
//...nastavit constraint...
pane.add(theComponent, c);
```
GridBagConstraint: attributes

- gridx, gridy
  - column and row of the top left corner of the component
  - the leftmost column gridx = 0
  - the top most row gridy = 0
  - the value GridBagConstraint.RELATIVE (default)
    - the component will be placed on the right side of the previous one (gridx) or below the previous one (gridy)
    - recommendation – always specify particular values for each component
GridBagConstraint: attributes

- gridwidth, gridheight
  - number of columns (gridwidth) and row (gridheight), which the component occupies
  - default value 1
  - hodnota GridBagConstraint.REMAINDER
    - komponenta bude poslední ve sloupci (gridwidth) nebo řádku (gridheight)
  - hodnota GridBagConstraint.RELATIVE
    - komponenta bude vedle předchozí
GridBagConstraint: attributes

- **fill**
  - defines how to change the component size if the area for the component is bigger than the component
  - values (constants on GridBagConstraint)
    - **NONE** (default)
      - no changes
    - **HORIZONTAL**
      - expands the component horizontally
      - no vertical change
    - **VERTICAL**
      - expands the component vertically
      - no horizontal change
    - **BOTH**
      - expands the component both horizontally and vertically
GridBagConstraint: attributes

- **ipadx, ipady**
  - internal padding of the component
  - default 0
  - how much space to add to the minimum size of the component
  - width of the component will be at least 2*ipadx
    - padding will be added to both sides
  - similarly height will be at least 2*ipady

- **insets**
  - external padding
  - the minimum amount of space between the component and the edges of its display area
  - by default none
  - value – java.awt.Insets
    - the constructor Insets(top, left, bottom, right)
GridBagConstraint: attributes

- anchor
  - where to place the component, when the component is smaller than its display area
  - values – constants on GridBagConstraint
GridBagConstraint: attributes

- weightx, weighty
  - values between 0.0 and 1.0
  - default 0
  - specifies how to distribute extra horizontal/vertical space
  - if all weight(x|y) = 0 in the row resp. column then components are placed in the center of the container
  - important for changes of the container size
GridBagLayout: example

- **Button1, Button2, Button3**: `weightx = 1.0`
- **Button4**: `weightx = 1.0`, `gridwidth = GridBagConstraints.REMAINDER`
- **Button5**: `gridwidth = GridBagConstraints.REMAINDER`
- **Button6**: `gridwidth = GridBagConstraints.RELATIVE`
- **Button7**: `gridwidth = GridBagConstraints.REMAINDER`
- **Button8**: `gridheight = 2`, `weighty = 1.0`
- **Button9, Button 10**: `gridwidth = GridBagConstraints.REMAINDER`
GridBagLayout: example

Všechna tlačítka: ipadx = 0, fill = GridBagConstraints.HORIZONTAL

**Button 1**: ipady = 0, weightx = 0.5, weighty = 0.0, gridwidth = 1, anchor = GridBagConstraints.CENTER, insets = new Insets(0,0,0,0), gridx = 0, gridy = 0

**Button 2**: weightx = 0.5, gridx = 1, gridy = 0

**Button 3**: weightx = 0.5, gridx = 2, gridy = 0

**Button 4**: ipady = 40, weightx = 0.0, gridwidth = 3, gridx = 0, gridy = 1

**Button 5**: ipady = 0, weightx = 0.0, weighty = 1.0, anchor = GridBagConstraints.SOUTH, insets = new Insets(10,0,0,0), gridwidth = 2, gridx = 1, gridy = 2
SpringLayout

• since JDK 1.4
• very flexibile
  – can emulate most of the previous layout
• low-level
  – intended for IDEs
  – not intended for direct usage
    • but it is possible
no layout

- placement of components to fixed positions

```java
pane.setLayout(null);
JButton b1 = new JButton("one");
JButton b2 = new JButton("two");
JButton b3 = new JButton("three");
pane.add(b1);
pane.add(b2);
pane.add(b3);
Insets insets = pane.getInsets();
Dimension size = b1.getPreferredSize();
b1.setBounds(25 + insets.left, 5 + insets.top, size.width, size.height);
size = b2.getPreferredSize();
b2.setBounds(55 + insets.left, 40 + insets.top, size.width, size.height);
size = b3.getPreferredSize();
b3.setBounds(150 + insets.left, 15 + insets.top, size.width + 50, size.height + 20);
```
Own layout

- implementing the interface `java.awt.LayoutManager`
- methods
  - `void addLayoutComponent(String, Component)`
    - called by the container in the method `add`
    - adds components to the layout
    - associates the component with a string
  - `void removeLayoutComponent(Component)`
    - called by the container in the methods `remove a removeAll`
  - `Dimension preferredLayoutSize(Container)`
    - an ideal size of the container
  - `Dimension minimumLayoutSize(Container)`
    - a minimal size of the container
  - `void layoutContainer(Container)`
    - called when firstly shown and after each change of the size of the container
Swing

Component overview
Label

- class JLabel
- for displaying
  - short text
  - image
  - both
Buttons

- many kinds of buttons
- all of them extends AbstractButton
  - regular button (JButton)
    - "click" button
  - toggle button (JToggleButton)
    - two-state button (on/off)
  - check box (JCheckBox)
    - selected / deselected box
  - radio button (JRadioButton)
    - typically only one button in a group can be selected
- event – ActionEvent
- listener – ActionListener
Groups of buttons

• a group of buttons – selected can be only one button
  – typically for radio buttons
• the ButtonGroup class

```java
RadioButton buttons[] = new JButton [4];

for (int i=0; i<4; i++) {
    pane.add(buttons[i] =
        new JButton("Button "+(i+1)));
}

ButtonGroup bg = new ButtonGroup();

for (int i=0; i<4; i++) {
    bg.add(buttons[i]);
}
```
Buttons and HTML

- A text of buttons and other components (label,...) can be set in HTML
- Older JDKs may support HTML only partially or not at all
- Not recommended to use

```java
new JButton("<html><b><u>T</u>wo<br>lines</b></html>")
new JLabel("<html><font color=#ff0000>Hello</font></html>")
```
Icons

• the interface `Icon`
  - can be used with labels, buttons, menus,...
• the class `ImageIcon`
  - implements `Icon`
  - an icon created from an image
    • loaded from file, URL,...
    - jpg, png, gif

    new JButton("Click", new ImageIcon("ystar.png"));

    new JLabel("Hello", new ImageIcon("gstar.png"),
               SwingConstants.CENTER);
Tool tips

• "small" help
  − a "bubble" with a text
  − displays when the cursor lingers over the component
• can be set to components, which extends JComponent

```java
button.setToolTipText("Click here");
```
Text fields

- the class JTextField
- an editable single line of text
- after the ENTER key is pressed → ActionEvent
- methods
  - String getText()
    • returns the contained text
  - void setText(String text)
    • sets the text

- the class JTextArea
  - a multi-line editable area
  - have to be inserted to the JScrollPane in order to show scrollbars
    • new JScrollPane(new JTextArea)
    • JScrollPane works with anything that implements Scrollable
Combo box

• the class JComboBox
• a button with selection of choices
  – can be edited – setEditable(boolean b)
• generates the ActionEvent when changed

String[] list = { "aaaa", "bbbb", ... };
JComboBox cb = new JComboBox(list);
cb.setEditable(true);
List box

• the class JList
• a list of items
• items can be selected
  – a single one or several of them
    • setSelectionMode(int mode)
• methods
  – int getSelectedIndex()
  – Object getSelectedValue()
• ListSelectionEvent
• ListSelectionListener
frame.setJMenuBar(createMenu());

private static JMenuBar createMenu() {
    JMenuBar mb = new JMenuBar();
    JMenu menu = new JMenu("File");
    JMenuItem item = new JMenuItem("Quit");
    menu.add(item);
    mb.add(menu);

    menu = new JMenu("Help");
    item = new JMenuItem("Content");
    menu.add(item);
    menu.add(new JSeparator());
    mb.add(menu);

    return mb;
}
Trees

- `javax.swing.JTree`
- displaying hierarchical data
- `JTree` does not hold data directly
  - only displays data
  - data are held by a *model* (*model-view* concept)
- in general
  - all more complex components have a model
    - `JTree, JTable, JList, JButton, ...`
  - the model determines how the data are stored and retrieved
  - a single component can have multiple models
    - e.g. `JList`
      - `ListModel` – holds a content of the list
      - `ListSelectionModel` – manages current selection
JTree: static content

```java
DefaultMutableTreeNode top =
    new DefaultMutableTreeNode("Root");
createNodes(top);
tree = new JTree(top);
...
private void createNodes(DefaultMutableTreeNode top) {
    DefaultMutableTreeNode node = null;
    DefaultMutableTreeNode leaf = null;

    node = new DefaultMutableTreeNode("Node1");
    top.add(node);

    leaf = new DefaultMutableTreeNode("Leaf1");
    node.add(leaf);
    leaf = new DefaultMutableTreeNode("Leaf2");
    node.add(leaf);

    node = new DefaultMutableTreeNode("Node2");
    top.add(node);
```
JTree: dynamic changes

rootNode = new DefaultMutableTreeNode("Root Node");
treeNode = new DefaultTreeModel(rootNode);
treeNode.addTreeModelListener(new MyTreeNodeModelListener());
tree = new JTree(treeModel);
tree.setEditable(true);
tree.getSelectionModel().setSelectionMode
    (TreeSelectionModel.SINGLE_TREE_SELECTION);
...

class MyTreeNodeModelListener implements TreeModelListener {
    public void treeNodesChanged(TreeModelEvent e) {
    }
    public void treeNodesInserted(TreeModelEvent e) {
    }
    public void treeNodesRemoved(TreeModelEvent e) {
    }
    public void treeStructureChanged(TreeModelEvent e) {
    }
}
public DefaultMutableTreeNode addObject(DefaultMutableTreeNode parent, Object child, boolean shouldBeVisible) {

    DefaultMutableTreeNode childNode =
        new DefaultMutableTreeNode(child);
    ...
    treeModel.insertNodeInto(childNode, parent, parent.getChildCount());

    if (shouldBeVisible) {
        tree.scrollPathToVisible(new TreePath(childNode.getPath()));
    }
    return childNode;
}
JTree: own model

- **model-view**
  - Model
    - describes data (e.g. DefaultTreeModel)
  - View
    - defines how to display data (JTree)
- **default model** – DefaultTreeModel
- **if not suitable** → **own model**
  - e.g., by default, nodes in the tree are DefaultMutableTreeNode and implements the TreeNode interface
    - own model can have nodes of a completely different type
- **the model must implement** TreeModel interface
void addTreeModelListener(TreeModelListener l);

Object getChild(Object parent, int index);

int getChildCount(Object parent);

int getIndexOfChild(Object parent, Object child);

Object getRoot();

boolean isLeaf(Object node);

void removeTreeModelListener(TreeModelListener l);

void valueForPathChanged(TreePath path, Object; newValue);
Icons in JTree

- TreeCellRenderer
  - interface
- setCellRenderer(TreeCellRenderer r)
  - method of JTree

```java
class MyRenderer extends DefaultTreeCellRenderer {
    public Component
        getTreeCellRendererComponent(JTree tree, Object value, boolean sel, boolean expanded,
                                       boolean leaf, int row, boolean hasFocus) {

        super.getTreeCellRendererComponent(tree, value,
                                             sel, expanded, leaf, row, hasFocus); 

        if (....) {
            setIcon(someIcon);
            setToolTipText("....");
        } else { .....}
        return this;
    }
}
```
Icons in JTree

ImageIcon leafIcon = createImageIcon(".."神通)

if (leafIcon != null) {
    DefaultTreeCellRenderer renderer =
    new DefaultTreeCellRenderer();

    renderer.setLeafIcon(leafIcon);
    tree.setCellRenderer(renderer);
}
Swing

Dialogs
Overview

- **JDialog**
  - *a dialog = a window similar to the frame*
  - *dialogs depend on a frame*
  - a dialog is modal
    - if it is displayed, input to other windows of an application is blocked
    - non-modal dialogs can be created also
- managing the dialog – almost the same as for frame
- JOptionPane
  - a component simplifying creation of standard dialogs
  - predefined dialogs
//default title and icon
JOptionPane.showMessageDialog(frame,
    "Eggs aren't supposed to be green.");

//custom title, warning icon
JOptionPane.showMessageDialog(frame,
    "Eggs aren't supposed to be green.",
    "Inane warning",
    JOptionPane.WARNING_MESSAGE);

//custom title, error icon
JOptionPane.showMessageDialog(frame,
    "Eggs aren't supposed to be green.",
    "Inane error",
    JOptionPane.ERROR_MESSAGE);

//custom title, no icon
JOptionPane.showMessageDialog(frame,
    "Eggs aren't supposed to be green.",
    "A plain message",
    JOptionPane.PLAIN_MESSAGE);

//custom title, custom icon
JOptionPane.showMessageDialog(frame,
    "Eggs aren't supposed to be green.",
    "Inane custom dialog",
    JOptionPane.INFORMATION_MESSAGE, icon);
JOptionPane

- predefined dialogs
  - but can be configured
- a set of static methods creating dialogs (always several variants of the single method)
  - showMessageDialog()
    - a dialog with message
  - showInputDialog()
    - a dialog with an input line
    - returns String
  - showConfirmDialog()
    - a dialog with a question (Yes/No/Cancel)
    - returns int
  - showOptionDialog()
    - selection of several choices (Yes-No-Maybe-Cancel)
JOptionPane

• can be also used directly
  – by creating an instance of JOptionPane
    • several constructors
  – the created object can inserted to a dialog
JFileChooser

• a standard dialog for file selection

JFileChooser chooser = new JFileChooser();
chooser.setDialogType(JFileChooser.OPEN_DIALOG);
FileNameExtensionFilter filter =
    new FileNameExtensionFilter("Images", "jpg", "gif");
chooser.setFileFilter(filter);
int returnVal = chooser.showOpenDialog(parent);
if (returnVal == JFileChooser.APPROVE_OPTION) {
    System.out.println("Selected file: "+
    chooser.getSelectedFile().getName());
}
**JColorChooser**

- choosing colors
- can be used
  - as a dialog
  - as a component
JToolBar

- a bar with buttons
- can be dragged to other place
- can be dragged out
JSplitPane

- displays 2 components
  - horizontally
  - vertically
- the separator between components can be moved
JTable

- table
- constructors (some of them)
  - JTable(Object[][] rowData, Object[] columnNames)
  - JTable(TableModel dm)

<table>
<thead>
<tr>
<th>First Name</th>
<th>Last Name</th>
<th>Sport</th>
<th># of Years</th>
<th>Vegetarian</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kathy</td>
<td>Smith</td>
<td>Snowboarding</td>
<td>5</td>
<td>false</td>
</tr>
<tr>
<td>John</td>
<td>Doe</td>
<td>Rowing</td>
<td>3</td>
<td>true</td>
</tr>
<tr>
<td>Sue</td>
<td>Black</td>
<td>Knitting</td>
<td>2</td>
<td>false</td>
</tr>
<tr>
<td>Jane</td>
<td>White</td>
<td>Speed reading</td>
<td>20</td>
<td>true</td>
</tr>
<tr>
<td>Joe</td>
<td>Brown</td>
<td>Pool</td>
<td>10</td>
<td>false</td>
</tr>
</tbody>
</table>
TableModel

- void addTableModelListener(TableModelListener l)
- Class<?> getColumnClass(int columnIndex)
- int getColumnCount()
- String getColumnName(int columnIndex)
- int getRowCount()
- Object getValueAt(int rowIndex, int columnIndex)
- boolean isCellEditable(int rowIndex, int columnIndex)
- void removeTableModelListener(TableModelListener l)
- void setValueAt(Object aValue, int rowIndex, int columnIndex)
AbstractTableModel

- prepared implementation of a model
- only the following methods have to be implemented
  - public int getColumnCount()
  - public int getRowCount()
  - public Object getValueAt(int row, int col)
JDesktopPane

- „a window in a window“
- JDesktopPane
  - desktop
- JInternalFrame
  - inner window