Developing with GTK+

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Outline

- Introducing GTK+
  An introduction to GTK+ and a look at a simple program.
- Principles of GTK+
  The ideas you need to know to build a GTK+ pprogram.
- Building an Application
  Applying what we've learned to a real program.
- Beyond GTK+
  Related libraries, language bindings, extending GTK+.

Part I: GTK+ Basics

History
Background
Hello World
Basic Concepts
Compiling a GTK+ program

History of GTK+

Fall 1996 GTK+ started as part of the GIMP project by Spencer Kimball and Peter Mattis.

Spring 1998 GTK+ version 1.0 released.
GIMP version 1.0 released

Winter 1999 GTK+ version 1.2 released

Spring 1999 GNOME version 1.0 released

Summer 1999 Development of version 1.4 of GTK+

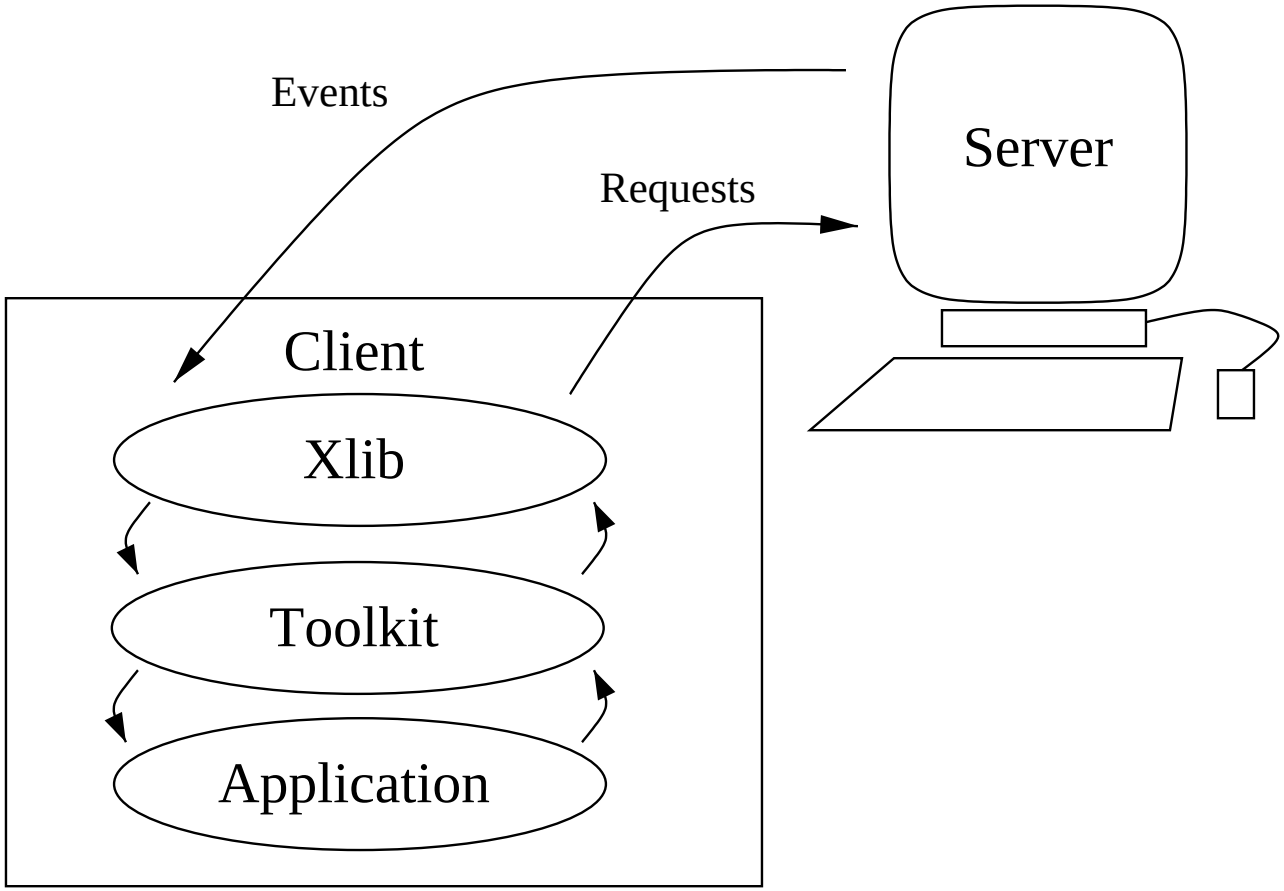
Some projects using GTK+

- GIMP (of course...)
- GNOME
- Mozilla
- AbiWord
- Approx. 500 other free and commercial software projects

Benefits of GTK+

- Convenient but powerful programming interface
- Widespread portability and availability
- Modern appearance, customizable with themes
- Unrestrictive Licensing (LGPL)
- Availability of Language Bindings

Architecture of X

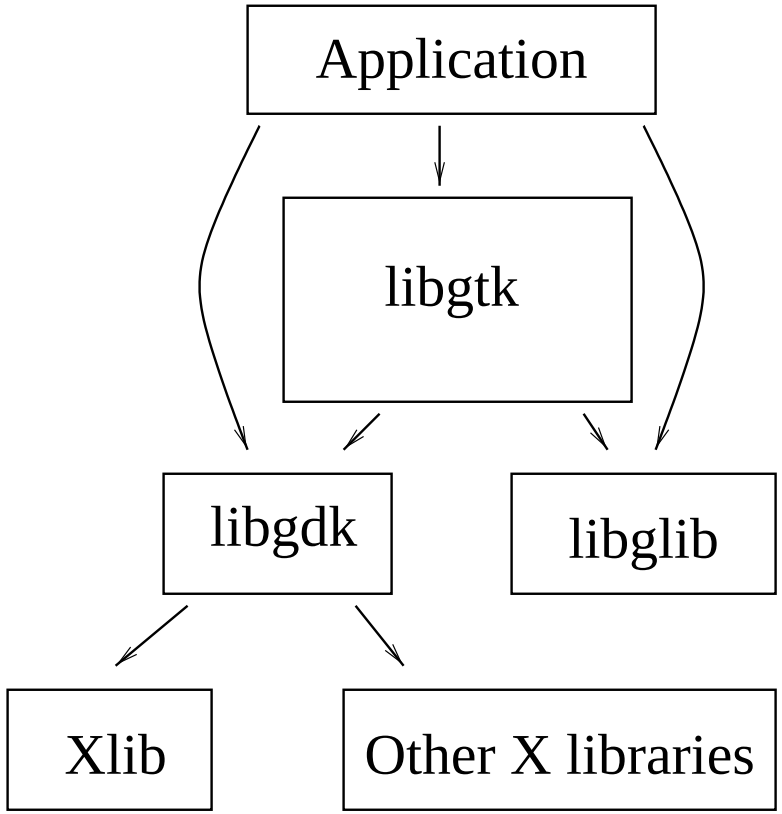


What is a widget?

- User interface component.
- May:
  - Display information.
  - Take input from user.
  - Arrange other widgets.

Button	Entry	FileSelection	Label
List	Menu	MenuItem	Notebook
Scrollbar	SpinButton	Table	Window

The GTK+ Libraries



The GTK+ Libraries

libgtk The widget system and widgets

- GTK+ object model
- Core code for managing, arranging widgets
- 80 types of widgets

libgdk Portability layer for drawing

- Provides basic drawing operations
- A Wrapper around Xlib
- Can be ported to other windowing systems (Win32, BeOS)

libglib Convenient C routines.

- Portable replacements for non-portable C library functions.
- High-level data types.
- Main loop abstraction.

Hello World

```
#include <gtk/gtk.h>

int main (int argc, char **argv)
{
  GtkWidget *window, *button;

  gtk_init (&argc, &argv);

  window = gtk_window_new (GTK_WINDOW_TOPLEVEL);

  button = gtk_button_new_with_label ("Hello World");
  gtk_container_add (GTK_CONTAINER (window), button);

  gtk_signal_connect (GTK_OBJECT (button), "clicked",
                      GTK_SIGNAL_FUNC (clicked), NULL);

  gtk_widget_show_all (window);

  gtk_main();

  return 0;
}
```

Hello World (cont)

Callbacks:

```
void clicked (GtkWidget *widget, gpointer data)
{
  gtk_main_quit();
}
```

Object Orientation

```
GtkWidget *window, *button;

gtk_container_add (GTK_CONTAINER (window), button);
```

- “Objects” represented as structures.
- “Methods” take pointer to object structure as first parameter
- Polymorphism - can call methods for parent classes as well as for object’s own class.

Containers

```
gtk_container_add (GTK_CONTAINER (window), button);
```

- *container* widgets contain other widgets.
- Can have one child (Window widget) or many children (Table widget).
- Even a button is a container that contains the label (or pixmap).
- All layout intelligence lives in container widgets - a container knows how to arrange its children.

Event Driven Programming

```
gtk_main();
```

- All actions done within “main loop”
- Receive events from user, dispatch to program
- Callbacks by *signals*

Signals

```
gtk_signal_connect (GTK_OBJECT (button), "clicked",
                    GTK_SIGNAL_FUNC (clicked), NULL);

void clicked (GtkWidget *widget, gpointer data)
{
  gtk_main_quit();
}
```

- For *notification* and *customization*
- Callback types identified by strings.
- Different prototypes callbacks possible.
- Pass in data to the callback as last argument.

Visibility

```
gtk_widget_show_all (window);
```

- Each widget can be visible or not visible.
- Widgets start off not visible.
- `gtk_widget_show()` shows one widget.
- `gtk_widget_show_all()` shows entire hierarchy.

Compiling a GTK+ program

- Use `gtk-config` to get options

```
$ gtk-config --cflags

-I/usr/X11R6/include -I/opt/gnome/lib/glib/include
   -I/opt/gnome/include

$ gtk-config --libs

-L/opt/gnome/lib -L/usr/X11R6/lib -lgtk -lgdk
   -rdynamic -lgmodule -lglib -ldl -lXi -lXext -lX11 -lm

$ cc -o helloworld ‘gtk-config --cflags‘ helloworld.c \
  ‘gtk-config --libs‘
```

Part II: Principles of GTK+

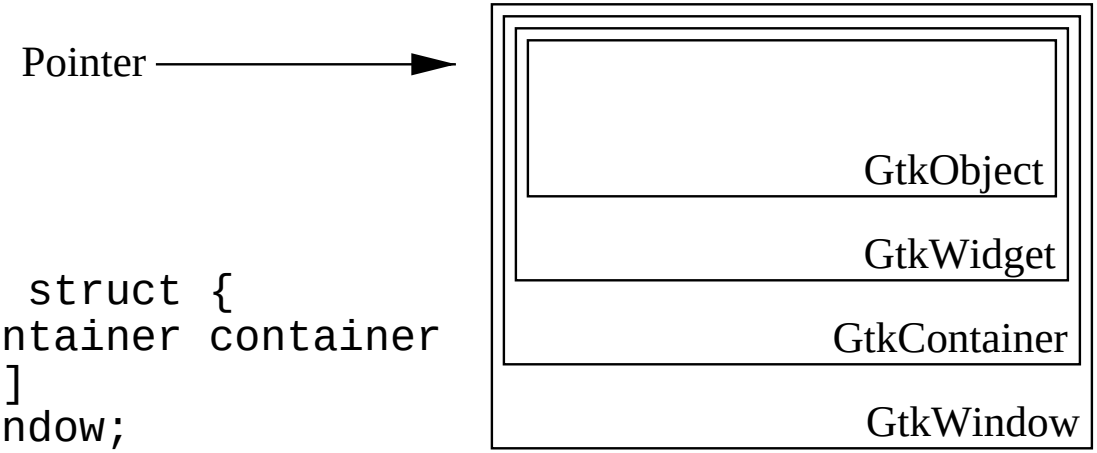
Object System
Geometry Management
Signals and Events
Reference Counting

Object System

- Built in straight C
- Supports conventional object-oriented features
  - Encapsulation
  - Inheritance
  - Polymorphism
- Tuned to needs of GUI programming
  - Introspection
  - Signal system for callbacks
  - Argument system for setting properties via a GUI builder
  - Types can be registered dynamically at run time

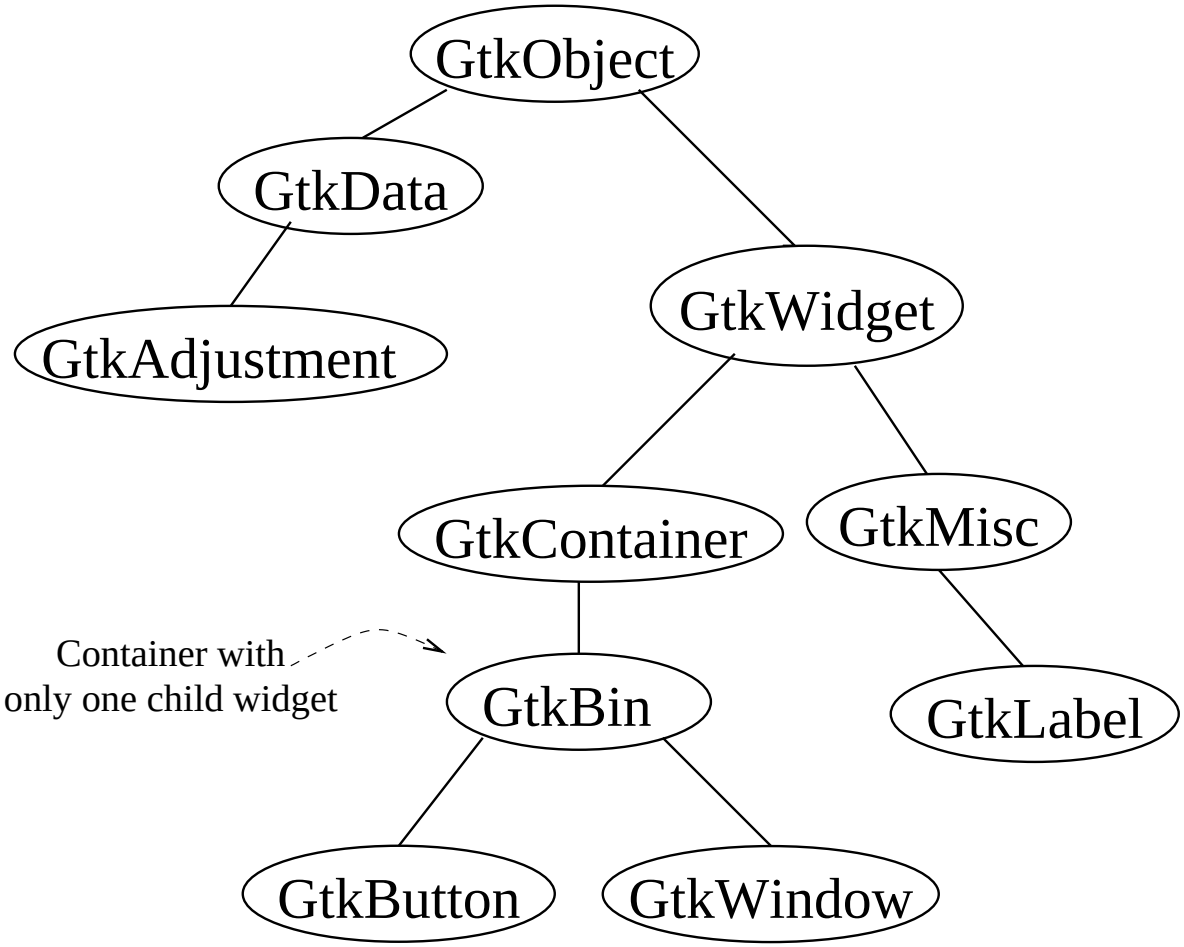
Inheritance

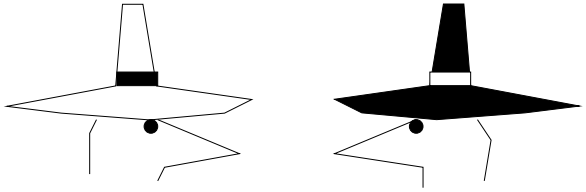
- An object can also be used as any of its parent classes.
- Inheritance done by nesting classes.




```
typedef struct {
  GtkContainer container
   [...]
} GtkWindow;
```

Widget inheritance tree





Hierarchy vs. Hierarchy

- Class Hierarchy
  - parent: base class
  - child: class inheriting from parent
- Widget Hierarchy
  - parent: container
  - child: containee

Casting Macros

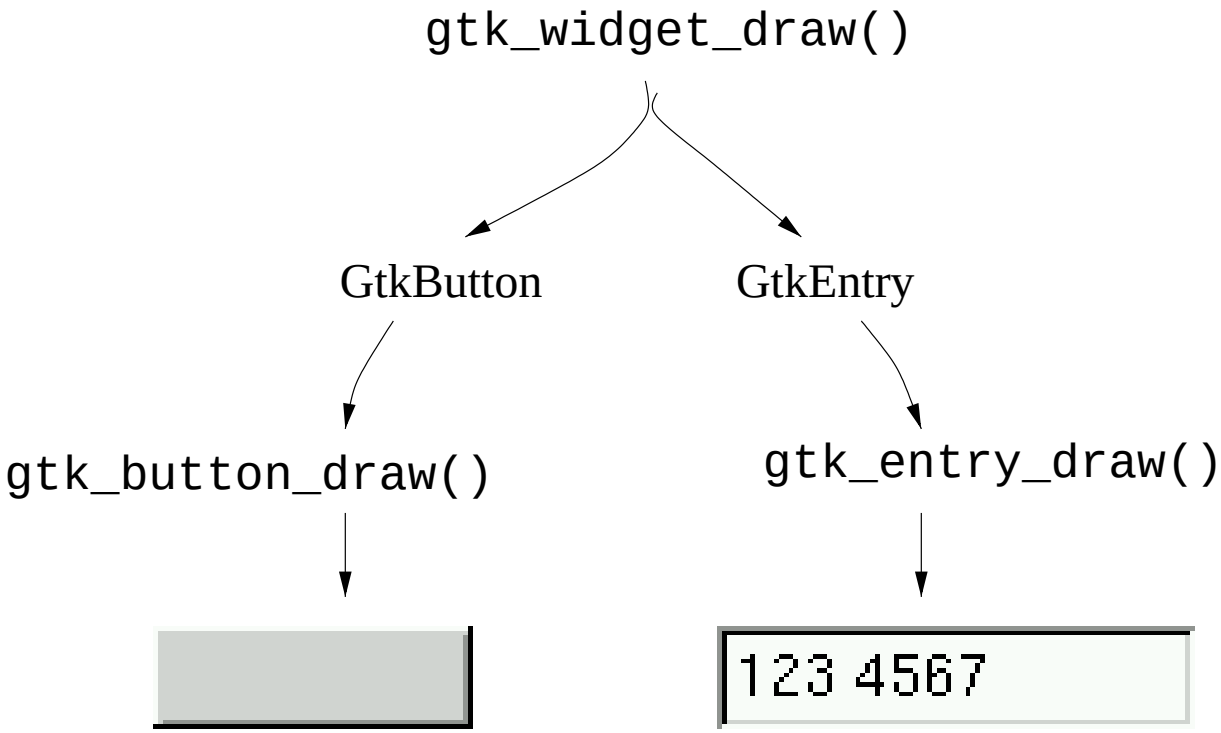
```
GtkWidget *window = gtk_window_new (GTK_WINDOW_TOPLEVEL);
gtk_window_set_title (GTK_WINDOW (window), "My Application");
```

- Typically, pointers to widgets stored as type `GtkWidget *`.
- Each class has standard macros for converting to that class
- `GTK_WINDOW`(window) casts to a `GtkWindow *` but *with checking*.
- `GTK_WINDOW`(button) will producing warning

  ```
  Gtk-WARNING **: invalid cast from ‘GtkButton’ to ‘GtkWindow’
  ```

- Checks are efficient but can be disabled at compile time

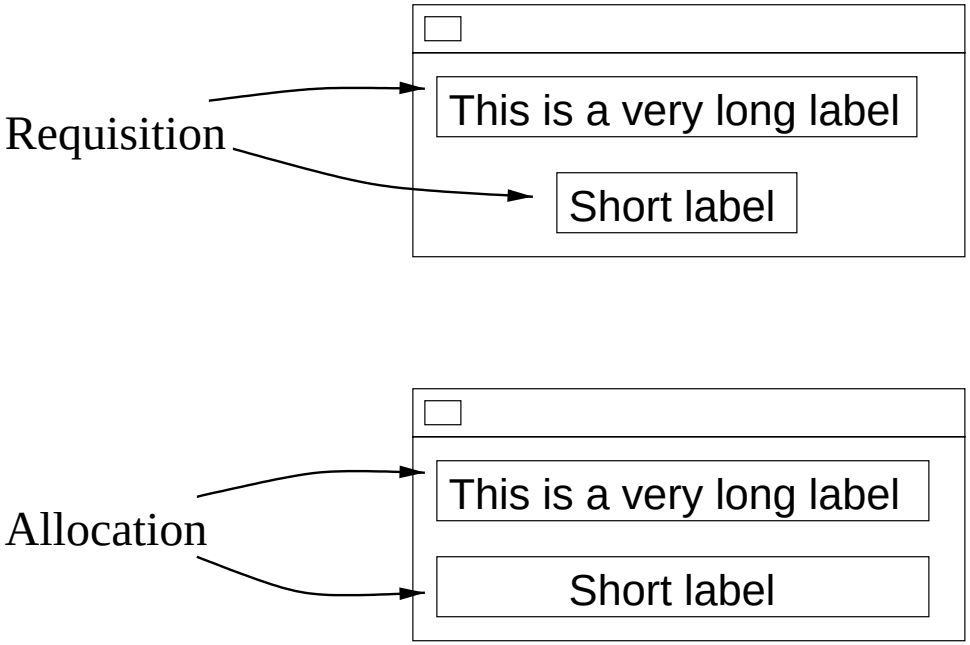
Polymorphism



Geometry Negotiation

- *requisition* is amount of space widget needs based on its contents
- Containers request space based on size of children. (VBox's requested height is sum of height of all children, plus padding.)
- Each child then assigned an *allocation*.
- allocation never smaller than requisition, but may be larger.

Geometry Example



- Allocation will generally be at least as big as requisition, may be bigger.

Packing Boxes

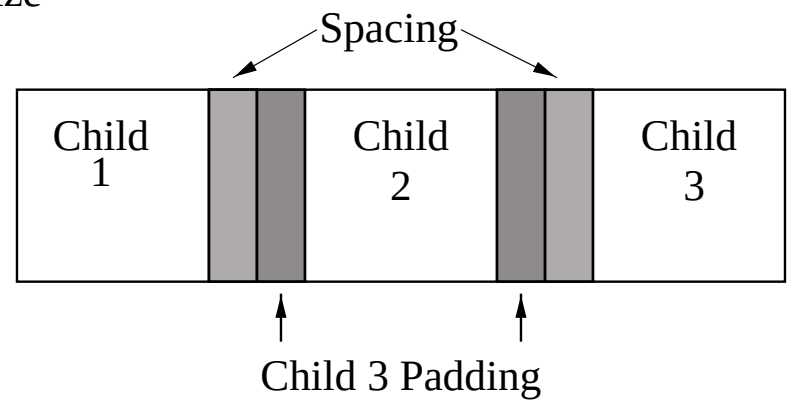
```
void
gtk_hbox_new (gboolean homogeneous, guint spacing);

void
gtk_box_pack_start (GtkBox *box, GtkWidget *child,
                    gboolean expand, gboolean fill, guint padding);
```

- Arrange child horizontally (HBox) or vertically (VBox).
- Per-box `homogeneous` and `spacing` options.
- Each child has `expand`, `fill`, and `paddding` options.

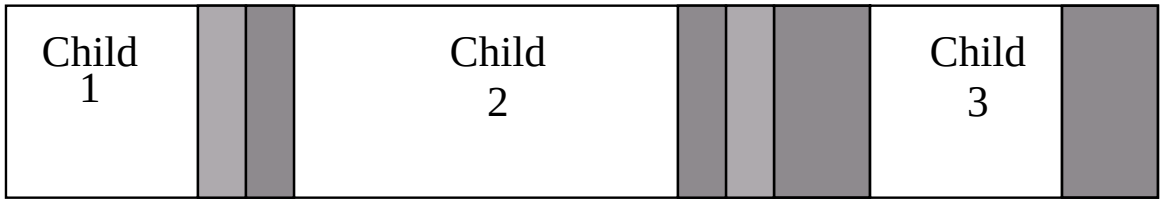
Packing Boxes (cont)

Box	Expand	Fill
1	NO	NO
2	YES	YES
3	YES	NO

Normal Size



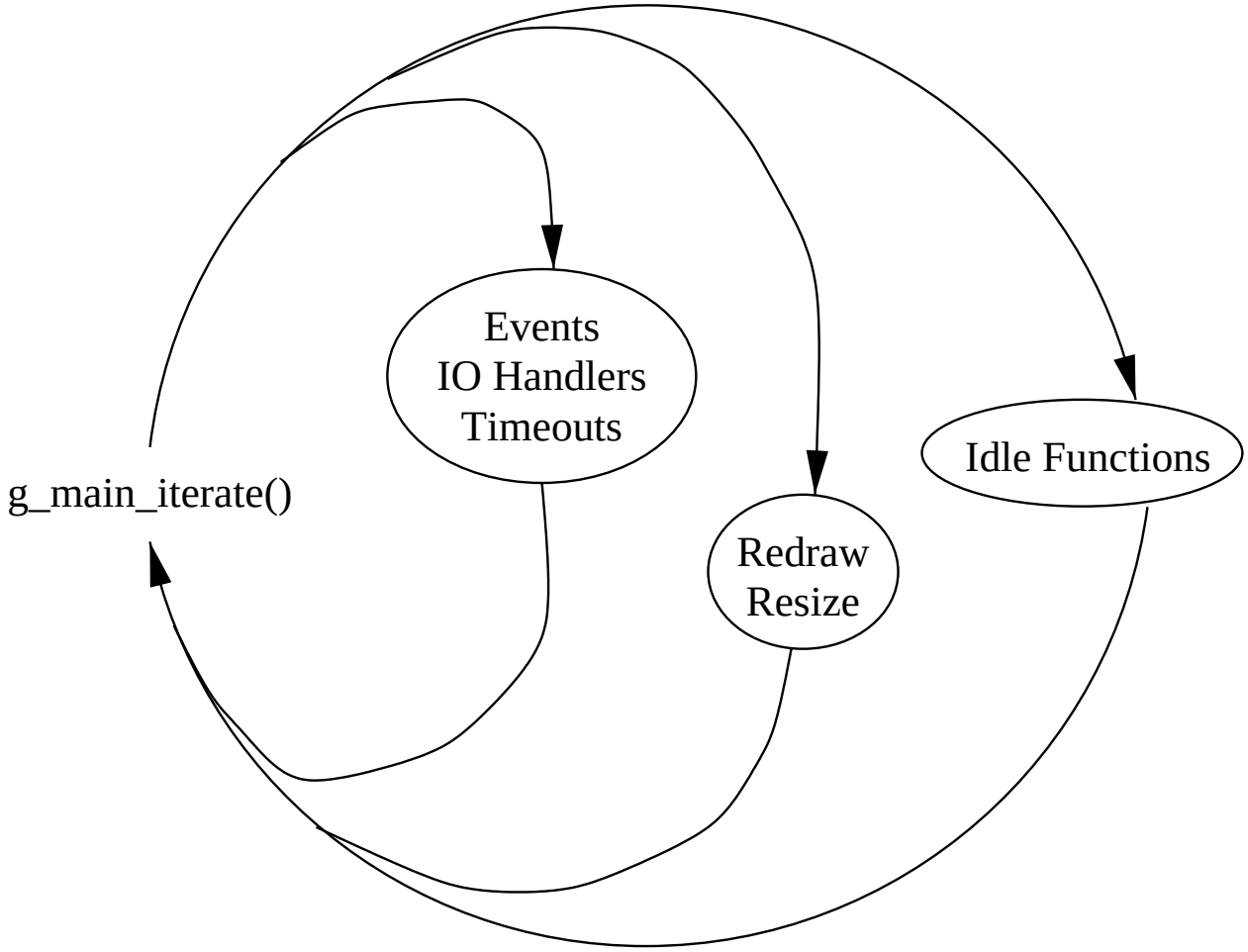
Expanded by User



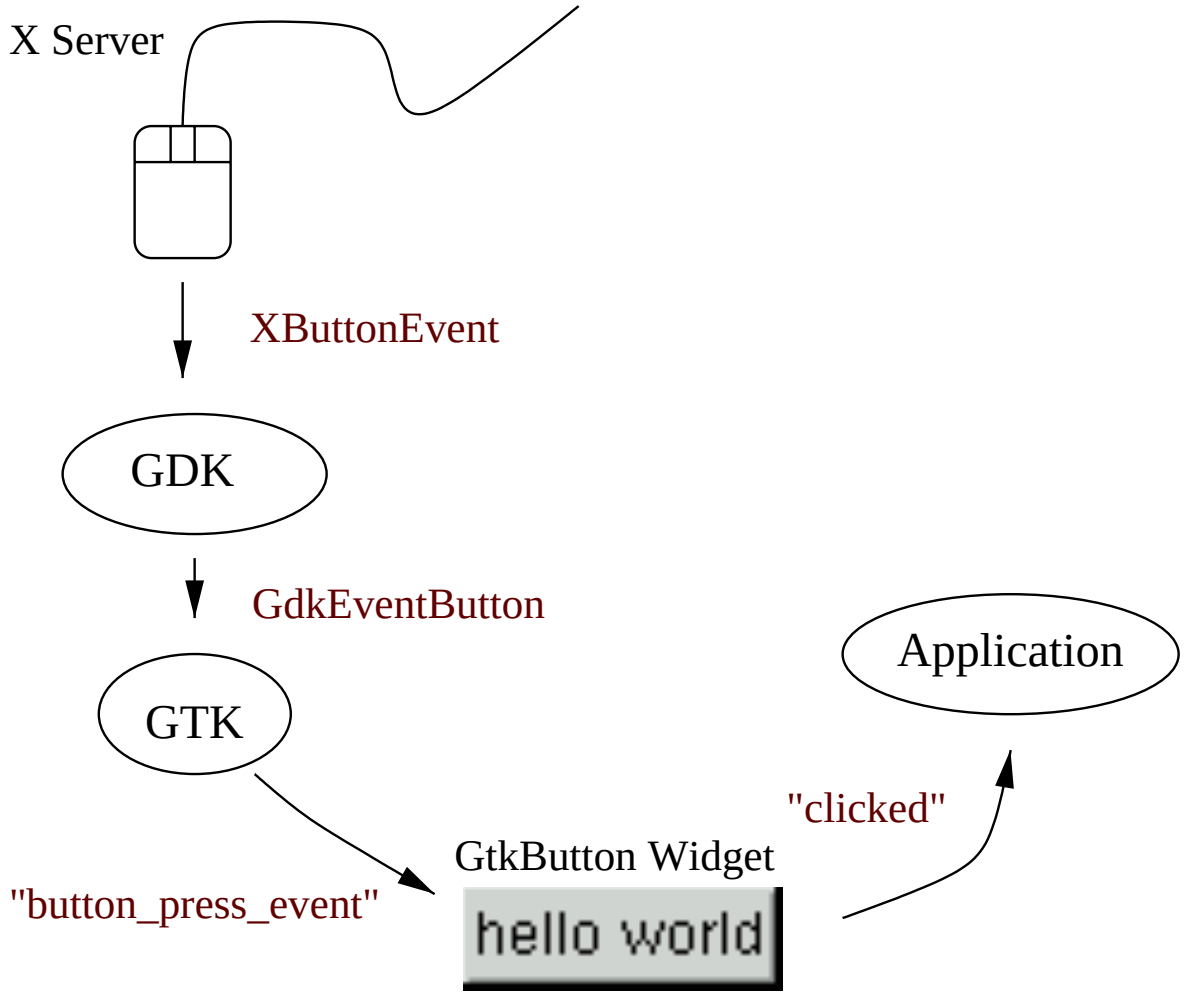
Main Loop

- Events retrieved from event *sources*
- Standard event sources:
  Glib: Timeouts, IO Handlers, Idle Handlers
  GDK: X events
- Additional source types can be created.
- Sources prioritized
  1. Incoming X Events
  2. GTK+'s redraw, resize queues
  3. Application's idle handlers.
- Lower priority sources not serviced until high priority sources finished.

Main Loop (cont)



Events and Signals



Events and Signals

- Lowlevel events sent from X server
- Corresponding signals sent to appropriate widget
- Widgets generate highlevel events
- Event signals have a distinct signature
- Return value determines propagation. `TRUE` => handled.

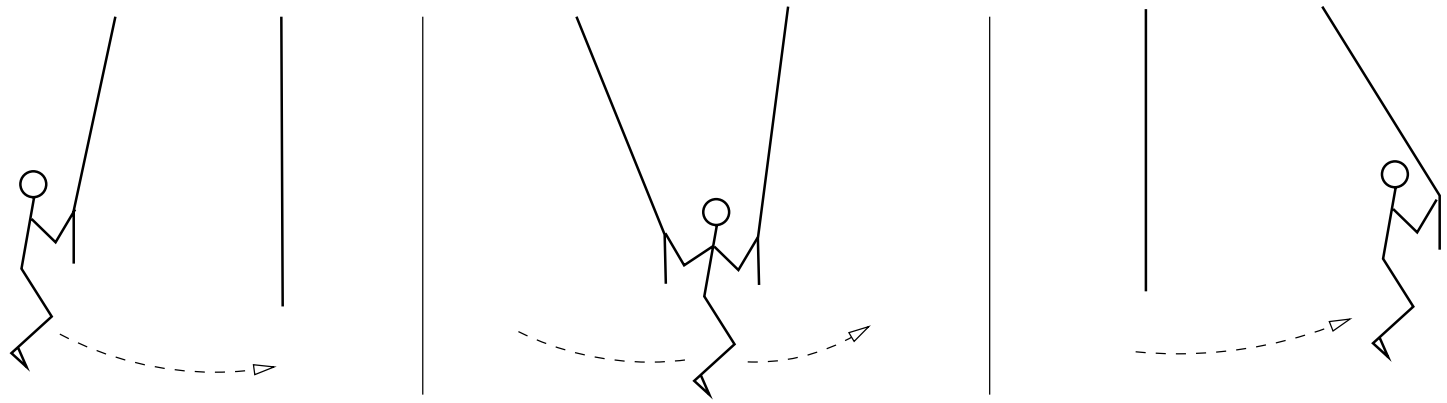
Reference Counting

- Need to know when objects are unused (garbage collection)
- Explicit ownership works badly for GUIs.
- Keep a reference count
  - Create an item, refcount is 1.
  - Begin using item, increase refcount by 1 - `ref()`
  - Finish using item, decrease refcount by 1 - `unref()`
  - When reference count drops to zero, free object

Reference Counting example

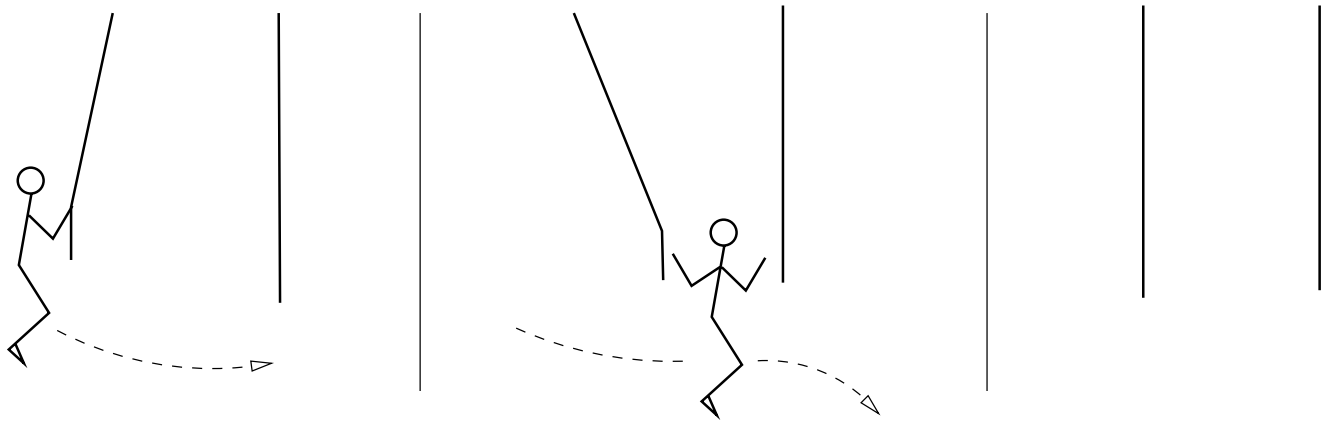
- Parent keeps reference count on children
- Removing child from parent causes it to be freed
- So, to move child from one to other, need to do:

```
gtk_object_ref (GTK_OBJECT (child));
gtk_container_remove (GTK_CONTAINER (old_parent), child);
gtk_container_add (GTK_CONTAINER (new_parent), child);
gtk_object_unref (GTK_OBJECT (child));
```



Reference Counting example (cont)

- If you forget to refcount...



Floating and Sinking

- Reference counting for GtkObject not quite so simple
- Don't want to have to write:

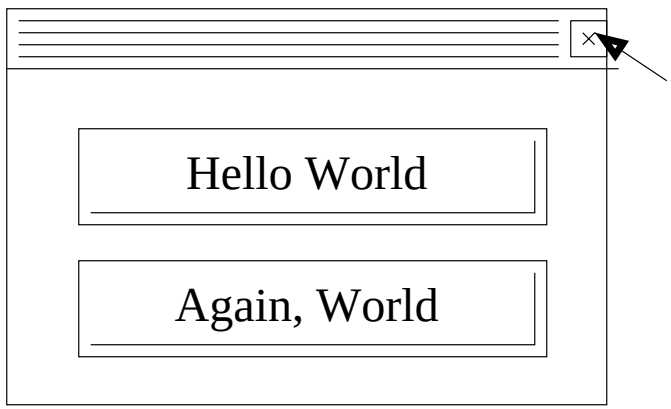
```
button = gtk_button_new_with_label ("Hello World");
gtk_container_add (GTK_CONTAINER (window), button);
gtk_widget_unref (button);
```

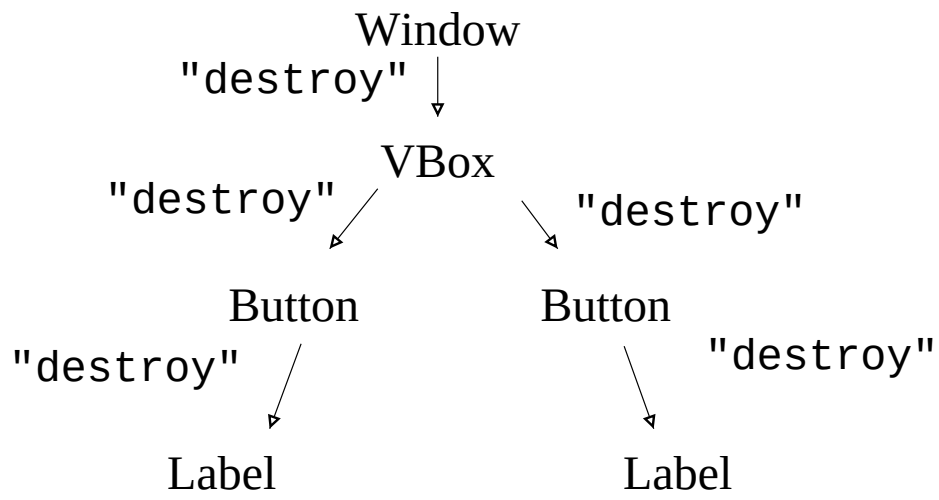
- So, container *assumes* reference count of child.
- GtkObject initially created and marked floating. (Reference count can be assumed)
- Parent calls `gtk_widget_sink()` to remove flag.

The Life Cycle of a Widget

Create	`gtk_label_new()`	
Parenting	`gtk_container_add()`	
Show	`gtk_widget_show()`	
Size Request		`"size_request"`
Size Allocate		`"size_allocate"`
Realize		`"realize"`
Map		`"map"`
Expose		`"expose"`
Destroy	`gtk_widget_destroy()`	`"destroy"`
Unmap		`"unmap"`
Unrealize		`"unrealize"`
Unparent		
Finalize		

Widget Destruction





- Reference counting vulnerable to *cycles*.
- Explicit destruction helps.
- Triggered by user closing window, or app calling `gtk_widget_destroy()`
- Destruction propagates recursively to children.

Life cycle of GdkWindow

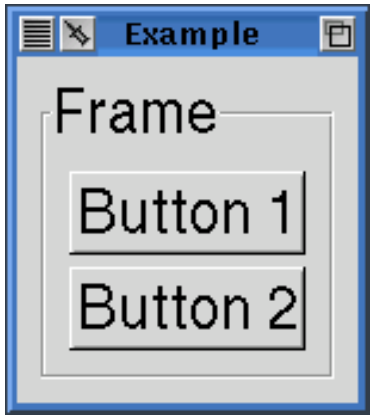
- GdkWindow is server side object. Used to receive events and clip drawing.
- Includes toplevel windows, but also children of those windows.
- **Realization** GDK/X Window for widget is created.

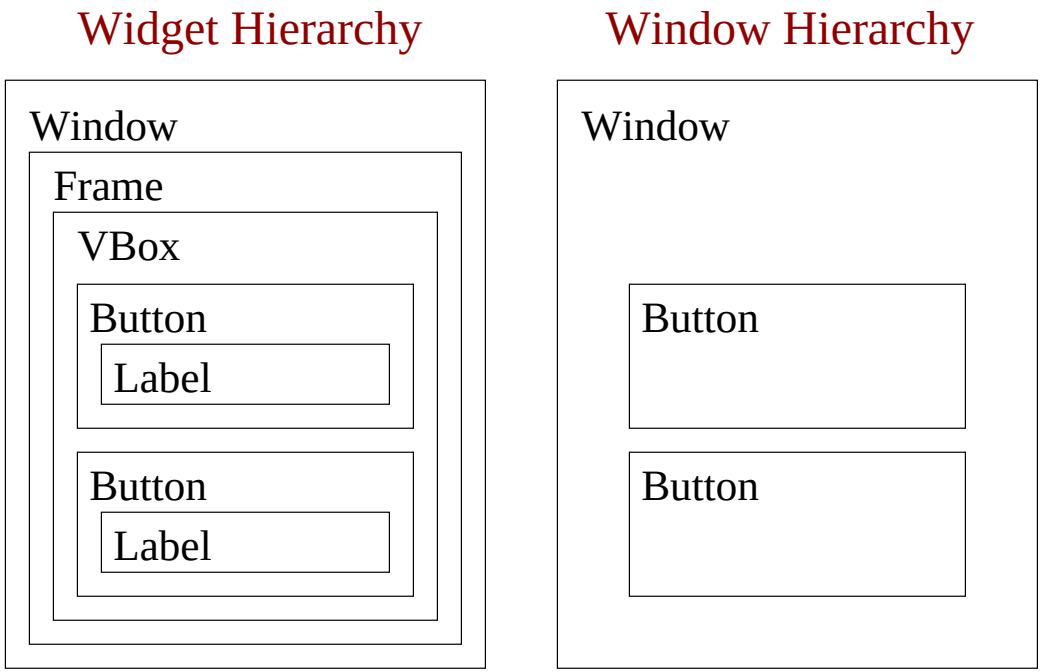
  Map GdkWindow is made visible.

  Expose X asks toolkit to refresh the widget's display.

  Unrealize widget removed from the screen.
- Generally these steps occur automatically. Only time you have to worry about realization is when you want to make GDK calls and need the GdkWindow for a widget.

Widgets and GdkWindows



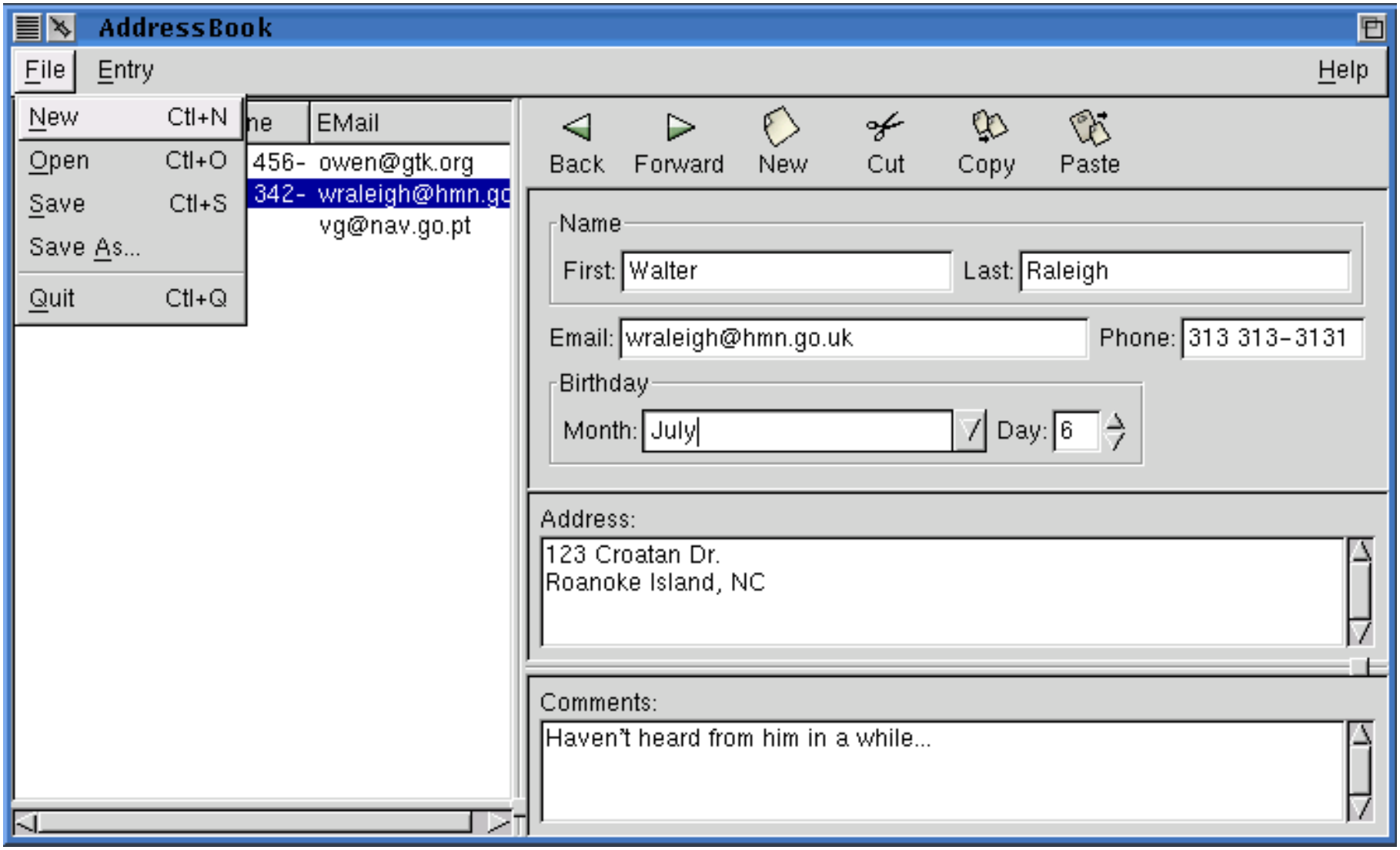


- GdkWindows used for delivering events
- Many widgets do not have corresponding GdkWindow
  Frame, VBox, Label: `NO_WINDOW` widgets.
  These widgets draw on parent widget's window.
- Other widgets have windows: Window, Button, etc.

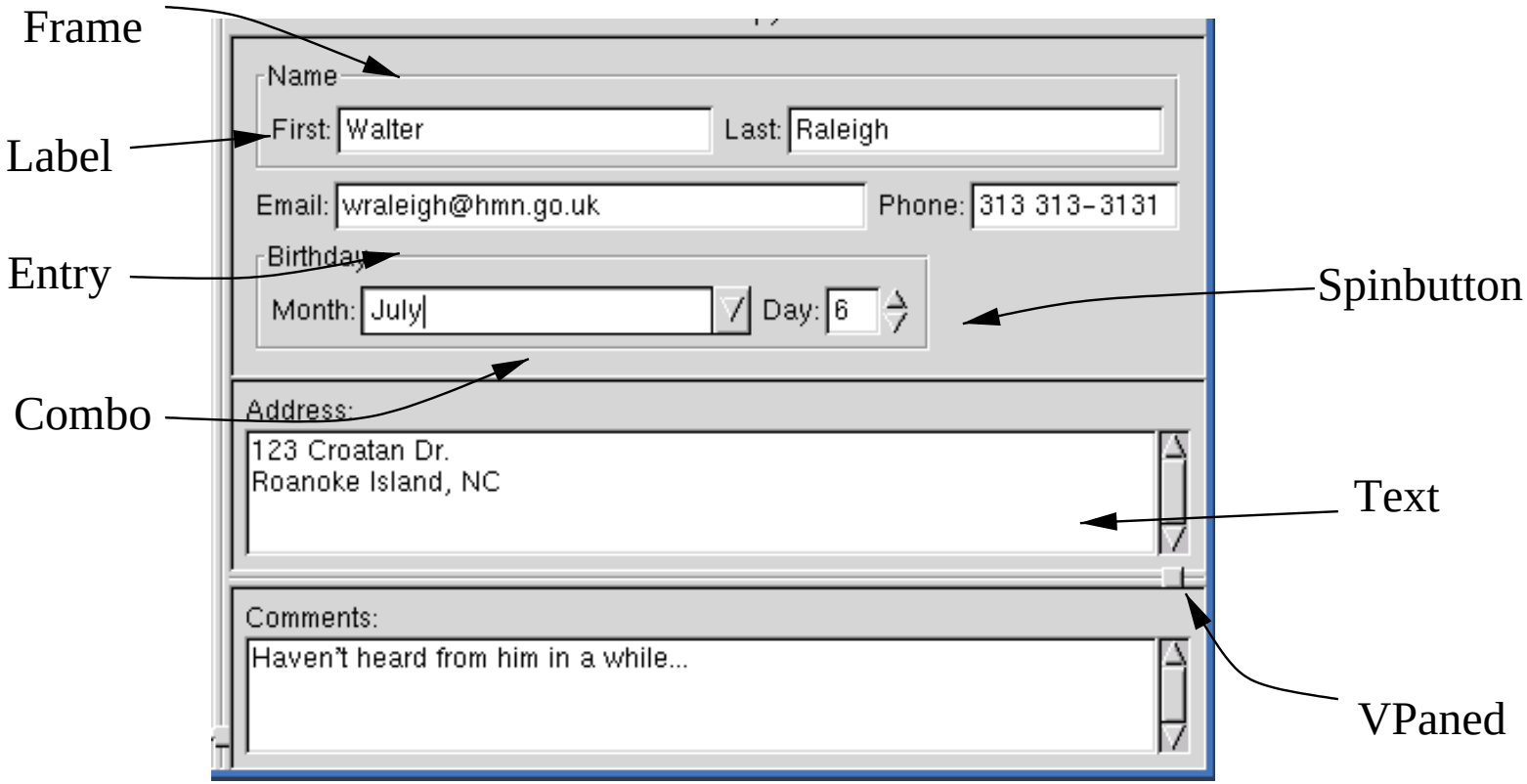
Part III: Building an application

The Application
Widget tour
Geometry management in detail
Using GLib

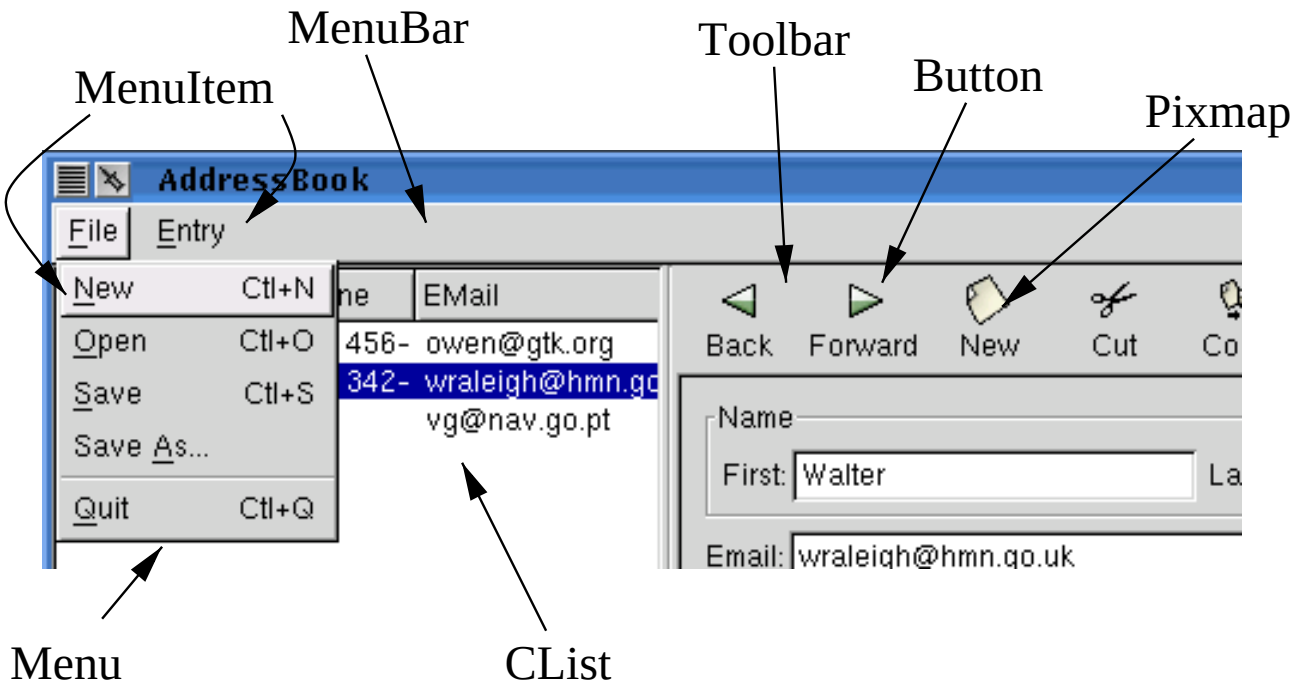
The example


AddressBook
File
Entry
Help
New Ctl+N
Open Ctl+O
Save Ctl+S
Save As...
Quit Ctl+Q
EMail
456- owen@gtk.org
342- wraleigh@hmn.go
vg@nav.go.pt
Back
Forward
New
Cut
Copy
Paste
Name
First: Walter
Last: Raleigh
Email: wraleigh@hmn.go.uk
Phone: 313 313-3131
Birthday
Month: July
Day: 6
Address:
123 Croatan Dr.
Roanoke Island, NC
Comments:
Haven't heard from him in a while...

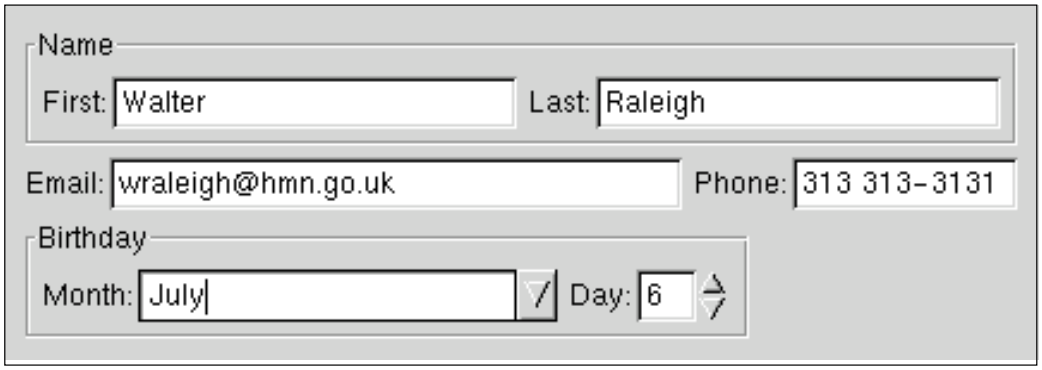
Widgets in an addressbook

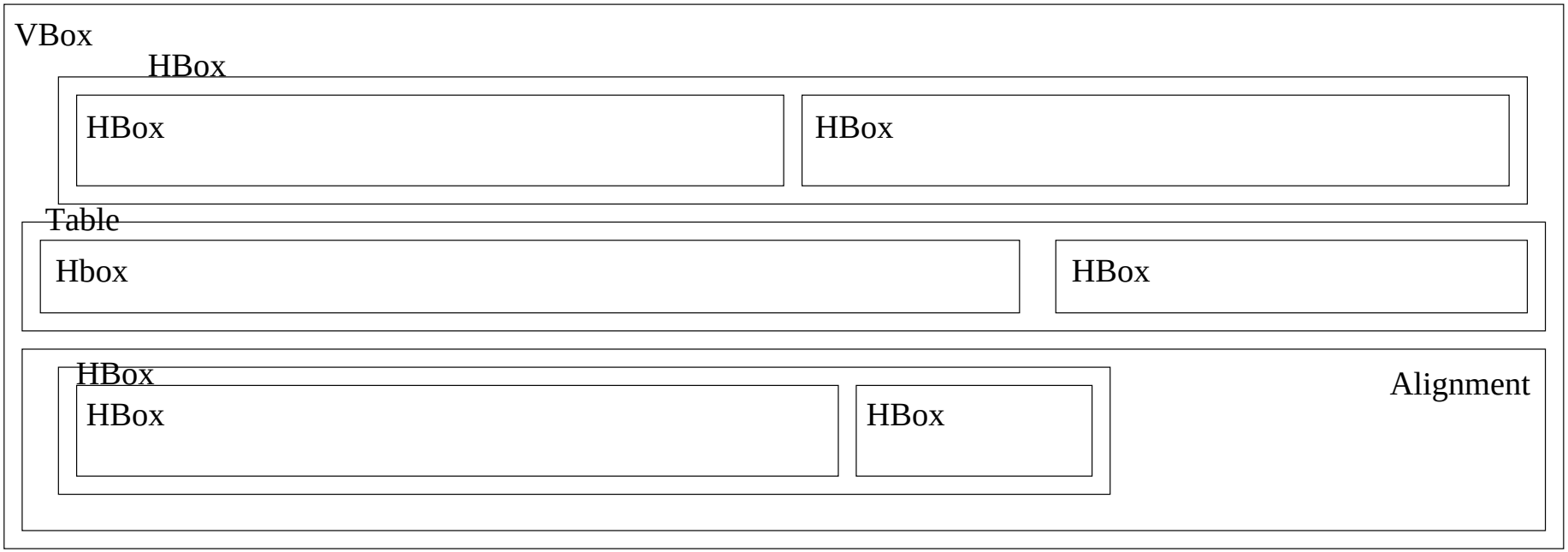


More widgets in an addressbook



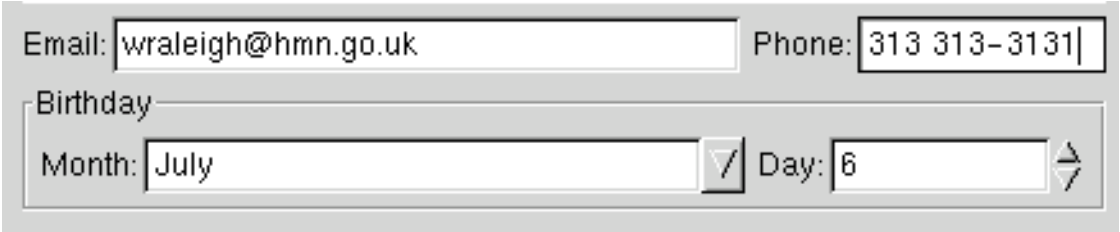
Complex Geometry Management



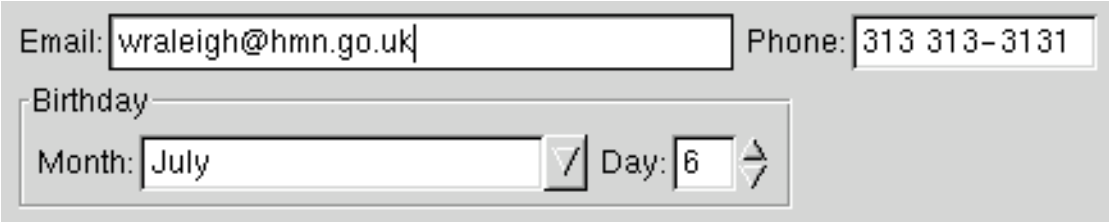


Using a GtkAlignment

- Want widget to take up only part of space

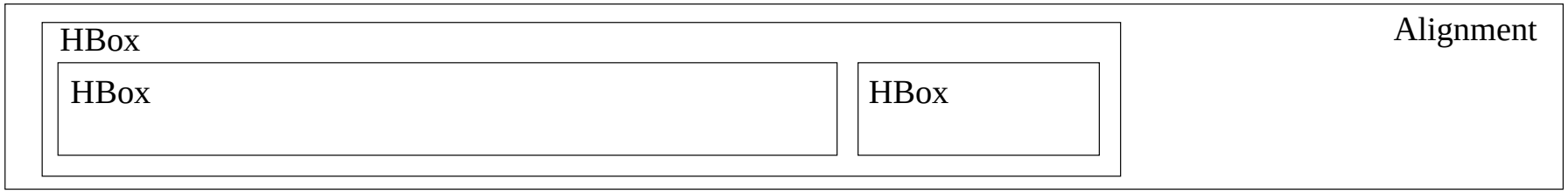


- Solution: use a GtkAlignment



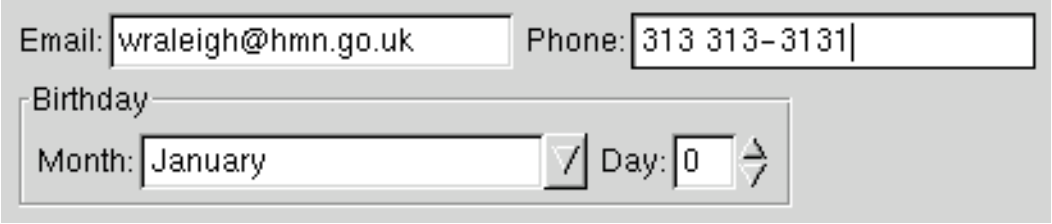

```
GtkWidget *gtk_alignment_new (gfloat xalign, gfloat yalign,
                              gfloat xscale, gfloat yscale);
```

`xscale: 0.0` (no expansion) `xalign: 0.0` (left)

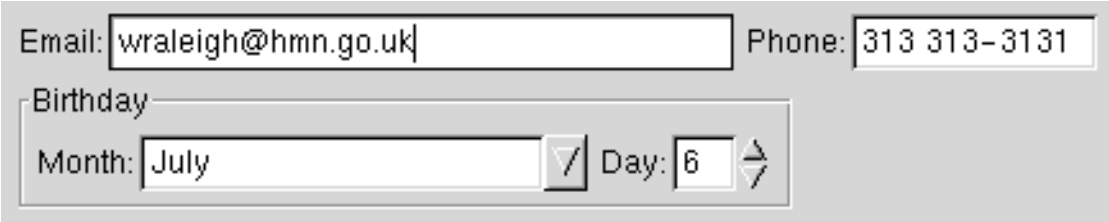


Enforcing a 2:1 ratio between elements

- Want email twice as wide as phone number

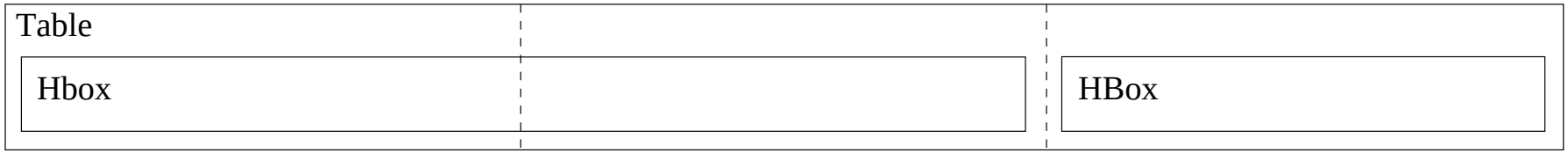


- Solution: use a homogeneous GtkTable




```
GtkWidget *gtk_table_new (guint rows, guint columns,
                          gboolean homogeneous);
```

`rows: 1  columns: 3  homogeneous: TRUE`



Using signals for *behavior modification*

- Many methods routed through signals; allow modifying behavior without inheriting and overriding the methods.
- Example: create an entry that only accepts `[0-9- ]`.
- GtkEditable (parent class of GtkText and GtkEntry) has `"insert_text"` signal.
- Connect to this signal, and in signal handler
  1. Modify text as desired
  2. Insert this text (being careful not to recurse)
  3. Stop the default handler from running

```
gtk_signal_connect (GTK_OBJECT (phone_entry), "insert_text",
                    GTK_SIGNAL_FUNC (insert_text_handler),
                    NULL);
```

Using signals for *behavior modification* (cont)

```
void
insert_text_handler (GtkEditable *editable, const gchar *text,
                     gint length, gint *position, gpointer data)
{
  int i, j;
  gchar *result = g_new (gchar, length);

  [ copy text into result, stripping out unwanted characters ]

  /* Block ourselves, and insert modified text */
  gtk_signal_handler_block_by_func (GTK_OBJECT (editable),
                                    GTK_SIGNAL_FUNC (insert_text_handler)
                                    data);
  gtk_editable_insert_text (editable, result, length, position);
  gtk_signal_handler_unblock_by_func (GTK_OBJECT (editable),
                                      GTK_SIGNAL_FUNC (insert_text_handle
                                      data);

  /* Keep default handler from being run */
  gtk_signal_emit_stop_by_name (GTK_OBJECT (editable), "insert_text");

  g_free (result);
}
```

Item Factory

- Menus normal containers
- Creating menus and menu items by hand repetition
- Solution: automatic creation from an array

```
static GtkItemFactoryEntry menu_items[] =
{
  /* menu-path      accelerator    callback + action  item-type */
  { "/_File",       NULL,          NULL, 0,           "<Branch>" },
  { "/File/_Open",  "<control>O",  do_open, 0,        NULL },
  { "/File/_Save",  "<control>S",  do_save, 0,        NULL },
  { "/File/sep1",   NULL,          NULL, 0,           "<Separator>" },
  { "/File/_Quit",  "<control>Q",  do_quit, 0,        NULL
};
static int nmenu_items = sizeof (menu_items) / sizeof (menu_items[0]);

gtk_item_factory_create_items (item_factory,
                               nmenu_items, menu_items, NULL);
```

GLib

- Main loop
- Portability functions
  `g_strcasecmp()`, `g_snprintf()`
- Convenience functions
  `g_strsplit()`, `g_get_home_dir()`
- Data types

  GList linked lists

  GHashTable hash tables

  GTree balanced trees

  GString string type
- GScanner - run-time configurable tokenizer

GString

- automatically handles memory allocation, reallocation

```
GString *string = g_string_new (NULL);

g_string_append (string, "Goodbye");
g_string_append_c (string, ',');
g_string_append (string, " Old Paint");

printf(string->str);
g_string_free (string, TRUE);
```

GList

- Doubly-linked list
- Also GSList - singly linked list
- NULL represents empty list

```
GList *word_list, *result = NULL;
for (i=0; i<n_words; i++)
  word_list = g_list_prepend (word_list, g_strdup (word));
[...]
result = g_list_find_custom (word_list, "blue", g_str_equal);
if (result)
{
  word_list = g_list_remove_link (word_list, result);
  g_free (result->data);
  g_list_free_1 (result);
}
```

Part IV: Beyond GTK+

Extending GTK+

Language Bindings

GNOME

Future Directions

Creating custom user interface elements

- If needs are light, can use GtkDrawingArea.
  - Receive low-level events: `"button_press_event"`, `"key_press_event"`.
  - Get notified to size changes by `"size_allocate"`.
  - In response to `"expose"`, draw on widget's window with GDK drawing calls.
- May be better to use GnomeCanvas widget. (see later)
- For heavier applications, can derive own widget types. (code reuse).

Creating widgets

- Define object and *class* structures for new type.
- class structure
  - Pointed to from object structure.
  - Contains function pointers to the *virtual functions* of the widget.
  - Nested like object structures.
  - Usually widgets will override virtual functions from GtkWidget like `size_request()`, `size_alllocate()`, and `expose()`.
- Register type with `init()` and `class_init()` functions.
- `init()` function initializes newly created object structures.
- `class_init()` function initializes class structure, creates signal and argument types for class.

Language Bindings

- GTK+'s object orientation maps well onto languages with native OO features.
- Languages with OO features often make using GTK+ more concise.
- Ability to query types at runtimes simplifies creating language bindings.
- Many language bindings exist:
  C++, Perl, Python, Ada, Dylan, Eiffel, Guile, Haskell, JavaScript, Objective C, Camel, Label, Pascal, Pike, TOM. . .

Perl/GTK

```
use Gtk;
Gtk::init();

$window = new Gtk::Window;
$button = new Gtk::Button "Hello World";
$window->add($button);

$button->signal_connect("clicked",
                sub { Gtk::main_quit() });

$window->show_all;
Gtk::main();
```

PyGtk

```
from _gtk import *
from GTK import *

def clicked(*args):
    mainquit()

window = GtkWindow()
button = GtkButton('Hello World')
window.add(button)

button.connect('clicked', clicked)

window.show_all
mainloop()
```

GLADE

- GUI builder
- Graphically build widget tree
- Write out code (C, C++, Ada), or XML
- Rebuild widget tree in application from XML (libglade)

GNOME

- Layer between GTK+ and application.
- Provides high-level functionality, more widgets.
- Enforces consistency.
- See `http://developer.gnome.org` for more info.

GNOME Widgets

- GnomeMessageBox - easy to display error messages
- GnomeIconList - file-manager-style icon display
- GnomeColorPicker, GnomeFontPicker – standard interfaces for a color or font selection button.
- GnomeDruid – Wizard(tm) style setup dialogs.
- Many more...

GnomeCanvas

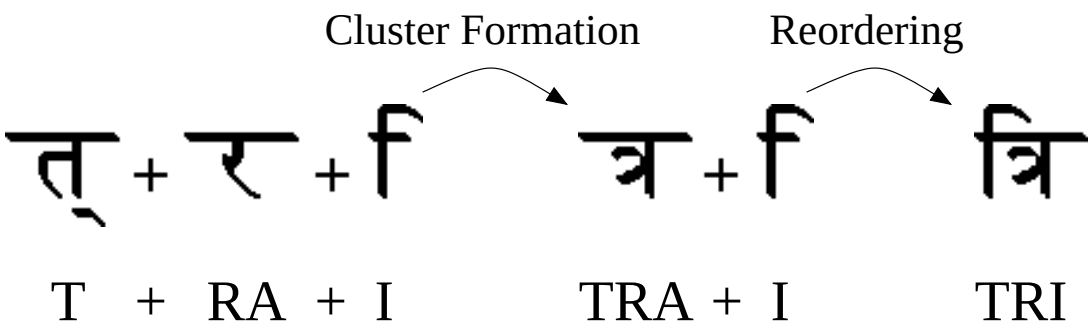
- Structured graphics - hierarchy of graphics objects much like widget hierarchy.
- Easy to make complex, user-manipulatible displays.
- Flicker-free.
- Standard items:
  rectangle, circle, text, image...
- Can implement custom items.
- Can render *anti-aliased*

GNOME High-level Functionality

- Configuration data storage.
- Session-management.
- Application framework.
- Help System.
- Mime-type support.

Unicode and enhanced internationalization support

- GTK+ currently supports Asian double-byte languages and input methods.
- Move to Unicode - 1 encoding for all languages.
- Support right-to-left languages like Hebrew.
- Support *complex-text* languages like Hindi.
- Use “pango” - a toolkit independent framework for rendering with Unicode.



Enhanced Object Model

- Mostly single inheritance works well for GTK+, but sometimes clumsy.
- Java-style multiple interfaces will be added 1.4 - GtkRadioButton and GtkRadioMenuItem would both export a GtkRadio interface.
- Improvements to argument system to better support GUI builders, themes.
  - Notification on changes.
  - Ability to set arguments from an RC file.

Win32 Port

- Only GDK layer needs to be ported.
- Done by Tor Lillqvist.
- Has been functioning for 6 months to the point of running the GIMP.
- Will be integrated in with main line of GTK+ for 1.4.

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