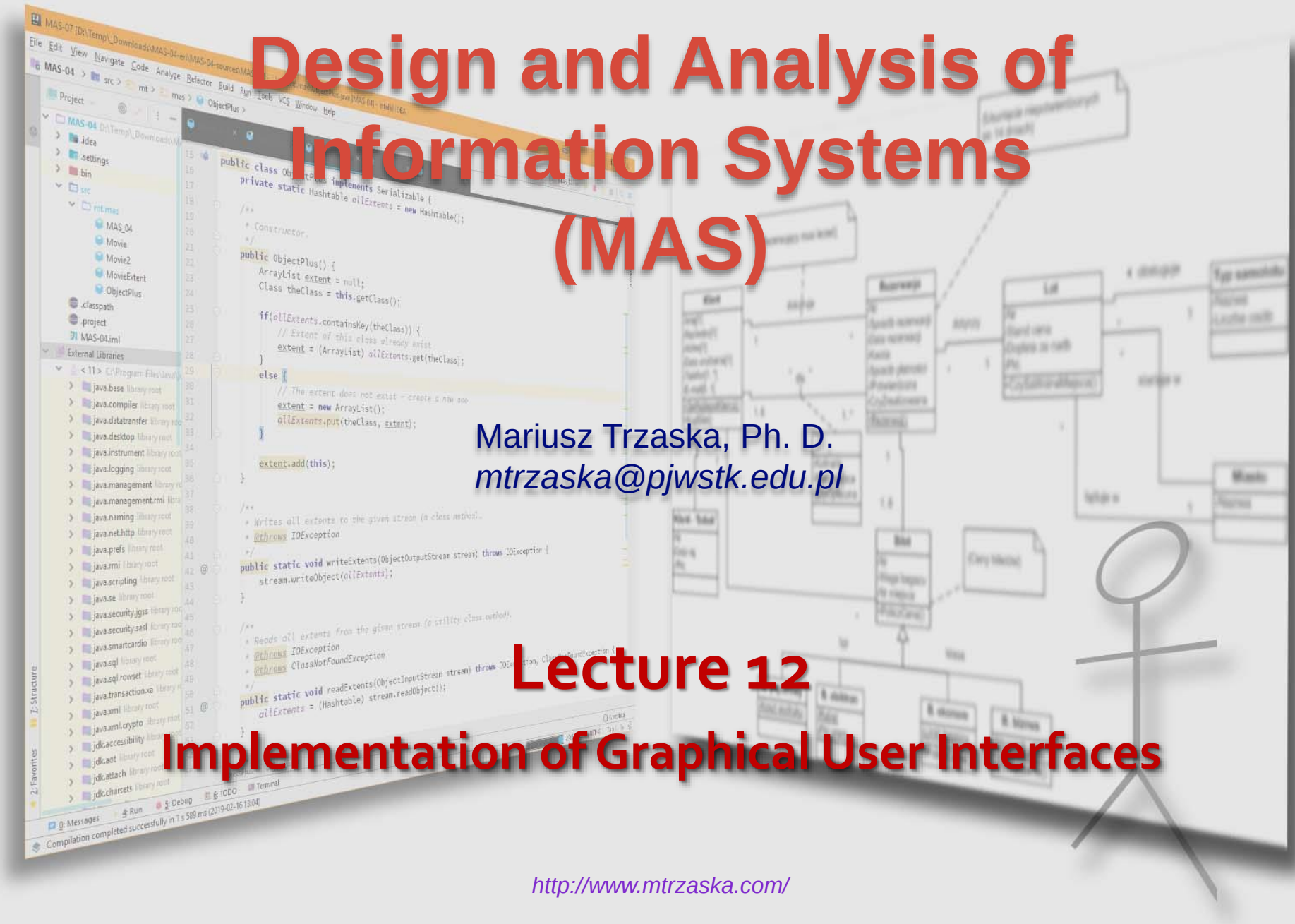
Design and Analysis of Information Systems (MAS)



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Lecture 12

Implementation of Graphical User Interfaces

Outline

- An introduction
- The GUI libraries for
  - the Javy,
  - The C++,
  - The C#.
- A custom GUI library
- A GUI implementation using
  - Manually written code,
  - A visual editor,
  - A declarative way.
- A summary.

The slides make use of the www.wikipedia.org,

GUI Libraries

- Utilization of the libraries
  - Shipped with the language,
  - Third parties,
  - Custom implementations.
- The choice based on
  - Easiness,
  - Customization,
  - Performance,
  - Portability,
  - Price,
  - Aesthetics.

GUI Libraries for the Java

- Possibilities
  - AWT,
  - Swing,
  - SWT,
  - JavaFX
- Evaluation of the possibilities
  - Easiness,
  - Customization,
  - Performance,
  - Portability.

GUI Libraries for the Java (2)

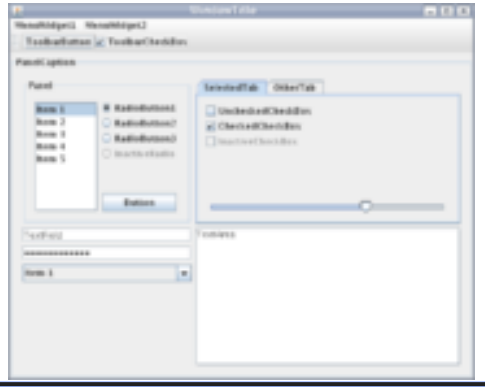
- AWT (Abstract Window Toolkit; *http://java.sun.com/products/jdk/awt/*),
  - Published: 1995,
  - Uses the native widgets of the platform (different L&F on different OS),
  - Basic set of widgets (buttons, text fields, menus, etc.),
  - Events,
  - An interface between OS and the Java application,
  - Layout managers,
  - Clipboard and *Drag&Drop*,

GUI Libraries for the Java (3)

- AWT (Abstract Window Toolkit) – cont.,
  - An access to input devices such a mouse or a keyboard,
  - Native AWT interface making possible rendering directly on the widget's surface,
  - Access to the system clipboard (not on every OS),
  - Ability to execute some system applications (e.g. mail or an internet browser).

GUI Libraries for the Java (4)

- Swing (http://www.javaswing.net/,),
  - Published: 1997,
  - Appearance and behaviour determined by the Java (the same on all platforms/OS). Rendered using the Java2D,
  - Extended (comparing to the AWT) set of widgets,
  - Look&Feel of the Swing application is defined by the selected theme (*pluggable look and feel*),
  - Independence from the platform,
  - Customization,
  - Components oriented,



GUI Libraries for the Java (5)

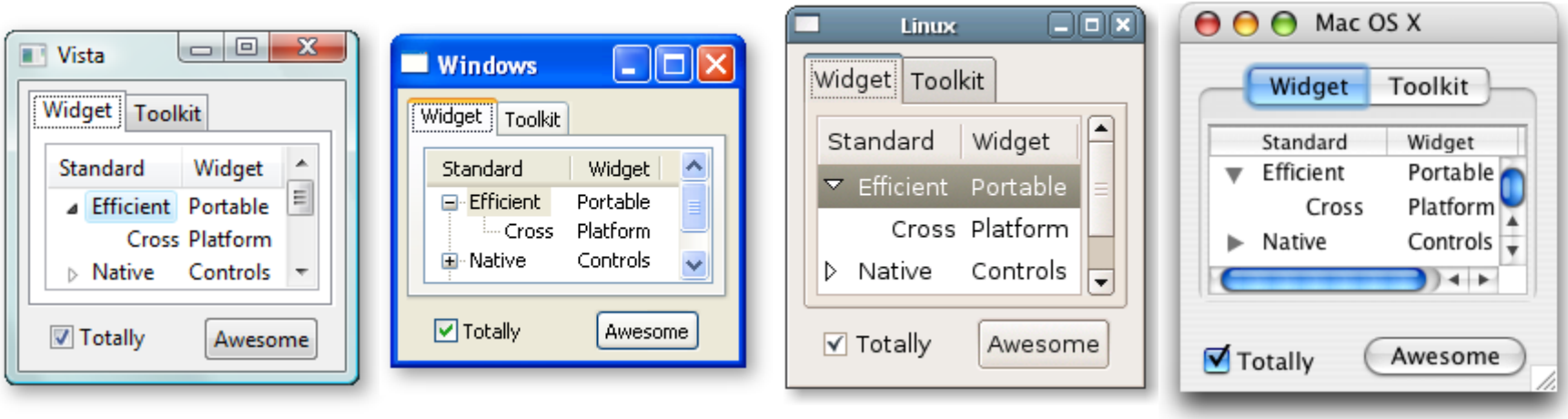
- Swing (http://www.javaswing.net/,) – *cont.*,
  - Easy to customize:
    - Utilization of the existing elements during rendering process: *border*, *inset*, *decorations*,
    - Easy modification of properties (e.g. *border*),
    - Renderers,
  - Run-time customization,
  - „Light" *UI*. Own rendering mechanism.
  - Partial utilization of the AWT, e.g. `component.paint()`,

GUI Libraries for the Java (6)

- Swing (*http://www.javaswing.net/*,) – *cont.*,
  - The MVC (Model-View-Controller) oriented. Most of the widgets has own models (defined by the Java interfaces), which determines the way of working with data.
  - The library is shipped with some basic implemented models.
  - Events:
    - „physical", e.g. a mouse button click,
    - „logical" (model oriented), e.g. adding a table row, selecting a table row. Popular event, e.g. `ActionPerformed`.

GUI Libraries for the Java (7)

- SWT (Standard Widget Toolkit; *http://www.eclipse.org/swt/*)
  - Created by the IBM, and currently developed by the Eclipse foundation,
  - Uses native OS mechanism for rendering controls,



GUI Libraries for the Java (8)

- SWT (Standard Widget Toolkit; http://www.eclipse.org/swt/) – *cont.*
  - The Eclipse Foundation: *SWT is an open source widget toolkit for Java designed to provide efficient, portable access to the user-interface facilities of the operating systems on which it is implemented.*
  - Performance: SWT vs Swing:
    - Faster in rendering,
    - Slower in data manipulation (uses JNI - *Java Native Interface*).
  - The programs which use SWT are portable but they require dedicated version of the libraries (different even for the Windows x86 and x64). Not always available.
  - Very good implementation for the Windows.

GUI Libraries for the Java (9)

- SWT (Standard Widget Toolkit; http://www.eclipse.org/swt/) – *cont*.
  - In case that widgets under some OS do not provide a functionality, the SWT uses own implementation.
  - Does not use the MVC, but there is a possibility to use 3rd party libraries to support it (e.g. JFace),
  - Because of native widgets the customization could be hard to achieve.
  - Necessity for manual releasing the resources: the `.dispose()` method. (subclasses of the `Resource`: `Image`, `Color` and `Font`).

GUI Libraries for the Java (10)

- JavaFX
  - first release published on 2008-12,
  - desktop applications and RIAs (Rich Internet Applications),
  - replacement for the Swing library,
  - visual editor and FXML (XML format),
  - classes: `Stage`, `Scene`, `Node` (parts of a graph defining a scene),

GUI Libraries for the Java (11)

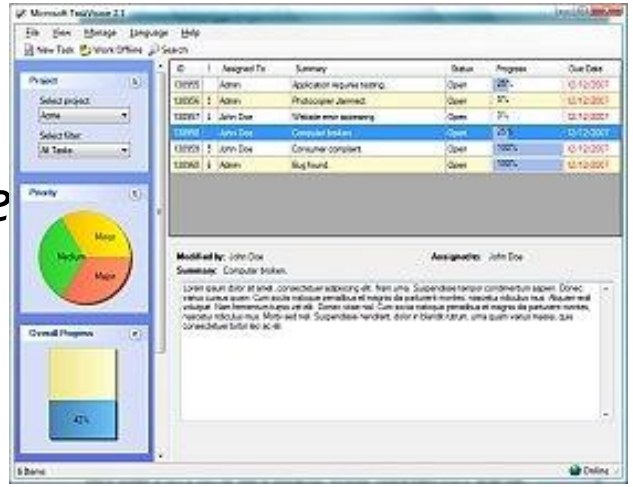
- JavaFX – *cont.*
  - events driven, but with bindable properties,
  - theming with CSS,
  - special effects (shadows, blur, mirror),
  - rich animations,
  - suport for 3d graphics.

GUI Libraries for the C/C++

- Microsoft
  - Win32 API,
    - Low level,
    - The best performance,
    - Uses: GDI (*Graphics Device Interface*), *Common Dialog Box Library*, *Common Control Library*.
  - MFC (*Microsoft Foundation Class Library*),
    - „wraps" Win32 API,
    - More object-oriented but still lack of pure OO,
  - Borland (legacy?) products: OWL (*Object Windows Library*), VCL (*Visual Component Library*).

GUI Libraries for the C/C++ (2)

- Microsoft – *cont*.
  - WinForms (*Windows Forms*; *http://windowsclient.net/*),
    - Works also with the MS C#,
    - Distributed with the MS .NET,
    - Wraps the Win32 API, but much better then the MFC,
    - Very big number of controls,
    - Extended by the *User Interface Process Application Block – Version 2.0* (introduces MVC).



GUI Libraries for the C/C++ (3)

- Microsoft – *cont*.
  - WPF (*Windows Presentation Foundation*; http://windowsclient.net/).
    - Works also with the MS C#,
    - The best capabilities in terms of visual appearance:
      - Classic controls with themes,
      - Complicated texts,
      - Images,
      - Video,
      - 2D,
      - 3D.
    - Big number of controls.

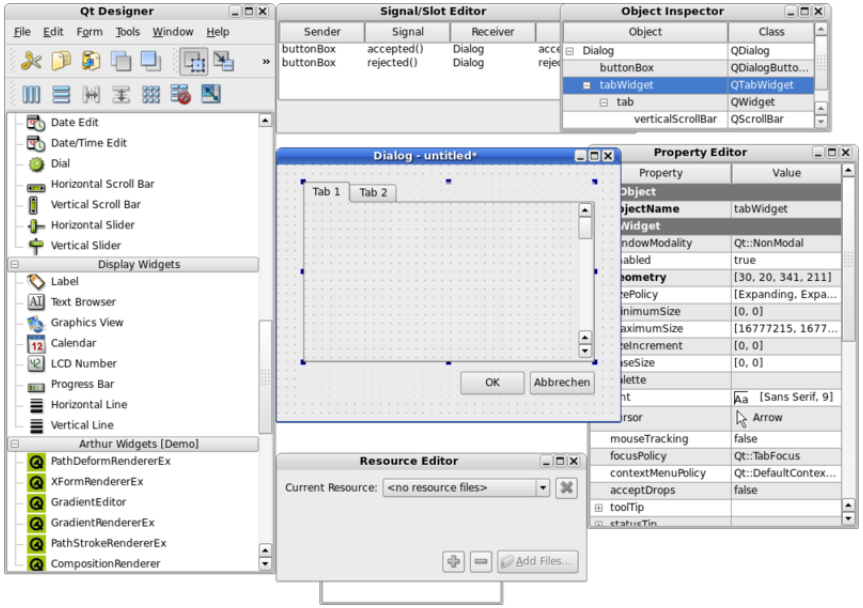
GUI Libraries for the C/C++ (4)

- Microsoft – c.d.
  - WPF (*Windows Presentation Foundation*; http://windowsclient.net/) – *cont.*
    - Declarative way of creating GUIs (the XAML language),
    - A new tool for designers: *MS Expression Blend*.

	WinForms	PDF	WinForms + GDI	WMP	Direct3D	WPF
Forms, Controls	X		X			X
Complex text		X				X
Images			X			X
Video / Audio				X		X
2D Graphics			X			X
3D Graphics					X	X

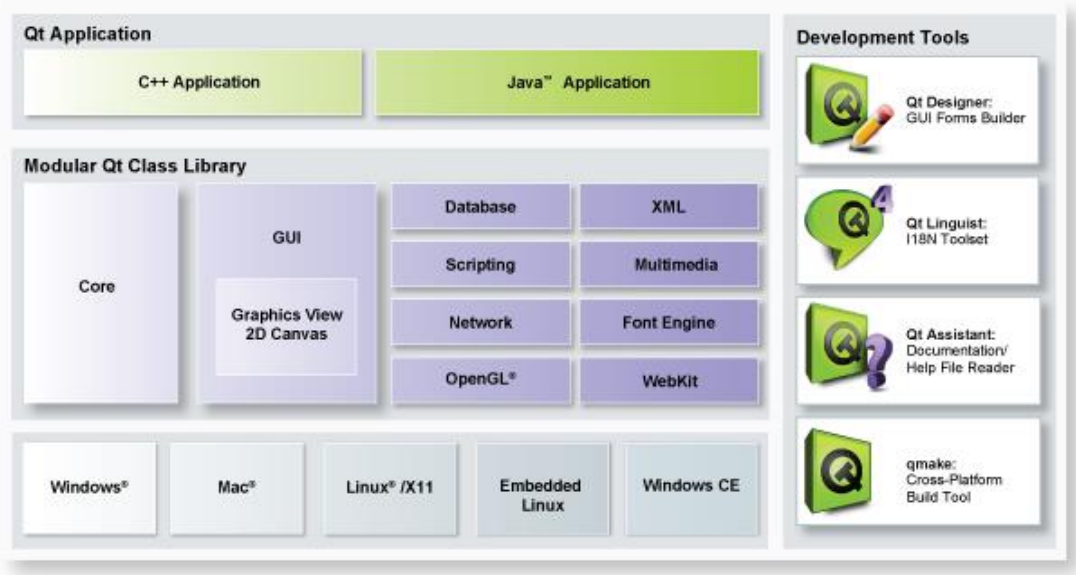
GUI Libraries for the C/C++ (5)

- Qt (*http://www.trolltech.com/products/qt/*)
  - Started in 1991,
  - Portable (Unix, Linux, MacOS X, Windows, Windows CE, Java),
  - Uses non-standard extensions which are processed by the pre-processor,
  - Support for:
    - i18n,
    - SQL,
    - XML,
    - Threading,
    - Network programming,
    - Files.



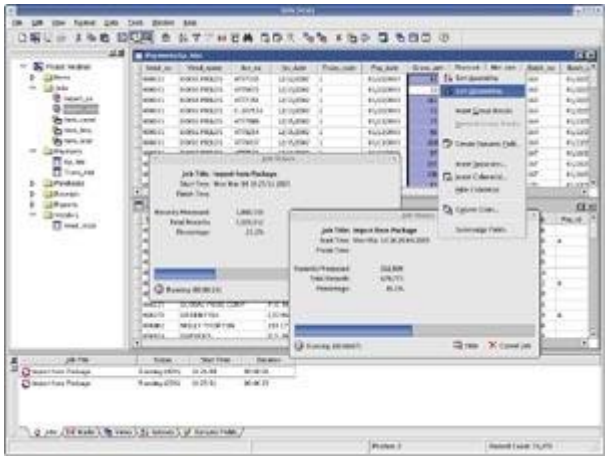
GUI Libraries for the C/C++ (6)

- Qt – *cont.*
  - The last releases use OS technologies for visualizing controls,
  - A meta-compiler delivers information, which are not available in „pure” C++. Such a solution allows e.g. asynchronous method calls.
  - Applications:
    - KDE,
    - Opera,
    - Google Earth,
    - Skype,
    - Photoshop Elements,
    - Virtual Box.



GUI Libraries for the C/C++ (7)

- wxWidgets (*http://wxwidgets.org/*),
  - Started in 1992.
  - Portability: Mac OS, Linux/Unix (X11, Motif, and GTK+), OpenVMS, OS/2, AmigaOS.
  - Uses native OS capabilities,
  - Resource management,
  - Additional functionalities, e.g
    - OpenGL support,
    - ODBC,
    - Network communication.



GUI Libraries for the C/C++ (8)

- GTK+ (The GIMP Toolkit, *http://www.gtk.org/*),
  - Portability,
  - Created for the GIMP,
  - Different engines for visualizing controls (e.g. emulation of popular *L&F*),
  - New version (GTK+ 2) contains better control rendering, new theme engine, Unicode support.
- Many other libraries…

GUI Libraries for the C#

- Microsoft WinForms,
- Microsoft WPF (*Windows Presentation Foundation*)
- wxWidgets (binding for the C#),
- GTK+ (binding for the C#),
- Mono (open implementation of the .NET including WinForms),
- Xamarin (*Forms* and *Native*).

Your Own GUI Library

- Why do not use existing libraries?
- Selecting a model:
  - „Physical” events,
  - „Logical” (semantic) events,
  - Mixed,
  - Other?
- Set of widgets,
- Rendering widgets,
- Connecting events with methods (code).

Your Own GUI Library (2)

- Usually, such an implementation requires very low-level work:
  - Catch OS events: pressing/releasing keyboard buttons, cursor movements, pressing/releasing mouse buttons.
  - Drawing widgets using primitive operations (like drawing a line, rectangle, square, bitmap).
- Quite hard work.

The GUI Implementation

- Manually written code
- Utilization of a visual editor,
- A declarative way.

The GUI Implementation – manually written code

- The best possible control over the final result in terms of:
  - Functionality,
  - Performance,
  - Portability,
  - Usability,
  - Aesthetic.
- Usually requires a lot of work and decent knowledge.

The GUI Implementation – manually written code (2)

- Harder (in some cases) modifications.
- Relatively slow development process.
- Error-prones.
- Usually it is better to use another approach.
- But sometimes this is the only way to achieve the right result.

The GUI Implementation – Visual Editors

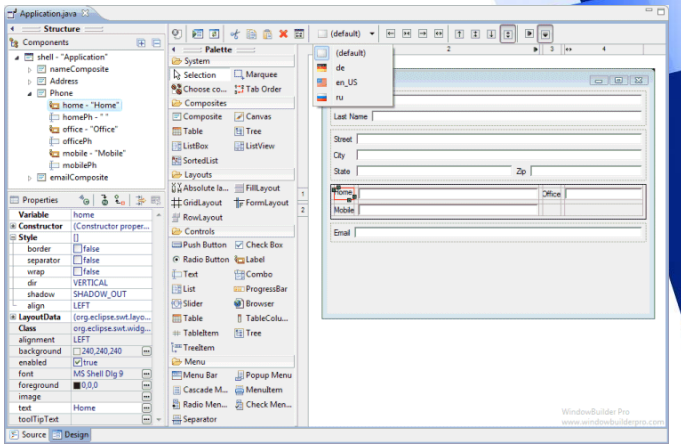
- Different qualities of existing tools:
  - Only generation of the code. Manual modifications are lost during regeneration of the project.
  - Bi-directional code generation. The editor reflects manual modifications of the source code in the visual design.
- Quite fast way of developing the GUI.
- Less errors.
- Instant visualization of the project.

The GUI Implementation – Visual Editors (2)

- It seems that using a good GUI editor is the best way for creating interfaces.
- Recommended solutions:
  - Microsoft Visual Studio:
    - Languages: C#, C++,
    - Libraries: WinForms, WPF, MFC
  - NetBeans IDE

The GUI Implementation – Visual Editors (3)

- Recommended solutions – *cont.*:
  - Eclipse WindowBuilder Pro
    - SWT, Swing, GWT Designer
    - Currently part of the Eclipse



  - IntelliJ IDEA IDE
    - http://www.jetbrains.com/idea/
    - Free edition (Community)

The GUI Implementation – A Declarative Way

- Some magic: maybe a „computer” will create a GUI for us?
- Let’s focus on:
  - What to do,
  - Rather then how to do?
- Different levels of automation:
  - A **semantic** declarativness: defining which model’s parts should have widgets,
  - A **component** declarativness: defining which widgets should be created.

The GUI Implementation – A Declarative Way (2)

- It seems that this way of working will be more popular in the future.
- Especially in case of GUIs which are:
  - Quite common (visualization, functionality)
  - Business-oriented.
- Finding a balance between:
  - A programmer involvement,
  - Universality of the solution.

The GUI Implementation – A Declarative Way (3)

- Existing commercial solutions, e.g. Microsoft XAML (*Extensible Application Markup Language*, *Extensible Avalon Markup Language*),
  - Heavily utilized in .NET, and especially in the WPF, Xamarin and Windows Store Apps.
  - Defining:
    - GUI items: 2D, 3D,
    - Data binding,
    - Events,
    - Special effects: rotation, animation.
  - Direct translation to the C# code.
  - A programmer has a lot of work defining those elements anyway.

The GUI Implementation – A Declarative Way (4)

- Microsoft XAML – *cont.*
  - Sample XAML code:

```
<Button Content="Click me">
        <Button.Margin>
                <Thickness Left="10" Top="20" Right="10" Bottom="30"/>
        </Button.Margin>
</Button>

<Page
        xmlns="http://schemas.microsoft.com/winfx/2006/xaml/presentation"
        xmlns:x="http://schemas.microsoft.com/winfx/2006/xaml"
        x:Class="MyNamespace.MyPageCode">

        <Button Click="ClickHandler" >Click Me!</Button>

</Page>
```

The GUI Implementation – A Declarative Way (5)

- More useful approach could be described in the following way:
  - A programmer tells which parts of model (classes) should have GUI:
    - Attributes,
    - Methods.
  - A system generates forms (windows with controls/widgets) allowing creating new data instances, visualization, modifications, etc.
  - Optional additional descriptions:
    - Tooltips, labels
    - Widgets kinds,
    - ...

The Summary

- Modern programming languages are shipped with GUI libraries.
- It is also possible to utilize products provided by 3rd parties: both free and commercial. Sometimes they are faster, more portable or easier to use.
- GUI could be implemented using the following approaches:
  - Manually written source code,
  - Visual editors,
  - Declarative.
- It seems that currently the best way is to employ a visual editor.
- However, in the future it could change in favour of the declarative way.