Beginning GTK+ Programming

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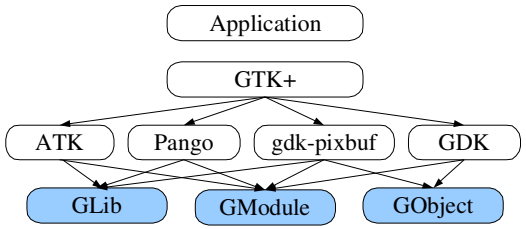
Plan of Tutorial

Basic Terminology
Object Oriented Programming in C
A first program
The Glade GUI builder
Geometry management
libglade

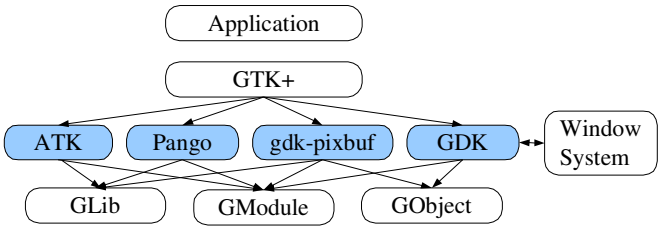
Program organization
GtkDialog
GtkTextView
GtkTreeView
GdkPixbuf
UTF-8, Pango, internationalizatoin

The Libraries



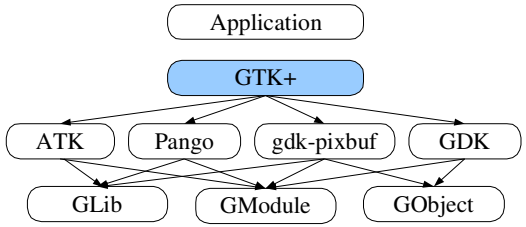
- GLib - data structures (hash tables, linked lists), portability, main loop
- GModule - dynamic object loading
- GObject - object system for C libraries

The Libraries (2)



- ATK - connect toolkit to screen readers,etc.
- Pango - internationalized text layout, rendering
- gdk-pixbuf - Image loading and manipulationh
- GDK - drawing, connection to window system

The Libraries (3)

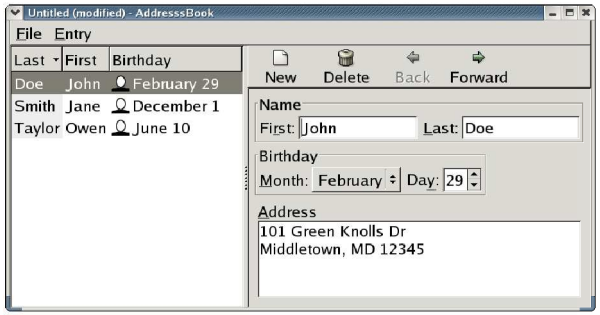


- GTK+
  - Widget system (layout, focusing, key shortcuts, ...)
  - Simple widgets (push buttons, labels)
  - Complex widgets (text editor, tree/list view)

Widgets, Containers

- *Widget* - a control
  - GtkEntry - Single line text entry field
  - GtkButton - Push Button
  - GtkLabel - text label
- *Container* - a widget that contains other widgets
  - GtkWindow - toplevel frame with titlebar
  - GtkHBox - arrange a row of widgets
  - GtkButton - just a container for a GtkLabel

Addressbook Example



Object Oriented Programming

- "Object" represented by a structure

```
typedef struct AddressEntry AddressEntry;

struct AddressEntry {
    char *firstname;
    char *lastname;
    int day;  /* Birth day */
    int month; /* Birth month */
};
```

- Always use structures by reference (pointer)

```
AddressEntry *entry = address_entry_new ();
```

Constructor

- Allocates memory block, fills in initial field values

```
AddressEntry *
address_entry_new (void)
{
   AddressEntry *entry;

   entry = g_malloc (sizeof (AddressEntry));
   entry->firstname = g_strdup ("");
   entry->lastname = g_strdup ("");
   [...]

   return entry;
}
```

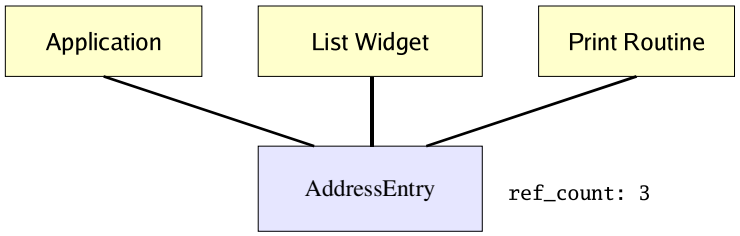
Methods

- Methods are functions
  - Object passed as first argument

```
void
address_entry_set_firstname (AddressEntry *entry,
                             const char   *firstname)
{
  g_free (entry->firstname);
  entry->firstname = g_strdup (firstname);
}

const char *
address_entry_get_firstname (AddressEntry *entry)
{
  return entry->firstname;
}
```

Memory Management

- How do we know we know when to free an object?
- Reference counting - keep track of number of parties interested



Reference Counting

```
/* ref_count set to 1 in address_entry_new() */

AddressEntry *entry
address_entry_ref (AddressEntry *entry)
{
  entry->ref_count++;

  return entry;
}

void
address_entry_unref (AddressEntry *entry)
{
  entry->ref_count--;
  if (entry->ref_count == 0)
    {
      /* No longer in use, free contents and entry */
      g_free (entry->firstname);
      [...]
      g_free (entry);
    }
}
```

Inheritance

- Inheritance done by nesting

```
struct ModernAddress {
   AddressEntry address;
   char *email;
}
```

  - Same pointer value used for both

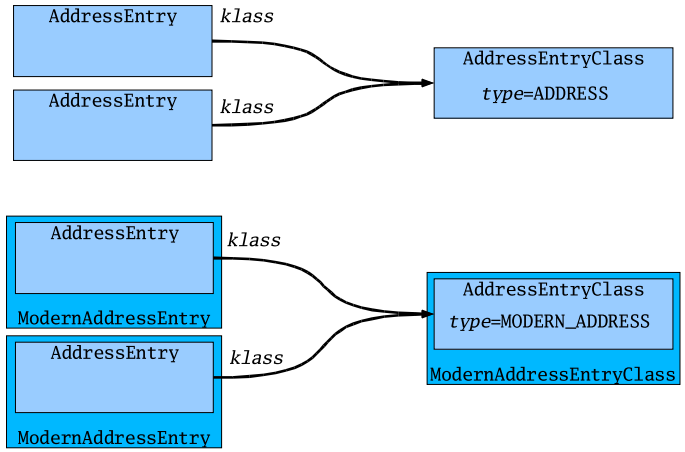
```
address_entry_set_name (entry, "John Doe");
modern_address_set_email ((ModernAddress *)entry,
                          "john.doe@acme.com");
```

Class Structures

- How does address_entry_unref() know how to free entry if it might be an ModernEntry?
- Class structure holds information about the type

```
struct AddressEntry {
   AddressEntryClass *klass;
   char *firstname;
   [...]
};

struct AddressEntryClass {
   enum { ADDRESS, MODERN_ADDRESS } type;
   void (*free) (Address *entry);
};
```

Class Structures (2)



Cast Macros

- What if we try to use a non-ModernAddress as a ModernAddress? Compiles, but crashes.
- Replace (ModernAddress *) with cast macro

```
modern_address_set_email (MODERN_ADDRESS (address),
                          "john.doe@acme.com");
```

- Get a runtime warning

```
***Warning***: Invalid cast to modern address
```

- Run program with `--g-fatal-warnings` to stop in debugger on failure

Cast Macro Example

```
#ifdef G_DISABLE_CAST_CHECKS
#define MODERN_ADDRESS(a) ((ModernAddress *)(a))
#else
#define MODERN_ADDRESS(a) (modern_address_check_cast(a))
#endif

ModernAddress *
modern_address_check_cast (AddressEntry *a)
{
  if (a->klass->type == MODERN_ADDRESS)
    return (ModernAddress *)a;
  else
    {
      g_warning ("Invalid cast to ModernAddress");
      return NULL;
    }
}
```

A First Program

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

  gtk_init (&argc, &argv);

  window = gtk_window_new (GTK_WINDOW_TOPLEVEL);
  g_signal_connect (window, "destroy",
                    G_CALLBACK (gtk_main_quit), NULL);

  button = gtk_button_new_with_label ("Hello");
  g_signal_connect (button, "clicked",
                    G_CALLBACK (hello_clicked), window);

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

  gtk_main ();

  return 0;
}
```

Compiling GTK+ programs

- `pkg-config` command line utility gives proper compiler, linker flags.

```
$ gcc -o hello `pkg-config --cflags --libs gtk+-2.0`

gcc -o hello -I/usr/include/gtk-2.0
-I/usr/lib/gtk-2.0/include -I/usr/include/atk-1.0
-I/usr/include/pango-1.0 -I/usr/X11R6/include
-I/usr/include/freetype2 -I/usr/include/glib-2.0
-I/usr/lib/glib-2.0/include -Wl,--export-dynamic
-lgtk-x11-2.0 -lgdk-x11-2.0 -latk-1.0 -lgdk_pixbuf-2.0 -lm
-lpangoxft-1.0 -lpangox-1.0 -lpango-1.0 -lgobject-2.0
-lgmodule-2.0 -ldl -lglib-2.0
```

  - Note backticks ``

OOP in GTK+

- Object represented by a pointer

```
GtkWidget *window;
```

- Naming convention for methods:

```
gtk_window_set_title (GTK_WINDOW (window), ...);
gtk_container_add (GTK_CONTAINER (window), ...);
gtk_widget_show_all (window);
```

- Cast macros

```
GTK_WINDOW (window);
```

- Reference counting - in base GObject class

```
g_object_ref (object);
g_object_unref (object)
```

Signals

- Notification essential part of GUI
  - Need to find out when, e.g., a button is clicked
- “connect” a callback function to “signal”

```
g_signal_connect (button, "clicked",
                  G_CALLBACK (hello_clicked), window);

static void
hello_clicked (GtkButton *button,
               gpointer   user_data)
{
  GtkWidget *window = user_data;

  g_print ("Hello");
  gtk_widget_destroy (window);
}
```

Signals (2)

- Set of signals associated with each class
  - Button has "pressed", "released", "clicked", ...
  - Also inherits "focus_in_event", "focus_out_event" from GtkWidget, etc, etc.
- Differerent signals, different signatures:

```
void clicked_cb       (GtkButton         *GtkButton,
                       gpointer           user_data);
void row_activated_cb (GtkTreeView       *tree_view,
                       GtkTreePath       *path,
                       GtkTreeViewColumn *column,
                       gpointer           user_data);
```

  - Listed in reference documentation
  - User data always last argument

Boolean signal returns

- Some signals have boolean return values
  - Example: "delete_event", emitted when user clicks on close button in title bar:

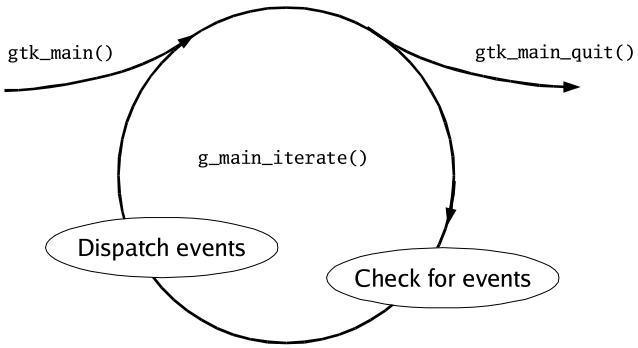
```
gboolean delete_event_cb (GtkWidget   *widget,
                          GdkEventAny *event,
                          gpointer     user_data);
```

  - Convention is TRUE return stops signal emission
  - TRUE: I handled it, don't do anything more
  - FALSE: I didn't handle it, do whatever you would normally do. (Here, destroy the window)

Main Loop

- Event Driven Programming:
  - After initial setup, program waits for “events” and reacts for them.
- Low level events (button presses, keystrokes) handled by GTK+ and converted into high-level callbacks.
- gtk_main() starts even loop and runs until gtk_main_quit() is called.

Main Loop (2)

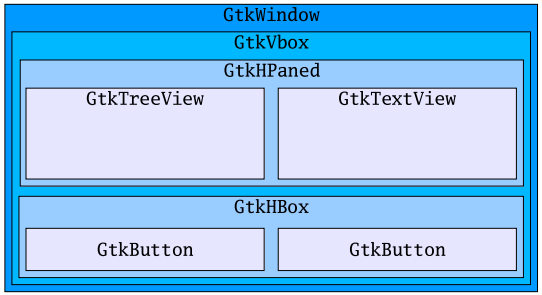


GLib Types

- GLib contains various typedefs for integer types:
  - gboolean: FALSE/TRUE boolean
  - guint: Unsigned integer
  - gint32: 32 bit integer
  - gint64: 64 bit integer
- Also contains 'g' names for standard types
  - gint, gdouble, glong, ...
  - These are *exactly the same* as the standard types
  - Just used for visual consistency
  - No need to cast

Containership

- Container is a widget that *contains* other widgets
  - Contained widgets are called *children*
- Heirarchy of containers define layout



Container examples

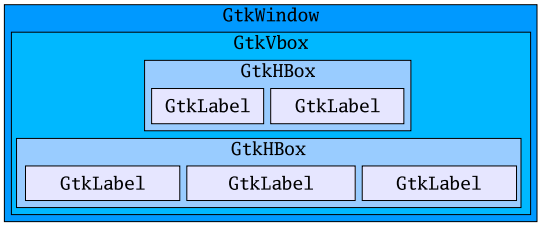
- GtkBin - container with one child
  - GtkWindow: toplevel window
  - GtkButton: just a container for its label
  - GtkAlignment: align, add padding to child
- Other containers have multiple children
  - GtkHBox: horizontal row of widgets
  - GtkVBox: vertical row of widgets
  - GtkTable: 2D layout of widgets (like HTML table)
  - GtkHPaned/GtkVPaned: two children with user-adjustable division.

Allocation and Requisition

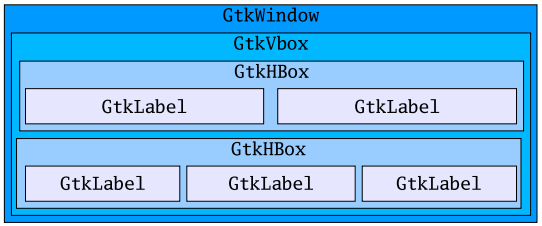
- Requisition
  - Each widget says how much space it needs
  - Parent widget adds up space of children
  - Figure out how much space is needed for toplevel
- Allocation
  - Start from toplevel
  - Each container divides allocated space among its children

Allocation and Requisition (2)

Requisitions



Allocations



Using Glade/libglade

- Glade
  - GUI editor for visual layouts
  - Saves layouts as XML files
  - Also generates code: DONT USE
- libglade
  - Loads XML layouts into application

Boxes

- Layout out widgets in a line:
  - GtkHBox: Horizontally
  - GtkVBox: Vertically
- Two boolean properties for each child:
  - Expand: If there is excess space allocated to the box, does it go to this child?
  - Fill: Should excess space actually go to the child, or simply be used as padding.

Tables

- GtkTable allows for grid based layout
- Specify child position by left, right, top, bottom edges.
- Also specify options (expand, fill) and padding for each dimension

```
gtk_table_attach (GTK_TABLE (table), child
                  /* x */                /* y */
/* attach */      0, 1,                  0, 1,
/* options */     GTK_EXPAND | GTK_FILL,  GTK_FILL,
/* padding */     0,                     0);
```

Glade Demo

- Adding widgets ... toplevel window, vbox, labels
- Adjusting properties - label alignment
- GtkScrolledWindow automatically added for GtkTextView
- Selecting widgets with the widget tree
- Setting box spacing for name/widget pairs
- Copying a portion of the widget tree / using the clipboard.

Glade Demo (2)

- Adding an alignment to control extra space
- Adjusting packing properties
- Setting widget names
- Signals and autoconnect

GtkScrolledWindow

- Many widgets allow scrolling larger area
  - GtkTextView
  - GtkTreeView
  - GtkViewport (scroll any widget)
- Any such *scrollable* widget can be put inside GtkScrolledWindow to add scrollbars
- Set policy for each scrollbar:
  - NEVER
  - ALWAYS
  - AUTOMATIC

- Often need to position widget in larger space
- Set how much of available space to use:
  - xscale: 0.0 => 1.0
  - yscale: 0.0 => 1.0
- Where to put the widget in available space
  - xposition: 0.0 => 1.0
  - yposition: 0.0 => 1.0

libglade example

```
GladeXML *glade;
GtkWidget *main_window;
GtkWidget *address_list;

/* Create dialog from XML file */
glade = glade_xml_new ("addressbook.glade",
                       "addressbook-window",
                        NULL); /* translation domain */

/* Extract widgets for future reference */
main_window = glade_xml_get_widget (glade, "addressbook-window");
address_list = glade_xml_get_widget (glade, "addressbook-treeview");

/* Get rid of file object */
g_object_unref (G_OBJECT (glade));
```

Autoconnect

- Can specify callback names in Glade, have libglade look them them up in program

```
GladeXML *glade;

glade = glade_xml_new ("addressbook.glade",
                       "addressbook-window",
                       NULL);

glade_xml_signal_autoconnect (glade);
```

- Functions need to be exported:
  - Have to be public, not static
  - `pkg-config --libs libglade` gives proper linker flags

Part II

10 Minute Break

Program Organization
GtkDialog
GtkTextView
GtkTreeView

Organizing a Program

- Base around application data structures

```
typedef struct AddressBook AddressBook;
struct AddressBook {
      gchar *filename;
      GtkListStore *address_list;
      GtkWidget *name_entry;
      GtkWidget *address_text_view;
};
```

- Often have one structure for toplevel window

Object Data

- Way of attaching application data to a widget
- String key identifies each piece of data
- Store data:

```
g_object_set_data (G_OBJECT (window),
                   "address-book", address_book);
```

- Get data:

```
address_book = g_object_get_data (G_OBJECT (window),
                                  "address-book");
```

Object Data (cont)

- Storing object data on top-level widget avoids having to store it on each individual widget:

```
AddressBook *
get_address_book (GtkWidget *widget)
{
   GtkWidget *toplevel;
   toplevel = gtk_widget_get_toplevel (widget);
   return g_object_get_data (toplevel, "address-book");
}
```

GtkDialog

- Window widget with buttons
- Used for temporary interaction
- Convience: gtk_dialog_run()
  - Starts main loop, waits until button pressed
  - Returns *response id* for chosen button

GtkDialog Example

```
GtkWidget *dialog;
int response;

dialog =
  gtk_dialog_new_with_buttons ("Print document", parent_window,
                          GTK_DIALOG_DESTROY_WITH_PARENT,
                          "Print",           GTK_RESPONSE_OK,
                          GTK_STOCK_CANCEL, GTK_RESPONSE_CANCEL,
                          NULL);

/* Add contents to dialog */

response = gtk_dialog_run (GTK_DIALOG (dialog));

if (response == GTK_RESPONSE_OK)
  {
    /* Print */
  }

gtk_widget_destroy (dialog);
```

GtkMessageDialog

- GtkDialog that just holds a message

```
gtk_message_dialog_new (parent_window,
                        GTK_DIALOG_DESTROY_WITH_PARENT,
                        GTK_MESSAGE_WARNING,
                        GTK_BUTTONS_OK,
                        "Error when printing: %s",
                        error->message);
```

- Trap: string is format string
  - Arbitrary message string might contain '%'
  - So, use "%s", message, not "message"

Model/View

- Widgets so far are small and simple
- GTK+ contains two widgest for display of large amounts of information
  - GtkTextView: multiple line text display
  - GtkTreeView: trees and lists (a list is just a flat tree)
- Split apart widget (*view)* from data store (*model)*
  - GtkTextView <=> GtkTextBuffer
  - GtkTreeView <=> GtkTreeModel (GtkListStore, GtkTreeStore, ...)
  - Can have multiple views of same model

GtkTextView example

```
GtkWidget *view;
GtkTextBuffer *buffer;
GtkTextIter start, end;
char *text;

view = gtk_text_view_new (NULL); /* NULL - create new buffer */
buffer = gtk_text_view_get_buffer (GTK_TEXT_VIEW (view));

/* Set text */
gtk_text_buffer_set_text (buffer, "Some Text");

/* Get text */
gtk_text_buffer_get_start_iter (buffer, &start);
gtk_text_buffer_get_end_iter (buffer, &end);

text = gtk_text_buffer_get_text (buffer,
                                 &start, &end, /* range */
                                 FALSE); /* include invisible? */
g_print ("The text is %s\n", text);
g_free (text);
```

Iterators

- Refer to a track of a place in data (GtkTextBuffer)
- Methods to navigate (iterate) through the data

```
GtkTextIter iter;
gtk_text_buffer_get_start_iter (buffer, &iter);
gtk_text_iter_forward_line (&iter);
```

- Temporary
  - Changes in buffer invalidate iter
  - Use GtkTextMark for permanent “bookmark”

Object Properties

- Properties are attributes of object
- Set:

```
g_object_set (entry,
              "text", "Hello World",
               "cursor_position", 3,
               NULL);
```

Value

Property name

- Get

Terminating NULL

```
g_object_get (entry
              "text", &text,
              "cursor_position", &cursor_position,
              NULL);
```

Location to store value

Interfaces

- Sometimes inheritance not enough
- Example from GTK+-2.4:
  - GtkFileChooserDialog is both a GtkDialog and a GtkFileChooser
  - Inherits from GtkDialog
  - Has GtkFileChooser as an interface
- Cast macros in same way as inheritance:

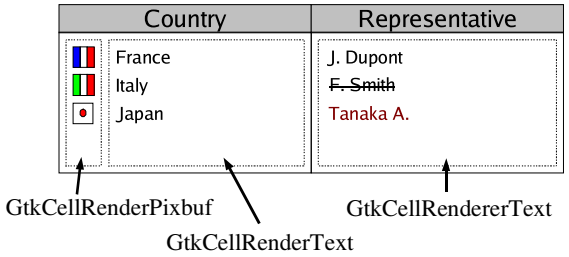
```
GtkFileChooser *chooser = GTK_FILE_CHOOSER (dialog);
```

Introducing GtkTreeView

- Handles both lists and trees
- Model/View: Data stored separately from widget
- GtkTreeView: The widget
- GtkTreeModel: data interface
  - GtkListStore: Flat data
  - GtkTreeStore: Heirarchical data
  - Can also create custom models (but difficult)

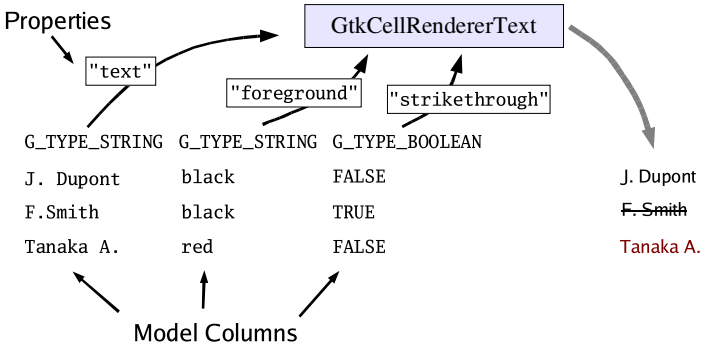
GtkTreeView Column

- Lists and trees have multiple columns of information
- Each column drawn by one or more *renderers*



Cell Renderer Properties

- Properties for each cell renderer are set, row by row, from the GtkTreeModel



GtkTreeModel

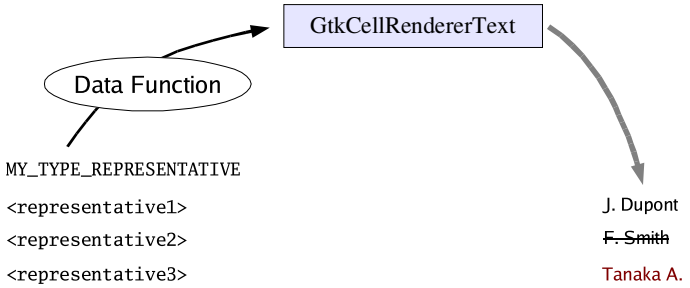
- Each GtkTreeModel has some number of columns, each with a type
  - G_TYPE_STRING: a string
  - G_TYPE_BOOLEAN: boolean
  - G_TYPE_INTEGER: integer
- Ever row in model stores one item in each column
- GtkTreeIter points to a single row in model

GtkTreeModel Example

```
enum {
  NAME_COLUMN,
  COLOR_COLUMN,
  STRIKETHROUGH_COLUMN
};

GtkListStore *list_store;
GtkTreeIter iter;

list_store = gtk_list_store_new (3, /* number of columns,
                                    G_TYPE_STRING,
                                    G_TYPE_STRING,
                                    G_TYPE_BOOLEAN);

/* Append a row, iter is set to point to it */
gtk_list_store_append (list_store, &iter);

gtk_list_store_set (list_store, &iter,
                    NAME_COLUMN, "Tanaka A.",
                    COLOR_COLUMN, "red",
                    STRIKETHROUGH_COLUMN, FALSE,
                    -1);  /* Terminates arguments */
```

Data Functions

- Can use *data function* to set all properties from a single column



Data Function Example

```
static void
name_data_func (GtkTreeViewColumn *tree_column,
                GtkCellRenderer   *cell,
                GtkTreeModel      *tree_model,
                GtkTreeIter       *iter,
                gpointer           data)
{
  Representative *rep;

  gtk_tree_model_get (tree_model, iter,
                      REPRESENTATIVE_COLUMN, &rep,
                      -1);

  g_object_set (cell,
                "text", representative_get_name (rep),
                "strikethrough", !representative_made_quota (rep),
                NULL);

  representative_unref (rep);
}
```

Boxed Types

- Need to tell GTK+ about AddressEntry in order to use in a GtkListStore

```
#define ADDRESS_TYPE_ENTRY (address_entry_get_type ())
GType
address_entry_get_type (void)
{
  static GType our_type = 0;
  if (our_type == 0)
    our_type = g_boxed_type_register_static ("AddressEntry",
                  (GBoxedCopyFunc) address_entry_ref,
                  (GBoxedFreeFunc) address_entry_unref);

  return our_type;
}
```

GtkTreeSelection

- Auxilliary object representing current selection
- Has:
  - Methods for retrieving currently selected rows
  - Signal "selection_changed" for reacting to changes
  - Selection mode setting (`gtk_tree_selection_set_mode()`)
  - `GTK_SELECTION_SINGLE`: 0 or 1 row selected
  - `GTK_SELECTION_BROWSE`: 1 row selected
  - `GTK_SELECTION_MULTIPLE`: 0-N rows selected

GtkTreeSelection Example

```
GtkTreeSelection *selection;

selection = gtk_tree_view_get_selection (treeview);
g_signal_connect (selection, "changed",
                  G_CALLBACK (selection_changed), book);


static void
selection_changed (GtkTreeSelection *selection,
                                AddressBook      *book)
{
  GtkTreeModel *model;
  AddressEntry *entry;
  GtkTreeIter iter;

  if (gtk_tree_selection_get_selected (selection, &model, &iter))
    {
      gtk_tree_model_get (model, &iter, 0, &entry, -1);
      /* do something with entry */
      address_entry_unref (entry);
    }
}
```

GtkTreeView Sorting

- Idea: User clicks on column, sort on that column
- But how does GtkTreeView now how to sort on a *view* column?
  - Might have multiple renderers, custom renderer, etc.
- Idea application sets *sort column ID* for each column in the view.
- Default action for sort column ID N is to sort on *model column* N
- Possible to also set custom sorting for a sort ID (useful for a data func)

Sorting Example

```
gtk_tree_sortable_set_sort_func (GTK_TREE_SORTABLE (list_store),
                                 SORT_BIRTHDAY,
                                 compare_birthday, NULL, NULL);

int
compare_firstname  (GtkTreeModel *model,
                    GtkTreeIter  *a, GtkTreeIter  *b,
                    gpointer      user_data)
{
  AddressEntry *entry_a, *entry_b;
  int result;

  gtk_tree_model_get (model, a, 0, &entry_a, -1);
  gtk_tree_model_get (model, b, 0, &entry_b, -1);

  result = strcmp (entry_a->firstname, entry_b->firstname);

  address_entry_unref (entry_a);
  address_entry_unref (entry_b);

  return result;
}
```

GdkPixbuf

- GdkPixbuf represents an image
- Can load many image types
  - PNG, JPEG, GIF, TIFF, BMP, ICO, TGA, ANI, XBM, XPM, WBMP, PCX, RAS
  - Also extensible: librsvg installs SVG loader
- Direct client side pixel access. Compare:
  - GdkPixbuf - client-side image, directly manipulate pixels
  - GdkPixmap - server-side image, GDK drawing primitives, no direct pixel access

GdkPixbuf example

```
GdkPixbuf *pixbuf;
GError *error = NULL;

pixbuf = gdk_pixbuf_new_from_file ("my.png",&error);
if (!pixbuf)
  {
    g_printerr ("Unable to load image: %s\n",
                error->message);
    g_error_free (error);
  }
else
  {
    /* use pixbuf */

    g_object_unref (pixbuf);
  }
```

Unicode

- Character set including characters for almost all languages in world
- Standardized as ISO-10646
- All text in GTK+ is in Unicode

UTF-8

- Easiest encoding of Unicode is 4 bytes per character ... inefficient.
- Instead use multibyte encoding:
  - Each character one or more bytes

    0xxxxxxx
    110xxxxx 10xxxxxx
    1110xxxx 10xxxxxx 10xxxxxx
    11110xxx 10xxxxxx 10xxxxxx 10xxxxxx
- ASCII compatible

Pango

- Text layout engine
  - Input: Unicode text
  - Output: positioned *glyphs*
- Handles most of the world's languages
  - Right to left text (and mixed LTR/RTL)
  - Complex joins, ligatures
- Hides the complexity from application developer

PangoLayout

- Holds a paragraph of text

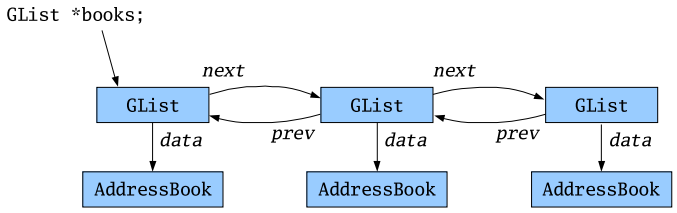
```
PangoLayout *layout;
int width, height;
layout = gtk_widget_create_pango_layout (widget,
                                         "Hi There");
pango_layout_get_pixel_size (layout,
                             &width, &height);

gdk_draw_layout (widget->window,
                 widget->style->black_gc,
                 x, y,
                 layout);
g_object_unref (layout);
```

Pango Markup

- Usually don't use Pango directly; hidden by widgets.
- Mini-XML-like language allows using more features of Pango

```
const char *markup = "This is <big>big text</big>";
gtk_label_set_markup (label, markup);
```

GList



- Linked list of data items
  - List represented by pointer to first item
  - Empty list represented by NULL

GList example

```
static GList *books;

books = g_list_prepend (books, book);

[...]

books = g_list_remove (books, book);
if (books == NULL)
  gtk_main_quit ();
```

More information:

- These slides:

  `http://people.redhat.com/otaylor/tutorial/guadec2003/`

- Main GTK+ site:

  `http://www.gtk.org`

- API documentation

  `http://developer.gnome.org/doc/API/`