OO for GUI Design

Graphical user interface (GUI) programming is probably the most fertile application of object-oriented ideas.

The requirements of GUI programming are complex, to say the least.

First of all, there is the issue of layout. How to write a program so that the layout displayed on a computer terminal maintains its visual aesthetic and functionality as the user resizes a GUI to suit his/her particular needs?

Then there is the issue of rendering graphics, displaying images, playing video clips and sounds files — all compute-intensive operations.

Additionally, a GUI must be programmed in such a way that it remains responsive to user interaction even as it is engaged in compute-intensive operations.

Over the years, OO has emerged as the best way to meet these diverse requirements of GUI programming.

With regard to what the various OO toolkits can do for GUI design, it is instructive to ponder the similarities between programming up a functional and aesthetically pleasing GUI, on the one hand, and designing and constructing a beautiful building, on the other.

There is no science of GUI design, just as there is no science of architecture.

Yet, over the years we have learned that humans have distinct preferences with regard to how a GUI is laid out and how its functionality is engineered, just as we know about our distinct preferences concerning the various dimensions of living spaces and how the spaces are put to use.

We could refer to these human preferences as *invariances*.

This analogy with architecture is important to us for two reasons:

First, the programming tools for GUI must not allow easy violation of the universal human preferences I referred to as invariances, in the same sense that the written and the unwritten rules of architecture do not allow for living spaces that are aesthetically and functionally offensive to humans.

The second reason for the importance of the architecture analogy is that just as a study of the history of building construction and design is important to inculcate in a student a sense of what has worked in the past and what serves as a foundation for the future, a study of the history of the GUI toolkits is likely to serve the same purpose.

History of Programming for GUI

It all started with X. (*arguably true*)

The X window system gave us a network-transparent method of working on remote computers through virtual terminals on workstations.

Although X was developed originally for Unix environments, it's now available for practically all other operating systems.

Although X was without doubt an enormous development in its own right, the support it contains for GUI programming consists essentially of

- low-level function calls for drawing lines and rectangles,
- for setting foreground and background colors, and
- for having events, such as those produced by a mouse, reported back to you.

X does not provide facilities for direct creation of what we now take for granted in modern GUI design – buttons, scrollbars, dialog boxes, popups, toolbars, tabbed pages, etc.

Motif:

The first X based GUI toolkit that facilitated higher-level programming required for graphical components was Motif, which is a combination of both a toolkit and a GUI design specification.

Motif makes calls to a lower-level toolkit called Xt (for X toolkit) that sits on top of Xlib, the X library. Xlib is the lowest-level programming API for working with X.

Xt, which was one of the first large software systems to simulate object-orientation directly in C, allows one to directly create a graphical object, such as a window object, but does not require that the window object come with a title bar and have a certain "look-and-feel" to it.

The "look-and-feel" specification was supplied by Motif and is now known as the Motif "look-and-feel." The modern Common Desktop Environment (CDE) that ships with most Unix workstations is based on Motif.

While Motif was gaining steam within Unix circles, Win32 API was introduced by Microsoft for PC's.

The main goal of WIN32 API differed from Motif's goal of performing network-transparent computing through virtual terminals on graphics enabled machines.

But, like Motif, WIN32 provided the basic programming tools for creating graphical interfaces that users could interact with either by mouse clicking or through keystrokes.

... and then came complaints from applications developers

As demands arose for creating more and more sophisticated user interfaces, programmers found it cumbersome to work with Motif or Win32.

Programs written using these API's were often error-prone and difficult to debug.

With both Motif and Win32, a programmer had to spend far too much time on getting the syntax and the program flow to work right in relation to the time for programming in the core functionality needed for an application.

Thus there arose a need for even higher-level toolkits that could hide bothersome details regarding how to make sure that the events generated by human interaction actually reached their intended recipients.

Another factor behind the development of the higher-level toolkits was the issue of portability across diverse platforms.

The higher level API's that have come into existence during the last few years include

- AWT and SWING in Java,
- Qt in C++,
- wxWindows for both Windows and Unix platforms,
- GNOME/GTK+ in C,
- Microsoft Foundation Classes (MFC),
- and many others.

The various GUI design toolkits we will consider all sit on top of a more native GUI toolkit API (and sometimes on top of a “tower” of API’s).

How far down a high-level API reaches into the underlying lower-level API’s has a bearing on what visual and design effects can be achieved with the high-level API.

For example, if a high-level API has to call on Motif to process its GUI widget construction code, the final “look-and-feel” is likely to correspond to Motif.

On the other hand, if a high-level API reached all the way into Xlib or directly into the operating system, it could generate its own look-and-feel.

```
Java Swing       Java AWT          Gnome            Qt
----------       --------          -----          -----
    |            |      |            |            |    |
    |            |      |            |            |    |
    |            |      |           GTK+          |    |
    |            |      |            |            |    |
    |            |      |            |            |    |
    |            |      |            |            |    |
    |            |    Motif         GDK           |    |
    |            |      |            |            |    |
    |            |      |            |            |    |
    |          Win32    |            |            |  Win32
    |            |      |            |            |    |
    |            |      |            |            |    |
    |            |      Xt           |            |    |
    |            |      |            |            |    |
    |            |      |            |            |    |
    |            |    -------------------------------  |
    |            |   |            Xlib               | |
    |            |    -------------------------------  |
    |            |               |                     |
    |            |               |                     |
    |            |               |                     |
   ------------------------------------------------------
  |                       OS                             |
   ------------------------------------------------------
```

Overview of Java AWT/Swing Components

In Java, the graphical components one places on a screen come from either the `java.awt` package or the various packages that begin with the prefix `javax.swing`.

The components are designed so as to generate events when subject to human interaction.

These events can be captured and processed by objects that implement certain interfaces defined in the `java.awt.event` and the `javax.swing.event` packages.

Top-Level Containers:

AWT/Swing components that are top-level containers are meant for holding other graphical objects, which can be intermediate-level containers or atomic components.

Graphical components including other graphical components give rise to `containment hierarchies`.

Every Swing program must have at least one top-level container and every containment hierarchy in a Swing program must have a top-level container at its root.

Moreover, a GUI component cannot be made visible on a screen unless it is in some containment hierarchy.

Examples of the commonly used Swing top-level containers are

- JFrame
- JDialog
- JApplet

All of these are heavyweight containers.

The heavyweight Swing containers are extensions of their AWT counterparts, which are all heavyweight.

Intermediate Containers:

Intermediate containers are often not directly visible but are nonetheless useful for organizing the visual layout of the graphical objects they hold.

Examples: `JPanel`, `JScrollPane`, `JTabbedPane`, etc.

Atomic Components:

The self-contained graphical components – referred to as the atomic components – are held by the containers.

Examples of these are `JButton`, `JTextField`, `JScrollBar`, etc. All of the atomic components from the Swing packages are lightweight.

Miscellaneous Classes:

These include classes for managing the layout of the components, for controlling the look and feel, for fetching information from the underlying operating system, etc.

Examples of these are `GridLayout`, `FlowLayout`, `Toolkit`, `Graphics`, etc.

```
                        Object
                         |
                         |
                         |
                         |
 -----------------------------------------------------------------
|                      | | |                  | | | | | | | | | | |
|                      | | |                  | | | | | | | | | | |
|                      | | |                  | | | | | | | | | | awt.Graphics
|                      | | |                  | | | | | | | | | |
awt.Component          | | |                  | | | | | | | | | |
|     |                | | swing.BorderFactory| | | | | | | | | awt.Color
|     |                | |                    | | | | | | | | |
|     swing.Box.Filler | |                    | | | | | | | | awt.BorderLayout
|                      | swing.BoxLayout      | | | | | | | |
|                      |                      | | | | | | | awt.GridLayout
awt.Container          |                      | | | | | | |
  |     | | |          swing.ButtonGroup      | | | | | | awt.CardLayout
  |     | | |                                 | | | | | |
  |     | | swing.Box                         | | | | | awt.FlowLayout
  |     | |                                   | | | | |
  |     | swing.                              | | | | awt.Toolkit
  |     |  CellRendererPane                   | | | |
  |     |                                     | | | swing.LookAndFeel
  |     swing.JComponent                      | | |
  |          |         |                      | | swing.UIManager
  |          |         |                      | |
  |          |         |                      | swing.UIManager.LookAndFeel
  |          |         swing.AbstractButton   |
  |          |          |     |    |          swing.FocusManager
  |          |          |     |    |
  |          |          |     |    swing.JMenuItem
  |          |          |     |             |  |  |
  |          |          |     |             |  |  |
  |          |          |     swing.JButton |  |  |
  |          |          |                   |  |  swing.JCheckBoxMenuItem
  |          |          |                   |  |
  |          |          |                   |  |
  |          |          swing.JToggleButton |  swing.JMenu
  |          |               |    |         |
  |          |               |    |         |
  |          |               |    |         swing.JRadioButtonMenuItem
  |          |               |    |
  |          |               |    swing.JCheckBox
  |          |               |
  |          |               swing.JRadioButton
  |          |
  |          |
  |       ---------------------------------------------------------
  |      | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
  |      | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
  |      | | | | | | | | | | | | | | | | | | | | | | | | | | | | | swing.JList
  |      | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
  |      | | | | | | | | | | | | | | | | | | | | | | | | | | | | swing.JLabel
  |      | | | | | | | | | | | | | | | | | | | | | | | | | | | |
  |      | | | | | | | | | | | | | | | | | | | | | | | | | | | swing.JMenuBar
  |      | | | | | | | | | | | | | | | | | | | | | | | | | | |
  |      | | | | | | | | | | | | | | | | | | | | | | | | | | swing.JPanel
|      | | | | | | | | | | | | | | | | | | | | | | | | | |
|      | | | | | | | | | | | | | | | | | | | | | | | | | swing.JColorChooser
|      | | | | | | | | | | | | | | | | | | | | | | | | |
|      | | | | | | | | | | | | | | | | | | | | | | | | swing.JLayeredPane
|      | | | | | | | | | | | | | | | | | | | | | | | |               |
|      | | | | | | | | | | | | | | | | | | | | | | | |               |
|      | | | | | | | | | | | | | | | | | | | | | | | |      swing.JDesktopPane
|      | | | | | | | | | | | | | | | | | | | | | | | |
|      | | | | | | | | | | | | | | | | | | | | | | | swing.JFileChooser
|      | | | | | | | | | | | | | | | | | | | | | | |
|      | | | | | | | | | | | | | | | | | | | | | | |
|      | | | | | | | | | | | | | | | | | | | | | | swing.JPopupMenu
|      | | | | | | | | | | | | | | | | | | | | | |
|      | | | | | | | | | | | | | | | | | | | | | swing.JProgressBar
|      | | | | | | | | | | | | | | | | | | | | |
|      | | | | | | | | | | | | | | | | | | | | swing.JOptionPane
|      | | | | | | | | | | | | | | | | | | | |
|      | | | | | | | | | | | | | | | | | | | swing.JLabel
|      | | | | | | | | | | | | | | | | | | |       |
|      | | | | | | | | | | | | | | | | | | |       |
|      | | | | | | | | | | | | | | | | | | |    swing.DefaultListRenderer
|      | | | | | | | | | | | | | | | | | | |                |
|      | | | | | | | | | | | | | | | | | | |                |
|      | | | | | | | | | | | | | | | | | | |   swing.DefaultListCellRenderer
|      | | | | | | | | | | | | | | | | | | |
|      | | | | | | | | | | | | | | | | | | |
|      | | | | | | | | | | | | | | | | | | swing.JInternalFrame
|      | | | | | | | | | | | | | | | | | |
|      | | | | | | | | | | | | | | | | | |
|      | | | | | | | | | | | | | | | | | swing.JInternalFrame.JDesktopIcon
|      | | | | | | | | | | | | | | | | |
|      | | | | | | | | | | | | | | | | swing.JComboBox
|      | | | | | | | | | | | | | | | |
|      | | | | | | | | | | | | | | | swing.JRootPane
|      | | | | | | | | | | | | | | |
|      | | | | | | | | | | | | | | swing.JScrollBar
|      | | | | | | | | | | | | | |               |
|      | | | | | | | | | | | | | swing.JTable    |
|      | | | | | | | | | | | | |                 JScrollPane.ScrollBar
|      | | | | | | | | | | | | |
|      | | | | | | | | | | | | swing.JScrollPane
|      | | | | | | | | | | | |
|      | | | | | | | | | | | swing.JSeparator
|      | | | | | | | | | | |
|      | | | | | | | | | | swing.JSlider
|      | | | | | | | | | |
|      | | | | | | | | | swing.JSplitPane
|      | | | | | | | | |
|      | | | | | | | | swing.JTabbedPane
|      | | | | | | | |
|      | | | | | | | swing.JTextComponent
|      | | | | | | |            | |     |
|      | | | | | | |            | |     swing.JEditorPane
|      | | | | | | |            | |         |
|      | | | | | | |            | |         swing.JTextPane
|      | | | | | | |            | |
|      | | | | | | |            |   swing.JTextArea
|      | | | | | | |            |
|      | | | | | | |            swing.JTextField
```

```
    |      | | | | | | |                       |
    |      | | | | | | |                       |
    |      | | | | | | swing.JToolBar          swing.JPasswordField
    |      | | | | | |
    |      | | | | | swing.JSeparator
    |      | | | | |         |    |
    |      | | | | |         |    swing.PopupMenu.Separator
    |      | | | | |         |
    |      | | | | |         swing.JToolBar.Separator
    |      | | | | |
    |      | | | | swing.JToolBar
    |      | | | |
    |      | | | swing.JToolTip
    |      | | |
    |      | | swing.JTree
    |      | |
    |      | swing.JViewport
    |
    |
 ----------------------
|                      |
|                      |
awt.Window             awt.Panel
 |   |   |                  |
 |   |   |                  |
 |   |   awt.Dialog         awt.Applet
 |   |       |               |
 |   |       |               |
 |   |       |            swing.JApplet
 |   |       |
 |   |       swing.JDialog
 |   |
 |   |
 |   awt.Frame
 |        |
 |        |
 |        swing.JFrame
 |
 |
 swing.JWindow
```

First came AWT with Java in 1995.

From the standpoint of designing sophisticated GUI and applets, AWT was fairly rudimentary.

Under AWT, each Java component created a corresponding component using the native GUI API.

This implied that Java could only support those components that existed in all the important platforms of the day.

This fact – referred to as the “least common denominator” approach – caused a Java button on a Unix platform to look like a Motif button, and on a Windows platform to look like a Windows button.

While early on, the least common denominator approach of Java to create the native look-and-feel in GUI was considered to be a positive point, as time went on the thinking in the community changed as people began to realize that some components, such as scrollbars, exhibited inconsistent behaviors across platforms.

As a result (or perhaps because of changing tastes), the developers of applications wanted a programmable look-and-feel that would give the developers the option of having their GUI's have the same look-and-feel across platforms.

Enter Swing at this juncture.

The Swing packages (which form a large constituent of the *Java Foundation Classes (JFC)*), besides giving the application developers a programmable look-and-feel, has many other innovations:

- Compared to pure AWT, computationally less-demanding lightweight components,
- better debugging support,
- more efficient event handling,
- decorative borders,
- ability to place icons on components,
- double buffering, etc.

Overview of C++ Qt Widgets

Qt widgets are objects of type `QObject`, as is made clear by the class hierarchy shown in the tree diagram below:

```
                             QObject
                                 |
                                 |
 ---------------------------------------------------------
|        |||||||||           |||||||| |             ||||||||
|        |||||||||           |||||||| |             ||||||||
QWidget  ||||||||QClipboard  |||||||| QCanvas       |||||||QApplication
 |       ||||||||            ||||||||               |||||||
 |       |||||||QAccel       |||||||QSignalMapper   ||||||QNPInstance
 |       |||||||             |||||||                ||||||
 |       |||||||             ||||||QFileIconProvider|||||QToolTipGroup
 |       |||||||             ||||||                 |||||
 |       ||||||QServerSocket |||||QSessionManager   ||||QSignal
 |       ||||||              |||||                  ||||
 |       |||||QSocketNofifier|||||                  |||QSound
 |       |||||               ||||QSocket            |||
 |       |||||               ||||                   |||
 |       |||||               ||||                   ||QNetworkProtocol
 |       ||||QTranslator     |||QUrlOperator        ||         |
 |       ||||                |||                    ||         |
 |       ||||                ||QValidator           |QAction   |
 |       |||QStyleSheet      ||   ||                |          |
 |       |||                 ||   ||                |          |
 |       |||                 ||   |QDoubleValidator |          |
 |       |||                 ||   |                 |          |
         |||                 ||   QIntValidator     |          |
 |       |||                 ||                     |          |
 |       |||                 |QNetworkOperation     QDragObject|
 |       |||                 |                         |       |
 |       ||QTimer            QStyle                    |       |
 |       ||                     |                      |      --
 |       |QTimer                |                      |      ||
 |       |                      QCommonStyle           |      ||
 |       |                       ||                    |   QFtp|
 |       QLayout                 ||                    |       |
 |         ||                    |QWindowsStyle        |       QLocalFs
 |         ||                    |           |         |
 |         |QGridLayout          |           |         |
 |         |                     |   QPlatinumStyle    |
 |         |                     QMotifStyle           |
 |         QBoxLayout                |||             ----
 |            ||                     |||             ||||
 |            ||                     |||             ||||
 |            ||                     |||             |||QIconDrag
 |            ||                     |||             |||
 |            ||                     ||QCDEStyle     ||QImageDrag
 |            |QHBoxLayout           ||              ||
 |            |                      |QMotifPlusStyle||
 |            QVBoxLayout            |               |QTextDrag
 |                                   QSGIStyle       |
 |                                                   QStoredDrag
 |                                                       ||
 |                                                       ||
 |                                                       |QColorDrag
 |                                                       |
 |                                                       QUrlDrag
 |
------------------------------------------------------
```

```
|       |||||        ||||         |||||            |||||
|       |||||        ||||         |||||            |||||
|       |||||        ||||         |||||            |||||
QDialog |||| QDial   |||QCombobox |||||            ||||QScrollBar
     |  ||||         |||          |||||            ||||
     |  ||||         |||          |||||            ||||
     |  |||QHeader   ||QSizeGrip  ||||QWorkspace   |||QTabBar
     |  |||          ||           ||||             |||
     |  |||          ||           ||||             |||
     |  ||QLineEdit  |QTabWidget  |||QToolBar       ||QSemiModal
     |  ||           |            |||              ||         |
     |  ||           |            |||              ||         |
     |  |QMainWindow QSlider      ||QStatusBar     |QGLWidget |
     |  |                         ||               |          |
     |  |                         ||               |  QProgressDialog
     |  |                         ||               |
     |  QNPWidget                 |QXtWidget       QButton
     |                            |                   |
     |                            |                   |
     |                            |                   |
     |                        QFrame                ----
     |                          |                   ||||
     |                          |                   ||||
     |                          |                   |||QCheckBox
     |                          |                   |||
     |                          |                   ||QPushButton
     |                          |                   ||
     |                          |                   |QRadioButton
     |                          |                   |
     |                          |                   QToolButton
     |                          |
     |                          |
     |                      --------------------------
   -----                   |||||||               ||||||
  |||||||                  |||||||               ||||||
  |||||||                  ||||||QLabel          |||||QMenuBar
  ||||||QColorDialog       ||||||                |||||
  ||||||                   |||||QPopupMenu       ||||QLabel
  |||||QFontDialog         |||||                 ||||
  |||||                    ||||QProgressBar      |||QLCDNumber
  |||||                    ||||                  |||
  ||||QFileDialog          |||QSpinBox           ||QSplitter
  ||||                     |||                   ||
  ||||                     ||QWidgetStack        |QTableView
  ||||                     ||                    |    |
  ||||                     ||                    |    QMultiLineEdit
  |||QInputDialog          ||                    |
  |||                      |QHBox                QScrollView
  |||                      |   |                     |
  |||                      |   QVBox                 |
  |||                      |                         |
  ||QMessageDialog         QGroupBox                 |
  ||                           |||                   |
  ||                           |||                   |
  |QTabDialog                  ||QHGroupBox          |
  |                            ||                    |
  |                            |QVGroupBox           |
  QWizard                      |                     |
                               |                   ------
```

```
QButtonGroup        ||||||
    ||              ||||||
    ||              |||||QCanvasView
    |QHButtonGroup  |||||
    |               ||||QIconView
    QVButtonGroup   ||||
                    |||QListView
                    |||
                    ||QListView
                    ||
                    |QTable
                    |
                    |
                    QTextView
                       |
                       |
                       QTextBrowser
```

Examples of top-level widgets would be `QFrame`, `QDialog`, `QFileDialog`, etc..

Intermediate containers, intended mostly for organizing the more atomic widgets, include `QGroupBox`, `QHBox`, `QVBox`, etc.

There are very many atomic widgets; for example, `QButton`, `QStatusBar`, `QLabel` etc.

Example of the utility classes include `QApplication`, `QSocket`, `QLayout`, etc.

Overview of GNOME/GTK+ Widgets

```
            GtkObject
               ^
               |
               |
               |
  --------------------------------------------------------------
 |     |       |    |    |             |  |    |           |    |
 |     |       |    |    |             |  |    |           |    |
 |     |       |    |    |             |  |    |           |    |
 | GnomeClient |    | GnomeCanvasItem  |  | GnomeEntryEdit |    |
 |     .       |    |   |.             |  |                |    |
 |         GnomeMDI |   |   GnomeMDIChild |     GnomeDockLayout |
 |                  |   |                 |                     |
GtkWidget      GtkData  |      GtkItemFactory        GtkXmHTMLParser
   |                    |
   |                    |
   |                    |
   |    --------------------------------------------------
   |   |             | | |   |               |    |       |
   |   |             | | |   |               |    |       |
   | GnomeCanvasLine | | |  GnomeCanvasGroup |    |   GnomeCanvasPolygon
   |                 | | |                   |    |
   |     GnomeCanvasRE | |      GnomeCanvasImage  |
   |     |             | |                        |
   |     |GnomeCanvasRect|                        |
   |     |               |                        |
   |     |          GnomeCanvasText   GnomeCanvasWidget
   |     |
   |   GnomeCanvasEllipse
   |
  ------------------------------------------------------------------
 |           |     |   |     |    |   |         |    |  |  |        |
 |           |     |   |     |    |   |         |    |  |  |        |
 |           |     |   |     |    |   |         |    |  |  |        |
GtkContainer |     | GtkMisc |    | GtkCalendar |    |  | GtkRuler  |
  |          |     | |       |    |             |    |  |           |
  |  GnomeAnimator | | GnomePixmap|          GtkDial | GtkEditable  |
  |               | |            |                  |              |
  |         GtkRange |   GtkSeparator       GtkProgress  GtkDrawingArea
  |                  |
  |                  |
  |     ---------------------------------
  |    |          |            |         |
  | GtkLabel  GtkArrow  GtkImage  GtkPixmap
  |    |
  |    |
  |    |
  |  ----------------------------
  | |               |            |
  | GtkAccelLabel  GtkClock  GtkTipsQuery
  |
  |
  -----------------------------------------------------------------------
 |      |   |  |      |   |    |      | |    |     | |   |         | | | |
 |      |   |  |      |   |    |      | |    |     | |   |         | | | |
 |      |   |  |      |   |    |      | |    |     | |   |         | | | |
 GtkBin |   | GtkList |   |  GtkCList | | GtkFixed | | GtkNotebook | | | GtkXmHTML
  |     |   |         |   |           | |          | |             | | |
  | GtkTRee |   GtkPacker |   GtkSocket |   GtkTable |      GtkPaned | |
  |         |             |             |            |               | |
  |    GtkToolbar  GtkMenuShell    GnomeDock  GnomeDockBand     GtkBox GtkLayout
  |                                                                 |   |
  |                                                                 |   |
  |                                                                 |   |
  ----------------------------------------------------------        |GnomeCanvas
 |         |    |   |       |  |      |     |         |     |       |
 |         |    |   |       |  |      |     |         |     |       |
 |         |    |   |       |  |      |     |         |     |       |
 GtkWindow |    |  GtkFrame | GtkItem |  GtkInvisible | GtkViewPort |
  |        |    |    |      |       | |               |             |
  |        |    |    |      |       | |               |             |
  | GtkDockItem |    |  GtkEventBox | GtkHandleBox   GtkButton      |
  |             |    |              |                |              |
  |             |    |              |                |              |
  |             |   GtkAspectFrame  |                |              |
  |             |                   |                |              |
  |    GtkScrolledWindow            |                |              |
  |                                 |                |              |
  |               -------------------------------    |              |
  |              |               |               |   |              |
  |       GtkMenuItem    GtkListItem    GtkTreeItem  |              |
  |         |                                        |              |
  |         |                                        |              |
  |         |                                        |              |
  |   ----------------------------------             |              |
  |  |                   |              |             |              |
  | GtkCheckMenuItem     |     GtkTearofMenuItem     |              |
  |                      |                           |              |
  |              GtkPixmapMenuItem                   |              |
  |                                                  |              |
  |                       ---------------------------------         |
  |                      |         |         |             |        |
  |       GnomeColorPicker  GnomeHRef GtkToggleButton GtkOptionMenu |
  |                                                                 |
  |                                                                 |
  |                                 --------------------------------
  |                                 |        |         |
  |                                 |        |         |
  |                             GtkHBox    GtkVBox    GtkButtonbox
  |                              |                            |
  |                              |                            |
  |                              |                            |
  |       --------------------------------------------        |
  |      |        |           |   |            |      |       |
  |      |        |           |   |            |      |       |
  | GnomeProcBar GnomeAppBar  | GnomeFileEntry | GtkStatusbar |
  |                           |                |              |
  |                       GtkCombo     GnomeNumberEntry       |
   |                                                           |
   |                                                           |
   --------------------------------------------------          |
  |           |   |          |         |             |         |
  |           |   |          |         |             |   -------------
  |           |   |          |         |             |  |             |
  GnomeDialog |  GnomeApp   GtkPlug    |             | GtkHButtonBox GtkVButtonbox
   |          |                        |             |
   | GtkColorSlectionDialog   GtkFileSlection   GtkFontSelectionDialog
   |
   |
   |
  ------------------------------------------------------
 |                |                |                    |
 |                |                |                    |
 GnomeAbout   GnomeMessageBox  GnomePropertyBox  GnomeScores
```

Many of the non-widget classes that hang from the root class `GtkObject` are meant for displaying graphics that can consist of shapes, images, text, etc.