GTK+ / Gnome Application Development

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I. Overview

The first chapter of the book gives you an overview of GTK+ and Gnome technologies. Chapters 2 and 3 rapidly cover the basics of GTK+ programming. These chapters move very quickly, and give you the information you need to understand the remainder of the book. For a gentler introduction to GTK+, you may wish to read the *GTK+ Tutorial* or Eric Harlow's book *Developing Linux Applications with GTK+ and GDK*.

Introduction

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This chapter gives you an overview of the technologies described in this book.

What is Gnome?

Gnome is a free (or "open source") software development project started in 1997 by Miguel de Icaza of the Mexican Autonomous National University and a small team of programmers from around the world. Inspired by the success of the similar K Desktop Environment (KDE) project, the burgeoning popularity of the GNU/Linux operating system, and and the power of the GTK+ graphical toolkit, Gnome grew quickly --- within a year, hundreds of programmers were involved and many thousands of lines of code had been written. Gnome has become a powerful framework for GUI application development which runs on any modern variety of UNIX.

"Gnome" is actually an acronym: GNU Network Object Model Environment. Originally, the project was intended to create a framework for application objects, similar to Microsoft's OLE and COM technologies. However, the scope of the project rapidly expanded; it became clear that substantial groundwork was required before the "network object" part of the name could become reality. The latest development versions of Gnome include an object embedding architecture called Bonobo, and Gnome 1.0 included a fast, light CORBA 2.2 ORB called ORBit.

Gnome is a part of the GNU Project, whose overall goal is developing a free operating system (named GNU) plus applications to go with it. GNU stands for "GNU's Not UNIX", a humorous way of saying that the GNU operating system is UNIX-compatible. You can learn more about GNU at http://www.gnu.org.

Gnome has two important faces. From the user's perspective, it is an integrated desktop environment and application suite. From the programmer's perspective, it is an application development framework (made up of numerous useful libraries). Applications written with the Gnome libraries run fine even if the user isn't running the desktop environment, but they integrate nicely with the Gnome desktop if it's available.

The desktop environment includes a file manager, a "panel" for task switching, launching programs, and docking applets, a "control center" for configuration, and several smaller bells and whistles. These programs hide the traditional UNIX shell behind an easy-to-use graphical interface.

Gnome's development framework makes it possible to write consistent, easy-to-use, interoperable applications. The X Window System designers made a deliberate decision not to impose any user interface policy on developers; Gnome adds a "policy layer," creating a consistent look-and-feel. Finished Gnome applications work well with the Gnome desktop, but can also be used "standalone" --- users only need to install Gnome's shared libraries. It's even possible to write Gnome applications which do not rely on the X Window System; you might want to provide a non-graphical CORBA service, for example.

This book is about Gnome from a developer's point of view; it describes how to write a Gnome application using the Gnome libraries and tools.

The Gnome Development Framework

Gnome's application development framework centers around a suite of libraries, all written in portable ANSI C and intended to be used on UNIX-like systems. Libraries which involve graphics realy on the X Window System. Wrappers are available which export the Gnome API to nearly any language you can think of, including Ada, Scheme, Python, Perl, Tom, Eiffel, Dylan, and Objective C. There are at least three different C++ wrappers as well.

This book will cover the C interface to the libraries; however, it should be useful for users of any language binding, since the mapping from C to your preferred language is typically straightforward. The book covers version 1.0 of the Gnome libraries (including the compatible bug fix releases, such as 1.0.9---all 1.0.x versions are compatible).

Non-Gnome Libraries

Taking full advantage of the free software tradition, Gnome didn't start from scratch. It uses several libraries which are maintained separately from the Gnome project. These are a part of the Gnome application development framework, and you can count on their presence in a Gnome environment.

glib

glib is the base of the Gnome infrastructure. It's a C utility library, providing routines to create and manipulate common data structures. It also addresses portability issues; for example, many systems lack the snprintf() function, but glib contains an implementation called g_snprintf() which is both guaranteed to exist on all platforms and slightly safer than snprintf() (it always NULL-terminates the target buffer).

Gnome 1.0 uses glib version 1.2 and works with any glib in the 1.2 series (1.2.1, 1.2.2, etc.). All glib versions beginning with 1.2 are compatible bug-fix releases.

GTK+

GTK+, or the Gimp Tool Kit, is the GUI toolkit used in Gnome applications. GTK+ was originally written for the Gimp (GNU Image Manipulation Program --- http://www.gimp.org), but has become a general-purpose library. GTK+ depends on glib.

The GTK+ package includes GDK, the Gimp Drawing Kit, which is a simplification and abstraction of the low-level X Window System libraries. Since GTK+ uses GDK rather than calling X directly, a port of GDK permits GTK+ to run on windowing systems other than X with relatively few modifications. GTK+ and the Gimp have already been ported to the Win32 platform in this way.

GTK+ provides several features for Gnome applications:

- A dynamic type system.
- An object system written in C, complete with inheritance, type checking, and a signal/callback infrastructure. The type and object systems are not GUI-specific.
- A GtkWidget object written using the object system, which defines the interface GTK+'s graphical components implement.
- A large collection of useful GtkWidget subclasses (*widgets*); this collection forms the bulk of GTK+'s code.

Gnome adds a number of additional widgets to the basic GTK+ collection.

Gnome 1.0 is based on GTK+ version 1.2. All GTK+ versions beginning with 1.2 are compatible bug-fix releases; 1.2.1, for example.

ORBit

ORBit is a CORBA 2.2 ORB written in C. It was designed to be small and fast compared to other ORBs, and supports the C language mapping. ORBit is implemented as a suite of libraries.

CORBA, or Common Object Request Broker Architecture, is a specification for Object Request Brokers, or *ORB*s. An ORB is much like a dynamic linker, but it works with objects, rather than subroutines. At runtime, a program can request the services of a particular object; the ORB locates the object and creates a connection between it and the program. For example, an email program might request an ``addressbook'' object, and use it to look up a person's name. Unlike dynamic linking, CORBA works fine across a network, and even allows different programming languages and operating systems to interact with one another. If you're familiar with DCOM on the Windows operating system, CORBA is analagous.

Imlib

Imlib ("Image Library") provides routines for loading, saving, displaying, and scaling images in a variety of popular formats (including GIF, JPEG, PNG, and TIFF). It comes in two versions; an Xlib-only version, and a GDK-based version. Gnome uses the GDK version.

Gnome Libraries

The libraries in this section are a part of the gnome-libs package and were developed specifically for the Gnome Project.

libgnome

libgnome is a collection of non-GUI-related routines for use by Gnome applications. It includes code to parse configuration files, for example. It also includes interfaces to some external facilities, such as internationalization (via the GNU gettext package), argument parsing (via the popt package), and sound (via the Enlightenment Sound Daemon, esound). The gnome-libs package takes care of interacting with these external libraries, so the programmer does not need to concern herself with their implementation or availability.

libgnomeui

libgnomeui collects GUI-related Gnome code. It consists primarily of widgets designed to enhance and extend GTK+. Gnome widgets generally impose user interface policy, which permits a more convenient API (since there is less for the programmer to specify). It also results in applications with more consistent interfaces, of course.

Highlights of libgnomeui include:

- The GnomeApp widget, which makes it easy to create a nice main window for your application. It uses another widget called GnomeDock which enables users to rearrange and "undock" toolbars.
- The GnomeCanvas widget which makes it easy to write intricate, flicker-free custom displays.
- The Gnome stock pixmaps (icons for open, close, save, and other operations).
- Convenient routines for creating and using dialogs.
- The GnomePixmap widget which is more versatile than GtkPixmap.

libgnorba

libgnorba provides CORBA-related facilities, including a security mechanism and object activation. (Object activation is the process of obtaining a reference to an object that implements a given interface; it can involve executing a server program, loading a shared library module, or asking an existing program for a new object instance.)

libzvt

This small library contains a terminal widget (ZvtTerm) you can use in your Gnome programs.

libart_lgpl

This library contains graphics rendering routines by Raph Levien. The routines included here are released under the GNU Library General Public License and used in the GnomeCanvas widget; Raph Levien also sells an enhanced proprietary version. libart_lgpl provides antialiasing, microtile refresh regions, and other magic. In essence it is a vector graphics rasterization library, functionally analogous to the PostScript language.

Other Libraries

These libraries are commonly used in Gnome applications, but are not a part of gnome-libs proper.

gnome-print

gnome-print is still somewhat experimental, but very promising. It uses libart_lgpl and works nicely with GnomeCanvas. It provides virtual output devices (called "print contexts"), so a single codebase can output to a print preview widget, to PostScript, and eventually to other printer formats. gnome-print also includes printing-related GUI elements, like a print setup dialog, and a virtual font interface (to deal with the problem that X fonts are not printable).

gnome-xml

gnome-xml is a non-validating XML engine written by Daniel Veillard of the World Wide Web Consortium. It can parse XML into a tree structure, and output a tree structure as XML. It's useful for any application that needs to load and save structured data; many Gnome applications use it as a file format. This library does not depend on any of the others, not even glib --- so it is tied to Gnome in name only. However, you can expect most Gnome users to have it installed, so it should not inconvenience your users if your application uses this library.

Guile

Guile is an implementation of the Scheme programming language in a library, so that any application can have an embedded Scheme interpreter. It is the official extension language of the GNU Project, and is used by several Gnome applications. Adding an extension language to your application might sound complex, but Guile makes it almost trivial. (Several Gnome applications support Perl and Python as well; it is usually easy to support several languages once you implement the first. But Guile has a special place in the Gnome developer's hearts.)

Bonobo

At press time, the Gnome hackers were putting the finishing touches on Bonobo. Bonobo is a compound document architecture in the tradition of Microsoft's OLE; it allows you to embed charts in spreadsheets, for example. It will be used pervasively throughout Gnome; any application will be able to display MIME-typed data such as plain text, HTML, or images by asking the Gnome libraries for an appropriate Bonobo component. Look for Bonobo technology in the next major Gnome release.

A Word About Header Files

Throughout the book, the exact header file which declares each function is given alongside the function prototype. This is to facilitate your exploration of the source code. However, you probably don't want to manually include the hundreds of headers found in GTK+ and Gnome. You can include all GTK+ headers *en masse* by including the gtk/gtk.h header file. gtk/gtk.h also includes gdk/gdk.h for you. You can include all Gnome headers by including gnome.h; gnome.h includes gtk/gtk.h for you. Most Gnome application files simply include gnome.h.

Structure of the Book

This book is divided into several parts:

- Right now you're reading Part 1. This chapter gives you an overview of the Gnome application development framework. The following two chapters quickly introduce glib and GTK+ -- if you're already familiar with GTK+ programming, you may want to move directly to Part 2.
- Part 2 guides you through the development of a skeletal Gnome application. It starts with the creation of the source tree, and then explains how to write menus, dialogs, and other essential application components. At the end of Part 2, there's a checklist of features every application should have.
- Part 3 describes some advanced topics, including the internals of the GTK+ object and type system, writing a custom GtkWidget subclass, and using the GnomeCanvas widget. It also covers GDK.
- The appendices include a map of the GTK+ and Gnome object hierarchy, with a short description of each object; a map of the GTK+ and Gnome header files; and some pointers to online programming resources.

This book assumes some knowledge of GTK+ programming; chapters 2 and 3 will give you a quick overview if your knowledge is minimal, but they move very quickly. Most of the specific widgets in GTK+ are not covered. The book is intended to introduce Gnome programming, and some advanced GTK+ topics; it is a supplement to an introductory GTK+ book.

Due to time and space limitations, only the central Gnome libraries are covered; in particular, CORBA, printing, XML, plugins, and scripting are not covered. Most large applications will use these features in addition to the core libraries.

glib: Portability and Utility

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glib is a C portability and utility library for UNIX-like systems and Windows. This chapter covers some of the most commonly-used library features in GTK+ and Gnome applications. glib is simple, and the concepts are familiar; so we'll move quickly. For more complete coverage of glib, see glib.h or the free glib reference manual that comes with the library. (By the way: don't be afraid of using the glib, GTK+, or Gnome header files; they are very clean and easy to read, and are handy as a quick reference. For that matter, don't be afraid to look at the source code, if you have very specific questions about the implementation.)

glib's various facilities are intended to have a consistent interface; the coding style is semi-object-oriented, and identifiers are prefixed with "g" to create a kind of namespace.

glib has a single header file, glib.h.

Basics

glib provides substitutes for many standard and commonly-used C language constructs. This section describes glib's fundamental type definitions, macros, memory allocation routines, and string utility functions.

Type Definitions

Rather than using C's standard types (int, long, etc.) glib defines its own. These serve a variety of purposes. For example, gint32 is guaranteed to be 32 bits wide, something no standard C type can ensure. guint is simply easier to type than unsigned. A few of the typedefs exist only for consistency; for example, gchar is always equivalent to the standard char.

The following primitive types are defined by glib:

- gint8, guint8, gint16, guint16, gint32, guint32, gint64, guint64---these give you integers of a guaranteed size. Not all platforms provide 64-bit integers; if a platform has them, glib will define G_HAVE_GINT64. (If it isn't obvious, the guint types are unsigned, the gint types are signed.)
- gboolean is useful to make your code more readable, since C has no bool type.
- gchar, gshort, glong, gint, gfloat, gdouble are purely cosmetic.
- gpointer may be more convenient to type than void *. gconstpointer gives you const void*. (const gpointer will *not* do what you typically mean it to; spend some time with a good book on C if you don't see why.)

Frequently Used Macros

glib defines a number of familiar macros used in many C programs, shown in Figure 1. All of these should be self-explanatory. MIN()/MAX() return the smaller or larger of their arguments. ABS() returns the absolute value of its argument. CLAMP(x, low, high) means x, unless x is outside the range [low, high]; if x is below the range, low is returned; if x is above the range, high is returned. In addition to the macros shown in Figure 1, TRUE/FALSE/NULL are defined as the usual 1/0/((void*)0).

```
#include <glib.h>
```

MAX(*a*, *b*);

MIN(*a*, *b*);

ABS(*x*);

CLAMP(*x*, *low*, *high*);

Figure 1. Familiar C Macros

There are also many macros unique to glib, such as the portable gpointer-to-gint and gpointer-to-guint conversions shown in Figure 2.

Most of glib's data structures are designed to store a gpointer. If you want to store pointers to dynamically allocated objects, this is the right thing. However, sometimes you want to store a simple list of integers without having to dynamically allocate them. Though the C standard does not strictly guarantee it, it is possible to store a gint or guint in a gpointer variable on the wide range of platforms glib has been ported to; in some cases, an intermediate cast is required. The macros in Figure 2 abstract the presence of the cast.

Here's an example:

```
gint my_int;
gpointer my_pointer;

my_int = 5;
my_pointer = GINT_TO_POINTER(my_int);
printf("We are storing %d\n", GPOINTER_TO_INT(my_pointer));
```

Be careful, though; these macros allow you to store an integer in a pointer, but storing a pointer in an integer will *not* work. To do that portably, you must store the pointer in a long. (It's undoubtedly a bad idea to do so, however.)

```
#include <glib.h>
```

GINT_TO_POINTER(*p*);

GPOINTER_TO_INT(*p*);

GUINT_TO_POINTER(*p*);

GPOINTER_TO_UINT(*p*);

Figure 2. Macros for storing integers in pointers

Debugging Macros

glib has a nice set of macros you can use to enforce invariants and preconditions in your code. GTK+ uses these liberally---one of the reasons it's so stable and easy to use. They all disappear when you define G_DISABLE_CHECKS or G_DISABLE_ASSERT, so there's no performance penalty in production code. Using these liberally is a very, very good idea. You'll find bugs much faster if you do. You can even add assertions and checks whenever you find a bug to be sure the bug doesn't reappear in future versions---this complements a regression suite. Checks are especially useful when the code you're writing will be used as a black box by other programmers; users will immediately know when and how they' ve misused your code.

Of course you should be very careful to ensure your code isn't subtly dependent on debug-only statements to function correctly. Statements that will disappear in production code should *never* have side effects.

```
#include <glib.h>
```

g_return_if_fail(*condition*);

g_return_val_if_fail(*condition*, *retval*);

Figure 3. Precondition Checks

Figure 3 shows glib's precondition checks. g_return_if_fail() prints a warning and immediately returns from the current function if condition is FALSE. g_return_val_if_fail() is similar but allows you to return some retval. These macros are incredibly useful---if you use them liberally, especially in combination with GTK+'s runtime type checking, you'll halve the time you spend looking for bad pointers and type errors.

Using these functions is simple; here's an example from the glib hash table implementation:

```

void
g_hash_table_foreach (GHashTable *hash_table,
                      GHFunc      func,
                      gpointer    user_data)
{
  GHashNode *node;
  gint i;

  g_return_if_fail (hash_table != NULL);
  g_return_if_fail (func != NULL);

  for (i = 0; i < hash_table->size; i++)
    for (node = hash_table->nodes[i]; node; node = node->next)
      (* func) (node->key, node->value, user_data);
}
```

Without the checks, passing NULL as a parameter to this function would result in a mysterious segmentation fault. The person using the library would have to figure out where the error occurred with a debugger, and maybe even dig in to the glib code to see what was wrong. With the checks, they'll get a nice error message telling them that NULL arguments are not allowed.

```
#include <glib.h>
```

g_assert(*condition*);

g_assert_not_reached(void);

Figure 4. Assertions

glib also has more traditional assertion macros, shown in Figure 4. g_assert() is basically identical to assert(), but responds to G_DISABLE_ASSERT and behaves consistently across all platforms. g_assert_not_reached() is also provided; this is an assertion which always fails. Assertions call abort() to exit the program and (if your environment supports it) dump a core file for debugging purposes.

Fatal assertions should be used to check *internal consistency* of a function or library, while g_return_if_fail() is intended to ensure sane values are passed to the public interfaces of a program module. That is, if an assertion fails, you typically look for a bug in the module containing the assertion; if a g_return_if_fail() check fails, you typically look for the bug in the code which invokes the module.

This code from glib's calendrical calculations module shows the difference:

```

GDate*
g_date_new_dmy (GDateDay day, GDateMonth m, GDateYear y)
{
  GDate *d;
  g_return_val_if_fail (g_date_valid_dmy (day, m, y), NULL);

  d = g_new (GDate, 1);

  d->julian = FALSE;
  d->dmy    = TRUE;

  d->month = m;
  d->day   = day;
  d->year  = y;
  g_assert (g_date_valid (d));

  return d;
}
```

The precondition check at the beginning ensures the user passes in reasonable values for the day, month and year; the assertion at the end ensures that glib constructed a sane object, given sane values.

g_assert_not_reached() should be used to mark "impossible" situations; a common use is to detect switch statements that don't handle all possible values of an enumeration:

```
  switch (val)
    {
      case FOO_ONE:
        break;
      case FOO_TWO:
        break;
      default:
        /* Invalid enumeration value */
        g_assert_not_reached();
        break;
    }
```

All of the debugging macros print a warning using glib's g_log() facility, which means the warning includes the name of the originating application or library, and you can optionally install a replacement warning-printing routine. For example, you might send all warnings to a dialog box or log file instead of printing them on the console.

Memory

glib wraps the standard malloc() and free() with its own g_ variants, g_malloc() and g_free(), shown in Figure 5. These are nice in several small ways:

- g_malloc() always returns a gpointer, never a char*, so there's no need to cast the return value.
- g_malloc() aborts the program if the underlying malloc() fails, so you don't have to check for a NULL return value.

- g_malloc() gracefully handles a size of 0, by returning NULL.
- g_free() will ignore any NULL pointers you pass to it.

In addition to these minor conveniences, g_malloc() and g_free() can support various kinds of memory debugging and profiling. If you pass the --enable-mem-check option to glib's configure script, the compiled g_free() will warn you whenever you free the same pointer twice. The --enable-mem-profile option enables code which keeps memory use statistics; when you call g_mem_profile() they are printed to the console. Finally, you can define USE_DMALLOC and the glib memory wrappers will use the MALLOC(), etc. debugging macros available in dmalloc.h on some platforms.

```
#include <glib.h>
```

gpointer g_malloc(gulong *size*);

void g_free(gpointer *mem*);

gpointer g_realloc(gpointer *mem*, gulong *size*);

gpointer g_memdup(gconstpointer *mem*, guint *bytesize*);

Figure 5. glib memory allocation

It's important to match g_malloc() with g_free(), plain malloc() with free(), and (if you're using C++) new with delete. Otherwise bad things can happen, since these allocators may use different memory pools (and new/delete call constructors and destructors).

Of course there's a g_realloc() equivalent to realloc(). There's also a convenient g_malloc0() which fills allocated memory with 0s, and g_memdup() which returns a copy of bytesize bytes starting at mem. g_realloc() and g_malloc0() will both accept a size of 0, for consistency with g_malloc(). However, g_memdup() will not.

If it isn't obvious: g_malloc0() fills raw memory with unset bits, not the value 0 for whatever type you intend to put there. Occasionally someone expects to get an array of floating point numbers initialized to 0.0; this will *not* work.

Finally, there are type-aware allocation macros, shown in Figure 6. The type argument to each of these is the name of a type, and the count argument is the number of type-size blocks to allocate. These macros save you some typing and multiplication, and are thus less error-prone. They automatically cast to the target pointer type, so attempting to assign the allocated memory to the wrong kind of pointer should trigger a compiler warning. (If you have warnings turned on, as a responsible programmer should!)

```
#include <glib.h>
```

g_new(*type*, *count*);

g_new0(*type*, *count*);

g_renew(*type*, *mem*, *count*);

Figure 6. Allocation macros

String Handling

glib provides a number of functions for string handling; some are unique to glib, and some solve portability concerns. They all interoperate nicely with the glib memory allocation routines.

For those interested in a better string than gchar*, there's also a GString type. It isn't covered in this book, but documentation is available at http://www.gtk.org/.

```
#include <glib.h>
```

gint g_snprintf(gchar* *buf*, gulong *n*, const gchar* *format*, ...);

gint g_strcasecmp(const gchar* *s1*, const gchar* *s2*);

gint g_strncasecmp(const gchar* *s1*, const gchar* *s2*, guint *n*);

Figure 7. Portability Wrappers

Figure 7 shows some substitutes glib provides for commonly-implemented but unportable extensions to ANSI C.

One of the annoying things about C is that it provides the crash-causing, security-hole-creating, generally evil sprintf(), but the relatively safe and widely implemented snprintf() is a vendor extension. g_snprintf() wraps native snprintf() on platforms that have it, and provides an implementation on those that don't. So you can say goodbye to sprintf()

forever. Even better: classically, snprintf() does not guarantee that it will NULL-terminate the buffer it fills. g_snprintf() does.

g_strcasecmp() and g_strncasecmp() perform a case-insensitive comparison of two strings, optionally with a maximum length. strcasecmp() is available on many platforms but not universally, so using glib instead is advisable.

The functions in Figure 8 modify a string in-place: the first two convert the string to lowercase or uppercase, respectively, while g_strreverse() reverses its characters. g_strchug() and g_strchomp() "chug" the string (remove leading spaces), or "chomp" it (remove trailing spaces). These last two return the string, in addition to modifying it in-place; in some cases it may be convenient to use the return value. There is a macro, g_strstrip(), which combines both functions to remove both leading and trailing spaces; it is used just as the individual functions are.

```
#include <glib.h>

void g_strdown(gchar* string);

void g_strup(gchar* string);

void g_strreverse(gchar* string);

gchar* g_strchug(gchar* string);

gchar* g_strchomp(gchar* string);
```

Figure 8. In-place string modifications

Figure 9 shows a few more semi-standard functions glib wraps. g_strtod is like strtod()---it converts string nptr to a double---with the exception that it will also attempt to convert the double in the "C" locale if it fails to convert it in the user's default locale. *endptr is set to the first unconverted character, i.e. any text after the number representation. If conversion fails, *endptr is set to nptr. endptr may be NULL, causing it to be ignored.

g_strerror() and g_strsignal() are like their non-g_ equivalents, but portable. (They return a string representation for an errno or a signal number.)

```
#include <glib.h>
```

gdouble g_strtod(const gchar* *nptr*, gchar** *endptr*);

gchar* g_strerror(gint *errnum*);

gchar* g_strsignal(gint *signum*);

Figure 9. String Conversions

Figure 10 shows glib's rich array of functions for allocating strings. Unsurprisingly, g_strdup() and g_strndup() produce an allocated copy of str or the first n characters of str. For consistency with the glib memory allocation functions, they return NULL if passed a NULL pointer. The printf() variants return a formatted string. g_strescape escapes any \ characters in its argument by inserting another \ before them, returning the escaped string. g_strnfill()returns a string of size length filled with fill_char.

g_strdup_printf() deserves a special mention; it is a simpler way to handle this common piece of code:

```
  gchar* str = g_malloc(256);
  g_snprintf(str, 256, "%d printf-style %s", 1, "format");
```

Instead you could say this, and avoid having to figure out the proper length of the buffer to boot:

```
  gchar* str = g_strdup_printf("%d printf-style %s", 1, "format");
#include <glib.h>
```

gchar* g_strdup(const gchar* *str*);

gchar* g_strndup(const gchar* *format*, guint *n*);

gchar* g_strdup_printf(const gchar* *format*, ...);

gchar* g_strdup_vprintf(const gchar* *format*, va_list *args*);

gchar* g_strescape(gchar* *string*);

gchar* g_strnfill(guint *length*, gchar *fill_char*);

Figure 10. Allocating Strings

glib provides some convenient functions for concatenating strings, shown in Figure 11. g_strconcat() returns a newly-allocated string created by concatenating each of the strings in the argument list. The last argument must be NULL, so g_strconcat() knows when to stop. g_strjoin() is similar, but separator is inserted between each string. If separator is NULL, no separator is used.

```
#include <glib.h>
```

gchar* g_strconcat(const gchar* *string1*, ...);

gchar* g_strjoin(const gchar* *separator*, ...);

Figure 11. Concatenating strings

Finally, Figure 12 summarizes a few routines which manipulate NULL-terminated arrays of strings. g_strsplit() breaks string at each delimiter, returning a newly-allocated array. g_strjoinv() concatenates each string in the array with an optional separator, returning an allocated string. g_strfreev() frees each string in the array and then the array itself.

```
#include <glib.h>
```

gchar** g_strsplit(const gchar* *string*, const gchar* *delimiter*, gint *max_tokens*);

gchar* g_strjoinv(const gchar* *separator*, gchar** *str_array*);

void g_strfreev(gchar** *str_array*);

Figure 12. Manipulating NULL-terminated string vectors

Data Structures

glib implements many common data structures, so you don’t have to reinvent the wheel every time you want a linked list. This section covers glib’s implementation of linked lists, sorted binary trees, N-ary trees, and hash tables.

Lists

glib provides generic single and doubly linked lists, GSList and GList, respectively. These are implemented as lists of gpointer; you can use them to hold integers with the GINT_TO_POINTER and GPOINTER_TO_INT macros. GSList and GList have identical API's, except that there is a g_list_previous() function and no g_slist_previous(). This section will discuss GSList but everything also applies to the doubly linked list.

In the glib implementation, the empty list is simply a NULL pointer. It's always safe to pass NULL to list functions since it's a valid list of length 0. Code to create a list and add one element might look like this:

```
GSList* list = NULL;
gchar* element = g_strdup("a string");
list = g_slist_append(list, element);
```

glib lists have a noticeable Lisp influence; the empty list is a special "nil" value for that reason. g_slist_prepend() works much like cons---it's a constant-time operation that adds a new cell to the front of the list.

Notice that you must replace the list passed to list-modifying functions with their return value, in case the head of the list changes. glib will handle memory issues, deallocating and allocating list links as needed.

For example, the following code would remove the above-added element and empty the list:

```
list = g_slist_remove(list, element);
```

list is now NULL. You still have to free element yourself, of course. To clear an entire list, use g_slist_free(), which removes all the links in one fell swoop. g_slist_free() has no return value because it would always be NULL, and you can simply assign that value to your list if you like. Obviously, g_slist_free() frees only the list cells; it has no way of knowing what to do with the list contents.

To access a list element, you refer to the GSList struct directly:

```
gchar* my_data = list->data;
```

To iterate over the list, you might write code like this:

```
GSList* tmp = list;
while (tmp != NULL)
  {
    printf("List data: %p\n", tmp->data);
    tmp = g_slist_next(tmp);
  }
```

Figure 13 shows the basic functions for changing GSList contents. For all of these, you must assign the return value to your list pointer in case the head of the list changes. Note that glib does *not* store a pointer to the tail of the list, so prepending is a constant-time operation, while append, insert, and remove are proportional to the list's size.

In particular, this means that constructing a list using g_slist_append() is a *terrible* idea; use g_slist_prepend() and then call g_slist_reverse() if you need items in a particular order. If you anticipate frequently appending to a list, you can also keep a pointer to the last element. The following code can be used to perform efficient appends:

```
void
efficient_append(GSList** list, GSList** list_end, gpointer data)
{
  g_return_if_fail(list != NULL);
  g_return_if_fail(list_end != NULL);

  if (*list == NULL)
    {
      g_assert(*list_end == NULL);

      *list = g_slist_append(*list, data);
      *list_end = *list;
    }
  else
    {
      *list_end = g_slist_append(*list_end, data)->next;
    }
}
```

To use this function, you would store the list and its end somewhere, and pass their address to efficient_append():

```
  GSList* list = NULL;
  GSList* list_end = NULL;

  efficient_append(&list, &list_end, g_strdup("Foo"));
  efficient_append(&list, &list_end, g_strdup("Bar"));
  efficient_append(&list, &list_end, g_strdup("Baz"));
```

Of course you have to be careful not to use any list functions that might change the end of the list without updating list_end.

```
#include <glib.h>
```

GSList* g_slist_append(GSList* *list*, gpointer *data*);

GSList* g_slist_prepend(GSList* *list*, gpointer *data*);

GSList* g_slist_insert(GSList* *list*, gpointer *data*, gint *position*);

GSList* g_slist_remove(GSList* *list*, gpointer *data*);

Figure 13. Changing linked list contents

For accessing list elements, the functions in Figure 14 are provided. None of these change the list's structure. g_slist_foreach() applies a GFunc to each element of the list. A GFunc is defined as follows:

```
typedef void (*GFunc)(gpointer data, gpointer user_data);
```

Used in g_slist_foreach(), your GFunc will be called on each list->data in list, passing the user_data you provided to g_slist_foreach(). g_slist_foreach() is comparable to Scheme's "map" function.

For example, you might have a list of strings, and you might want to be able to create a parallel list with some transformation applied to the strings. Here is some code, using the efficient_append() function from an earlier example:

```
typedef struct _AppendContext AppendContext;
```

```
struct _AppendContext {
  GSList* list;
  GSList* list_end;
  const gchar* append;
};

static void
append_foreach(gpointer data, gpointer user_data)
{
  AppendContext* ac = (AppendContext*) user_data;
  gchar* oldstring = (gchar*) data;

  efficient_append(&ac->list, &ac->list_end,
                   g_strconcat(oldstring, ac->append, NULL));
}

GSList*
copy_with_append(GSList* list_of_strings, const gchar* append)
{
  AppendContext ac;

  ac.list = NULL;
  ac.list_end = NULL;
  ac.append = append;

  g_slist_foreach(list_of_strings, append_foreach, &ac);

  return ac.list;
}
```

glib and GTK+ use the "function pointer and user data" idiom heavily. If you have functional programming experience, this is much like using lambda expressions to create a *closure*. (A closure combines a function with an *environment*---a set of name-value bindings. In this case the "environment" is the user data you pass to append_foreach(), and the "closure" is the combination of the function pointer and the user data.)

```
#include <glib.h>
```

GSList* g_slist_find(GSList* *list*, gpointer *data*);

GSList* g_slist_nth(GSList* *list*, guint *n*);

gpointer g_slist_nth_data(GSList* *list*, guint *n*);

```
GSList* g_slist_last(GSList* list);

gint g_slist_index(GSList* list, gpointer data);

void g_slist_foreach(GSList* list, GFunc func, gpointer user_data);
```

Figure 14. Accessing data in a linked list

There are some handy list-manipulation routines, listed in Figure 15. With the exception of g_slist_copy(), all of these affect the lists in-place. Which means you must assign the return value and forget about the passed-in pointer, just as you do when adding or removing list elements. g_slist_copy() returns a newly-allocated list, so you can continue to use both lists and must free both lists eventually.

```
#include <glib.h>

guint g_slist_length(GSList* list);

GSList* g_slist_concat(GSList* list1, GSList* list2);

GSList* g_slist_reverse(GSList* list);

GSList* g_slist_copy(GSList* list);
```

Figure 15. Manipulating a linked list

Finally, there are some provisions for sorted lists, shown in Figure 16. To use these, you must write a GCompareFunc, which is just like the comparison function in the standard C qsort(). Using glib types, this becomes:

```
typedef gint (*GCompareFunc) (gconstpointer a, gconstpointer b);
```

If a < b, the function should return a negative value; if a > b a positive value; if a == b it should return 0.

Once you have a comparison function, you can insert an element into an already-sorted list, or sort an entire list. Lists are sorted in ascending order. You can even recycle your GCompareFunc to find list elements, using g_slist_find_custom(). (A word of caution: GCompareFunc is used inconsistently in glib; sometimes it glib expects an equality predicate instead of a qsort()-style function. However, the usage is consistent within the list API.)

Be careful with sorted lists; misusing them can rapidly become very inefficient. For example, g_slist_insert_sorted() is an O(n) operation, but if you use it in a loop to insert multiple elements the loop runs in exponential time. It's better to simply prepend all your elements, then call g_slist_sort().

```
#include <glib.h>
```

GSList* g_slist_insert_sorted(GSList* *list*, gpointer *data*, GCompareFunc *func*);

GSList* g_slist_sort(GSList* *list*, GCompareFunc *func*);

GSList* g_slist_find_custom(GSList* *list*, gpointer *data*, GCompareFunc *func*);

Figure 16. Sorted lists

Trees

There are two different kinds of tree in glib; GTree is your basic balanced binary tree, useful to store key-value pairs sorted by key; GNode stores arbitrary tree-structured data, such as a parse tree or taxonomy.

GTree

To create and destroy a GTree, use the constructor-destructor pair displayed in Figure 17. GCompareFunc is the same qsort()-style comparison function described for GSList; in this case it's used to compare keys in the tree.

```
#include <glib.h>
```

GTree* g_tree_new(GCompareFunc *key_compare_func*);

void g_tree_destroy(GTree* *tree*);

Figure 17. Creating and destroying balanced binary trees

Functions for manipulating the contents of the tree are shown in Figure 18. All very straightforward; g_tree_insert() overwrites any existing value, so be careful if the existing value is your only pointer to a chunk of allocated memory. If g_tree_lookup() fails to find the key, it returns

NULL, otherwise it returns the associated value. Both keys and values have type gpointer, but the GPOINTER_TO_INT() and GPOINTER_TO_UINT() macros allow you to use integers instead.

```
#include <glib.h>
```

void g_tree_insert(GTree* *tree*, gpointer *key*, gpointer *value*);

void g_tree_remove(GTree* *tree*, gpointer *key*);

gpointer g_tree_lookup(GTree* *tree*, gpointer *key*);

Figure 18. Manipulating GTree contents

There are two functions which give you an idea how large the tree is, shown in Figure 19.

```
#include <glib.h>
```

gint g_tree_nnodes(GTree* *tree*);

gint g_tree_height(GTree* *tree*);

Figure 19. Determining the size of a GTree

Using g_tree_traverse() (Figure 20) you can walk the entire tree. To use it, you provide a GTraverseFunc, which is passed each key-value pair and a data argument you give to g_tree_traverse(). Traversal continues as long as the GTraverseFunc returns FALSE; if it ever returns TRUE then traversal stops. You can use this to search the tree by value. Here is the definition of GTraverseFunc:

```
typedef gint (*GTraverseFunc)(gpointer key, gpointer value, gpointer
data);
```

GTraverseType is an enumeration; there are four possible values. Here are their meanings with respect to GTree.

- G_IN_ORDER first recurses the left child of the node (the "lower" key according to your GCompareFunc), then calls the traversal function on the key-value pair of the current node, then recurses the right child. This traversal is in order from lowest to highest, according to your GCompareFunc.

- G_PRE_ORDER calls the traversal function on the key-value pair of the current node, then recurses the left child, then recurses the right child.
- G_POST_ORDER recurses the left child, then recurses the right child, and finally calls the traversal function on the current node's key-value pair.
- G_LEVEL_ORDER is only meaningful for GNode, it is not allowed with GTree.

```
#include <glib.h>
```

void g_tree_traverse(GTree* *tree*, GTraverseFunc *traverse_func*, GTraverseType *traverse_type*, gpointer *data*);

Figure 20. Traversing GTree

GNode

A GNode is an N-way tree, implemented as a doubly linked list with parent and child lists. Thus, most list operations have analogues in the GNode API. You can also walk the tree in various ways. Here's the declaration for a node:

```

typedef struct _GNode GNode;

struct _GNode
{
  gpointer data;
  GNode   *next;
  GNode   *prev;
  GNode   *parent;
  GNode   *children;
};
```

There are macros to access GNode members, shown in Figure 21. As with GList, the data member is intended to be used directly. These macros return the next, prev, and children members respectively; they also check whether their argument is NULL before dereferencing it, and return NULL if it is.

```
#include <glib.h>
```

g_node_prev_sibling(*node*);

```
g_node_next_sibling(node);

g_node_first_child(node);
```

Figure 21. Accessing GNode members

To create a node, the usual _new() function is provided (Figure 22). g_node_new() creates a childless and parentless node containing data. Typically g_node_new() is used only to create the root node; convenience macros are provided which automatically create new nodes as needed.

```
#include <glib.h>

GNode* g_node_new(gpointer data);
```

Figure 22. Creating a GNode

To build a tree the fundamental operations shown in Figure 23 are used. Each operation returns the just-added node, for convenience when writing loops or recursing the tree. Unlike GList, it is safe to ignore the return value.

```
#include <glib.h>

GNode* g_node_insert(GNode* parent, gint position, GNode* node);

GNode* g_node_insert_before(GNode* parent, GNode* sibling, GNode* node);

GNode* g_node_prepend(GNode* parent, GNode* node);
```

Figure 23. Building a GNode tree

The convenience macros shown in Figure 24 are implemented in terms of the fundamental operations. g_node_append() is analagous to g_node_prepend(); the rest take a data argument, automatically allocate a node for it, and call the corresponding basic operation.

```
#include <glib.h>

g_node_append(parent, node);

g_node_insert_data(parent, position, data);

g_node_insert_data_before(parent, sibling, data);
```

```
g_node_prepend_data(parent, data);

g_node_append_data(parent, data);
```

Figure 24. Building a GNode

To remove a node from the tree, there are two functions shown in Figure 25. g_node_destroy() removes the node from a tree, destroying it and all its children. g_node_unlink() removes a node and makes it into a root node; i.e., it converts a subtree into an independent tree.

```
#include <glib.h>

void g_node_destroy(GNode* root);

void g_node_unlink(GNode* node);
```

Figure 25. Destroying a GNode

There are two macros for detecting the top and bottom of a GNode tree, shown in Figure 26. A root node is defined as a node with no parent or siblings. A leaf node has no children.

```
#include <glib.h>

G_NODE_IS_ROOT(node);

G_NODE_IS_LEAF(node);
```

Figure 26. Predicates for GNode

You can ask glib to report useful information about a GNode, including the number of nodes it contains, its root node, its depth, and the node containing a particular data pointer. These functions are shown in Figure 27.

GTraverseType was introduced earlier, with respect to GTree; here are the possible values for GNode:

- G_IN_ORDER first recurses the leftmost child of the node, then visits the node itself, then recurses the rest of the node's children. This isn't very useful; mostly it is intended for use with GTree.
- G_PRE_ORDER visits the current node, then recurses each child in turn.

- G_POST_ORDER recurses each child in order, then visits the current node.
- G_LEVEL_ORDER first visits the node itself; then each of the node's children; then the children of the children; then the children of the children of the children; and so on. That is, it visits each node of depth 0, then each node of depth 1, then each node of depth 2, etc.

GNode's tree-traversal functions have a GTraverseFlags argument. This is a bitfield used to change the nature of the traversal. Currently there are only three flags---you can visit only leaf nodes, only non-leaf nodes, or all nodes:

- G_TRAVERSE_LEAFS means to traverse only leaf nodes.
- G_TRAVERSE_NON_LEAFS means to traverse only non-leaf nodes.
- G_TRAVERSE_ALL is simply a shortcut for (G_TRAVERSE_LEAFS | G_TRAVERSE_NON_LEAFS).

```
#include <glib.h>
```

guint g_node_n_nodes(GNode* *root*, GTraverseFlags *flags*);

GNode* g_node_get_root(GNode* *node*);

gboolean g_node_is_ancestor(GNode* *node*, GNode* *descendant*);

guint g_node_depth(GNode* *node*);

GNode* g_node_find(GNode* *root*, GTraverseType *order*, GTraverseFlags *flags*, gpointer *data*);

Figure 27. GNode Properties

The remaining GNode functions are straightforward; most of them are simply operations on the node's list of children. Figure 28 lists them. There are two function typedefs unique to GNode:

```

typedef gboolean (*GNodeTraverseFunc) (GNode* node, gpointer data);
typedef void (*GNodeForeachFunc) (GNode* node, gpointer data);
```

These are called with a pointer to the node being visited, and the user data you provide. A GNodeTraverseFunc can return TRUE to stop whatever traversal is in progress; thus you can use GNodeTraverseFunc in combination with g_node_traverse() to search the tree by value.

```
#include <glib.h>
```

void g_node_traverse(GNode* *root*, GTraverseType *order*, GTraverseFlags *flags*, gint *max_depth*, GNodeTraverseFunc *func*, gpointer *data*);

guint g_node_max_height(GNode* *root*);

void g_node_children_foreach(GNode* *node*, GTraverseFlags *flags*, GNodeForeachFunc *func*, gpointer *data*);

void g_node_reverse_children(GNode* *node*);

guint g_node_n_children(GNode* *node*);

GNode* g_node_nth_child(GNode* *node*, guint *n*);

GNode* g_node_last_child(GNode* *node*);

GNode* g_node_find_child(GNode* *node*, GTraverseFlags *flags*, gpointer *data*);

gint g_node_child_position(GNode* *node*, GNode* *child*);

gint g_node_child_index(GNode* *node*, gpointer *data*);

GNode* g_node_first_sibling(GNode* *node*);

GNode* g_node_last_sibling(GNode* *node*);

Figure 28. Accessing a GNode

Hash Tables

GHashTable is a simple hash table implementation, providing an associative array with constant-time lookups. To use the hash table, you must provide a GHashFunc, which should return a positive integer when passed a hash key:

```
typedef guint (*GHashFunc) (gconstpointer key);
```

Each returned guint (modulus the size of the table) corresponds to a "slot" or "bucket" in the hash; GHashTable handles collisions by storing a linked list of key-value pairs in each slot. Thus, the guint values returned by your GHashFunc must be fairly evenly distributed over the set of possible guint values, or the hash table will degenerate into a linked list. Your GHashFunc must also be fast, since it is used for every lookup.

In addition to GHashFunc, a GCompareFunc is required to test keys for equality. Somewhat unpleasantly, GHashTable does not use GCompareFunc in the same way GSList and GTree do, although the function signature is the same. Here GCompareFunc is expected to be an equality operator, returning TRUE if its arguments are equal. It should *not* be a qsort()-style comparison function. The key comparison function is used to find the correct key-value pair when hash collisions result in more than one pair in the same hash slot.

To create and destroy a GHashTable, use the constructor and destructor listed in Figure 29. Remember that glib has no way of knowing how to destroy the data contained in your hash table; it only destroys the table itself.

```
#include <glib.h>
```

GHashTable* g_hash_table_new(GHashFunc *hash_func*, GCompareFunc *key_compare_func*);

void g_hash_table_destroy(GHashTable* *hash_table*);

Figure 29. GHashTable

Ready-to-use hash and comparison functions are provided for the most common keys: integers, pointers, and strings. These are listed in Figure 30. The functions for integers accept a pointer to a gint, rather than the gint itself. If you pass NULL as the hash function argument to g_hash_table_new(), g_direct_hash() is used by default. If you pass NULL as the key equality function, then simple pointer comparison is used (equivalent to g_direct_equal(), but without a function call).

```
#include <glib.h>
```

guint g_int_hash(gconstpointer *v*);

gint g_int_equal(gconstpointer *v1*, gconstpointer *v2*);

guint g_direct_hash(gconstpointer *v*);

gint g_direct_equal(gconstpointer *v1*, gconstpointer *v2*);

guint g_str_hash(gconstpointer *v*);

gint g_str_equal(gconstpointer *v1*, gconstpointer *v2*);

Figure 30. Pre-written hashes/comparisons

Manipulating the hash is simple. The routines are summarized in Figure 31. Insertions do *not* copy the key or value; these are entered into the table exactly as you provide them, overwriting any pre-existing key-value pair with the same key ("same" is defined by your hash and equality functions, remember). If this is a problem, you must do a lookup or remove before you insert. Be especially careful if you dynamically allocate keys or values.

The simple g_hash_table_lookup() returns the value it finds associated with key, or NULL if there is no value. Sometimes this won't do. For example, NULL may be a valid value in itself. If you're using strings as keys, especially dynamically allocated strings, knowing that a key is in the table might not be enough; you might want to retrieve the exact gchar* the hash table is using to represent key "foo". A second lookup function is provided for cases like these. g_hash_table_lookup_extended() returns TRUE if the lookup succeeded; if it returns TRUE, it places the key and value it found in the locations it's given.

```
#include <glib.h>
```

void g_hash_table_insert(GHashTable* *hash_table*, gpointer *key*, gpointer *value*);

void g_hash_table_remove(GHashTable * *hash_table*, gconstpointer *key*);

gpointer g_hash_table_lookup(GHashTable * *hash_table*, gconstpointer *key*);

gboolean g_hash_table_lookup_extended(GHashTable* *hash_table*, gconstpointer *lookup_key*, gpointer* *orig_key*, gpointer* *value*);

Figure 31. Manipulating GHashTable

GHashTable keeps an internal array whose size is a prime number. It also keeps a count of the number of key-value pairs stored in the table. If the average number of pairs per available slot drops below 0.3 (or so), the array is made smaller; if it goes above 3, the array is made larger to reduce collisions. Resizing happens automatically whenever you insert or remove pairs from the table. This ensures the hash table's memory use is optimal. Unfortunately, it is inefficient to rebuild the hash table over and over if you're doing a large number of insertions or removals.

To solve the problem, the hash table can be *frozen*, meaning that resizing is temporarily suppressed. When you're done adding and removing items, you simply *thaw* the table, resulting in a single optimal-size calculation. (Be careful though; a frozen table can end up with many hash collisions if you add large quantities of data. This should be fine as long as you thaw before you do any lookups.) The functions are in Figure 32.

```
#include <glib.h>

void g_hash_table_freeze(GHashTable* hash_table);

void g_hash_table_thaw(GHashTable* hash_table);
```

Figure 32. Freezing and thawing GHashTable

Other Features

There simply isn't space to cover all of glib's features in this book. It's worth looking at glib whenever you find yourself thinking, "There really *should* be a function that..."---glib.h and the glib documentation on http://www.gtk.org/ are excellent resources.

Here's a brief list of features not already mentioned:

- FLOAT_MAX, etc. equivalents for many numeric types.
- Byte-order conversions.
- g_memmove() is more portable them memmove().
- G_DIR_SEPARATOR handles Windows/UNIX differences.
- G_VA_COPY copies a va_list in a portable way.
- Numerous macros to permit the use of compiler extensions (especially gcc extensions) in a portable way.
- Portable g_htonl() and other host-to-network conversions.
- A GCache generic cache facility.
- "Callback maintenance" routines---registering and unregistering of callbacks.
- The g_log() facility, allows you to print warnings, messages, etc. with configurable log levels and pluggable print routines.
- GMemChunk facility allows you to allocate a large pool of small memory chunks, for efficiency gains compared to g_malloc(). Used in the GList implementation, for example.
- A timer facility.
- Convenience/portability routines to get the user's home directory, get the name of a /tmp directory, and similar tasks.

- Filename manipulation, such as g_basename() and g_path_is_absolute().
- Bitfield manipulation.
- Enhanced string and array classes. Pointer and byte arrays.
- GQuark---two way mapping from strings to integer identifiers.
- Routines to associate data with strings, or with arbitrary pointers.
- A lexical scanner.
- Tab completions.
- Calendrical/date-arithmetic functions.
- A generic event loop abstraction, used to implement GTK+'s event loop.
- A portable threads abstraction.

If you need some generally-useful routine that's not in glib already, consider writing it in glib style and contributing it to the library! You get free assistance with design, debugging, and maintenance, and other programmers benefit from the facility you've written. By the time you read this, it's also possible that the feature you want is already in the latest version of glib.

GTK+ Basics

Table of Contents

This chapter does the usual Hello, World to give you an overview of GTK+, then moves on to discuss some of the essential details you need to start developing GTK+ applications.

If you've already read the GTK+ Tutorial from http://www.gtk.org/, or the book *Developing Linux Applications with Gtk+ and Gdk* (also from New Riders), you may be able to skip or just skim this chapter. If you haven't used GTK+ before, this chapter is going to be very fast; read with care.

Whirlwind Tour of GTK+

GTK+'s object-oriented coding style, clean design, and carefully followed API-naming conventions make programs simple to write and simple to understand. To make the point, here's a complete "Hello, World" in GTK+;

most likely you can guess what 80% of the code does with no GTK+ experience whatsoever.

A Complete Hello, World

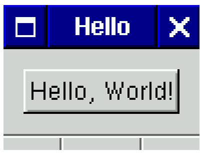

Figure 1. Hello, World

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

static gint delete_event_cb(GtkWidget* w, GdkEventAny* e, gpointer
data);
static void button_click_cb(GtkWidget* w, gpointer data);

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

  gtk_init(&argc, &argv);

  window = gtk_window_new(GTK_WINDOW_TOPLEVEL);

  button = gtk_button_new();

  label  = gtk_label_new("Hello, World!");

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

  gtk_window_set_title(GTK_WINDOW(window), "Hello");
  gtk_container_set_border_width(GTK_CONTAINER(button), 10);

  gtk_signal_connect(GTK_OBJECT(window),
                     "delete_event",
                     GTK_SIGNAL_FUNC(delete_event_cb),
                     NULL);

  gtk_signal_connect(GTK_OBJECT(button),
                     "clicked",
                     GTK_SIGNAL_FUNC(button_click_cb),
                     label);

  gtk_widget_show_all(window);

  gtk_main();

  return 0;
}

static gint
delete_event_cb(GtkWidget* window, GdkEventAny* e, gpointer data)
{
  gtk_main_quit();
  return FALSE;
}

static void
button_click_cb(GtkWidget* w, gpointer data)
{
  GtkWidget* label;
  gchar* text;
  gchar* tmp;

  label = GTK_WIDGET(data);

  gtk_label_get(GTK_LABEL(label), &text);

  tmp = g_strdup(text);

  g_strreverse(tmp);

  gtk_label_set_text(GTK_LABEL(label), tmp);

  g_free(tmp);
}
```

Compiling Hello, World

GTK+ comes with a shell script called gtk-config; this script is created when GTK+ is built. Its purpose is to report the compiler flags you need to compile GTK+ programs. The following shell session demonstrates its features:

```
$ gtk-config --version
1.2.0
$ gtk-config --prefix
/home/hp/local
$ gtk-config --exec-prefix
/home/hp/local
$ gtk-config --libs
-L/home/hp/local/lib -L/usr/X11R6/lib -lgtk -lgdk -rdynamic -lgmodule
-lglib -ldl -lXext -lX11 -lm
$ gtk-config --libs gthread
-L/home/hp/local/lib -L/usr/X11R6/lib -lgtk -lgdk -rdynamic -lgmodule
-lgthread -lglib -lpthread -ldl -lXext -lX11 -lm
$ gtk-config --cflags
-I/usr/X11R6/include -I/home/hp/local/lib/glib/include
-I/home/hp/local/include
$
```

If you're using a Bourne shell variant, such as bash, you can use backticks (*not* single quotes!) to execute gtk-config and substitute its output. A simple Makefile for compiling Hello, World might look like this:

```
CC=gcc

all: hello.c
        $(CC) `gtk-config --libs` `gtk-config --cflags` -o hello hello.c

clean:
        /bin/rm -f *.o *~
```

Of course, this Makefile is far too simple for real-world applications; the chapter called *Creating Your Source Tree* describes how to set up a more realistic build using automake and autoconf.

gtk-config allows you to locate GTK+ on the user's system, instead of hard-coding a location in your Makefile. It also comes in handy if you have two versions of GTK+ on your own system; if you install them each in a dedicated directory tree, you can choose one or the other by placing the correct gtk-config in your shell's search path.

How It Works

This simple program contains all the essential elements of a GTK+ application. It doesn't contain any Gnome features; but since Gnome builds on GTK+, the same concepts will apply.

Initialization

First, GTK+ must be initialized:

```
gtk_init(&argc, &argv);
```

This call connects to an X server, and parses some default arguments understood by all GTK+ programs. Parsed arguments are removed from argv, and argc is decremented accordingly. gtk_init() also registers a "cleanup function" using atexit(). In practice, this is only important when you fork(); the child process must exit with _exit() rather than exit() to avoid shutting down GTK+ in the parent.

Widgets

Next, any program will have some user interface elements. In the X tradition, these are called *widgets*. All widgets are subclasses of the GtkWidget base class, so you can use a GtkWidget* to refer to them. (Since C has no native support for object inheritance, GTK+ has its own mechanism---the chapter called *The GTK+ Object and Type System* describes this.)

```
window = gtk_window_new(GTK_WINDOW_TOPLEVEL);

button = gtk_button_new();

label  = gtk_label_new("Hello, World!");
```

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

gtk_window_set_title(GTK_WINDOW(window), "Hello");
gtk_container_set_border_width(GTK_CONTAINER(button), 10);
```

Each widget has a function called gtk_widgetname_new(), analagous to a constructor in C++ or Java. This function allocates a new object, initializes it, and returns a pointer to it. All of the _new() routines return a GtkWidget*, even though they allocate a subclass; this is for convenience.

Once you have a GtkWidget* representing an object, you can manipulate the object using its methods. All GTK+ widget functions begin with the name of the type they operate on, and accept a pointer to that type as the first argument. In the above code, gtk_container_add() accepts a GtkContainer* as the first argument. The macro GTK_CONTAINER() casts the GtkWidget*, and also performs a runtime type check. Casting is required because C does not understand the inheritance relationship.

As you might imagine, GtkButton and GtkWindow are both subclasses of GtkContainer. A GtkContainer can hold any other widget inside. The code creates a toplevel window, places a button inside it, and places a label (line of text) inside the button. Then it sets the window title, and adds a small cosmetic border around the button.

Signals

Next, you'll want to arrange to respond when users manipulate the widgets. In this simple application, there are two interesting things that can happen: the user can click the button, or close the window using a window manager decoration. Widgets (actually, all GtkObjects) emit *signals* when something interesting happens a program might want to respond to. To respond to a signal, you "connect a callback" to it---i.e., register a function to be called when the signal is emitted. Here's that code again:

```
gtk_signal_connect(GTK_OBJECT(window),
                   "delete_event",
                   GTK_SIGNAL_FUNC(delete_event_cb),
                   NULL);
```

```
  gtk_signal_connect(GTK_OBJECT(button),
                     "clicked",
                     GTK_SIGNAL_FUNC(button_click_cb),
                     label);
```

gtk_signal_connect() specifies the GtkObject to monitor, which signal to connect to, the callback to connect, and finally a user_data argument---this is an arbitrary gpointer which will be passed to the callback. The macro GTK_SIGNAL_FUNC() casts the callback to a standard function signature; since callbacks have a variety of type signatures, the alternative would be dozens of gtk_signal_connect() variants.

GTK+ performs copious runtime sanity checking; the GTK_OBJECT() macro includes a runtime type check in addition to a C cast, and gtk_signal_connect() will verify that the object can actually emit the signal you've specified.

Entering the Main Loop

Once everything is set up, two steps remain: you need to show the window on the screen, and wait for user input.

```

  gtk_widget_show_all(window);

  gtk_main();

  return 0;
```

gtk_widget_show_all() recursively calls gtk_widget_show() on a container and its children. The following code would have the same effect in this case:

```

  gtk_widget_show(label);
  gtk_widget_show(button);
  gtk_widget_show(window);
```

It's necessary to show each and every widget that you want to appear on the screen. The opposite operation is called gtk_widget_hide(); widgets start their life hidden, and can be re-hidden/re-shown any number of times.

It's good practice to show all child widgets before showing the outermost container; otherwise, the user will see the container appear first, followed by its children. Widgets are not actually visible on the screen until their parent container is shown---the exception to the rule is GtkWindow, since it has no parent.

Once your widgets have been shown, you want to wait for the user to do something with them. gtk_main() enters the GTK+ main loop; the main loop is event-driven. That is, user actions trigger *events* which generally result in signals being emitted and your callbacks being called. gtk_main() blocks indefinitely, waiting for and responding to user input. The main loop is described in more detail in the section called *The Main Loop*. Events and their relation to the main loop are described in the section called *Events* in the chapter called *GDK Basics*.

More on Signals and Callbacks

If either of the signals the program connects to is emitted, the corresponding callback is called. Our "delete_event" callback ends the gtk_main() event loop by calling gtk_main_quit(); this causes gtk_main() to return, ending the program. The "clicked" callback replaces the text from the label with the same text in reverse. Notice that the label was passed to the callback as the user_data parameter to gtk_signal_connect().

A common mistake is to assume that all signals use the same kind of callback---not true. Each signal requires a callback with a particular type signature and particular behavior. The "clicked" signal has a very common callback type; its callback receives a pointer to the widget emitting the signal and any user_data provided by the programmer. This callback *must* return void or memory corruption is likely to occur.

"delete_event", on the other hand, is something of a special case. It accepts three arguments; the first and last are analagous to "clicked", while the second is a pointer to the event which triggered the signal (*events* are messages from X to the application, reporting mouse movements, key presses, and the like). The "delete_event" callback returns a "magic" value---if FALSE is returned, GTK+ will destroy the window; if TRUE is returned, GTK+ will do nothing. Return TRUE if you need to do something other than destroy the window; for example, you might want to warn the user about an unsaved document.

Widget header files are the best quick reference for callback signatures. The "class structure" for the widget will have a space for a default signal handler; your handler should be modeled on the default one. For example, in gtk/gtkbutton.h the GtkButton class struct looks like this:

```
struct _GtkButtonClass
{
  GtkBinClass        parent_class;

  void (* pressed)  (GtkButton *button);
  void (* released) (GtkButton *button);
  void (* clicked)  (GtkButton *button);
  void (* enter)    (GtkButton *button);
  void (* leave)    (GtkButton *button);
};
```

the chapter called *The GTK+ Object and Type System* explains exactly what a class struct is for; for now, just pay attention to the function pointers, and note that they correspond to signals. To get from this:

```
  void (* clicked)  (GtkButton *button);
```

to this:

```
  static void button_click_cb(GtkWidget* w, gpointer data);
```

simply add a gpointer data to the class struct function's signature. In Hello, World I've also changed the type from GtkButton* to GtkWidget*; this is common, since it can be more convenient to have a GtkWidget*. The argument will always be the GtkButton emitting the signal.

Another example may be useful; here is "delete_event" from gtk/gtkwidget.h:

```
  gint (* delete_event)             (GtkWidget          *widget,
                                     GdkEventAny        *event);
```

and the callback from Hello, World:

```
static gint delete_event_cb(GtkWidget* w, GdkEventAny* e, gpointer
data);
```

That's all there is to it. You can write simple GTK+ applications using only the information presented in this section. GTK+ and Gnome are powerful application development tools because you can think about real functionality, instead of struggling to get a window on the screen.

Containers And Widget Layout

There are two kinds of container widgets in GTK+. All of them are subclasses of the abstract GtkContainer. The first type of container widget always descends from GtkBin, another abstract base class. Descendents of GtkBin can contain only one child widget; these containers add some kind of functionality to the child. For example, GtkButton is a GtkBin which makes the child into a clickable button. GtkFrame is a GtkBin which draws a relieved border around the child. GtkWindow allows the child to appear in a toplevel window.

The second type of container widget often has GtkContainer as its immediate parent. These containers can have more than one child, and their purpose is to manage layout. "Manage layout" means that these containers assign *sizes* and *positions* to the widgets they contain. For example, GtkVBox arranges its children in a vertical stack. GtkFixed allows you to position children at arbitrary coordinates. GtkPacker gives you Tk-style layout management.

This chapter is about the second kind of container. To produce the layout you want without hard-coding any sizes, you'll need to understand how to use these. The goal is to avoid making assumptions about window size, screen size, widget appearance, fonts, and so on. Your application should automatically adapt if these factors change.

Size Allocation

To understand layout containers, you first have to understand how GTK+ widgets negotiate their size. It's quite simple really; there are only two concepts, *requisition* and *allocation*. These correspond to the two phases of layout.

Requisition

A widget's *requisition* consists of a width and a height---the size the widget would like to be. This is represented by a GtkRequisition struct:

```
typedef struct _GtkRequisition    GtkRequisition;

struct _GtkRequisition
{
  gint16 width;
  gint16 height;
};
```

Different widgets choose what size to request in different ways. GtkLabel, for example, requests enough size to display all the text in the label. Most container widgets base their size request on the size requests of their children. For example, if you place several buttons in a box, the box will ask to be large enough to hold all the buttons.

The first phase of layout starts with a toplevel widget such as GtkWindow. Since it's a container, GtkWindow asks its child widget for a size request; that child might ask its own children; and so on recursively. When all child widgets have been queried, GtkWindow will finally get a GtkRequisition back from its child. Depending on how it was configured, GtkWindow may or may not be able to expand to accomodate the size request.

Allocation

Phase two of layout begins at this point. GtkWindow makes a decision about how much space is actually available for its child, and communicates its decision to the child. This is known as the child's *allocation*, represented by the following struct:

```
typedef struct _GtkAllocation     GtkAllocation;

struct _GtkAllocation
{
  gint16 x;
  gint16 y;
  guint16 width;
  guint16 height;
};
```

The width and height elements are identical to GtkRequisition; they represent the size of the widget. A GtkAllocation also includes the coordinates of the child with respect to its parent. GtkAllocations are assigned to children by their parent container.

Widgets are required to honor the GtkAllocation given to them. GtkRequisition is only a request; widgets must be able to cope with any size.

Given the layout process, it's easy to see what role containers play. Their job is to assemble each child's requisition into a single requisition to be passed up the widget tree; then to divide the allocation they receive between their children. Exactly how this happens depends on the particular container.

GtkBox

A GtkBox manages a row (GtkHBox) or column (GtkVBox) of widgets. For GtkHBox, all the widgets are assigned the same height; the box's job is to distribute the available width between them. GtkHBox optionally uses some of the available width to leave gaps (called "spacing") between widgets. GtkVBox is identical, but in the opposite direction (i.e., it distributes available height rather than width). GtkBox is an abstract base class; GtkVBox and GtkHBox can be used almost entirely via its interface. Boxes are the most useful container widget.

To create a GtkBox, you use one of the constructors shown in Figure 2 and Figure 3. The box constructor functions take two parameters. If TRUE, homogeneous means that all children of the box will be allocated the same amount of space. spacing specifies the amount of space between each child. There are functions to change spacing and toggle homogeneity after the box is created.

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

GtkWidget* gtk_hbox_new(gboolean *homogeneous*, gint *spacing*);

Figure 2. GtkHBox Constructor

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

GtkWidget* gtk_vbox_new(gboolean *homogeneous*, gint *spacing*);

Figure 3. GtkVBox Constructor

There are two basic functions to add a child to a GtkBox; they are shown in Figure 4.

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

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

void gtk_box_pack_end(GtkBox* *box*, GtkWidget* *child*, gboolean *expand*, gboolean *fill*, gint *padding*);

Figure 4. Packing GtkBox

A box can contain two sets of widgets. The first set is packed at the "start" (top or left) of the box; the second at the "end" (bottom or right). If you pack three widgets into the start of a box, the first widget you pack appears topmost or leftmost; the second follows the first; and the third appears closest to the center of the box. If you then pack three widgets into the end of the same box, the first appears bottommost or rightmost; the second follows it; and the third appears closest to the center. With all six widgets packed, the order from top/left to bottom/right is: 1, 2, 3, 3, 2, 1. Figure 5 shows this for GtkVBox. Order of packing is only important within each end of the box; i.e., we could have alternated packing start and packing end, with the same results.

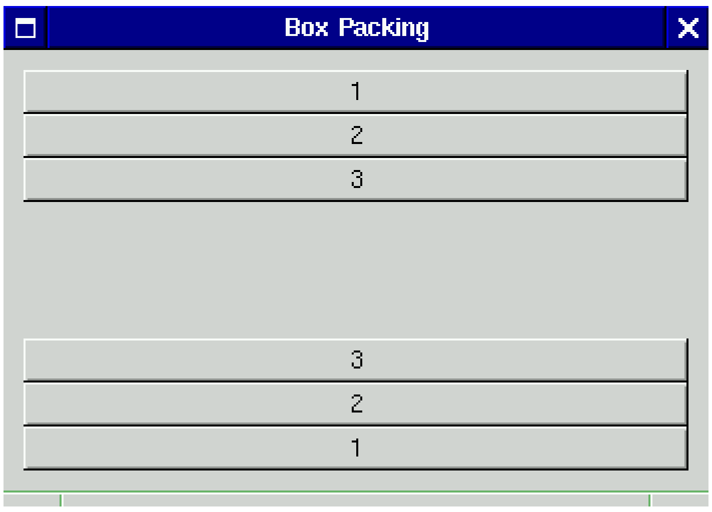

Figure 5. Buttons packed into a GtkVBox

GtkBox Layout Details

Packing is affected by three parameters, which are the same for both start and end packing; the meaning of these parameters is somewhat complicated, because they interact with the homogeneous setting of the box and with each other.

Here's how a GtkBox computes its size request for the "interesting" direction (width for GtkHBox, height for GtkVBox):

1. The total requested size of each child is considered to be the child's size request, plus two times the padding value used to pack the child. A child's padding is the amount of blank space on either side of it. In short, Child Size = (Child Widget's Size Request) + 2*(Child Padding).
2. If the box is homogeneous, the base size request for the entire box is equal to the size (request + padding) of the largest child, times the number of children. In a homogeneous box, all children are as large as the largest child.
3. If the box is not homogeneous, the base size request for the entire box is the sum of the size (request + padding) of each child.
4. The box-wide spacing setting determines how much blank space to leave between children; so this value is multiplied by the number of chilren minus one, and added to the base size request. Note that *spacing* does not belong to a child; it is blank space between children and is unaffected by the expand and fill parameters. *Padding*, on the other hand, is the space around each child and *is* affected by the child's packing parameters.
5. All containers have a "border width" setting; two times the border width is added to the request, representing a border on either side. Thus, the total size requested by a GtkBox is: (Sum of Child Sizes) + Spacing*(Number of Children - 1) + 2*(Border Width).

After computing its size request and delivering it to its parent container, GtkBox will receive its size allocation and distribute it among its children as follows:

1. Enough space for the border width and inter-child spacing is subtracted from the allocation; the remainder is the available space for children themselves. This space is divided into two chunks: the amount actually requested by the children (child requisitions and padding), and the "extra." Extra = (Allocation Size) - (Sum of Child Sizes).
2. If the box is not homogeneous, the "extra" space is divided among those children with the expand parameter set to TRUE. These children can expand to fit available space. If no child can expand, the extra

is used to add more space in the center of the box, between the start-packed widgets and the end-packed widgets.

3. If the box is homogeneous, the extra is distributed according to need; those children who requested more space get less extra, so that everyone ends up with the same amount of space. The expand parameter is ignored for homogeneous boxes---extra is distributed to all children, not just the expandable ones.
4. When a child gets some extra space, there are two possibilities. More padding can be added around the child, or the child widget itself can be expanded. The fill parameter determines which will happen. If TRUE, the child widget expands to fill the space---that is, the entire space becomes the child's allocation; if fill is FALSE, the child's padding is increased to fill the space, and the child is allocated only the space it requested. Note that fill has no effect if expand is set to FALSE and the box is not homogeneous, because the child will never receive any extra space to fill.

Whew! Who wants to think about all that? Fortunately, there are some common patterns of usage, so you don't need to solve a multivariate equation to figure out how to use the widget. The authors of the GTK+ Tutorial boil things down nicely to five cases that occur in practice; we'll follow in their footsteps here.

Non-Homogeneous Box Packing Patterns

There are three interesting ways to pack a non-homogeneous box. First, you can pack all the widgets into the end of the box, with their natural size. This means setting the expand parameter to FALSE:

```
gtk_box_pack_start(GTK_BOX(box),
                   child,
                   FALSE, FALSE, 0);
```

The result is shown in Figure 6. The expand parameter is the only one that matters in this case; no children are receiving extra space, so they wouldn't be able to fill it even if fill were TRUE.

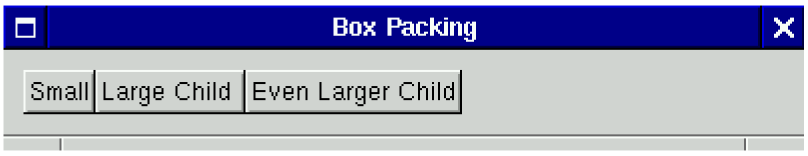

Figure 6. Non-homogeneous, with expand = FALSE

Second, you can spread widgets throughout the box, letting them keep their natural size as in Figure 7; this means setting the expand parameter to TRUE:

```
gtk_box_pack_start(GTK_BOX(box),
                   child,
                   TRUE, FALSE, 0);
```

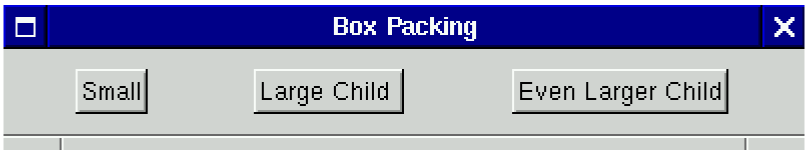

Figure 7. Non-homogeneous, with expand = TRUE and fill = FALSE

Finally, you can fill the box with widgets (letting larger children have more space) by setting the fill parameter to TRUE as well:

```
gtk_box_pack_start(GTK_BOX(box),
                   child,
                   TRUE, TRUE, 0);
```

This configuration is shown in Figure 8

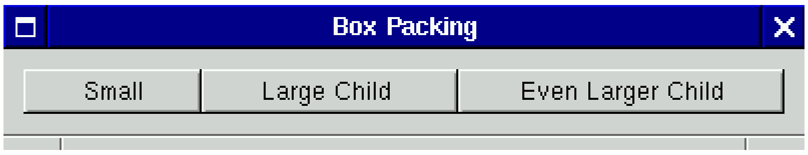

Figure 8. Non-homogeneous, with expand = TRUE and fill = TRUE

Homogeneous Box Packing Patterns

There are only two interesting ways to pack a homogeneous box. Recall that the expand parameter is irrelevant for homogeneous boxes; so the two cases correspond to the fill parameter's setting.

If fill is FALSE, you get Figure 9. Notice that the box is logically divided into three equal parts, but only the largest child widget occupies its entire space. The others are padded to fill their third of the area. If fill is TRUE, you get Figure 10; all the widgets are the same size.

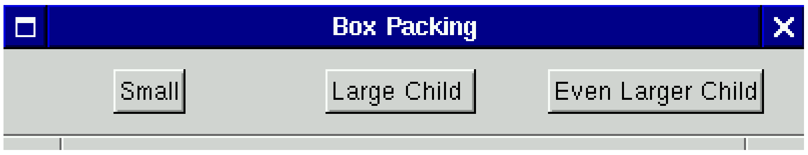

Figure 9. Homogeneous, with fill = FALSE

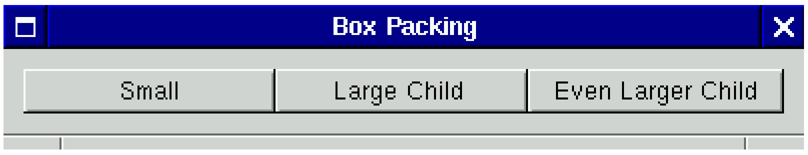

Figure 10. Homogeneous, with fill = TRUE

Box Packing Summary

Figure Figure 11 shows all five box-packing techniques together. (They are packed into a homogeneous GtkVBox with fill set to TRUE and an interchild spacing of two pixels.) This should give you a sense of their relative effects. Keep in mind that you can also tweak the padding and spacing parameters, to increase or decrease the amount of blank space between widgets. However, you can easily create an ugly layout by using inconsistent spacing---it's a good idea to try to keep widgets "lined up" and consistently spaced.

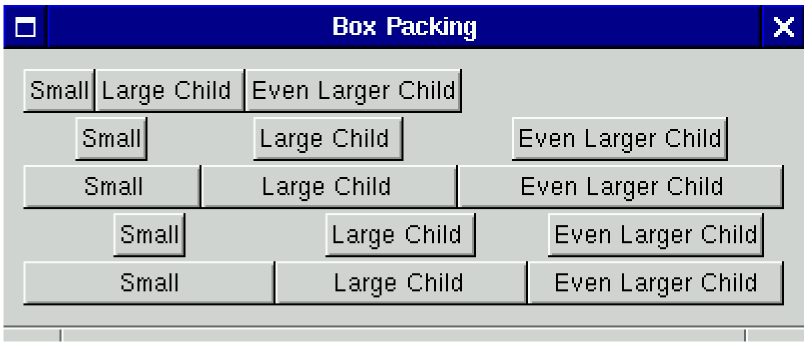

Figure 11. All Five Ways to Pack a Box

A final point: notice that the expand and fill parameters are only relevant when a box's size allocation is larger than its size request. That is, these parameters determine how *extra* space is distributed. Typically, extra space appears when a user resizes a window to make it larger than its default size. Thus, you should always try resizing your windows to be sure your boxes are packed correctly.

GtkTable

The second most common layout container is GtkTable. GtkTable divides a region into cells; you can assign each child widget to a rectangle made up of one or more cells. You can think of GtkTable as a sheet of graph paper (with more flexibility---the grid lines do not have to be equidistant, though they can be).

GtkTable comes with the usual constructor, and some functions to attach children to it; these are shown in Figure 12. When creating a table, you specify the number of cells you plan to use; this is purely for efficiency. The table will automatically grow if you place children in cells outside its current area. Like boxes, tables can be homogeneous or not.

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

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

GtkWidget* gtk_table_attach(GtkTable* *table*, GtkWidget* *child*, guint *left_side*, guint *right_side*, guint *top_side*, guint *bottom_side*, GtkAttachOptions *xoptions*, GtkAttachOptions *yoptions*, guint *xpadding*, guint *ypadding*);

Figure 12. GtkTable

The first two arguments to gtk_table_attach() are the table and the child to place in the table. The next four specify which grid lines should form the bounding box of the child. Grid lines are numbered from the top left (northwest) corner of the table, starting with 0; so a 2 by 3 table will have vertical lines 0, 1, 2 and horizontal lines 0,1,2,3. The last two arguments are the amount of padding to put on the left-right sides of the child (xpadding) and the top-bottom (ypadding). This is analagous to padding in boxes.

The GtkAttachOptions arguments require some explanation. Here's a summary of possible values. The values are bitmasks, so more than one can be specified by or-ing them together.

- GTK_EXPAND specifies that this section of the table will expand to fit available space, much like the expand option when packing boxes.
- GTK_FILL specifies that the child widget will expand to fill available space. Important only if GTK_EXPAND is set, because GTK_EXPAND permits extra space to exist.

- GTK_SHRINK determines what will happen if there is insufficient space to meet the child's size request. If GTK_SHRINK is set, the child is given a smaller allocation which reflects available space---i.e., the table shrinks the child. If it isn't set, the child is given its requested size; this may result in overlapping children within the table, and children will be "chopped off" at the table edges (because they'll try to draw outside the table's GdkWindow).

It's possible to set spacing between rows and columns, in addition to padding around particular children; the terms "spacing" and "padding" mean the same thing with respect to tables and boxes. See gtk/gtktable.h for a complete list of available GtkTable functions.

GtkTable Example

The following code creates a table with four cells and three children; one child covers two cells. The children are packed using different parameters:

```
GtkWidget* window;
GtkWidget* button;
GtkWidget* container;

window = gtk_window_new(GTK_WINDOW_TOPLEVEL);

container = gtk_table_new(2, 2, FALSE);

gtk_container_add(GTK_CONTAINER(window), container);

gtk_window_set_title(GTK_WINDOW(window), "Table Attaching");

gtk_container_set_border_width(GTK_CONTAINER(container), 10);

/* This would be a bad idea in real code; but it lets us
 * experiment with window resizing.
 */
gtk_window_set_policy(GTK_WINDOW(window), TRUE, TRUE, TRUE);

gtk_signal_connect(GTK_OBJECT(window),
                   "delete_event",
                   GTK_SIGNAL_FUNC(delete_event_cb),
                      NULL);

  button = gtk_button_new_with_label("1. Doesn't shrink\nor expand");
  gtk_table_attach(GTK_TABLE(container),
                   button,
                   0, 1,
                   0, 1,
                   GTK_FILL,
                   GTK_FILL,
                   0,
                   0);

  button = gtk_button_new_with_label("2. Expands and
shrinks\nvertically");
  gtk_table_attach(GTK_TABLE(container),
                   button,
                   0, 1,
                   1, 2,
                   GTK_FILL,
                   GTK_FILL | GTK_EXPAND | GTK_SHRINK,
                   0,
                   0);

  button = gtk_button_new_with_label("3. Expands and shrinks\nin both
directions");
  gtk_table_attach(GTK_TABLE(container),
                   button,
                   1, 2,
                   0, 2,
                   GTK_FILL | GTK_EXPAND | GTK_SHRINK,
                   GTK_FILL | GTK_EXPAND | GTK_SHRINK,
                   0,
                   0);
```

It's instructive to observe the resulting table as the window is resized. First, a quick summary of how the children are attached:

1. The first child will always receive its requested size; it neither expands nor shrinks.
2. The second child can expand and shrink only in the Y direction.
3. The third child can expand and shrink in either direction.

The window's natural size is shown in Figure 13; notice that some cells are given more space than the widgets inside them requested because table cells have to remain aligned. (Recall that a button with a label will request only enough space to display the entire label.) The GTK_FILL flag causes GtkTable to allocate extra space to the widgets themselves, instead of leaving blank padding around them.

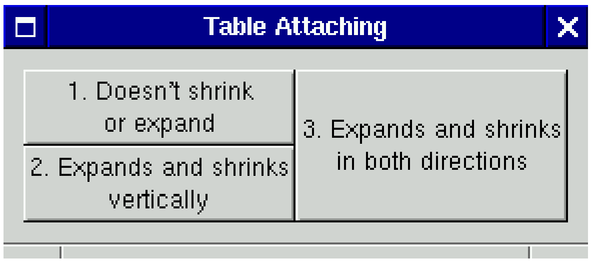
Table Attaching
1. Doesn't shrink or expand
2. Expands and shrinks vertically
3. Expands and shrinks in both directions

Figure 13. GtkTable before resizing

Now imagine the user expands the window vertically; notice that extra space is given to the widgets with GTK_EXPAND turned on in the Y direction---namely widgets two and three---while the widget in the top-left corner remains unchanged. Figure 14 shows this state of affairs.

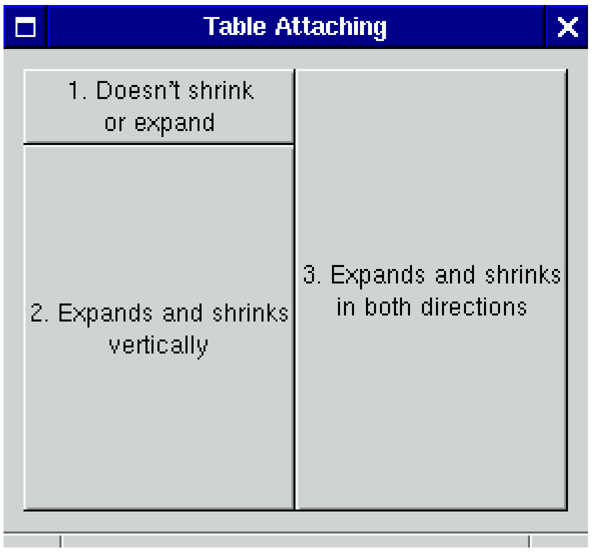
Table Attaching
1. Doesn't shrink or expand
2. Expands and shrinks vertically
3. Expands and shrinks in both directions

Figure 14. GtkTable after expanding the window vertically

Next, imagine the user expanding the window horizontally; only child widget number three can expand horizontally. Figure 15 shows this.

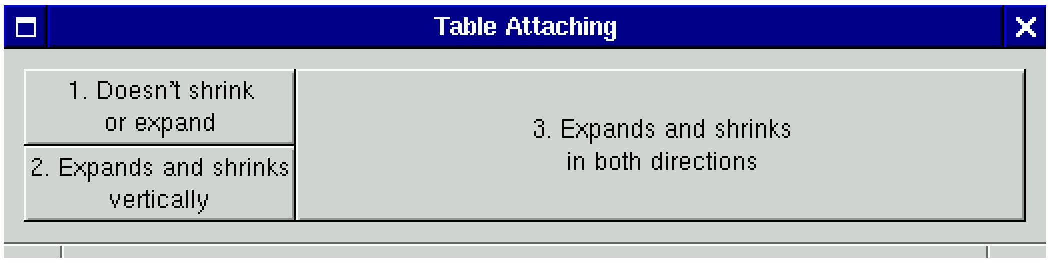
Table Attaching
1. Doesn't shrink or expand
2. Expands and shrinks vertically
3. Expands and shrinks in both directions

Figure 15. GtkTable after expanding the window horizontally

Figure 16 shows the result if the user shrinks the table vertically, so that there isn't enough vertical space to give all the widgets their size requests. Child number two gets shortchanged, while child number one gets all the vertical space it needs.

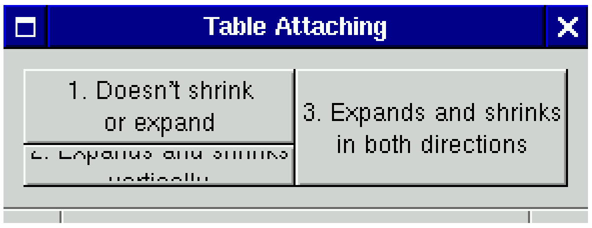
Table Attaching
1. Doesn't shrink or expand
3. Expands and shrinks in both directions

Figure 16. GtkTable after shrinking the window vertically

Finally, Figure 17 shows the result if the user shrinks the table horizontally. Child number three gets the short end of the stick in this situation.

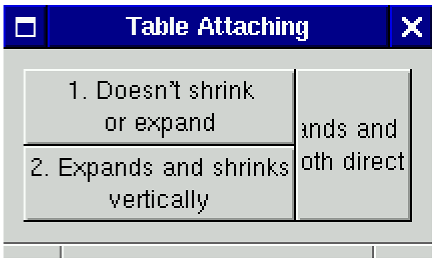
Table Attaching
1. Doesn't shrink or expand
2. Expands and shrinks vertically
ınds and
oth direct

Figure 17. GtkTable after shrinking the window horizontally

It's not a bad idea to try resizing your window like this whenever you're designing a layout, just to be sure something sane happens. The definition of "sane" varies with the exact widgets you've placed in the layout.

Using gtk_table_attach_defaults()

Since gtk_table_attach() is somewhat cumbersome, there's a simpler version called gtk_table_attach_defaults(), shown in Figure 18. This version attaches the child with the options GTK_EXPAND and GTK_FILL, and no padding.

It's tempting to use gtk_table_attach_defaults() all the time to save typing, but really you shouldn't; in fact, it's probably fair to say that it's rarely used. The function is only useful if the defaults happen to be exactly the settings you want. Most of the time, you need to carefully tweak your table attachment parameters to get really nice behavior when your window is resized. Always try resizing your window to be sure you've designed your layout well.

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

GtkWidget* gtk_table_attach_defaults(GtkTable* *table*, GtkWidget* *child*, guint *left_side*, guint *right_side*, guint *top_side*, guint *bottom_side*);

Figure 18. Attaching with Defaults

Other Layout Widgets

Boxes and tables are the most commonly-used layout widgets by far. However, there are a few others for special situations.

- GtkButtonBox is a special kind of box appropriate for the "action area" of a dialog.
- GtkPacker supports Tk-style packing, useful if you're familiar with Tk.
- GtkLayout provides an infinite scrolling area. In general, scrolling areas in GTK+ are limited to just over 30,000 pixels, because that is the maximum size of an X window.
- GtkFixed allows you to manually position widgets at fixed coordinates.

Manually Affecting Layout

It's possible to manually override GTK+'s geometry management. This is a bad idea 95% of the time, because GTK+'s geometry is essentially the user's preferred geometry, determined by the theme, and resizing toplevel windows. If you find yourself wanting to do things manually, it's probably because you're using the wrong layout container, or you really should be writing a custom container widget.

You can force a size or position on a widget with the functions shown in Figure 19. However, it is rarely a good idea to use them. In particular, gtk_widget_set_usize() should not be used to set a toplevel window's default size. Usually you want to set window size because you've saved the application's state and you're restoring it, or because the user specified a window geometry on the command line. Unfortunately, if you use gtk_widget_set_usize() the user will be unable to shrink the window, and you'll get hate mail. Rather than force a size, you want to specify an initial size with gtk_window_set_default_size(), shown in Figure 20. gtk_widget_set_usize() is almost never a good idea for non-toplevel widgets either; most of the time, you can get better results using the proper layout widget.

gtk_widget_set_uposition() is only useful for toplevel windows; it borders on nonsensical for other widgets, and will most likely cause bad things to happen. It's primarily used to honor a --geometry command line argument.

All three of these functions can accept -1 for the x, y, width, or height argument. The functions ignore any -1 argument; this allows you to set only one of the two arguments, leaving the default value for the other.

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

void gtk_widget_set_uposition(GtkWidget* *widget*, gint *x*, gint *y*);

void gtk_widget_set_usize(GtkWidget* *widget*, gint *width*, gint *height*);

Figure 19. Forcing Allocations

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

void gtk_window_set_default_size(GtkWindow* *window*, gint *width*, gint *height*);

Figure 20. Default Window Size

Widget Concepts

This section discusses concepts that apply to all widgets, including memory management and certain special states widgets can be in. It's a "conceptual" section; however, the concepts are very important to practical topics covered later in the book.

Widget Life Cycle

Widget resource and memory management is mostly automatic. However, there are a couple of "gotchas" to keep in mind if you're doing more complicated things.

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

void gtk_widget_destroy(GtkWidget* *widget*);

Figure 21. Widget Destruction

A widget can be destroyed at any time by calling gtk_widget_destroy() (shown in Figure 21); destroying a widget frees any associated memory and other resources. If the widget is inside a container, it is automatically removed from the container before it's destroyed. It's worth noting that gtk_widget_destroy() is simply another name for gtk_object_destroy(); GtkObjects have "virtual destructors" so gtk_object_destroy() will always do the right thing.

Internally, a reference count is maintained for all widgets (actually, all GtkObjects). Objects begin their life with a reference count of 1, even though they have not yet been referenced. At this stage the object is said to be *floating* and is flagged as such. It is possible to remove the object's initial reference; this is called *sinking* the floating object and will destroy the object if the floating reference was the only one.

Containers first reference and then sink any floating widgets that are added to them. By sinking a widget, a container "takes ownership" of it for resource management purposes. Thus, the reference count of the widget remains 1, but the object is no longer flagged as floating. When a widget is removed from a container---or the container is destroyed---the reference count is decremented to 0. When an object's reference count reaches 0, it is destroyed.

In practice, this means that you only have to destroy toplevel widgets; any widgets that are inside a container will be destroyed along with the container.

There's a danger here, however. Sometimes you want to remove a widget from a container; perhaps some element of your interface is optional or only appears under certain circumstances. When you remove the widget (using gtk_container_remove()), it will be unreferenced, its reference count will drop to 0, and it will be destroyed. To avoid this situation, you should add a reference to the widget before you remove it. Figure 22 lists the functions to manipulate reference counts.

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

void gtk_object_ref(GtkObject* *object*);

void gtk_object_unref(GtkObject* *object*);

void gtk_object_sink(GtkObject* *object*);

Figure 22. Reference Counting

gtk_object_ref() and gtk_object_unref() have widget-specific variants (gtk_widget_ref(), etc.) but the object and widget versions are completely synonymous. The widget-specific versions are leftovers from earlier versions of GTK+.

So to safely remove a widget from a container, you might do this:

```

  gtk_widget_ref(widget);
  gtk_container_remove(container, widget);
```

The widget now has one reference, held by your code. At some point you'll need to release the reference, destroying the widget. (It would make sense to do so after re-adding the widget to some other container, for example.)

It's worth pointing out that removing widgets from containers is uncommon; in general it's faster to simply hide the widget with gtk_widget_hide(), then gtk_widget_show() it at some later time.

gtk_object_sink() is used almost exclusively in widget implementations, when you expect to be the primary "owner" of an object. If an object is not "floating", gtk_object_sink() has no effect. To claim ownership of a widget, do this:

```

  gtk_widget_ref(widget);
  gtk_object_sink(GTK_OBJECT(widget));
```

This code adds one reference to the widget; if the widget was "floating," it also subtracts one reference. If the widget was not floating, gtk_widget_sink() has no effect.

It's important to understand the details because in some cases they can be important. But most of the time, you can get by with a few simple rules:

- You must destroy any toplevel widgets when you are done with them, but child widgets are destroyed automatically.
- If you want to remove a widget from a container without destroying it, you must first add a reference to the widget.
- If you add a reference to a widget, you are responsible for unreferencing the widget again when you're done with it.

Realizing, Mapping, and Showing

Fully understanding GTK+ requires some minimal understanding of the X Window System. This book assumes you have a user-level understanding---you know what an X server is, that X is network transparent, what a window manager does, and so on. A few more details are needed to write programs, however.

One detail is particularly important: the X Window System maintains a tree of *windows*. "Window" in this sense refers to an X window, not a GtkWindow---GtkWindow is a GTK+-specific concept, a widget that corresponds to an application's toplevel X window. An X window is not the user-visible concept "window" represented by GtkWindow; rather, it's an abstraction used by the X server to partition the screen. The "background" displayed by your X server is the *root window*; the root window has no parent. Application windows are typically near-children of the root window; most window managers create a child of the root window to hold the window's titlebar and other decorations, and place the application window inside. Window managers have total control over application windows---they can reposition them, reparent them, and iconify them at will. Application windows can in turn contain subwindows, which are controlled by the application. Note that GTK+ uses the GDK library, rather than using X directly; in GDK, there is a thin X window wrapper called GdkWindow. Don't confuse GdkWindow and GtkWindow.

An X window, or a GdkWindow, gives the X server hints about the structure of the graphics being displayed. Since X is network transparent, this helps reduce network traffic. The X server knows how to show windows on the screen; hide them; move them around (keeping children in position relative to their parents); capture events such as mouse movements on a per-window basis; and so on. A GdkWindow is also the fundamental unit for drawing graphics---you can't draw to "the screen" as a whole, you must draw on a GdkWindow.

Most GTK+ widgets have a corresponding GdkWindow. There are exceptions, such as GtkLabel; these are referred to as "no window widgets," and are relatively lightweight. Widgets with no associated GdkWindow draw into their parent's GdkWindow. Some operations, such as capturing events, require a GdkWindow; thus they are impossible on no-window widgets.

Widgets pass through a number of states related to their GdkWindow:

- A widget is said to be *realized* if its corresponding GdkWindow has been created. Widgets are realized via gtk_widget_realize(), and unrealized via gtk_widget_unrealize(). Since an X window must have a parent, if a widget is realized its parent must also be.
- A widget is *mapped* if gdk_window_show() has been called on its GdkWindow. This means the server has been asked to display the window on the screen; obviously the GdkWindow must exist, implying that the widget is realized.
- A widget is *visible* if it will automatically be mapped when its parent is mapped. This means that gtk_widget_show() has been called on the widget. A widget can be rendered invisible by calling gtk_widget_hide(); this will either unschedule the pending map, or unmap the widget (hide its GdkWindow). Since toplevel widgets have no parent, they are mapped as soon as they are shown.

In typical user code, you only need to call gtk_widget_show(); this implies realizing and mapping the widget as soon as its parent is realized and mapped. It's important to understand that gtk_widget_show() has no immediate effect, it merely schedules the widget to be shown. This means you don't have to worry about showing widgets in any particular order; it also means that you can't immediately access the GdkWindow of a widget. Sometimes you need to access the GdkWindow; in those cases you'll want to manually call gtk_widget_realize() to create it. gtk_widget_realize() will also realize a widget's parents, if appropriate. It's uncommon to need gtk_widget_realize(); if you find that you do, perhaps you are approaching the problem incorrectly.

Destroying a widget automatically reverses the entire sequence of events, recursively unrealizing the widget's children and the widget itself.

Figure 23 summarizes the functions discussed in this section.

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

```
void gtk_widget_realize(GtkWidget* widget);

void gtk_widget_unrealize(GtkWidget* widget);
void gtk_widget_map(GtkWidget* widget);

void gtk_widget_unmap(GtkWidget* widget);

void gtk_widget_show(GtkWidget* widget);

void gtk_widget_hide(GtkWidget* widget);
```

Figure 23. Showing/Realizing Widgets

Figure 24 summarizes macros for querying the states discussed in this section.

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

```
GTK_WIDGET_NO_WINDOW(widget);

GTK_WIDGET_REALIZED(widget);

GTK_WIDGET_MAPPED(widget);

GTK_WIDGET_VISIBLE(widget);
```

Figure 24. Widget Predicates

Other Widget Concepts

This section describes a few other concepts associated with the GtkWidget base class, including *sensitivity*, *focus*, and *widget states*.

Sensitivity

Widgets can be *sensitive* or *insensitive*; insensitive widgets do not respond to input. (On other platforms, this is termed "ghosted" or "inactive").

gtk_widget_set_sensitive() (Figure 25) changes a widget's sensitivity.

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

```
void gtk_widget_set_sensitive(GtkWidget* widget, gboolean setting);
```

Figure 25. Changing Sensitivity

By default sensitivity is set to TRUE. A widget is only "really" sensitive if all its parents are sensitive; that is, you can make an entire container full of widgets (in)sensitive by setting the sensitivity of the container. The "real" sensitivity of a widget, including its parent's state, can be tested with the GTK_WIDGET_IS_SENSITIVE() macro. The sensitivity of the widget itself, which only matters if the widget's parent is sensitive, can be queried using GTK_WIDGET_SENSITIVE(). These are in Figure 26.

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

GTK_WIDGET_IS_SENSITIVE(*widget*);

GTK_WIDGET_SENSITIVE(*widget*);

Figure 26. Sensitivity

Focus

Within each toplevel window, one widget at a time may have the *keyboard focus*. Any key events received by the toplevel window are forwarded to the focused widget. This is important because typing something on the keyboard should have only one effect---changing only one text entry field, for example.

Most widgets will give some visual indication that they have the current focus. Using the default GTK+ theme, the focused widget is typically surrounded by a thin black frame. The user can move the focus between widgets, using the arrow keys or the Tab key. Focus can also move to a widget if the user clicks it.

The concept of focus is important for keyboard navigation. For example, pressing Enter or the space bar "activates" many widgets if they have the focus; you can move between buttons with the Tab key, and press one with Space, for example.

Grabs

Widgets can *grab* the pointer and keyboard away from other widgets. This essentially means that the widget becomes "modal"; input goes only to that widget, and the focus can't be changed to another widget. A typical reason to grab input is to create a modal dialog; if a window has the grab, interaction with other windows is blocked. Note that there is another, GDK-level "grab"; a GDK keyboard or pointer grab occurs on an

X-server-wide basis---that is, other applications are unable to receive keyboard or mouse events. A widget grab is a GTK+ concept; it only grabs events away from other widgets in the same application.

Default

Each window may have at most one *default* widget. For example, dialogs typically have a default button which is activated when the user presses the Enter key.

Widget States

Widgets have *states* which determine their appearance:

- *Normal*: just like it sounds.
- *Active*: a button is currently pressed in, or a check box is currently checked, for example.
- *Prelight*: the mouse is over the widget (and typically clicking would have some effect). Buttons "highlight" when you move over them, for example.
- *Selected*: the widget is in a list or other set of alternatives, and is the currently selected option.
- *Insensitive*: the widget is "ghosted," inactive, or unresponsive; it will not respond to input.

The exact meaning and visual representation of a given state depends on the particular widget and the current theme. You can access the state of the widget GTK_WIDGET_STATE() (Figure 27). This macro returns one of the constants GTK_STATE_NORMAL, GTK_STATE_ACTIVE, GTK_STATE_PRELIGHT, GTK_STATE_SELECTED, or GTK_STATE_INSENSITIVE.

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

GTK_WIDGET_STATE(*widget*);

Figure 27. State Accessor

The Main Loop

The GTK+ main loop's primary role is to listen for events on a file descriptor connected to the X server, and forward them to widgets. the section called *Receiving GDK Events in GTK+* in the chapter called *GDK*

Basics describes the main loop's event handling in more detail. This section explains the main loop in general terms, and describes how to add new functionality to the main loop: callbacks to be invoked when the loop is idle, at a specified interval, when a file descriptor is ready for reading or writing, and when the main loop exits.

Main Loop Basics

The main loop is primarily implemented by glib, which has a generic main loop abstraction. GTK+ attaches the glib main loop to GDK's X server connection, and presents a convenient interface (the glib loop is slightly lower-level than the GTK+ loop). The core GTK+ main loop interface is shown in Figure 28.

gtk_main() runs the main loop. gtk_main() will not return until gtk_main_quit() is called. gtk_main() can be called recursively; each call to gtk_main_quit() exits one instance of gtk_main(). gtk_main_level() returns the level of recursion; that is, it returns 0 if no gtk_main() is on the stack, 1 if one gtk_main() is running, etc.

All instances of gtk_main() are functionally identical; they are all watching the same connection to the X server and working from the same event queue. gtk_main() instances are used to block, halting a function's flow of control until some conditions are met. All GTK+ programs use this technique to keep main() from exiting while the application is running. The gnome_dialog_run() function (see the section called *Modal Dialogs* in the chapter called *User Communication: Dialogs*) uses a recursive main loop, so it doesn't return until the user clicks a dialog button.

Sometimes you want to process a few events, without handing the flow of control to gtk_main(). You can perform a single iteration of the main loop by calling gtk_main_iteration(). This might process a single event, for example; it depends on what tasks are pending. You can check whether any events need to be processed by calling the gtk_events_pending() predicate. Together, these two functions allow you to temporarily return control to GTK+, so the GUI can "catch up." For example, during a long computation, you will want to display a progress bar; you must allow the GTK+ main loop to run periodically, so GTK+ can redraw the progress bar. Use this code:

```
  while (gtk_events_pending())
    gtk_main_iteration();
```

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

```
void gtk_main(void);

void gtk_main_quit(void);

void gtk_main_iteration(void);

gint gtk_events_pending(void);

guint gtk_main_level(void);
```

Figure 28. Main Loop

Quit Functions

A *quit function* is a callback to be invoked when gtk_main_quit() is called. In other words, the callback runs just before gtk_main() returns. The callback should be a GtkFunction, defined as follows:

```
typedef gint (*GtkFunction) (gpointer data);
```

Quit functions are added with gtk_quit_add() (Figure 29). When adding a quit function, you must specify a main loop level, as returned by gtk_main_level(). The second and third arguments specify a callback and callback data.

The callback's return value indicates whether the callback should be invoked again. As long as the callback returns TRUE, it will be repeatedly invoked. As soon as it returns FALSE, it is disconnected. When all quit functions have returned FALSE, gtk_main() can return.

gtk_quit_add() returns an ID number that can be used to remove the quit function with gtk_quit_remove(). You can also remove a quit function by passing its callback data to gtk_quit_remove_by_data().

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

guint gtk_quit_add(guint main_level, GtkFunction function, gpointer data);

void gtk_quit_remove(guint quit_handler_id);

void gtk_quit_remove_by_data(gpointer data);
```

Figure 29. Quit Functions

Timeout Functions

Timeout functions are connected and disconnected exactly as quit functions are; the expected callback is the same. gtk_timeout_add() expects an interval argument; the callback is invoked every interval milliseconds. If the callback ever returns FALSE, it is removed from the list of timeout functions, just as if you'd called gtk_timeout_remove(). It is not safe to call gtk_timeout_remove() from within a timeout function; this modifies the timeout list while GTK+ is iterating over it, causing a crash. Instead, return FALSE to remove a function.

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

guint gtk_timeout_add(guint32 *interval*, GtkFunction *function*, gpointer *data*);

void gtk_timeout_remove(guint *timeout_handler_id*);

Figure 30. Timeout Functions

Idle Functions

Idle functions run continuously while the GTK+ main loop has nothing else to do. Idle functions run only when the event queue is empty and the main loop would normally sit idly, waiting for something to happen. As long as they return TRUE they are invoked over and over; when they return FALSE, they are removed, just as if gtk_idle_remove() had been called.

The idle function API, shown in Figure 31, is identical to the timeout and quit function APIs. Again, gtk_idle_remove() should not be called from within an idle function, because it will corrupt GTK+'s idle function list. Return FALSE to remove the idle function.

Idle functions are mostly useful to queue "one-shot" code, which is run after all events have been handled. Relatively expensive operations such as GTK+ size negotiation and GnomeCanvas repaints take place in idle functions that return FALSE. This ensures that expensive operations are performed only once, even though multiple consecutive events independently request the recalculation.

The GTK+ main loop contains a simple scheduler; idle functions actually have priorities assigned to them, just as UNIX processes do. You can assign a non-default priority to your idle functions, but it's a complicated topic outside the scope of this book.

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

guint gtk_idle_add(GtkFunction *function*, gpointer *data*);

void gtk_idle_remove(guint *idle_handler_id*);

void gtk_idle_remove_by_data(gpointer *data*);

Figure 31. Idle Functions

Input Functions

Input functions are handled on the GDK level. They are invoked when a given file descriptor is ready for reading or writing. They're especially useful for networked applications.

To add an input function, you specify the file descriptor to monitor, the state you want to wait for (ready for reading or writing), and a callback/data pair. Figure 32 shows the API. Functions can be removed using the tag returned by gdk_input_add(). Unlike quit, timeout, and idle functions, it should be safe to call gdk_input_remove() from inside the input function; GTK+ will not be in the midst of iterating over the list of input functions.

To specify the condition(s) to wait for, use the GdkInputCondition flags: GDK_INPUT_READ, GDK_INPUT_WRITE, and GDK_INPUT_EXCEPTION. You can OR one or more flags together. These correspond to the three file descriptor sets passed to the select() system call; consult a good UNIX programming book for details. If any condition is met, the input function is invoked.

The callback should look like this:

```
typedef void (*GdkInputFunction) (gpointer data,
                                  gint source_fd,
                                  GdkInputCondition condition);
```

It receives your callback data, the file descriptor being watched, and the conditions that were met (possibly a subset of those you were watching for).

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

gint gdk_input_add(gint *source_fd*, GdkInputCondition *condition*, GdkInputFunction *function*, gpointer *data*);

void gdk_input_remove(gint *tag*);

Figure 32. Input Functions

II. Building a Gnome Application

With the basic concepts out of the way, you're ready to start building a full-scale Gnome application. This part of the book walks you through the creation of a generic application skeleton: a source tree using automake and autoconf, argument parsing, session management, internationalization, the main window, dialogs, toolbars, and menubars. Many examples in Part 2 come from a simple application called "GnomeHello"; the source code for this application is included in the back of the book.

Of course the "meat" of the application is up to you; but in Part 3 of the book we'll cover a range of library features you can use to develop it.

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Creating Your Source Tree

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Installing Support Files

Almost all Gnome applications use the same build system based on the GNU tools automake, autoconf, and libtool. GTK+ and Gnome provide a set of autoconf macros that make it easy to create a portable, standards-compliant build setup. Due to the bewildering array of tools involved, it can be difficult to figure out how Gnome source trees work; there are manuals available for each tool, but none describes the "big picture." This chapter gives you a simple overview that should help you get started. It also covers some Gnome-specific details, and tells you how to ship and install your application's icons, translations, and documentation.

If you're writing a large application, or a library, this chapter won't have all the information you need; you will probably need to consult the GNU tools' manuals to get more details. A complete discussion would fill the entire book.

Beginning with this chapter and continuing throughout Part 2 of the book, a sample application called GnomeHello will be used to demonstrate Gnome features. The GnomeHello source code is listed in Appendix E and the entire GnomeHello source tree is available online. It may be convenient to use it as a template for your own application's source code.

You may miss the simple Makefile made possible by the gtk-config script; there is an equivalent gnome-config script (use gnome-config --help to learn how to use it). However, these simple makefiles are not adequate for any real-world application.

Overview of a Gnome Source Tree

Gnome application build trees and distributed tarballs follow a set of conventions, most of them widespread in the free software community. Aspects of these conventions are formalized in documents such as the GNU Project's Coding Standards (http://www.gnu.org/prep/standards_toc.html) and the Linux Filesystem Hierarchy Standard (http://www.pathname.com/fhs/). It's worth using these standards even with non-free software---partially because they are very good from a technical standpoint, and partially because "going with the flow" will save you a lot of trouble, especially if you're using the GNU toolset. Besides, you might want to free your software someday.

The GNU toolset, including automake and autoconf will make it easy to comply with these standards. However, sometimes there are reasons not to use the GNU tools; for example, you may want a unified build that works on platforms such as Windows and MacOS. (Some of the tools do work with Windows using the Cygnus "Cygwin" environment, however; see http://sourceware.cygnus.com/cygwin.)

If you use autoconf and automake, users are not required to have these tools in order to build your software. The purpose of the tools is to build portable shell scripts and makefiles that will work in the user's environment.

The autoconf package encompasses the aclocal, autoheader, and autoconf executables. Together, these tools are used to create a portable shell script called configure; configure is distributed to users with your software package. It explores the compilation system and creates makefiles and a special header called config.h. The files created by configure are adapted to the specifics of the user's system.

configure creates each Makefile from a template, called Makefile.in; automake is a tool for creating these templates. automake generates Makefile.in from a hand-written Makefile.am. You distribute Makefile.in with your software, and users create a Makefile when they run configure.

The libtool package is the third important GNU tool; its purpose is to abstract the idiosyncracies of shared libraries (static library behavior is fairly uniform across UNIX-like systems, but shared libraries present major portability issues).

Informally, here are some of characteristics most Gnome packages have in common:

- A file called README that describes the package.
- A file called INSTALL that explains how to compile and install the package.
- A script called configure that automatically adapts the program to platform-specific features (or the lack thereof). configure is expected to take an argument --prefix, specifying where to install the package.
- Standard make targets, such as clean, etc.
- A file called COPYING containing the package's copyright.
- A ChangeLog in which changes to the software are recorded.
- Tar files are traditionally compressed with gzip and their name includes the package version (for example, foo-0.2.1.tar.gz). They should unpack into a single directory, named with package and version---foo-0.2.1.

- *Internationalization* is provided via the GNU gettext package. A copy of gettext is shipped along with the application, so users do not have to have one.

Source Tree Checklist

As an initial overview, here are the important steps in creating a skeletal Gnome source tree. If you are starting a new program, you can simply follow this list and you won't forget anything. The rest of this chapter explains the checklist in more detail. It might also be helpful to download a Gnome package or two to look at as you follow the discussion (in particular, the "GnomeHello" source tree is intended to illustrate a proper build setup).

1. Create a toplevel directory to hold all the components of your application, including build files, documentation, and translations.
2. It's often nice to create a src subdirectory of this toplevel directory to keep source code separate from everything else.
3. In the toplevel directory, create AUTHORS, NEWS, COPYING, and README files. If desired, also create an empty ChangeLog.
4. Write a configure.in; the main purpose of configure.in is to determine which compiler, compiler flags, and linker flags to use. configure.in can also #define symbols to reflect features of the current platform, placing these definitions in the automatically-generated file config.h.
5. Write acconfig.h, which is a template for config.h.in. This file should #undef each symbol you will potentially #define in config.h. The autoheader program creates config.h.in based on acconfig.h, and autoconf creates config.h. autoheader comes with autoconf.
6. Create an empty file, stamp.h.in; this is used by the AM_CONFIG_HEADER macro in configure.in.
7. Write a Makefile.am in the toplevel directory listing each subdirectory which contains source code; in each subdirectory, also write a Makefile.am.
8. Run the gettextize program that comes with the gettext package. This creates the intl and po directories, needed for internationalization (gettextize is documented in the gettext manual). The intl contains the GNU gettext source code; if users compiling the program do not have gettext, they can pass the --with-included-gettext option to configure to automatically compile a static version in the intl directory. The po directory holds the translation files; gettextize will also create a file called po/Makefile.in.in, used to build the translations.

9. Create a file called po/POTFILES.in listing source files which should be scanned for strings to translate. POTFILES.in can be empty at first.
10. Copy autogen.sh and the macros directory from another Gnome module. You must modify autogen.sh to reflect the name of your package. Running autogen.sh will invoke libtoolize, aclocal, autoheader, automake, and autoconf.
11. autogen.sh invokes automake with the --add-missing argument. This will add some files, such as INSTALL with generic installation instructions. You can (and should) edit INSTALL to include any specific instructions for your application. autogen.sh will also create a Makefile in each directory.

configure.in

autoconf processes configure.in to produce a configure script. configure is a portable shell script which examines the build environment to determine which libraries are available, which features the platform has, where libraries and headers are located, and so on. Based on this information, it modifies compiler flags, generates makefiles, and/or outputs the file config.h with appropriate preprocessor symbols defined. Again, configure does not require autoconf to run; you generate it before distributing your software, so users do not have to have autoconf.

Your job is to write configure.in. The file is basically a series of m4 macros, which expand to snippets of shell script according to the parameters you pass them. You can also write shell code manually. Really understanding how to write a configure.in requires some knowledge of m4 (which is pretty simple) and some knowledge of the Bourne shell (which is a black art). Fortunately, you can cheat: start with an existing configure.in and modify it slightly to suit your application. There's also an extensive autoconf manual, which describes the many pre-written macros shipped with autoconf.

The GTK+ and Gnome developers have simplified things still further, by providing macros to locate GTK+ and Gnome on the user's system.

Here is a sample configure.in, from a Gnome version of "Hello, World":

```
AC_INIT(src/hello.c)

AM_CONFIG_HEADER(config.h)

AM_INIT_AUTOMAKE(GnomeHello, 0.1)
```

```
AM_MAINTAINER_MODE

AM_ACLOCAL_INCLUDE(macros)

GNOME_INIT

AC_PROG_CC
AC_ISC_POSIX
AC_HEADER_STDC
AC_ARG_PROGRAM
AM_PROG_LIBTOOL

GNOME_COMPILE_WARNINGS

ALL_LINGUAS="da de es fr gl nl no pl ru sv fi uk"
AM_GNU_GETTEXT

AC_SUBST(CFLAGS)
AC_SUBST(CPPFLAGS)
AC_SUBST(LDFLAGS)

AC_OUTPUT([
Makefile
macros/Makefile
src/Makefile
intl/Makefile
po/Makefile.in
pixmaps/Makefile
doc/Makefile
doc/C/Makefile
doc/es/Makefile
])
```

Before describing each macro, some general points should be made. First, those macros that begin with AC come with autoconf, and those that begin with AM usually come with automake. (This is useful when you're trying to find documentation for them.) The macros that begin with GNOME come in the Gnome macros directory. These macros are written in m4; the standard ones from autoconf/automake reside in /usr/share/aclocal, if you installed autoconf/automake under /usr. (An aside: the macros directory is not a good thing; each Gnome package should install its own m4 files to /usr/share/aclocal. Newer Gnome versions attempt to fix the problem.)

- AC_INIT is always the first macro in configure.in. It expands to a lot of boilerplate code shared by all configure scripts; this code parses the command line arguments to configure. The macro's one argument is a file that should be present in the source directory; this is used as a sanity check, to be sure configure has correctly located the source directory.
- AM_CONFIG_HEADER specifies a header file to create; this will almost always be config.h. The created header file will contain C preprocessor symbols defined by configure. At a minimum, the symbols PACKAGE and VERSION will be defined, which makes it easy to put the name and version of your program in your code without hard-coding them. (Your non-public source files should #include <config.h> to take advantage of its definitions; however, config.h should never be installed, because it would conflict with other packages.)
- AM_INIT_AUTOMAKE initializes automake; the arguments to this macro are the name and version of the package being compiled. (These arguments become the values of PACKAGE and VERSION, defined in config.h.)
- AM_MAINTAINER_MODE turns off maintainer-only makefile targets by default, and changes configure to understand a --enable-maintainer-mode option. --enable-maintainer-mode turns the maintainer-only targets back on. The maintainer-only makefile targets permit end users to clean automatically-generated files such as configure, which means they have to have autoconf and automake installed to repair the damage. AM_MAINTAINER_MODE makes it a bit harder for users to shoot themselves in the foot. Note, however, that the autogen.sh script used in Gnome automatically passes --enable-maintainer-mode to configure, since autogen.sh is intended for developers to use.
- AM_ACLOCAL_INCLUDE specifies an additional directory in which to search for m4 macros. In this case, it specifies the macros subdirectory, where you should have copied the Gnome macros.
- GNOME_INIT adds a number of Gnome-related command-line arguments to configure, and defines makefile variables containing the necessary preprocessor and linker flags for Gnome programs. These flags are obtained from a gnome-config script installed by the gnome-libs package.
- AC_PROG_CC locates the C compiler.
- AC_ISC_POSIX adds some flags needed for POSIX compatibility on certain platforms.

- AC_HEADER_STDC checks whether the present system has the standard ANSI header files, and defines STDC_HEADERS if so.
- AC_ARG_PROGRAM adds options to configure so that users can modify the name of an installed program. (Useful if your program happens to have the same name as some locally-installed program on their system.)
- AM_PROG_LIBTOOL is used by automake to set up its use of libtool. This is only required if you are planning to build a shared library or dynamically loadable modules; it is unnecessary for this early version of GnomeHello, but we're planning ahead.
- GNOME_COMPILE_WARNINGS adds a number of warning options to the gcc command line, but does nothing for most other compilers.
- ALL_LINGUAS="es" is not a macro, just a bit of shell code. It contains a space-separated list of language abbreviations, corresponding to .po files in the po subdirectory. (.po files contain translations into other languages, so ALL_LINGUAS should list all languages your program has been translated into.)
- AM_GNU_GETTEXT is used by automake, but the macro itself is distributed with the gettext package. It causes automake to perform a number of internationalization-related tasks.
- AC_SUBST "exports" a variable into the files generated by configure. More on this below.
- AC_OUTPUT lists the files to be created by the configure script. These will be created from a file with the same name, with .in appended. For example, the output file src/Makefile is generated from src/Makefile.in, and config.h comes from config.h.in.

In the AC_OUTPUT stage, configure processes files containing variables marked with two @ symbols; for example, @PACKAGE@. It recognizes such variables only if AC_SUBST was used to "export" the variable (many of the pre-written macros discussed above use AC_SUBST to define variables). Most commonly, this features is used to convert a Makefile.in to a Makefile. Makefile.in is typically generated by automake from Makefile.am. (However, you can use autoconf without automake, and write Makefile.in yourself.)

Makefile.am

automake processes Makefile.am to produce a standards-compliant Makefile.in. automake does a lot of work for you: it keeps up with dependencies between source files, for example. It creates all the standard targets, such as install and clean. It also creates more complex targets: simply typing make dist creates a standard .tar.gz file if your Makefile.am is correct.

The Makefile.am in the top source directory is generally very simple; here is an example:

```
SUBDIRS = macros po intl src pixmaps doc

## We dist autogen.sh since this is an example program
## Real-world programs do not need to distribute autogen.sh
EXTRA_DIST = \
        gnome-hello.desktop \
    autogen.sh

Applicationsdir = $(datadir)/gnome/apps/Applications
Applications_DATA = gnome-hello.desktop
```

The SUBDIRS line instructs automake to recursively look for Makefile.am files in the given subdirectories. (the section called *.desktop Entries* describes the remainder of the file, ignore it for now.) The Makefile.am in the src directory is a little more interesting:

```
INCLUDES = -I$(top_srcdir) -I$(includedir) $(GNOME_INCLUDEDIR) \
         -DG_LOG_DOMAIN=\"GnomeHello\"
-DGNOMELOCALEDIR=\""$(datadir)/locale"\" \
    -I../intl -I$(top_srcdir)/intl

bin_PROGRAMS = gnome-hello

gnome_hello_SOURCES =         \
        app.c           \
        hello.c         \
        menus.c     \
    app.h       \
    hello.h     \
    menus.h

gnome_hello_LDADD = $(GNOMEUI_LIBS) $(GNOME_LIBDIR) $(INTLLIBS)
```

automake understands a number of "magic variables" and can use them to create Makefile.in. In the small example above, the following variables are used:

- INCLUDES specifies flags to pass to the C compiler during the compile phase (as opposed to the link phase). The variables used in this line come from the configure.in shown in the previous section.
- bin_PROGRAMS lists the programs to be compiled.
- hello_SOURCES lists the files to be compiled and linked to create the program called hello; hello must be listed in bin_PROGRAMS. All files in this variable are automatically included in the distribution.
- hello_LDADD lists flags to be passed to the linker. In this case, Gnome library flags determined by configure.

Several elements of the INCLUDES line should be used in all Gnome programs. G_LOG_DOMAIN should always be defined; error messages from checks and assertions will report this value, so you can determine where the error occurred (in your code, or in a library). GNOMELOCALEDIR is used to locate translation files. The intl directory is added to the header search path so the application can find the intl headers.

There are many more complex things one can do in Makefile.am; in particular, you can add @-bounded variables to be substituted by configure, you can conditionally include portions of the Makefile based on configure checks, and you can build libraries. The automake manual gives more details.

Table 1 summarizes the most interesting targets generated by automake. Of course the default target is all, which compiles the program. The GNU Coding Standards (http://www.gnu.org/prep/standards_toc.html) have more information about these targets and GNU makefiles in general.

Table 1. Standard make targets

Target	Description
dist	Builds a tarball (.tar.gz) for distribution
distcheck	Builds a tarball, then tries to compile it
clean	Deletes the results of compilation (object files and executables), but may not delete some generated files that come with the distribution.
install	Creates installation directories if needed, and copies the software into them.
uninstall	Reverses the install (deletes installed files).
distclean	Reverse the effects of the configure script and the all

	target; that is, revert a tarball to its pristine state.
mostlyclean	Nearly the same as clean, but leaves some object files that most likely don't need to be rebuilt.
maintainer-clean	More thorough than clean; may delete some files that require special tools to rebuild, such as machine-generated source code.
TAGS	Creates a tag table, for use with Emacs.
check	Runs a test suite if you have one

Relevant GNU Documentation

A number of GNU manuals are relevant to the topics discussed in this chapter, and will give you a deeper understanding. It is worth reading the tutorial sections of each of these. GNU manuals come with the software, and are also available from http://www.gnu.org/doc/doc.html.

- The libtool manual explains the intermediate .lo and .la files created while your program or library is compiling; automake generates makefiles which use libtool.
- The autoconf manual explains how to write configure.in and its associated files.
- The automake manual explains how to write a Makefile.am.
- The gettext manual has sections titled "Programmers" and "Maintainers"; you should read these to learn how the intl and po subdirectories work.
- The GNU coding standards describe how GNU packages should behave; autoconf and automake try to implement these standards.
- The GNU hello package is intended to demonstrate the GNU packaging standards, and is an excellent source of examples. "GnomeHello" and other Gnome packages are a good source of Gnome-specific examples, of course.
- The manuals for make, the Bourne shell, and m4 are essential if you need to write custom configure checks or add Makefile targets outside of automake's capabilities.

Installing Support Files

Complete Gnome applications consist of more than just code. They have online help, are listed on the Gnome panel's menu, have translations, and have a desktop icon. They might come with pixmaps as well: a logo for the "about" dialog, a graphic for a "wizard," or a small icons to help the user rapidly distinguish menu items or list elements. This section tells you how to ship some of these files.

Installing Datafiles: Documentation and Pixmaps

Documentation and pixmaps are installed in much the same way; automake allows you to install datafiles to arbitrary locations, and you can use variables defined by configure to decide where they should go.

Pixmaps

To install datafiles from your Makefile.am you simply come up with a name for the install target---pixmap seems good---then create a variable for the directory and a corresponding variable for the files to install there. For example:

```
EXTRA_DIST = gnome-hello-logo.png

pixmapdir = $(datadir)/pixmaps

pixmap_DATA = gnome-hello-logo.png
```

The "pixmap" string connects the pixmapdir variable with the pixmap_DATA variable. automake interprets the _DATA suffix and generates appropriate rules in Makefile.in. This Makefile.am segment installs gnome-hello-logo.png into $(datadir)/pixmaps; $(datadir) is a variable filled in by configure. Typically $(datadir) is /usr/local/share (more precisely, $(prefix)/share), which is the standard location for architecture-independent data files (that is, files which can be shared between several systems with different binary file formats).

the section called *EXTRA_DIST* describes the EXTRA_DIST variable.

The standard location for Gnome pixmaps is $(datadir)/pixmaps, so we used that in the example. The Gnome Project encourages the use of PNG format for all pixmaps; this format is supported by gdk_imlib, the Gnome image-loading library. It is also small, fast, and unencumbered by patents.

Documentation

Installing documentation uses the same principles, with a little more complication. Gnome documentation is typically written in DocBook. DocBook is an SGML DTD ("Document Type Definition") just as HTML is. However, DocBook's tags are designed for technical documentation. Documentation written in DocBook can be converted to several other formats, including PostScript and HTML. Standardly, you want to install the HTML format so users can read it with their web browser or the Gnome help browser.

The Gnome libraries and help browser understand a file called topic.dat, which is simply a list of help topics with corresponding URLs. It serves as an index of help topics for your application. Here's an example, with only two entries:

```
gnome-hello.html        GnomeHello manual
advanced.html           Advanced Topics
```

URLs are relative to the directory where you install your help files.

You should consider in advance that your documentation will be translated into other languages. It is nice to make a subdirectory in your source tree for each locale; for example, the default C locale or the es (Spanish) locale. That way translations don't cause clutter. Gnome expects help to be installed in a directory named after the locale, so this arrangement is convenient from that point of view as well. Your documentation directory might look like this one from the GnomeHello example application:

```
doc/
  Makefile.am
  C/
    Makefile.am
    gnome-hello.sgml
    topic.dat
  es/
    Makefile.am
    gnome-hello.sgml
    topic.dat
```

Here is doc/C/Makefile.am:

```
gnome_hello_helpdir = $(datadir)/gnome/help/gnome-hello/C

gnome_hello_help_DATA =         \
        gnome-hello.html        \
        topic.dat

SGML_FILES =                    \
        gnome-hello.sgml

# files that aren't in a binary/data/library target have to be listed here
# to be included in the tarball when you 'make dist'
EXTRA_DIST = \
        topic.dat               \
        $(SGML_FILES)


## The - before the command means to ignore it if it fails.  that way
## people can still build the software without the docbook tools

all:

gnome-hello.html: gnome-hello/gnome-hello.html
    -cp gnome-hello/gnome-hello.html .

gnome-hello/gnome-hello.html: $(SGML_FILES)
    -db2html gnome-hello.sgml

## when we make dist, we include the generated HTML so people don't
## have to have the docbook tools
dist-hook:
    mkdir $(distdir)/gnome-hello
    -cp gnome-hello/*.html gnome-hello/*.css $(distdir)/gnome-hello
    -cp gnome-hello.html $(distdir)

install-data-local: gnome-hello.html
    $(mkinstalldirs) $(gnome_hello_helpdir)/images
    -for file in $(srcdir)/gnome-hello/*.html
$(srcdir)/gnome-hello/*.css; do \
    basefile=`basename $$file`; \
    $(INSTALL_DATA) $(srcdir)/$$file
$(gnome_hello_helpdir)/$$basefile; \
    done

gnome-hello.ps: gnome-hello.sgml
    -db2ps $<

gnome-hello.rtf: gnome-hello.sgml
    -db2rtf $<
```

In particular notice the install directory for the generated HTML files: $(datadir)/gnome/help/gnome-hello/C. The Gnome libraries look for help here. Each application's help goes in its own directory under $(datadir)/gnome/help. Each locale's documentation is installed in its own subdirectory of the application directory. Other rules in Makefile.am run the DocBook-to-HTML converter, include HTML in the distribution tarball, and create PostScript and Rich Text Format targets. (Users can create PostScript by typing make gnome-hello.ps explicitly.)

.desktop Entries

Gnome programs come with ".desktop entries," which are simply small files describing how the application should appear in menus. Installing a .desktop entry causes your application to show up in the Gnome panel menu. Here is gnome-hello.desktop:

```
[Desktop Entry]
Name=Gnome Hello
Name[es]=Gnome Hola
Name[fi]=GNOME-hei
Name[gl]=Ola GNOME
Name[no]=Gnome hallo
Name[sv]=Gnome Hej
Name[pl]=Halo GNOME
Comment=Hello World
Comment[es]=Hola Mundo
Comment[fi]=Hei, maailma
Comment[gl]=Ola Mundo
Comment[sv]=Hej Världen
Comment[no]=Hallo verden
Comment[pl]=Witaj ¶wiecie
Exec=gnome-hello
```

```
Icon=gnome-hello-logo.png
Terminal=0
Type=Application
```

The file consists of key-value pairs. The Name key specifies the name of your application in the default (C) locale; any key can have translations with a locale appended in brackets, such as Name[es]. The Comment key is a "tooltip" or hint describing the application in more detail. Exec is the command line to use to execute the program. Terminal is a boolean value; if non-zero, the program will be run inside a terminal. Type should always be "Application" in this context.

Installing a .desktop entry is simple; here is the toplevel Makefile.am from GnomeHello again:

```

SUBDIRS = macros po intl src pixmaps doc

## We dist autogen.sh since this is an example program
## Real-world programs do not need to distribute autogen.sh
EXTRA_DIST = \
        gnome-hello.desktop \
    autogen.sh

Applicationsdir = $(datadir)/gnome/apps/Applications
Applications_DATA = gnome-hello.desktop
```

Notice that there is a directory tree under $(datadir)/gnome/apps/ with subdirectories that arrange programs into categories. GnomeHello installs itself in the "Applications" category; other programs might choose "Games," "Graphics," "Internet," or whatever is appropriate. Try to choose a category that already exists, rather than inventing your own.

EXTRA_DIST

The EXTRA_DIST variable in a Makefile.am lists files to be included in the distribution (tarball). Most important files are automatically included; for example, all files listed as source files for binaries or libraries. However, automake does not know about .desktop files, or SGML documentation; so these files must be listed in EXTRA_DIST. make distcheck's attempt to build the distribution will normally fail if you leave files out of EXTRA_DIST.

Gnome Application Basics

Table of Contents

This chapter describes the most rudimentary aspects of a Gnome application, including initializing the libraries, marking strings for translation, parsing command line arguments, saving configuration files, and responding to requests from the session manager. From here on, the book assumes you know how to write a simple GTK+-only application.

Initializing the Libraries

On startup, your application must initialize the GTK+ and Gnome libraries with a call to gnome_init(). gnome_init() (Figure 1) takes the place of gtk_init() for Gnome apps (it calls gtk_init() for you).

The first argument to gnome_init() is a short name for your application, and the second is a string representing the application's version. These are used internally by the Gnome libraries (in some default messages provided by the argument parser, for example).

```
#include <libgnomeui/gnome-init.h>
```

int gnome_init(const char* *app_id*, const char* *app_version*, int *argc*, char** *argv*);

Figure 1. Initializing Gnome

Like gtk_init(), gnome_init() parses the command-line arguments; unlike gtk_init(), it will not change argc and argv. If you want to parse application-specific options, you should use gnome_init_with_popt_table(), described in the next section.

The return value from gnome_init() is supposed to be non-zero if initialization fails, but the current implementation always returns 0. (gnome_init() will simply abort if there's a problem, such as a missing X server.) Common practice is to ignore this return value, at least in

Gnome 1.0, but it's a good idea to check it anyway in case future versions do return an error.

[FOOTNOTE - reference after "always returns 0."] Most people consider this a misfeature, but gtk_init() shared the same problem until just before Gnome 1.0, so there was little to be done. Future versions will hopefully fix the problem.

Internationalization

All user-visible strings in a Gnome application should be marked for translation. Translation is achieved using the GNU gettext facility. gettext is simply a message catalog; it stores key-value pairs, where the key is the string hard-coded into the program, and the value is a translated string (if appropriate) or simply the key (if there's no translation, or the key is already in the correct language).

As a programmer, it's not your responsibility to provide translations. However, you must make sure strings are marked for translation---so that gettext's scripts can extract a list of strings to be translated---and you must call a special function on each string when the catalog lookup should take place.

```
#include <libgnome/gnome-i18n.h>
```

_(*string*);

N_(*string*);

Figure 2. Translation Macros

Gnome makes this easy, by defining two macros shown in Figure 2. The macro _() both marks the string for translation and performs the message-catalog lookup. You should use it in any context C permits a function call. The N_() macro is a no-op, but marks the string for translation. You can use it when C does not permit a function call; for example in static array initializers. If you mark a string for translation with N_(), you must eventually call _() on it to actually perform the lookup.

Here's a simple example:

```

#include <gnome.h>

```

```
static char* a[] = {
  N_("Translate Me"),
  N_("Me Too")
};

int main(int argc, char** argv)
{
  bindtextdomain(PACKAGE, GNOMELOCALEDIR);
  textdomain(PACKAGE);

  printf(_("Translated String\n"));
  printf(_(a[0]));
  printf(_(a[1]));

  return 0;
}
```

Notice that the string literals "Translate Me" and "Me Too" are marked so that gettext can find them and produce a list of strings to be translated. Translators will use this list to create the actual translations. Later, _() includes a function call to perform the tranlation lookup on each member of the array. Since a function call is allowed when the string literal "Translated String" is introduced, everything can happen in a single step.

At the beginning of your program, you have to call bindtextdomain() and textdomain() as shown in the above example. In the above code, PACKAGE is a string representing the package the program is found in, typically defined in config.h (see the chapter called *Creating Your Source Tree*). You must arrange to define GNOMELOCALEDIR, typically in your Makefile.am ($(prefix)/share/locale, or $(datadir)/locale, is the standard value). Translations are stored in GNOMELOCALEDIR.

When marking strings for translation, you must make sure your strings are translatable. Avoid constructing a string at runtime via concatenation. For example, do not do this:

```

  gchar* message = g_strconcat(_("There is an error on device "),
                               device, NULL);
```

The problem is that in some languages it may be correct to put the name of the device first (or in the middle). If you use g_snprintf() or g_strdup_printf() instead of concatenation, the translator can change the word order. Here's the right way to do it:

```
  gchar* message = g_strdup_printf(_("There is an error on device %s"),
                                    device);
```

Now the translator can move %s as needed.

Complicated syntax-on-the-fly should be avoided whenever possible. For example, translating this is a major problem:

```
  printf(_("There %s %d dog%s\n"),
         n_dogs > 1 ? _("were") : _("was"),
         n_dogs,
         n_dogs > 1 ? _("s") : "");
```

It is better to move the conditional out of the printf():

```
  if (n_dogs > 0)
    printf(_("There were %d dogs\n"), n_dogs);
  else
    printf(_("There was 1 dog\n"));
```

However, as the gettext manual points out, even this will not always work; some languages will distinguish more categories than "exactly one" and "more than one" (that is, they might have a word form for "exactly two" in addition to English's singular and plural forms). That manual suggests that a lookup table indexed by the number you plan to use might work in some cases:

```
static const char* ndogs_phrases[] = {
  N_("There were no dogs.\n"),
  N_("There was one dog.\n"),
  N_("There were two dogs.\n"),
  N_("There were three dogs.\n")
};
```

As you can see, this rapidly becomes unpleasant to deal with. Avoid it if you can. The gettext documentation has more examples, if you find yourself in a hairy situation.

Internationalization must also be considered when parsing or displaying certain kinds of data, including dates and decimal numbers. In general, the C library provides sufficient facilities to deal with this; use strftime(), strcoll(), and so on to handle these cases; a good C or POSIX book will explain them. The glib GDate facility handles dates using strftime() internally.

One common mistake to avoid: don't use locale-dependent functions when reading and writing files. For example, printf() and scanf() adjust their decimal number format for the locale, so you can't use this format in files. Users in Europe won't be able to read files created in the United States.

Argument Parsing with popt

Gnome uses a powerful option-parsing library called popt. popt handles all the default Gnome options---to see the default options, pass the --help option to any Gnome application. You can add a "popt table" with your custom options. To do so, replace gnome_init() with the gnome_init_with_popt_table() variant (Figure 3).

```
#include <libgnomeui/gnome-init.h>
```

int gnome_init_with_popt_table(const char* *app_id*, const char* *app_version*, int *argc*, char** *argv*, const struct poptOption* *options*, int *flags*, poptContext* *return_ctx*);

Figure 3. Init with Argument Parsing

A popt table is simply an array of struct poptOption, defined as follows:

```
struct poptOption {
  const char* longName;
  char shortName;
  int argInfo;
  void* arg;
  int val;
  char* descrip;
  char* argDescrip;
};
```

The first two components are the long and short names for the option; for example, "help" and 'h' would correspond to command-line options --help and -h. These can be NULL and '\0' respectively, if you want only one name for the option.

The arginfo member tells what kind of table entry this is. Here are the possible values:

- POPT_ARG_NONE means the option is a simple switch, it takes no argument.
- POPT_ARG_STRING means the option takes a string argument, as in --geometry="300x300+50+100".
- POPT_ARG_INT means the option takes an int argument, as in --columns=10.
- POPT_ARG_LONG means the option takes a long argument.
- POPT_ARG_INCLUDE_TABLE means that this struct poptOption does not specify an option, but rather another popt table to be included.
- POPT_ARG_CALLBACK means that this struct poptOption does not specify an option, but rather a callback function to be used for parsing options in this table. This kind of entry should be at the beginning of your table.
- POPT_ARG_INTL_DOMAIN means that this struct poptOption specifies the translation domain for this table and any subtables.

The meaning of arg depends on the arginfo member. For options that take an argument, arg should point to a variable of the argument type. popt will fill the pointed-to variable with the argument. For POPT_ARG_NONE, *arg is set to TRUE if the option is found on the command line. In all cases, arg may be NULL, causing popt to ignore it.

For POPT_ARG_INCLUDE_TABLE, arg points to the table to include; for POPT_ARG_CALLBACK, it points to the callback to invoke; for POPT_ARG_INTL_DOMAIN it should be the translation domain string.

The val member serves as an identifier for each option. Typically it isn't that useful in Gnome applications, but if you use a callback it will be available in the callback. If you aren't going to use it, set it to 0.

The final two members are used to automatically generate output for the --help option. descrip describes an option; argDescrip describes the argument to that option, if applicable. For example, the help for the --display option looks like this:

```
  --display=DISPLAY                X display to use
```

Here argDescrip is "DISPLAY" and descrip is "X display to use." Remember to mark these two strings for translation.

descrip has a slightly different meaning for POPT_ARG_INCLUDE_TABLE; in this case it titles a "group" of options in the help output. For example, "Help options" in the following output:

```
Help options
  -?, --help                      Show this help message
  --usage                         Display brief usage message
```

If you place an entry of type POPT_ARG_CALLBACK at the beginning of a popt table, a user-defined callback will be invoked with information about each option found on the command line. Here is the type your callback is expected to have:

```
typedef void (*poptCallbackType)(poptContext con,
                                 enum poptCallbackReason reason,
                                 const struct poptOption* opt,
                                 const char* arg,
                                 void* data);
```

The opaque poptContext object contains all of popt's state. This makes it possible to use popt more than once in the same program, or parse more than one set of options simultaneously. You can also extract information about the current parsing state from the poptContext, using functions provided by popt.

Possible poptCallbackReason values are:

- POPT_CALLBACK_REASON_PRE
- POPT_CALLBACK_REASON_POST
- POPT_CALLBACK_REASON_OPTION

Your callback is called once for each option found on the command line with POPT_CALLBACK_REASON_OPTION as the reason argument. If you request, it can also be called before and after argument parsing. In these cases reason will be POPT_CALLBACK_REASON_PRE or POPT_CALLBACK_REASON_POST. To specify that you want your callback to be called before or after parsing, you have to combine a pair of flags with POPT_ARG_CALLBACK. For example, the following struct poptOption initializer specifies a callback to be invoked both before and after argument parsing:

```
{ NULL, '\0', POPT_ARG_CALLBACK|POPT_CBFLAG_PRE|POPT_CBFLAG_POST,
  &parse_an_arg_callback, 0, NULL}
```

The opt argument to the callback is the struct poptOption corresponding to the most recently-seen command line option (you can access the val member of this struct to determine which option you are looking at). The arg argument is the text of any argument passed to the command line option; the data argument is the callback data, given as the descrip member of the struct poptOption which specified the callback.

The flags argument to gnome_init_with_popt_table() can basically be ignored in a Gnome context; the available flags are not very useful.

If you pass a non-NULL pointer for return_ctx, the final argument to gnome_init_with_popt_table(), the current context will be returned; you can use this to extract the non-option components of the command line, such as filenames. This is done with the function poptGetArgs()---here's an example:

```
  char** args;
  poptContext ctx;
  int i;

  bindtextdomain (PACKAGE, GNOMELOCALEDIR);
  textdomain (PACKAGE);

  gnome_init_with_popt_table(APPNAME, VERSION, argc, argv,
                             options, 0, &ctx);

  args = poptGetArgs(ctx);

  if (args != NULL)
    {
      i = 0;
      while (args[i] != NULL)
        {
          /* Do something with each argument */
          ++i;
        }
    }

  poptFreeContext(ctx);
```

Notice that you must free the poptContext if you ask for it; however, if you pass NULL for return_ctx the library will free it for you. Also keep in mind that poptGetArgs() will return NULL if there are no arguments on the command line.

Argument Parsing in GnomeHello

The GnomeHello application outputs the following if you invoke it with the --help option:

```
$ ./hello --help
Usage: hello [OPTION...]

GNOME Options
  --disable-sound              Disable sound server usage
  --enable-sound               Enable sound server usage
  --espeaker=HOSTNAME:PORT     Host:port on which the sound server to use
is
                               running

Help options
  -?, --help                   Show this help message
  --usage                      Display brief usage message

GTK options
  --gdk-debug=FLAGS            Gdk debugging flags to set
  --gdk-no-debug=FLAGS         Gdk debugging flags to unset
  --display=DISPLAY            X display to use
  --sync                       Make X calls synchronous
  --no-xshm                    Don't use X shared memory extension
  --name=NAME                  Program name as used by the window manager
  --class=CLASS                Program class as used by the window
manager
  --gxid_host=HOST
  --gxid_port=PORT
  --xim-preedit=STYLE
  --xim-status=STYLE
  --gtk-debug=FLAGS            Gtk+ debugging flags to set
  --gtk-no-debug=FLAGS         Gtk+ debugging flags to unset
  --g-fatal-warnings           Make all warnings fatal
  --gtk-module=MODULE          Load an additional Gtk module
```

```
GNOME GUI options
  -V, --version

Help options
  -?, --help                  Show this help message
  --usage                     Display brief usage message

Session management options
  --sm-client-id=ID           Specify session management ID
  --sm-config-prefix=PREFIX   Specify prefix of saved configuration
  --sm-disable                Disable connection to session manager

GnomeHello options
  -g, --greet                 Say hello to specific people listed on the
                              command line
  -m, --message=MESSAGE       Specify a message other than "Hello,
World!"
  --geometry=GEOMETRY         Specify the geometry of the main window
$
```

Almost all of these options are common to all Gnome applications; only the last three, labelled "GnomeHello options," are specific to GnomeHello. The --greet or -g option turns on "greet mode"; GnomeHello will expect a list of names on the command line, and create a dialog to say hello to each person named. The --message option expects a string argument which replaces the usual "Hello, World!" message; the --geometry option expects a standard X geometry string, specifying the position and size of the main application window.

Here are the variables and popt table GnomeHello uses to do its argument parsing:

```


static int greet_mode = FALSE;
static char* message  = NULL;
static char* geometry = NULL;

struct poptOption options[] = {
  {
    "greet",
    'g',
    POPT_ARG_NONE,
    &greet_mode,
    0,
    N_("Say hello to specific people listed on the command line"),
    NULL
  },
  {
    "message",
    'm',
    POPT_ARG_STRING,
    &message,
    0,
    N_("Specify a message other than \"Hello, World!\""),
    N_("MESSAGE")
  },
  {
    "geometry",
    '\0',
    POPT_ARG_STRING,
    &geometry,
    0,
    N_("Specify the geometry of the main window"),
    N_("GEOMETRY")
  },
  {
    NULL,
    '\0',
    0,
    NULL,
    0,
    NULL,
    NULL
  }
};
```

And here's the first part of main(), where GnomeHello checks that the arguments are properly combined and assembles a list of people to greet:

```

  GtkWidget* app;

  poptContext pctx;

  char** args;
  int i;
  GSList* greet = NULL;

  GnomeClient* client;

  bindtextdomain(PACKAGE, GNOMELOCALEDIR);
  textdomain(PACKAGE);

  gnome_init_with_popt_table(PACKAGE, VERSION, argc, argv,
                             options, 0, &pctx);

  /* Argument parsing */

  args = poptGetArgs(pctx);

  if (greet_mode && args)
    {
      i = 0;
      while (args[i] != NULL)
        {
          greet = g_slist_prepend(greet, args[i]);
          ++i;
        }
      /* Put them in order */
      greet = g_slist_reverse(greet);
    }
  else if (greet_mode && args == NULL)
    {
      g_error(_("You must specify someone to greet."));
    }
  else if (args != NULL)
    {
      g_error(_("Command line arguments are only allowed with
--greet."));
    }
  else
    {
      g_assert(!greet_mode && args == NULL);
    }

  poptFreeContext(pctx);
```

Again, complete source for GnomeHello is included in Appendix E.

Saving Configuration Information

libgnome comes with the ability to store simple key-value pairs in plain text configuration files. Convenience routines are provided for numeric and boolean types which transparently convert to and from a text representation of each type. The standard location for Gnome configuration files is ~/.gnome, and the library will use that location by default. However, the library can be used with any file. There are also variants of each function which save to ~/.gnome_private, a directory with user permissions only. The basic functions to store and retrieve data are listed in Figure 4 in the section called *Reading Stored Config Data* and Figure 5 in the section called *Storing Data In Configuration Files*. This module of libgnome is often referred to as gnome-config. Don't confuse this usage of "gnome-config" with the gnome-config script that reports the compile and link flags for Gnome programs.

The gnome-config functions work with a *path*. A path has three components:

- The *filename* to use, underneath the ~/.gnome or ~/.gnome_private directory. By convention this is the name of your application.
- A *section*---a logical subcategory of related configuration information.
- A *key*---the key half of a key-value pair. The key is actually associated with a piece of configuration data.

A path is passed to Gnome as a string, with the form "/filename/section/key". If you want to use a filename which is *not* in the standard Gnome directories, you can bracket the entire path with the '=' character and it will be interpreted as absolute. You can even use this as a simple datafile format (it is used for the .desktop files programs install in order to appear on the Gnome panel menu). However, XML (perhaps using the gnome-xml package) is almost certainly a better choice for that. XML may also be a better choice for storing some kinds of configuration information; the primary advantage of the libgnome configuration library is its simplicity.

gnome-config has a long history; it was first written for the WINE Windows emulator project, then used in the GNU Midnight Commander file manager, and finally migrated into the Gnome libraries. The plan is to replace gnome-config with something more powerful in the next version of Gnome; we want to support per-host configuration, backends such as LDAP, and other features. However, the gnome-config API will almost certainly be supported even if the underlying engine changes dramatically.

Reading Stored Config Data

Retrieving data from files is simple. You simply call a function to retrieve the value for a given key. The value-retrieving functions (shown in Figure 4) accept a path as their argument. For example, you might ask whether the user wants to see a dialog box:

```
gboolean show_dialog;

show_dialog =
  gnome_config_get_bool("/myapp/General/dialog");
```

If the config file doesn't exist yet, or there is no key matching the path you provide, these functions return 0, FALSE, or NULL. The functions that return a string return allocated memory; you should g_free() the returned string. The string vector functions return an allocated vector full of allocated strings (g_strfreev() is the easiest way to free this vector).

You can specify a default value to be returned if the key does not exist; to do so, append an "=value" to the path. For example:

```
gboolean show_dialog;

show_dialog =
  gnome_config_get_bool("/myapp/General/dialog=true");
```

Each function has a with_default variant; these tell you whether the return value was taken from a config file or from the default you specified. For example:

```
gboolean show_dialog;
gboolean used_default;

show_dialog =
  gnome_config_get_bool_with_default("/myapp/General/dialog=true",
                                     &used_default);

if (used_default)
  printf("Default value used for show_dialog\n");
```

gnome_config_push_prefix() and gnome_config_pop_prefix() (in Figure 7 in the section called *Other Config File Operations*) can be used to avoid specifying the entire path each time. For example:

```
gboolean show_dialog;

gnome_config_push_prefix("/myapp/General/");

show_dialog =
  gnome_config_get_bool("dialog=true");

gnome_config_pop_prefix();
```

These functions also work when saving values.

The configuration functions with private in their name use a .gnome_private directory with restricted permissions, as discussed above. The translated_string functions qualify the provided key with the name of the current locale; these are used when Gnome reads .desktop files (see the section called *.desktop Entries* in the chapter called *Creating Your Source Tree*) and are probably not useful to applications.

```
#include <libgnome/gnome-config.h>
```

gchar* gnome_config_get_string(const gchar* *path*);

gchar* gnome_config_get_translated_string(const gchar* *path*);

gint gnome_config_get_int(const gchar* *path*);

gdouble gnome_config_get_float(const gchar* *path*);

gboolean gnome_config_get_bool(const gchar* *path*);

void gnome_config_get_vector(const gchar* *path*, gint* *argcp*, gchar*** *argvp*);

gchar* gnome_config_private_get_string(const gchar* *path*);

gchar* gnome_config_private_get_translated_string(const gchar* *path*);

gint gnome_config_private_get_int(const gchar* *path*);

gdouble gnome_config_private_get_float(const gchar* *path*);

gboolean gnome_config_private_get_bool(const gchar* *path*);

void gnome_config_private_get_vector(const gchar* *path*, gint* *argcp*, gchar*** *argvp*);

gchar* gnome_config_get_string_with_default(const gchar* *path*, gboolean* *was_default*);

gchar* gnome_config_get_translated_string_with_default(const gchar* *path*, gboolean* *was_default*);

gint gnome_config_get_int_with_default(const gchar* *path*, gboolean* *was_default*);

gdouble gnome_config_get_float_with_default(const gchar* *path*, gboolean* *was_default*);

gboolean gnome_config_get_bool_with_default(const gchar* *path*, gboolean* *was_default*);

void gnome_config_get_vector_with_default(const gchar* *path*, gint* *argcp*, gchar*** *argvp*, gboolean* *was_default*);

gchar* gnome_config_private_get_string_with_default(const gchar* *path*, gboolean* *was_default*);

gchar* gnome_config_private_get_translated_string_with_default(const gchar* *path*, gboolean* *was_default*);

gint gnome_config_private_get_int_with_default(const gchar* *path*, gboolean* *was_default*);

gdouble gnome_config_private_get_float_with_default(const gchar* *path*, gboolean* *was_default*);

gboolean gnome_config_private_get_bool_with_default(const gchar* *path*, gboolean* *was_default*);

void gnome_config_private_get_vector_with_default(const gchar* *path*, gint* *argcp*, gchar*** *argvp*, gboolean* *was_default*);

Figure 4. Retrieving data from configuration files

Storing Data In Configuration Files

Saving data is simply the inverse of loading it; you provide a "/file/section/key" path in just the same way, along with the value to store. Data is not written immediately; you must call gnome_config_sync() to ensure the file is written to disk.

```
#include <libgnome/gnome-config.h>
```

void gnome_config_set_string(const gchar* *path*, const gchar* *value*);

void gnome_config_set_translated_string(const gchar* *path*, const gchar* *value*);

void gnome_config_set_int(const gchar* *path*, gint *value*);

void gnome_config_set_float(const gchar* *path*, gdouble *value*);

void gnome_config_set_bool(const gchar* *path*, gboolean *value*);

void gnome_config_set_vector(const gchar* *path*, gint *argc*, const gchar* const *argv[]*);

void gnome_config_private_set_string(const gchar* *path*, const gchar* *value*);

void gnome_config_private_set_translated_string(const gchar* *path*, const gchar* *value*);

void gnome_config_private_set_int(const gchar* *path*, gint *value*);

void gnome_config_private_set_float(const gchar* *path*, gdouble *value*);

void gnome_config_private_set_bool(const gchar* *path*, gboolean *value*);

void gnome_config_private_set_vector(const gchar* *path*, gint *argc*, const gchar* const *argv[]*);

Figure 5. Saving data to configuration files

Config File Iterators

Iterators are used to scan the sections in a given file, or the keys in a given section. Applications can use this feature to store lists of data, by dynamically generating key or section names to save and later iterating over them to discover what was saved. The functions are summarized in Figure 6 in the section called *Section Iterators*.

An iterator is an opaque data type; you pass gnome_config_init_iterator() the name of a section to iterate over and receive an iterator in return. You then call gnome_config_iterator_next() to obtain key-value pairs from the section. The key and value returned from gnome_config_iterator_next() must be freed with g_free(), and the return value of gnome_config_iterator_next() is a pointer to the next iterator. When gnome_config_iterator_next() returns NULL, all key-value pairs have been traversed.

Iteration Example from gnome-apt

Here's an example from gnome-apt, a C++ application used to manage packages on Debian systems. gnome-apt loads and saves the position of some columns in a tree display. The columns are identified by the GAptPkgTree::ColumnType enumeration. GAptPkgTree::ColumnTypeEnd is the last element in the column type enumeration, and equal to the number of valid column types. This example is frighteningly "real world" and checks for a number of error conditions.

```
static void
load_column_order(vector<GAptPkgTree::ColumnType> & columns)
{
  gpointer config_iterator;
  guint loaded = 0;

  config_iterator =
gnome_config_init_iterator("/gnome-apt/ColumnOrder");

  if (config_iterator != 0)
    {
      gchar * col, * pos;
      columns.reserve(GAptPkgTree::ColumnTypeEnd);

      loaded = 0;
      while ((config_iterator =
              gnome_config_iterator_next(config_iterator,
                                         &col, &pos)))
        {
          // shouldn't happen, but I'm paranoid
          if (pos == 0 || col == 0)
            {
              if (pos) g_free(pos);
              if (col) g_free(col);
              continue;
            }

          GAptPkgTree::ColumnType ct = string_to_column(col);

          gint index = atoi(pos);

          g_free(pos); pos = 0;
          g_free(col); col = 0;

          // the user could mangle the config file to make this happen
          if (static_cast<guint>(index) >= columns.size())
            continue;

          columns[index] = ct;

          ++loaded;
        }
    }

  if (loaded != static_cast<guint>(GAptPkgTree::ColumnTypeEnd))
    {
      // Either there was no saved order, or something is busted - use
      // default order
      columns.clear();

      int i = 0;
      while (i < GAptPkgTree::ColumnTypeEnd)
        {
          columns.push_back(static_cast<GAptPkgTree::ColumnType>(i));
          ++i;
        }

      // Clean the section - otherwise an old entry could
      //  remain forever and keep screwing us up in the future.
      gnome_config_clean_section("/gnome-apt/ColumnOrder");
      gnome_config_sync();
    }
  g_return_if_fail(columns.size() ==
                   static_cast<guint>(GAptPkgTree::ColumnTypeEnd));
}
```

It might be helpful to see the function that saves the column positions:

```

static void
save_column_order(const vector<GAptPkgTree::ColumnType> & columns)
{
  g_return_if_fail(columns.size() ==
                   static_cast<guint>(GAptPkgTree::ColumnTypeEnd));

  int position = 0;
  vector<GAptPkgTree::ColumnType>::const_iterator i = columns.begin();
  while (i != columns.end())
    {
      gchar key[256];
      g_snprintf(key, 255, "/gnome-apt/ColumnOrder/%s",
column_to_string(*i));
      gchar val[30];
      g_snprintf(val, 29, "%d", position);
      gnome_config_set_string(key, val);

      ++position;
      ++i;
    }

  gnome_config_sync();
}
```

When writing this code, the decision was made to store enumeration values as strings rather than integers. The column_to_string() and string_to_column() functions use a simple array of column names indexed by the enumeration values to convert back and forth. There are two reasons to do this: it will not break when the enumeration is altered in future versions of the program, and it keeps the configuration file human-editable.

You may also notice that the column positions are stored with gnome_config_set_string() instead of gnome_config_set_int(). This is because gnome_config_iterator_next() returns a string representation of the stored information, as found in the file. Most likely, gnome_config_set_int() stores integers as strings atoi() would understand (in fact it does), but it is technically not guaranteed by the API. If the code used gnome_config_set_int(), it would have to obtain only the key from gnome_config_iterator_next() and then call gnome_config_get_int() to obtain the integer value. Using atoi() on the string value would make unwarranted assumptions about gnome-config's implementation.

Section Iterators

gnome_config_init_iterator_sections() allows you to iterate over the sections in a file, rather than over the keys in a section. When iterating over sections, gnome_config_iterator_next() ignores its value argument and places the section name in the key argument.

```
#include <libgnome/gnome-config.h>
```

void* gnome_config_init_iterator(const gchar* *path*);

void* gnome_config_private_init_iterator(const gchar* *path*);

void* gnome_config_init_iterator_sections(const gchar* *path*);

void* gnome_config_private_init_iterator_sections(const gchar* *path*);

void* gnome_config_iterator_next(void* *iterator_handle*, gchar** *key*, gchar** *value*);

Figure 6. Configuration file iterators

Other Config File Operations

Figure 7 lists some additional operations available for manipulating config files. The most important of these have already been mentioned in passing. gnome_config_sync() writes the configuration file to disk, and gnome_config_push_prefix() allows you to shorten the path passed to the other gnome-config functions. There are also boolean tests, to ask gnome-config whether a given section exists.

Two new operations are introduced: to *drop* a file or section means to forget any information about it stored in memory, including cached values loaded from the file and values not yet saved to the file with gnome_config_sync(). To *clean* a file, section, or key means to unset its value(s), so the file, section, or key will not exist once gnome_config_sync() is called.

gnome_config_sync() automatically calls gnome_config_drop_all() to free all gnome-config resources, since the information is safely stored on disk.

Functions are also provided to get the "real" (filesystem) path of a configuration file from a gnome-config path. These are unlikely to be useful in application code.

```
#include <libgnome/gnome-config.h>
```

gboolean gnome_config_has_section(const gchar* *path*);

gboolean gnome_config_private_has_section(const gchar* *path*);

void gnome_config_drop_all(void);

void gnome_config_sync(void);

void gnome_config_sync_file(const gchar* *path*);

void gnome_config_private_sync_file(const gchar* *path*);

void gnome_config_drop_file(const gchar* *path*);

void gnome_config_private_drop_file(const gchar* *path*);

void gnome_config_clean_file(const gchar* *path*);

void gnome_config_private_clean_file(const gchar* *path*);

void gnome_config_clean_section(const gchar* *path*);

void gnome_config_private_clean_section(const gchar* *path*);

void gnome_config_clean_key(const gchar* *path*);

void gnome_config_private_clean_key(const gchar* *path*);

gchar* gnome_config_get_real_path(const gchar* *path*);

gchar* gnome_config_private_get_real_path(const gchar* *path*);

void gnome_config_push_prefix(const gchar* *path*);

```
void gnome_config_pop_prefix(void);
```

Figure 7. Miscellaneous configuration file functions

Session Management

The term *session* refers to a snapshot of the state of a user's desktop: what applications are open, where their windows are located, what windows each application has open, what size those windows are, what documents are open, current cursor position, and so on. Users should be able to save their session before logging out, and have it automatically restored as closely as possible next time they log in. For this to work, applications must cooperate by having the ability to record and restore those aspects of their state not controlled by the window manager.

A special program called the *session manager* notifies applications when they should save their state. The Gnome desktop environment comes with a session manager called gnome-session, but Gnome uses the X session management specification, which is several years old. CDE uses the same specification, and at press time, KDE was planning to adopt it as well; an application that implements session management via the Gnome interfaces should work on any session-managed desktop. Gnome does implement some extensions to the basic specification (notably, startup "priorities") but these should not break other session managers and will likely be implemented in KDE as well.

It's worthwhile to read the session management documentation that comes with X; it's a good introduction to what's going on "behind the scenes." The Gnome libraries also come with a useful document, called session-management.txt; have a look at it, and the heavily-commented gnome-client.h header file, for additional details not covered in this section.

Using the GnomeClient Object

Gnome shields you from the raw session management interface that comes with X. This is done via a GtkObject called GnomeClient. GnomeClient represents your application's connection to the session manager.

Gnome manages most of the details of session management. For most applications, you only have to respond to two requests.

- When a session is saved, the session manager will ask each client to save enough information to restore its state the next time the user logs in. Your application should save as much interesting state as possible: the current open documents, cursor position, command histories, and so on. Applications should *not* save their current window geometries; the window manager is responsible for that.
- Sometimes the session manager will ask your client to shut down and exit (typically when the user logs out). When you receive this request you should do whatever is necessary to exit the application.

When the session manager requests action from your application, a the GnomeClient object emits an appropriate signal. The two important signals are "save_yourself" and "die". "save_yourself" is emitted when an application should save its state, and "die" is emitted when an application should exit. A "save_yourself" callback is fairly complex and has quite a few arguments; a "die" callback is trivial.

GnomeHello obtains a pointer to the GnomeClient object and connects to its signals as follows:

```
  client = gnome_master_client ();
  gtk_signal_connect (GTK_OBJECT (client), "save_yourself",
                      GTK_SIGNAL_FUNC (save_session), argv[0]);
  gtk_signal_connect (GTK_OBJECT (client), "die",
                      GTK_SIGNAL_FUNC (session_die), NULL);
```

argv[0] will be used in the "save_yourself" callback.

First, here's the "die" callback from GnomeHello:

```
static void
session_die(GnomeClient* client, gpointer client_data)
{
  gtk_main_quit ();
}
```

Straightforward; the application just exits.

Now the "save_yourself" callback:

```
static gint
save_session (GnomeClient *client, gint phase, GnomeSaveStyle
save_style,
              gint is_shutdown, GnomeInteractStyle interact_style,
              gint is_fast, gpointer client_data)
{
  gchar** argv;
  guint argc;

  /* allocate 0-filled, so it will be NULL-terminated */
  argv = g_malloc0(sizeof(gchar*)*4);
  argc = 1;

  argv[0] = client_data;

  if (message)
    {
      argv[1] = "--message";
      argv[2] = message;
      argc = 3;
    }

  gnome_client_set_clone_command (client, argc, argv);
  gnome_client_set_restart_command (client, argc, argv);

  return TRUE;
}
```

This is a bit more complex. A "save_yourself" must tell the session manager how to restart and "clone" (create a new instance of) the application. The restarted application should remember as much state as possible; in GnomeHello's case, it will remember the message being displayed. The simplest way to store application state is to generate a command line, as GnomeHello does. It's also possible to ask GnomeClient for a prefix to be used with the gnome-config API; you can then save information to a per-session configuration file. Applications with significant state will need to use this method.

The Main Window: GnomeApp

Table of Contents

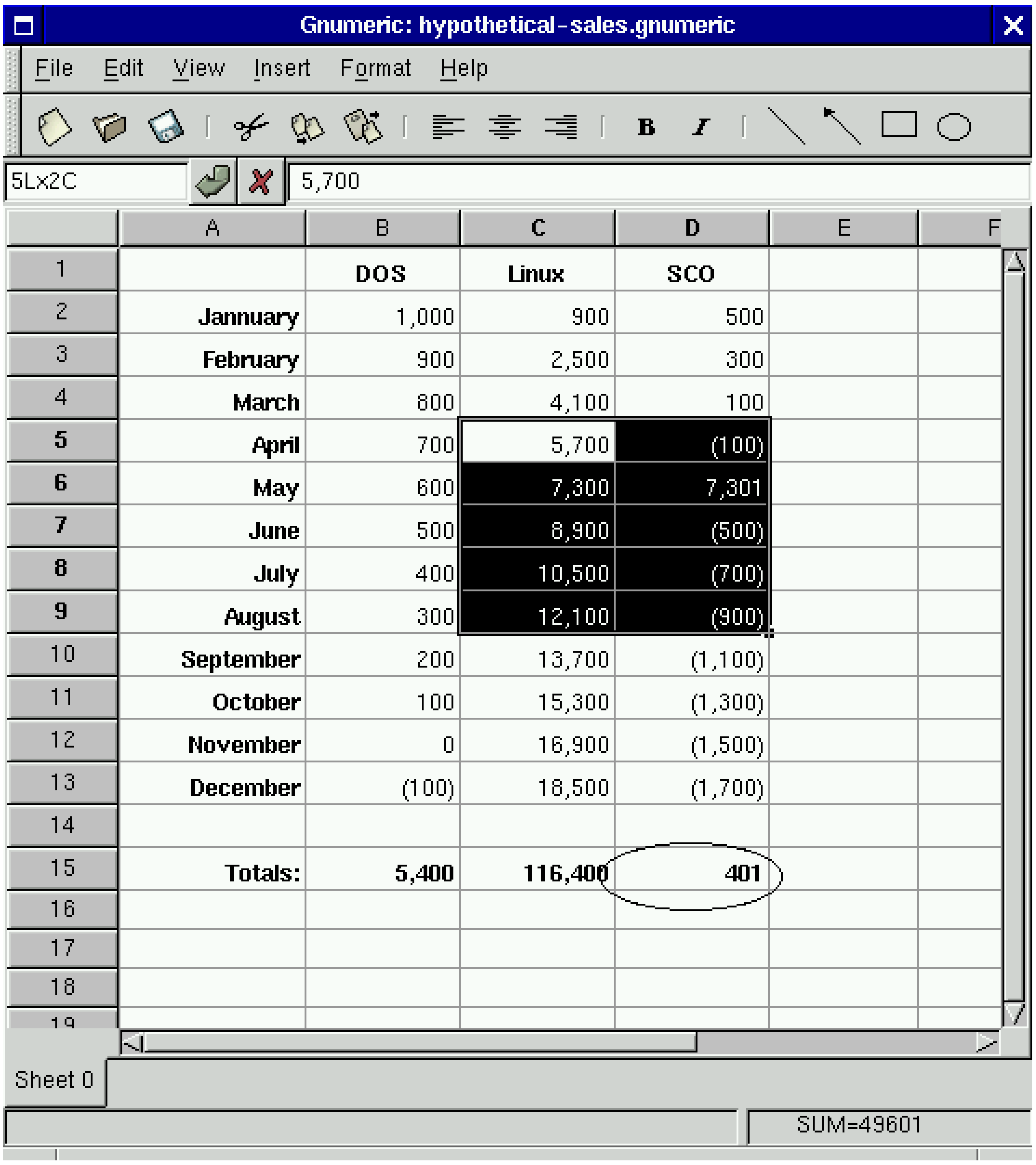
This chapter describes Gnome's features for creating your application's main window, complete with menus and a toolbar.

The GnomeApp Widget

All Gnome applications, excluding a few with special needs, use the GnomeApp widget for their main window. GnomeApp is a subclass of GtkWindow; it extends the basic toplevel window with convenient menu and toolbar handling. A GnomeApp window is automatically user-configurable in several ways:

- Menu and toolbars can be detached from the window, or rearranged in relation to one another and the main window contents.
- Users can elect to disable detachable bars for all Gnome applications.
- Users can choose whether to have small icons in the application's menus.

More options will probably be added in the future.



	A	B	C	D	E	F
1		DOS	Linux	SCO		
2	Jannuary	1,000	900	500		
3	February	900	2,500	300		
4	March	800	4,100	100		
5	April	700	5,700	(100)		
6	May	600	7,300	7,301		
7	June	500	8,900	(500)		
8	July	400	10,500	(700)		
9	August	300	12,100	(900)		
10	September	200	13,700	(1,100)		
11	October	100	15,300	(1,300)		
12	November	0	16,900	(1,500)		
13	December	(100)	18,500	(1,700)		
14						
15	Totals:	5,400	116,400	401		
16						
17						
18						
19						

Figure 1. The Gnumeric spreadsheet, which uses the GnomeApp widget

GnomeApp has the usual constructor function, shown in Figure 2. The first argument, app_id, is an internal name Gnome can use to work with this application. It should be the same as the app_id passed to gnome_init(); the name of the executable is a good choice. The second argument is simply a title for the application window; if you use NULL here, the title will not be set.

```
#include <libgnomeui/gnome-app.h>
```

GtkWidget* gnome_app_new(gchar* *app_id*, gchar* *title*);

Figure 2. GnomeApp Constructor

GnomeApp has a single "content area" in the center, where you place the main functionality of your application. On all four sides of this central area, you can add toolbars, menubars, and statusbars. Figure 3 lists the relevant functions.

These functions should be self-explanatory. They simply install the widget you give them in the appropriate place on the GnomeApp. There are easy ways to create the menubar, toolbar, and statusbar; the remainder of this chapter describes them.

```
#include <libgnomeui/gnome-app.h>
```

void gnome_app_set_contents(GnomeApp* *app*, GtkWidget* *contents*);

void gnome_app_set_menus(GnomeApp* *app*, GtkMenuBar* *menubar*);

void gnome_app_set_toolbar(GnomeApp* *app*, GtkToolbar* *toolbar*);

void gnome_app_set_statusbar(GnomeApp* *app*, GtkWidget* *statusbar*);

Figure 3. Adding Widgets to GnomeApp

Menus and Toolbars with GnomeUIInfo

It's tedious to create large menus, especially if they have features such as icons and keyboard accelerators. Gnome provides a simple solution. You assemble a GnomeUIInfo struct as a template for each menu item, simply listing its characteristics: name, icon, accelerator, and so on. The Gnome libraries can automatically create menus from arrays of GnomeUIInfo templates. The same method works with toolbars.

Here's the declaration of struct GnomeUIInfo.

```

typedef struct {
  GnomeUIInfoType type;
  gchar* label;
  gchar* hint;
  gpointer moreinfo;
  gpointer user_data;
  gpointer unused_data;
  GnomeUIPixmapType pixmap_type;
  gpointer pixmap_info;
  guint accelerator_key;
  GdkModifierType ac_mods;
  GtkWidget* widget;
} GnomeUIInfo;
```

A static initializer is the most convenient way to fill in the struct (but of course you can create it dynamically if you prefer). Gnome's routines accept an array of GnomeUIInfo, and macros are provided to simplify and standardize the most common static initializers. Here's a typical example, a File menu:

```

static GnomeUIInfo file_menu[] = {
  GNOMEUIINFO_MENU_NEW_ITEM(N_("_New Window"),
                            N_("Create a new text viewer window"),
                            new_app_cb, NULL),
  GNOMEUIINFO_MENU_OPEN_ITEM(open_cb,NULL),
  GNOMEUIINFO_MENU_SAVE_AS_ITEM(save_as_cb,NULL),
  GNOMEUIINFO_SEPARATOR,
  GNOMEUIINFO_MENU_CLOSE_ITEM(close_cb,NULL),
  GNOMEUIINFO_MENU_EXIT_ITEM(exit_cb,NULL),
  GNOMEUIINFO_END
};
```

There isn't always a nice macro for the menu item you want, so sometimes you must manually specify each element of the struct:

```

{
  GNOME_APP_UI_ITEM, N_("_Select All"),
  N_("Select all cells in the spreadsheet"),
  select_all_cb, NULL,
  NULL, 0, 0, 'a', GDK_CONTROL_MASK
}
```

By now you're probably wondering what the struct members mean. Simple enough. Here's a breakdown:

- type is a type marker from the GnomeUIInfoType enumeration. See Table 1.
- label is the text of the menu or toolbar button. It should be marked for internationalization with the N_() macro.

- hint is a long description of the item's function. For toolbar buttons, it will appear in a tooltip; for menus, it can be made to appear in the statusbar.
- moreinfo depends on the type of the item. See Table 1.
- user_data will be passed to your callback function, if this item type has a callback.
- unused_data should be set to NULL, and is not used yet. It may be used in future versions of Gnome.
- pixmap_type is a value from the GnomeUIPixmapType enumeration; its purpose is to specify the type of the next member, pixmap_info.
- pixmap_info can be raw pixmap data, a filename, or the name of a Gnome stock pixmap.
- accelerator_key is the key to be used as an accelerator for this item . You can use a character such as 'a', or a value from gdk/gdkkeysyms.h.
- ac_mods is a modifier mask to be used with the accelerator.
- widget should be NULL; Gnome fills it in when it creates the menu item or toolbar button. You can then retrieve it, if you need to manipulate the widget in some way.

You might also be wondering why the menu item names contain an underscore. The underscore is used to mark the key shortcut for the menu item; translators can move it around as needed to make it intuitive in their language. Gnome will parse the menu item name to obtain the accelerator, then remove the underscore.

Table 1 summarizes the possible values for the type field of a GnomeUIInfo struct. See libgnomeui/gnome-app-helper.h for more details. There are actually a few more possible values, but the others are used internally by the library. The values in Table 1 should be sufficient for application code.

Table 1. GnomeUIInfoType Values

GnomeUIInfoType	**Description**	**moreinfo Field**
GNOME_APP_UI_ENDOFINFO	Terminates a table of GnomeUIInfo	None
GNOME_APP_UI_ITEM	Normal item (or radio item inside radio group)	Callback function
GNOME_APP_UI_TOGGLEITEM	Toggle/check item	Callback function
GNOME_APP_UI_RADIOITEMS	Radio item group	Array of radio items in the group

GNOME_APP_UI_SUBTREE	Submenu	Array of GnomeUIInfo in the subtree
GNOME_APP_UI_SEPARATOR	Separator	None
GNOME_APP_UI_HELP	Help item	Help node to load

To create an entire menu tree, you include pointers to previous menu tables using the GNOMEUIINFO_SUBTREE() macro:

```
static GnomeUIInfo main_menu[] = {
  GNOMEUIINFO_SUBTREE(N_("_File"), file_menu),
  GNOMEUIINFO_END
};
```

In this particular case, there is a better macro to use, however:

```
static GnomeUIInfo main_menu[] = {
  GNOMEUIINFO_MENU_FILE_TREE(file_menu),
  GNOMEUIINFO_END
};
```

The main advantage of this macro is standardization; it ensures that all Gnome file menus use the same key shortcut and have the same name. There are quite a few analagous macros; see libgnomeui/gnome-app-helper.h for the complete list.

Converting GnomeUIInfo to a Widget

Once you have a menu table, Gnome will process it and convert it to a widget. The functions are listed in Figure 4

```
#include <libgnomeui/gnome-app-helper.h>
```

void gnome_app_create_menus(GnomeApp* *app*, GnomeUIInfo* *uiinfo*);

void gnome_app_create_menus_with_data(GnomeApp* *app*, GnomeUIInfo* *uiinfo*, gpointer *user_data*);

void gnome_app_create_toolbar(GnomeApp* *app*, GnomeUIInfo* *uiinfo*);

void gnome_app_create_toolbar_with_data(GnomeApp* *app*, GnomeUIInfo* *uiinfo*, gpointer *user_data*);

void gnome_app_fill_toolbar(GtkToolbar* *toolbar*, GnomeUIInfo* *uiinfo*, GtkAccelGroup* *accel_group*);

void gnome_app_fill_toolbar_with_data(GtkToolbar* *toolbar*, GnomeUIInfo* *uiinfo*, GtkAccelGroup* *accel_group*, gpointer *data*);

void gnome_app_fill_menu(GtkMenuShell* *menushell*, GnomeUIInfo* *uiinfo*, GtkAccelGroup* *accel_group*, gboolean *uline_accels*, gint *pos*);

void gnome_app_fill_menu_with_data(GtkMenuShell* *menushell*, GnomeUIInfo* *uiinfo*, GtkAccelGroup* *accel_group*, gboolean *uline_accels*, gint *pos*, gpointer *user_data*);

Figure 4. Creating Widgets from GnomeUIInfo

If you are using the GnomeApp widget, gnome_app_create_menus() and gnome_app_create_toolbar() create a menubar or toolbar from the GnomeUIInfo table you provide, then attach that to the GnomeApp. Most of the time these are the functions you want to use; they do everything automatically. There is a _with_data() variant of each function which overrides the user_data field of GnomeUIInfo.

If you have more specialized needs, you can manually fill a menubar or toolbar and then add it to the container of your choice. The fill functions require you to specify an accelerator group to add accelerators to; for GnomeApp, an accelerator group already exists in the widget struct (the accel_group member). The fill functions for menus take two additional arguments: you can toggle whether to parse the underscores in menu item labels to extract accelerators, and you can specify at which position in the GtkMenuShell the function will begin inserting menu items.

(GtkMenuShell is simply the base class for GtkMenuBar and GtkMenu, i.e. it is a widget that contains menu items. An accelerator group is just a collection of accelerators, normally attached to a GtkWindow; use GNOME_APP(widget)->accel_group in this case.)

When you use a GnomeUIInfo table to create a menubar or toolbar, pointers to the individual menu item or toolbar button widgets are placed in the widget member of each GnomeUIInfo struct. You can use these pointers to access the individual widgets; for example, if you create a check menu item you might want to set the state of the check. The pointer is also useful if you want to manually create some part of the menu; you can create an empty subtree item, for example, and manually build the contents of the subtree.

GnomeHello: An Example

The GnomeHello application has menus and a toolbar created using the GnomeUIInfo method; the relevant code is in a separate file, menus.c. Appendix E lists this file in its entirety.

Adding a Status Bar

Adding a status bar is simple enough. Simply call the aptly-named gnome_app_set_statusbar function (Figure 5) with your statusbar widget as the second argument.

However, there are some additional things to keep in mind. First, you can use either GtkStatusbar or GnomeAppBar as a statusbar. Second, you probably want to use the statusbar to display help about menu items as the user moves over them; Gnome comes with convenience functions to do this. This section describes the two status bar widgets; the section called *Online Help* discusses using the statusbar to display menu item help.

```
#include <libgnomeui/gnome-app.h>
```

void gnome_app_set_statusbar(GnomeApp* *app*, GtkWidget* *statusbar*);

Figure 5. Installing a Statusbar

GnomeAppBar

There's no real reason to prefer GnomeAppBar or GtkStatusbar; they simply have different APIs. The GnomeAppBar widget was written later, with several goals in mind:

- To simplify the GtkStatusbar API.
- To support an optional progress bar next to the status bar, similar to Netscape's.
- Eventual support for "interactive" use in the tradition of the Emacs "minibuffer." This is unfinished in Gnome 1.0, however.

To create a GnomeAppBar, use gnome_appbar_new() (Figure 6). The constructor lets you configure the capabilities of GnomeAppBar: it can have a progress bar (or not), have a status text area (or not), and be interactive (or not). You must have either a status text area or a progress bar. GnomePreferencesType is a kind of extended boolean value:

- GNOME_PREFERENCES_NEVER means the bar is never interactive.
- GNOME_PREFERENCES_USER means the bar is interactive if the user has activated that feature as a Gnome-wide preference.
- GNOME_PREFERENCES_ALWAYS means the bar is always interactive.

In Gnome 1.0, interactivity is incompletely implemented; so avoid GNOME_PREFERENCES_ALWAYS. There are some experimental Gnome functions which provide an abstraction of certain user interactions, allowing users to choose between dialogs and the Emacs-style minibuffer approach; when these are more developed, GNOME_PREFERENCES_USER will make sense even if you don't explicitly use the interactivity. So GNOME_PREFERENCES_USER is the recommended setting.

```
#include <libgnomeui/gnome-appbar.h>
```

GtkWidget* gnome_appbar_new(gboolean *has_progress*, gboolean *has_status*, GnomePreferencesType *interactivity*);

Figure 6. GnomeAppBar Constructor

Using a GnomeAppBar is simple. The progress-bar element presents a GtkProgress interface; to use it, simply extract the GtkProgress with gnome_appbar_get_progress() (Figure 7) and use the GtkProgress functions. Note that you should not make assumptions about the particular subclass of GtkProgress; in particular, do not cast it to GtkProgressBar.

```
#include <libgnomeui/gnome-appbar.h>
```

GtkProgress* gnome_appbar_get_progress(GnomeAppBar* *appbar*);

Figure 7. Extracting GtkProgress

Status texts are stored in a stack; when the bar is refreshed, the top item of the stack is displayed. The bar is refreshed anytime you manipulate the stack. So pushing some text onto the status stack will display that text.

There are two other sources for the status text. You can set some "default" text; this is displayed if the stack is empty. The default default text is "". You can also set the status text without changing the stack; this "transient" text is immediately displayed, but not stored. On the next refresh (the next time you push, pop, or set the default), the text disappears forever, replaced by the top of the stack.

Figure 8 lists the functions to manipulate the status text. gnome_appbar_set_status() is used to set the transient status text; gnome_appbar_refresh() forces a refresh without changing the stack---this is useful to be sure any transient text has been cleared. The other functions should be obvious.

Note that you can use the GnomeAppBar as a simple label---one message at a time, always replacing the previous message---just stick to either setting the default or setting the transient text, and never use the stack.

```
#include <libgnomeui/gnome-appbar.h>
```

void gnome_appbar_set_status(GnomeAppBar* *appbar*, const gchar* *status*);

void gnome_appbar_set_default(GnomeAppBar* *appbar*, const gchar* *default_status*);

void gnome_appbar_push(GnomeAppBar* *appbar*, const gchar* *status*);

void gnome_appbar_pop(GnomeAppBar* *appbar*);

void gnome_appbar_clear_stack(GnomeAppBar* *appbar*);

void gnome_appbar_refresh(GnomeAppBar* *appbar*);

Figure 8. Setting GnomeAppBar Text

GtkStatusbar

GtkStatusbar has no default text or "transient" text, as in GnomeAppBar; it only has a message stack. However, each message is tagged with a "context" identified by a string. When you pop a message off the stack, you must specify a context; the topmost message *in that context* is popped. If there are no messages in the context you specify, no text is popped. In essence, the GtkStatusbar "pop" operation works only within namespaces. There's no way to unconditionally pop all messages or unconditionally pop the topmost message.

In principle this lets different parts of the program use the statusbar without interfering with one another. However, in my experience there's no need for this. For example, Netscape doesn't even have a stack for its statusbar; its statusbar is simply a label. In general it is poor interface design to make anything *essential* appear in the statusbar, since the user might not notice it. Accidentally deleting a message should not be a major worry.

Figure 9 shows the GtkStatusbar functions.

To use the statusbar:

1. First obtain a context ID with gtk_statusbar_get_context_id(); the context_description argument can be any string you like.
2. Push a message onto the statusbar using gtk_statusbar_push(); the message is tagged with the given context ID. The return value is a message ID you can use to remove the message. (Unlike GnomeAppBar, GtkStatusbar lets you remove a message that isn't on top of the stack.)
3. Eventually remove the message with gtk_statusbar_remove() or gtk_statusbar_pop(). The former refers to a specific message by ID, the latter removes the topmost message in the supplied context.

Note that gtk_statusbar_push() pushes a message on top of all other messages, even those in other contexts; but gtk_statusbar_pop() will only pop from the context supplied. Contexts do not refer to separate stacks, they merely restrict which messages you are permitted to pop.

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

GtkWidget* gtk_statusbar_new(void);

guint gtk_statusbar_get_context_id(GtkStatusbar* *statusbar*, const gchar* *context_description*);

guint gtk_statusbar_push(GtkStatusbar* *statusbar*, guint *context_id*, const gchar* *text*);

void gtk_statusbar_pop(GtkStatusbar* *statusbar*, guint *context_id*);

void gtk_statusbar_remove(GtkStatusbar* *statusbar*, guint *context_id*, guint *message_id*);

Figure 9. GtkStatusbar

Online Help

Finished applications should provide online help and documentation. Of course, the first "line of defense" is to have an intuitive interface in the first place. But you should give users a way to get more information if they need it.

This section describes the two major ways you can explain your interface to users:

- By writing documentation, and providing buttons and menu items that jump to relevant sections. For example, the "Help" button in a properties dialog should bring up a help window describing the dialog.
- By adding "tooltips," explanatory text that appears if the mouse remains motionless over a widget for a short time. For menu items, explanatory text appears in the window's status bar as the user moves over the item.

Gnome Documentation and Help Menu Items

The Gnome documentation installation process was described in the section called *Documentation* in the chapter called *Creating Your Source Tree*. Recall that applications install documentation in HTML format in directories named after locales. Each locale directory contains both help files and a topic.dat file indexing the available help topics.

Gnome makes it ridiculously easy to create menu items for the nodes in topic.dat. Simply create a help menu using the GNOMEUIINFO_HELP() macro, like this:

```
static GnomeUIInfo help_menu [] = {
  GNOMEUIINFO_HELP ("gnome-hello"),

  GNOMEUIINFO_MENU_ABOUT_ITEM(about_cb, NULL),

  GNOMEUIINFO_END
};
```

The single argument to GNOMEUIINFO_HELP() is the name of the directory where you've installed your help files. The Gnome libraries will read topic.dat for the user's locale (or the C locale if there is no translation) and create a menu item for each topic. Activating these menu items will launch a help browser to display the appropriate URL. (Users can configure the exact browser Gnome will launch.) If topic.dat isn't found, Gnome creates no menu items.

In other contexts, you will have to manually set up widgets and callbacks to open your help files. Gnome provides some helper functions; the two most important ones are shown in Figure 10. gnome_help_file_find_file() returns the complete path to a help file, given the name of your help directory and the name of a help file (relative to one of the locale directories). If the help file is not found, NULL is returned. For example:

```
gchar* helpfile;

helpfile = gnome_help_file_find_file("gnome-hello",
                                     "gnome-hello.html");

if (helpfile != NULL)
  {
    gchar* url;

    url = g_strconcat("file:", helpfile, NULL);

    gnome_help_goto(NULL, url);

    g_free(url);
    g_free(helpfile);
  }
else
  {
    gnome_error_dialog(_("Couldn't find the GnomeHello manual!"));
  }
```

gnome_help_file_find_file() takes the user's locale into account when generating the help file's pathname.

gnome_help_goto() simply directs the help browser to a URL. You must prepend "file:" to a path to make it a valid URL before calling this function. The first argument to gnome_help_goto() is ignored; this makes it convenient to connect gnome_help_goto() as a callback function, for example to a button's "clicked" signal.

libgnome/gnome-help.h contains a few other variants of gnome_help_goto() suited for connection to signals with different signatures; in particular, there's a callback there for the GnomePropertyBox's "help" signal.

One caveat: the Gnome libraries look for files in the Gnome installation prefix, not in your application's installation prefix. For now, users should install Gnome applications and libraries in the same place. This was done for simplicity's sake when Gnome was much smaller; it's clearly the wrong behavior and will be fixed in a future version. If you use Gnome library functions such as gnome_help_file_find_file(), your application will automatically take advantage of this future Gnome enhancement.

```
#include <libgnome/gnome-help.h>
```

gchar* gnome_help_file_find_file(const gchar* *app*, const gchar* *filename*);

void gnome_help_goto(void* *ignore*, const gchar* *url*);

Figure 10. Help Files

Menu Hints

As the user moves over your application menus, a short description of each menu item should appear in the statusbar. Gnome makes this very easy; just call the gnome_app_install_menu_hints() (Figure 11) after you create your menus and statusbar. The GnomeUIInfo struct passed to this function must have its widget fields filled in by one of the menu-creation functions, and the GnomeApp must have a GnomeAppBar or GtkStatusbar in its statusbar slot.

```
#include <libgnomeui/gnome-app-helper.h>
```

void gnome_app_install_menu_hints(GnomeApp* *app*, GnomeUIInfo* *uiinfo*);

Figure 11. Installing Menu Hints

Tooltips

GTK+ provides tooltip functionality; you simply create a GtkTooltips and attach it to a widget. I like to use the following convenience function in my applications:

```
void
set_tooltip(GtkWidget* w, const gchar* tip)
{
  GtkTooltips* t = gtk_tooltips_new();

  gtk_tooltips_set_tip (t, w, tip, NULL);
}
```

The GtkTooltips will be destroyed along with the widget. Make your tooltips long rather than short; there's no reason to skimp on the amount of information you provide here. You should get in the habit of calling set_tooltip() every time you create a button or other widget that could benefit from it.

Note that toolbars created from a GnomeUIInfo template will have tooltips installed automatically.

Finishing Touches

Really polished application windows behave well on small screens, and set hints so the window manager can keep track of them.

Adapting to Screen Size

The functions in Figure 12 allow you to query the size of the screen in pixels. You can use this information to adjust the layout of your application window; for example, if you know your usual application window is too large for a 640 by 480 display, you could provide an alternative widget layout for small screens. Applications that automatically adapt to the screen size are very impressive.

Of course, you should leave control in the hands of the user; users with large screens might want the small version of your application anyway, and you should always try to respond sensibly if the user resizes the window. Use the screen size to select the best default from among your application's possible configurations.

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

gint gdk_screen_width(void);

gint gdk_screen_height(void);

Figure 12. Querying Screen Size

Setting Window Class Hints

The "class hint" is a property of GtkWindow window managers can read to decide how to treat the window. Most window managers allow you to set icons and other properties based on the class hint. Two elements make up the hint. The wmclass_name field should be unique for each kind of toplevel window in an application (such as the main window or a tools dialog). The wmclass_class field is conventionally set to the name of the application, capitalized. For example: xterm windows set these properties to xterm (name) and XTerm (class). The GIMP toolbox sets its name to toolbox and its class to Gimp. The gtk_window_set_wmclass() function sets these hints for GtkWindow.

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

void gtk_window_set_wmclass(GtkWindow* *window*, const gchar* *wmclass_name*, const gchar* *wmclass_class*);

Figure 13. Setting Class Hints

User Communication: Dialogs

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Dialogs are a continuous annoyance in plain GTK+; every time you want to tell the user anything, you have to create a window, create some buttons, create a label, pack the buttons and label into the window, set up callbacks, remember to capture "delete_event", and so on. It's a pain. Gnome saves you from this pain, with an easy-to-use general-purpose dialog widget, and several subclasses of it that implement common dialog types. Gnome also has easy functions for using modal dialogs.

The GnomeDialog Widget

Since dialogs in plain GTK+ are painstakingly constructed from scratch, there are at least as many ways to write a dialog as there are programmers. The programmer must decide where to place the dialog on the screen, how much padding to have, whether to put a separator above the buttons, what container to put the buttons in, what the keyboard shortcuts are, and so on. The premise of GnomeDialog is that the programmer should not have to care about these things; if they're variable at all, the user should configure them the way they want. From the programmer's perspective, dialogs "just work."

Creating a Dialog

A GnomeDialog is easy to create. Here's a summary of the basic steps, more detail follows:

1. Read the section called *Special Dialog Types* and decide whether one of the special dialog subclasses is appropriate. If so, skip the below steps and create that subclass instead.
2. Create the widget with gnome_dialog_new(). Pass this function the title of the dialog (displayed by the window manager) and the name of each button you'd like to have.
3. Populate GNOME_DIALOG(dialog)->vbox with the contents of your dialog.
4. Plan how your dialog will work. You can connect to the "close" or "clicked" signals, as appropriate. You can have the dialog hide or destroy itself when closed. You can also have the dialog automatically close when clicked, or handle this yourself. There are a number of ways the user can interact with a dialog, so it's important to be sure the combination of settings you choose will work no matter what the user does.

To create a dialog, use gnome_dialog_new(), shown in Figure 1. The argument list is a NULL-terminated list of buttons to insert in the dialog. For example, you might say:

```
GtkWidget* dialog;
dialog = gnome_dialog_new(_("My Dialog Title"),
                          _("OK"),
                          _("Cancel"),
                          NULL);
```

This creates a dialog titled "My Dialog Title" with an OK and a Cancel button; the strings are marked for translation with the _() macro. The OK button will be the leftmost button in the dialog.

```
       #include <libgnomeui/gnome-dialog.h>
```

GtkWidget* gnome_dialog_new(const gchar* *title*, ...);

Figure 1. GnomeDialog Constructor

The GnomeDialog API numbers the buttons you add starting with 0; you use these numbers to refer to the buttons later, since you don't have a pointer to the automatically-created button widgets. In this case, the OK button is button 0, and the Cancel button is button 1. (Note that this is standard Gnome practice---OK or Yes goes first, then Cancel or No. In fact libgnomeui/gnome-uidefs.h contains the macros GNOME_YES, GNOME_OK, GNOME_NO, and GNOME_CANCEL which represent the dialog button numbers for these items in a two-button dialog.)

The above example, which specifies buttons called "OK" and "Cancel," is not quite correct for production code. Gnome provides a set of "stock buttons" for common button names. These ensure everyone uses "OK" instead of "Ok" or "OK!"; they allow translators to translate common strings only once; and they often insert icons in the buttons, making them more attractive and recognizable to users. You should always use stock buttons if possible.

You can use stock buttons in gnome_dialog_new(). Simply substitute the stock button macros for the button names:

```
dialog = gnome_dialog_new(_("My Dialog Title"),
                          GNOME_STOCK_BUTTON_OK,
                          GNOME_STOCK_BUTTON_CANCEL,
                          NULL);
```

Gnome includes many stock buttons, stock menu items, and stock pixmaps---it's a good idea to check these out so you don't reinvent the wheel. There's a complete list in libgnomeui/gnome-stock.h.

Filling in the Dialog

After creating a dialog, you'll want to put something inside. If you just want a label inside, probably you should use GnomeMessageBox or one of the convenience routines (such as gnome_ok_dialog()) instead of constructing the dialog manually. Otherwise, filling a dialog is very simple:

```
GtkWidget* button;
/* ... create dialog as shown earlier ... */
button = gtk_button_new_with_label(_("Push Me"));
gtk_box_pack_start(GTK_BOX(GNOME_DIALOG(dialog)->vbox)),
                   button,
                   TRUE,
                   TRUE,
                   0);
```

Of course you can pack the contents of dialog->vbox using the packing options of your choice. The above code is just an example.

Figure 2 shows a dialog from the Gnumeric spreadsheet, with its components labelled.

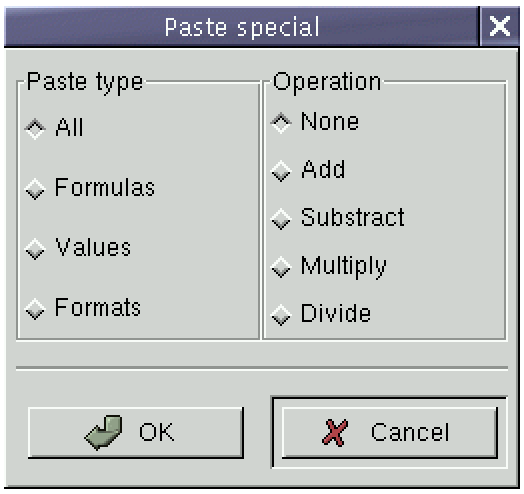

Figure 2. A GnomeDialog from the Gnumeric spreadsheet

Handling `GnomeDialog` Signals

Now for the tricky part. You have to prepare yourself to handle anything the user might do to your dialog. Here's a brief list of possibilities; it's worth going over the list whenever you create a dialog:

- Closing the dialog by pressing the Escape key
- Closing the dialog by clicking the window manager's close decoration
- Clicking one of the dialog's buttons
- Interacting with the contents of the dialog
- If the dialog is not modal, interacting with other parts of the application

GnomeDialog emits two signals in addition to those it inherits from parent classes. If the user clicks one of the dialog's buttons, a "clicked" signal is emitted. (This is *not* the "clicked" signal from GtkButton; it's a different signal, emitted by GnomeDialog.) A GnomeDialog"clicked" handler should have three arguments: the dialog emitting the signal, the number of the button clicked, and your callback data.

GnomeDialog also has a "close" signal. It is emitted when gnome_dialog_close() is called; all the built-in event handlers (e.g. for the Escape shortcut) call this function to close the dialog. GnomeDialog's default handler for "close" has two possible behaviors: it can call either gtk_widget_hide() or gtk_widget_destroy() on the dialog. The behavior is configurable by calling gnome_dialog_close_hides(), shown in Figure 3.

```
#include <libgnomeui/gnome-dialog.h>
```

void gnome_dialog_close_hides(GnomeDialog* *dialog*, gboolean *setting*);

void gnome_dialog_set_close(GnomeDialog* *dialog*, gboolean *setting*);

Figure 3. Closing GnomeDialog

By default, "close" destroys the dialog. This is what you usually want; however, if a dialog is noticeably time-consuming to create, you might want to merely hide and re-show it between uses, without ever destroying it. You might also want to hide the dialog from the user, extract the state of any widgets inside it, and then destroy it with gtk_widget_destroy(). The decision depends on the structure of your code. However, in general it is simpler and less error-prone to let the dialog be destroyed when clicked. You can connect to the "clicked" signal if you need to query the state of widgets in the dialog.

If you connect a handler to "close", that handler should return a boolean value. If it returns TRUE, the hide or destroy will not take place. You can use this to keep the user from closing the dialog, for example if they have not filled in all the fields of a form.

The "close" signal is designed to collect several possible user actions into a single handler: it should be emitted when the user presses Escape or the window manager's window close button is clicked. It's often convenient to emit close when the dialog's buttons are clicked as well. You can ask GnomeDialog to emit close whenever a button is clicked with gnome_dialog_set_close() (Figure 3); if its setting argument is TRUE, the dialog will emit "close" in addition to "clicked" if any of its buttons are clicked. By default, this setting is FALSE for GnomeDialog, but for many of the special dialog types the default is TRUE (the inconsistency is an unfortunate misfeature).

Note that the "close" signal is emitted when the dialog receives "delete_event"; this means you only have to write one signal handler to deal with all dialog closings. There is no need to handle "delete_event" as a separate case.

Finishing Touches

The difference between a good dialog and a great dialog is in the details. GnomeDialog comes with a number of features to make that final polish easy. Figure 4 sums them up.

```
      #include <libgnomeui/gnome-dialog.h>
```

void gnome_dialog_set_parent(GnomeDialog* *dialog*, GtkWindow* *parent*);

void gnome_dialog_set_default(GnomeDialog* *dialog*, gint *button*);

void gnome_dialog_editable_enters(GnomeDialog* *dialog*, GtkEditable* *editable*);

void gnome_dialog_set_sensitive(GnomeDialog* *dialog*, gint *button*, gboolean *setting*);

Figure 4. GnomeDialog Polish

Dialogs have a logical *parent*, usually the main application window. You can tell the library about this parent-child relationship; this lets Gnome honor certain user preferences, and in turn indicates the relationship to the window manager. Most window managers will minimize child dialogs when the parent window is minimized, and keep child dialogs on top of their parent.

It's important to use gnome_dialog_set_parent() with *transient* dialogs only. A transient dialog is one that appears and is dismissed relatively quickly. (GnomeDialog is really meant for transient dialogs.) Some "dialogs" are just small windows, such as the tool palette in the Gimp. These persistent ("floating") dialogs should be minimizable without minimizing the parent, and they should not be forced to stay above the parent window.

Your dialog should have a sensible *default button*---this is the button activated when the user presses the Enter key. gnome_dialog_set_default() specifies the default button. It's a judgment call which button should be the default. Often the best choice is the least-destructive action (i.e., "Cancel" rather than "OK"), but if neither is destructive, user convenience might guide your decision.

Typically, operations such as deleting data or quitting an application have "Cancel" or "No" as the default; dialogs that ask the user to enter text or other information typically have "OK" as the default. Remember that many window managers will focus windows when they pop up, so keystrokes users intend to go to their current application might go to your dialog instead. If your dialog has "delete all my files" as the default button, you will get hate mail.

Editable widgets emit the "activate" signal when Enter is pressed. Typically users expect Enter to activate the default dialog button, but if you have an editable widget such as GtkEntry in your dialog, it will capture any Enter presses, and keep the dialog's buttons from responding to them. gnome_dialog_editable_enters() activates the dialog's default button when the GtkEditable is activated, solving the problem.

gnome_dialog_set_sensitive() calls gtk_widget_set_sensitive() on button. If clicking a button makes no sense at a given time it should be desensitized.

Finally, you should make sure you do not create multiple instances of a dialog. Many applications allow you to pop up multiple Preferences or About dialogs; users will not trigger this bug very often, but it is a nice touch to avoid the problem. The following code deals with it in a simple way (note that the details of creating and showing the dialog have been omitted).

```
void
do_dialog()
{
  static GtkWidget* dialog = NULL;

  if (dialog != NULL)
    {
      /* This code tries to de-iconify and raise the dialog.
       * It assumes the dialog is realized; if you can't
       * ensure that, check that dialog->window != NULL.
       */

      gdk_window_show(dialog->window);
      gdk_window_raise(dialog->window);
    }
  else
    {
      dialog = gnome_dialog_new();      /* Arguments elided. */

      gtk_signal_connect(GTK_OBJECT(dialog),
                         "destroy",
                         GTK_SIGNAL_FUNC(gtk_widget_destroyed),
                         &dialog);

      /* Show the dialog, connect callbacks, etc. here */
    }
}
```

gtk_widget_destroyed() is defined in gtk/gtkwidget.h, and simply assigns NULL to its second argument. The code resets the dialog variable each time the user closes the dialog, and raises/deiconifies the dialog if the user tries to open it while another one is active. Note that the window manager has some say in whether the raise/deiconify is successful, so it is not guaranteed to happen.

Modal Dialogs

Sometimes you need to prevent interaction with the rest of your application while the user manipulates a dialog. Dialogs that freeze the rest of the application in this way are called *modal* dialogs.

There is a lot of debate about when to use modal dialogs; some users hate them passionately, but there are times when they are necessary. Unfortunately, it is a little bit easier to write code using modal dialogs, because you can stop in the middle of a function, wait for a user response, then continue. With nonmodal dialogs, you have to return the flow of control to the main application, and arrange callbacks to pick up where you left off when the user finally deals with the dialog. With a complex sequence of dialogs, the result is ugly spaghetti code. This tempts many programmers to use modal dialogs all the time, or at least a little too often. Avoid the temptation, and your users will thank you.

Avoid modal dialogs if users might want to refer back to information in the main application as they use the dialog, or if they might want to cut-and-paste between the application and the dialog. "Properties" dialogs should usually be nonmodal; because users will want to experiment with the effects of the changes they make, without having to close the dialog. And there's no reason to make trivial message boxes modal, since clicking on them has no effect on the rest of the application.

Do not be afraid to use a modal dialog if it makes sense, however. For example, I wrote a frontend for the Debian package manager, called gnome-apt. The main application allows the user to select software packages for installation and removal; then there are a series of dialogs which ask for confirmation and perform the requested changes. These dialogs are modal, because it would make no sense to change a request in the middle of performing it. Changing the request should imply restarting the request-fulfillment process and asking for confirmation a second time. Another example: the "File Properties" dialog for the Gnome file manager is modal, because otherwise the user could delete the file while its properties were being edited---a strange situation. There are no hard and fast rules; you'll have to use your judgment on a dialog-by-dialog basis.

All that said, it is very easy to create a modal dialog. In GTK+, any window can be made modal with gtk_window_set_modal() (Figure 5).

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

gtk_window_set_modal(GtkWindow* *window*, gboolean *modality*);

Figure 5. Modal Windows

Since GnomeDialog is a GtkWindow subclass, this function works fine. It simply blocks all interaction with windows other than the modal one.

Typically you want to go a step further, and wait for the user to click one of the dialog buttons without setting up a lot of callbacks. In GTK+ this is done by running a second instance of gtk_main(), entering another, nested event loop. When the second loop exits, the flow of control returns to just after your gtk_main() call. However there are a host of complications and race conditions, due to the large number of ways to close a dialog; the resulting code is somewhat unpleasant and error-prone. The two functions in Figure 6 are provided to save your from the mess.

```
    #include <libgnomeui/gnome-dialog.h>
```

gint gnome_dialog_run(GnomeDialog* *dialog*);

gint gnome_dialog_run_and_close(GnomeDialog* *dialog*);

Figure 6. "Running" a Dialog

These two functions block until the user clicks a dialog button, clicks the window manager's close decoration, or does the equivalent with a key shortcut. If a button was clicked, they return that button's number; recall that GnomeDialog buttons are numbered from left to right starting with 0. If no button was clicked (the dialog was closed via window manager), they return -1 instead.

The dialog is automatically made modal for the duration of the call; otherwise chaos would reign. (For example, calling gtk_main_quit() from your main application code would quit the nested gtk_main() rather than the primary one.) However, if you plan to leave the dialog open after gnome_dialog_run() returns, and you want it to be modal, you should manually make it modal; gnome_dialog_run() will only change the dialog's modality temporarily.

It is your responsibility to figure out how the dialog will be closed or destroyed before you call gnome_dialog_run(). You can set the dialog up so that no user actions destroy it, then destroy it yourself after gnome_dialog_run() returns. Or you can set the dialog up so that all user actions destroy it, then forget about it after gnome_dialog_run() returns. You could also write a loop, calling gnome_dialog_run() repeatedly until the user gives valid input, and closing the dialog only after the loop ends. If you write a loop, be careful to manually make the dialog modal; otherwise there will be short intervals where it is not.

gnome_dialog_run_and_close() monitors the dialog's "close" and "destroy" signals, and closes the dialog if and only if it does not close "naturally" in response to user clicks or keystrokes. Using this function guarantees that gnome_dialog_close() will be called exactly once before it returns, unless you connect truly malicious callbacks to sabotage the process. gnome_dialog_run_and_close() is not very useful in my opinion; it is little more than a way to avoid thinking about how the dialog will be closed.

A Dialog Example

Here's a piece of code from the Gnome plot and chart component, Guppi. This is used for an "Open file" dialog. Future versions of Gnome will have a GnomeFileSelection widget, which would be more appropriate for this particular task than a custom dialog; but the example is nonetheless instructive.

```
  GtkWidget * dialog;

  dialog = gnome_dialog_new(_("Guppi: Open"),
                            GNOME_STOCK_BUTTON_OK,
                            GNOME_STOCK_BUTTON_CANCEL,
                            NULL);

  gnome_dialog_set_close(GNOME_DIALOG(dialog), TRUE);
  gnome_dialog_close_hides(GNOME_DIALOG(dialog), TRUE);

  guppi_setup_dialog(dialog);

  GtkWidget* fileentry =
    gnome_file_entry_new("guppi:guppi_loadsave_history",
                         _("Guppi: Browse Files For Open"));

  gnome_dialog_editable_enters(GNOME_DIALOG(dialog),

GTK_EDITABLE(gnome_file_entry_gtk_entry(GNOME_FILE_ENTRY(fileentry))));
  gnome_dialog_set_default(GNOME_DIALOG(dialog), GNOME_OK);

  gtk_box_pack_start(GTK_BOX(GNOME_DIALOG(dialog)->vbox),
                     fileentry,
                     TRUE, TRUE, GNOME_PAD);
```

```
gtk_widget_show_all(dialog);

int reply = gnome_dialog_run(GNOME_DIALOG(dialog));

if (reply == GNOME_OK)
  {
    gchar* s =
      gnome_file_entry_get_full_path(GNOME_FILE_ENTRY(fileentry),
                                     TRUE);

    /* Application-specific details of actually
     * loading the file omitted.
     */
  }

gtk_widget_destroy(dialog);
```

gnome_dialog_set_close() is called, so this dialog will close if any of its buttons are clicked. However, closing the dialog only calls gtk_widget_hide(), rather than destroying it; gnome_dialog_close_hides() configures this behavior. guppi_setup_dialog() is a wrapper function that calls gnome_dialog_set_parent() to set the main application window as the dialog's parent.

Since the purpose of the dialog is to get a filename, it will be convenient to have the Enter key press the "OK" button; thus the "OK" button should be the default. However, the text entry box would normally steal the Enter key press; gnome_dialog_editable_enters() fixes the problem. gnome_dialog_run() waits for the user to take some action; if "OK" is clicked, we fetch the contents of the text entry and load the file. Note that the dialog is *not* destroyed after gnome_dialog_run() returns, because we called gnome_dialog_close_hides(). However, the dialog is *closed* after gnome_dialog_run() returns, because the code ensures that all user actions will close it (using gnome_dialog_set_close() and relying on the default behavior for the window manager's close button). Finally, gtk_widget_destroy() is necessary, since the dialog was not destroyed when it was closed.

Special Dialog Types

This section describes some special kinds of dialog that exist for your convenience, and for UI consistency. Of course nearly everything said so far about GnomeDialog also applies to its subclasses.

GnomeAbout

Gnome applications should have an "About Foo" menu item which displays this widget (where "Foo" is the name of your application). Using it is ridiculously easy; there's only one function involved, gnome_about_new() (Figure 7). The arguments are, respectively: the title of your application, the version of your application, a one-line copyright notice, a NULL-terminated vector of author's names, a short paragraph saying anything you want to say, and an image filename to display as your application's logo. Only the authors argument is required; the others can be NULL, but your dialog will look fairly strange if all of them are.

```
       #include <libgnomeui/gnome-about.h>
```

GtkWidget* gnome_about_new(const gchar* *title*, const gchar* *version*, const gchar* *copyright*, const gchar** *authors*, const gchar* *comments*, const gchar* *logo*);

Figure 7. GnomeAbout

GnomeAbout automatically closes when clicked, so you don't really need to worry about it; just create and show the dialog. Remember to ensure only one instance exists at any given time, as explained in the section called *Finishing Touches*.

Here's a menu item callback to show an about dialog, from the Gnome calendar application:

```

static void
about_calendar_cmd (GtkWidget *widget, void *data)
{
   GtkWidget *about;
   const gchar *authors[] = {
     "Miguel de Icaza <miguel@kernel.org>",
     "Federico Mena <federico@gimp.org>",
     "Arturo Espinosa <arturo@nuclecu.unam.mx>",
     NULL
   };
```

```
  about = gnome_about_new (_("Gnome Calendar"), VERSION,
                           "(C) 1998 the Free Software Foundation",
                           authors,
                           _("The GNOME personal calendar and schedule
manager."),
                           NULL);
  gtk_window_set_modal (GTK_WINDOW (about), TRUE);

  gtk_widget_show (about);
}
```

Note that the authors give both their name and email address; that way people can use the dialog to decide where to send hate mail and bug reports. (Or thank you notes!) The VERSION macro comes from config.h, and is defined by configure. The Gnome Calendar authors chose to prevent multiple dialog instances by making the dialog modal---the user can't re-select the menu item while the dialog is open. It is probably better to use the technique described in the section called *Finishing Touches*, so the dialog is deiconified and raised if the user reselects the menu item.

GnomePropertyBox

GnomePropertyBox is used for application preferences, or to edit the properties of a user-visible object. It's a dialog with a GtkNotebook inside, and four buttons: "OK," "Apply," "Close," and "Help." The "OK" button is equivalent in all respects to clicking "Apply" followed by "Close." "Apply" should immediately make any changes the user has requested using the widgets you've placed in the GnomePropertyBox. Unsurprisingly, "Help" should display help. "OK" and "Close" are handled automatically by the property box, so you can ignore them.

You don't need to deal with the property box's buttons directly; instead GnomePropertyBox emits "apply" and "help" signals. Handlers for these should look like:

```
void handler(GtkWidget* propertybox, gint page_num, gpointer data);
```

page_num is the currently-active page of the GtkNotebook inside the dialog. (GtkNotebook pages are numbered from front to back, starting with 0; the front page is the first one you add to the notebook.) For "help", the page number lets you provide context-sensitive help. When the user clicks the "Apply" or "OK" button, the "apply" signal is emitted once per page, then emitted a final time with -1 as the page_num value. The multiple emissions of "apply" are something of an anachronism, because it has become de facto standard behavior to simply apply all pages when the -1 page number is received.

To create a property box, you first create the dialog, then create each page and add it. Creating a GnomePropertyBox is straightforward; gnome_property_box_new() takes no arguments.

```
       #include <libgnomeui/gnome-propertybox.h>
```

GtkWidget* gnome_property_box_new(void);

gint gnome_property_box_append_page(GnomePropertyBox* *pb*, GtkWidget* *page*, GtkWidget* *tab*);

Figure 8. GnomePropertyBox

You then create a widget for each page (probably a container with a number of controls inside), and append it to the property box with gnome_property_box_append_page() (Figure 8). Its page argument is the widget to place inside the new notebook page, and tab is a widget to use on the notebook tab. The page number of the newly-added page is returned, so you don't have to keep a count yourself.

It's your responsibility to keep track of any user interaction with the contents of each page. When the user changes a setting, you must notify the property box; it uses this information to set the "Apply" and "OK" buttons sensitive if and only if there are unapplied changes. The relevant routines are in Figure 9.

```
       #include <libgnomeui/gnome-propertybox.h>
```

void gnome_property_box_changed(GnomePropertyBox* *pb*);

void gnome_property_box_set_state(GnomePropertyBox* *pb*, gboolean *setting*);

Figure 9. Property Box State

gnome_property_box_changed() tells the property box about changes; the property box will automatically unset its internal "changes pending" flag when "apply" is emitted. If you need to change that internal flag for some reason (unlikely), you can use gnome_property_box_set_state().

GnomeMessageBox

A GnomeMessageBox is a GnomeDialog subclass that conveys a short message or asks a simple question. Gnome provides several "types" of message box; they have different icons next to the text, and corresponding titles. The icons look nice, and allow users to quickly classify the message being presented.

The API is very simple; there are no functions specific to GnomeMessageBox other than the constructor, in Figure 10. The first argument is the message to display; the second is a string encoding the message box type. Then you can list any buttons, just as you would with gnome_dialog_new(). Unlike the unadorned GnomeDialog, GnomeMessageBox closes on any button click by default. Of course you can change this behavior using gnome_dialog_set_close().

```
      #include <libgnomeui/gnome-messagebox.h>
```

GtkWidget* gnome_message_box_new (const gchar* *message*, const gchar* *messagebox_type*, ...);

Figure 10. Message Box Constructor

Macros are provided for the available message box types.

- GNOME_MESSAGE_BOX_INFO should be used for "FYI" messages.
- GNOME_MESSAGE_BOX_WARNING should be used for nonfatal errors.
- GNOME_MESSAGE_BOX_ERROR should be used if an operation fails entirely.
- GNOME_MESSAGE_BOX_QUESTION should be used if your dialog asks a question.
- GNOME_MESSAGE_BOX_GENERIC should be used if none of the other types apply.

Here's how you might use GnomeMessageBox:

```

  GtkWidget * mbox;
```

```
mbox = gnome_message_box_new (message,
                              GNOME_MESSAGE_BOX_INFO,
                              GNOME_STOCK_BUTTON_OK,
                              NULL);

gtk_widget_show (mbox);
```

Notice that GnomeMessageBox, like most GnomeDialog subclasses but not GnomeDialog itself, automatically closes when clicked. So there is no need to destroy it by hand.

Convenience Routines

Since message boxes almost always have the same button (a single "OK"), there are convenience routines covering that case. Each routine has a _parented() variant which calls gnome_dialog_set_parent(). The three function pairs in Figure 11 display an info box, a warning box, and an error box, respectively; they create and show the widget, so you can ignore the return value if you like.

The only purpose of these functions is to save you typing. They are pure syntactic sugar. I find it much easier to remember them than to use gnome_message_box_new(), though; I always forget the order of the arguments to gnome_message_box_new().

```
   #include <libgnomeui/gnome-dialog-util.h>
```

GtkWidget* gnome_ok_dialog(const gchar* *message*);

GtkWidget* gnome_ok_dialog_parented(const gchar* *message*, GtkWindow* *parent*);

GtkWidget* gnome_warning_dialog(const gchar* *warning*);

GtkWidget* gnome_warning_dialog_parented(const gchar* *warning*, GtkWindow* *parent*);

GtkWidget* gnome_error_dialog(const gchar* *error*);

GtkWidget* gnome_error_dialog_parented(const gchar* *error*, GtkWindow* *parent*);

Figure 11. Convenience Dialogs

Gnome Application Checklist

Almost all Gnome applications should support a common set of features. This checklist summarizes the most important ones. Always remember: Gnome is a direct response to the problem of application heterogeneity in the X environment, and one of the most important goals of any Gnome application should be look-and-feel consistent with other Gnome applications, starting with the source code seen by programmers and ending with the spiffy GUI you present to users.

- Create a standards-compliant source tree. Use the Gnome autoconf macros, or the gnome-config script, to reliably locate the Gnome libraries and header files.
- Include a README describing the package.
- Include the standard INSTALL file describing how to compile and install the package; change the standard file to reflect anything specific to your application.
- Include a copyright, in a file called COPYING.
- Internationalize your application with GNU gettext and the standard C library functions.
- Include the intl directory with your application, so users can build the application without having gettext. Include intl in your header file search path.
- Define the G_LOG_DOMAIN preprocessor symbol to identify the origin of glib error messages.
- Define the GNOMELOCALEDIR preprocessor symbol so Gnome can find translation files.
- Install a .desktop file so your application will appear on the Gnome desktop's menus.
- Install help files along with topic.dat files so the Gnome help browser can locate them.
- Be sure the make distcheck target works; this is will catch many common makefile errors.
- Set up a popt argument parser; at a minimum, you will probably want to support a --geometry option.
- All configuration should be possible via the GUI; the easiest way to achieve this is with the Gnome configuration library.
- Your application should support session management; at a minimum, it should save and restore the currently open documents.
- If appropriate, use the GnomeApp for your main document windows; this widget gives Gnome applications a consistent look-and-feel.

- Call gtk_window_set_wmclass() to set the class hint on your windows, so users can customize how window managers treat them.
- Use GnomeUIInfo to create menus and toolbars; when appropriate, use the Gnome macros for standard menu items.
- Add a status bar to display hints for the menu items, and any other status your application has to report.
- Use GnomeDialog and its subclasses for your dialogs.
- Add online help, including tooltips and documentation for display in the help browser.
- Keep a ChangeLog detailing changes to your source code. This will help other people understand the evolution of the application, and help you understand why you made certain changes years later.

III. Advanced GTK+/Gnome Techniques

The previous part got you started with a skeletal application. This part of the book describes features available to the Gnome developer as she begins to implement the main functionality of the program. The first few chapters in this part cover some useful GTK+ details. The later chapters branch out to describe facilities unique to Gnome. You may not use all the tools described here for a given application, but you will probably use many of them.

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The GTK+ Object and Type System

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People often ask why GTK+ was written in C rather than an object-oriented language. The answer is that C is more portable and standardly available than any other language. However, although C lacks syntactic sugar for object-oriented programming, it in no way prohibits an object-oriented approach.

GTK+ implements its own custom object system, which offers standard object-oriented features such as inheritance and virtual functions. In the tradition of languages such as Lisp, Smalltalk, and Java, the GTK+ object system is more runtime-centric than that of C++, allowing interpreted language bindings and GUI builders to interact with it in powerful ways.

You may recall from the chapter called *GTK+ Basics* that widgets are a special type of GtkObject; any object with GtkWidget in its ancestry is a widget. Widgets represent a region on the screen---most of them are user interface elements, such as buttons or menus. There's nothing GUI-specific about GtkObject; the object system can be used in non-graphical programs.

This chapter dives right into the details of GTK+'s object system, giving you an idea what's happening "behind the scenes" in any GTK+ program. Sooner or later you'll need this information: to write your own objects, debug existing objects, or just understand GTK+ code on a conceptual level.

Object and Class Structures

Each GtkObject has two essential components: a struct representing an *instance* of the object, and a struct representing the *class*. In general, the instance struct contains the data members for each instance, and the class struct contains class function pointers (which can be overridden by subclasses). The class struct can also contain class data members---however, it's more typical to use static variables in the .c file implementing the object. If you're familiar with C++, the class struct is equivalent to a vtable, only the class struct is written by hand. It stores virtual functions for an object type.

Here are the structs used in GtkButton:

```
typedef struct _GtkButton       GtkButton;
typedef struct _GtkButtonClass  GtkButtonClass;
```

```
struct _GtkButton
{
  GtkBin bin;

  GtkWidget *child;

  guint in_button : 1;
  guint button_down : 1;
  guint relief : 2;
};

struct _GtkButtonClass
{
  GtkBinClass        parent_class;

  void (* pressed)  (GtkButton *button);
  void (* released) (GtkButton *button);
  void (* clicked)  (GtkButton *button);
  void (* enter)    (GtkButton *button);
  void (* leave)    (GtkButton *button);
};
```

Notice that the first member of struct _GtkButton is GtkBin---that's because GtkButton is a subclass of GtkBin. (GtkBin is a GtkContainer that can hold one child.) Since GtkBin is the first member, we can safely cast a GtkButton to GtkBin. In struct _GtkButtonClass, the same principle applies, and GtkBinClass is the first member.

Type Checking and New Types

GTK+ has an extensive type system, which is to some extent independent of its object system. However, the object system makes use of the larger type system. Every object has a type, and every type has a unique integer identifier. When writing a GtkObject, it's customary to provide a function which returns the type's identifier.

In the case of GtkButton, the relevant function is:

```
GtkType gtk_button_get_type();
```

The first time this function is invoked, it will register a GtkButton type with the object system, and in the process obtain a type identifier. On subsequent calls, the type identifier is simply returned. GtkType is a typedef (unsigned int is the actual type of GTK+'s type identifiers).

The type system allows GTK+ to check the validity of casts. To facilitate this, objects customarily provide macros like these in their header file:

```
#define GTK_TYPE_BUTTON            (gtk_button_get_type ())
#define GTK_BUTTON(obj)            (GTK_CHECK_CAST ((obj), \
                                    GTK_TYPE_BUTTON, GtkButton))
#define GTK_BUTTON_CLASS(klass)    (GTK_CHECK_CLASS_CAST ((klass), \
                                    GTK_TYPE_BUTTON, GtkButtonClass))
#define GTK_IS_BUTTON(obj)         (GTK_CHECK_TYPE ((obj),  \
                                    GTK_TYPE_BUTTON))
#define GTK_IS_BUTTON_CLASS(klass) (GTK_CHECK_CLASS_TYPE ((klass),  \
                                    GTK_TYPE_BUTTON))
```

Instead of simply casting an object, you can use the GTK_BUTTON() macro. If GTK_NO_CHECK_CASTS is defined, these macros are equivalent to simple casts. Otherwise, they retrieve the type of the object and compare it to the type you're attempting to cast to.

GTK+ also provides convenient runtime type checking, with the GTK_IS_BUTTON() macro. This is often used in preconditions; for example, a function expecting a button as an argument might have this check at the beginning:

```
  g_return_if_fail(GTK_IS_BUTTON(widget));
```

The GTK+ and Gnome library functions have many such checks. You can also use the macro to make certain code conditional on an object's type, though this is most likely a poor idea from a design standpoint.

To give you an idea what sort of information GTK+ stores about each object type, here's the implementation of gtk_button_get_type():

```
GtkType
gtk_button_get_type (void)
{
  static GtkType button_type = 0;

  if (!button_type)
    {
      static const GtkTypeInfo button_info =
      {
        "GtkButton",
        sizeof (GtkButton),
        sizeof (GtkButtonClass),
        (GtkClassInitFunc) gtk_button_class_init,
        (GtkObjectInitFunc) gtk_button_init,
        /* reserved_1 */ NULL,
        /* reserved_2 */ NULL,
        (GtkClassInitFunc) NULL,
      };

      button_type = gtk_type_unique (GTK_TYPE_BIN, &button_info);
      gtk_type_set_chunk_alloc (button_type, 16);
    }

  return button_type;
}
```

The code fills in a struct with information about the class, then hands that struct to GTK+ to get a type identifier (GtkType). Only six components of the GtkTypeInfo struct are important. GtkButton gives GTK+ a human-readable name for the class, used in error messages and the like; the size of the instance and class structs; then a function to initialize the class struct and another to initialize each new instance. The sixth and seventh members of the struct (reserved_1 and reserved_2) are obsolete and preserved only for compatibility. The final member is a pointer to a base class initialization function, used to initialize the class struct of any subclasses.

gtk_type_unique() registers the new type and obtains a type identifier. The GTK_TYPE_BIN argument is a macro containing the type of GtkButton's parent class, GtkBin. The call to gtk_type_set_chunk_alloc() optimizes memory allocation for this type; it is never required, and should only be used for frequently-allocated types like GtkButton.

Given a registered GtkButton type, the following code creates a type instance:

```
GtkWidget*
gtk_button_new (void)
{
  return GTK_WIDGET (gtk_type_new (gtk_button_get_type ()));
}
```

The newborn GtkButton will be initialized by its instance initializer. The instance initialization function is called each time an instance of the type is created; it gives the object's data members reasonable default values:

```
static void
gtk_button_init (GtkButton *button)
{
  GTK_WIDGET_SET_FLAGS (button, GTK_CAN_FOCUS);
  GTK_WIDGET_UNSET_FLAGS (button, GTK_NO_WINDOW);

  button->child = NULL;
  button->in_button = FALSE;
  button->button_down = FALSE;
  button->relief = GTK_RELIEF_NORMAL;
}
```

Remember that gtk_button_init() was passed to gtk_type_unique() when the GtkButton type was created. GTK+ stores the function pointer and uses it to create GtkButton instances.

Instance structs are created with all bits set to 0; so settings members to 0 or NULL is not strictly necessary. Still, most GTK+ code does initialize the members, for clarity.

The class initialization and base class initialization functions require some background information to understand fully; you will know how to write them after you read this chapter.

Initializing a New Class

When a type is first used, GTK+ creates an instance of its class struct (using the information supplied to gtk_type_unique()). To initialize the class struct for a type, GTK+ first checks that all parent classes are initialized and initializes them if not. Then it fills the top portion of the class struct with a byte-for-byte copy of the parent's class struct. This means the subclass inherits any function pointers found in the parent class.

Next, the base class initialization functions of each parent class and that of the class itself are called in order, starting with GtkObject. (The base class init function is the last argument to gtk_type_unique()). A base class initializer is optional; in the GtkButton case, there is none. If present, the base class initializer supplements the byte-for-byte copy of the class struct; for example, some functions should not be inherited. To prevent class function inheritance, the base class initializer can zero certain function pointers. Normally you do not need a base class initializer.

Finally, GTK+ calls the type's own class init function. The class init function can override functions from the parent class by replacing them in the class struct. It should also fill in any functions unique to the subclass, and register signals and object arguments (discussed later in the chapter).

A concrete example should make the class creation process clear. The class hierarchy for GtkButton is shown in Figure 1. When the GtkButton type is registered, an empty GtkButtonClass is created. This class struct is initialized as follows:

1. The class struct for GtkBin, GtkButton's immediate parent, is copied into it. This means GtkButton inherits class functions from GtkBin.
2. The base class initialization function for GtkObject is called on it. This zeroes some GtkObject class functions that should not be inherited.
3. There is no base class initializer for GtkWidget, or it would be called.
4. The base class initializer for GtkContainer is called. This zeroes some GtkContainer class functions that should not be inherited, and initializes a GtkContainerClass data member.
5. There is no base class initializer for GtkBin, or it would be called.
6. There is no base class initializer for GtkButton, or it would be called.
7. The class initializer is called for GtkButton. This fills in the GtkButtonClass structure, registers signals, and registers object arguments.

When writing a new class, you only need to concern yourself with the final two steps---you should consider whether a base class initializer is needed, and supply it if so; you must supply a class initializer in all cases.

Figure 1. GtkButton Ancestry

```
GtkObject
   |
GtkWidget
   |
GtkContainer
   |
GtkBin
   |
GtkButton
```

Here is the GtkButton class initialization function, just to give you an initial sense of things; read on to learn what this code does.

```
static void
gtk_button_class_init (GtkButtonClass *klass)
{
  GtkObjectClass *object_class;
  GtkWidgetClass *widget_class;
  GtkContainerClass *container_class;

  object_class = (GtkObjectClass*) klass;
  widget_class = (GtkWidgetClass*) klass;
  container_class = (GtkContainerClass*) klass;

  parent_class = gtk_type_class (GTK_TYPE_BIN);

  gtk_object_add_arg_type ("GtkButton::label",
                           GTK_TYPE_STRING,
                           GTK_ARG_READWRITE,
                           ARG_LABEL);
  gtk_object_add_arg_type ("GtkButton::relief",
                           GTK_TYPE_RELIEF_STYLE,
                           GTK_ARG_READWRITE,
                           ARG_RELIEF);
  button_signals[PRESSED] =
    gtk_signal_new ("pressed",
                    GTK_RUN_FIRST,
                    object_class->type,
                    GTK_SIGNAL_OFFSET (GtkButtonClass, pressed),
                    gtk_marshal_NONE__NONE,
                    GTK_TYPE_NONE, 0);
  button_signals[RELEASED] =
    gtk_signal_new ("released",
                    GTK_RUN_FIRST,
                    object_class->type,
                    GTK_SIGNAL_OFFSET (GtkButtonClass, released),
                    gtk_marshal_NONE__NONE,
                    GTK_TYPE_NONE, 0);
  button_signals[CLICKED] =
    gtk_signal_new ("clicked",
                    GTK_RUN_FIRST | GTK_RUN_ACTION,
                    object_class->type,
                    GTK_SIGNAL_OFFSET (GtkButtonClass, clicked),
                    gtk_marshal_NONE__NONE,
                    GTK_TYPE_NONE, 0);
  button_signals[ENTER] =
    gtk_signal_new ("enter",
                    GTK_RUN_FIRST,
                    object_class->type,
                    GTK_SIGNAL_OFFSET (GtkButtonClass, enter),
                    gtk_marshal_NONE__NONE,
                    GTK_TYPE_NONE, 0);
  button_signals[LEAVE] =
    gtk_signal_new ("leave",
                    GTK_RUN_FIRST,
                    object_class->type,
                    GTK_SIGNAL_OFFSET (GtkButtonClass, leave),
                    gtk_marshal_NONE__NONE,
                    GTK_TYPE_NONE, 0);

  gtk_object_class_add_signals (object_class, button_signals,
LAST_SIGNAL);


  object_class->set_arg = gtk_button_set_arg;
  object_class->get_arg = gtk_button_get_arg;

  widget_class->activate_signal = button_signals[CLICKED];
  widget_class->realize = gtk_button_realize;
  widget_class->draw = gtk_button_draw;
  widget_class->draw_focus = gtk_button_draw_focus;
  widget_class->draw_default = gtk_button_draw_default;
  widget_class->size_request = gtk_button_size_request;
  widget_class->size_allocate = gtk_button_size_allocate;
  widget_class->expose_event = gtk_button_expose;
  widget_class->button_press_event = gtk_button_button_press;
  widget_class->button_release_event = gtk_button_button_release;
  widget_class->enter_notify_event = gtk_button_enter_notify;
  widget_class->leave_notify_event = gtk_button_leave_notify;
  widget_class->focus_in_event = gtk_button_focus_in;
  widget_class->focus_out_event = gtk_button_focus_out;

  container_class->add = gtk_button_add;
  container_class->remove = gtk_button_remove;
  container_class->child_type = gtk_button_child_type;

  klass->pressed = gtk_real_button_pressed;
  klass->released = gtk_real_button_released;
  klass->clicked = NULL;
  klass->enter = gtk_real_button_enter;
  klass->leave = gtk_real_button_leave;
}
```

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GtkArg and the Type System

Before delving further into GtkObject, you will need more details on GTK+'s type system. The type system is used in many contexts:

- It allows signals and callbacks with any signature to be dynamically registered and dynamically queried. Function argument lists can be constructed at runtime.
- It allows object attributes (values that you can "get" or "set") to be dynamically queried and manipulated.
- It exports information about enumerations and bitfields (lists of permitted values, and human-readable names).

- It is possible to identify types at runtime and traverse the object class hierarchy.

Because of its type system, GTK+ is particularly easy to manipulate from dynamically-typed, interactive languages. There are bindings available for nearly all popular languages, and the bindings can be lightweight (since GTK+ already includes much of the needed functionality, and types can be handled generically so the amount of glue code is reduced). You can find a complete list of functions for querying and using GTK+'s type system in gtk/gtktypeutils.h; most of these are not useful in applications. Only the functions of general interest are described in this book.

GTK+ has a number of so-called *fundamental* types which are automatically registered during gtk_init() (or gnome_init()). The fundamental types include all the primitive C types, some GTK+ types such as GTK_TYPE_SIGNAL, and GTK_TYPE_OBJECT. Fundamental types are essentially the "base classes" understood by the GTK+ type system; for example, the fundamental type of any enumeration is GTK_TYPE_ENUM, and the fundamental type of any GtkObject subclass is GTK_TYPE_OBJECT. Fundamental types are supposed to cover all the "special cases" in the GTK+ type system; all types ultimately derive from some fundamental type. A type's fundamental type is extracted from a GtkType with the GTK_FUNDAMENTAL_TYPE() macro. The fundamental types are shown in Table 1.

There is a second category of GtkType values: *builtin* types are registered by GTK+ and libgnomeui during library initialization and are thus always available. Builtin types include enumerations, flags, and some structs (GdkWindow, or GdkImlibImage, for example). Builtin types are distinct from fundamental types because the GTK+ object system does not have to understand them; for the purposes of getting and setting argument values, they can be treated as fundamental types. They are somewhat arbitrarily distinguished from user-registered enumeration or flag types. (The difference between builtin types and user types is the time of registration.)

Builtin types are all accessible via macros that come with GTK+ and Gnome. These begin with GTK_TYPE_, as in: GTK_TYPE_WINDOW, GTK_TYPE_GDK_WINDOW, GTK_TYPE_RELIEF_STYLE, GTK_TYPE_GNOME_DIALOG. As you can see, the name of the type macro is derived from the name of the GtkObject, struct, or enumeration; if the object name begins with "Gtk," the "Gtk" is dropped. The above examples map to the GtkWindow widget, GdkWindow struct, GtkReliefStyle enumeration, and GnomeDialog widget, respectively.

The final major category of GtkType values consists of the registered GtkObject types. These are registered the first time the _get_type() routine for each object is called.

Table 1. The GTK+ Fundamental Types

GtkType Constant	Corresponding C Type
GTK_TYPE_INVALID	None
GTK_TYPE_NONE	void
GTK_TYPE_CHAR	gchar
GTK_TYPE_UCHAR	guchar
GTK_TYPE_BOOL	gboolean
GTK_TYPE_INT	gint
GTK_TYPE_UINT	guint
GTK_TYPE_LONG	glong
GTK_TYPE_ULONG	gulong
GTK_TYPE_FLOAT	gfloat
GTK_TYPE_DOUBLE	gdouble
GTK_TYPE_STRING	gchar*
GTK_TYPE_ENUM	Any enumeration
GTK_TYPE_FLAGS	guint
GTK_TYPE_BOXED	gpointer
GTK_TYPE_POINTER	gpointer
GTK_TYPE_SIGNAL	GtkSignalFunc, gpointer
GTK_TYPE_ARGS	gint, GtkArg*
GTK_TYPE_CALLBACK	GtkCallbackMarshal, gpointer, GtkDestroyNotify
GTK_TYPE_C_CALLBACK	GtkFunction, gpointer
GTK_TYPE_FOREIGN	gpointer, GtkDestroyNotify
GTK_TYPE_OBJECT	GtkObject*

Some of the fundamental types require further explanation. In brief:

- GTK_TYPE_INVALID: used to signal errors.

- GTK_TYPE_NONE: used to indicate a void return value when specifying the signature of a signal.
- GTK_TYPE_BOXED: Subtypes of GTK_TYPE_BOXED are used to mark the type of a generic pointer; language bindings will special case these types. Most GDK types, such as GdkWindow, are registered as boxed types.
- GTK_TYPE_SIGNAL: special-cased in GtkObject; it allows users to connect signal handlers with gtk_object_set(). It should not be useful in application code.
- GTK_TYPE_ARGS: type of an array of GtkArg (when used with gtk_object_set(), an integer array length followed by the array itself are expected as arguments).
- GTK_TYPE_CALLBACK: interpreted language bindings can use this to pass signal callbacks around.
- GTK_TYPE_C_CALLBACK: this is used for other kinds of callbacks, i.e. callbacks that are not attached to signals (such as the argument to a _foreach() function).
- GTK_TYPE_FOREIGN: unused in current GTK+ code. Represents a pointer plus a function used to destroy the pointed-to resource; intended to represent object data (see the section called *Attaching Data to Objects*), for example.

A fundamental type describes not only describe the data layout but also how memory is managed. For values passed in as arguments, the called function is not allowed to retain the pointer beyond the duration of the call. For returned values, the caller assumes ownership of the memory. GTK_TYPE_BOXED, GTK_TYPE_ARGS, and GTK_TYPE_STRING obey this rule.

Note that you should almost always use the most informative type available. Notably, GTK_TYPE_POINTER should only be used for generic pointers (gpointer); whenever possible, prefer a "subclass" of GTK_TYPE_BOXED such as GTK_TYPE_GDK_WINDOW or GTK_TYPE_GDK_EVENT. Similarly, it is better to use a specific enumeration type, rather than GTK_TYPE_ENUM. GTK_TYPE_CALLBACK is normally preferred to GTK_TYPE_C_CALLBACK or GTK_TYPE_SIGNAL, because GTK_TYPE_CALLBACK includes information about how to marshal the function and destroy the callback data.

GTK+ has a consistent interface for passing typed values around; to do this, it needs a data structure which stores a type tag and a value. GtkArg fills the bill. Here is its definition, from gtk/gtktypeutils.h:

```
typedef struct _GtkArg GtkArg;
```

```
struct _GtkArg
{
  GtkType type;
  gchar *name;

  union {
    gchar char_data;
    guchar uchar_data;
    gboolean bool_data;
    gint int_data;
    guint uint_data;
    glong long_data;
    gulong ulong_data;
    gfloat float_data;
    gdouble double_data;
    gchar *string_data;
    gpointer pointer_data;
    GtkObject *object_data;

    struct {
      GtkSignalFunc f;
      gpointer d;
    } signal_data;
    struct {
      gint n_args;
      GtkArg *args;
    } args_data;
    struct {
      GtkCallbackMarshal marshal;
      gpointer data;
      GtkDestroyNotify notify;
    } callback_data;
    struct {
      GtkFunction func;
      gpointer func_data;
    } c_callback_data;
    struct {
      gpointer data;
      GtkDestroyNotify notify;
    } foreign_data;
  } d;
};
```

The type field contains the value's GtkType, as you might expect. The name field is an object argument name---more on arguments in a moment. The final union stores a value of the appropriate type; there is one union member for each fundamental type. This value field should be accessed using a special set of macros provided for the purpose, listed in Figure 2; each macro corresponds to a fundamental type. These macros are defined so that you can use the & operator on them; e.g. &GTK_VALUE_CHAR(arg).

To print a GtkArg's value, you might write code like this:

```
   GtkArg arg;

   /* ... */

   switch (GTK_FUNDAMENTAL_TYPE (arg.type))
     {
     case GTK_TYPE_INT:
       printf("arg: %d\n", GTK_VALUE_INT(arg));
       break;
     /* ... case for each type ... */
     }
#include <gtk/gtktypeutils.h>
```

GTK_VALUE_CHAR(*arg*);

GTK_VALUE_UCHAR(*arg*);

GTK_VALUE_BOOL(*arg*);

GTK_VALUE_INT(*arg*);

GTK_VALUE_UINT(*arg*);

GTK_VALUE_LONG(*arg*);

GTK_VALUE_ULONG(*arg*);

GTK_VALUE_FLOAT(*arg*);

GTK_VALUE_DOUBLE(*arg*);

GTK_VALUE_STRING(*arg*);

GTK_VALUE_ENUM(*arg*);

GTK_VALUE_FLAGS(*arg*);

GTK_VALUE_BOXED(*arg*);

GTK_VALUE_POINTER(*arg*);

GTK_VALUE_OBJECT(*arg*);

GTK_VALUE_SIGNAL(*arg*);

GTK_VALUE_ARGS(*arg*);

GTK_VALUE_CALLBACK(*arg*);

GTK_VALUE_C_CALLBACK(*arg*);

GTK_VALUE_FOREIGN(*arg*);

Figure 2. Macros for Accessing GtkArg Values

Some uses of GtkArg require you to assign a value to it. The GTK_VALUE_ macros are not appropriate here; instead, a parallel set of macros exist which return a pointer to an assignable location. These are called GTK_RETLOC_CHAR(), GTK_RETLOC_UCHAR(), and so on.

Object Arguments

Arguments are one of the most interesting features of GtkObject. Arguments are a mechanism for handling what CORBA's Interface Definition Language (IDL) calls an *attribute*: a value with a "getter" and a "setter." In concrete terms, object arguments pair a key (which is a string) with a value (represented as a GtkArg). Each GtkObject subclass can register permissible keys and the GtkTypes of their associated values.

Using object arguments, one can discover at runtime what attributes an object has, and then get or set their values. This is very useful for people implementing GUI builders, since some of the widget configuration dialogs can be automated. Similarly, it makes it much easier to write GTK+ bindings for scripting languages. It can also be convenient for programmers, since they can avoid writing all the get/set functions---the GnomeCanvas, for example, uses object arguments for almost all of its API. Finally, object arguments may be configurable via the gtkrc configuration mechanism in a future version of GTK+, making it possible for users to extensively customize GTK+ software.

Setting Object Arguments

Most commonly, arguments are used as an API to set attributes of widgets. However, not all of the GTK+ API has been exported via arguments, so it is not always possible.

To set widget attributes, the most convenient interface is gtk_object_set(). Here's an example:

```
gtk_object_set(GTK_OBJECT(vbox),
               "GtkContainer::border_width", (gulong) 10,
               NULL);
```

The above code is identical in effect to:

```
gtk_container_set_border_width(GTK_CONTAINER(vbox), 10);
```

It's up to you which to use; it depends on the context. Typically, you would use the argument mechanism if you have a reason to, i.e. if you are using its dynamic, runtime-oriented features. However, if you are setting several attributes, it may be easier to type and read.

gtk_object_set() takes a GtkObject as the first argument, followed by any number of key-value pairs. If a key is not defined for the object you pass in, a runtime error will be triggered. The list of key-value pairs must be terminated with a NULL key. When a GtkObject registers itself with GTK+, it tells GTK+ what type of value to expect after each key. For the aggregate fundamental types gtk_object_set() will expect more than one C function argument after the key. For example, first a signal function and then a user data pointer will be expected after GTK_TYPE_SIGNAL arguments. (Table 1 in the section called *GtkArg and the Type System* gives the types of the expected arguments.)

It is permissible to leave off the object class portion of an argument name---"GtkContainer::border_width" can be simply "border_width":

```
gtk_object_set(GTK_OBJECT(vbox),
               "border_width", (gulong) 10,
               NULL);
```

If you do not specify the class name as part of the argument name, GTK+ will start with the real type of the object and look up the argument name in the argument table for each superclass until it finds the right one (GtkContainer in this case). If you do specify the class name, GTK+ will only look for the argument in the specified class's argument table.

Since gtk_object_set() uses C variable argument lists, it has limited type safety. This can be a real problem in your code. You may have noticed the cast to gulong in the sample call to gtk_object_set(). The argument GtkContainer::border_width has type GTK_TYPE_ULONG. GTK+ will extract sizeof(gulong) bytes from the argument list when it encounters this argument. If you leave out the cast, C will probably pass only sizeof(gint) bytes to the function. As you might imagine, this causes memory corruption on many platforms. A similar problem arises with arguments of type GTK_TYPE_DOUBLE; if you type 5 instead of 5.0, C will pass an integer to gtk_object_set(). These bugs are very hard to find, once you introduce them.

gtk_object_set() is syntactic sugar for a more fundamental function call, gtk_object_setv(). gtk_object_setv() takes a vector of GtkArg (gtk_object_set() converts each key-value pair in its argument list to GtkArg internally).

```
GtkArg args[1];
args[0].name = "GtkContainer::border_width";
args[0].type = GTK_TYPE_ULONG;
GTK_VALUE_ULONG(args[0]) = 10;
gtk_object_setv(GTK_OBJECT(button),
                1,
                args);
```

The second argument to gtk_object_setv() is the length of the array of GtkArg. gtk_object_set() is plainly easier to use when you are typing the code in manually, but gtk_object_setv() can be passed a dynamically-constructed argument array---which is convenient if you're exporting GTK+ functionality to an interpreted environment.

It is also possible to set object arguments when objects are created. You can create most objects using the gtk_object_new() function, and most widgets with the gtk_widget_new() function. The routines take a GtkType as their first argument, and create an object or widget of that type. They then take a list of argument-value pairs, just as gtk_object_set() does. There are also gtk_object_newv() and gtk_widget_newv() variants.

Reading Object Arguments

To get the value of one or more arguments, you simply create an array of GtkArg, filling in the name field of each GtkArg. gtk_object_getv() fills in the type fields and the argument values. If an error occurs, the type field is set to GTK_TYPE_INVALID. If the fundamental type of the returned value is GTK_TYPE_STRING, GTK_TYPE_BOXED, or GTK_TYPE_ARGS, you are responsible for freeing it.

Here's a simple example:

```
GtkArg args[2];

args[0].name = "GtkContainer::border_width";
args[1].name = "GtkContainer::resize_mode";
gtk_object_getv(GTK_OBJECT(button),
                2,
                args);

g_assert(args[0].type == GTK_TYPE_ULONG);
g_assert(args[1].type == GTK_TYPE_RESIZE_MODE);
g_assert(GTK_FUNDAMENTAL_TYPE(args[1].type) == GTK_TYPE_ENUM);

printf("Border width: %lu Resize mode: %d\n",
       GTK_VALUE_ULONG(args[0]), GTK_VALUE_ENUM(args[1]));
```

Using Object Arguments in Your Own GtkObject Subclass

If you're writing a custom GtkObject or a custom subclass of some existing object, you can register your own object arguments in the class initialization function, at the same time you register your object's signals. To do this, call gtk_object_add_arg_type()---here's an example from GtkContainer:

```
  gtk_object_add_arg_type("GtkContainer::border_width",
                          GTK_TYPE_ULONG,
                          GTK_ARG_READWRITE,
                          ARG_BORDER_WIDTH);
```

The first argument must be a static string constant, because GTK+ does not copy it. It must also begin with the name of your new class, separated from the name of the argument by two colons (reminiscent of the C++ scope operator). The second argument should be the type of the argument; this can be any GtkType GTK+ knows about.

The third argument contains one or more flags, defined in gtk/gtkobject.h. The available flags are:

- GTK_ARG_READABLE means the argument's value can be read, using gtk_object_getv().
- GTK_ARG_WRITABLE means the argument's value can be written, using gtk_object_set() or gtk_object_setv()
- GTK_ARG_CONSTRUCT means the argument should be initialized with a default value. This applies to numeric and pointer types; they are set to 0 or NULL, respectively. (This happens within gtk_object_new() or gtk_widget_new(), which call gtk_object_default_construct().)
- GTK_ARG_CONSTRUCT_ONLY means the argument is *only* used for object construction; it cannot be read or written later. That is, you can't use these arguments with gtk_object_set().
- GTK_ARG_CHILD_ARG is used by subclasses of GtkContainer; GtkContainer implements a specialized variation on the argument system to permit setting the attributes of child-container pairs (such as packing flags for GtkBox---the flags are not a property of the child or the container, but of the pair). You will only use this flag if you're writing a new type of container, or some other kind of object with similar semantics.
- GTK_ARG_READWRITE is shorthand for (GTK_ARG_READABLE | GTK_ARG_WRITABLE).

There are some limitations on which flags can be used.

- All arguments must be either readable or writable.
- GTK_ARG_CONSTRUCT arguments must be both readable and writable.
- GTK_ARG_CONSTRUCT_ONLY arguments must be writable.
- GTK_ARG_CHILD_ARG should not be used outside of container-style object implementations; it is used internally by the GtkContainer child argument functions.

The fourth and final argument to gtk_object_add_arg_type() is an argument ID to be used by the object subclass to identify this argument. This can be any integer except 0, but it is customary to use a private enumeration in the object implementation's .c file. GtkObject has two class functions any subclass with arguments must implement: one to get arguments specific to the subclass, and one to set them. These functions are passed the argument ID, so they know which argument to get or set. Argument IDs reduce the need for string comparisons, increasing the efficiency of argument manipulation.

For example, GtkContainer defines these functions:

```
static void gtk_container_get_arg(GtkObject* object,
                                  GtkArg* arg,
                                  guint arg_id);
static void gtk_container_set_arg(GtkObject* object,
                                  GtkArg* arg,
                                  guint arg_id);
```

It uses this enumeration to create its argument IDs:

```
enum {
  ARG_0,              /* Skip 0, an invalid argument ID */
  ARG_BORDER_WIDTH,
  ARG_RESIZE_MODE,
  ARG_CHILD
};
```

It registers its arguments in gtk_container_class_init() as follows:

```
  gtk_object_add_arg_type("GtkContainer::border_width",
                          GTK_TYPE_ULONG,
                          GTK_ARG_READWRITE,
                          ARG_BORDER_WIDTH);
  gtk_object_add_arg_type("GtkContainer::resize_mode",
                          GTK_TYPE_RESIZE_MODE,
                          GTK_ARG_READWRITE,
                          ARG_RESIZE_MODE);
  gtk_object_add_arg_type("GtkContainer::child",
                          GTK_TYPE_WIDGET,
                          GTK_ARG_WRITABLE,
                          ARG_CHILD);
```

gtk_container_set_arg() and gtk_container_get_arg() are installed in the class struct:

```
  object_class->get_arg = gtk_container_get_arg;
  object_class->set_arg = gtk_container_set_arg;
```

gtk_container_set_arg() and gtk_container_get_arg() are then implemented like this:

```
static void
gtk_container_set_arg (GtkObject    *object,
                       GtkArg       *arg,
                       guint         arg_id)
{
  GtkContainer *container;

  container = GTK_CONTAINER (object);

  switch (arg_id)
    {
    case ARG_BORDER_WIDTH:
      gtk_container_set_border_width (container, GTK_VALUE_ULONG
(*arg));
      break;
    case ARG_RESIZE_MODE:
      gtk_container_set_resize_mode (container, GTK_VALUE_ENUM
(*arg));
      break;
    case ARG_CHILD:
      gtk_container_add (container, GTK_WIDGET (GTK_VALUE_OBJECT
(*arg)));
      break;
    default:
      break;
    }
}

static void
gtk_container_get_arg (GtkObject    *object,
                       GtkArg       *arg,
                       guint         arg_id)
{
  GtkContainer *container;

  container = GTK_CONTAINER (object);

  switch (arg_id)
    {
    case ARG_BORDER_WIDTH:
      GTK_VALUE_ULONG (*arg) = container->border_width;
      break;
    case ARG_RESIZE_MODE:
      GTK_VALUE_ENUM (*arg) = container->resize_mode;
      break;
    default:
      arg->type = GTK_TYPE_INVALID;
      break;
    }
}
```

Notice that the type must be set to GTK_TYPE_INVALID if your subclass doesn't understand the argument ID. This is used as an error indicator; users who call gtk_object_getv() will check for it.

If you flip back to page XXXX and have another look at the GtkButton class initialization function, you should now understand what is going on with respect to object arguments.

Discovering the Available Object Arguments

You can easily find out at runtime what arguments a given GtkObject understands, using the gtk_object_query_args(). Here is a nifty piece of code which prints out the arguments for the entire class hierarchy of a given GtkObject:

```

void
print_arguments(GtkObject* object)
{
  GtkType type;

  type = GTK_OBJECT_TYPE(object);

  do {
    GtkArg* args;
    guint32* flags;
    guint n_args;
    guint i;

    args = gtk_object_query_args(type,
                                 &flags,
                                 &n_args);

    printf("Displaying arguments for object type `%s'\n",
           gtk_type_name(type));

    i = 0;
    while (i < n_args)
      {
        printf(" - Argument %u is called `%s' and has type `%s'\n",
               i,
               args[i].name,
               gtk_type_name(args[i].type));

        ++i;
      }

    g_free(args);
    g_free(flags);

    type = gtk_type_parent(type);
  }
  while (type != GTK_TYPE_INVALID);
}
```

Notice that a type's parent type can be obtained using the gtk_type_parent() function, and that you can extract the GtkType tag from a GtkObject using the GTK_OBJECT_TYPE() macro. GTK_OBJECT_TYPE() is defined as follows:

```
#define GTK_OBJECT_TYPE(obj) (GTK_OBJECT (obj)->klass->type)
```

An object's type is stored in its class structure, and a pointer to an object's class structure is stored in each instance of the object. (The class structure pointer is called klass rather than class to avoid confusing C++ compilers.)

Figure 3 summarizes the functions for reading, writing, and querying object arguments.

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

void gtk_object_getv(GtkObject* *object*, guint *n_args*, GtkArg* *args*);

void gtk_object_set(GtkObject* *object*, const gchar* *first_arg_name*, ...);

void gtk_object_setv(GtkObjec* *object*, guint *n_args*, GtkArg* *args*);

void gtk_object_add_arg_type(const gchar* *arg_name*, GtkType *arg_type*, guint *arg_flags*, guint *arg_id*);

GtkArg* gtk_object_query_args(GtkType *class_type*, guint32** *arg_flags*, guint* *n_args*);

Figure 3. Manipulating Object Arguments

Signals

A GtkObject can emit a *signal*. Signals are stored in a global table by GTK+. *Handlers* or *callbacks* can be *connected* to signals; when a signal is *emitted*, its callbacks are invoked. The process of invoking all handlers for a signal is called *emission*.

Abstractly, a signal is a *kind* of message that an object wants to broadcast; the kind of message is associated with certain conditions (such as the user selecting a list item) and with message-specific parameter types which are passed to connected callbacks (such as the index of the row the user selected). User callbacks are connected to a particular signal and to a particular object instance. That is, you do not connect callbacks to the "clicked" signal of all buttons; rather, you connect to the "clicked" signal of a particular one. (However, there is a way to monitor all emissions of a signal---these callbacks are called "emission hooks.")

Signals are typically associated with a class function pointer which is invoked every time the signal is emitted; if non-NULL, the pointed-to class function serves as a default handler for the signal. It is up to the author of each GtkObject subclass whether to provide a space in the class struct for a default handler, and whether to implement the default handler in the base class. Conventionally, signals have the same name as the class function they are associated with.

For example, the GtkButtonClass struct has a member called clicked; this member is registered as the default handler for the "clicked" signal. However, the GtkButton base class does not implement a default handler, and leaves the clicked member set to NULL. Subclasses of GtkButton could optionally fill it in with an appropriate function. If GtkButton did implement a default clicked handler, subclasses could still override it with a different one.

Note that GTK+ signals have nothing to do with UNIX signals. Sometimes new GTK+ users confuse the two.

Adding a New Signal

Once you understand the GTK+ type system and GtkArg, signal registration is fairly transparent. Here is the signal registration code from GtkButton again:

```
button_signals[PRESSED] =
  gtk_signal_new ("pressed",
                  GTK_RUN_FIRST,
                  object_class->type,
                  GTK_SIGNAL_OFFSET (GtkButtonClass, pressed),
                  gtk_marshal_NONE__NONE,
                  GTK_TYPE_NONE, 0);
button_signals[RELEASED] =
  gtk_signal_new ("released",
                  GTK_RUN_FIRST,
                  object_class->type,
                  GTK_SIGNAL_OFFSET (GtkButtonClass, released),
                  gtk_marshal_NONE__NONE,
                  GTK_TYPE_NONE, 0);
button_signals[CLICKED] =
  gtk_signal_new ("clicked",
                  GTK_RUN_FIRST | GTK_RUN_ACTION,
                  object_class->type,
                  GTK_SIGNAL_OFFSET (GtkButtonClass, clicked),
                  gtk_marshal_NONE__NONE,
                  GTK_TYPE_NONE, 0);
button_signals[ENTER] =
  gtk_signal_new ("enter",
                  GTK_RUN_FIRST,
                  object_class->type,
                    GTK_SIGNAL_OFFSET (GtkButtonClass, enter),
                    gtk_marshal_NONE__NONE,
                    GTK_TYPE_NONE, 0);
  button_signals[LEAVE] =
    gtk_signal_new ("leave",
                    GTK_RUN_FIRST,
                    object_class->type,
                    GTK_SIGNAL_OFFSET (GtkButtonClass, leave),
                    gtk_marshal_NONE__NONE,
                    GTK_TYPE_NONE, 0);

  gtk_object_class_add_signals (object_class, button_signals,
LAST_SIGNAL);
```

Earlier in gtkbutton.c, an enumeration and an array were declared as follows:

```
enum {
  PRESSED,
  RELEASED,
  CLICKED,
  ENTER,
  LEAVE,
  LAST_SIGNAL
};


static guint button_signals[LAST_SIGNAL] = { 0 };
```

gtk_signal_new() has the following effects:

- It registers the name of the signal.
- It associates the signal with a particular GtkType.
- It tells GTK+ where to find the default handler in the class struct, if any.
- It tells GTK+ what signature the signal's callbacks will have.
- It registers a *marshaller*, a function which invokes the signal's callbacks in an appropriate way.

- It generates an integer identifier which can be used to refer to the signal. (If you refer to the symbol by name, GTK+ will find the ID associated with the name and then use the ID.)

gtk_object_class_add_signals() attaches signal identifiers to the object's class struct, so the signals for a given class can be rapidly located. Conventionally, the argument to this function is an enumeration-indexed static array, as shown for GtkButton. The static array is also useful when implementing the functionality of the class (the signal identifiers are used to emit the signals).

The first argument to gtk_signal_new() is a name for the signal; you refer to the signal by name when you call gtk_signal_connect(), for example. The third argument is the GtkType of the object type emitting the signal, and the fourth is the location of the associated class function in the type's class struct. A macro is provided to compute the offset. If you specify an offset of 0, no class function will be associated with the signal. Note that giving a zero offset is distinct from giving a valid offset but setting the function member in the struct to NULL; in the latter case, subclasses of the object can fill in a value for the default handler.

The second argument is a bitfield. Here are the associated flags:

- GTK_RUN_FIRST means that the default handler in the class struct, if any, will run before user-connected callbacks. If this flag is set, signal handlers should not return a value.
- GTK_RUN_LAST means the opposite, the default handler will run last. (Caveat: user callbacks connected with gtk_signal_connect_after() run after a GTK_RUN_LAST default handler. There is no way to ensure a default handler is *always* run last. GTK_RUN_FIRST handlers are always first, however.)
- GTK_RUN_BOTH is an alias for (GTK_RUN_FIRST | GTK_RUN_LAST), so the default handler will run twice (on either side of user-connected callbacks).
- GTK_RUN_NO_RECURSE means that the signal should not be called recursively. If a handler for a signal emits the same signal again, normally the second emission is performed as usual (calling all handlers), and then the first emission continues, invoking its remaining handlers. With GTK_RUN_NO_RECURSE in effect, a second emission aborts the first emission (ignoring any handlers that remain), and restarts the emission process. So only one emission is in progress at a time. (Right now this is used only for GtkAdjustment's "changed" and "value_changed" signals. Usually you don't care about how many times a value changed, only whether it

  changed and its most recent value. GTK_RUN_NO_RECURSE "compresses" multiple emissions into a single emission.)
- GTK_RUN_ACTION means the signal can be "bound" and invoked by the user. In other words, no special setup or shutdown is required in order to emit it. Among other things, GTK+ will allow users to bind keyboard accelerators to these signals using statements in the .gtkrc configuration file.
- GTK_RUN_NO_HOOKS means that emission hooks are not allowed (you can't monitor this signal for an entire object type, only for particular object instances). It is used for GtkObject's "destroy" signal because hooks are not invoked on objects with the GTK_DESTROYED flag set and that flag is set before emitting "destroy". It's probably not good for anything else.

The last few arguments to gtk_signal_new() provide a *marshaller*, and tell GTK+ the marshaller's type. A marshaller invokes a callback function, based on an array of GtkArg it receives from GTK+. Marshallers are needed because C function argument lists cannot be constructed at runtime. GTK+ comes with a number of prewritten marshallers; here is the one used for all GtkButton signals:

```
typedef void (*GtkSignal_NONE__NONE) (GtkObject* object,
                                      gpointer user_data);
void
gtk_marshal_NONE__NONE (GtkObject * object,
                        GtkSignalFunc func,
                        gpointer func_data,
                        GtkArg * args)
{
  GtkSignal_NONE__NONE rfunc;
  rfunc = (GtkSignal_NONE__NONE) func;
  (*rfunc) (object,
            func_data);
}
```

As you can see, the NONE__NONE refers to the fact that the expected callback type returns no value and has no "special" arguments. GTK+ automatically passes the object emitting the signal and a user_data field to all callbacks; special signal arguments are inserted in between these two. Since there are no signal-specific arguments in this case, the array of GtkArg is ignored.

The naming convention for marshallers places a double underscore between the return value and the special arguments, if any. Here's a more complex example:

```
typedef gint (*GtkSignal_INT__POINTER) (GtkObject * object,
                                        gpointer arg1,
                                        gpointer user_data);
void
gtk_marshal_INT__POINTER (GtkObject * object,
                          GtkSignalFunc func,
                          gpointer func_data,
                          GtkArg * args)
{
  GtkSignal_INT__POINTER rfunc;
  gint *return_val;
  return_val = GTK_RETLOC_INT (args[1]);
  rfunc = (GtkSignal_INT__POINTER) func;
  *return_val = (*rfunc) (object,
                          GTK_VALUE_POINTER (args[0]),
                          func_data);
}
```

Notice that the last element of the array of GtkArg is a space for the return value; if there is no return value, this element will have type GTK_TYPE_NONE and can be ignored. GTK+ provides macros such as GTK_RETLOC_INT() to extract a "return location" from a GtkArg. Similar GTK_RETLOC_ macros exist for all the fundamental types.

The function pointer signatures in the class structure for an object will correspond to the type of the signal. This is a convenient way to find out what signature the callbacks connected to a signal should have, if the GTK+ header files are readily available on your system.

The last arguments to gtk_signal_new() give the type of the signal's marshaller. First a return value type is given, then the number of special arguments, then a variable argument list containing that many GtkType values in the appropriate order. Since GtkButton has no examples of signals with arguments, here is one from GtkWidget:

```
  widget_signals[BUTTON_PRESS_EVENT] =
    gtk_signal_new("button_press_event",
                   GTK_RUN_LAST,
                   object_class->type,
                   GTK_SIGNAL_OFFSET (GtkWidgetClass,
button_press_event),
                   gtk_marshal_BOOL__POINTER,
                   GTK_TYPE_BOOL, 1,
                   GTK_TYPE_GDK_EVENT);
```

"button_press_event" returns a boolean value, and has a GdkEvent* argument. Notice that the marshaller works with any GTK_TYPE_POINTER, but the signal requires the more-specific boxed type GTK_TYPE_GDK_EVENT, allowing language bindings to query the correct *kind* of pointer.

Signals can have many arguments; here is one from GtkCList:

```

  clist_signals[SELECT_ROW] =
    gtk_signal_new ("select_row",
                    GTK_RUN_FIRST,
                    object_class->type,
                    GTK_SIGNAL_OFFSET (GtkCListClass, select_row),
                    gtk_marshal_NONE__INT_INT_POINTER,
                    GTK_TYPE_NONE, 3,
                    GTK_TYPE_INT,
                    GTK_TYPE_INT,
                    GTK_TYPE_GDK_EVENT);
```

The "select_row" signal returns no value, but has three arguments (the selected row and column number, and the event that caused the selection).

Using Existing Signals

Figure 4 shows the wide array of functions available for manipulating signals. You should already be familiar with the most fundamental signal operation: connecting a signal handler to be invoked when the signal is emitted, like this:

```

  gtk_signal_connect(GTK_OBJECT(window),
                     "delete_event",
                     GTK_SIGNAL_FUNC(delete_event_cb),
                     NULL);

  gtk_signal_connect(GTK_OBJECT(button),
                     "clicked",
                     GTK_SIGNAL_FUNC(button_click_cb),
                     label);
```

You may not be aware that gtk_signal_connect() returns a "handler ID" which can be used to refer to the connection it creates. Using the handler ID, you can unregister the callback with gtk_signal_disconnect(). You can also temporarily "block" the callback by calling gtk_signal_handler_block(). This increments a "block count"; the callback will not be invoked until the block count returns to 0. gtk_signal_handler_unblock() decrements the block count. Both gtk_signal_disconnect() and gtk_signal_handler_unblock() have variants that search for the handler ID given a callback function or user data pointer; these are possibly more convenient, with some loss of efficiency.

It can be useful to block signal handlers if you'll be changing some aspect of an object yourself, and thus don't need to run the callbacks you use to respond to user actions. For example, you normally change some boolean variable if the user clicks a toggle button, in a callback to the "toggled" signal. If you update the toggle button programmatically because the flag was changed via some mechanism other than the button, "toggled" will still be emitted; but you want to block your callback, since the flag is already correct.

gtk_signal_connect() is not the only way to connect to a signal. You can also use gtk_signal_connect_object(); this simply swaps the signal-emitting object pointer and the user data pointer in the arguments passed to the callback. Normally, the object comes first, then any arguments unique to the signal, and finally the user data pointer; with gtk_signal_connect_object(), the object is last and user data is first. This function is useful when you want to use a pre-existing function as a callback without writing a wrapper to move its arguments. For example:

```
gtk_signal_connect_object(GTK_OBJECT(button),
                          "clicked",
                          GTK_SIGNAL_FUNC(gtk_widget_destroy),
                          GTK_OBJECT(dialog));
```

Because the user data and the button are swapped, the first argument to gtk_widget_destroy() will be the dialog rather than the button, closing the dialog. When using gtk_signal_connect_object(), your callback data must be a GtkObject to avoid confusing marshallers that expect an object as their first argument.

gtk_signal_connect_after() asks GTK+ to run the callback after the object's default signal handler, rather than before it. This only works with certain signals, those with the GTK_RUN_LAST flag set; the section called *Adding a New Signal* explains this flag.

gtk_signal_connect_object_after() combines the effects of gtk_signal_connect_object() and gtk_signal_connect_after().

gtk_signal_connect_full() gives you complete control over the connection and is mostly useful in language bindings. The object_signal and after arguments can be TRUE or FALSE, toggling argument order and time of callback invocation. The functions we just mentioned also let you change this, so gtk_signal_connect_full() adds little. Its unique features are the ability to specify a callback marshaller, and the ability to specify a GtkDestroyNotify function. Notice that gtk_signal_connect_full() does not expect the same kind of marshaller described in the section called *Adding a New Signal*; it expects a more general marshaller appropriate for marshalling functions written in languages other than C. If you give a non-NULLGtkDestroyNotify function, it will be invoked on the user data pointer when this handler is disconnected or the GtkObject is destroyed. Here is the proper signature for the function:

```
typedef void (*GtkDestroyNotify)   (gpointer   data);
```

Conveniently, you can use g_free() or gtk_object_destroy() as a GtkDestroyNotify. Of course, if these aren't appropriate you can write a custom function.

gtk_signal_connect_while_alive() is a variant on gtk_signal_connect(); its additional argument is an object to monitor. When the monitored object is destroyed (emits the "destroy" signal), the handler will be disconnected. That is, handlers connected with this function are automatically disconnected when a specified object no longer exists.

There's rarely a need to do so, but you can look up a signal's ID number given the signal name and the object type that emits it. This function is gtk_signal_lookup(). Note that names are not globally unique, but they are unique with respect to a particular object type. On the other hand, signal IDs *are* globally unique.

During the emission of a signal (that is, during the process of invoking its handlers), you can call gtk_signal_emit_stop() (or its _by_name() variant) to halt the emission. These functions are only useful from within signal handlers, because they must be called during the emission process or they won't have anything to stop. They do not take effect immediately; instead, they set a variable that GTK+ checks at key points during emission. the section called *What Happens When A Signal Is Emitted* describes this in detail.

Emission hooks can be used to monitor all emissions of a given signal (regardless of the object instance doing the emitting). Emission hooks have the following signature:

```
typedef gboolean (*GtkEmissionHook) (GtkObject      *object,
                                      guint           signal_id,
                                      guint           n_params,
                                      GtkArg         *params,
                                      gpointer        data);
```

They are passed the same parameters GTK+ would normally pass to callback marshallers (see the section called *Adding a New Signal*). You can connect an emission hook with a destroy notify function to be invoked on the user data pointer when the hook is removed. When you add an emission hook, an integer identify is returned. You can remove emission hooks with this ID number.

Emission hooks are rarely useful, but sometimes they are the only way to do something. For example, Gnome optionally plays sound effects when certain signals are emitted (such as button clicks).

Finally, you can ask everything you ever wanted to know about a signal using gtk_signal_query(). This function is intended for GUI builders and language bindings to use; it is probably not useful in application code. It returns a GtkSignalQuery structure filled with information about the signal. The return value should be freed with g_free() but not modified in any way (it contains pointers to internal data which isn't copied). Here is the definition of GtkSignalQuery:

```
typedef struct _GtkSignalQuery GtkSignalQuery;

struct  _GtkSignalQuery
{
  GtkType          object_type;
  guint            signal_id;
  const gchar     *signal_name;
  guint            is_user_signal : 1;
  GtkSignalRunType signal_flags;
  GtkType          return_val;
  guint            nparams;
  const GtkType   *params;
};
#include <gtk/gtksignal.h>
```

guint gtk_signal_lookup(const gchar* *name*, GtkType *object_type*);

gchar* gtk_signal_name(guint *signal_id*);

void gtk_signal_emit_stop(GtkObject* *object*, guint *signal_id*);

void gtk_signal_emit_stop_by_name(GtkObject* *object*, const gchar* *name*);

guint gtk_signal_connect(GtkObject* *object*, const gchar* *name*, GtkSignalFunc *func*, gpointer *func_data*);

guint gtk_signal_connect_after(GtkObject* *object*, const gchar* *name*, GtkSignalFunc *func*, gpointer *func_data*);

guint gtk_signal_connect_object(GtkObject* *object*, const gchar* *name*, GtkSignalFunc *func*, GtkObject* *slot_object*);

guint gtk_signal_connect_object_after(GtkObject* *object*, const gchar* *name*, GtkSignalFunc *func*, GtkObject* *slot_object*);

guint gtk_signal_connect_full(GtkObject* *object*, const gchar* *name*, GtkSignalFunc *func*, GtkCallbackMarshal *marshal*, gpointer *data*, GtkDestroyNotify *destroy_func*, gint *object_signal*, gint *after*);

void gtk_signal_connect_object_while_alive(GtkObject* *object*, const gchar* *signal*, GtkSignalFunc *func*, GtkObject* *alive_object*);

void gtk_signal_connect_while_alive(GtkObject* *object*, const gchar* *signal*, GtkSignalFunc *func*, gpointer *func_data*, GtkObject * *alive_object*);

void gtk_signal_disconnect(GtkObject* *object*, guint *handler_id*);

void gtk_signal_disconnect_by_func(GtkObject* *object*, GtkSignalFunc *func*, gpointer *func_data*);

void gtk_signal_disconnect_by_data(GtkObject * *object*, gpointer *func_data*);

void gtk_signal_handler_block(GtkObject* *object*, guint *handler_id*);

void gtk_signal_handler_block_by_func(GtkObject* *object*, GtkSignalFunc *func*, gpointer *func_data*);

void gtk_signal_handler_block_by_data(GtkObject* *object*, gpointer *func_data*);

void gtk_signal_handler_unblock(GtkObject* *object*, guint *handler_id*);

void gtk_signal_handler_unblock_by_func(GtkObject* *object*, GtkSignalFunc *func*, gpointer *func_data*);

void gtk_signal_handler_unblock_by_data(GtkObject* *object*, gpointer *func_data*);

guint gtk_signal_add_emission_hook(guint *signal_id*, GtkEmissionHook *hook_func*, gpointer *data*);

guint gtk_signal_add_emission_hook_full(guint *signal_id*, GtkEmissionHook *hook_func*, gpointer *data*, GDestroyNotify *destroy*);

void gtk_signal_remove_emission_hook(guint *signal_id*, guint *hook_id*);

GtkSignalQuery* gtk_signal_query(guint *signal_id*);

Figure 4. Using Signals

Emitting A Signal

It's your object's responsibility to emit its signals at appropriate times. This is very simple; if you've saved the return value from gtk_signal_new(), that identifier can be used to emit the signal. Otherwise, you can emit the signal by name (with some cost in execution speed, since GTK+ will have to look up the identifier in a hash table).

Here is code from gtk/gtkbutton.c which is used to emit the "button_pressed" signal:

```
void
gtk_button_pressed (GtkButton *button)
{
  g_return_if_fail (button != NULL);
  g_return_if_fail (GTK_IS_BUTTON (button));

  gtk_signal_emit (GTK_OBJECT (button), button_signals[PRESSED]);
}
```

If a signal has arguments (other than the standard two), you must specify those as a variable argument list:

```
  gtk_signal_emit (GTK_OBJECT (widget), widget_signals[SIZE_REQUEST],
                   &widget->requisition);
```

If a signal returns a value, you must pass a location for the returned value as the final argument:

```
  gint return_val;

  return_val = FALSE;

  gtk_signal_emit (GTK_OBJECT (widget), widget_signals[EVENT], event,
                   &return_val);
```

Notice that return_val is initialized to something sane; if there are no signal handlers, none of them will assign a value to return_val. So you must initialize the variable. Each signal handler's return value will be assigned to the same location, so the final value of return_val is determined by the last signal handler to run. Note that certain return values (such as strings) must be freed by the signal emitter.

gtk_signal_emit_by_name() is the same as gtk_signal_emit(), except that the second argument is a signal name rather than a signal ID number. There are also variants of both emission functions that take a vector of GtkArg instead of a variable argument list. These variants expect arrays of *n+1*GtkArg structs, where *n* is the number of signal arguments and there is an additional GtkArg for the return value. The GtkArg structs should be initialized with sane values. If the function returns no value, the return value GtkArg will have GTK_TYPE_NONE.

All four signal emission functions are summarized in Figure 5.

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

void gtk_signal_emit(GtkObject* *object*, guint *signal_id*, ...);

void gtk_signal_emit_by_name(GtkObject* *object*, const gchar* *name*, ...);

void gtk_signal_emitv(GtkObject* *object*, guint *signal_id*, GtkArg* *params*);

void gtk_signal_emitv_by_name(GtkObject* *object*, const gchar* *name*, GtkArg* *params*);

Figure 5. Signal Emission

Keep in mind that it is usually inappropriate to simply emit a signal outside of an object's implementation. Only GTK_RUN_ACTION signals are guaranteed to work properly without special setup or shutdown. Objects often export functions you can use to emit signals properly; for example, to emit the "size_request" signal, GtkWidget provides this function:

```

void
gtk_widget_size_request (GtkWidget      *widget,
                         GtkRequisition *requisition)
{
  g_return_if_fail (widget != NULL);
  g_return_if_fail (GTK_IS_WIDGET (widget));

  gtk_widget_ref (widget);
  gtk_widget_ensure_style (widget);
  gtk_signal_emit (GTK_OBJECT (widget), widget_signals[SIZE_REQUEST],
                   &widget->requisition);

  if (requisition)
    gtk_widget_get_child_requisition (widget, requisition);

  gtk_widget_unref (widget);
}
```

As you can see, particular actions are required before and after emitting the signal; thus it should only be emitted via the gtk_widget_size_request() function.

What Happens When A Signal Is Emitted

Given the many different options when creating signals and connecting callbacks, you may be thoroughly confused about what happens when a signal is emitted. Here's a summary of the sequence of events:

1. If you are emitting the signal by name, the signal ID is looked up.
2. If another emission of the same signal is in progress, and the signal has the GTK_RUN_NO_RECURSE flag set, GTK+ signals the previous emission to restart and this emission ends.
3. If the signal is GTK_RUN_FIRST, the default signal handler is called using the signal's marshaller. If the emission is stopped from within the handler, (using gtk_emit_stop_by_name() or one of its cousins), this emission ends. If the signal is re-emitted from within the handler and is GTK_RUN_NO_RECURSE, this emission restarts.
4. If there are any emission hooks installed for this signal, they are invoked. GTK+ does *not* check whether the emission has been stopped or re-emitted at this point; it will not check until the next step. Emission hooks should not re-emit the signal they are watching, or try to stop the emission.
5. Any normally-connected callbacks are invoked using the signal's marshaller. Callbacks connected with gtk_signal_connect_after() are not invoked at this point. After invoking each callback, GTK+ checks whether it stopped the signal and the emission ends if so. GTK+ also checks whether the signal was re-emitted, and if so restarts the emission process for GTK_RUN_NO_RECURSE signals.
6. If the signal is GTK_RUN_LAST, the default handler is invoked. Afterward GTK+ again checks whether the emission has been stopped or should be restarted.
7. Any callbacks connected with gtk_signal_connect_after() are invoked. After invoking each one, GTK+ checks whether the emission should be stopped or restarted.

Within each step the handlers are invoked in the order they were connected. The order of the steps is fixed: GTK_RUN_FIRST default handler, emission hooks, normal connections, GTK_RUN_LAST default handler, "after" connections.

Object Finalization

To write a GtkObject, you must implement the methods provided by the GtkObject interface, or at least be sure you are happy with the default implementations. There are only five GtkObject methods; two of them are get_arg and set_arg, described in the section called *Using Object Arguments in Your Own GtkObject Subclass*. The other three implement object destruction; here are the fields in GtkObjectClass:

```

  void (* shutdown) (GtkObject *object);
  void (* destroy)  (GtkObject *object);

  void (* finalize) (GtkObject *object);
```

As you might guess from this, objects are destroyed in a three-stage process. Each method represents one stage in the process; if your object subclass overrides any of them, it must "chain up" to the corresponding method in the parent class (see the section called *Chaining Up*). The three methods do the following:

- The shutdown method allows objects to perform actions before destruction begins. Most subclasses do not override this method; the default shutdown method emits the "destroy" signal to start the next phase. (The default implementation will *always* be invoked, even if overridden, because subclasses are required to "chain up.")
- The destroy method marks the object "useless" and cleans up associated resources, but does not free the object itself. Typically a destroy method would free data, strings, and so on stored in the instance struct, and set the struct members to NULL. This is the method most subclasses override.
- The finalize method is invoked *only when the object's reference count reaches 0*. The default implementation frees the object instance struct, so that further attempts to use the object result in a segmentation fault. The finalize method must also consider that user code could have been invoked after the destroy method, and free any data that user code could have allocated.

Note: *Objects can be destroyed regardless of their reference count*. This means that the shutdown method is invoked and the destroy signal is emitted. However, as long as the reference count is greater than 0, the object will not be *finalized*.

The shutdown method has no defined role; its purpose depends on the particular object. For example, the GtkWidget shutdown implementation removes the widget from its parent container, and unrealizes the widget. This is especially important for containers: their destroy method destroys all children of the container. If the container was not unrealized before destruction, it would still be visible and the user would see each child disappear, followed by the container. With the shutdown method, everything disappears at once.

The destroy method frees as many resources as possible without rendering the object "unsafe." If your object has invariants describing its integrity, a destroy method will not violate them. All public functions exported by an object implementation should gracefully handle destroyed objects (they should not crash---remember that an object can be destroyed while references to it persist). The finalize method actually frees the object, meaning that attempts to use the object become dangerous bugs.

The statement that "public functions exported by an object implementation should gracefully handle destroyed objects" requires some qualification. This is the intended behavior; otherwise, code could not ensure the sanity of an object by increasing its reference count. However, the implementation does not yet live up to the guarantee in all cases. Some public functions in GTK+ and Gnome still assume data structures freed in the destroy method exist, or re-allocate data structures the destroy method already freed. Unless the finalize method re-frees those data structures, they will be leaked. To avoid these bugs, it is best to avoid calling functions on destroyed objects (in practice, it would be uncommon to do so).

You *can* count on being able to check the type and object flags of a destroyed object, however; and it is certainly safe to call gtk_object_unref() on a destroyed object. In your own object implementations, be sure you implement each public function correctly; check whether the object is destroyed with GTK_OBJECT_DESTROYED(), and keep in mind that user code can run between the destroy method and the finalize method.

Notice that the destroy method is the default handler for a "destroy" signal, but the shutdown and finalize methods are class functions only. This reduces the complexity and increases the speed of the finalization process. Also, because finalize destroys the integrity of an object, it would be unsafe to emit as a signal (GTK+ does have a facility called "weak references" that allows you to invoke a callback when an object is finalized---weak references do not assume that the GtkObject is in a sane state).

To make things more concrete, let's look at the functions you would use to destroy an object. First, gtk_object_destroy():

```
void
gtk_object_destroy (GtkObject *object)
{
  g_return_if_fail (object != NULL);
  g_return_if_fail (GTK_IS_OBJECT (object));
  g_return_if_fail (GTK_OBJECT_CONSTRUCTED (object));

  if (!GTK_OBJECT_DESTROYED (object))
    {
      gtk_object_ref (object);
      object->klass->shutdown (object);
      gtk_object_unref (object);
    }
}
```

Notice that destroyed-but-not-finalized objects are flagged, and this flag can be checked with the GTK_OBJECT_DESTROYED() macro. gtk_object_destroy() ensures that objects are not destroyed twice by ignoring any already-destroyed objects. If an object has not been destroyed, gtk_object_destroy() references it to prevent finalization during the destroy process and invokes the shutdown method; by default, that method looks like this:

```

static void
gtk_object_shutdown (GtkObject *object)
{
  GTK_OBJECT_SET_FLAGS (object, GTK_DESTROYED);
  gtk_signal_emit (object, object_signals[DESTROY]);
}
```

This method sets the destroyed flag, to ensure that any recursive gtk_object_destroy() calls have no effect; then it emits the "destroy" signal. gtk_object_shutdown() seems pointless by itself; however, subclasses may override this method with something more substantial, chaining up to the GtkObject default method (see the section called *Chaining Up*).

It may be unclear that gtk_object_shutdown() is a method implementation, while gtk_object_destroy() is a public function. Note that gtk_object_shutdown() is the internal function that implements the shutdown method for the GtkObject class, while gtk_object_destroy() is part of the public API. The GtkObject implementation of the destroy method is called gtk_object_real_destroy():

```
static void
gtk_object_real_destroy (GtkObject *object)
{
  if (GTK_OBJECT_CONNECTED (object))
    gtk_signal_handlers_destroy (object);
}
```

This code simply cleans up any signal handlers associated with the object. gtk_object_real_destroy() is the default handler invoked when the "destroy" signal is emitted. gtk_object_destroy() invokes the (possibly overridden) class function shutdown; the default shutdown method emits the "destroy" signal.

Finalization is initiated by gtk_object_unref(), if and only if the reference count has reached 0. gtk_object_unref() can be invoked directly by a user, but often gtk_object_destroy() invokes it. Here it is:

```
void
gtk_object_unref (GtkObject *object)
{
  g_return_if_fail (object != NULL);
  g_return_if_fail (GTK_IS_OBJECT (object));
  g_return_if_fail (object->ref_count > 0);

  if (object->ref_count == 1)
    {
      gtk_object_destroy (object);

      g_return_if_fail (object->ref_count > 0);
    }

  object->ref_count -= 1;

  if (object->ref_count == 0)
    {
      object->klass->finalize (object);
    }
}
```

If an object has a reference count of 1, calling gtk_object_unref() invokes the shutdown and destroy methods (via gtk_object_destroy()) and then finalizes the object (unless the reference count was incremented sometime during the shutdown/destroy process; this is allowed and will prevent finalization). If an object's reference count is greater than 1 at the start of gtk_object_unref(), the reference count is simply decremented.

Again, notice that an object can be *destroyed* while the reference count is greater than 1 if the user calls gtk_object_destroy(); if this happens, finalization does not take place until the holders of the remaining references call gtk_object_unref(). In the most common case, the gtk_object_destroy() implementation holds the last reference count --- have another look at the gtk_object_destroy() code with this in mind.

For completeness, here is GtkObject's default finalize method:

```
static void
gtk_object_finalize (GtkObject *object)
{
  gtk_object_notify_weaks (object);

  g_datalist_clear (&object->object_data);

  gtk_type_free (GTK_OBJECT_TYPE (object), object);
}
```

The three function calls in this method do the following:

- Invoke "weak references," which are callbacks invoked on object finalization. This is a little-used GtkObject feature not described in this book (usually connecting to the "destroy" signal is more appropriate).
- Clear any object data (described in the section called *Attaching Data to Objects*).
- Free the instance struct.

the section called *Widget Life Cycle* in the chapter called *GTK+ Basics* has more to say about reference counting and destruction with respect to widgets.

Chaining Up

If an object overrides the shutdown, destroy, or finalize methods, it should chain up to the default implementation, to ensure that each parent class has a chance to clean up. Here is an example of chaining up:

```
static void
gtk_widget_real_destroy (GtkObject *object)
{

  /* ... */

  if (parent_class->destroy)
    parent_class->destroy (object);

};
```

gtk_widget_real_destroy() is installed in the widget's class struct in the class initialization function, overwriting the GtkObject default. parent_class is a pointer to the parent's class struct; usually you will want to store this pointer in your class initialization function, as GtkWidget does:

```
static GtkObjectClass *parent_class = NULL;

/* ... code omitted ... */

static void
gtk_widget_class_init (GtkWidgetClass *klass)
{
  GtkObjectClass *object_class;

  object_class = (GtkObjectClass*) klass;

  parent_class = gtk_type_class (gtk_object_get_type ());

  /* ... code omitted ... */

  object_class->set_arg = gtk_widget_set_arg;
  object_class->get_arg = gtk_widget_get_arg;
  object_class->shutdown = gtk_widget_shutdown;
  object_class->destroy = gtk_widget_real_destroy;
  object_class->finalize = gtk_widget_finalize;
}
```

Of course, if parent_class is not a GtkObjectClass*, you will need to cast it with the GTK_OBJECT_CLASS() macro.

An aside: notice that you should *not* chain up when implementing get_arg and set_arg --- GTK+ special-cases these methods in gtk_object_set() and gtk_object_get(). Recall that the GtkObject base class initializer zeroes these two methods, rather than leaving the default implementation. When setting or getting an argument value, GTK+ uses the information provided on argument registration to jump directly to the correct class struct and invoke only the correct get_arg or set_arg method. Chaining up would be a much slower way to implement the same thing (and would require unique argument IDs within the same class ancestry).

Attaching Data to Objects

You can "attach" arbitrary string-pointer pairs to a GtkObject instance, in effect adding a new data member. GTK+ uses this some internally, but it can also be a convenient way to pass data around in your application. In particular, it's a nice way to pass information to callbacks.

Here's a simple example:

```
GtkWidget* button = gtk_button_new();
GtkWidget* label  = gtk_label_new(_("Foo"));

gtk_object_set_data(GTK_OBJECT(button), "my_label_key", label);
```

Later, when you have a pointer to the button but not the label (perhaps in a callback connected to the button's "clicked" signal), you can do this:

```
GtkWidget* label = gtk_object_get_data(GTK_OBJECT(button),
                                       "my_label_key");

/* If no data is found for the key, NULL is returned. */

if (label == NULL)
  {
    g_warning("No data was associated with 'my_label_key'!");
  }
```

A pair of convenience functions use a predetermined key and thus save typing (and remembering) the object data key. These are gtk_object_set_user_data() and gtk_object_get_user_data(). You can also register a function to free the data when the data is removed or replaced, or the GtkObject is destroyed; This function should be of type GtkDestroyNotify:

```
typedef void (*GtkDestroyNotify) (gpointer data);
```

Conveniently, g_free() and gtk_object_unref() will work here. You register a "destroy notification" function when you set the data, using gtk_object_set_data_full(). You can remove data before the object is destroyed with gtk_object_remove_data(), or remove it without calling the destroy function with gtk_object_remove_no_notify(). Setting the data to NULL is equivalent to removing it with gtk_object_remove_data(), and will also call the destroy function if you registered one. Figure 6 summarizes the object data functions.

It's worth pointing out that the object data system is a thin wrapper around the GData facility in glib, which can be used standalone.

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

void gtk_object_set_data(GtkObject* *object*, const gchar* *key*, gpointer *data*);

void gtk_object_set_data_full(GtkObject* *object*, const gchar* *key*, gpointer *data*, GtkDestroyNotify *destroy*);

void gtk_object_remove_data(GtkObject* *object*, const gchar* *key*);

gpointer gtk_object_get_data(GtkObject* *object*, const gchar* *key*);

void gtk_object_remove_no_notify(GtkObject* *object*, const gchar* *key*);

void gtk_object_set_user_data(GtkObject* *object*, gpointer *data*);

gpointer gtk_object_get_user_data(GtkObject* *object*);

Figure 6. Attaching key-value pairs to a GtkObject

GDK Basics

Table of Contents

This chapter will discuss GDK, the underpinning of GTK+, and some of the occasions you might have to use it. To write custom widgets and canvas items, you will need to understand a few of these low-level details. Like chapters two and three, this chapter is a quick summary that doesn't hold your hand; there is no way to cover all of GDK in a single chapter. However, the chapter will try to cover the important concepts and data types of GDK, and should be a useful reference on certain topics. As details come up in later chapters, you can use this background to understand them. This chapter does not attempt to exhaustively catalog GDK's API.

GDK and Xlib

The X Window System comes with a low-level and thoroughly unpleasant library called Xlib. Almost every function in GDK is a very thin wrapper around a corresponding Xlib function; but some of the complexity (and functionality) of Xlib is hidden, to simplify programming and to make GDK easier to port to other windowing systems. (There is a port of GDK to Windows available.) The concealed Xlib functionality will rarely be of interest to application programmers; for example, many features used only by window managers are not exposed in GDK. If necessary, you can use Xlib directly in your application by including the special gdk/gdkx.h header file. (Check out the GDK source code to see how to extract the low-level Xlib data structures from their GDK wrappers.)

If you need excruciating details on a GDK function, you can typically glance at the source to determine the Xlib function it wraps, and then read the man page for the Xlib function. For example, here is the implementation of gdk_draw_point():

```
void
gdk_draw_point (GdkDrawable *drawable,
                GdkGC       *gc,
                gint         x,
                gint         y)
{
  GdkWindowPrivate *drawable_private;
  GdkGCPrivate *gc_private;

  g_return_if_fail (drawable != NULL);
  g_return_if_fail (gc != NULL);

  drawable_private = (GdkWindowPrivate*) drawable;
  if (drawable_private->destroyed)
    return;
  gc_private = (GdkGCPrivate*) gc;

  XDrawPoint (drawable_private->xdisplay, drawable_private->xwindow,
              gc_private->xgc, x, y);
}
```

Each data structure is cast to its "private" version, which contains information relating to the particular window system GDK is being used on; this is to keep window-system-specific declarations out of the gdk/gdk.h header file. The private version of each data structure contains a wrapped Xlib data structure, which is passed to XDrawPoint(). So the XDrawPoint() documentation will also apply to gdk_draw_point().

GdkWindow

GdkWindow is a wrapper around Xlib's Window object. (It was discussed briefly in the section called *Realizing, Mapping, and Showing* in the chapter called *GTK+ Basics*.) A GdkWindow represents a region on the screen. It can be shown or hidden (called *mapping* and *unmapping* the window in Xlib). You can capture events received by a GdkWindow, draw graphics inside it, and move or resize it. GdkWindows are arranged in a tree structure; that is, each window can have child windows. Child windows are positioned relative to their parent window, and move when the parent moves. Child windows don't draw outside of their parent's bounds (i.e. they are clipped by the parent window).

The tree of GdkWindows is not specific to each application; there is a global tree of windows controlled by the X server and the window manager.

The *root window* has no parent; all windows derive from it. All or part of it is visible as your desktop background. Each window can be owned by a different UNIX process; some windows will be created by the window manager, some will come from user applications.

GdkWindow and GtkWindow are very different things; GtkWindow is a GTK+ widget used to represent toplevel windows (toplevel windows are the highest application-controlled windows in the window hierarchy). Window managers typically create *decorations* for toplevel windows; decorations include title bars, close buttons, and the like.

It's important to understand that an X window is primarily an object on the X server. X clients receive a unique integer ID for each window, and refer to windows by ID. Thus, all window operations take place on the server; all functions that deal with X windows go across the network.

GdkWindow is a wrapper around the integer ID returned by X. It does keep local copies of some information (such as the window's dimensions), so some GDK operations are more efficient than the corresponding Xlib operations. Still, GdkWindow is essentially a handle for a server-side object. Many GDK objects are similar; fonts, pixmaps, cursors, and so on are also handles for server-side objects.

GdkWindow and GtkWidget

Many GtkWidget subclasses have an associated GdkWindow. In theory, GTK+ applications could create only toplevel windows, and have all widgets draw into them. However, it would make little sense to do so; GdkWindow allows the X Window System to automatically handle many details. For example, events received from GDK are marked with the window they occurred in; GTK+ can rapidly determine which widget each event corresponds to.

There are some widgets with no associated GdkWindow; these are called "no window" widgets, an allusion to the GTK_NO_WINDOW flag that marks them. (You can test this flag with the macro GTK_WIDGET_NO_WINDOW().) Widgets without a window render themselves into their parent container's GdkWindow. Windowless widgets are relatively small and lightweight; GtkLabel is the most common example. Because events are always received on a GdkWindow, windowless widgets do not receive events. (The GtkEventBox container can be used if you need to capture events on a windowless widget.)

GdkWindow Attributes

gdk_window_new() (shown in Figure 1) allows you to specify all of a window's attributes when you create it; many of them can be changed later as well. To specify a block of attributes, you pass in a GdkWindowAttr object; its contents will give you an idea what attributes a GdkWindow can have:

```
typedef struct _GdkWindowAttr GdkWindowAttr;

struct _GdkWindowAttr
{
  gchar *title;
  gint event_mask;
  gint16 x, y;
  gint16 width;
  gint16 height;
  GdkWindowClass wclass;
  GdkVisual *visual;
  GdkColormap *colormap;
  GdkWindowType window_type;
  GdkCursor *cursor;
  gchar *wmclass_name;
  gchar *wmclass_class;
  gboolean override_redirect;
};
```

Because some of the fields in GdkWindowAttr are optional, gdk_window_new() is used with an attributes_mask to specify which optional fields contain valid information (bit flags are available representing each optional field). GDK will only examine the optional fields given in the mask, so you can let the default values remain for fields you aren't interested in. Table 1 summarizes them briefly; fields with no attributes_mask flag are required and have no default value.

gdk_window_new() is typically used in widget implementations to create the widget's GdkWindow; you will rarely use it in any other context. gdk_window_destroy() destroys a window when you are done with it. Windows are also reference counted; be sure to read the section called *GDK Resource Management* for more details on this.

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

GdkWindow* gdk_window_new(GdkWindow* *parent*, GdkWindowAttr* *attributes*, gint *attributes_mask*);

void gdk_window_destroy(GdkWindow* *window*);

Figure 1. GdkWindow

A GdkWindow's title is only really important for toplevel windows; most window managers will place it in the titlebar. Usually you should not specify it when creating a GdkWindow, however; instead, let your widget's users call gtk_window_set_title().

The window's event mask determines which events will be received on this window; the section called *Events* goes into more detail about events.

The X and Y coordinates for a window are specified in pixels, relative to the parent window's origin. The origin of each window is its top left ("northwest") corner. Notice that a 16-bit signed integer is used; X windows have a maximum size of 32768 pixels. Negative values are allowed, but the window will be clipped by its parent window (only the portion inside the parent window will be visible).

The width and height of a window are given in pixels, and are also 16-bit signed integers.

A window's GdkWindowClass can have one of two values:

- GDK_INPUT_OUTPUT is a normal window.
- GDK_INPUT_ONLY is a window that has a position and receives events but has no visual representation. Its children must also be input only. You can set the cursor and other attributes for an input only window, but there is no way to draw to it (it's invisible). Input-only windows are occasionally useful to capture events or change the cursor in a region that overlaps two normal windows.

A *visual* describes the color-handling characteristics of a display; a *colormap* contains the colors you can use to draw. the section called *Visuals and Colormaps* gives details on visuals and colormaps.

Windows can be one of several different types, specified by the GdkWindowType enumeration:

- GDK_WINDOW_ROOT is the type of the GDK wrapper for the root window, created at initialization time.

- GDK_WINDOW_TOPLEVEL is a toplevel window; the parent argument to gdk_window_new() should be NULL in this case. GDK automatically uses the root window as the window's parent.
- GDK_WINDOW_CHILD is a subwindow within a toplevel window.
- GDK_WINDOW_DIALOG is essentially the same as a toplevel window; its parent should be NULL and GDK will substitute the root window. A hint will be set to tell the window manager the window is a dialog; some window managers take this into account.
- GDK_WINDOW_TEMP is used for popup menus and the like; it's a window that will exist only briefly. It's a toplevel window, so its parent should be NULL. These windows are always override redirect and their cursor is always the same as their parent's. So they will ignore those elements of the attributes struct.
- GDK_WINDOW_PIXMAP is not a window at all; GdkPixmap and GdkWindow are almost always treated the same way, so GDK uses the same struct to represent them. They can both be considered kinds of GdkDrawable. See the section called *Drawables and Pixmaps*.
- GDK_WINDOW_FOREIGN identifies a wrapper around a window not created by GDK.

Only GDK_WINDOW_TOPLEVEL, GDK_WINDOW_CHILD, GDK_WINDOW_TEMP, and GDK_WINDOW_DIALOG are valid for gdk_window_new(). Library users may not create a GDK_WINDOW_ROOT. Pixmaps (GDK_WINDOW_PIXMAP) are created with gdk_pixmap_new(). Foreign windows (GDK_WINDOW_FOREIGN) are X windows created outside of GDK and wrapped using gdk_window_foreign_new() (declared in gdk/gdkx.h, since you will only need this function if you are using Xlib directly).

The cursor field specifies the mouse pointer (cursor) to use in this window; see the section called *The Mouse Pointer* for information about cursors.

The "class hint" is described in the section called *Setting Window Class Hints* in the chapter called *The Main Window: GnomeApp*. When writing widgets, you will not usually set the class hint. It is only relevant for toplevel windows; GTK+ provides gtk_window_set_wmclass() so application authors can set it to something sensible.

The last field in GdkWindowAttr determines whether the window is "override redirect." Normally, window managers intercept all requests to show, hide, move, or resize a toplevel window. They can then redirect or cancel these requests, to force windows to behave according to the window manager's layout policy. You can override this behavior by setting override_redirect to TRUE. Since window managers can not move windows with this flag set, they will normally not put a title bar or other decorations on them. Note that all GDK_WINDOW_TEMP windows use TRUE for this field;

recall that GDK_WINDOW_TEMP is often used for popup menus, which are not controlled by the window manager.

Typically you should not change the override_redirect field; the default is almost always right, if you specify the correct GdkWindowType. However, there are some exceptions; the Gnome panel application sets this field, for example.

Table 1. GdkWindowAttr Fields

Field	**Type**	**Flag**	**Default Value**	**Purpose**
title	gchar*	GDK_WA_TITLE	Program Name	The window's title
event_mask	gint	none	none	Events to receive on this window
x	gint16	GDK_WA_X	0	X position relative to parent window
y	gint16	GDK_WA_Y	0	Y position relative to parent window
width	gint16	none	none	Width of window
height	gint16	none	none	Height of window
wclass	GdkWindowClass	none	none	GDK_INPUT_ONLY vs. GDK_INPUT_OUTPUT
visual	GdkVisual*	GDK_WA_VISUAL	X's "default visual"	Visual for this window
colormap	GdkColormap*	GDK_WA_COLORMAP	X's "default colormap" [PD]footnote!	Colormap for this window
window_type	GdkWindowType	none	none	Window type (see text)
cursor	GdkCursor*	GDK_WA_CURSOR	Parent window's cursor	Mouse pointer for this window
wmclass_name	gchar*	GDK_WA_WMCLASS	none (doesn't set hint)	Set the "name" part of the class hint (see text)
wmclass_class	gchar*	GDK_WA_WMCLASS	none (doesn't set hint)	Set the "class" part of the class hint (see text)

override_redirect	gboolean	GDK_WA_NOREDIR	FALSE [PD] footnote!	Make the window "override redirect" (see text)

Visuals and Colormaps

Unfortunately, not all hardware is created equal. The most primitive X servers support only two colors; each pixel is either on or off. This is referred to as a "one bit per pixel (bpp)" display. A display with one bit per pixel is said to have a *depth* of one. More advanced X servers support 24 or 32 bits per pixel, and allow you to specify a different depth on a window-by-window basis. 24 bits per pixel allows 2^24 different pixels, which includes more colors than the human eye can differentiate.

Conceptually, a bitmap display consists of a rectangular grid of pixels. Each pixel consists of some fixed number of bits; pixels are mapped to visible colors in a hardware-dependent way. One way to think about this is to imagine a two-dimensional array of integers, where the integer size is chosen to hold the required number of bits. Alternatively, you can think of a display like this as a stack of *bit planes*, or two-dimensional arrays of bits. If all the planes are parallel to one another, a pixel is a perpendicular line passing through the same coordinates on each plane, taking a single bit from each one. This is the origin of the term *depth*, since the number of bits per pixel is equal to the depth of the stack of bit planes.

In the X Window System, pixels represent entries in a color lookup table. A *color* is a red, green, blue (RGB) value---monitors mix red, green, and blue light in some ratio to display each pixel. Take an eight bit display, for example: eight bits are not enough to encode a color in-place; only a few arbitrary RGB values would be possible. Instead, the bits are interpreted as an integer and used to index an array of RGB color values. This table of colors is called the *colormap*; it can sometimes be modified to contain the colors you plan to use, though this is hardware-dependent---some colormaps are read-only.

A *visual* is required to determine how a pixel's bit pattern is converted into a visible color. Thus, a visual also defines how colormaps work. On an 8-bit display, the X server might interpret each pixel as an index into a single colormap containing the 256 possible colors. 24-bit visuals typically have three colormaps: one for shades of red, one for shades of green, and one for shades of blue. Each colormap is indexed with an eight-bit value; the three eight-bit values are packed into a 24-bit pixel. The visual defines the meaning of the pixel contents. Visuals also define whether the colormap is read-only or modifiable.

In short, a visual is a description of the color capabilities of a particular X server. In Xlib, you have to do a lot of fooling around with visuals; GDK and GTK+ shield you from most of the mess.

GdkVisual

Xlib can report a list of all available visuals and information about each; GDK keeps a client-side copy of this information in a struct called GdkVisual. GDK can report the available visuals, and rank them in different ways. Most of the time you will only use gdk_visual_get_system(), which returns a pointer to the default visual (Figure 2). (If you're writing a GtkWidget, gtk_widget_get_visual() returns the visual you should use; more on this in the chapter called *Writing a GtkWidget*.) The returned visual is not a copy, so there is no need to free it; GDK keeps visuals around permanently.

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

```
GdkVisual* gdk_visual_get_system(void);
```

Figure 2. Default Visual

For reference, here are the contents of GdkVisual; most of the members are used to calculate pixel values from colors. Since this is fairly involved and rarely used, this book glosses over the topic. The depth member is convenient sometimes. the section called *Types of Visual* has more to say about the type member.

```

typedef struct _GdkVisual GdkVisual;

struct _GdkVisual
{
  GdkVisualType type;
  gint depth;
  GdkByteOrder byte_order;
  gint colormap_size;
  gint bits_per_rgb;
  guint32 red_mask;
  gint red_shift;
  gint red_prec;

  guint32 green_mask;
  gint green_shift;
  gint green_prec;

  guint32 blue_mask;
  gint blue_shift;
  gint blue_prec;
};
```

Types of Visual

Visuals differ along several dimensions. They can be grayscale or RGB, colormaps can be modifiable or fixed, and the pixel value can either index a single colormap or contain packed red, green, and blue indexes. Here are the possible values for GdkVisualType:

- GDK_VISUAL_STATIC_GRAY means the display is either monochrome or gray scale, and the colormap cannot be modified. A pixel value is simply a level of gray; each pixel is "hard coded" to represent a certain on-screen color.
- GDK_VISUAL_GRAYSCALE means the display has a modifiable colormap, but only levels of gray are possible. The pixel represents an entry in the colormap, so a given pixel can represent a different level of gray at different times.
- GDK_VISUAL_STATIC_COLOR represents a color display which uses a single read-only colormap rather than a separate colormap for each of red, green, and blue. The display is almost certainly 12-bit or less (a 24-bit display using a single colormap would need a colormap with 2^24 entries, occupying close to half a gigabyte---not very practical!). This is an annoying visual, because relatively few colors are available and you can't change which colors they are.
- GDK_VISUAL_PSEUDO_COLOR is the most common visual on low-end PC hardware from several years ago. If you have a one-megabyte 256-color video card, this is most likely your X server's visual. It represents a color display with a read/write colormap. Pixels index a single colormap.
- GDK_VISUAL_TRUE_COLOR is a color display with three read-only colormaps, one for each of red, green, and blue. A pixel contains three indexes, one per colormap. There is a fixed mathematical

relationship between pixels and RGB triplets; you can get a pixel from red, green, and blue values in [0, 255] using the formula: gulong pixel = (gulong)(red*65536 + green*256 + blue).

- GDK_VISUAL_DIRECT_COLOR is a color display with three read-write colormaps. If you use the GDK color handling routines, they simply fill up all three colormaps to emulate a true color display, then pretend the direct color display is true color.

Color and GdkColormap

A GdkColor stores an RGB value and a pixel. Red, green, and blue are given as 16-bit unsigned integers; so they are in the range [0, 65535]. The contents of the pixel depend on the visual. Here is GdkColor:

```
typedef struct _GdkColor GdkColor;

struct _GdkColor
{
  gulong  pixel;
  gushort red;
  gushort green;
  gushort blue;
};
```

Before you can use a color to draw, you must:

- Ensure that the pixel value contains an appropriate value.
- Ensure that the color exists in the colormap of the drawable you intend to draw to. (A *drawable* is a window or pixmap you can draw to; see the section called *Drawables and Pixmaps*.)

In Xlib, this is an enormously complicated process, because it has to be done differently for every kind of visual. GDK conceals things fairly well. You simply call gdk_colormap_alloc_color() to fill in the pixel value and add the color to the colormap (Figure 3). Here is an example; it assumes a preexisting GdkColormap* colormap, which should be the colormap of the drawable you are targetting:

```
  GdkColor color;

  /* Describe a pure red */
  color.red   = 65535;
  color.green = 0;
  color.blue  = 0;

  if (gdk_colormap_alloc_color(colormap, &color, FALSE, TRUE))
    {
      /* Success! */
    }
```

If gdk_colormap_alloc_color() returns TRUE, then the color was allocated and color.pixel contains a valid value. The color can then be used to draw. The two boolean arguments to gdk_colormap_alloc_color() specify whether the color should be *writeable*, and whether to try to find a "best match" if the color can't be allocated. If a best match is used instead of allocating a new color, the color's RGB values will be changed to the best match. If you request a best match for a non-writeable entry, allocation really should not fail, since even on a black and white display either black or white will be the best match; only an empty colormap could cause failure. The only way to get an empty colormap is to create a custom colormap yourself. If you don't ask for the best match, failure is quite possible on displays with a limited number of colors. Failure is always possible with writeable colormap entries (where best match makes no sense, because the entry can be modified).

A *writeable* colormap entry is one that you can change at any time; some visuals support this, and some don't. The purpose of a writeable colormap entry is to change an on-screen color without redrawing the graphics. Some hardware stores pixels as indices into a color lookup table, so changing the lookup table changes how the pixels are displayed. The disadvantages of writeable colormap entries are numerous. Most notably: not all visuals support them, and writeable colormap entries can't be used by other applications (read-only entries can be shared, since other applications know the color will remain constant). Thus, it is a good idea to avoid allocating writeable colors. On modern hardware, they are more trouble than they're worth; the speed gain compared to simply redrawing your graphics will not be noticeable.

When you're finished with a color, you can remove it from the colormap with gdk_colormap_free_colors(). This is only really important for pseudo color and grayscale visuals, where colors are in short supply and the colormap can be modified by clients. GDK will automatically do the right thing for each visual type, so always call this function.

A convenient way to obtain RGB values is the gdk_color_parse() function. This takes an X color specification, and fills in the red, green, and blue fields of a GdkColor. An X color specification can have many forms; one possibility is an RGB string:

```
RGB:FF/FF/FF
```

This specifies white (red, green, and blue are all at full intensity). The RGB: specifies a "color space," and determines the meaning of the numbers after it. X also understands several more obscure color spaces. If the color specification string doesn't begin with a recognized color space, X assumes it's a color name and looks it up in a database of names. So you can write code like this:

```
  GdkColor color;

  if (gdk_color_parse("orange", &color))
    {
      if (gdk_colormap_alloc_color(colormap, &color, FALSE, TRUE))
        {
          /* We have orange! */
        }
    }
```

As you can see, gdk_color_parse() returns TRUE if it figures out the string you pass it. There is no way to know exactly what will be in the color database, so always check this return value.

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

gboolean gdk_colormap_alloc_color(GdkColormap* *colormap*, GdkColor* *color*, gboolean *writeable*, gboolean *best_match*);

void gdk_colormap_free_colors(GdkColormap* *colormap*, GdkColor* *colors*, gint *ncolors*);

gint gdk_color_parse(gchar* *spec*, GdkColor* *color*);

Figure 3. Color Allocation

Obtaining a Colormap

If you're writing a GtkWidget subclass, the correct way to obtain a colormap is with gtk_widget_get_colormap() (see the chapter called *Writing a GtkWidget*). Otherwise, the system (default) colormap is usually what you want; call gdk_colormap_get_system(), which takes no arguments and returns the default colormap.

The GdkRGB module (see the section called *RGB Buffers*) is another way to deal with colors; among other capabilities, it can set the foreground and background colors of a graphics context from an RGB value. The relevant functions are gdk_rgb_gc_set_foreground() and gdk_rgb_gc_set_background(). GdkRGB has a pre-allocated colormap that it uses to pick a best-match color; using it means that your application can share limited colormap resources with other applications using GdkRGB (such as the Gimp). You can also obtain GdkRGB's colormap and use it directly (see the section called *RGB Buffers*).

Drawables and Pixmaps

A *pixmap* is an off-screen buffer you can draw graphics into. After drawing into a pixmap, you can copy it to a window, causing it to appear on the screen (when the window is visible). (You can also draw into a window directly, of course. Using a pixmap as a buffer allows you to rapidly update the screen without repeating a series of primitive drawing operations.) Pixmaps are also good to store image data loaded from disk, such as icons and logos. You can then copy the image to a window. In GDK, the pixmap type is called GdkPixmap. A pixmap with a single bit representing each pixel is called a bitmap; GDK's bitmap type is GdkBitmap. "Bitmap" is not really a separate type; from X's point of view, it is simply a pixmap with a depth of 1. Like windows, pixmaps are server-side resources.

In X terminology, a *drawable* is anything you can draw graphics on. GDK has a corresponding type, called GdkDrawable. Drawables include windows, pixmaps, and bitmaps. Here is how the types are defined in GDK:

```
typedef struct _GdkWindow GdkWindow;
typedef struct _GdkWindow GdkPixmap;
typedef struct _GdkWindow GdkBitmap;
typedef struct _GdkWindow GdkDrawable;
```

On the client side, pixmaps and bitmaps are just GdkWindows with type GDK_WINDOW_PIXMAP. GdkDrawable is used in function declarations when either a window or a pixmap is an acceptable argument. Functions that draw graphics take either type; functions that move windows around or set window manager hints accept only windows. Only windows can receive events. GDK_INPUT_ONLY windows are a special case; they are not drawables and you can't draw on them.

Three of the four logical combinations of "window features" and drawability actually exist:

	Drawable	Not Drawable
Window Features	Normal Window	Input Only Window
No Window Features	Pixmap/Bitmap	---

Unfortunately, all three of these logically distinct cases appear the same from a type-checking point of view. So be careful not to use the wrong one. Also keep in mind that a normal window is not drawable until it actually appears on the screen; you should wait until you receive an expose event before you draw. Expose events are covered in the section called *Expose Events*.

Like GdkWindow, a GdkPixmap is merely a client-side handle for an object located on the X server. Because of this, some things are entirely infeasible from a performance point of view; notably, if you are doing anything which requires significant manipulation of individual pixels, drawables will be far too slow. On the other hand, copying a pixmap to a window is not as slow as you might think, because both objects are on the same machine.

Creating a pixmap is much easier than creating a window, because most of the window attributes are not relevant to pixmaps. The function is gdk_pixmap_new() (Figure 4). It accepts an initial size, and a bit depth. If a depth of -1 is given, the depth is copied from its GdkWindow argument. You can't choose an arbitrary number for the depth---the server will not support all depths, and the pixmap's depth must match the depth of any windows you plan to copy it to. To destroy a pixmap, call gdk_pixmap_unref().

The GdkWindow argument to gdk_pixmap_new() may not seem strictly necessary. However, the function wraps XCreatePixmap(), which takes an X window as an argument. It uses this argument to determine which *screen* to create the window on; some X servers have multiple displays. Screens are an Xlib concept totally concealed by GDK; GDK supports only one screen at a time. Thus the window argument to gdk_pixmap_new() seems mysterious from a GDK point of view.

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

GdkPixmap* gdk_pixmap_new(GdkWindow* *window*, gint *width*, gint *height*, gint *depth*);

void gdk_pixmap_unref(GdkPixmap* *pixmap*);

Figure 4. GdkPixmap Constructor

Events

Events are sent to your application to indicate changes in a GdkWindow or user actions you might be interested in. All events are associated with a GdkWindow. They also come to be associated with a GtkWidget; the GTK+ main loop passes events from GDK to the GTK+ widget tree.

Types of Event

There are many kinds of events; the GdkEvent union can represent any of them. A special event type, GdkEventAny, contains the three fields common to all events; any event can be cast to GdkEventAny. The first field in GdkEventAny is a type marker, GdkEventType; GdkEventType is also included in the GdkEvent union. Confused yet? Seeing the code should help. Here is GdkEventAny:

```

struct _GdkEventAny
{
  GdkEventType type;
  GdkWindow *window;
  gint8 send_event;
};
```

and GdkEvent:

```
union _GdkEvent
{
  GdkEventType              type;
  GdkEventAny               any;
  GdkEventExpose            expose;
  GdkEventNoExpose          no_expose;
  GdkEventVisibility        visibility;
  GdkEventMotion            motion;
  GdkEventButton            button;
  GdkEventKey               key;
  GdkEventCrossing          crossing;
  GdkEventFocus             focus_change;
  GdkEventConfigure         configure;
  GdkEventProperty          property;
  GdkEventSelection         selection;
  GdkEventProximity         proximity;
  GdkEventClient            client;
  GdkEventDND               dnd;
};
```

Every event type has the three members of GdkEventAny as its first three members. Thus, the type of an event can be referred to in many ways (assume a GdkEvent* called event):

- event->type
- event->any.type
- event->button.type
- ((GdkEventAny*)event)->type
- ((GdkEventButton*)event)->type

You'll probably see all these in GTK+ source code. Of course, each event subtype has its own unique members; the type field tells you which subtype is valid.

The window field of GdkEventAny is the GdkWindow the event was sent to. If the send_event flag is TRUE, then the event was synthesized by another (or your own) application; if FALSE, it originated with the X server. GDK does not export the X interface for sending events (XSendEvent()). However, GTK+ often "makes up" an event by declaring a static event struct, filling it in, then emitting the event's corresponding widget signal. These synthesized events will have send_event set to TRUE. the section called *Receiving GDK Events in GTK+* explains how GTK+ associates events with widget signals.

There are more possible values for GdkEventType than there are members in the GdkEvent union. Many event types share the same data; for example, GDK_BUTTON_PRESS and GDK_BUTTON_RELEASE both use the button member of GdkEvent, since the same information is conveyed when mouse buttons are pressed and released. Table 2 shows all possible values of the GdkEventType enumeration, and the corresponding GdkEvent member. The meaning of each event type is described later in this section.

Table 2. GdkEventType Values

Value	GdkEvent Member
GDK_NOTHING	none [PD] footnote!
GDK_DELETE	GdkEventAny
GDK_DESTROY	GdkEventAny
GDK_EXPOSE	GdkEventExpose
GDK_MOTION_NOTIFY	GdkEventMotion
GDK_BUTTON_PRESS	GdkEventButton
GDK_2BUTTON_PRESS	GdkEventButton
GDK_3BUTTON_PRESS	GdkEventButton
GDK_BUTTON_RELEASE	GdkEventButton
GDK_KEY_PRESS	GdkEventKey
GDK_KEY_RELEASE	GdkEventKey
GDK_ENTER_NOTIFY	GdkEventCrossing
GDK_LEAVE_NOTIFY	GdkEventCrossing
GDK_FOCUS_CHANGE	GdkEventFocus
GDK_CONFIGURE	GdkEventConfigure
GDK_MAP	GdkEventAny
GDK_UNMAP	GdkEventAny
GDK_PROPERTY_NOTIFY	GdkEventProperty
GDK_SELECTION_CLEAR	GdkEventSelection
GDK_SELECTION_REQUEST	GdkEventSelection
GDK_SELECTION_NOTIFY	GdkEventSelection
GDK_PROXIMITY_IN	GdkEventProximity

GDK_PROXIMITY_OUT	GdkEventProximity
GDK_DRAG_ENTER	GdkEventDND
GDK_DRAG_LEAVE	GdkEventDND
GDK_DRAG_MOTION	GdkEventDND
GDK_DRAG_STATUS	GdkEventDND
GDK_DROP_START	GdkEventDND
GDK_DROP_FINISHED	GdkEventDND
GDK_CLIENT_EVENT	GdkEventClient
GDK_VISIBILITY_NOTIFY	GdkEventVisibility
GDK_NO_EXPOSE	GdkEventNoExpose

The Event Mask

Each GdkWindow has an associated *event mask* which determines which events on that window the X server will forward to your application. You specify the event mask when a GdkWindow is created, as part of the GdkWindowAttr struct (*the section called GdkWindow Attributes*). You can access and change the event mask later using gdk_window_set_events() and gdk_window_get_events(). If the GdkWindow in question belongs to a widget, you should not change the event mask directly; rather, call gtk_widget_set_events() or gtk_widget_add_events(). gtk_widget_set_events() should be used after a widget is realized; gtk_widget_add_events() can be used to add events to the existing mask at any time. Figure 5 and Figure 6 show these functions.

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

GdkEventMask gdk_window_get_events(GdkWindow* *window*);

void gdk_window_set_events(GdkWindow* *window*, GdkEventMask *event_mask*);

Figure 5. GdkWindow Event Mask

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

gint gdk_widget_get_events(GtkWidget* *widget*);

void gtk_widget_add_events(GtkWidget* *widget*, gint *event_mask*);

```
void gtk_widget_set_events(GtkWidget* widget, gint event_mask);
```

Figure 6. Widget Event Mask

Table 3 shows which event masks request which events. Some events do not have to be selected to be received; in particular:

- Map, unmap, destroy, and configure events are selected with GDK_STRUCTURE_MASK, but GDK automatically selects them on any new window. (Xlib programmers beware; Xlib does not do this.)
- Selection, client, drag-and-drop, and delete events have no masks, because they are automatically selected (Xlib selects them for all windows).

Table 3. Event Masks

Mask	**Event Type**
GDK_EXPOSURE_MASK	GDK_EXPOSE
GDK_POINTER_MOTION_MASK	GDK_MOTION_NOTIFY
GDK_POINTER_MOTION_HINT_MASK	N/A (see the section called *Mouse Movement Events*)
GDK_BUTTON_MOTION_MASK	GDK_MOTION_NOTIFY (while a button is pressed)
GDK_BUTTON1_MOTION_MASK	GDK_MOTION_NOTIFY (while button 1 is pressed)
GDK_BUTTON2_MOTION_MASK	GDK_MOTION_NOTIFY (while button 2 is pressed)
GDK_BUTTON3_MOTION_MASK	GDK_MOTION_NOTIFY (while button 3 is pressed)
GDK_BUTTON_PRESS_MASK	GDK_BUTTON_PRESS, GDK_2BUTTON_PRESS, GDK_3BUTTON_PRESS
GDK_BUTTON_RELEASE_MASK	GDK_BUTTON_RELEASE
GDK_KEY_PRESS_MASK	GDK_KEY_PRESS
GDK_KEY_RELEASE_MASK	GDK_KEY_RELEASE
GDK_ENTER_NOTIFY_MASK	GDK_ENTER_NOTIFY
GDK_LEAVE_NOTIFY_MASK	GDK_LEAVE_NOTIFY

GDK_FOCUS_CHANGE_MASK	GDK_FOCUS_IN, GDK_FOCUS_OUT
GDK_STRUCTURE_MASK	GDK_CONFIGURE, GDK_DESTROY, GDK_MAP, GDK_UNMAP
GDK_PROPERTY_CHANGE_MASK	GDK_PROPERTY_NOTIFY
GDK_VISIBILITY_NOTIFY_MASK	GDK_VISIBILITY_NOTIFY
GDK_PROXIMITY_IN_MASK	GDK_PROXIMITY_IN
GDK_PROXIMITY_OUT_MASK	GDK_PROXIMITY_OUT
GDK_SUBSTRUCTURE_MASK	Receive GDK_STRUCTURE_MASK events for *child windows*
GDK_ALL_EVENTS_MASK	All events

Receiving GDK Events in GTK+

In a GTK+ program, you will never receive GDK events directly. Instead, all events are passed to a GtkWidget, which emits a corresponding signal. You handle events by connecting handlers to GtkWidget signals.

The X server sends each X client a stream of events. Events are sent and received in the order of their occurrence. GDK converts each XEvent it receives into a GdkEvent, then places events in a queue. GTK+ monitors GDK's event queue; for each event received, it decides which widget (if any) should receive the event. The GtkWidget base class defines signals for most event types (such as "button_press_event"); it also defines a generic "event" signal. The GTK+ main loop calls gtk_widget_event() to deliver an event to a widget; this function first emits the "event" signal, then emits a signal for the specific event type (if appropriate). Some events are handled in special ways; notably, drag-and-drop events do not directly correspond to drag-and-drop signals.

In general, events go to the widget owning the GdkWindow the event occurred on. However, there are certain special cases.

if a widget has the grab (i.e., if gtk_grab_add() was called, see the section called *Grabs* in the chapter called *GTK+ Basics*), certain events will only be forwarded to the widget with the grab, or the children of that widget. Events that occur on other widgets are ignored. Only certain user-initiated events such as button events and key events are affected by a grab.

Widget sensitivity (see the section called *Sensitivity* in the chapter called *GTK+ Basics*) also affects where events are sent. Events representing user interaction are not forwarded to insensitive widgets.

As you might expect, widgets with no associated GdkWindow do not originate events; X only sends events to windows. There is one exception: containers synthesize expose events for their windowless children.

The GTK+ main loop *propagates* certain events from child widgets to their parent containers. That is, for each event, a signal is emitted first from a child widget, then from its immediate parent, then from the parent's parent, and so on. For example, if you click a GtkMenuItem, it ignores the button press and lets the menu it's a part of handle it. Some events are not propagated; Table 4 gives details.

Event propagation ends once a widget "handles" the event. This ensures that only one user-visible change results from any user action. Handlers for GtkWidget's event signals must return a gint value. Recall that the last signal handler to run determines the return value of a signal emission---see the section called *Emitting A Signal* in the chapter called *The GTK+ Object and Type System*. All event signals are GTK_RUN_LAST, so the return value will come from:

- The last handler connected with gtk_signal_connect_after(), if any.
- Otherwise, the widget's default signal handler, if any.
- Otherwise, the last handler connected with gtk_signal_connect(), if any.
- Otherwise, the default return value is FALSE.

If the emission of an event signal returns TRUE, the GTK+ main loop will stop propagating the current event. If it returns FALSE, the main loop will propagate the event to the widget's parent. Recall that each event results in two signal emissions: a generic "event" signal and a specific signal (such as "button_press_event" or "key_press_event"). If *either* emission returns TRUE, event propagation ends. The return value from the generic "event" signal has one additional effect: if TRUE, the second, more specific signal will not be emitted.

Table 4 summarizes how GtkWidget signals correspond to event types, which events are affected by an active grab, and which events are propagated from parent to child. Signal handlers for all event signals should return a gint and take three arguments: the widget emitting the signal, the event which triggered the signal, and a user data pointer.

Table 4. GtkWidget Events

Event Type	GtkWidget **Signal**	**Propagated?**	**Grabbed?**
GDK_DELETE	"delete_event"	No	No
GDK_DESTROY	"destroy_event"	No	No
GDK_EXPOSE	"expose_event"	No	No
GDK_MOTION_NOTIFY	"motion_notify_event"	Yes	Yes
GDK_BUTTON_PRESS	"button_press_event"	Yes	Yes
GDK_2BUTTON_PRESS	"button_press_event"	Yes	Yes
GDK_3BUTTON_PRESS	"button_press_event"	Yes	Yes
GDK_BUTTON_RELEASE	"button_release_event"	Yes	Yes
GDK_KEY_PRESS	"key_press_event"	Yes	Yes
GDK_KEY_RELEASE	"key_release_event"	Yes	Yes
GDK_ENTER_NOTIFY	"enter_notify_event"	No	Yes
GDK_LEAVE_NOTIFY	"leave_notify_event"	No	Yes [PD] footnote!
GDK_FOCUS_CHANGE	"focus_in_event", "focus_out_event"	No	No
GDK_CONFIGURE	"configure_event"	No	No
GDK_MAP	"map_event"	No	No
GDK_UNMAP	"unmap_event"	No	No
GDK_PROPERTY_NOTIFY	"property_notify_event"	No	No
GDK_SELECTION_CLEAR	"selection_clear_event"	No	No
GDK_SELECTION_REQUEST	"selection_request_event"	No	No
GDK_SELECTION_NOTIFY	"selection_notify_event"	No	No
GDK_PROXIMITY_IN	"proximity_in_event"	Yes	Yes
GDK_PROXIMITY_OUT	"proximity_out_event"	Yes	Yes
GDK_CLIENT_EVENT	"client_event"	No	No
GDK_VISIBILITY_NOTIFY	"visibility_notify_event"	No	No
GDK_NO_EXPOSE	"no_expose_event"	No	No

Button Events

Four different event types result in a GdkEventButton:

- GDK_BUTTON_PRESS means a mouse button was pressed down.
- GDK_BUTTON_RELEASE means a button was released after being pressed down. Will not necessarily be received after a button press event: if the user moves the mouse to a different GdkWindow, that window will receive it instead.
- GDK_2BUTTON_PRESS means a mouse button was pressed down twice in a short interval---a "double click." Always preceded by a GDK_BUTTON_PRESS/GDK_BUTTON_RELEASE pair for the first click.
- GDK_3BUTTON_PRESS means a mouse button was pressed down three times in a short interval; a "triple click." Preceded by two GDK_BUTTON_PRESS/GDK_BUTTON_RELEASE pairs and GDK_2BUTTON_PRESS.

If you click three times quickly, on the same GdkWindow, the following events are received in order:

1. GDK_BUTTON_PRESS
2. GDK_BUTTON_RELEASE
3. GDK_BUTTON_PRESS
4. GDK_2BUTTON_PRESS
5. GDK_BUTTON_RELEASE
6. GDK_BUTTON_PRESS
7. GDK_3BUTTON_PRESS
8. GDK_BUTTON_RELEASE

The X server automatically causes a pointer grab when a button is pressed, and releases it when it is released. This means that the button release event always goes to the same window that received the button press event. Xlib allows you to change this behavior, but GDK does not. (In the Xlib documentation, this automatic grab is referred to as a "passive" grab. It's distinct from an "active" grab initiated with gdk_pointer_grab(), described in the section called *Grabbing the Pointer*.)

A button event is defined as follows:

```

typedef struct _GdkEventButton GdkEventButton;

struct _GdkEventButton
{
  GdkEventType type;
  GdkWindow *window;
  gint8 send_event;
  guint32 time;
  gdouble x;
  gdouble y;
  gdouble pressure;
  gdouble xtilt;
  gdouble ytilt;
  guint state;
  guint button;
  GdkInputSource source;
  guint32 deviceid;
  gdouble x_root, y_root;
};
```

Button events are marked with a time stamp (time) by the X server. The time is given in milliseconds of "server time"; every few weeks the integer overflows and timestamps begin again at 0. Thus, you should not rely on the value as an absolute measure of time; it is intended only to determine relative time between events.

The mouse pointer's X and Y coordinates (relative to the window the event occurred in) are included in GdkEventButton. Keep in mind that the pointer may be outside the window (if a pointer grab is in effect; see the section called *The Mouse Pointer*). If the pointer is outside the window, its coordinates could be negative or larger than the window's size. Coordinates are given as doubles rather than integers, because some input devices such as graphics tablets have sub-pixel resolution. For most purposes, you will want to cast the doubles to integers. pressure, xtilt, and ytilt are also special features of some input devices; they can be ignored almost all the time.

The state member of GdkEventButton indicates which modifier keys or mouse buttons were held down an instant before the button was pressed. It is a bitfield, with one or more of the flags in Table 5 set. Since the modifiers are read just before the button press, it follows that button press events do not have the pressed button in state, but button release events do have it.

Be careful to check for the presence of certain bit masks, rather than the exact value of state. That is, prefer this:

```

 if ( (state & GDK_SHIFT_MASK) == GDK_SHIFT_MASK )
```

and avoid this:

```
if ( state == GDK_SHIFT_MASK )
```

If you check the exact value of state, your application will mysteriously stop working if the user has Num Lock or some other obscure modifier turned on.

Table 5. Modifier Masks for Key and Button Events

Modifier Mask	**Meaning**
GDK_SHIFT_MASK	Shift
GDK_LOCK_MASK	Caps Lock
GDK_CONTROL_MASK	Control
GDK_MOD1_MASK	Mod1 (often Meta or Alt)
GDK_MOD2_MASK	Mod2
GDK_MOD3_MASK	Mod3
GDK_MOD4_MASK	Mod4
GDK_MOD5_MASK	Mod5
GDK_BUTTON1_MASK	Button 1
GDK_BUTTON2_MASK	Button 2
GDK_BUTTON3_MASK	Button 3
GDK_BUTTON4_MASK	Button 4
GDK_BUTTON5_MASK	Button 5
GDK_RELEASE_MASK	Key releases

The button member of GdkEventButton indicates which button triggered the event (i.e., the button which was pressed or released). Buttons are numbered from one to five; most of the time, button one is the left button, button two is the middle button, and button three is the right button. Left-handed users might reverse these. Button four and five events are generated by some scroll wheel mice when you spin the scroll wheel; GTK+ attempts to send capture these events and move nearby scroll bars. You should probably ignore any events you receive for buttons four or five.

The three standard mouse buttons have conventional meanings in Gnome. Button one is used for selection, drag and drop, and operating widgets: the most common tasks. Button three typically activates a pop-up menu. Button two is traditionally used to move objects, such as the panel. Sometimes button one moves objects also; for example, desktop icons can be moved with either button one or two. It is a good idea to be consistent with other applications whenever possible.

The source and deviceid members are used to determine which device triggered the event; the user may have a graphics tablet and a mouse connected simultaneously, for example. You can ignore these fields unless you are writing an application that can take advantage of non-mouse devices.

The last two members of GdkEventButton, x_root and y_root, are the x and y coordinates translated to be relative to the root window rather than the window receiving the event. You can use these as "absolute" coordinates to compare events from two different windows.

Keyboard Events

There are only two types of key event: GDK_KEY_PRESS and GDK_KEY_RELEASE. Some hardware does not generate key release events; you should not write code that depends on GDK_KEY_RELEASE events, though your code should respond sanely if one is received.

Here are the contents of a key event:

```
typedef struct _GdkEventKey GdkEventKey;

struct _GdkEventKey
{
  GdkEventType type;
  GdkWindow *window;
  gint8 send_event;
  guint32 time;
  guint state;
  guint keyval;
  gint length;
  gchar *string;
};
```

The first three members are the standard members from GdkEventAny; the time and state members are identical to those found in GdkEventButton.

keyval contains a *keysym*. The X server keeps a global translation table which converts combinations of physical keys and modifiers to keysyms. For example, the key marked "A" on the keyboard typically generates the keysym GDK_a with no modifiers, and GDK_A with shift held down. Users can change the physical-key-to-keysym mapping; for example, they may rearrange their keys to create a Dvorak keyboard (more commonly, they might swap Control and Caps Lock, or use the Alt key as a Meta key). Keysyms are defined in gdk/gdkkeysyms.h. You will need to include this file to use the keyval field.

Keysyms are matched with a string representation. For example, the GDK_a keysym typically maps to the string "a". (However, X allows the keysym-to-string mapping to be modified.) The string member of GdkEventKey contains a keysym's string representation, and the length member contains the string's length. Keep in mind that the length may be 0 (many non-alphanumeric keys have no string representation by default). (If you're familiar with Xlib, the string field is simply the result of XLookupString() or XmbLookupString(). Even if you aren't familiar with Xlib, the man pages for these functions may be helpful.)

In general, if you are reading key events in order to create a textual representation of what the user is typing, you should use the string field of GdkEventKey. GtkEntry and GtkText use the string field, for example. A word processor would also read this field. If you're reading key events for some other reason (such as keyboard shortcuts), or if you are interested in keys with no string representation by default (such as function keys or arrow keys), you will need to use the keyval field and the keysyms defined in gdk/gdkkeysyms.h.

Here is a sample key event callback demonstrating how to extract information from a key event. It would be suitable for connection to the "key_press_event" signal of any GtkWidget:

```
static gint
key_press_cb(GtkWidget* widget, GdkEventKey* event, gpointer data)
{
  if (event->length > 0)
    printf("The key event's string is `%s'\n", event->string);

  printf("The name of this keysym is `%s'\n",
        gdk_keyval_name(event->keyval));

  switch (event->keyval)
    {
    case GDK_Home:
      printf("The Home key was pressed.\n");
      break;
    case GDK_Up:
      printf("The Up arrow key was pressed.\n");
      break;
    default:
      break;
    }

  if (gdk_keyval_is_lower(event->keyval))
    {
      printf("A non-uppercase key was pressed.\n");
    }
  else if (gdk_keyval_is_upper(event->keyval))
    {
      printf("An uppercase letter was pressed.\n");
    }
}
```

gdk_keyval_name() is useful for debugging; it returns the name of the keysym without the GDK_ prefix. For example, it returns "Home" if passed the value GDK_Home. The string is statically allocated. gdk_keyval_is_lower() returns FALSE if the keysym has an uppercase equivalent. Thus it returns TRUE for lowercase letters, numbers, and all non-alphanumeric characters. It returns FALSE only for uppercase letters. gdk_keyval_is_upper() returns the opposite values.

Mouse Movement Events

Events are emitted to let you track the mouse as it moves around the screen. *Motion events* are emitted as the pointer moves inside a window; *crossing events* are emitted when the pointer enters or leaves a GdkWindow. The type field for motion events is GDK_MOTION_NOTIFY. There are two kinds of crossing events: GDK_ENTER_NOTIFY and GDK_LEAVE_NOTIFY.

There are two ways to track motion events. If you specify GDK_POINTER_MOTION_MASK in the event mask for a window, you will receive as many motion events as the X server can generate. If the user moves the pointer rapidly, you will be deluged in motion events; you must handle them quickly, or your application may become unresponsive while it processes the backlog. If you *also* specify GDK_POINTER_MOTION_HINT_MASK, motion events are sent one at a time. At most one event will be sent until you call gdk_window_get_pointer(), the pointer leaves and re-enters the window, or a button or key event occurs. Thus, each time you receive a motion event, you must call gdk_window_get_pointer() to get the current pointer position and signal the server that you are ready for another event. See the section called *The Mouse Pointer* for details on gdk_window_get_pointer().

Which mode you choose depends on the application. If you need to trace the exact trajectory of the pointer, you will want to get all motion events. If you only care about the most recent pointer position, you will want to include GDK_POINTER_MOTION_HINT_MASK in your window's event mask to minimize network traffic and maximize responsiveness. One caveat: gdk_window_get_pointer() requires a server round-trip to obtain the pointer position; so it does place some maximum limit on your application's responsiveness. If you can handle motion events quickly enough to keep them from backlogging, your application will probably seem faster without GDK_POINTER_MOTION_HINT_MASK. Motion events are unlikely to come more often than a couple hundred per second --- so if you can handle them in less than 5 milliseconds, you should be OK.

You can ask to receive motion events only while one or more mouse buttons are held down. To receive motion events while any button is down, use GDK_BUTTON_MOTION_MASK in place of GDK_POINTER_MOTION_MASK. You can use GDK_POINTER_MOTION_HINT_MASK with GDK_BUTTON_MOTION_MASK to limit the number of events received, just as you can use it with GDK_POINTER_MOTION_MASK. If you are only interested in motion events while a certain button is pressed, you can use the more specific GDK_BUTTON1_MOTION_MASK, GDK_BUTTON2_MOTION_MASK, and GDK_BUTTON3_MOTION_MASK. Any combination of these three is allowed. They can also be combined with GDK_POINTER_MOTION_HINT_MASK to limit the number of events.

In sum, you can select which motion events to receive along the "button state" dimension using these five masks:

- GDK_POINTER_MOTION_MASK: all motion events regardless of button state.
- GDK_BUTTON_MOTION_MASK: all motion events while any button is held.
- GDK_BUTTON1_MOTION_MASK: all motion events while button 1 is held.
- GDK_BUTTON2_MOTION_MASK: all motion events while button 2 is held.
- GDK_BUTTON3_MOTION_MASK: all motion events while button 3 is held.

By default, you are deluged with events as quickly as the X server can generate them; adding GDK_POINTER_MOTION_HINT_MASK to the event mask enables one-at-a-time behavior.

Motion events are represented by GdkEventMotion:

```
typedef struct _GdkEventMotion GdkEventMotion;

struct _GdkEventMotion
{
  GdkEventType type;
  GdkWindow *window;
  gint8 send_event;
  guint32 time;
  gdouble x;
  gdouble y;
  gdouble pressure;
  gdouble xtilt;
  gdouble ytilt;
  guint state;
  gint16 is_hint;
  GdkInputSource source;
  guint32 deviceid;
  gdouble x_root, y_root;
};
```

Most of these fields should be familiar to you from GdkEventButton; in fact, the only field unique to GdkEventMotion is the is_hint flag. If this field is TRUE, GDK_POINTER_MOTION_HINT_MASK was selected. You might use this flag if you are writing a widget for other people to use, and you want to let them choose how to receive motion events. In your motion event handler, you could do this:

```
  double x, y;

  x = event->motion.x;
  y = event->motion.y;

  if (event->motion.is_hint)
    gdk_window_get_pointer(event->window, &x, &y, NULL);
```

That is, you call gdk_window_get_pointer() only if necessary. If you are using GDK_POINTER_MOTION_HINT_MASK, you should prefer the results from gdk_window_get_pointer() to the coordinates given in the event, because they are more recent. (If you are receiving every event, it makes no sense to call gdk_window_get_pointer() because it is relatively slow and will worsen the backlog---you're getting every event eventually anyway.)

Crossing events occur when the mouse pointer enters or leaves a window. If you move the mouse pointer rapidly across your application, GDK generates these events for every window you pass through. However, GTK+ will try to remove the events "in the middle" and forward only the first leave event and the last enter event to widgets. If you feel you should be getting enter/leave events when you aren't, this optimization is a likely cause.

Here is GdkEventCrossing:

```
typedef struct _GdkEventCrossing GdkEventCrossing;

struct _GdkEventCrossing
{
  GdkEventType type;
  GdkWindow *window;
  gint8 send_event;
  GdkWindow *subwindow;
  guint32 time;
  gdouble x;
  gdouble y;
  gdouble x_root;
  gdouble y_root;
  GdkCrossingMode mode;
  GdkNotifyType detail;
  gboolean focus;
  guint state;
};
```

Again, many of the fields should be familiar; coordinates relative to the event window and the root window, a time stamp, a state bitfield indicating which buttons and modifiers are active, and the standard three fields from GdkEventAny. However, there are several new fields.

The standard window field contains a pointer to the window the pointer is entering or leaving; x and y are relative to this window. However, the pointer may have been in a child of the window receiving the event before a leave event occurred; the pointer may end up in a child window when an enter event occurs. In these cases, subwindow is set to the child window. Otherwise subwindow is NULL. Note that the child window will receive its own enter and leave events, if it GDK_ENTER_NOTIFY_MASK or GDK_LEAVE_NOTIFY_MASK are in its event mask.

The mode field indicates whether the event occurred normally, or as part of a pointer grab. When the pointer is grabbed or ungrabbed (see the section called *The Mouse Pointer*), the pointer may be moved; crossing events caused by a grab have the GDK_CROSSING_GRAB mode, those caused by an ungrab have GDK_CROSSING_UNGRAB, and all others have GDK_CROSSING_NORMAL. This field appears to be completely useless; some quick greps through GTK+ and Gnome reveal no examples of its use.

The detail field is rarely used. It gives information about the relative tree positions of the window being left and the window being entered. It has two simple and useful values:

- GDK_NOTIFY_INFERIOR marks a crossing event received by a parent window when the pointer moves into or out of a child window.
- GDK_NOTIFY_ANCESTOR marks a crossing event received by a child window when the pointer moves into or out of its parent window.

Several other values are also possible: GDK_NOTIFY_VIRTUAL, GDK_NOTIFY_INFERIOR, GDK_NOTIFY_NONLINEAR, GDK_NOTIFY_NONLINEAR_VIRTUAL, and GDK_NOTIFY_UNKNOWN. However, they are never used and are too complicated to explain here.

Keyboard Focus

The focus field in GdkEventCrossing indicates whether the event window or one of its ancestors has the keyboard input focus. Keyboard focus is an X concept, used to determine which window should receive key events. The window manager decides which toplevel window has the focus (usually the focused window is highlighted and brought to the top; most window managers let you choose between "focus follows mouse" and "click to focus" modes). When an application has the focus, it is free to move it among its subwindows---perhaps different text entry fields. However, GTK+ does not use the X focus mechanism for subwindows. Toplevel GtkWindow widgets are the only ones which receive the X focus. Thus, they receive all raw key events from X (by way of GDK). GTK+ implements its own concept of *widget focus*, which is analagous to X's window focus, but in reality entirely distinct. When a toplevel GtkWindow widget receives key events, it forwards them to the widget with GTK+'s focus.

In short, this means the focus flag will be TRUE if the toplevel GtkWindow containing the event window currently has the X focus. The focus flag is unrelated to GTK+'s widget focus concept.

Focus Change Events

The previous section explained the difference between GTK+'s concept of keyboard focus and the X/GDK concept. This makes focus events a little bit confusing. There is only one type of focus event, GDK_FOCUS_CHANGE, which is received whenever a window gains or loses the keyboard focus. As we just said, only toplevel GtkWindow widgets ever gain or lose the focus from GDK's point of view; so this event may not seem useful. However, each GtkWindow maintains a current "focus widget" and forwards key events to that widget. It also synthesizes GDK-style focus events as the focus widget changes. Thus, even though GDK-style focus is not being used, widgets receive events in the same way they would if it were being used. There are subtle differences: for example, widgets receive focus events whether or not their GdkWindow's event mask includes GDK_FOCUS_CHANGE_MASK. Only toplevel widgets need to specify this mask.

Focus events themselves are very simple. When a widget gains the keyboard focus, it receives a focus event with its in member set to TRUE (a "focus in event") and when a widget loses the focus it receives a focus event with the in member set to FALSE (a "focus out event"). Otherwise, focus events contain only the three standard fields from GdkEventAny:

```
typedef struct _GdkEventFocus GdkEventFocus;

struct _GdkEventFocus
{
  GdkEventType type;
  GdkWindow *window;
  gint8 send_event;
  gint16 in;
};
```

Expose Events

Expose events are received when a previously-obscured region of a window becomes visible. GdkWindow contents are not recorded; that is, if you draw to a GdkWindow, then the X server places another window on top of it, the graphics in the bottom window will be lost. When the top window is moved away, the bottom window will receive an expose event indicating the region that needs to be re-drawn. Expose events are also sent when a window first appears on-screen. (Incidentally, you should not draw into a GdkWindow until you receive the first expose event. The first expose event is your signal that the window is actually on-screen.)

Expose events have a unique feature: GTK+ synthesizes them for windowless widgets. This is the only kind of event GTK_NO_WINDOW widgets will receive.

Expose events are very simple:

```
typedef struct _GdkEventExpose GdkEventExpose;

struct _GdkEventExpose
{
  GdkEventType type;
  GdkWindow *window;
  gint8 send_event;
  GdkRectangle area;
  gint count;
};
```

area is the area that has been exposed and should be redrawn. count is the number of expose events that follow this one; conceivably you might want to compress successive events into a single redraw. However, GDK already makes a reasonable effort to do this, so adding another pass is unlikely to gain much. GdkRectangle is defined as follows:

```
typedef struct _GdkRectangle GdkRectangle;

struct _GdkRectangle
{
  gint16 x;
  gint16 y;
  guint16 width;
  guint16 height;
};
```

There is one other time you will receive expose events. If you call gdk_window_copy_area() to copy part of one window into another, the source window region may be partially or completely obscured. If it is, X will be unable to copy something sensible from the obscured region. By default, expose events will be generated for the areas of the *destination* window X was unable to copy something to. Your program's standard redraw routine can then refresh these areas of the destination window by hand. You can turn this behavior off by calling gdk_gc_set_exposures() on the *graphics context* passed to gdk_window_copy_area(). (Graphics contexts are discussed in the section called *Graphics Contexts*.)

If the source window region is *not* obscured, gdk_window_copy_area() can successfully draw the entire destination region. In this case, no expose events are generated; a single "no expose" event is generated instead. This event contains no information beyond the standard event fields:

```

typedef struct _GdkEventNoExpose GdkEventNoExpose;

struct _GdkEventNoExpose
{
  GdkEventType type;
  GdkWindow *window;
  gint8 send_event;
};
```

Window Change Events

As a GdkWindow is shown, hidden, resized, or destroyed, events are emitted.

Configure events indicate that the size or position of the event window has changed. They include the new size and positon of the window:

```

typedef struct _GdkEventConfigure GdkEventConfigure;

struct _GdkEventConfigure
{
  GdkEventType type;
  GdkWindow *window;
  gint8 send_event;
  gint16 x, y;
  gint16 width;
  gint16 height;
};
```

All widgets receive this event (since GDK_STRUCTURE_MASK is automatically in the event mask), but the widget size allocation system already conveys the necessary information. That is, most widgets resize their GdkWindow themselves in response to a size allocation; configure events just report back the resize---not very useful. There are two notable exceptions. First, the toplevel GtkWindow widget is in charge of initiating the size allocation process, and has no parent to get an allocation from, so it monitors configure events to determine its size allocation. When you resize a GtkWindow using its window manager decorations, it will receive configure events and act accordingly. The second exception is GtkDrawingArea. GtkDrawingArea sends itself a configure event when it receives its size allocation. This is convenient, since you will usually want to repaint the contents of the drawing area if it is resized. Like all "fake" events GTK+ creates, send_event will be TRUE for this configure event.

Other changes in a GdkWindow are signalled with GdkEventAny; these events contain no special information, they just tell you that something has occurred. They are distinguished by their type field:

- GDK_DELETE means that the window manager has asked the application to destroy this window. If a *widget* receives the signal corresponding to this event, and the signal emission returns FALSE, the widget is automatically destroyed by the GTK+ main loop. Because FALSE is the default return value, you must connect a signal handler which returns TRUE to prevent users from destroying GtkWindow widgets.
- GDK_DESTROY means the window has been destroyed. Widgets normally destroy their own windows when they are unrealized. If a widget is not destroyed after a destroy event on its window, the GTK+ main loop destroys it.
- GDK_MAP means the window has been shown on the screen. You should wait for the first expose event before you draw to the window, however.
- GDK_UNMAP means the window has been hidden; perhaps it was iconified, or perhaps you called gtk_widget_hide().

Little-used Events

There are a few other event types that aren't very useful, so this book does not cover them in detail. This section gives a brief description of each one, for completeness. You can safely skip this section.

Visibility Events

Visibility events occur when a window is obscured or unobscured. They are not very useful, because other events already give you the information you need. In particular, when a window is unobscured you receive expose events indicating which newly-visible areas should be redrawn. Here is the event:

```
typedef struct _GdkEventVisibility GdkEventVisibility;

struct _GdkEventVisibility
{
  GdkEventType type;
  GdkWindow *window;
  gint8 send_event;
  GdkVisibilityState state;
};
```

state is an enumeration value indicating whether the window was obscured or unobscured.

Property Events

X associates *properties* with windows. These are basically key-value pairs used for interclient communication; most commonly, they relay some information about a toplevel window to the window manager. GTK+ provides a high-level interface for all the important properties, so you should not need to deal with them directly. Property events are sent when a property's value changes.

```
typedef struct _GdkEventProperty GdkEventProperty;

struct _GdkEventProperty
```

```
{
  GdkEventType type;
  GdkWindow *window;
  gint8 send_event;
  GdkAtom atom;
  guint32 time;
  guint state;
};
```

Selection Events

X has a simple cut-and-paste mechanism (typically, you select some text with button 1 and paste with button 2). The current contents of the "clipboard" are called the *selection*. You only need to know about this if you are writing a widget like GtkText or GtkEntry that allows you to cut and paste text. Selection events indicate that the current selection has changed, and look like this:

```

typedef struct _GdkEventSelection GdkEventSelection;

struct _GdkEventSelection
{
  GdkEventType type;
  GdkWindow *window;
  gint8 send_event;
  GdkAtom selection;
  GdkAtom target;
  GdkAtom property;
  guint32 requestor;
  guint32 time;
};
```

Most GTK+ widgets deal with the selection using a higher-level interface, found in gtk/gtkselection.h. If you're interested in writing selection-handling code, have a look at this header.

Client Events

Client events are an arbitrary chunk of data sent from one application to another. However, there are some conventional "messages" that can be sent, mostly defined in the Inter-Client Communication Conventions Manual

(ICCCM). The ICCCM is free with the X Window System distribution from the Open Group. Client events are mostly used for communication between applications and the window manager. (The Xlib event being wrapped is called ClientMessage, so look for ClientMessage in the ICCCM.) An important ClientMessage event is sent from the window manager to applications, asking for windows to be deleted. However, GDK converts these events to a GdkEventAny with type GDK_DELETE, so a GdkEventClient will not be received. Some events involved in drag-and-drop are also ClientMessage events, but GDK translates these to GdkEventDND, so a GdkEventClient will not be received for them either. GdkEventClient will only be received if some other client sends your application an unconventional message GDK and GTK+ are not prepared to understand. Most of the common messages are nicely wrapped in a high-level interface.

Just for reference, here is the event:

```
typedef struct _GdkEventClient GdkEventClient;

struct _GdkEventClient
{
  GdkEventType type;
  GdkWindow *window;
  gint8 send_event;
  GdkAtom message_type;
  gushort data_format;
  union {
    char b[20];
    short s[10];
    long l[5];
  } data;
};
```

The union at the end is used to hold the contents of the message. send_event is always TRUE, since this event is always sent from one client to another and does not come from the X server.

Drag and Drop Events

Drag and drop events are actually pretty useful if you're implementing a drag and drop feature in your application. However, since few applications need to do this and the topic is fairly involved, this books glosses over the topic. GTK+ comes with some documentation on drag and drop and several examples.

```
typedef struct _GdkEventDND GdkEventDND;

struct _GdkEventDND {
  GdkEventType type;
  GdkWindow *window;
  gint8 send_event;
  GdkDragContext *context;

  guint32 time;
  gshort x_root, y_root;
};
```

Proximity Events

Proximity events are generated when using GDK's wrapper for the XInput extension. The XInput extension is an add-on for standard X that allows you to use nonstandard devices such as graphics tablets. A proximity event indicates that the stylus has moved in or out of contact with the tablet, or perhaps that the user's finger has moved in or out of contact with a touch screen. The X distribution comes with some documentation for the XInput extension, and Owen Taylor's gsumi application contains example GDK code.

```
typedef struct _GdkEventProximity GdkEventProximity;

struct _GdkEventProximity
{
  GdkEventType type;
  GdkWindow *window;
  gint8 send_event;
  guint32 time;
  GdkInputSource source;
  guint32 deviceid;
};
```

The Mouse Pointer

The mouse pointer is represented on the screen by a small bitmap called the *cursor*. The cursor is normally an arrow shape, but it can be changed on a window-by-window basis. As the pointer moves, it generates motion events and moves the cursor on the screen to give the user feedback.

Pointer Location

You can query the pointer's location with gdk_window_get_pointer() (Figure 7). This function requests the X and Y coordinates of the pointer relative to the window passed as its first argument. It also requests the currently active modifiers (including modifier keys and buttons; this field is identical to the state field in several events, such as button events). If NULL is passed for the x, y, or state arguments, that argument will be ignored.

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

GdkWindow* gdk_window_get_pointer(GdkWindow* *window*, gint* *x*, gint* *y*, GdkModifierMask* *state*);

Figure 7. Querying Pointer Location

Grabbing the Pointer

It is possible to *grab* the pointer, which means that all pointer events will go to the *grab window* for the duration of the grab. Normally pointer events go to the window the pointer is inside. You should grab the pointer, for example, if the user is using click-and-drag selection to select a rectangular area. If they click and then inadvertently drag the pointer outside the window, you should continue to track the pointer's location and change the selection accordingly. The grab also ensures that pointer events won't be sent to other applications.

To grab the pointer, call gdk_pointer_grab(), shown in Figure 8. The first argument to this function is the grab window; this window will receive events during the grab. The next argument should be TRUE or FALSE; it specifies whether events will go only to the grab window, or to its child windows as well. The confine_to argument specifies a window to confine the pointer to. The user will not be able to move the pointer outside this window. You can specify a different cursor for the duration of the grab; see the next section for details on creating a cursor. If you don't want to change the cursor, give NULL as the cursor argument. (Side note: it is safe to destroy the cursor immediately after calling gdk_pointer_grab()

because it is a server-side resource and X will not deallocate it until the grab is over.)

The final argument, time, specifies when the grab should take effect, in server time. This is intended to resolve conflicts if two clients try to grab the pointer simultaneously; the time must be after the last grab time, and it must not be in the future. Usually, you will want to use the time field from the event you're processing, or the GDK_CURRENT_TIME macro. GDK_CURRENT_TIME is a magic constant that tells the X server to substitute the current time.

gdk_pointer_grab() returns TRUE if it succeeds. It is possible for it to fail if the grab window or confine_to window is hidden, another client has the grab already, or any of the arguments are invalid. Regrettably few applications check this return value, which is a bug (granted, a difficult-to-trigger one).

To ungrab the pointer, call gdk_pointer_ungrab(); the time argument is identical to the one in gdk_pointer_grab(). You can find out if the pointer is grabbed using gdk_pointer_is_grabbed(). You *must* ungrab the pointer when you're finished with it, because the user will be unable to use other applications while the pointer is grabbed.

Note that the GDK-level concept of grabbing the pointer is distinct from the GTK+-level grab concept. A GTK+ grab redirects certain events to a grabbing *widget*, creating a "modal" widget such as a dialog (see the section called *Grabs* in the chapter called *GTK+ Basics*). GTK+'s grab only affects the current application; only events that occur on one of the current application's widgets are redirected. The scope of a GDK grab is wider, encompassing the entire X server, not just your application.

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

gint gdk_pointer_grab(GdkWindow* *window*, gint *owner_events*, GdkWindow* *confine_to*, GdkCursor* *cursor*, guint32 *time*);

void gdk_pointer_ungrab(guint32 *time*);

gint gdk_pointer_is_grabbed(void);

Figure 8. Grabbing the Pointer

Changing the Cursor

You can change the cursor shape at any time; cursor shapes are set on a window-by-window basis with gdk_window_set_cursor() (Figure 9). By default, windows use their parent's cursor; you can restore the default cursor by setting a window's cursor to NULL.

Two ways are provided to create a cursor. The simplest way is to choose a cursor from the cursor font that comes with X. The cursor font contains cursors instead of characters; you can view it with the command xfd -fn cursor. You can also browse the available cursors using the testgtk program that comes with GTK+. Each cursor shape has a constant defined in gdk/gdkcursors.h. gdk_cursor_new() accepts one of these constants as its only argument:

```
GdkCursor* cursor;
cursor = gdk_cursor_new(GDK_CLOCK);
gdk_window_set_cursor(window, cursor);
gdk_cursor_destroy(cursor);
```

Notice that you can destroy the cursor as soon as you attach it to a window; GdkCursor is a client-side handle for a server-side resource, and X will keep the server-side resource around as long as it's in use.

If none of the cursors in the cursor font are appropriate, you can create a custom cursor from a bitmap. Two bitmaps, actually: the source pixmap, and the mask. Since these are bitmaps, every pixel is either on or off (0 or 1). If a pixel is 0 in the mask, that pixel will be transparent. If a pixel is 1 in both pixmaps, it will be displayed in the fg (foreground) color passed to gdk_cursor_new_from_pixmap(). If a pixel is 1 in the mask but 0 in the source pixmap, it will be displayed in the bg (background) color. The source and mask pixmaps must be the same size, and they must have a depth of one.

The foreground and background colors should be contrasting, so the cursor will be visible against any background. Most cursors are drawn in the foreground color and outlined in the background color. (To see this, move an X cursor over a dark background; you will notice a white outline around its edges.) To achieve this, mask should be slightly larger than source, but the same shape.

The final two arguments to gdk_cursor_new_from_pixmap() are the coordinates of the cursor's *hot spot*. This is the point drawn at the mouse pointer's location---the tip of an arrow cursor, or the center of a crosshair cursor. gdk_cursor_new_from_pixmap() will fail if the hot spot is not within the bitmap.

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

GdkCursor* gdk_cursor_new(GdkCursorType *cursor_type*);

GdkCursor* gdk_cursor_new_from_pixmap(GdkPixmap* *source*, GdkPixmap* *mask*, GdkColor* *fg*, GdkColor* *bg*, gint *x*, gint *y*);

void gdk_cursor_destroy(GdkCursor* *cursor*);

void gdk_window_set_cursor(GdkWindow* *window*, GdkCursor* *cursor*);

Figure 9. GdkCursor

Fonts

An X font is (yet another) a server-side resource. In essence, a font is a collection of bitmaps representing characters. The bitmaps in a single font will have a similar size and style. GDK allows you to manipulate fonts with a client-side handle called GdkFont.

To obtain a GdkFont, call gdk_font_load() (or use the font from a preexisting GtkStyle; more on this in the section called *GtkStyle and Themes*). Fonts are loaded by name; font names are a fairly involved topic. Names follow a convention called the "X Logical Font Description," or XLFD. The best way to get a feel for XLFD is to play with the xfontsel program that comes with X. You can also get a list of font names on your X server with the xlsfonts program. The standard X distribution includes a 30-page XLFD manual, but the basics aren't too complicated.

A font name is a string made up of hyphen-separated fields. Each field describes some aspect of the font. For example:

```

-misc-fixed-medium-r-normal--0-0-75-75-c-0-iso8859-1
```

or

```

 -adobe-new century
schoolbook-bold-i-normal--11-80-100-100-p-66-iso8859-1
```

The fourteen fields are:

- Foundry: the vendor who created the font, such as Adobe or Sony. misc is used for some generic fonts that come with X.
- Family: the typeface or style of the font---Courier, Times, Helvetica, etc.
- Weight: Bold, demibold, medium, etc.
- Slant: Italic, Roman, Oblique (abbreviated as i, r, or o
- Set Width: the "proportionate width" of the font; possible values include normal, condensed, semicondensed, etc.
- "Add Style": any additional information about the font can go in this field; it is used to distinguish two fonts that otherwise have the same name. There are no constraints on the string.
- Pixels: the pixel size of the font.
- Points: the point size of the font, in tenths of a point. A point is 1/72 of an inch; the relationship of point size to pixel size is determined by the resolution (dots per inch) the X server thinks the display has. Typically people do not configure their X server to match their monitor, so the X server's idea of the current resolution may be wildly inaccurate.
- Horizontal Resolution: horizontal display resolution in dots per inch (dpi) the font is designed for.
- Vertical Resolution: vertical display resolution the font is designed for.
- Spacing: Monospace (abbreviated m) or proportional (abbreviated p). Indicates whether all characters have the same width or different characters may have different widths.
- Average Width: the mean width of all characters in the font, in tenths of a pixel.
- Character Set Registry: the organization or standard defining the character set.
- Character Set Encoding: specifies the specific character set encoding. These last two fields in combination specify the character set. For European languages iso8859-1 will almost always be used. This is the "Latin-1" character set, which is an 8-bit encoding including ASCII as a subset.

It is not necessary to specify all 14 fields when requesting a font. "Wild cards" are allowed: * matches any number of characters, and ? matches a single character. For example, a 160 point Bold Roman Helvetica font can be requested like this:

```

-*-helvetica-bold-r-*-*-*-160-*-*-*-*-*-*
```

When you pass a font name to gdk_font_load(), you should consider it a default choice only. Users in other countries will certainly want to use a font appropriate to their language; US and European users might want to customize fonts too. Also, there are no fonts guaranteed to exist on all servers. Thus you should provide a way to customize any fonts you use. The easiest way is to use fonts from a widget's GtkStyle (again, see the section called *GtkStyle and Themes*).

gdk_font_load() returns NULL if it fails to find a font matching the supplied name. When you are done with a font, you should release it by calling gdk_font_unref(). Figure 10 summarizes these functions.

When loading fonts, you will need to specify at least the font name, the weight, the slant, and a size---otherwise the * wildcards would probably load a random bold italic font, which is unlikely to be what you want. The *Xlib Programming Manual* suggests that you always specify the font size in points, so that users with different monitors will get the right effect; however, X servers do not reliably know the display resolution, so this is more theory than reality. Perhaps it's better to specify pixels, because you do know the pixel size of other elements of your display. Neither is perfect; be sure you make your application's fonts configurable.

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

GdkFont* gdk_font_load(const gchar* *font_name*);

void gdk_font_unref(GdkFont* *font*);

Figure 10. GdkFont

Font Metrics

To use a font, you typically need detailed information about its *metrics*. Font metrics are used to position characters with respect to one another, and to determine the size of strings rendered in the font. The most fundamental metrics are the *ascent* and *descent* of the font. Text is placed on a *baseline*; the baseline is like a rule on a sheet of notebook paper. The bottom of each character touches the baseline. Some characters (such as lowercase "p" and "y") extend below the baseline. A font's *descent* is the maximum distance below the baseline reached by its characters. Its *ascent* is the maximum distance above the baseline. The *height* of a font is the sum of the ascent and the descent. When rendering multiple lines of text, you should leave at least the font's height between each baseline.

Ascent and descent are available as members of the GdkFont struct:

```
typedef struct _GdkFont GdkFont;

struct _GdkFont
{
  GdkFontType type;
  gint ascent;
  gint descent;
};
```

The type field distinguishes fonts from fontsets; fontsets are used to display non-European languages.

Individual characters in a font have their own ascent and descent; a character's ascent and descent will always be less than or equal to the font's ascent and descent. GDK can calculate the sum of the maximum ascent and descent for a particular string, rather than an entire font; this height will be less than or equal to the font's height. The relevant functions are gdk_string_height(), gdk_text_height(), and gdk_char_height(). gdk_text_height() is different from gdk_string_height() because it accepts the length of the string as an argument; gdk_string_height() calls strlen() for you. Thus gdk_text_height() is preferred if you already know a string's length.

In addition to its vertical metrics, each character in a font has three metrics describing its horizontal dimensions. The *width* of a character is the distance from the left origin of the character to the start of the next character. Note: the width is *not* the distance to the furthest-right pixel in a character; in some fonts, especially italic fonts, characters may lean over past the start of the next character. The *left-side-bearing* or *lbearing* is the distance from the left origin to the leftmost pixel in the character; the *right-side-bearing* or *rbearing* is the distance from the origin to the rightmost pixel in the character. Thus the *rbearing* can be larger than the width, in the case of italic fonts that lean over past the start of the next character.

GDK functions that return a character or string width return the width of the character, or the sum of the character widths in the string. If the rbearing of the rightmost character is greater than its width, a string may require more space than gdk_string_width(), gdk_text_width(), or gdk_char_width() will return. Like the height-measurement functions, the _string_ variant computes the length of the string for you, and the _text_ variant accepts a precomputed length as an argument.

The functions ending in _measure are more often what you want. For a string with *N* characters, these return the sum of the widths of the first *N-1* characters, plus the rbearing of the final character. That is, they take into account the fact that rbearing may be greater than width. If you're trying to decide how much space to leave for rendering a string, you probably want the gdk_string_measure(), gdk_text_measure(), or gdk_char_measure() functions. Sometimes you don't want to consider the rbearing, however; for example, if you're centering a string, it may look nicer to use the width (because a small italic flourish extending past the width won't "fill" the space and the string will look slightly left of center).

gdk_text_extents() and gdk_string_extents() return *all* the metrics for a string, including both bearings, the width, ascent, and descent. The returned left-side-bearing is the leftmost pixel in the string; the right-side-bearing is the rightmost pixel as returned by gdk_text_measure(). The width is the sum of character widths, as returned by gdk_text_width().

Figure 11 depicts the various font metrics. Figure 12 summarizes the API for querying font metrics. All font metrics are computed on the client side, so these functions are not expensive compared to most of the drawing API.

Figure 11. Font Metrics

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

gint gdk_string_width(GdkFont* *font*, const gchar* *string*);

gint gdk_text_width(GdkFont* *font*, const gchar* *string*, gint *string_length*);

gint gdk_char_width(GdkFont* *font*, gchar *character*);

gint gdk_string_measure(GdkFont* *font*, const gchar* *string*);

gint gdk_text_measure(GdkFont* *font*, const gchar* *string*, gint *string_length*);

gint gdk_char_measure(GdkFont* *font*, gchar *character*);

gint gdk_string_height(GdkFont* *font*, const gchar* *string*);

gint gdk_text_height(GdkFont* *font*, const gchar* *string*, gint *string_length*);

gint gdk_char_height(GdkFont* *font*, gchar *character*);

void gdk_string_extents(GdkFont* *font*, const gchar* *string*, gint* *lbearing*, gint* *rbearing*, gint* *width*, gint* *ascent*, gint* *descent*);

void gdk_text_extents(GdkFont* *font*, const gchar* *string*, gint *string_length*, gint* *lbearing*, gint* *rbearing*, gint* *width*, gint* *ascent*, gint* *descent*);

Figure 12. Font Metrics

Graphics Contexts

A *graphics context*, or GC, is simply a set of parameters to be used when drawing (such as color, clip mask, font, and so on). It is a server-side resource, just as pixmaps and windows are. GCs reduce the number of arguments to the GDK drawing functions, and also reduce the number of parameters passed from client to server with each drawing request.

A graphics context can be created with a GdkGCValues struct, analagous to GdkWindowAttr; the struct contains all the interesting features of a graphics context, and you pass gdk_gc_new_with_values() flags indicating which fields are valid. The other fields retain their default value. You can also create an all-default GC with gdk_gc_new() (this is usually easier). Functions are provided to change GC settings after the GC is created as well---but remember that each change requires a message to the X server. These functions are summarized in Figure 16. The attributes of a GC, and the flags used as the final argument to gdk_gc_new_with_values(), are summarized in Table 6.

All GCs are not interchangeable; they are tied to a particular depth and visual. The GC's depth and visual must match the depth and visual of the drawable you are drawing to. A GC's depth and visual are taken from the GdkWindow* argument to gdk_gc_new(), so the easiest way to handle this issue is to create the GC with the window you plan to draw on.

GdkGCValues is a nice summary of a GC's attributes:

```
typedef struct _GdkGCValues GdkGCValues;

struct _GdkGCValues
{
  GdkColor          foreground;
  GdkColor          background;
  GdkFont          *font;
  GdkFunction       function;
  GdkFill           fill;
  GdkPixmap        *tile;
  GdkPixmap        *stipple;
  GdkPixmap        *clip_mask;
  GdkSubwindowMode  subwindow_mode;
  gint              ts_x_origin;
  gint              ts_y_origin;
  gint              clip_x_origin;
  gint              clip_y_origin;
  gint              graphics_exposures;
  gint              line_width;
  GdkLineStyle      line_style;
  GdkCapStyle       cap_style;
  GdkJoinStyle      join_style;
};
```

The foreground color is the "pen color" used to draw lines, circles, and other shapes. The purpose of the background color depends on the particular drawing operation. These colors must be allocated in the current colormap with gdk_color_alloc().

The font field is unused: in Xlib, it specifies the font to use when drawing text. In GDK, it used to have the same purpose; but now the GDK routines for drawing text all require a GdkFont* argument instead. An Xlib graphics context can only store plain fonts, but a GdkFont can also represent a fontset (used to render some foreign languages). GDK should probably store a font field in its GdkGC instead of requiring a font argument to the text-drawing functions, but it doesn't.

The function field specifies how each pixel being drawn is combined with the pixel that already exists in the drawable. There are many possible values, but only two are ever used:

- GDK_COPY is the default. It ignores the existing pixel (just writes the new pixel over it).

- GDK_XOR combines the old and new pixels in an invertable way. That is, if you perform exactly the same GDK_XOR operation twice, the first draw is undone by the second. GDK_XOR is often used for "rubberbanding," since it makes it easy to restore the original contents of the drawable once rubberbanding is complete.

The fill field determines how the tile and stipple fields are used. A tile is a pixmap with the same depth as the destination drawable; it is copied over and over into the destination drawable---the origin of the first tile is (ts_x_origin, ts_y_origin). A stipple is a bitmap (pixmap with depth 1); stipples are also tiled starting at (ts_x_origin, ts_y_origin). Possible fill values are:

- GDK_SOLID means to ignore the tile and stipple. Shapes are drawn in the foreground and background colors.
- GDK_TILED means that shapes are drawn with the tile, instead of the foreground and background colors. Imagine a tiled surface underneath your drawable; drawing in GDK_TILED mode will scratch away the contents of the drawable, revealing the tiled surface underneath.
- GDK_STIPPLED is like GDK_SOLID with a bitmask defined by the stipple. That is, bits not set in the stipple are not drawn.
- GDK_OPAQUE_STIPPLED draws bits set in the stipple with the foreground color, and bits not set in the stipple with the background color.

Some X servers do not implement the more obscure function and fill modes very efficiently. Don't be surprised if using them noticeably slows down drawing.

The optional clip_mask is a bitmap; only bits set in this bitmap will be drawn. The mapping from the clip mask to the drawable is determined by clip_x_origin and clip_y_origin; these define the drawable coordinates corresponding to (0,0) in the clip mask. It is also possible to set a clip rectangle (the most common and useful form of clipping) or a clip region (a region is an arbitrary area on the screen, typically a polygon or list of rectangles). To set a clip rectangle, use gdk_gc_set_clip_rectangle():

```
GdkRectangle clip_rect;
clip_rect.x = 10;
clip_rect.y = 20;
clip_rect.width = 200;
clip_rect.height = 100;
```

```
  gdk_gc_set_clip_rectangle(gc, &clip_rect);
```

To turn off clipping, set the clip rectangle, clip region, or clip mask to NULL.

The subwindow_mode of a GC only matters if the drawable is a window. The default setting is GDK_CLIP_BY_CHILDREN; this means that child windows are not affected by drawing on parent windows. This preserves the illusion that child windows are "on top" of parents, and child windows are opaque. GDK_INCLUDE_INFERIORS will draw right over the top of any child windows, overwriting any graphics the child windows may contain; normally this mode is not used. If you do use GDK_INCLUDE_INFERIORS, you will probably use GDK_XOR as your drawing function, since it allows you to restore the child windows' previous contents.

graphics_exposures is a boolean value which defaults to TRUE; it determines whether gdk_window_copy_area() sometimes generates expose events. the section called *Expose Events* explained this in more detail.

The final four GC values determine how lines are drawn. These values are used for drawing lines, including the borders of unfilled polygons and arcs. The line_width field specifies the width of a line, in pixels. A line width of 0 specifies a "thin line"; thin lines are one-pixel lines that can be drawn very quickly (usually with hardware acceleration), but the exact pixels drawn depend on the X server in use. For consistent results, use a width of 1 instead.

The line_style field can have one of three values:

- GDK_LINE_SOLID is the default; a solid line.
- GDK_LINE_ON_OFF_DASH draws a dashed line with the foreground color, leaving the "off" parts of the dash blank.
- GDK_LINE_DOUBLE_DASH draws a dashed line in the foreground color, but the "off" parts of the dash are drawn in the background color.

Dashes are specified with gdk_gc_set_dashes(); GdkGCValues does not include a field for this. gdk_gc_set_dashes() accepts three arguments:

- dash_list is an array of dash lengths. Even-indexed lengths are "on" dashes; these are drawn in the foreground color. Odd-indexed lengths are "off" dashes; they are not drawn or drawn in the background color, depending on line_style. 0 is not a permitted value; all lengths must be positive.

- dash_offset is the index of the first pixel to use in the dash list. That is, if the dash list specifies 5 pixels "on" and 5 "off", and the offset is 3, the line will begin in the middle of the "on" dash.
- n is simply the number of elements in dash_list.

You might set a whimsical dash pattern this way, for example:

```
gchar dash_list[] = { 5, 5, 3, 3, 1, 1, 3, 3 };
gdk_gc_set_dashes(gc, 0, dash_list, sizeof(dash_list));
```

The default dash list is {4, 4} with an offset of 0.

Figure 13 shows some dashed lines drawn with GDK_LINE_DOUBLE_DASH. The graphics context's foreground color is black, and its background color is a light gray. The first five lines are the default {4, 4} dash pattern with offsets of 0, 1, 2, 3, and 4. Remember that 0 is the default. Figure 14 shows a magnified view of these five lines. The last line is the whimsical dash pattern mentioned above; it's shown magnified in Figure 15.

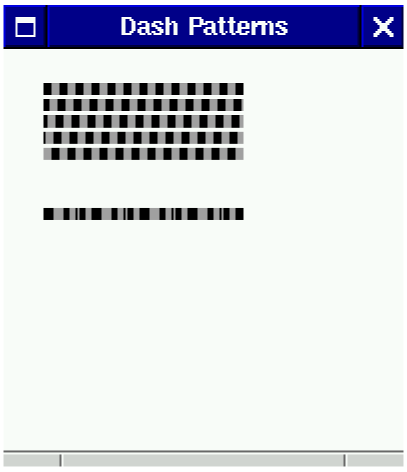


Figure 13. Five dashed lines, with GDK_LINE_DOUBLE_DASH

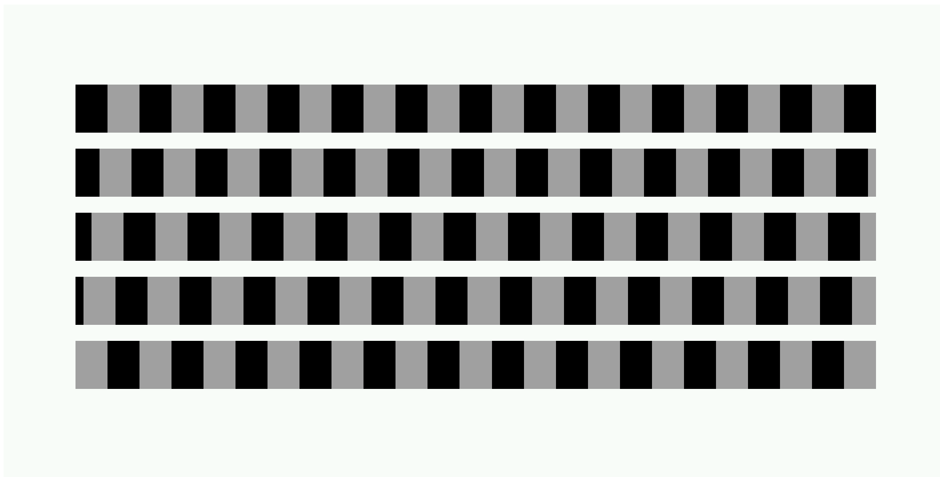


Figure 14. Default dash pattern, with varied offsets

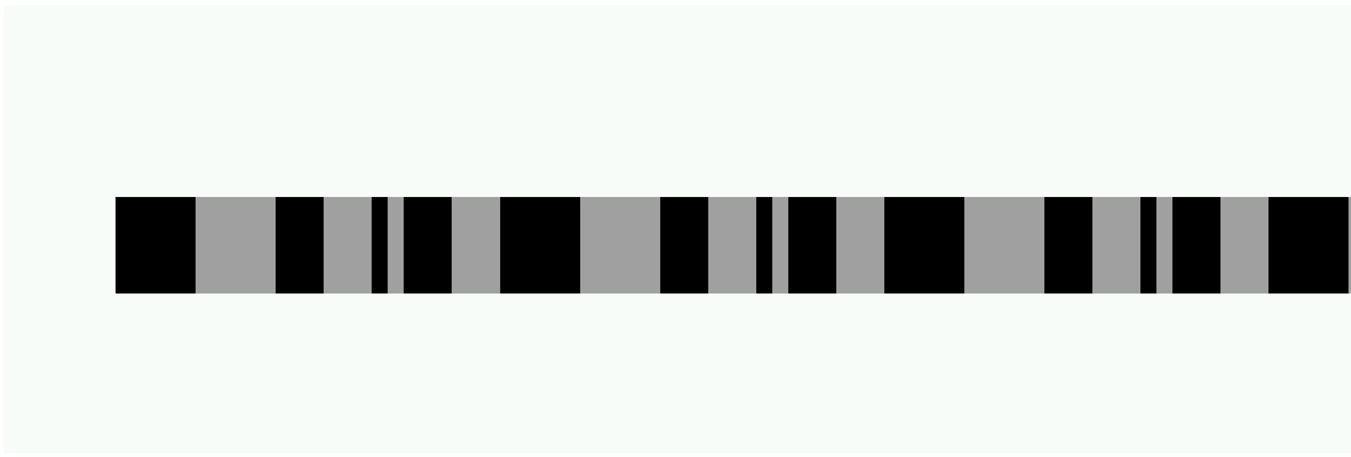


Figure 15. A complex dash pattern

cap_style determines how X draws line endpoints (or dash endpoints, if a line is dashed). It has four possible values:

- GDK_CAP_BUTT is the default; it means that lines have square ends (as you might expect).
- GDK_CAP_NOT_LAST specifies that the last pixel is skipped for one-pixel lines. It is otherwise the same as GDK_CAP_BUTT.
- GDK_CAP_ROUND draws a small arc on the end of the line, extending beyond the line's endpoint. The center of the arc is on the endpoint, and the radius of the arc is one-half the width of the line. For one-pixel lines, it has no effect (since there is no way to draw a one-pixel-wide arc).
- GDK_CAP_PROJECTING extends the line past its endpoint by one-half its width. It has no effect on one-pixel lines.

The join_style parameter affects how lines are connected to one another, when drawing a polygon or drawing multiple lines in one function call. If you think of lines as long, thin rectangles, it is clear that they do not connect smoothly; there is a "notch" where the two endpoints come together. The three join styles fill in this notch:

- GDK_JOIN_MITER is the default; it draws a sharp angle where the lines intersect.
- GDK_JOIN_ROUND creates rounded corners by drawing an arc in the notch.
- GDK_JOIN_BEVEL creates a flat corner, filling the notch with the smallest possible shape.

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

```
GdkGC* gdk_gc_new(GdkWindow* window);

GdkGC* gdk_gc_new_with_values(GdkWindow* window, GdkGCValues* values,
GdkGCValuesMask values_mask);

void gdk_gc_set_dashes(GdkGC* gc, gint dash_offset, gchar dash_list,
gint n);

void gdk_gc_unref(GdkGC* gc);
```

Figure 16. GdkGC

Table 6. GC Attributes

Attribute	GdkGCValuesMask	Modifying Function	Default Value
GdkColor foreground	GDK_GC_FOREGROUND	gdk_gc_set_foreground()	black
GdkColor background	GDK_GC_BACKGROUND	gdk_gc_set_background()	white
GdkFont *font	GDK_GC_FONT	gdk_gc_set_font	depends on X se
GdkFunction function	GDK_GC_FUNCTION	gdk_gc_set_function()	GDK_COPY
GdkFill fill	GDK_GC_FILL	gdk_gc_set_fill()	GDK_SOLID
GdkPixmap *tile	GDK_GC_TILE	gdk_gc_set_tile()	pixmap filled w foreground colo (i.e. effective

			none)
GdkPixmap *stipple	GDK_GC_STIPPLE	gdk_gc_set_stipple()	all-bits-on bi (i.e. effectiv none)
GdkPixmap *clip_mask	GDK_GC_CLIP_MASK	gdk_gc_set_clip_mask()	none
GdkSubwindowMode subwindow_mode	GDK_GC_SUBWINDOW	gdk_gc_set_subwindow()	GDK_CLIP_BY_CH
gint ts_x_origin	GDK_GC_TS_X_ORIGIN	gdk_gc_set_ts_origin()	0
gint ts_y_origin	GDK_GC_TS_Y_ORIGIN	gdk_gc_set_ts_origin()	0
gint clip_x_origin	GDK_GC_CLIP_X_ORIGIN	gdk_gc_set_clip_origin()	0
gint clip_y_origin	GDK_GC_CLIP_Y_ORIGIN	gdk_gc_set_clip_origin()	0
gint graphics_exposures	GDK_GC_EXPOSURES	gdk_gc_set_exposures()	TRUE
gint line_width	GDK_GC_LINE_WIDTH	gdk_gc_set_line_attributes()	0
GdkLineStyle line_style	GDK_GC_LINE_STYLE	gdk_gc_set_line_attributes()	GDK_LINE_SOLID
GdkCapStyle cap_style	GDK_GC_CAP_STYLE	gdk_gc_set_line_attributes()	GDK_CAP_BUTT
GdkJoinStyle join_style	GDK_GC_JOIN_STYLE	gdk_gc_set_line_attributes()	GDK_JOIN_MITER
gchar dash_list[]	none	gdk_gc_set_dashes()	{4, 4}
gint dash_offset	none	gdk_gc_set_dashes()	0

Drawing

Once you understand drawables, colors, visuals, graphics contexts, and fonts, actually drawing is very simple. This section is a quick summary of the GDK drawing routines. Remember that drawing is a server-side operation; for example, if you ask to draw a line, Xlib will send the line's endpoints to the server, and the server will do the actual drawing using the specified GC (the GC is also a server-side resource). Often this is an important performance consideration.

Points

You can draw a single point with gdk_draw_point(), or multiple points with gdk_draw_points() (Figure 17). The point is drawn in the current foreground color. Multiple points are given as an array. A GdkPoint looks like this:

```
typedef struct _GdkPoint GdkPoint;

struct _GdkPoint
{
  gint16 x;
  gint16 y;
};
```

Remember that X coordinates start in the top left corner, are relative to the drawable, and may not overflow a signed sixteen-bit integer.

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

void gdk_draw_point(GdkDrawable* *drawable*, GdkGC* *gc*, gint *x*, gint *y*);

void gdk_draw_points(GdkDrawable* *drawable*, GdkGC* *gc*, GdkPoint* *points*, gint *npoints*);

Figure 17. Drawing Points

Lines

To draw a single line, pass its endpoints as arguments to gdk_draw_line() (Figure 18). To draw connected lines, you pass a list of points to gdk_draw_lines(); GDK will "connect the dots." To draw multiple lines that aren't necessarily connected, pass a list of segments to gdk_draw_segments(); a GdkSegment is:

```
typedef struct _GdkSegment GdkSegment;

struct _GdkSegment
{
  gint16 x1;
  gint16 y1;
  gint16 x2;
  gint16 y2;
};
```

If lines or segments drawn in the same request meet at their endpoints, they are joined with the join style from the GC.

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

void gdk_draw_line(GdkDrawable* *drawable*, GdkGC* *gc*, gint *x1*, gint *y1*, gint *x2*, gint *y2*);

void gdk_draw_lines(GdkDrawable* *drawable*, GdkGC* *gc*, GdkPoint* *points*, gint *npoints*);

void gdk_draw_segments(GdkDrawable* *drawable*, GdkGC* *gc*, GdkSegment* *segments*, gint *nsegments*);

Figure 18. Drawing Lines

Rectangles

Rectangles are drawn with gdk_draw_rectangle() (Figure 19). The filled argument indicates whether to fill the rectangle; TRUE means to fill it.

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

void gdk_draw_rectangle(GdkDrawable* *drawable*, GdkGC* *gc*, gint *filled*, gint *x*, gint *y*, gint *width*, gint *height*);

Figure 19. Drawing Rectangles

Arcs

gdk_draw_arc() draws an ellipse or a portion of one. (Figure 20). The arc can be filled or unfilled; the third argument to the function toggles fill. The fourth through seventh arguments describe a rectangle; the ellipse is inscribed in this rectangle. angle1 is the angle at which to start drawing; it is relative to the 3 o'clock position (that is, 0 radians). angle2 is the distance to travel around the arc; if positive, travel is counterclockwise, otherwise travel is clockwise. Both angle1 and angle2 are specified in sixty-fourths of a degree; so, 360 degrees is given as

360*64. This allows more precise specification of the arc's size and shape, without using floating point numbers. angle2 should not exceed 360 degrees, since it is nonsensical to move more than 360 degrees around the ellipse.

To draw a circle, draw from 0 to 360*64 inside a square:

```
gdk_draw_arc(drawable, gc, TRUE,
             0, 0,
             50, 50,
             0, 360*64);
```

To draw half an ellipse, change the aspect ratio and halve the span of the arc:

```
gdk_draw_arc(drawable, gc, TRUE,
             0, 0,
             100, 50,
             0, 180*64);
```

Many X servers draw the edges of filled arcs in an aesthetically unpleasing way; in particular, very small circles may not look very circular. You can work around this by also drawing the circle's outline.

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

void gdk_draw_arc(GdkDrawable* *drawable*, GdkGC* *gc*, gint *filled*, gint *x*, gint *y*, gint *width*, gint *height*, gint *angle1*, gint *angle2*);

Figure 20. Drawing Arcs

Polygons

gdk_draw_polygon() draws a filled or unfilled polygon (Figure 21). Notice that gdk_draw_lines() can also be used to draw an unfilled polygon (there is no reason to prefer one or the other). The arguments to gdk_draw_polygon() are the same as those to gdk_draw_lines(). The polygon does not have to be convex. It may also be self-intersecting. Self-intersecting polygons are filled with an "Even-Odd Rule," which means regions with an odd number of polygon areas overlapping them are not filled. That is, if the polygon does not overlap itself, it is entirely filled; if a region is overlapped once, it is not filled; if it's overlapped twice, it is filled; and so on.

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

void gdk_draw_polygon(GdkDrawable* *drawable*, GdkGC* *gc*, gint *filled*, GdkPoint* *points*, gint *npoints*);

Figure 21. Drawing Polygons

Text

There are two functions to draw strings; as an optimization, gdk_draw_text() takes the length of the string to draw as an argument. gdk_draw_string() uses strlen() to compute the string length for you. Otherwise the two are identical. The x and y coordinates specify the location of the left side of the text's baseline. See the section called *Fonts* for more information on fonts and font metrics. Text is drawn in the foreground color.

There is no way to draw scaled or rotated text with GDK. GnomeCanvasText offers a slow and low-quality way to render scaled and rotated text (see the section called *Text Item* in the chapter called *GnomeCanvas*). If you need high-quality scaling and rotating, you will need to use additional libraries, such as t1lib for Type 1 fonts or FreeType for True Type fonts. Another possibility is the Display Postscript extension to X (XDPS); the GNU Project is working on a free implementation of XDPS. The Gnome project also has a text solution in development, as part of the gnome-print library.

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

void gdk_draw_string(GdkDrawable* *drawable*, GdkFont* *font*, GdkGC* *gc*, gint *x*, gint *y*, const gchar* *text*);

void gdk_draw_text(GdkDrawable* *drawable*, GdkFont* *font*, GdkGC* *gc*, gint *x*, gint *y*, const gchar* *text*, gint *text_length*);

Figure 22. Drawing Text

Pixmaps

gdk_draw_pixmap() copies a region from a pixmap to another drawable (pixmap or window). The source and destination drawables must have the same depth and visual. If you pass -1 for the width or height, the full size of the source pixmap is substituted. The source can actually be any drawable, including a window, but gdk_window_copy_area() will make your code clearer if the source is a window. Figure 23 shows gdk_draw_pixmap().

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

void gdk_draw_pixmap(GdkDrawable* *drawable*, GdkGC* *gc*, GdkDrawable* *src*, gint *xsrc*, gint *ysrc*, gint *xdest*, gint *ydest*, gint *width*, gint *height*);

Figure 23. Drawing Pixmaps

RGB Buffers

GDK's GdkRGB module allows you to copy a client-side buffer of image data to a drawable. If you need to manipulate images extensively, or copy image data to the server, this is the correct way to do it. You can't directly manipulate a GdkPixmap because a pixmap is a server-side object. Copying image data to the server with gdk_draw_point() would be unbelievably slow, since each point would require a server request (probably more than one, since you will need to change the GC for each point).

Internally, GdkRGB uses an object called GdkImage to rapidly copy image data to the server in a single request. This is still somewhat slow---sizeable data does have to be copied---but GdkRGB is highly tuned and uses shared memory if the client and server happen to be on the same machine. So it's the fastest way to perform this task, given the X architecture. It will also handle some tricky issues for you (such as adapting to the colormaps and visuals available on a given X server).

The GdkRGB functions are in a separate header, gdk/gdkrgb.h. Before using any GdkRGB functions, you must initialize the module with gdk_rgb_init() (Figure 24); this sets up the visual and colormap GdkRGB will use, and some internal data structures.

The drawable you intend to copy the RGB buffer to must use GdkRGB's visual and colormap. If the drawable is a part of a widget, the easiest way to ensure this is to push the GdkRGB visual and colormap when you create the widget:

```
GtkWidget* widget;
gtk_widget_push_visual(gdk_rgb_get_visual());
gtk_widget_push_colormap(gdk_rgb_get_cmap());
widget = gtk_whatever_new();
gtk_widget_pop_visual();
gtk_widget_pop_colormap();
```

The current version of GTK+ will be better-behaved if you do this when creating the toplevel window containing the drawable, instead of when creating the drawable itself. However, in principle you can do it for only the drawable.

GdkRGB understands several kinds of image data, including 24- and 32-bit RGB data, 8-bit grayscale, and 8-bit indexes into an array of RGB values (a client-side GdkRgbCmap). This section describes only the simplest, 24-bit RGB data; this kind of buffer is rendered with gdk_draw_rgb_image(). There are separate functions to render the other buffer types, but all of them work in essentially the same way.

A 24-bit RGB buffer is a one-dimensional array of bytes; every byte triplet makes up a pixel (byte 0 is red, byte 1 is green, byte 2 is blue). Three numbers describe the size of the array and the location of bytes within it:

- The *width* is the number of pixels (byte triplets) per row of the image.
- The *height* is the number of rows in the image.
- The *rowstride* is the number of bytes between rows. That is, for a buffer with rowstride *r*, if row *n* starts at array index *i* row *n+1* starts at array index *i+r*. The rowstride is not necessarily three times the buffer's width; GdkRGB is faster if both the source pointer and the rowstride are aligned to a 4-byte boundary. Specifying a rowstride allows you to use padding to achieve this.

The x, y, width, and height arguments to gdk_rgb_draw_image() define a region of the target drawable to copy the RGB buffer to. The RGB buffer must have at least width columns and height rows. Row 0, column 0 of the RGB buffer will be copied to point (x, y) on the drawable.

Dithering simulates a larger number of colors on displays with a limited palette. Dithering only matters on 8- and 16-bit displays; 24-bit displays do not have a limited palette. The dither argument is an enumerated type; it has three possible values:

- GDK_RGB_DITHER_NONE specifies that no dithering will be done. It's appropriate for text or line drawings with few colors, but inappropriate for photographic images.
- GDK_RGB_DITHER_NORMAL specifies dithering on 8-bit displays, but not 16-bit displays. This is usually the best quality/performance tradeoff.
- GDK_RGB_DITHER_MAX specifies that dithering will always be done on 8- and 16-bit displays. The quality gain on 16-bit displays is probably not worth the speed penalty.

The gc argument to gdk_draw_rgb_image() is simply passed through to gdk_draw_image() (recall that GdkRGB uses GdkImage internally). The gc components that make sense are used (such as the clip mask, drawing function, and subwindow mode).

```
#include <gdk/gdkrgb.h>
```

void gdk_rgb_init(void);

GdkColormap* gdk_rgb_get_cmap(void);

GdkVisual* gdk_rgb_get_visual(void);

void gdk_draw_rgb_image(GdkDrawable* *drawable*, GdkGC* *gc*, gint *x*, gint *y*, gint *width*, gint *height*, GdkRGBDither *dither*, guchar* *rgb_buf*, gint *rowstride*);

Figure 24. GdkRGB

GDK Resource Management

GDK objects have either reference counting or destruction, but not both. Pixmaps, fonts, graphics contexts, and colormaps are purely reference counted. (gdk_gc_destroy() exists but is deprecated --- it's just a wrapper for gdk_gc_unref().) In general, reference counting is analagous to GtkObject reference counting. That is, objects start with a reference count of one; when the reference count reaches 0 then the object is destroyed.

Cursors and images are not reference counted; they simply have a destroy function. Some types represent static objects that are never destroyed; GdkVisual is the main example.

GdkWindow is the strange case; it's reference counted, but gdk_window_destroy() *must* be called at some point. The reference counting applies to the client-side GdkWindow handle; gdk_window_destroy() applies to the actual server-side object. See the section called *GdkWindow* for an explanation of the distinction. gdk_window_destroy() unreferences the client-side handle after it destroys the server-side object. It's safe to call any of the GdkWindow functions on a destroyed window that still has a reference count greater than zero; they will all return immediately without taking any action.

In practice this means that one section of code should "own" the GdkWindow; it will create the window, and hold the initial reference (remember that objects are created with a reference count of one). It will also call gdk_window_destroy() eventually, destroying the server-side object and removing the initial reference count. If no other code increases the count, the client-side handle will be freed. If some other code has increased the reference count with gdk_window_ref(), the client-side handle will remain safe to use but attempts to use it will have no effect. When the reference count is eventually decremented to zero, the client-side handle will be freed.

In GTK+, windows are generally created and destroyed by the same widget; if other widgets want to draw on the window, they increase the window's reference count.

GtkStyle and Themes

GtkStyle is not part of GDK, but it is an important abstraction layer between GTK+ and GDK that allows users to customize how widgets are rendered. Instead of drawing with GDK directly, widgets should prefer GDK resources from a GtkStyle, and special drawing functions provided in gtk/gtkstyle.h. Often there is no appropriate function, but when there is it should be used.

A GtkStyle stores GDK resources to be used when drawing widgets. Styles allow widgets to share these resources, reducing overhead; they also permit users to customize GTK+'s appearance. Here is the GtkStyle struct:

```
typedef struct _GtkStyle GtkStyle;

struct _GtkStyle
{
  GtkStyleClass *klass;
  GdkColor fg[5];
  GdkColor bg[5];
  GdkColor light[5];
  GdkColor dark[5];
  GdkColor mid[5];
  GdkColor text[5];
  GdkColor base[5];

  GdkColor black;
  GdkColor white;
  GdkFont *font;

  GdkGC *fg_gc[5];
  GdkGC *bg_gc[5];
  GdkGC *light_gc[5];
  GdkGC *dark_gc[5];
  GdkGC *mid_gc[5];
  GdkGC *text_gc[5];
  GdkGC *base_gc[5];
  GdkGC *black_gc;
  GdkGC *white_gc;

  GdkPixmap *bg_pixmap[5];

  /* private */

  gint ref_count;
  gint attach_count;

  gint depth;
  GdkColormap *colormap;

  GtkThemeEngine *engine;

  gpointer        engine_data;

  GtkRcStyle     *rc_style;

  GSList         *styles;
};
```

The private fields should be ignored. The public fields contain GDK resources for widget rendering. The first group of fields contains arrays of colors; these arrays are indexed by the widget state enumeration (GTK_STATE_ACTIVE, etc.). A widget might use widget->style->fg[GTK_STATE_NORMAL] to render text, for example. Each widget has an associated style, stored in the style field of GtkWidget.

Widgets should use the font stored in their associated GtkStyle; they should use the style's graphics contexts when drawing in the style's colors.

GtkStyle also contains a virtual table, GtkStyleClass, which can be implemented by a dynamically-loaded theme engine. The virtual table is quite large, so it isn't reproduced here. Have a look at gtk/gtkstyle.h.

gtk/gtkstyle.h contains drawing functions that use a style's virtual table to draw various GUI elements. There are two variants of each drawing function. One variant, prefixed with gtk_draw_, renders to any drawable; the other variant, prefixed with gtk_paint_, renders part of a widget. For example, gtk_draw_shadow() looks like this:

```
void gtk_draw_shadow  (GtkStyle      *style,
                       GdkWindow     *window,
                       GtkStateType   state_type,
                       GtkShadowType  shadow_type,
                       gint           x,
                       gint           y,
                       gint           width,
                       gint           height);
```

While gtk_paint_shadow() adds area, widget, and detail arguments:

```
void gtk_paint_shadow  (GtkStyle     *style,
                        GdkWindow    *window,
                        GtkStateType  state_type,
                        GtkShadowType shadow_type,
                        GdkRectangle  *area,
                        GtkWidget     *widget,
                        gchar         *detail,
                        gint           x,
                        gint           y,
                        gint           width,
                        gint           height);
```

Each of these corresponds to the draw_shadow member in GtkStyleClass.

All gtk_paint_ functions add the same three arguments to their gtk_draw_ counterparts; the area argument is a clipping rectangle, the widget argument is the widget being drawn to, and the detail argument is a hint used by theme engines. Here's a call to gtk_paint_shadow() from the GtkEntry source code, for example:

```
gtk_paint_shadow (widget->style, widget->window,
                  GTK_STATE_NORMAL, GTK_SHADOW_IN,
                  NULL, widget, "entry",
                  x, y, width, height);
```

Here the area argument is NULL, specifying that no clipping should be used.

Because there are a couple dozen functions in GtkStyleClass, and there are numerous examples in the GTK+ source code, this book won't describe them in detail. When writing your own widgets, simply locate a GTK+ widget that draws a similar graphical element, and use the same gtk_paint_ function it uses.

Writing a GtkWidget

Table of Contents

This chapter describes how to write a new GtkWidget. A widget is any GtkObject that derives from GtkWidget; before reading this chapter, you should be familiar with the chapter called *The GTK+ Object and Type System*. This chapter will discuss the details of GtkWidget, but will not re-explain GtkObject in general. You will also need to know something about GDK to write a widget; be sure to skim the chapter called *GDK Basics* if you haven't.

Widgets are easy to create; you only need to cut-and-paste the usual GtkObject boilerplate (instance and class initializers, a get_type()

function, and so on), and then implement your widget's functionality. Writing new widgets is an important application development technique.

After a brief overview, this chapter jumps straight to the implementation of a very simple widget called GtkEv. Then it takes a step back, describing widget implementation more systematically. It ends with more examples, taken from GTK+ itself. (It pays to become familiar with the GTK+ source code: often the easiest way to implement a widget is to subclass or slightly modify the most similar stock GTK+ widget. Of course, you must comply with the terms of GTK+'s license if you cut-and-paste code from the library.)

Overview

This section gives a brief overview, including the different kinds of widget you might encounter, and the general functionality a GtkWidget is required to have.

Kinds of Widget

The term "widget" is really very broad, since it encompasses any object that implements the GtkWidget interface. There are many ways to classify widgets:

- *Containers* are widgets that store other widgets inside, such as the boxes and tables described in the chapter called *GTK+ Basics*. As the chapter called *GTK+ Basics* discussed, containers can be subdivided into those that add functionality to a single child (GtkButton, GtkFrame, GtkEventBox, etc.), and those that manage layout for multiple children (GtkBox, GtkTable, etc.). Container widgets are harder to implement than "plain" widgets because the GtkContainer interface must be implemented in addition to the GtkWidget interface.
- *Composite* widgets are containers that already contain a useful collection of child widgets in a nice package. For example, the GtkFileSelection widget is a subclass of GtkWindow that already contains a list widget to show files, dialog buttons, and so on. Widgets like this are easy to write, and are a convenient way to code applications. You could write a "MainWindow" widget for your main application window, for example, and then create a new instance of the widget whenever the user opens a new document. GnomeApp and GnomeDialog are two important composite widgets in Gnome.

- Non-container widgets can be actual controls (buttons, scroll bars, etc.), information displays (GtkLabel), or decorative flourishes (GtkSeparator, for example). As the chapter called *GTK+ Basics* briefly mentioned, there are two major ways to implement widgets: most widgets (those that need to receive events or draw their own background) have an associated GdkWindow; "no window" widgets draw on their parent container. Widgets without windows are implemented slightly differently. All containers have a GdkWindow (since widgets without one might need to draw on it, among other reasons).

This chapter presents several widgets as examples, including a GtkEv widget written especially for this book, GtkVBox from GTK+, and GnomeAppBar from libgnomeui.

What a Widget Does

A minimal widget implements the following (though GtkWidget's default implementation may be sufficient in many cases):

- Creation and destruction; this means the usual GtkObject boilerplate (instance and class initializers, shutdown, destroy and finalize methods). See the chapter called *The GTK+ Object and Type System*, especially the section called *Object and Class Structures* in the chapter called *The GTK+ Object and Type System* and the section called *Object Finalization* in the chapter called *The GTK+ Object and Type System*. Also see the section called *Widget Life Cycle* in the chapter called *GTK+ Basics*.
- The realize/map/unmap/unrealize cycle discussed in the section called *Realizing, Mapping, and Showing* in the chapter called *GTK+ Basics*. Widgets must be able to create and uncreate their associated X resources any number of times, and they must be able to show and hide themselves any number of times.
- Geometry negotiation, discussed in the section called *Size Allocation* in the chapter called *GTK+ Basics*. Your widget must respond to size requests, and honor size allocations.
- Drawing; widgets must be able to draw themselves on the screen. For container widgets, the widget itself may be invisible but it must ensure child widgets are drawn.
- The widget's unique functionality. Typically this means implementing handlers for some of the widget's event signals.

The `GtkWidget` Base Class

Obviously, to subclass GtkWidget, you will have to be familiar with the base class. This section offers a brief tour of the GtkWidget class and instance structs, and some important GTK+ routines that aren't very common in everyday programming.

The `GtkWidget` Instance Struct

A GtkWidget instance looks like this:

```
typedef struct _GtkWidget GtkWidget;

struct _GtkWidget
{
  GtkObject object;

  guint16 private_flags;

  guint8 state;

  guint8 saved_state;

  gchar *name;

  GtkStyle *style;

  GtkRequisition requisition;

  GtkAllocation allocation;

  GdkWindow *window;

  GtkWidget *parent;
};
```

The private_flags, state, and saved_state fields should all be accessed with macros, if at all. Some of these macros will come up as we discuss widget implementations. The state field stores the widget's state as described in the section called *Widget States* in the chapter called *GTK+ Basics*. saved_state is used to save the widget's previous state when the current state is GTK_STATE_INSENSITIVE; when the widget is re-sensitized, its original state is restored. As the section called *Widget States* in the chapter called *GTK+ Basics* explains, the current state can be accessed with the GTK_WIDGET_STATE() macro.

The name of a widget is used in a gtkrc file to group widgets together for customization purposes. By default, the name of a widget is the type name registered with the object system (in GTK+, this type name is always the name of the instance struct, such as "GtkLabel"). Particular widgets can be given a different name with gtk_widget_set_name(); for example, if you want a particular label to appear in a different font, you can give it a name like "FunkyFontLabel" and then specify a different font for that name in a gtkrc shipped with your application.

The requisition and allocation fields store the last requested and allocated size of the widget, respectively. the section called *Size Negotiation* will have more to say about this.

The window field stores the widget's GdkWindow, or the widget's parent's GdkWindow if the widget has none. The parent field is a pointer to the widget's parent container; it will be NULL if the widget is not inside a container.

The `GtkWidget` Class Struct

There are a truly huge number of class functions in GtkWidgetClass. Thankfully, in most cases you only have to override a few of them. Here is the code:

```

typedef struct _GtkWidgetClass GtkWidgetClass;

struct _GtkWidgetClass
{
  GtkObjectClass parent_class;

  guint activate_signal;

  guint set_scroll_adjustments_signal;

  /* Basics */
  void (* show)                (GtkWidget      *widget);
  void (* show_all)            (GtkWidget      *widget);
  void (* hide)                (GtkWidget      *widget);
  void (* hide_all)            (GtkWidget      *widget);
  void (* map)                 (GtkWidget      *widget);
  void (* unmap)               (GtkWidget      *widget);
  void (* realize)             (GtkWidget      *widget);
  void (* unrealize)           (GtkWidget      *widget);
  void (* draw)                (GtkWidget      *widget,
                                GdkRectangle   *area);
  void (* draw_focus)          (GtkWidget      *widget);
  void (* draw_default)        (GtkWidget      *widget);
  void (* size_request)        (GtkWidget      *widget,
                                GtkRequisition *requisition);
  void (* size_allocate)       (GtkWidget      *widget,
                                GtkAllocation  *allocation);
  void (* state_changed)       (GtkWidget      *widget,
                                GtkStateType    previous_state);
  void (* parent_set)          (GtkWidget      *widget,
                                GtkWidget      *previous_parent);
  void (* style_set)           (GtkWidget      *widget,
                                GtkStyle       *previous_style);

  /* Accelerators */
  gint (* add_accelerator)     (GtkWidget      *widget,
                                guint           accel_signal_id,
                                GtkAccelGroup  *accel_group,
                                guint           accel_key,
                                GdkModifierType accel_mods,
                                GtkAccelFlags   accel_flags);
  void (* remove_accelerator)  (GtkWidget      *widget,
                                GtkAccelGroup  *accel_group,
                                guint           accel_key,
                                GdkModifierType accel_mods);

  /* Explicit focus */
  void (* grab_focus)          (GtkWidget      *widget);

  /* Events */
  gint (* event)                   (GtkWidget          *widget,
                                    GdkEvent           *event);
  gint (* button_press_event)      (GtkWidget          *widget,
                                    GdkEventButton     *event);
  gint (* button_release_event)    (GtkWidget          *widget,
                                    GdkEventButton     *event);
  gint (* motion_notify_event)     (GtkWidget          *widget,
                                    GdkEventMotion     *event);
  gint (* delete_event)            (GtkWidget          *widget,
                                    GdkEventAny        *event);
```

```
gint (* destroy_event)          (GtkWidget          *widget,
                                 GdkEventAny        *event);
gint (* expose_event)           (GtkWidget          *widget,
                                 GdkEventExpose     *event);
gint (* key_press_event)        (GtkWidget          *widget,
                                 GdkEventKey        *event);
gint (* key_release_event)      (GtkWidget          *widget,
                                 GdkEventKey        *event);
gint (* enter_notify_event)     (GtkWidget          *widget,
                                 GdkEventCrossing   *event);
gint (* leave_notify_event)     (GtkWidget          *widget,
                                 GdkEventCrossing   *event);
gint (* configure_event)        (GtkWidget          *widget,
                                 GdkEventConfigure  *event);
gint (* focus_in_event)         (GtkWidget          *widget,
                                 GdkEventFocus      *event);
gint (* focus_out_event)        (GtkWidget          *widget,
                                 GdkEventFocus      *event);
gint (* map_event)              (GtkWidget          *widget,
                                 GdkEventAny        *event);
gint (* unmap_event)            (GtkWidget          *widget,
                                 GdkEventAny        *event);
gint (* property_notify_event)  (GtkWidget          *widget,
                                 GdkEventProperty   *event);
gint (* selection_clear_event)  (GtkWidget          *widget,
                                 GdkEventSelection  *event);
gint (* selection_request_event) (GtkWidget         *widget,
                                 GdkEventSelection  *event);
gint (* selection_notify_event) (GtkWidget          *widget,
                                 GdkEventSelection  *event);
gint (* proximity_in_event)     (GtkWidget          *widget,
                                 GdkEventProximity  *event);
gint (* proximity_out_event)    (GtkWidget          *widget,
                                 GdkEventProximity  *event);
gint (* visibility_notify_event)  (GtkWidget        *widget,
                                  GdkEventVisibility *event);
gint (* client_event)           (GtkWidget          *widget,
                                 GdkEventClient     *event);
gint (* no_expose_event)        (GtkWidget          *widget,
                                 GdkEventAny        *event);

/* Selection */
void (* selection_get)          (GtkWidget          *widget,
                                 GtkSelectionData
*selection_data,
                                    guint               info,
                                    guint               time);
  void (* selection_received)      (GtkWidget          *widget,
                                    GtkSelectionData
*selection_data,
                                    guint               time);

  /* Source side drag signals */
  void (* drag_begin)              (GtkWidget          *widget,
                                    GdkDragContext     *context);
  void (* drag_end)                (GtkWidget          *widget,
                                    GdkDragContext     *context);
  void (* drag_data_get)           (GtkWidget          *widget,
                                    GdkDragContext     *context,
                                    GtkSelectionData
*selection_data,
                                    guint               info,
                                    guint               time);
  void (* drag_data_delete)        (GtkWidget          *widget,
                                    GdkDragContext     *context);

  /* Target side drag signals */
  void (* drag_leave)              (GtkWidget          *widget,
                                    GdkDragContext     *context,
                                    guint               time);
  gboolean (* drag_motion)         (GtkWidget          *widget,
                                    GdkDragContext     *context,
                                    gint                x,
                                    gint                y,
                                    guint               time);
  gboolean (* drag_drop)           (GtkWidget          *widget,
                                    GdkDragContext     *context,
                                    gint                x,
                                    gint                y,
                                    guint               time);
  void (* drag_data_received)      (GtkWidget          *widget,
                                    GdkDragContext     *context,
                                    gint                x,
                                    gint                y,
                                    GtkSelectionData
*selection_data,
                                    guint               info,
                                    guint               time);
  /* Action signals */
  void (* debug_msg)                (GtkWidget          *widget,
                                     const gchar        *string);

  /* Padding for future expansion */
  GtkFunction pad1;
  GtkFunction pad2;
  GtkFunction pad3;
  GtkFunction pad4;
};
```

Most of the functions in GtkWidgetClass are registered as default handlers for signals. The exceptions are show_all and hide_all, which are class functions only. Of course, GtkWidgetClass inherits the five class functions and single signal ("destroy") from GtkObjectClass. This chapter will describe the important methods in more detail; also, the section called *Events* in the chapter called *GDK Basics* is important for understanding the event methods. the section called *GtkWidget In Detail* describes the default implementation of each method in some detail.

Overridable Signals

You may notice that GtkWidgetClass contains two signal identifiers in addition to function pointers. These are 0 by default; otherwise, they indicate the signal to emit to "activate" the widget, or to set its scroll adjustments.

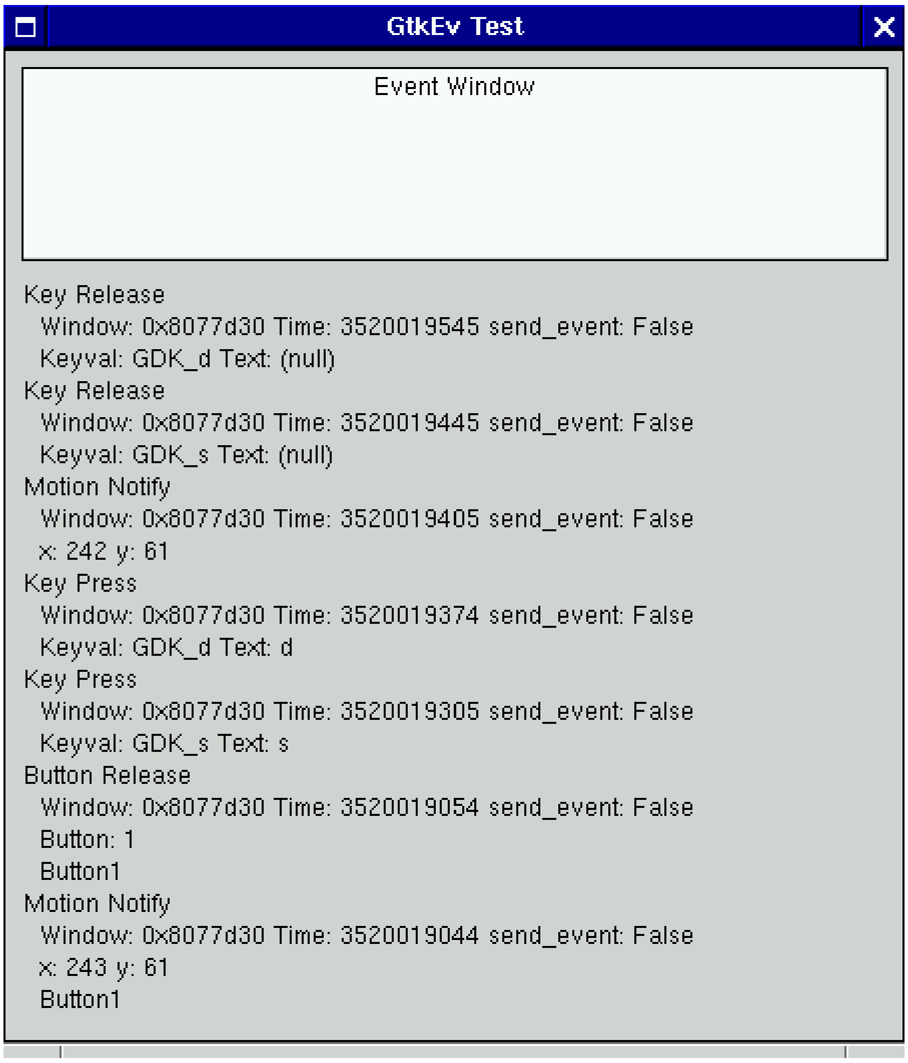
The activate_signal is emitted when the user presses the space bar or Enter key while the widget is focused; for buttons, it will be the "clicked" signal, for menu items, the "activate" signal.

The set_scroll_adjustments_signal is used by GtkScrolledWindow to set the scroll adjustments used by the widget. GtkLayout, GtkCList, and others have a signal to set the scroll adjustments.

These two hacks are necessary because GTK+ 1.2 does not support interfaces or multiple inheritance. (A future version of GTK+ may support interfaces similar in spirit to Java's interfaces.) Ideally, there would be "GtkActivatable" and "GtkScrollable" base classes or interfaces, and all widgets supporting these actions would derive from them. Including the two signal IDs in GtkWidgetClass is a short-term workaround.

An Example: The GtkEv Widget

This section describes a very simple widget called GtkEv, inspired by the xev client that comes with X. GtkEv has two components: a small sub-window that receives events, and a larger window where information about each event is reported. Figure 1 shows GtkEv in action. The complete GtkEv source code is in Appendix E. GtkEv would be a lovely way to implement an xev-style application for Gnome; it packages the core application functionality in a nice module.



```
Key Release
  Window: 0x8077d30 Time: 3520019545 send_event: False
  Keyval: GDK_d Text: (null)
Key Release
  Window: 0x8077d30 Time: 3520019445 send_event: False
  Keyval: GDK_s Text: (null)
Motion Notify
  Window: 0x8077d30 Time: 3520019405 send_event: False
  x: 242 y: 61
Key Press
  Window: 0x8077d30 Time: 3520019374 send_event: False
  Keyval: GDK_d Text: d
Key Press
  Window: 0x8077d30 Time: 3520019305 send_event: False
  Keyval: GDK_s Text: s
Button Release
  Window: 0x8077d30 Time: 3520019054 send_event: False
  Button: 1
  Button1
Motion Notify
  Window: 0x8077d30 Time: 3520019044 send_event: False
  x: 243 y: 61
  Button1
```

Figure 1. The GtkEv widget. Events are reported for the white subwindow.

Overview

GtkEv uses two GdkWindows; the larger one, GtkEv's widget->window, has a gray background and is used to render text describing each event. The smaller one is a child of the primary window, and is the window the widget reports events for.

Here are the class and instance structs for GtkEv:

```
typedef struct _GtkEv       GtkEv;
typedef struct _GtkEvClass  GtkEvClass;

struct _GtkEv
{
  GtkWidget widget;

  GdkWindow*     event_window;

  GdkRectangle   event_window_rect;

  GdkRectangle   description_rect;

  GList*         buffer;
  GList*         buffer_end;
  gint           buffer_size;
};

struct _GtkEvClass
{
  GtkWidgetClass parent_class;


};
```

As you can see, GtkEv has no class functions or signals of its own. Each instance stores a pointer to the small event window in event_window. Two rectangles cache the area covered by the event window, and the area covered by the event description text. The widget's allocation is divided between these two areas. Finally, GtkEv stores a list of string vectors describing events; it caches the end of the list and the length of the list. As events are received, text describing them is pushed on to the front of the buffer. When the list becomes too long to fit on the screen, GtkEv removes an event from the back of the buffer each time it adds a new event to the front, keeping the buffer size constant.

GtkObject Features

Like all GtkObjects, GtkEv provides for its creation and destruction.

Creation

GtkEv's init, class init, and constructor functions are pure boilerplate and should require no explanation; here they are, to help you get oriented:

```
static GtkWidgetClass *parent_class = NULL;

guint
gtk_ev_get_type (void)
{
  static guint ev_type = 0;

  if (!ev_type)
    {
      static const GtkTypeInfo ev_info =
      {
        "GtkEv",
        sizeof (GtkEv),
        sizeof (GtkEvClass),
        (GtkClassInitFunc) gtk_ev_class_init,
        (GtkObjectInitFunc) gtk_ev_init,
        /* reserved_1 */ NULL,
        /* reserved_2 */ NULL,
        (GtkClassInitFunc) NULL,
      };

      ev_type = gtk_type_unique (gtk_widget_get_type (), &ev_info);
    }

  return ev_type;
}

static void
gtk_ev_class_init (GtkEvClass *klass)
{
  GtkObjectClass *object_class;
  GtkWidgetClass *widget_class;
  object_class = (GtkObjectClass*) klass;
  widget_class = (GtkWidgetClass*) klass;

  parent_class = gtk_type_class (gtk_widget_get_type ());

  object_class->destroy = gtk_ev_destroy;

  widget_class->realize = gtk_ev_realize;
  widget_class->unrealize = gtk_ev_unrealize;

  widget_class->size_request = gtk_ev_size_request;

  widget_class->size_allocate = gtk_ev_size_allocate;

  widget_class->draw = gtk_ev_draw;

  widget_class->event = gtk_ev_event;

  widget_class->draw_focus = gtk_ev_draw_focus;

  widget_class->expose_event = gtk_ev_expose;

  widget_class->focus_in_event = gtk_ev_focus_in;
  widget_class->focus_out_event = gtk_ev_focus_out;
}

static void
gtk_ev_init (GtkEv *ev)
{
  GTK_WIDGET_SET_FLAGS (GTK_WIDGET(ev), GTK_CAN_FOCUS);

  ev->event_window = NULL;
  ev->buffer       = NULL;
  ev->buffer_end   = NULL;
  ev->buffer_size  = 0;

  ev->event_window_rect.x = ev->event_window_rect.y = 0;
  ev->event_window_rect.width = ev->event_window_rect.height = 0;

  ev->description_rect.x = ev->description_rect.y = 0;
  ev->description_rect.width = ev->description_rect.height = 0;
}
```

```
GtkWidget*
gtk_ev_new (void)
{
  GtkEv *ev;

  ev = gtk_type_new (gtk_ev_get_type ());

  return GTK_WIDGET (ev);
}
```

Destruction

GtkEv overrides only the destroy method from GtkObject, to clean up the event description buffer. The widget's windows will be destroyed in GtkWidget's shutdown method, which unrealizes the widget. GtkWidget's finalize method cleans up some GtkWidget resources and then chains to the GtkObject method which frees the instance struct. (Refer to the section called *Object Finalization* in the chapter called *The GTK+ Object and Type System* for more details on these methods.)

Because GtkEv has no object arguments, it does not need to implement get_arg or set_arg methods.

Here is its destroy method implementation:

```

static void
gtk_ev_destroy       (GtkObject   *object)
{
  GtkEv* ev;
  GList* tmp;

  g_return_if_fail(object != NULL);
  g_return_if_fail(GTK_IS_EV(object));

  ev = GTK_EV(object);

  tmp = ev->buffer;
  while (tmp != NULL)
    {
      g_strfreev((gchar**)tmp->data);
      tmp = g_list_next(tmp);
    }

  g_list_free(ev->buffer);

  ev->buffer = NULL;
  ev->buffer_end = NULL;
  ev->buffer_size = 0;

  /* Chain up */
  if (GTK_OBJECT_CLASS(parent_class)->destroy)
    (* GTK_OBJECT_CLASS(parent_class)->destroy) (object);
}
```

The only detail worthy of note is that freed pointers are set to NULL, because a destroyed object should remain "sane," unlike a finalized object. The GtkEv code depends on the fact that destroyed widgets are always unrealized; otherwise, text could be re-added to the buffer after destruction but before finalization, and a finalize method would be required.

Realization and Mapping

If you aren't familiar with the concept of *realizing* and *mapping* a widget, go back and read the section called *Realizing, Mapping, and Showing* in the chapter called *GTK+ Basics* before reading this section.

GtkEv does not override the map or unmap method; the default GtkWidget methods suffice. The defaults set and unset the GTK_WIDGET_MAPPED flag, and show or hide widget->window.

Any widget with a GdkWindow that has GtkWidget as its immediate parent will need to override the realize method; the default is only suitable for windowless widgets. GtkEv is no exception. GtkEv also overrides the unrealize method, in order to destroy the event window.

Here is GtkEv's realize method:

```

static void
gtk_ev_realize          (GtkWidget        *widget)
{
  GdkWindowAttr attributes;
  gint attributes_mask;
  GtkEv* ev;
  GdkCursor* cursor;

  g_return_if_fail(widget != NULL);
  g_return_if_fail(GTK_IS_EV(widget));

  ev = GTK_EV(widget);

  /* Set realized flag */

  GTK_WIDGET_SET_FLAGS (widget, GTK_REALIZED);

  /* Main widget window */

  attributes.window_type = GDK_WINDOW_CHILD;
  attributes.x = widget->allocation.x;
  attributes.y = widget->allocation.y;
  attributes.width = widget->allocation.width;
  attributes.height = widget->allocation.height;
  attributes.wclass = GDK_INPUT_OUTPUT;
  attributes.visual = gtk_widget_get_visual (widget);
  attributes.colormap = gtk_widget_get_colormap (widget);
  attributes.event_mask = gtk_widget_get_events (widget) |
GDK_EXPOSURE_MASK;

  attributes_mask = GDK_WA_X | GDK_WA_Y | GDK_WA_VISUAL |
GDK_WA_COLORMAP;

  widget->window = gdk_window_new (gtk_widget_get_parent_window
(widget),
                                   &attributes, attributes_mask);
  gdk_window_set_user_data (widget->window, widget);

  /* Event window */

  cursor = gdk_cursor_new(GDK_CROSSHAIR);

  attributes.window_type = GDK_WINDOW_CHILD;
  attributes.x = ev->event_window_rect.x;
  attributes.y = ev->event_window_rect.y;
  attributes.width = ev->event_window_rect.width;
  attributes.height = ev->event_window_rect.height;
  attributes.wclass = GDK_INPUT_OUTPUT;
  attributes.visual = gtk_widget_get_visual (widget);
  attributes.colormap = gtk_widget_get_colormap (widget);
  attributes.event_mask = GDK_ALL_EVENTS_MASK;
  attributes.cursor = cursor;

  attributes_mask = GDK_WA_X | GDK_WA_Y | GDK_WA_VISUAL |
    GDK_WA_COLORMAP | GDK_WA_CURSOR;

  ev->event_window = gdk_window_new (widget->window,
                                  &attributes, attributes_mask);
  gdk_window_set_user_data (ev->event_window, widget);

  gdk_window_show(ev->event_window);

  gdk_cursor_destroy(cursor);

  /* Style */

  widget->style = gtk_style_attach (widget->style, widget->window);

  gtk_style_set_background (widget->style, widget->window,
GTK_STATE_NORMAL);

  gdk_window_set_background (ev->event_window,
                             &widget->style->base[GTK_STATE_NORMAL]);
}
```

The first step in any realize method is to set the GTK_REALIZED flag; this is a small but important detail. After that, most of the realize method is concerned with creating the two GdkWindows, as described in the section called *GdkWindow* in the chapter called *GDK Basics*. widget->window should be created as a subwindow of the widget's parent's GdkWindow; the parent window is obtained with gtk_widget_get_parent_window().

Notice that *all* events are requested on the event window, for obvious reasons. Also, the event window has a special cursor, to give the user visual feedback when the pointer moves into it. The client-side cursor handle is destroyed immediately after attaching the cursor to the window; the X server will keep it around as long as it's in use.

After creating each GdkWindow, a pointer to the GtkEv is stored in the GdkWindow's "user data" field. GTK+ uses the contents of this field to determine which widget should receive events that occur on the window. Recall that GTK+ receives a stream of events from GDK, and that each GdkEvent has a window field indicating the GdkWindow that received it. GTK+ forwards each event to the widget owning the event's GdkWindow. (the section called *Events* in the chapter called *GDK Basics* details this process if you don't remember.)

The code calls gdk_window_show() on the event window but not widget->window; widget->window should not be shown until the widget is mapped. Because the event window is a child of widget->window, it will remain offscreen until its parent is shown. Alternatively, GtkEv could implement a map method to show the child, but this way seems simpler.

All widgets must take create their associated GtkStyle in their realize method, because a style contains X resources. (See the section called *GtkStyle and Themes* in the chapter called *GDK Basics* for more information about GtkStyle.) Recall from the section called *Realizing, Mapping, and Showing* in the chapter called *GTK+ Basics* that widgets allocate all X resources in their realize method. GTK+ provides a simple function to create a widget's style:

```
widget->style = gtk_style_attach (widget->style, widget->window);
```

After filling in widget->style, GtkEv uses colors from the style to set window backgrounds. It sets the main window's background using gtk_style_set_background(), which could do almost anything (it might invoke a routine from a dynamically loaded theme module). If the default theme is running, it simply sets the window's background to an appropriate color or pixmap tile. There is no special style function to set the background of the event window, so we set it to the "base" color (the base color is white by default; it's the background color for lists and text entries). Selecting a color from the style means that users will be able to customize the widget's color. It's also convenient to avoid allocating and deallocating a custom color.

Notice that the realize method does not chain up to the default realize method, because the default isn't appropriate for GtkEv.

Unrealizing GtkEv is relatively simple:

```
static void
gtk_ev_unrealize (GtkWidget        *widget)
{
  GtkEv* ev;

  g_return_if_fail(widget != NULL);
  g_return_if_fail(GTK_IS_EV(widget));

  ev = GTK_EV(widget);

  /* Hide all windows */

  if (GTK_WIDGET_MAPPED (widget))
    gtk_widget_unmap (widget);

  GTK_WIDGET_UNSET_FLAGS (widget, GTK_MAPPED);

  /* Destroy our child window */

  if (ev->event_window)
    {
      gdk_window_set_user_data(ev->event_window, NULL);
      gdk_window_destroy(ev->event_window);
      ev->event_window = NULL;
    }

  /* This destroys widget->window and unsets the realized flag
   */
  if (GTK_WIDGET_CLASS(parent_class)->unrealize)
    (* GTK_WIDGET_CLASS(parent_class)->unrealize) (widget);
}
```

First, the unrealize method ensures that the widget is unmapped. This is essential: GTK+ maintains the invariant that mapped widgets are also realized. Next, the unrealize method destroys the event window. It sets the window's user data to NULL before destroying it; otherwise GtkEv would receive a useless destroy event. Finally, GtkEv chains up to the default unrealize method, which unsets the GTK_WIDGET_REALIZED flag and destroys widget->window. Unrealize implemenations are *required* to chain up to their base class's implementation.

When writing your realize and unrealize methods, keep in mind that they can be called multiple times, but they are always paired. That is, a widget can be unrealized and re-realized over and over, but it will never be realized twice without an intervening unrealize. The pairing is guaranteed; that is, if a widget is realized it will definitely be unrealized sooner or later, unless the program exits.

Size Negotiation

the section called *Size Allocation* in the chapter called *GTK+ Basics* describes the size negotiation process; be sure you're familiar with it before reading this section.

There's no obvious "right" size for GtkEv, so the size request method requests an arbitrary size that looks nice:

```
static void
gtk_ev_size_request   (GtkWidget        *widget,
                       GtkRequisition   *requisition)
{
  g_return_if_fail(widget != NULL);
  g_return_if_fail(GTK_IS_EV(widget));

  /*
   * GtkEv always wants to be the same fixed size.
   */

  requisition->width  = 450;
  requisition->height = 300;
}
```

GTK+ takes care of storing a widget's last size request in widget->requisition.

If GtkEv were a real-life widget rather than an illustrative example, it would be unnecessary to implement a size request method. The default GtkWidget method simply returns the current value of widget->requisition, so GtkEv could initialize widget->requisition in gtk_ev_init() and use the default method.

Alternatively, the size request method could be implemented more elaborately; GtkEv could attempt to predict the maximum width of the text to be displayed, for example.

Once a widget's parent container decides how much space is actually available, the widget receives a size allocation. The size allocation method should do the following:

- Assign the new allocation to widget->allocation; this does *not* happen automatically, as it does for widget->requisition.
- Divide the allocation among any child widgets.
- Resize any GdkWindows, if the widget is realized.
- Perform any widget-specific tasks; for example, GtkEv updates the two GdkRectangles representing its internal layout.

Here is the GtkEv size allocation method; it should be self-explanatory:

```
static void
gtk_ev_size_allocate  (GtkWidget        *widget,
                       GtkAllocation    *allocation)
{
  static const gint spacing = 10;
  GtkEv* ev;

  g_return_if_fail(widget != NULL);
  g_return_if_fail(GTK_IS_EV(widget));

  ev = GTK_EV(widget);

  widget->allocation = *allocation;

  ev->event_window_rect.width =
    MAX(allocation->width - spacing*2, 0);
  ev->event_window_rect.height =
    MAX(allocation->height / 5 - spacing / 2, 0);

  ev->event_window_rect.x =
    (allocation->width - ev->event_window_rect.width)/2;
  ev->event_window_rect.y =
    MIN(spacing, allocation->height);

  ev->description_rect.x = ev->event_window_rect.x;
  ev->description_rect.y =
    ev->event_window_rect.y + ev->event_window_rect.height + spacing;
  ev->description_rect.width =
    ev->event_window_rect.width;
  ev->description_rect.height =
    MAX((allocation->height - ev->event_window_rect.height -
spacing*3), 0);

  if (GTK_WIDGET_REALIZED (widget))
    {
      gdk_window_move_resize (widget->window,
                              allocation->x,
                              allocation->y,
                              allocation->width,
                              allocation->height);

      gdk_window_move_resize (ev->event_window,
                              ev->event_window_rect.x,
                              ev->event_window_rect.y,
                              ev->event_window_rect.width,
                              ev->event_window_rect.height);
    }
}
```

Drawing

There are three common situations that require a widget to redraw all or part of itself:

1. Expose events signal that all or part of a widget's GdkWindow has just become visible on the screen and needs repainting (see the section called *Expose Events* in the chapter called *GDK Basics*). A widget's expose_event method performs these redraws.
2. GTK+ sometimes determines that a widget should be redrawn. This might happen when a widget receives a new size allocation different from its previous size allocation, or when a new theme is loaded. A widget's draw method, usually invoked via gtk_widget_queue_draw() or gtk_widget_queue_clear(), handles this case.
3. Widgets sometimes decide to redraw themselves. For example, if you change the text of a GtkLabel, the label will redraw itself to reflect the new text. Widget implementations are free to handle this case however they like, but most will use the draw method.

There are two special cases of the second situation. The first occurs when a widget receives or loses the keyboard focus; the second occurs when the widget becomes (or unbecomes) the "default" widget. Widgets should indicate these states visually, but they can often do so without a complete redraw. Thus, there are special draw_focus and draw_default signals to handle them. These signals only have to be implemented if a widget can meaningfully receive the focus or default.

Because there is typically little difference between a widget's draw and expose methods, a common convention is to write a static function to handle both of them. This function is standardly called gtk_whatever_paint(). It's also possible to avoid implementing the draw method, because the default draw method synthesizes an expose event covering the widget's entire allocation and invokes the expose method. (Remember that a synthetic expose event will have its send_event flag set to TRUE; you can use this to distinguish synthetic events.)

The primary reason for distinguishing expose events from other draws is that expose events are marked with the window they occurred on; for widgets with multiple windows such as GtkEv, this can increase efficiency. GtkEv implements two private functions, gtk_ev_paint() and gtk_ev_paint_event_window(), which it uses to implement the expose and draw methods.

Here is the draw method:

```
static void
gtk_ev_draw           (GtkWidget        *widget,
                       GdkRectangle     *area)
{
  GdkRectangle event_window_area;
  GdkRectangle intersection;
  GtkEv* ev;

  g_return_if_fail(widget != NULL);
  g_return_if_fail(GTK_IS_EV(widget));

  ev = GTK_EV(widget);

  gtk_ev_paint(ev, area);

  event_window_area = *area;

  if (gdk_rectangle_intersect(area, &ev->event_window_rect,
&intersection))
    {
      /* Make the intersection relative to the event window */
      intersection.x -= ev->event_window_rect.x;
      intersection.y -= ev->event_window_rect.y;

      gtk_ev_paint_event_window(ev, &intersection);
    }
}
```

And the expose method:

```
static gint
gtk_ev_expose         (GtkWidget        *widget,
                       GdkEventExpose   *event)
{
  if (event->window == widget->window)
    gtk_ev_paint(GTK_EV(widget), &event->area);
  else if (event->window == GTK_EV(widget)->event_window)
    gtk_ev_paint_event_window(GTK_EV(widget), &event->area);
  else
    g_assert_not_reached();

  return TRUE;
}
```

Both the draw and expose methods should be self-explanatory. All the work is done in the two paint functions. Here is gtk_ev_paint(), which renders the main widget window:

```
static void
gtk_ev_paint          (GtkEv            *ev,
                       GdkRectangle     *area)
{
  GtkWidget* widget;

  g_return_if_fail(ev != NULL);
  g_return_if_fail(GTK_IS_EV(ev));

  widget = GTK_WIDGET(ev);

  if (!GTK_WIDGET_DRAWABLE (widget))
    return;
```

```
gdk_window_clear_area (widget->window,
                       area->x,
                       area->y,
                       area->width,
                       area->height);

gdk_gc_set_clip_rectangle(widget->style->black_gc, area);

/* Draw a black rectangle around the event window */

gdk_draw_rectangle(widget->window,
                   widget->style->black_gc,
                   FALSE,
                   ev->event_window_rect.x - 1,
                   ev->event_window_rect.y - 1,
                   ev->event_window_rect.width + 2,
                   ev->event_window_rect.height + 2);

gdk_gc_set_clip_rectangle(widget->style->black_gc, NULL);

/* Draw text in the description area, if applicable */

if (ev->buffer)
  {
    GdkRectangle intersection;

    if (gdk_rectangle_intersect(area,
                                &ev->description_rect,
                                &intersection))
      {
        static const gint space = 2;
        gint line;
        gint step;
        gint first_baseline;
        GList* tmp;

        step  = widget->style->font->ascent +
          widget->style->font->descent + space;

        first_baseline = ev->description_rect.y +
          widget->style->font->ascent + space;

        line = 0;
```

```
          tmp = ev->buffer;

          while (tmp != NULL)
            {
              gchar** this_event = tmp->data;
              gint i = 0;
              while (this_event[i])
                {
                  gtk_paint_string (widget->style,
                                    widget->window,
                                    widget->state,
                                    &intersection, widget, "ev",
                                    ev->description_rect.x,
                                    first_baseline + line*step,
                                    this_event[i]);
                  ++i;
                  ++line;
                }

              /* Bail out if we're off the bottom; the "- 2*step" is
               *  needed because the next baseline may be outside the
               *  redraw area but we are interested in the whole row of
               *  text, not the baseline. The 2* is because line is one
               *  larger than we've actually drawn.
               */
              if ((first_baseline + line*step - 2*step) >
                  (intersection.y + intersection.height))
                break;

              tmp = g_list_next(tmp);
            }
        }
    }

  if (GTK_WIDGET_HAS_FOCUS (widget))
    {
      gtk_paint_focus (widget->style, widget->window,
                       area, widget, "ev",
                       widget->allocation.x, widget->allocation.y,
                       widget->allocation.width-1,
widget->allocation.height-1);
    }
}
```

Most of gtk_ev_paint() is GtkEv-specific; it simply draws the contents of the window. Notice that it checks GTK_WIDGET_DRAWABLE() at the beginning; this is required because the draw method may invoke the function. Unsynthesized expose events guarantee that a widget's X window is on-screen and thus this check is not really necessary when responding to expose events.

gtk_ev_paint_event_window() paints the small subwindow; it's a very simple function:

```
static void
gtk_ev_paint_event_window  (GtkEv            *ev,
                            GdkRectangle     *area)
{
  GtkWidget* widget;
  gint width;
  gint x, y;
  const char* title;

  g_return_if_fail(ev != NULL);
  g_return_if_fail(GTK_IS_EV(ev));

  widget = GTK_WIDGET(ev);

  if (!GTK_WIDGET_DRAWABLE (widget))
    return;

  title = _("Event Window");

  gdk_window_clear_area (ev->event_window,
                         area->x,
                         area->y,
                         area->width,
                         area->height);

  gdk_gc_set_clip_rectangle(widget->style->black_gc, area);

  /* Clearly it would be better to cache this */

  width = gdk_string_width(widget->style->font,
                           title);
  x = (ev->event_window_rect.width - width)/2;
  y = widget->style->font->ascent + 2;

  gdk_draw_string(ev->event_window,
                  widget->style->font,
                  widget->style->black_gc,
                  x, y,
                  title);

  gdk_gc_set_clip_rectangle(widget->style->black_gc, NULL);
}
```

Handling Focus

GtkEv wants to receive key press events so it can report information about them. As discussed in the section called *Focus* in the chapter called *GTK+ Basics* and the section called *Keyboard Focus* in the chapter called *GDK Basics*, only toplevel windows receive key events from GDK. GtkWindow keeps track of a current *focus widget* and forwards key events to it.

If a widget wants to receive key events, it must:

- Set its GTK_CAN_FOCUS flag, so GTK+ will consider it as a possible focus widget.
- Respond to "focus_in" and "focus_out" signals by drawing and erasing a visual indication that it has the focus.

GtkEv set the GTK_CAN_FOCUS flag in gtk_ev_init(); it implements focus in and focus out methods as follows:

```
static gint
gtk_ev_focus_in       (GtkWidget        *widget,
                       GdkEventFocus    *event)
{
  g_return_val_if_fail(widget != NULL, FALSE);
  g_return_val_if_fail(GTK_IS_EV(widget), FALSE);

  GTK_WIDGET_SET_FLAGS (widget, GTK_HAS_FOCUS);
  gtk_widget_draw_focus (widget);
  return FALSE;
}

static gint
gtk_ev_focus_out      (GtkWidget        *widget,
                       GdkEventFocus    *event)
{
  g_return_val_if_fail(widget != NULL, FALSE);
  g_return_val_if_fail(GTK_IS_EV(widget), FALSE);

  GTK_WIDGET_UNSET_FLAGS (widget, GTK_HAS_FOCUS);
  gtk_widget_draw_focus (widget);

  return FALSE;
}
```

These implementations are the minimal ones; all focusable widgets must set or unset the GTK_HAS_FOCUS flag when they gain or lose the focus, and they must emit the "draw_focus" signal.

GtkEv has a lazy implementation of the "draw_focus" signal; it just calls the same gtk_ev_paint() used to respond to expose events and redraw requests. Recall that gtk_ev_paint() checks whether the GtkEv has the focus and draws a focus frame if so. Here is the code:

```

static void
gtk_ev_draw_focus     (GtkWidget        *widget)
{
  GdkRectangle rect;
  GtkEv* ev;

  g_return_if_fail(widget != NULL);
  g_return_if_fail(GTK_IS_EV(widget));

  ev = GTK_EV(widget);

  rect.x = 0;
  rect.y = 0;
  rect.width = widget->allocation.width;
  rect.height = widget->allocation.height;

  if (GTK_WIDGET_DRAWABLE (ev))
```

```
    gtk_ev_paint(ev, &rect);
}
```

Notice that widget implementations are responsible for emitting the "draw_focus" signal themselves; GTK+ does not emit it as the focus moves. Contrast this with the "draw_default" signal, which GTK+ automatically emits whenever a widget gains or loses the default. GtkEv cannot be the default widget, so it does not implement this signal.

GtkEv's Functionality

All the code presented so far implements the GtkWidget and GtkObject interfaces. GtkEv does have some unique functionality; namely, it responds to events on its event window by adding text describing the event to its buffer, and queueing a redraw. To do this, it overrides the default "event" signal handler.

Here is GtkEv's event method:

```

static gint
gtk_ev_event (GtkWidget        *widget,
              GdkEvent         *event)
{
  GtkEv* ev;

  g_return_val_if_fail(widget != NULL, FALSE);
  g_return_val_if_fail(GTK_IS_EV(widget), FALSE);

  ev = GTK_EV(widget);

  if (event->any.window == widget->window)
    {
      if (GTK_WIDGET_CLASS(parent_class)->event)
        return (* GTK_WIDGET_CLASS(parent_class)->event) (widget,
event);
      else
        return FALSE;
    }
  else
    {
      gchar* text;
      /* The event is either on ev->event_window, or it is a key event
       * passed down to us from the toplevel GtkWindow
       */

      text = event_to_text(event);

      gtk_ev_push_text(ev, text);

      g_free(text);

      /* If it was a motion event, make sure we get more */
      if (event->type == GDK_MOTION_NOTIFY)
        {
          gdk_window_get_pointer(ev->event_window, NULL, NULL, NULL);
        }

      /* We didn't "handle" the event, just listened in on it. */
      return FALSE;
    }
}
```

Notice that the window method of the event is used to distinguish events that occur on widget->window from events that occur on the event subwindow. Some events will be received from a different window entirely; for example, key events actually occur on a toplevel window, and are passed to GtkEv if GtkEv has the focus.

event_to_text() is a lengthy but trivial function that creates a string describing the event; gtk_ev_push_text() pushes the text onto the front of the buffer and queues a redraw. The implementation of these functions is part of the complete GtkEv code listing, in Appendix E.

GtkWidget In Detail

This section catalogs the functions in GtkWidgetClass more rigorously, and describes the default implementation of each.

Destruction

Widget destruction is not significantly different from object destruction in general, as described in the section called *Object Finalization* in the chapter called *The GTK+ Object and Type System*. As always, there are three phases: shutdown, destroy, and finalize. Only the destroy method is a signal; the others are class functions only. If you override any of the three, you must "chain up" to the parent class implementation.

GtkWidget has default implementations of all three; you should know what they do:

- In its shutdown method, a GtkWidget removes itself from its parent container (if any), and then unrealizes itself. This implies that widgets are always unrealized inside their destroy methods. It chains up to the GtkObject shutdown method which emits the "destroy" signal.
- In its destroy method, a GtkWidget releases the grab if it has it, unreferences its style and sets widget->style to NULL, and gives up any connections it had to the current selection. (GtkEntry and other editable-text widgets allow you to select and paste text.) It chains up to the GtkObject destroy method which disconnects any signal handlers for the object.
- In its finalize method, a GtkWidget frees a number of private data structures (stored as object data, see the section called *Attaching Data to Objects* in the chapter called *The GTK+ Object and Type System*), and frees widget->name. It chains up to the GtkObject finalize method which frees the instance struct.

Showing, Hiding, and Mapping

Four methods are provided to show and hide widgets. show and hide are rarely overridden; the default implementations almost always suffice. show_all and hide_all are overridden by container widgets; they show or hide the container and all its children. Their default implementation simply shows the widget itself: no non-container should need to change this. "show" and "hide" are registered as signals, but the _all variants are not.

The default implementation of show sets the GTK_VISIBLE flag, and maps the widget if its parent is mapped. When containers are mapped, they map any children with the GTK_VISIBLE flag set. Thus, the show implementation ensures that a widget will be mapped eventually. (When a widget is finally mapped, the GTK_MAPPED flag is set in addition to GTK_VISIBLE.)

The default hide implementation does the opposite: it unsets the GTK_VISIBLE flag, and unmaps the widget if GTK_MAPPED is set.

The default map and unmap implementations are much more frequently overridden. The default implementations should suffice for windowless widgets and widgets with a single window (widget->window). Widgets with additional subwindows or other special needs may need to override the defaults.

The map method is responsible for putting a widget on the screen. The default implementation sets the GTK_MAPPED flag, and calls gdk_window_show() on widget->window for widgets that have a window. If a widget has subwindows, or needs to take any special action when it appears on the screen, it must override the map method. (It may optionally chain up to the default method, however.) Container widgets are required to override the map method, because they must iterate over their children and map each child widget with the GTK_VISIBLE flag set (i.e., each child widget that's been shown).

The unmap method is simply the reverse of the map method; it undoes anything the map method did. By default, it unsets the GTK_MAPPED flag and calls gdk_window_hide() to hide widget->window. Container widgets must override the method to unmap their child windows.

Keep in mind that none of these methods are invoked directly; they are invoked by calling gtk_widget_show(), gtk_widget_map(), and so on. These functions may perform special actions before and after invocation. Here is a summary:

- gtk_widget_show() "queues a resize" on the widget before emitting the show signal. This means notifying the widget's parent container that it should rearrange its layout.
- gtk_widget_hide() does the same, since a newly-invisible widget implies recalculating the layout just as a newly-visible one does.
- gtk_widget_show_all() and gtk_widget_hide_all() don't do anything special, they simply invoke the corresponding class function.
- gtk_widget_map() realizes the widget before emitting the "map" signal, if the widget is not realized. This maintains an important invariant (all mapped widgets are also realized). After emitting the signal, gtk_widget_map() queues a draw for windowless widgets; widgets with windows will receive an expose event when the window appears on the screen, so queueing a draw is not necessary.
- gtk_widget_unmap() redraws part of the parent widget if a windowless child is unmapped (remember that windowless widgets draw on their parent's widget->window).

Realization

The realize and unrealize class functions are registered as signals. *Realization* is the process of creating GDK resources associated with the widget; including but not limited to widget->window and widget->style.

A realize method should do the following:

- Set the GTK_REALIZED flag.
- Create the widget's windows, especially widget->window which should be a child of the widget's parent's widget->window (obtained with gtk_widget_get_parent_window()).
- Place a pointer to the widget in the user data field of each window.
- For windowless widgets, widget->window should be set to the parent widget's window (obtained with gtk_widget_get_parent_window()). These widgets should also increase the reference count on widget->window by calling gdk_window_ref().
- Set widget->style using gtk_style_attach().
- Set the background of each window using gtk_style_set_background() if possible, and failing that using some color from the style. A windowless widget should not do this, since its parent already has.

The default implementation of realize is only appropriate for windowless widgets; it sets the GTK_REALIZED flag, sets widget->window to the parent widget's window, increases the reference count on the parent's window, and sets widget->style. Widgets with their own GdkWindow must override the realize method.

The "realize" signal invokes the realize method as its default handler. This signal should never be emitted directly, because there are substantial pre- and post-conditions to be enforced. gtk_widget_realize() takes care of the details. Among other things, it ensures that the widget's parent is realized; GTK+ maintains the invariant that widgets cannot be realized unless their parents are also realized.

As you might expect, the unrealize method reverses a widget's realization, freeing the resources created in realize. The default unrealize method is appropriate for all widgets; it does the following:

- Unmaps the widget if the widget is mapped; remember the GTK+ invariant that all mapped widgets are realized.
- Unrealizes all child widgets, if the widget is a container; this maintains the invariant that widgets cannot be realized unless their parents are also realized.

- Unreferences widget->style.
- Destroys widget->window (windowless widgets only unreference it).
- Unsets the GTK_REALIZED flag.

Widgets are required to chain up if they override their base class's unrealize method. This ensures that all resources are freed. Overriding the default method may be necessary if a widget has more than one GdkWindow or other special needs. All windows should be destroyed just as GtkEv destroys its event_window, that is, the window's user data field should be set to NULL before destruction:

```
    gdk_window_set_user_data(ev->event_window, NULL);
    gdk_window_destroy(ev->event_window);
    ev->event_window = NULL;
```

This keeps GTK+ from sending a useless GDK_DESTROY event for the window.

The "unrealize" signal is emitted via gtk_widget_unrealize(). gtk_widget_unrealize() does some internal bookkeeping which is important but not very interesting; just be careful to use this function rather than emitting the signal directly.

Drawing

The relationship between draw, draw_focus, draw_default, and expose_event was discussed in the section called *Drawing*. All four class functions are registered as default handlers for a signal of the same name. The "draw" signal redraws a portion of the widget; it is emitted by GTK+ or by widget implementations.

Widget implementations should emit the "draw_focus" signal themselves, generally in response to focus events; the signal draws or undraws a frame indicating that the widget is focused. gtk_window_set_default() emits the "draw_default" signal for both the widget losing default status and the widget gaining it. (gtk_widget_grab_default() calls gtk_window_set_default().) Only widgets with the GTK_CAN_FOCUS or GTK_CAN_DEFAULT flag set need to worry about the draw_focus and draw_default methods. These flags should be set in a widget's instance initialization function.

Only the draw method has a default implementation in GtkWidget; the default implementation synthesizes an expose event covering the widget's entire allocation. This allows you to write an expose event handler that also handles the draw signal.

GTK+ normally emits the "draw" signal in an idle function. That is, it keeps a list of widgets (and regions of them) that need to be redrawn; when no events are pending, the GTK+ main loop runs an idle function that traverses the list and emits the "draw" signal for each widget. Redraw areas are merged as much as possible to avoid multiple redraws, and the idle function is removed after it runs once. This arrangement minimizes the number of redraws and reduces flicker.

Size Negotiation

The size negotiation process has already been described in the section called *Size Allocation* in the chapter called *GTK+ Basics* and the section called *Size Negotiation*. The two signals/methods involved are size_request and size_allocate. GtkWidget provides default implementations of each.

Here is the default size_request method:

```
static void
gtk_widget_real_size_request (GtkWidget         *widget,
                              GtkRequisition    *requisition)
{
  g_return_if_fail (widget != NULL);
  g_return_if_fail (GTK_IS_WIDGET (widget));

  requisition->width = widget->requisition.width;
  requisition->height = widget->requisition.height;
}
```

This implementation is appropriate for widgets that always request the same size; GtkArrow and GtkDrawingArea, for example, use this default. Widgets using the default must initialize widget->requisition with their fixed request; GtkArrow does this in gtk_arrow_init(). GtkDrawingArea begins with a default size, but allows users to change the request with gtk_drawing_area_set_size().

Widgets whose request depends on their children, or the amount of text they contain, or some other factor, should override the default size request method with a method that calculates the size they want.

Size allocation is mildly more complicated; here is its default implementation:

```
static void
gtk_widget_real_size_allocate (GtkWidget     *widget,
                               GtkAllocation *allocation)
{
  g_return_if_fail (widget != NULL);
  g_return_if_fail (GTK_IS_WIDGET (widget));

  widget->allocation = *allocation;

  if (GTK_WIDGET_REALIZED (widget) &&
      !GTK_WIDGET_NO_WINDOW (widget))
     {
        gdk_window_move_resize (widget->window,
                                allocation->x, allocation->y,
                                allocation->width,
allocation->height);
     }
}
```

This should suffice for most simple widgets. Widgets like GtkEv, or any container, need to update internal data structures or distribute the allocation they receive among child widgets; these widgets will override size_allocate. It is possible but not required to chain up to the default implementation.

The wrapper function which emits the "size_allocate" signal is significantly more involved than the signal handlers. gtk_widget_size_allocate() takes into account gtk_widget_set_usize() and ensures widgets are redrawn if their size changes. (Unsurprisingly, gtk_widget_size_request() also exists and should be used instead of emitting "size_request" directly.)

GtkContainer

GtkContainer is the base class for all widgets that contain one or more other widgets. GtkBin is a subclass of GtkContainer, and is the base class for widgets with a single child.

The GtkContainer Instance Struct

Here is GtkContainer:

```
typedef struct _GtkContainer       GtkContainer;

struct _GtkContainer
{
  GtkWidget widget;

  GtkWidget *focus_child;

  guint border_width : 16;
  guint need_resize : 1;
  guint resize_mode : 2;

  GSList *resize_widgets;
};
```

The focus_child member is the child in the container with the keyboard focus; it can be NULL if no child has the focus. The GtkContainer implementation handles setting and unsetting this field. The border_width member is a width in pixels to add to the container's size request on all sides; the container will also subtract this value from its allocation. (In other words, the border_width is a blank space around the container.) Library users set the border_width field with gtk_container_set_border_width(); GtkContainer subclasses must honor its value in their size_request and size_allocate implementations.

The need_resize, resize_mode, and resize_widgets fields are implementation details that subclasses should not have to read or modify. These fields are used to implement gtk_widget_queue_resize(); when a resize is queued for a widget, the GtkContainer implementation ensures that the size negotiation process (requisition/allocation) will take place a in a one-shot idle handler. Subclasses of GtkContainer simply implement size_request and size_allocate, and everything works.

The GtkContainer Class Struct

```
typedef struct _GtkContainerClass  GtkContainerClass;

struct _GtkContainerClass
{
  GtkWidgetClass parent_class;

  guint   n_child_args;

  void (* add)                (GtkContainer    *container,
                               GtkWidget       *widget);
  void (* remove)             (GtkContainer    *container,
                               GtkWidget       *widget);
  void (* check_resize)       (GtkContainer    *container);
  void (* forall)             (GtkContainer    *container,
                               gboolean         include_internals,
                               GtkCallback      callback,
                               gpointer         callbabck_data);
  gint (* focus)              (GtkContainer    *container,
                               GtkDirectionType  direction);
  void (* set_focus_child)    (GtkContainer    *container,
                               GtkWidget       *widget);
  GtkType (*child_type)       (GtkContainer   *container);
  void    (*set_child_arg)    (GtkContainer   *container,
                               GtkWidget      *child,
                               GtkArg         *arg,
                               guint           arg_id);
  void    (*get_child_arg)    (GtkContainer   *container,
                               GtkWidget      *child,
                               GtkArg         *arg,
                               guint           arg_id);
  gchar*  (*composite_name)   (GtkContainer   *container,
                               GtkWidget      *child);

  /* Padding for future expansion */
  GtkFunction pad1;
  GtkFunction pad2;
};
```

Many of these class functions do not have corresponding signals. add, remove, check_resize, focus, and set_focus_child methods are default handlers for signals with the same name. The others are just methods.

The check_resize method recalculates layout if necessary; it is invoked by the idle handler installed by gtk_widget_queue_resize(). As the previous section mentioned, subclasses should not have to concern themselves with this process.

The focus and set_focus_child methods handle moving focus around a GtkWindow. Users can move the focus with the arrow keys and the tab key. This results in emissions of the "focus" signal, with the direction argument indicating which way the focus should move. The possible directions are: GTK_DIR_TAB_FORWARD, GTK_DIR_TAB_BACKWARD, GTK_DIR_UP, GTK_DIR_DOWN, GTK_DIR_LEFT, and GTK_DIR_RIGHT. GtkContainer provides a default implementation based on the geometric location of child widgets; it works fine for most standard layout containers, such as GtkBox and GtkTable. It should also work for GtkBin subclasses. More elaborate or unusual containers, such as the tree and list widgets, or GtkNotebook, override this method. The focus method should return TRUE if an appropriate child was found and the focus was moved (using gtk_widget_grab_focus()).

The set_focus_child method is used by gtk_widget_grab_focus() to set the focus child of a container. gtk_widget_grab_focus() can be invoked by the focus method of a container, or by a widget implementation (for example, GtkEntry grabs the focus if the user clicks on it). The default implementation simply sets the focus_child field of the container, and increments the child's reference count.

composite_name returns a special name for a child when it's a part of a particular container. For example, the composite names of the two GtkScrollbar widgets in a GtkScrolledWindow are "hscrollbar" and "vscrollbar." These names allow themes to specify widget attributes precisely. The default implementation of this method should always work fine; it returns the name set with gtk_widget_set_composite_name().

n_child_args, set_child_arg, and get_child_arg are exactly analagous to the n_args, get_arg, and set_arg fields of GtkObjectClass. the section called *Using Object Arguments in Your Own GtkObject Subclass* in the chapter called *The GTK+ Object and Type System* mentions this briefly. Child arguments are used to get and set attributes of the container-child unit, such as the packing parameters for GtkBox or the attachment parameters for GtkTable. In contrast, normal object arguments set the characteristics of a single object in isolation. Though the implementation differs, child arguments work almost exactly like the object arguments described in the chapter called *The GTK+ Object and Type System*. The only visible difference is that the get and set functions take a container and a widget as arguments, instead of a single object.

The following section introduces the remaining functions in GtkContainer by describing their implementation in GtkBin.

`GtkBin`: Containers With One Child

GtkBin doesn't introduce any new interfaces; it simply adds a data member to each container instance for storing a single child, and provides default implementations for the container methods that operate on this one child. GtkBin implements the add, remove, forall, and child_type methods from GtkContainer; combined with GtkContainer's default implementations, simple subclasses of GtkBin (such as GtkEventBox, GtkAlignment, and GtkFrame) do not need to override any GtkContainer methods. Here's the instance struct:

```
typedef struct _GtkBin       GtkBin;

struct _GtkBin
{
  GtkContainer container;

  GtkWidget *child;
};
```

And the class struct:

```
typedef struct _GtkBinClass  GtkBinClass;

struct _GtkBinClass
{
  GtkContainerClass parent_class;
};
```

No rocket science here.

Adding and Removing Children

The add and remove functions do not have a default implementation (well, technically they do: the default implementation prints a warning that they aren't implemented). All containers should override these functions; their corresponding signals are emitted when library users call gtk_container_add() and gtk_container_remove(). For containers that normally require parameters when adding children (such as GtkBox and GtkTable), the add method should simply use reasonable defaults.

GtkBin implements an add method as follows:

```
static void
gtk_bin_add (GtkContainer *container,
             GtkWidget    *child)
{
  GtkBin *bin;

  g_return_if_fail (container != NULL);
  g_return_if_fail (GTK_IS_BIN (container));
  g_return_if_fail (child != NULL);
  g_return_if_fail (GTK_IS_WIDGET (child));

  bin = GTK_BIN (container);
  g_return_if_fail (bin->child == NULL);

  gtk_widget_set_parent (child, GTK_WIDGET (bin));
  bin->child = child;

  if (GTK_WIDGET_VISIBLE (child->parent))
    {
      if (GTK_WIDGET_REALIZED (child->parent) &&
          !GTK_WIDGET_REALIZED (child))
        gtk_widget_realize (child);

      if (GTK_WIDGET_MAPPED (child->parent) &&
          !GTK_WIDGET_MAPPED (child))
        gtk_widget_map (child);
    }

  if (GTK_WIDGET_VISIBLE (child) && GTK_WIDGET_VISIBLE (container))
    gtk_widget_queue_resize (child);
}
```

Notice the required parts of the add method:

- gtk_widget_set_parent() is called to set the widget's parent; this fills in widget->parent and handles reference counting and some other internal details.
- The container saves a pointer to the child; this is easy for GtkBin, since there is only one child and it goes in bin->child.
- If the container has been shown (i.e., if its GTK_VISIBLE flag is set), parent and child's GTK_REALIZED and GTK_MAPPED states are synchronized. That is, the child is realized and mapped if the parent is realized and mapped.
- If both parent and child have been shown, a resize is queued. That is, layout will be recalculated in light of the new child.

The remove method reverses the process; here is its implementation:

```
static void
gtk_bin_remove (GtkContainer *container,
                GtkWidget    *child)
{
  GtkBin *bin;
  gboolean widget_was_visible;

  g_return_if_fail (container != NULL);
  g_return_if_fail (GTK_IS_BIN (container));
  g_return_if_fail (child != NULL);
  g_return_if_fail (GTK_IS_WIDGET (child));

  bin = GTK_BIN (container);
  g_return_if_fail (bin->child == child);

  widget_was_visible = GTK_WIDGET_VISIBLE (child);

  gtk_widget_unparent (child);
  bin->child = NULL;
  if (widget_was_visible)
    gtk_widget_queue_resize (GTK_WIDGET (container));
}
```

A remove method is little more than a wrapper for gtk_widget_unparent that queues a resize if necessary. Most remove methods would check the container's GTK_VISIBLE flag before queueing a resize, just as gtk_bin_add() does; GtkBin does not because toplevel widgets like GtkWindow derive from it, and those widgets always queue a resize, regardless of visibility.

Iterating Over Children

Containers have a forall method for iterating over their children; GtkContainer's default methods use forall, since they know nothing about the data members in subclasses' instance structs. The forall method invokes a callback on each child, with the provided callback data as the second argument. Obviously it's going to be trivial for GtkBin:

```
static void
gtk_bin_forall (GtkContainer *container,
                gboolean      include_internals,
                GtkCallback   callback,
                gpointer      callback_data)
{
  GtkBin *bin;

  g_return_if_fail (container != NULL);
  g_return_if_fail (GTK_IS_BIN (container));
  g_return_if_fail (callback != NULL);

  bin = GTK_BIN (container);

  if (bin->child)
    (* callback) (bin->child, callback_data);
}
```

You may notice that GtkBin ignores the include_internals argument. Some containers have "incidental" child widgets in addition to the user-provided children they are primarily designed to hold. For example, GtkNotebook has a widget labelling each of its tabs; GtkCList uses buttons to title each column in the list. These internal widgets must be included in the iteration in many cases; for example, when drawing each child in a container, or destroying each child in a container. However, some operations only operate on the "primary" children, such as the pages in GtkNotebook. The include_internals flag indicates whether to invoke the callback on incidental widgets.

Convenience functions are provided that invoke the forall method; these are used by application authors as well as GtkContainer internals. gtk_container_foreach() iterates over only the primary children of a container, while gtk_container_forall() iterates over all the children.

Child Type

The child_type method returns the type of children a container can hold. For example, a GtkMenuShell (parent class of GtkMenu and GtkMenuBar) can only hold children of type GTK_TYPE_MENU_ITEM. The child_type method allows GUI builders and scripting languages to determine at runtime what sort of children a container will accept. GTK_TYPE_NONE indicates that a container will not accept children at this time, for whatever reason.

The GtkBin implementation accepts GTK_TYPE_WIDGET if the bin is empty, and GTK_TYPE_NONE if the bin already contains a child:

```
static GtkType
gtk_bin_child_type (GtkContainer *container)
{
  if (!GTK_BIN (container)->child)
    return GTK_TYPE_WIDGET;
  else
    return GTK_TYPE_NONE;
}
```

Other GtkBin Functionality

GtkBin also provides default implementations of expose, map, unmap, and draw from GtkWidgetClass. Most GtkBin subclasses will override these methods to handle the unique features of the subclass, but chain up to the GtkBin method to deal with their child widget.

The GtkBin map and unmap implementations are mostly the usual boilerplate (set GTK_MAPPED, show widget->window) but they add an important step unique to containers: mapping the child if it has been shown (remember that GTK_VISIBLE signals a widget has been shown), and unmapping the child when the bin is unmapped. Here's the code:

```
static void
gtk_bin_map (GtkWidget *widget)
{
  GtkBin *bin;

  g_return_if_fail (widget != NULL);
  g_return_if_fail (GTK_IS_BIN (widget));

  GTK_WIDGET_SET_FLAGS (widget, GTK_MAPPED);
  bin = GTK_BIN (widget);

  if (bin->child &&
      GTK_WIDGET_VISIBLE (bin->child) &&
      !GTK_WIDGET_MAPPED (bin->child))
    gtk_widget_map (bin->child);

  if (!GTK_WIDGET_NO_WINDOW (widget))
    gdk_window_show (widget->window);
}

static void
gtk_bin_unmap (GtkWidget *widget)
{
  GtkBin *bin;

  g_return_if_fail (widget != NULL);
  g_return_if_fail (GTK_IS_BIN (widget));

  GTK_WIDGET_UNSET_FLAGS (widget, GTK_MAPPED);
  bin = GTK_BIN (widget);

  if (GTK_WIDGET_NO_WINDOW (widget))
     gtk_widget_queue_clear (widget);
  else
    gdk_window_hide (widget->window);

  if (bin->child && GTK_WIDGET_MAPPED (bin->child))
```

```
    gtk_widget_unmap (bin->child);
}
```

GtkBin's draw and expose implementations simply redraw the child widget; most subclasses will need to override these methods in order to draw themselves, then chain up to draw the child. The code:

```
static void
gtk_bin_draw (GtkWidget    *widget,
              GdkRectangle *area)
{
  GtkBin *bin;
  GdkRectangle child_area;

  g_return_if_fail (widget != NULL);
  g_return_if_fail (GTK_IS_BIN (widget));

  bin = GTK_BIN (widget);

  if (GTK_WIDGET_DRAWABLE (bin))
    {
      if (bin->child && GTK_WIDGET_DRAWABLE (bin->child) &&
          gtk_widget_intersect (bin->child, area, &child_area))
        gtk_widget_draw (bin->child, &child_area);
    }
}

static gint
gtk_bin_expose (GtkWidget      *widget,
                GdkEventExpose *event)
{
  GtkBin *bin;
  GdkEventExpose child_event;

  g_return_val_if_fail (widget != NULL, FALSE);
  g_return_val_if_fail (GTK_IS_BIN (widget), FALSE);
  g_return_val_if_fail (event != NULL, FALSE);

  if (GTK_WIDGET_DRAWABLE (widget))
    {
      bin = GTK_BIN (widget);
      child_event = *event;
      if (bin->child && GTK_WIDGET_DRAWABLE (bin->child) &&
          GTK_WIDGET_NO_WINDOW (bin->child) &&
          gtk_widget_intersect (bin->child, &event->area,
&child_event.area))
        gtk_widget_event (bin->child, (GdkEvent*) &child_event);
    }

  return FALSE;
}
```

Notice that expose events are only generated for windowless widgets; widgets with windows will receive their own expose events. Containers are required to generate expose events for windowless children.

You can probably guess that gtk_widget_intersect() determines the intersection of a rectangle and a child widget.

GtkVBox: A Windowless Container

This section describes some aspects of the GtkVBox widget, which differs substantially from the GtkEv widget presented earlier in the chapter. To understand this section you must first understand how GtkBox works from a user's point of view; see the section called *GtkBox* in the chapter called *GTK+ Basics*. You might want to look through the files gtkvbox.h and gtkvbox.c from your GTK+ distribution as you read.

Most of GtkVBox is implemented in the GtkBox base class; GtkVBox itself implements only size request and allocation. The GtkBox instance struct looks like this:

```

typedef struct _GtkBox        GtkBox;

struct _GtkBox
{
  GtkContainer container;

  GList *children;
  gint16 spacing;
  guint homogeneous : 1;
};
```

GtkBoxClass adds nothing to GtkContainerClass, and GtkVBox adds nothing to GtkBox.

Coding a GTK_NO_WINDOW Widget

The implementation of windowless widgets is slightly different from the implementation of "normal" widgets.

Windowless widgets must set the GTK_NO_WINDOW flag, so GTK+ can treat them appropriately. This should be done in the init function:

```
static void
gtk_box_init (GtkBox *box)
{
  GTK_WIDGET_SET_FLAGS (box, GTK_NO_WINDOW);

  box->children = NULL;
  box->spacing = 0;
  box->homogeneous = FALSE;
}
```

GtkBox uses the default realize method described in the section called *Realization*; because no GdkWindow needs to be created, a GTK_NO_WINDOW widget rarely needs a realize method. Recall that the default realize implementation sets the windowless widget's window field to the parent widget's window field.

Because boxes are invisible layout containers, the GtkBox draw and expose implementations simply pass the draw or expose request on to the box's children. This is identical to GtkBin's draw and expose implementations, except that there's a list of children to iterate over.

A GTK_NO_WINDOW widget that *isn't* invisible, such as GtkLabel, should be careful not to draw a background; the parent widget's background is used.

Size Negotiation

GtkVBox's purpose in life is size negotiation; it passes size requests up from its children, and then divides a size allocation among them. This leads to the layout behavior described in the section called *GtkBox* in the chapter called *GTK+ Basics*.

Here is the size request implementation:

```
static void
gtk_vbox_size_request (GtkWidget      *widget,
                       GtkRequisition *requisition)
{
  GtkBox *box;
  GtkBoxChild *child;
  GtkRequisition child_requisition;
  GList *children;
  gint nvis_children;
  gint height;

  g_return_if_fail (widget != NULL);
  g_return_if_fail (GTK_IS_VBOX (widget));
  g_return_if_fail (requisition != NULL);

  box = GTK_BOX (widget);
  requisition->width = 0;
  requisition->height = 0;
  nvis_children = 0;

  children = box->children;
  while (children)
    {
      child = children->data;
      children = children->next;

      if (GTK_WIDGET_VISIBLE (child->widget))
        {
          gtk_widget_size_request (child->widget, &child_requisition);

          if (box->homogeneous)
            {
              height = child_requisition.height + child->padding * 2;
              requisition->height = MAX (requisition->height, height);
            }
          else
            {
              requisition->height += child_requisition.height +
child->padding * 2;
            }

          requisition->width = MAX (requisition->width,
child_requisition.width);

          nvis_children += 1;
        }
    }

  if (nvis_children > 0)
    {
      if (box->homogeneous)
        requisition->height *= nvis_children;
      requisition->height += (nvis_children - 1) * box->spacing;
    }

  requisition->width += GTK_CONTAINER (box)->border_width * 2;
  requisition->height += GTK_CONTAINER (box)->border_width * 2;
}
```

If the box is homogenous, it multiplies the maximum child requisition times the number of children; otherwise, it sums the child requisitions. Then it adds padding, spacing, and border width, as appropriate. Recall that all containers must honor their border width, set with gtk_container_set_border_width() and available as the border_width field in the GtkContainer instance struct.

When reading this code, it may help to know that GtkBox stores a small struct for each child widget in its children field. The struct looks like this:

```
typedef struct _GtkBoxChild   GtkBoxChild;

struct _GtkBoxChild
{
  GtkWidget *widget;
  guint16 padding;
  guint expand : 1;
  guint fill : 1;
  guint pack : 1;
};
```

Size allocation is more complex; here, all the box-packing flags come into play. It will probably take you a while to fully understand this function, but there is no need to; the important thing is to see how layout takes place via size allocation.

```
static void
gtk_vbox_size_allocate (GtkWidget     *widget,
                        GtkAllocation *allocation)
{
  GtkBox *box;
  GtkBoxChild *child;
  GList *children;
  GtkAllocation child_allocation;
  gint nvis_children;
  gint nexpand_children;
  gint child_height;
  gint height;
  gint extra;
  gint y;

  g_return_if_fail (widget != NULL);
  g_return_if_fail (GTK_IS_VBOX (widget));
  g_return_if_fail (allocation != NULL);

  box = GTK_BOX (widget);
  widget->allocation = *allocation;

  nvis_children = 0;
  nexpand_children = 0;
  children = box->children;

  while (children)
    {
      child = children->data;
      children = children->next;

      if (GTK_WIDGET_VISIBLE (child->widget))
        {
          nvis_children += 1;
          if (child->expand)
            nexpand_children += 1;
        }
    }

  if (nvis_children > 0)
    {
      if (box->homogeneous)
        {
          height = (allocation->height -
                   GTK_CONTAINER (box)->border_width * 2 -
                   (nvis_children - 1) * box->spacing);
          extra = height / nvis_children;
        }
      else if (nexpand_children > 0)
        {
          height = (gint) allocation->height - (gint)
widget->requisition.height;
          extra = height / nexpand_children;
        }
      else
        {
          height = 0;
          extra = 0;
        }

      y = allocation->y + GTK_CONTAINER (box)->border_width;
      child_allocation.x = allocation->x + GTK_CONTAINER
(box)->border_width;
      child_allocation.width = MAX (1, (gint) allocation->width - (gint)
GTK_CONTAINER (box)->border_width * 2);

      children = box->children;
      while (children)
        {
          child = children->data;
          children = children->next;

          if ((child->pack == GTK_PACK_START) && GTK_WIDGET_VISIBLE
(child->widget))
            {
              if (box->homogeneous)
                {
                  if (nvis_children == 1)
                    child_height = height;
                  else
```

```
                    child_height = extra;

                  nvis_children -= 1;
                  height -= extra;
                }
              else
                {
                  GtkRequisition child_requisition;

                  gtk_widget_get_child_requisition (child->widget,
&child_requisition);
                  child_height = child_requisition.height +
child->padding * 2;

                  if (child->expand)
                    {
                      if (nexpand_children == 1)
                        child_height += height;
                      else
                        child_height += extra;

                      nexpand_children -= 1;
                      height -= extra;
                    }
                }

              if (child->fill)
                {
                  child_allocation.height = MAX (1, child_height -
(gint)child->padding * 2);
                  child_allocation.y = y + child->padding;
                }
              else
                {
                  GtkRequisition child_requisition;

                  gtk_widget_get_child_requisition (child->widget,
&child_requisition);
                  child_allocation.height = child_requisition.height;
                  child_allocation.y = y + (child_height -
child_allocation.height) / 2;
                }

              gtk_widget_size_allocate (child->widget,
&child_allocation);

              y += child_height + box->spacing;
            }
        }

      y = allocation->y + allocation->height - GTK_CONTAINER
(box)->border_width;

      children = box->children;
      while (children)
        {
          child = children->data;
          children = children->next;

          if ((child->pack == GTK_PACK_END) && GTK_WIDGET_VISIBLE
(child->widget))
            {
              GtkRequisition child_requisition;
              gtk_widget_get_child_requisition (child->widget,
&child_requisition);

              if (box->homogeneous)
                {
                  if (nvis_children == 1)
                    child_height = height;
                  else
                    child_height = extra;

                  nvis_children -= 1;
                  height -= extra;
                }
              else
                {
                  child_height = child_requisition.height +
child->padding * 2;

                  if (child->expand)
                    {
                      if (nexpand_children == 1)
                        child_height += height;
                      else
                        child_height += extra;
                      nexpand_children -= 1;
                      height -= extra;
                    }
                }

              if (child->fill)
                {
                  child_allocation.height = MAX (1, child_height -
(gint)child->padding * 2);
                  child_allocation.y = y + child->padding -
child_height;
                }
              else
                {
                  child_allocation.height = child_requisition.height;
                  child_allocation.y = y + (child_height -
child_allocation.height) / 2 - child_height;
                }

              gtk_widget_size_allocate (child->widget,
&child_allocation);

              y -= (child_height + box->spacing);
            }
        }
    }
}
```

Child Arguments

GtkBox implements *child arguments*, which were briefly described in the section called *Using Object Arguments in Your Own GtkObject Subclass* in the chapter called *The GTK+ Object and Type System*. Child arguments represent a property of a pair of objects. In this case, the box-packing flags for each child can be read and written using the object argument system.

Here's how GtkBox registers its child arguments, in gtk_box_class_init():

```
  gtk_container_add_child_arg_type ("GtkBox::expand", GTK_TYPE_BOOL,
GTK_ARG_READWRITE, CHILD_ARG_EXPAND);
```

```
  gtk_container_add_child_arg_type ("GtkBox::fill", GTK_TYPE_BOOL,
GTK_ARG_READWRITE, CHILD_ARG_FILL);
  gtk_container_add_child_arg_type ("GtkBox::padding", GTK_TYPE_ULONG,
GTK_ARG_READWRITE, CHILD_ARG_PADDING);
  gtk_container_add_child_arg_type ("GtkBox::pack_type",
GTK_TYPE_PACK_TYPE, GTK_ARG_READWRITE, CHILD_ARG_PACK_TYPE);
  gtk_container_add_child_arg_type ("GtkBox::position", GTK_TYPE_LONG,
GTK_ARG_READWRITE, CHILD_ARG_POSITION);
```

GtkBox then implements the get_child_arg and set_child_arg methods from GtkContainerClass. Here's gtk_box_get_child_arg(); the gtk_box_set_child_arg() is analagous.

```
static void
gtk_box_get_child_arg (GtkContainer   *container,
                       GtkWidget      *child,
                       GtkArg         *arg,
                       guint           arg_id)
{
  gboolean expand = 0;
  gboolean fill = 0;
  guint padding = 0;
  GtkPackType pack_type = 0;
  GList *list;

  if (arg_id != CHILD_ARG_POSITION)
    gtk_box_query_child_packing (GTK_BOX (container),
                                 child,
                                 &expand,
                                 &fill,
                                 &padding,
                                 &pack_type);

  switch (arg_id)
    {
    case CHILD_ARG_EXPAND:
      GTK_VALUE_BOOL (*arg) = expand;
      break;
    case CHILD_ARG_FILL:
      GTK_VALUE_BOOL (*arg) = fill;
      break;
    case CHILD_ARG_PADDING:
      GTK_VALUE_ULONG (*arg) = padding;
      break;
    case CHILD_ARG_PACK_TYPE:
      GTK_VALUE_ENUM (*arg) = pack_type;
      break;
    case CHILD_ARG_POSITION:
      GTK_VALUE_LONG (*arg) = 0;
      for (list = GTK_BOX (container)->children; list; list = list->next)
        {
          GtkBoxChild *child_entry;

          child_entry = list->data;
          if (child_entry->widget == child)
            break;
          GTK_VALUE_LONG (*arg)++;
        }
      if (!list)
        GTK_VALUE_LONG (*arg) = -1;
      break;
    default:
      arg->type = GTK_TYPE_INVALID;
      break;
    }
}
```

GnomeAppBar: A Trivial Composite Widget

This section quickly describes the GnomeAppBar widget; GnomeAppBar demonstrates how to bundle a pre-packed container and some special functionality into a single new object. the section called *GnomeAppBar* in the chapter called *The Main Window: GnomeApp* describes GnomeAppBar from a user's point of view.

A composite widget derives from some kind of container, then adds child widgets and sets up callbacks to implement some sort of functionality. GnomeAppBar derives from GtkHBox; the box is packed with a progress bar and/or a status line. GnomeAppBar has members in its instance struct to store a stack of status messages, and it adds some signals to the class struct for use with its "interactive" mode.

As an aside, GnomeAppBar does not follow the GTK+/Gnome naming conventions; because Bar is capitalized, the functions and macros should have an underscore, i.e. app_bar rather than appbar. Don't copy this aspect of the widget.

Here's the implementation of gnome_appbar_new():

```
GtkWidget*
gnome_appbar_new (gboolean has_progress,
                  gboolean has_status,
                  GnomePreferencesType interactivity)
{
  GnomeAppBar * ab = gtk_type_new (gnome_appbar_get_type ());

  gnome_appbar_construct(ab, has_progress, has_status, interactivity);

  return GTK_WIDGET(ab);
}

void
gnome_appbar_construct(GnomeAppBar * ab,
                       gboolean has_progress,
                       gboolean has_status,
                       GnomePreferencesType interactivity)
{
  GtkBox *box;


  g_return_if_fail( ((has_status == FALSE) &&
                     (interactivity == GNOME_PREFERENCES_NEVER)) ||
                    (has_status == TRUE));

  box = GTK_BOX (ab);

  box->spacing = GNOME_PAD_SMALL;
  box->homogeneous = FALSE;

  if (has_progress)
    ab->progress = gtk_progress_bar_new();
  else
    ab->progress = NULL;

  /*
```

```
   * If the progress meter goes on the right then we place it after we
   * create the status line.
   */
  if (has_progress && !gnome_preferences_get_statusbar_meter_on_right
())
    gtk_box_pack_start (box, ab->progress, FALSE, FALSE, 0);

  if ( has_status ) {
    if ( (interactivity == GNOME_PREFERENCES_ALWAYS) ||
         ( (interactivity == GNOME_PREFERENCES_USER) &&
           gnome_preferences_get_statusbar_interactive()) ) {
      ab->interactive = TRUE;

      ab->status = gtk_entry_new();

      gtk_signal_connect (GTK_OBJECT(ab->status), "delete_text",
                          GTK_SIGNAL_FUNC(entry_delete_text_cb),
                          ab);
      gtk_signal_connect (GTK_OBJECT(ab->status), "insert_text",
                          GTK_SIGNAL_FUNC(entry_insert_text_cb),
                          ab);
      gtk_signal_connect_after(GTK_OBJECT(ab->status),
"key_press_event",
                               GTK_SIGNAL_FUNC(entry_key_press_cb),
                               ab);
      gtk_signal_connect(GTK_OBJECT(ab->status), "activate",
                         GTK_SIGNAL_FUNC(entry_activate_cb),
                         ab);

      /* no prompt now */
      gtk_entry_set_editable(GTK_ENTRY(ab->status), FALSE);

      gtk_box_pack_start (box, ab->status, TRUE, TRUE, 0);
    }
    else {
      GtkWidget * frame;

      ab->interactive = FALSE;

      frame = gtk_frame_new (NULL);
      gtk_frame_set_shadow_type (GTK_FRAME(frame), GTK_SHADOW_IN);

      ab->status = gtk_label_new ("");
      gtk_misc_set_alignment (GTK_MISC (ab->status), 0.0, 0.0);
      gtk_box_pack_start (box, frame, TRUE, TRUE, 0);
      gtk_container_add (GTK_CONTAINER(frame), ab->status);

      gtk_widget_show (frame);
    }
  }
  else {
    ab->status = NULL;
    ab->interactive = FALSE;
  }

  if (has_progress && gnome_preferences_get_statusbar_meter_on_right
())
    gtk_box_pack_start (box, ab->progress, FALSE, FALSE, 0);

  if (ab->status) gtk_widget_show (ab->status);
  if (ab->progress) gtk_widget_show(ab->progress);
}
```

Most of this code could be in the instance initializer; it's in the constructor instead because it's dependent on the arguments passed to gnome_appbar_new(). There's not much to explain here; the code is straightforward. Do notice that gtk_widget_show() is called for each child widget; this ensures that the right thing happens when the user calls gtk_widget_show() on GnomeAppBar. Another approach would be to override the map method and map all children (normally, containers such as GtkBox only map children that have been shown). When you're writing a composite container, keep the gtk_widget_show_all() function in mind; never rely on hiding child widgets, because the user might accidentally show them.

A composite widget is just a special case of extending a base widget with additional functionality. You can extend widgets without adding new children to them; for example, GtkClock extends GtkLabel by constantly changing the label to reflect the time.

Other Examples

Here are some other widgets you might look at for inspiration and code; of course, these are only a few of the many widgets in GTK+ and Gnome. Appendix A gives a more comprehensive list of the available widgets, and a brief description of each one.

- Bins: GtkEventBox, GtkFrame, GtkButton
- Containers: GtkBox, GtkTable
- Composites: GtkFileSelection, GnomeAppBar
- Windowless: GtkLabel, GtkBox
- Set scroll adjustments: GtkCList, GtkLayout
- Activatable: GtkButton, GtkMenuItem
- Toplevel: GtkWindow
- Multiple GdkWindows: GtkCList,
- Extended Functionality for Existing Widgets: GtkClock, GnomeEntry, GtkCurve
- Floating Windows: GnomeDock, GtkHandleBox

GnomeCanvas

Table of Contents

This chapter describes the GnomeCanvas widget, and the standard canvas items that come with Gnome. The following chapter discusses in more detail how to write a custom canvas item.

Introduction to the Canvas

The canvas widget is a powerful and extensible object-oriented display engine, useful in a wide variety of Gnome applications. The widget itself is simply a blank area; you can place GnomeCanvasItems on it. A GnomeCanvasItem is a GtkObject representing some element of the display, such as an image, a rectangle, an ellipse, or some text. You can refer to this architecture as *structured graphics*; the canvas lets you deal with graphics in terms of items, rather than an undifferentiated grid of pixels. Since a GnomeCanvasItem is a GtkObject, you can create your own subclasses to supplement those that come with Gnome. This gives you quite a bit of flexibility. Using custom canvas items, the canvas can render almost anything. At the same time, you can use stock canvas items to save time and effort. The canvas puts you in control.

GnomeCanvas has two modes, representing a quality/speed tradeoff. In "GDK" mode, canvas items render directly to a GdkPixmap buffer using the GDK drawing primitives. The canvas copies the buffer to the screen once all items are rendered. In antialiased or "AA" mode, the canvas items write RGB pixels to a vector of bytes; after all the items have drawn on the RGB buffer, the canvas copies it to the screen. This RGB buffer mode is called "antialiased" mode because all the standard canvas items draw to the RGB buffer using the high-quality antialiased routines in libart_lgpl. This results in smooth lines and very high display quality, with some cost in speed.

Basic Canvas Architecture

This section introduces the architecture of the canvas, including the arrangement of items into hierarchical groups, and the many coordinate systems involved in using the canvas.

GnomeCanvasGroup

Canvas items are arranged in a tree structure. You can group items together, to be moved as a unit; canvas architect Federico Mena Quintero likes to use a circuit diagram editor as an example. You might group together the shapes representing each logic gate, so you could manipulate the logic gate as a unit. You could also collect several logic gates into a single component; that is, groups can contain subgroups. Within each group, the canvas maintains a stacking order; objects higher in the stacking order obscure objects lower in the stacking order.

To implement this, the canvas comes with a special kind of canvas item called GnomeCanvasGroup. As the name suggests, a canvas group groups a number canvas items together so you can manipulate the child items as a single item. A GnomeCanvasGroup is invisible; to render itself, it simply recurses its children, rendering each of them in turn. When you create a new GnomeCanvas, a default group called the "root" is created for you. All canvas items are added somewhere below the root group. The canvas widget only deals with the root canvas item directly; all other canvas items are managed by their parent group.

An accessor function is provided to access the root canvas group, shown in Figure 1.

```
#include <libgnomeui/gnome-canvas.h>
```

GnomeCanvasGroup* gnome_canvas_root(GnomeCanvas* *canvas*);

Figure 1. Root Group Accessor

Items must always be part of a group; there is no such thing as an "orphan" canvas item. When you create an item, you must specify its canvas group. It is also possible to reparent items after creation. However, items are permanently bound to the GnomeCanvas they were created on; it is not permitted to reparent an item to a group on a different canvas.

Coordinates

Many of the features of the canvas are implemented via translations between different coordinate systems. Canvas items can be moved, rotated, or scaled via *affine transformations*, described in more detail below. (Short version: an affine transformation is a way to convert from one coordinate system to another.) Here are the important coordinate systems which come up when using the canvas and writing custom canvas items:

- *World coordinates* are an absolute coordinate system; i.e., the same world coordinate refers to the same place on the canvas in all cases. World coordinates are conceptually infinite and are represented by a double. World coordinates are the real, toplevel, untransformed, canonical coordinate system. Consistent with the X Window System and GDK, Y coordinates increase as they move *downward*, so lower Y coordinates are toward the top of the canvas.
- *Item coordinates* are the coordinates used by a particular canvas item. Item coordinates exist because each canvas item has an affine transformation associated with it. In the case of GnomeCanvasGroup, this transformation is applied to the group's children. To convert from world coordinates to item coordinates for some particular item, you apply the transform for each canvas group in the item's ancestry, starting with the root canvas group; then you apply the item's own transform. (Don't worry, Gnome comes with a function to do this for you.) Like world coordinates, item coordinates are conceptually infinite.
- *Canvas coordinates* are pixel coordinates. While item and world coordinates are floating-point numbers, canvas pixel coordinates are integers. To use the canvas, you must specify a "scroll region," which is the rectangle in world coordinate space you want the user to be able to see. Canvas pixel coordinates are relative to this rectangle. Canvas pixel coordinates also take into account a scaling factor representing the number of pixels per world coordinate unit. To convert from world coordinates to canvas coordinates, the canvas subtracts the X and Y coordinates of the scroll region, multiplies by the scaling factor, and then rounds

to an integer. Thus, (0,0) in canvas coordinates will be the top left corner of the scroll region.

- *Buffer coordinates* are canvas coordinates modified by some offset. Item implementations use these during rendering. The canvas passes the item implementation a buffer (which is either a GdkDrawable or an RGB buffer, depending on the canvas mode). The canvas tells the item implementation which region of the screen the buffer represents---the buffer region is defined by an X offset, Y offset, width and height. The X and Y offsets are in canvas coordinates, and are equivalent to (0,0) in buffer coordinates. To convert from canvas coordinates to buffer coordinates, simply subtract the offset. Buffer coordinates are only valid from (0,0) to the maximum width and height of the buffer.
- *Window coordinates* are rarely used. The canvas eventually copies each temporary buffer to a GdkWindow (to be precise, it copies them to GTK_LAYOUT(canvas)->bin_window). Window coordinates are relative to this GdkWindow. In some rare cases you might want to draw to the window directly rather than using a canvas item, or you might want to respond to an event on the window (such as a drag-and-drop). Then you need to convert from window coordinates to one of the other coordinate systems.

When using preexisting canvas items, you will mostly be interested in world and item coordinates. When writing your own items, you will also need to use canvas and buffer coordinates.

There are two ways to convert between the various coordinate systems; one way is to obtain and use affines directly---this is described in the next section. The easy way is to use one of the convenience functions provided for the purpose, shown in Figure 2. Conversion between canvas and item coordinates requires you to convert to world coordinates first as an intermediate step. There is no function to convert to or from buffer coordinates, because this is a simple matter of subtracting the buffer offsets from the canvas coordinates (canvas to buffer), or adding the buffer offsets to the buffer coordinates (buffer to canvas).

```
#include <libgnomeui/gnome-canvas.h>
```

void gnome_canvas_w2c(GnomeCanvas* *canvas*, double *wx*, double *wy*, int* *cx*, int* *cy*);

void gnome_canvas_w2c_d(GnomeCanvas* *canvas*, double *wx*, double *wy*, double* *cx*, double* *cy*);

void gnome_canvas_c2w(GnomeCanvas* *canvas*, int *cx*, int *cy*, double* *wx*, double* *wy*);

void gnome_canvas_item_w2i(GnomeCanvasItem* *item*, double* *x*, double* *y*);

void gnome_canvas_item_i2w(GnomeCanvasItem* *item*, double* *x*, double* *y*);

void gnome_canvas_window_to_world(GnomeCanvas* *canvas*, double *winx*, double *winy*, double* *worldx*, double* *worldy*);

void gnome_canvas_world_to_window(GnomeCanvas* *canvas*, double *worldx*, double *worldy*, double* *winx*, double* *winy*);

Figure 2. Coordinate Conversions

Affine Transformations

An *affine* is a transformation matrix made up of six real numbers that can be *applied* to an ordered pair. Depending on the contents of the affine, the point it is applied to can be:

- *translated*---shifted by an arbitrary distance in either dimension;
- *rotated* some number of degrees;
- *scaled* by some factor.

Conceptually, an affine defines a relationship between points on a plane. For any point (A,B), the affine defines a single corresponding transformed point; the mapping is one-to-one, so given the transformed point you can determine the original point.

Affines have interesting properties that make them useful in computer graphics. Most importantly, they can be *composed*, *concatenated*, or *multiplied* (the three terms are synonymous). You can compose any number of affines to create a single affine; applying the single affine has the same effect as applying each of the original affines in order. Note that the order of composition is important! Unlike multiplication, affine composition is not commutative (which is a reason to avoid the term "multiply" in this context).

libart_lgpl contains a module for affine manipulation. It represents affines as an array of six doubles. Its affine functions are shown in Figure 3.

```
       #include <libart_lgpl/art_affine.h>
```

void art_affine_point(ArtPoint* *dst*, const ArtPoint* *src*, const double *affine[6]*);

void art_affine_invert(double *dst_affine[6]*, const double *src_affine[6]*);

void art_affine_multiply(double *dst[6]*, const double *src1[6]*, const double *src2[6]*);

void art_affine_identity(double *dst[6]*);

void art_affine_scale(double *dst[6]*, double *sx*, double *sy*);

void art_affine_rotate(double *dst[6]*, double *theta*);

void art_affine_translate(double *dst[6]*, double *tx*, double *ty*);

int art_affine_rectilinear(const double *src[6]*);

Figure 3. Affine Manipulation

art_affine_point() applies an affine to a point. The affine is applied to the second argument (src) and the result is copied into the first argument (dst). An ArtPoint is simply:

```
typedef struct _ArtPoint ArtPoint;

struct _ArtPoint {
  double x, y;
};
```

Affines can be *inverted*. If an affine converts points in coordinate system A into points in coordinate system B, its inverse converts points in coordinate system B into points in coordinate system A. art_affine_invert() fills its first argument with the inverse of its second.

art_affine_multiply() composes two affines as described earlier in this section, placing the result in its first argument.

Four functions are provided to create affines with particular properties.

- art_affine_identity() creates the identity affine. Applying the identity affine to a point has no effect.
- art_affine_rotate() gives an affine that rotates points by theta degrees.
- art_affine_translate() gives an affine that translates points tx in the X dimension and ty in the Y dimension.
- art_affine_scale() gives an affine which scales the plane by the given factors (a factor of 1.0 does no scaling, less than 1.0 shrinks, greater than 1.0 expands).

art_affine_rectilinear() returns TRUE if the affine rotates rectangles aligned to the axes in such a way that they remain aligned to the axes. That is, it returns TRUE if the rotation is 0, 90, 180, or 270 degrees.

You can ask the canvas widget to compute affines which convert between its various coordinate systems. These functions are shown in Figure 4; each of them fills an array you pass in with the affine being requested.

```
       #include <libgnomeui/gnome-canvas.h>
```

void gnome_canvas_item_i2w_affine(GnomeCanvasItem* *item*, double *affine[6]*);

void gnome_canvas_item_i2c_affine(GnomeCanvasItem* *item*, double *affine[6]*);

void gnome_canvas_w2c_affine(GnomeCanvas* *canvas*, double *affine[6]*);

Figure 4. Canvas Affines

Using the Canvas

GnomeCanvas is easy to use; this is its virtue compared to GtkDrawingArea or some other low-level approach. This section describes how to create a canvas, and work with canvas items. It ends with a programming example.

Preparing the GnomeCanvas Widget

The first decision you have to make is whether to use the canvas in GDK mode or antialiased mode. When you create a canvas widget, you must specify the mode you want; there is no way to change it later. gnome_canvas_new() creates a GDK canvas. gnome_canvas_new_aa() creates an antialiased canvas. These are shown in Figure 5.

Sometimes it matters which visual and colormap the canvas will use. In particular:

- In GDK mode, if you want to use the GnomeCanvasImage item to display images, you must use Imlib's visual and colormap. GnomeCanvasImage uses Imlib to render images.
- In antialiased mode, GDK's RGB buffer rendering facilities (see the section called *RGB Buffers* in the chapter called *GDK Basics*) are used to copy the RGB buffer to the screen. You must use the visual and colormap from the GDK RGB module.

To create a widget with a non-default visual and colormap, gtk_widget_push_visual() and gtk_widget_push_colormap() are used. Here is the code to create a GDK canvas that supports the image item:

```
GtkWidget* canvas;
gtk_widget_push_visual(gdk_imlib_get_visual());
gtk_widget_push_colormap(gdk_imlib_get_colormap());
canvas = gnome_canvas_new();
gtk_widget_pop_visual();
gtk_widget_pop_colormap();
```

To create an antialiased canvas, do this:

```
GtkWidget* canvas;
gtk_widget_push_visual(gdk_rgb_get_visual());
gtk_widget_push_colormap(gdk_rgb_get_cmap());
canvas = gnome_canvas_new_aa();
gtk_widget_pop_colormap();
gtk_widget_pop_visual();


    #include <libgnomeui/gnome-canvas.h>
```

GtkWidget* gnome_canvas_new(void);

GtkWidget* gnome_canvas_new_aa(void);

Figure 5. Canvas Constructors

Scroll Region

The canvas is practically infinite from a programmer's standpoint; however, in reality your application probably uses only a small area. When using the canvas you must specify which region is interesting to the user with gnome_canvas_set_scroll_region() (Figure 6). The scroll region is given in world coordinates. You can query the scroll region with gnome_canvas_get_scroll_region().

To add scroll bars to the canvas, simply create a GtkScrolledWindow and add the canvas to it:

```
GtkWidget* sw;
sw = gtk_scrolled_window_new(NULL, NULL);
gtk_container_add(GTK_CONTAINER(sw), canvas);
```

If you want to implement scrolling via some mechanism other than the scroll bars, you can get and set the "scroll offsets." The scroll offsets are in canvas pixel coordinates; they specify the top left visible pixel. Remember that canvas pixel coordinates are relative to the scroll region.

```
        #include <libgnomeui/gnome-canvas.h>
```

void gnome_canvas_set_scroll_region(GnomeCanvas* *canvas*, double *x1*, double *y1*, double *x2*, double *y2*);

void gnome_canvas_get_scroll_region(GnomeCanvas* *canvas*, double* *x1*, double* *y1*, double* *x2*, double* *y2*);

void gnome_canvas_scroll_to(GnomeCanvas* *canvas*, gint *cx*, gint *cy*);

void gnome_canvas_get_scroll_offsets(GnomeCanvas* *canvas*, gint* *cx*, gint* *cy*);

Figure 6. Canvas Scrolling

Zooming

The canvas gives you zooming "for free"; it is included in the world-to-canvas and canvas-to-world coordinate system conversions. You can set the zoom factor with gnome_canvas_set_pixels_per_unit() (Figure 7). By default, there ratio of pixels to canvas units is 1.0, meaning no zoom. Specifying a value less than 1.0 means reduced size; greater than 1.0 means increased size.

In antialiased mode, you could achieve the same visual effect by applying a scaling affine transformation to the root canvas group. The pixels_per_unit member of the GnomeCanvas struct predates the canvas's use of affines. Still, gnome_canvas_set_pixels_per_unit() is a bit more convenient than the affine transform method, and it does work in GDK mode. (Because GDK mode uses Xlib primitives, it's nontrivial to implement arbitrary affine transformations; a future version of Gnome may do so, however.)

```
        #include <libgnomeui/gnome-canvas.h>
```

void gnome_canvas_set_pixels_per_unit(GnomeCanvas* *canvas*, double *ppu*);

Figure 7. Canvas Zooming

Canvas Items

Most of the time you will be interested in canvas items rather than the canvas itself. Canvas items are typically very easy to use, compared to widgets; none of the standard items have any unique signals, since they are not interactive. (Since GnomeCanvasItem is a subclass of GtkObject, however, you could certainly have an item with signals if you wanted to.) The GnomeCanvasItem base class has a single signal, "event", which is used to convey all types of event. The "event" signal has no default handler; canvas items do not respond to events unless you connect handlers of your own. Figure 8 lists all the useful functions for working with the GnomeCanvasItem base class.

To create a canvas item, you use the generic gnome_canvas_item_new() (or gnome_canvas_item_newv()). This function accepts the group to place the item in, the GtkType of the GnomeCanvasItem subclass to create, and finally a NULL-terminated list of arguments to set. The argument list is purely for convenience, so you don't have to call gnome_canvas_item_set()

immediately. gnome_canvas_item_new() creates a new instance of the type with gtk_type_new(), adds the item to its GnomeCanvasGroup, and schedules it to be redrawn.

To destroy an item and remove it from the canvas, simply call gtk_object_destroy(). You can also use the standard reference counting mechanism with canvas items.

You can set an item's affine using gnome_canvas_item_affine_absolute(), or compose a new affine with the item's existing affine using gnome_canvas_item_affine_relative(). These functions can be used to translate, scale, or rotate a canvas item (however, scaling and rotation only work in antialiased mode).

Items in a group are normally stacked in the order you add them, with the most recently-added item "on top" and the oldest item on the bottom. You can manipulate the stacking order with gnome_canvas_item_raise() and gnome_canvas_item_lower(). These move an item up or down by the given number of positions. It is safe to pass in a too-large value for positions; the item will be moved as far as possible and no more. You can also request that an item is moved to one extreme or the other, using gnome_canvas_item_raise_to_top() and gnome_canvas_item_lower_to_bottom.

Items can be shown and hidden; hidden items are not rendered by the canvas and do not receive events. All items are visible by default. The routines are gnome_canvas_item_show() and gnome_canvas_item_hide().

Reparenting a canvas item is straightforward; the only rule is that the new group must be on the same canvas as the old group.

gnome_canvas_item_grab_focus() is analagous to gtk_widget_grab_focus(); it sends all key events to the item with the grab. It also sends focus change events to the item (when the item gains or loses the focus).

Canvas items can grab and ungrab the mouse pointer just as a GdkWindow can; the arguments to gnome_canvas_item_grab() are exactly analagous to those of gdk_pointer_grab() (see the chapter called *GDK Basics*). While a canvas item has the pointer grabbed, no other item receives events. Behind the scenes, GnomeCanvas uses gdk_pointer_grab() to implement gnome_canvas_item_grab(), so an item grabbing the mouse away from other items implies the canvas grabbing the mouse away from other widgets.

The visual properties of canvas items are manipulated almost entirely via object arguments. If you skipped the chapter called *The GTK+ Object and*

Type System, go back and read the section on object arguments now. Two functions are used to set canvas item properties: gnome_canvas_item_set() and gnome_canvas_item_setv(). These are almost but not quite equivalent to gtk_object_set() and gtk_object_setv()---they set object arguments in the same way, but they also mark the canvas item to be redrawn. So you should prefer them to the GtkObject variants. (This is something of a design bug, and future canvas versions will most likely allow you to use gtk_object_set().)

gnome_canvas_item_request_update() marks the canvas item as "dirty" and queues it to be redrawn. Internally, the canvas uses a one-shot idle function to perform redraws; that is, it waits until no more GTK+ events are pending, then redraws itself a single time. It does this by installing an idle function with gtk_idle_add() and removing it after it runs once. Thus gnome_canvas_item_request_update() can be called many times without creating an efficiency problem---it pretty much does nothing at all if an update is already pending.

```
       #include <libgnomeui/gnome-canvas.h>
```

GnomeCanvasItem* gnome_canvas_item_new(GnomeCanvasGroup* *parent*, GtkType *type*, const gchar* *first_arg_name*, ...);

GnomeCanvasItem* gnome_canvas_item_newv(GnomeCanvasGroup* *parent*, GtkType *type*, guint *nargs*, GtkArg* *args*);

void gnome_canvas_item_set(GnomeCanvasItem* *item*, const gchar* *first_arg_name*, ...);

void gnome_canvas_item_setv(GnomeCanvasItem* *item*, guint *nargs*, GtkArg* *args*);

void gnome_canvas_item_affine_relative(GnomeCanvasItem* *item*, const double *affine[6]*);

void gnome_canvas_item_affine_absolute(GnomeCanvasItem* *item*, const double *affine[6]*);

void gnome_canvas_item_raise(GnomeCanvasItem* *item*, int *positions*);

void gnome_canvas_item_lower(GnomeCanvasItem* *item*, int *positions*);

void gnome_canvas_item_raise_to_top(GnomeCanvasItem* *item*);

void gnome_canvas_item_lower_to_bottom(GnomeCanvasItem* *item*);

void gnome_canvas_item_show(GnomeCanvasItem* *item*);

void gnome_canvas_item_hide(GnomeCanvasItem* *item*);

void gnome_canvas_item_reparent(GnomeCanvasItem* *item*, GnomeCanvasGroup* *new_group*);

void gnome_canvas_item_grab_focus(GnomeCanvasItem* *item*);

int gnome_canvas_item_grab(GnomeCanvasItem* *item*, unsigned int *event_mask*, GdkCursor* *cursor*, guint32 *etime*);

void gnome_canvas_item_ungrab(GnomeCanvasItem* *item*, guint32 *etime*);

void gnome_canvas_item_get_bounds(GnomeCanvasItem* *item*, double* *x1*, double* *y1*, double* *x2*, double* *y2*);

void gnome_canvas_item_request_update(GnomeCanvasItem* *item*);

Figure 8. Using GnomeCanvasItem

Canvas Items and Events

The standard Gnome canvas items have only one signal, "event", which is emitted for *all* types of event. The canvas widget preprocesses all GDK events that it receives, and forwards some of them to canvas items. It also sythesizes certain events. Remember that X sends events only to X windows (GdkWindows), and canvas items do not have an associated GdkWindow. Thus the canvas widget must act as intermediary. Here are some of the actions it takes:

- Coordinates are automatically converted to canvas world coordinates. For example, if a canvas item receives an event of type GDK_BUTTON_PRESS, the x and y fields of the event will be in world coordinates. (The raw event was received on the canvas's GdkWindow and thus had window coordinates.)
- Enter/leave events are synthesized for canvas items as the mouse pointer moves across the canvas.
- Events are propagated up the canvas item hierarchy, until some item's "event" signal handler returns TRUE. This works just as it does with GtkWidget; events are first sent to the bottommost or leaf canvas item, and eventually make it up to the root item.

- Only user-generated events are sent to canvas items; many events you might expect to receive on a GdkWindow, such as expose and configure events, are not forwarded to canvas items.

The canvas does this work behind the scenes, so item events work intuitively and much like normal GDK events.

A canvas item event callback looks like this:

```
static gint
item_event_callback(GnomeCanvasItem* item,
                    GdkEvent* event,
                    gpointer data)
{
  switch (event->type) {
    case GDK_BUTTON_PRESS:
      break;

    case GDK_MOTION_NOTIFY:
      break;

    case GDK_BUTTON_RELEASE:
      break;

    default:
      break;
  }

  /* Returning FALSE propagates the event to parent items;
   * returning TRUE ends event propagation.
   */
  return FALSE;
}
```

Of course, a real callback would probably examine the contents of the event and take some action in response to some of them.

A Canvas Example

This section gives a brief example program, demonstrating the user of the canvas. It does not explain the particulars of the canvas items being created; see the section called *Standard Canvas Item Reference* for that. Figure 9 shows the example program in action. You can drag canvas items around the screen with the left mouse button; clicking an item with the Shift key held down destroys it.

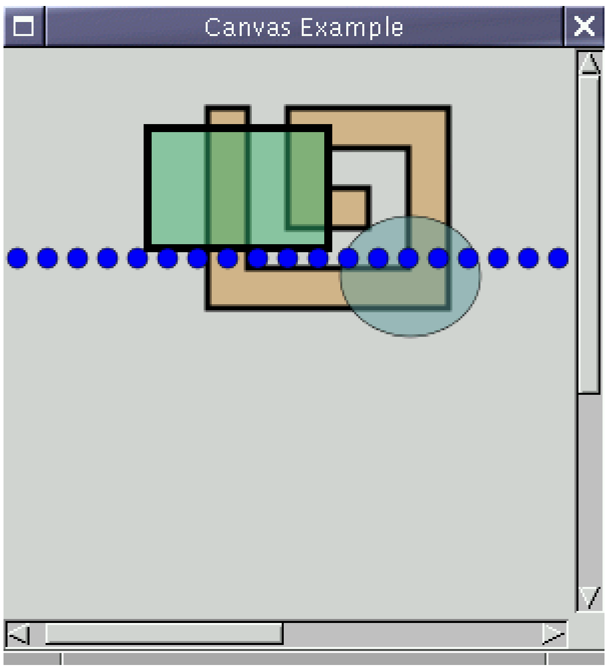


Figure 9. Simple GnomeCanvas program

Here is the code to create an antialiased canvas. Notice the call to gdk_rgb_init(); notice that the canvas's scroll region is set; finally, notice that the GdkRGB colormap and visual are pushed when creating the canvas.

```
#include <gnome.h>

static gint delete_event_cb(GtkWidget* window, GdkEventAny* e, gpointer
data);
static void create_canvas_items(GtkWidget* canvas);

int
main(int argc, char* argv[])
{
  GtkWidget* window;
  GtkWidget* sw;
  GtkWidget* canvas;

  gnome_init("canvas-example", "0.0", argc, argv);
  gdk_rgb_init();

  window = gtk_window_new(GTK_WINDOW_TOPLEVEL);

  gtk_window_set_title(GTK_WINDOW(window), "Canvas Example");

  gtk_window_set_policy(GTK_WINDOW(window), TRUE, TRUE, TRUE);

  gtk_signal_connect(GTK_OBJECT(window),
                     "delete_event",
                     GTK_SIGNAL_FUNC(delete_event_cb),
                     NULL);

  sw = gtk_scrolled_window_new(NULL, NULL);

  gtk_scrolled_window_set_policy(GTK_SCROLLED_WINDOW(sw),
                                 GTK_POLICY_AUTOMATIC,
                                 GTK_POLICY_AUTOMATIC);



  gtk_widget_push_visual(gdk_rgb_get_visual());
  gtk_widget_push_colormap(gdk_rgb_get_cmap());
  canvas = gnome_canvas_new_aa();
  gtk_widget_pop_colormap();
  gtk_widget_pop_visual();

  gnome_canvas_set_scroll_region(GNOME_CANVAS(canvas), 0, 0, 600, 450);

  create_canvas_items(canvas);

  gtk_container_add(GTK_CONTAINER(sw), canvas);
  gtk_container_add(GTK_CONTAINER(window), sw);

  gtk_window_set_default_size(GTK_WINDOW(window), 300, 300);

  gtk_widget_show_all(window);

  gtk_main();

  return 0;
}

static gint
```

```
delete_event_cb(GtkWidget* window, GdkEventAny* e, gpointer data)
{
  gtk_main_quit();
  return FALSE;
}
```

Once the canvas has been created, the program adds some items to it, and connects a simple callback to the item's "event" signal. Here's the code:

```
static gint
item_event(GnomeCanvasItem *item, GdkEvent *event, gpointer data)
{
  static double x, y;
  double new_x, new_y;
  GdkCursor *fleur;
  static int dragging;
  double item_x, item_y;

  item_x = event->button.x;
  item_y = event->button.y;
  gnome_canvas_item_w2i(item->parent, &item_x, &item_y);

  switch (event->type)
    {
    case GDK_BUTTON_PRESS:
      switch(event->button.button)
        {
        case 1:
          if (event->button.state & GDK_SHIFT_MASK)
            {
              gtk_object_destroy(GTK_OBJECT(item));
            }
          else
            {
              x = item_x;
              y = item_y;

              fleur = gdk_cursor_new(GDK_FLEUR);
              gnome_canvas_item_grab(item,
                                     GDK_POINTER_MOTION_MASK |
                                     GDK_BUTTON_RELEASE_MASK,
                                     fleur,
                                     event->button.time);
              gdk_cursor_destroy(fleur);
              dragging = TRUE;
            }
          break;

        default:
          break;
        }
      break;

    case GDK_MOTION_NOTIFY:
      if (dragging && (event->motion.state & GDK_BUTTON1_MASK))
        {
          new_x = item_x;
          new_y = item_y;

          gnome_canvas_item_move(item, new_x - x, new_y - y);
          x = new_x;
          y = new_y;
        }
      break;

    case GDK_BUTTON_RELEASE:
      gnome_canvas_item_ungrab(item, event->button.time);
      dragging = FALSE;
      break;

    default:
      break;
    }

  return FALSE;
}

static void
setup_item(GnomeCanvasItem *item)
{
  gtk_signal_connect(GTK_OBJECT(item), "event",
                     (GtkSignalFunc) item_event,
                     NULL);
}

static void
```

```
create_canvas_items(GtkWidget* canvas)
{
  GnomeCanvasPoints* points;
  GnomeCanvasGroup* group;
  GnomeCanvasItem* item;
  double affine[6];

  group = gnome_canvas_root(GNOME_CANVAS(canvas));

  /* A polygon */
  points = gnome_canvas_points_new(14);

  points->coords[0] = 270.0;
  points->coords[1] = 330.0;
  points->coords[2] = 270.0;
  points->coords[3] = 430.0;
  points->coords[4] = 390.0;
  points->coords[5] = 430.0;
  points->coords[6] = 390.0;
  points->coords[7] = 330.0;
  points->coords[8] = 310.0;
  points->coords[9] = 330.0;
  points->coords[10] = 310.0;
  points->coords[11] = 390.0;
  points->coords[12] = 350.0;
  points->coords[13] = 390.0;
  points->coords[14] = 350.0;
  points->coords[15] = 370.0;
  points->coords[16] = 330.0;
  points->coords[17] = 370.0;
  points->coords[18] = 330.0;
  points->coords[19] = 350.0;
  points->coords[20] = 370.0;
  points->coords[21] = 350.0;
  points->coords[22] = 370.0;
  points->coords[23] = 410.0;
  points->coords[24] = 290.0;
  points->coords[25] = 410.0;
  points->coords[26] = 290.0;
  points->coords[27] = 330.0;

  item = gnome_canvas_item_new(group,
                               gnome_canvas_polygon_get_type (),
                               "points", points,
                               "fill_color", "tan",
                               "outline_color", "black",
                               "width_units", 3.0,
                               NULL);

  setup_item(item);

  gnome_canvas_points_unref(points);

  /* Translate the polygon */

  art_affine_translate(affine, -150.0, -300.0);

  gnome_canvas_item_affine_relative(item, affine);

  /* A translucent rectangle */
  setup_item (gnome_canvas_item_new (group,
                                     gnome_canvas_rect_get_type(),
                                     "x1", 90.0,
                                     "y1", 40.0,
                                     "x2", 180.0,
                                     "y2", 100.0,
                                     "fill_color_rgba", 0x3cb37180,
                                     "outline_color", "black",
                                     "width_units", 4.0,
                                     NULL));

  /* A translucent ellipse */
  setup_item (gnome_canvas_item_new (group,
                                     gnome_canvas_ellipse_get_type(),
                                     "x1", 210.0,
                                     "y1", 80.0,
                                     "x2", 280.0,
                                     "y2", 140.0,
                                     "fill_color_rgba", 0x5f9ea080,
                                     "outline_color", "black",
                                     "width_pixels", 0,
                                     NULL));

  /* Create ellipses arranged in a line; they're manipulated as a
     single item. */

  group =
    GNOME_CANVAS_GROUP (gnome_canvas_item_new (group,
gnome_canvas_group_get_type(),
                                                "x", 0.0,
                                                "y", 0.0,
                                                NULL));
  setup_item(GNOME_CANVAS_ITEM(group));

  {
    double xpos = 20.0;
    while (xpos < 300.0)
      {
        gnome_canvas_item_new(group,
                              gnome_canvas_ellipse_get_type(),
                              "x1", xpos,
                              "y1", 100.0,
                              "x2", xpos + 10.0,
                              "y2", 110.0,
                              "fill_color_rgba", 0x0000FFFF,
                              "outline_color_rgba", 0xFF,
                              NULL);
        xpos += 15.0;
      }
  }
}
```

Standard Canvas Item Reference

This section describes each of the canvas items that come with Gnome, giving a table of arguments and describing any non-obvious arguments.

Rectangle and Ellipse Items

The GnomeCanvasRect and GnomeCanvasEllipse canvas items share exactly the same interface, via a GnomeCanvasRE base class. Their shape is given as a bounding box: a top left coordinate (x1, y1) and a bottom right coordinate (x2, y2). The rectangle item matches the shape of the bounding box; the ellipse is inscribed in the bounding box, touching the center of each side. Rectangles and ellipses can be filled or simply an outline. If they are only an outline, they are considered to be "hollow"; that is, the transparent area inside the shape is not part of the canvas item and events that occur in that area will not be relayed to the item.

GnomeCanvasRE does not behave gracefully if you give the coordinates in the wrong order. That is, x2 must be greater than x1, and y2 must be greater than y1; otherwise GnomeCanvasRE gets confused.

Table 1. GnomeCanvasRE Arguments

Name	**Type**	**Read/Write**	**Description**
x1	double	Both	Leftmost coordinate
y1	double	Both	Topmost coordinate
x2	double	Both	Rightmost coordinate
y2	double	Both	Bottommost coordinate
fill_color	gchar*	Write-only	Fill color; string for gdk_color_parse(), or NULL for transparent
fill_color_gdk	GdkColor*	Both	Fill color; specified as already-allocated GdkColor
fill_color_rgba	guint32	Both	Fill color; specified as 32-bit value packing red, green, blue, and alpha into bytes 1, 2, 3, and 4; alpha of 255 is opaque, 0 is invisible
outline_color	gchar*	Write-only	Outline color; string for gdk_color_parse, or NULL for transparent
outline_color_gdk	GdkColor*	Both	Outline color; specified as already-allocated GdkColor
outline_color_rgba	guint32	Both	Outline color; specified as 32-bit value packing red, green, blue, and alpha into bytes 1, 2, 3, and 4; alpha of 255 is opaque, 0 is invisible
fill_stipple	GdkBitmap*	Both	Stipple to use when drawing fill; GDK mode only
outline_stipple	GdkBitmap*	Both	Stipple to use when drawing outline; GDK mode only
width_pixels	guint	Write-only	Width of the outline, in pixels (independent of zoom)
width_units	double	Write-only	Width of the outline, in canvas units; pixel width changes with zoom factor (pixels per unit)

Line Item

GnomeCanvasLine represents one or more line segments joined at their endpoints. You can use it to represent an unfilled polygon as well. GnomeCanvasPolygon is used for filled polygons.

A line is specified using a GnomeCanvasPoints structure, which looks like this:

```
typedef struct {
        int num_points;
        double *coords;
        int ref_count;
} GnomeCanvasPoints;
```

The coords field contains an array of points, alternating X and Y coordinates. You fill the coords array directly, after creating a GnomeCanvasPoints with gnome_canvas_points_new(); the structure should be destroyed with gnome_canvas_points_unref().

Lines can have arrowheads on either end; the arrowhead shape is specified via three parameters, arbitrarily named A, B, and C. Parameter A (specified with the arrow_shape_a argument) specifies the distance from the base of the arrowhead to the tip. B specifies the distance from the tip of the arrowhead to one of the trailing points; C specifies the distance of a trailing point from the outer edge of the line.

Table 2. GnomeCanvasLine Arguments

Name	**Type**	**Read/Write**	**Description**
points	GnomeCanvasPoints*	Both	Points in the line
fill_color	gchar*	Write-only	Fill color; string for gdk_color_parse()
fill_color_gdk	GdkColor*	Both	Fill color; specified as already-allocated GdkColor
fill_color_rgba	guint32	Both	Fill color; specified as 32-bit value packing red, green, blue, and alpha into bytes 1, 2, 3, and 4; alpha of 255 is

			opaque, 0 is invisible
fill_stipple	GdkBitmap*	Both	Stipple to use when drawing line; GDK mode only
width_pixels	guint	Write-only	Width of the line, in pixels (independent of zoom)
width_units	double	Write-only	Width of the line, in canvas units; pixel width changes with zoom factor (pixels per unit)
cap_style	GdkCapStyle	Both	Cap style (GDK mode only)
join_style	GdkJoinStyle	Both	Join style (GDK mode only)
line_style	GdkLineStyle	Both	Line style (GDK mode only)
first_arrowhead	gboolean	Both	Whether to put an arrowhead at the start of the line
last_arrowhead	gboolean	Both	Whether to put an arrowhead at the end of the line
smooth	gboolean	Both	Whether to smooth the line using parabolic splines
spline_steps	guint	Both	Number of steps to use when rendering curves
arrow_shape_a	double	Both	Length of arrowhead
arrow_shape_b	double	Both	Length of arrowhead edges (tip to trailing points)
arrow_shape_c	double	Both	Width of arrowhead

Polygon Item

GnomeCanvasPolygon represents a filled polygon; it can be filled or only an outline. Unlike GnomeCanvasRE, an unfilled GnomeCanvasPolygon is not "hollow"; the transparent portion in the center is part of the canvas item. GnomeCanvasLine is used for "hollow" polygons.

Table 3. GnomeCanvasPolygon Arguments

Name	**Type**	**Read/Write**	**Description**
points	GnomeCanvasPoints*	Both	Points in the polygon

fill_color	gchar*	Write-only	Fill color; string for gdk_color_parse(), or NULL for transparent
fill_color_gdk	GdkColor*	Both	Fill color; specified as already-allocated GdkColor
fill_color_rgba	guint32	Both	Fill color; specified as 32-bit value packing red, green, blue, and alpha into bytes 1, 2, 3, and 4; alpha of 255 is opaque, 0 is invisible
outline_color	gchar*	Write-only	Outline color; string for gdk_color_parse, or NULL for transparent
outline_color_gdk	GdkColor*	Both	Outline color; specified as already-allocated GdkColor
outline_color_rgba	guint32	Both	Outline color; specified as 32-bit value packing red, green, blue, and alpha into bytes 1, 2, 3, and 4; alpha of 255 is opaque, 0 is invisible
fill_stipple	GdkBitmap*	Both	Stipple to use when drawing fill; GDK mode only
outline_stipple	GdkBitmap*	Both	Stipple to use when drawing outline; GDK mode only
width_pixels	guint	Write-only	Width of the outline, in pixels (independent of zoom)
width_units	double	Write-only	Width of the outline, in canvas units; pixel width changes with zoom factor (pixels per unit)

Image Item

GnomeCanvasImage places an image on the canvas; you pass it a GdkImlibImage, loaded using one of the Imlib routines. If the image has transparent areas, they will be properly handled (they won't be considered part of the item, and will not receive events). To use GnomeCanvasImage with a GDK canvas, you must push the Imlib visual and colormap before creating the canvas; see the section called *Preparing the GnomeCanvas Widget*.

Table 4. GnomeCanvasImage Arguments

Name	Type	Read/Write	Description
image	GdkImlibImage*	Both	GdkImlibImage to display
x	double	Both	X coordinate of the anchor point
y	double	Both	Y coordinate of the anchor point
anchor	GtkAnchorType	Both	Location of anchor point
width	double	Both	Width in canvas units (image will be scaled)
height	double	Both	Height in canvas units (image will be scaled)

Text Item

GnomeCanvasText displays a text string. You can specify the coordinates of the string as an ordered pair; these coordinates will represent the location of the text's *anchor*. For example, if the "anchor" argument is set to GTK_ANCHOR_NORTH, the text item's coordinates will represent the location of the top-center of the item. That is, the text will be centered around the X position and begin just below the Y position. Possible anchor values are:

- GTK_ANCHOR_CENTER
- GTK_ANCHOR_NORTH
- GTK_ANCHOR_NORTH_WEST
- GTK_ANCHOR_NORTH_EAST
- GTK_ANCHOR_SOUTH
- GTK_ANCHOR_SOUTH_WEST
- GTK_ANCHOR_SOUTH_EAST
- GTK_ANCHOR_WEST
- GTK_ANCHOR_EAST

Affine transformation of GnomeCanvasText is not implemented very well. Because the X font model is inflexible and limited, there is no good way to rotate and otherwise transform rendered text. In antialiased mode the canvas item implements this in the only way it can: it draws the entire font to a GdkPixmap, then copies the pixmap to a GdkImage, then reads individual pixels out of the image into a client-side bitmap, then copies the characters to be displayed from the entire-font bitmap into a temporary buffer, then uses libart_lgpl to apply any affine transformations to this buffer, then copies the transformed buffer to the canvas RGB buffer. Finally the canvas copies the RGB buffer to the screen. Needless to say this is slower than molasses: an entire bitmap goes over the network more than once. Moreover, scaling and rotating fonts as bitmaps leads to a low quality image. If you try to use GnomeCanvasText with antialiased mode, you will probably notice this; if your canvas is slow to update, suspect the text item.

There are plans to fix the text item, using a new font abstraction called GnomeFont. However, Gnome 1.0 lacks this feature.

There is not a good solution to the problem; if your application allows it, you can get dramatic speed increases by creating your own text item that caches the entire-font bitmaps. However, if you don't reuse the same fonts often, caching will be useless. Another possibility is to abandon X fonts and use Type 1 fonts with a rasterization library like t1lib, but this limits the fonts available to you and adds a library dependency. You could also use True Type fonts with the FreeType library, or use the Display PostScript extension to X (XDPS).

Unfortunately, your best bet is probably to wait for the GnomeFont feature in a future version of the Gnome libraries.

Table 5. GnomeCanvasText Arguments

Name	Type	Read/Write	Description
text	gchar*	Both	String to display
x	double	Both	X coordinate of the anchor point
y	double	Both	Y coordinate of the anchor point
anchor	GtkAnchorType	Both	Location of anchor point
font	gchar*	Write-only	Font name for gdk_font_load()
fontset	gchar*	Write-only	Fontset name for gdk_fontset_load()
font_gdk	GdkFont*	Both	Font for rendering the text
justification	GtkJustification	Both	Justification (multiline text only)
fill_color	gchar*	Write-only	Fill color; string for gdk_color_parse(), or NULL for transparent
fill_color_gdk	GdkColor*	Both	Fill color; specified as already-allocated GdkColor
fill_color_rgba	guint32	Both	Fill color; specified as 32-bit value packing red, green, blue, and alpha into bytes 1, 2, 3, and 4; alpha of 255 is opaque, 0 is invisible
fill_stipple	GdkBitmap*	Both	Stipple to use when drawing text; GDK mode

			only
clip_width	double	Both	Width of clip rectangle in canvas units
clip_height	double	Both	Height of clip rectangle in canvas units
clip	gboolean	Both	Enables or disables clipping
x_offset	double	Both	Horizontal offset to add to X position
y_offset	double	Both	Vertical offset to add to Y position
text_width	double	Read-only	Width of rendered text
text_height	double	Read-only	Height of rendered text

Widget Item

The GnomeCanvasWidget item places a widget on the canvas. The canvas item emulates a container widget, passing a size allocation to the widget it holds. You can specify an anchor point for the widget item, just as you can for GnomeCanvasText.

Table 6. GnomeCanvasWidget Arguments

Name	**Type**	**Read/Write**	**Description**
widget	GtkWidget*	Both	Widget to display
x	double	Both	X coordinate of the anchor point
y	double	Both	Y coordinate of the anchor point
anchor	GtkAnchorType	Both	Location of anchor point
width	double	Both	Width of widget
height	double	Both	Height of widget
size_pixels	gboolean	Both	Specifies how to interpret the width and height argument; if TRUE, they are in pixels; if FALSE, they are in canvas units

Writing a GnomeCanvasItem

Table of Contents

This chapter explains how to write a GnomeCanvasItem. Custom canvas items allows you to extend the canvas; consider writing a canvas item if the stock items (or some combination of them placed in a GnomeCanvasGroup) do not meet your needs. As an example, the chapter describes the implementation of GnomeCanvasRect.

Overview

To write a GnomeCanvasItem, you create a concrete implemenation of the GnomeCanvasItem abstract base class. This chapter assumes you've read the chapter called *The GTK+ Object and Type System* and understand how a GtkObject works; you will need to understand objects to write your own.

Canvas items can support GDK mode, antialiased mode, or both. The canvas has a flag indicating which kind of canvas it is; items can check this flag at runtime:

```
if (item->canvas->aa)
  {
    /* antialiased mode */
  }
else
  {
    /* Gdk mode */
  }
```

However, most code will be the same for both canvas types. The only real difference is in the drawing process: GDK mode draws to a pixmap, antialiased mode draws to an RGB buffer. You do not have to support both kinds of canvas, just be careful not to use your item with the unsupported canvas type.

Here is the GnomeCanvasItem type you will be subclassing:

```
typedef struct _GnomeCanvasItem       GnomeCanvasItem;
typedef struct _GnomeCanvasItemClass  GnomeCanvasItemClass;

struct _GnomeCanvasItem {
  GtkObject object;

  /* Canvas we are on */
  GnomeCanvas *canvas;

  /* Parent group */
  GnomeCanvasItem *parent;

  /* Bounding box for this item */
  double x1, y1, x2, y2;

  /* If NULL, the identity transform */
  double *xform;
};

struct _GnomeCanvasItemClass {
  GtkObjectClass parent_class;

  void (* update) (GnomeCanvasItem *item, double *affine,
                 ArtSVP *clip_path, int flags);

  void (* realize) (GnomeCanvasItem *item);

  void (* unrealize) (GnomeCanvasItem *item);

  void (* map) (GnomeCanvasItem *item);

  void (* unmap) (GnomeCanvasItem *item);

  /* Unused in Gnome 1.0 */
  ArtUta *(* coverage) (GnomeCanvasItem *item);

  /* Used only in Gdk mode */
  void (* draw) (GnomeCanvasItem *item, GdkDrawable *drawable,
               int x, int y, int width, int height);

  /* Used only in RGB mode */
  void (* render) (GnomeCanvasItem *item, GnomeCanvasBuf *buf);

  double (* point) (GnomeCanvasItem *item, double x, double y,
                  int cx, int cy,
                  GnomeCanvasItem **actual_item);

  /* Obsolete; not used in Gnome 1.0 */
  void (* translate) (GnomeCanvasItem *item, double dx, double dy);

  /* Deprecated, but occasionally used in Gnome 1.0 */
  void (* bounds) (GnomeCanvasItem *item,
                   double *x1, double *y1,
                   double *x2, double *y2);

  /* The only canvas item class function that is also a signal */
  gint (* event) (GnomeCanvasItem *item, GdkEvent *event);
};
```

This chapter explains everything in more detail; keep reading.

GnomeCanvasRect

GnomeCanvasRect and GnomeCanvasEllipse have almost identical implementations; in fact, all but three of GnomeCanvasItem's methods are implemented by the GnomeCanvasRE base class. GnomeCanvasRE handles their user-visible interface, as discussed in the previous chapter.

To understand the implementation of GnomeCanvasRect presented in this chapter, you should first read the previous chapter's discussion of the object arguments it supports. You'll also want to see the object itself:

```

typedef struct _GnomeCanvasRE GnomeCanvasRE;

struct _GnomeCanvasRE {
  GnomeCanvasItem item;

  double x1, y1, x2, y2;        /* Corners of item, item coordinates */
  double width;                 /* Outline width, item coordinates */

  guint fill_color;             /* Fill color, RGBA */
  guint outline_color;          /* Outline color, RGBA */

  gulong fill_pixel;            /* Fill color */
  gulong outline_pixel;         /* Outline color */

  GdkBitmap *fill_stipple;      /* Stipple for fill */
  GdkBitmap *outline_stipple;   /* Stipple for outline */
  GdkGC *fill_gc;              /* GC for filling */
  GdkGC *outline_gc;           /* GC for outline */

  /* Antialiased specific stuff follows */

  ArtSVP *fill_svp;            /* The SVP for the filled shape */
  ArtSVP *outline_svp;         /* The SVP for the outline shape */

  /* Configuration flags */

  unsigned int fill_set : 1;    /* Is fill color set? */
  unsigned int outline_set : 1; /* Is outline color set? */
  unsigned int width_pixels : 1;/* Is outline width specified in pixels
or units? */
};
```

GnomeCanvasRect adds no new members not found in GnomeCanvasRE. The method implementations discussed in this chapter should make clear the purpose of the various struct members.

This chapter discusses all the interesting parts of GnomeCanvasRect; complete source code comes with the Gnome libraries.

Drawing Methods

The most important task of any canvas item is rendering itself onto the canvas. Rendering is a two-stage process for efficiency reasons. The first stage, implemented in a GnomeCanvasItem's update method, is guaranteed to happen only once per item per rendering cycle; the idea is to do any expensive affine transformations or other calculations in the update method. In the second stage, the canvas item renders itself to some region on the screen. The render method implements stage two for antialiased items, while the draw method implements stage two for GDK items. An item's render or draw method may be invoked multiple times during a canvas repaint.

Rendering occurs in a one-shot idle function. That is, whenever the canvas receives an expose event or otherwise determines that a redraw is needed, it adds an idle function which removes itself after a single invocation. (An idle function runs when no GTK+ events are pending and the flow of execution is in the GTK+ main loop---see the section called *The Main Loop* in the chapter called *GTK+ Basics* for details.) The canvas maintains a list of redraw regions and adds to it whenever a redraw request is received, so it knows which areas to repaint when the idle handler is finally invoked.

Canvas items carry a flag indicating whether they need to be updated. Whenever a canvas item "changes" (for example, if you set a new fill color for GnomeCanvasRect), it will call gnome_canvas_item_request_update() to set the "update needed" flag for itself and the groups that contain it, up to and including the root canvas group. (The GnomeCanvas widget is only aware of a single canvas item, the root group---all other items are handled recursively when methods are invoked on the root group.) In its one-shot idle function, the canvas invokes the update method of the root canvas item if its update flag is set, then clears the flag so the update method will not be run next time. The GnomeCanvasGroup update method does the same for each child item.

Once all canvas items have been updated, the rendering process begins. The canvas creates an RGB or GdkPixmap buffer, converts its list of redraw regions into a list of buffer-sized rectangles, then invokes the render or draw method of the root canvas group once per rectangle. After each rectangle is rendered, the buffer is copied to the screen.

The Update Method

The update method is primarily used by antialiased canvas items. libart_lgpl can prebuild a vector path to be rendered, performing clipping and affine transformation in advance. The render method stamps the pre-assembled path into the RGB buffer.

The update method is one of the two that GnomeCanvasRect and GnomeCanvasEllipse have to implement differently. Here is the GnomeCanvasRect implementation:

```
static void
gnome_canvas_rect_update (GnomeCanvasItem *item, double affine[6],
                          ArtSVP *clip_path, gint flags)
{
  GnomeCanvasRE *re;
  ArtVpath vpath[11];
  ArtVpath *vpath2;
  double x0, y0, x1, y1;
  double dx, dy;
  double halfwidth;
  int i;

  gnome_canvas_re_update_shared (item, affine, clip_path, flags);

  re = GNOME_CANVAS_RE (item);

  if (item->canvas->aa) {
    x0 = re->x1;
    y0 = re->y1;
    x1 = re->x2;
    y1 = re->y2;

    gnome_canvas_item_reset_bounds (item);

    if (re->fill_set) {
      vpath[0].code = ART_MOVETO;
      vpath[0].x = x0;
      vpath[0].y = y0;
      vpath[1].code = ART_LINETO;
      vpath[1].x = x0;
      vpath[1].y = y1;
      vpath[2].code = ART_LINETO;
      vpath[2].x = x1;
      vpath[2].y = y1;
      vpath[3].code = ART_LINETO;
      vpath[3].x = x1;
      vpath[3].y = y0;
      vpath[4].code = ART_LINETO;
      vpath[4].x = x0;
      vpath[4].y = y0;
      vpath[5].code = ART_END;
      vpath[5].x = 0;
      vpath[5].y = 0;

      vpath2 = art_vpath_affine_transform (vpath, affine);

      gnome_canvas_item_update_svp_clip (item, &re->fill_svp,
art_svp_from_vpath (vpath2), clip_path);
      art_free (vpath2);
    } else
      gnome_canvas_item_update_svp (item, &re->fill_svp, NULL);

    if (re->outline_set) {
```

```
	if (re->width_pixels)
	  halfwidth = re->width * 0.5;
	else
	  halfwidth = re->width * item->canvas->pixels_per_unit * 0.5;

	if (halfwidth < 0.25)
	  halfwidth = 0.25;

	i = 0;
	vpath[i].code = ART_MOVETO;
	vpath[i].x = x0 - halfwidth;
	vpath[i].y = y0 - halfwidth;
	i++;
	vpath[i].code = ART_LINETO;
	vpath[i].x = x0 - halfwidth;
	vpath[i].y = y1 + halfwidth;
	i++;
	vpath[i].code = ART_LINETO;
	vpath[i].x = x1 + halfwidth;
	vpath[i].y = y1 + halfwidth;
	i++;
	vpath[i].code = ART_LINETO;
	vpath[i].x = x1 + halfwidth;
	vpath[i].y = y0 - halfwidth;
	i++;
	vpath[i].code = ART_LINETO;
	vpath[i].x = x0 - halfwidth;
	vpath[i].y = y0 - halfwidth;
	i++;

	if (x1 - halfwidth > x0 + halfwidth &&
	    y1 - halfwidth > y0 + halfwidth) {
	  vpath[i].code = ART_MOVETO;
	  vpath[i].x = x0 + halfwidth;
	  vpath[i].y = y0 + halfwidth;
	  i++;
	  vpath[i].code = ART_LINETO;
	  vpath[i].x = x1 - halfwidth;
	  vpath[i].y = y0 + halfwidth;
	  i++;
	  vpath[i].code = ART_LINETO;
	  vpath[i].x = x1 - halfwidth;
	  vpath[i].y = y1 - halfwidth;
	  i++;
```

```
        vpath[i].code = ART_LINETO;
        vpath[i].x = x0 + halfwidth;
        vpath[i].y = y1 - halfwidth;
        i++;
        vpath[i].code = ART_LINETO;
        vpath[i].x = x0 + halfwidth;
        vpath[i].y = y0 + halfwidth;
        i++;
      }
      vpath[i].code = ART_END;
      vpath[i].x = 0;
      vpath[i].y = 0;

      vpath2 = art_vpath_affine_transform (vpath, affine);

      gnome_canvas_item_update_svp_clip (item, &re->outline_svp,
art_svp_from_vpath (vpath2), clip_path);
      art_free (vpath2);
    } else
      gnome_canvas_item_update_svp (item, &re->outline_svp, NULL);
  } else {
    get_bounds (re, &x0, &y0, &x1, &y1);
    gnome_canvas_update_bbox (item, x0, y0, x1, y1);
  }
}
```

As you can see, the first thing this function does is invoke an update function shared by GnomeCanvasRect and GnomeCanvasEllipse; here is that function:

```
static void
gnome_canvas_re_update_shared (GnomeCanvasItem *item, double *affine,
                               ArtSVP *clip_path, int flags)
{
  GnomeCanvasRE *re;

  re = GNOME_CANVAS_RE (item);

  if (re_parent_class->update)
    (* re_parent_class->update) (item, affine, clip_path, flags);

  if (!item->canvas->aa) {
    set_gc_foreground (re->fill_gc, re->fill_pixel);
    set_gc_foreground (re->outline_gc, re->outline_pixel);
    set_stipple (re->fill_gc, &re->fill_stipple,
                 re->fill_stipple, TRUE);
    set_stipple (re->outline_gc, &re->outline_stipple,
                 re->outline_stipple, TRUE);
    set_outline_gc_width (re);
  }
}
```

There is a lot of code involved here; the update method is almost always the most complicated one, since it does all the work of preparing to render a canvas item. Also, the update method is different for GDK and antialiased mode; notice the code which depends on the item->canvas->aa flag.

The first thing GnomeCanvasRE does during an update is invoke the update method of its parent class. The GnomeCanvasItem default update method does nothing whatsoever in Gnome 1.0, but it is good practice to chain up for future robustness. Then, GnomeCanvasRE calls a series of utility routines to fill in its graphics contexts with their correct values. These are straightforward functions, so their implementations are omitted here.

Next gnome_canvas_rect_update() continues with GnomeCanvasRect-specific details. Several tasks are accomplished:

- The bounding box of the canvas item is updated. Every canvas item has an associated bounding box; the GnomeCanvasGroup draw and render methods use this box to determine which items are in the redraw region. The bounding box must be updated in both GDK and antialiased mode.
- In antialiased mode, a *sorted vector path* is created. A sorted vector path is simply a series of drawing instructions, similar to primitive PostScript operations, that libart_lgpl can render to an RGB buffer.
- In antialiased mode, the affine and clip_path arguments to the update method are used to transform the sorted vector path; thus the affine and clip path are implicitly stored for use in the render method. If you do not use libart_lgpl's sorted vector paths in your own canvas items, you must arrange some other way to ensure the affine and clip are taken into account when you render.
- In both modes, a redraw is requested for both the region the item used to occupy, *and* the region the item will now occupy.

Much of this work takes place behind the scenes in utility functions from libgnomeui/gnome-canvas-util.h. gnome_canvas_update_bbox() sets the item's new bounding box and requests a redraw on both the old and new bounding boxes; it is used in GDK mode. (gnome_canvas_update_bbox() expects canvas pixel coordinates; get_bounds() is a trivial function which computes the rectangle's bounds in canvas pixel coordinates.)

So you know what's happening behind the scenes, here is the implementation of gnome_canvas_update_bbox():

```
void
gnome_canvas_update_bbox (GnomeCanvasItem *item,
                          int x1, int y1,
                          int x2, int y2)
{
  gnome_canvas_request_redraw (item->canvas,
                               item->x1, item->y1,
                               item->x2, item->y2);
  item->x1 = x1;
  item->y1 = y1;
  item->x2 = x2;
  item->y2 = y2;
  gnome_canvas_request_redraw (item->canvas,
                               item->x1, item->y1,
                               item->x2, item->y2);
}
```

Of course you're free to do the equivalent yourself, this is merely a convenience function.

In GDK mode, that's about all that happens; we update the bounds and then return. Antialiased mode is a bit more complex, but essentially the same tasks are performed. First, gnome_canvas_item_reset_bounds() sets the item's bounds back to an empty rectangle. Then, two sorted vector paths are prepared; one for the solid part of the rectangle (if any), and one for the rectangle's outline (if any). The same procedure is followed each time. First, a vector path for libart_lgpl is prepared; next, the path is affine transformed; then gnome_canvas_item_update_svp_clip() is used to request a redraw on the old path, free the old path, clip the new path, request a redraw on the new one, and save the new one for use in rendering. If the rectangle's fill or outline has been turned off, a redraw is requested on the old vector path, but no new path is created.

To give you a clearer idea what is happening, here is the implementation of gnome_canvas_item_update_svp_clip():

```
void
gnome_canvas_item_update_svp_clip (GnomeCanvasItem *item,
                                   ArtSVP **p_svp, ArtSVP *new_svp,
                                   ArtSVP *clip_svp)
{
  ArtSVP *clipped_svp;

  if (clip_svp != NULL)
    {
      clipped_svp = art_svp_intersect (new_svp, clip_svp);
      art_svp_free (new_svp);
    }
  else
    {
      clipped_svp = new_svp;
    }

  gnome_canvas_item_update_svp (item, p_svp, clipped_svp);
}
```

and gnome_canvas_item_update_svp():

```
void
gnome_canvas_item_update_svp (GnomeCanvasItem *item,
                              ArtSVP **p_svp, ArtSVP *new_svp)
{
  ArtDRect bbox;

  gnome_canvas_update_svp (item->canvas, p_svp, new_svp);
  if (new_svp)
    {
      bbox.x0 = item->x1;
      bbox.y0 = item->y1;
      bbox.x1 = item->x2;
      bbox.y1 = item->y2;
      art_drect_svp_union (&bbox, new_svp);
      item->x1 = bbox.x0;
      item->y1 = bbox.y0;
      item->x2 = bbox.x1;
      item->y2 = bbox.y1;
    }
}
```

and then gnome_canvas_update_svp():

```

void
gnome_canvas_update_svp (GnomeCanvas *canvas,
                         ArtSVP **p_svp, ArtSVP *new_svp)
{
  ArtSVP *old_svp;
  ArtSVP *diff;
  ArtUta *repaint_uta;

  old_svp = *p_svp;
  if (old_svp != NULL && new_svp != NULL)
    {
      repaint_uta = art_uta_from_svp (old_svp);
      gnome_canvas_request_redraw_uta (canvas, repaint_uta);
      repaint_uta = art_uta_from_svp (new_svp);
      gnome_canvas_request_redraw_uta (canvas, repaint_uta);
    }
  else if (old_svp != NULL)
    {
      repaint_uta = art_uta_from_svp (old_svp);
      art_svp_free (old_svp);
      gnome_canvas_request_redraw_uta (canvas, repaint_uta);
    }
  *p_svp = new_svp;
}
```

Again, all of these are in libgnomeui/gnome-canvas-util.h for any canvas item to use. Ignore the implementation details; the idea is simply to see what work is being done. The code may be easier to understand if you know that an ArtDRect is a "rectangle defined with doubles," from libart_lgpl, and that an ArtUta is a "microtile array," basically a list of small regions. (The antialiased canvas tracks the redraw region in a fairly sophisticated way. Note that the "U" in "Uta" is supposed to suggest the greek letter symbolizing "micro," it does not stand for a word beginning with "U".)

Requesting Updates

It is the canvas item's responsibility to request an update or redraw when the properties of the item are changed and the screen should be refreshed. This is straightforward. For example, here is a snippet of code from gnome_canvas_re_set_arg(), which sets the "y2" argument:

```
  case ARG_Y2:
    re->y2 = GTK_VALUE_DOUBLE (*arg);

    gnome_canvas_item_request_update (item);
    break;
```

Since "y2" modifies the shape of the rectangle, the path must be recreated and an update is necessary. Note that gnome_canvas_item_request_update() simply sets a flag and installs an idle handler if none is pending, so it can be called many times without a performance penalty.

Not all changes require an update; a redraw may be sufficient, or perhaps the argument is unrelated to the display. It depends on the canvas item and what exactly is being changed.

The Render Method (Antialiased Mode)

The render method is shared between GnomeCanvasRect and GnomeCanvasEllipse; all it does is stamp the two paths created in the update method into the RGB buffer:

```
static void
gnome_canvas_re_render (GnomeCanvasItem *item,
                        GnomeCanvasBuf *buf)
{
  GnomeCanvasRE *re;
  guint32 fg_color, bg_color;
  re = GNOME_CANVAS_RE (item);

  if (re->fill_svp != NULL) {
    gnome_canvas_render_svp (buf, re->fill_svp, re->fill_color);
  }

  if (re->outline_svp != NULL) {
    gnome_canvas_render_svp (buf, re->outline_svp, re->outline_color);
  }
}
```

As you can see, most of the work takes place in gnome_canvas_render_svp(), another function from libgnomeui/gnome-canvas-util.h; here is its implementation:

```
void
gnome_canvas_render_svp (GnomeCanvasBuf *buf, ArtSVP *svp, guint32 rgba)
{
  guint32 fg_color, bg_color;

  if (buf->is_bg) {
    bg_color = buf->bg_color;
    fg_color = rgba >> 8;
    art_rgb_svp_aa (svp,
                    buf->rect.x0, buf->rect.y0, buf->rect.x1,
buf->rect.y1,
                    fg_color, bg_color,
                    buf->buf, buf->buf_rowstride,
                    NULL);
    buf->is_bg = 0;
    buf->is_buf = 1;
  } else {
    art_rgb_svp_alpha (svp,
                       buf->rect.x0, buf->rect.y0, buf->rect.x1,
buf->rect.y1,
                       rgba,
                       buf->buf, buf->buf_rowstride,
                       NULL);
  }
}
```

To understand gnome_canvas_render_svp(), or to do your own RGB buffer drawing (without using libart_lgpl), you will need to know what a GnomeCanvasBuf is:

```
typedef struct {
  guchar *buf;

  int buf_rowstride;

  ArtIRect rect;

  guint32 bg_color;

  unsigned int is_bg : 1;
  unsigned int is_buf : 1;
} GnomeCanvasBuf;
```

The buf member is an RGB buffer, as explained in the section called *RGB Buffers* in the chapter called *GDK Basics*. The buf_rowstride is the buffer's rowstride, also explained in the section called *RGB Buffers* in the chapter called *GDK Basics*. An ArtIRect is an integer rectangle; rect defines the redraw region in canvas pixel coordinates that this buffer represents. rect.x0 and rect.y0 are the buffer offsets and correspond to row 0, column 0 in the RGB buffer; you can convert from canvas pixel coordinates to RGB buffer coordinates by subtracting these values.

As an optimization, the canvas does not initialize the RGB buffer with the background color, because the first canvas item might cover the entire background anyway. Thus, if your canvas item is the first one to render, you must put some pixel value in every pixel of the redraw region defined by the buffer's rect. If your item does not cover a pixel, you should fill that pixel with the bg_color; bg_color is a packed RGB value (no alpha). If you do this manually, unpack an RGB value rgb like this:

```
    guchar r, g, b;

    r = (rgb >> 16) & 0xff;
    g = (rgb >> 8) & 0xff;
    b = rgb & 0xff;
```

However, a convenience function is provided to fill a GnomeCanvasBuf with its bg_color:

```
void
gnome_canvas_buf_ensure_buf (GnomeCanvasBuf *buf)
{
  guchar *bufptr;
  int y;

  if (!buf->is_buf) {
    bufptr = buf->buf;
    for (y = buf->rect.y0; y < buf->rect.y1; y++) {
      art_rgb_fill_run (bufptr,
                        buf->bg_color >> 16,
                        (buf->bg_color >> 8) & 0xff,
                        buf->bg_color & 0xff,
                        buf->rect.x1 - buf->rect.x0);
      bufptr += buf->buf_rowstride;
    }
    buf->is_buf = 1;
  }
}
```

As you can see from the implementation of gnome_canvas_buf_ensure_buf(), is_bg is a flag indicating that the RGB buffer still contains random memory garbage; it has not been initialized with RGB pixels. is_buf indicates that the buffer *has* been initialized, and subsequent items should only draw themselves, ignoring background pixels. These two flags are mutually exclusive; if your item receives a buffer with is_bg set, it should take steps to fill the buffer, unset is_bg, and set is_buf:

```
  if (buf->is_bg)
    {
      gnome_canvas_buf_ensure_buf(buf);
      buf->is_bg = FALSE;
    }
```

Speed and RGB Rendering

If you have a large number of objects, RGB mode can be faster than GDK mode. Drawing to an RGB buffer is a simple matter of assigning to an array, which is much, much faster than making a GDK call (since GDK has to contact the X server and ask it to do the actual drawing). The expensive part is copying the RGB buffer to the X server when you're done. However, the copy takes the same amount of time no matter how many canvas items you have, since it is done only once, when all the items have been rendered.

This is a big win in an application called "Guppi" I'm in the process of writing. Guppi is a plot program. One of the things it has to do is render a scatter plot with tens of thousands of points. Each point is a small colored shape; if I called GDK to render each, there would be tens of thousands of trips to the X server, possibly across a network. Instead, I use the canvas in RGB mode, with a custom canvas item representing the scatter plot. This allows me to do all the rendering on the client side, and then the canvas copies the RGB buffer to the server in a single burst. It's quite fast and responsive. For less speed-intensive elements of the plot, such as the legend, I can save time and use the built-in canvas items.

The one difficulty with direct-to-RGB rendering is that you need a rasterization library comparable to the GDK drawing primitives if you want to draw anything interesting. libart_lgpl is a very high-quality antialiased rasterization library, used by the default canvas items. You can use it in your custom items as well, and it is the best choice if you will only be drawing hundreds of shapes. If you're drawing thousands of shapes, however, you'll quickly see the need for something faster. Fortunately, this is available; the maintainers of a package called GNU Plotutils extracted the rasterization library from the X distribution, and during the development of Guppi I extracted it from Plotutils and hacked it to work with the canvas's RGB buffers. I also added alpha transparency support. The resulting library allows you to draw on an RGB buffer much as you would draw using GDK. The library is distributed under the same license as the X Window System, and is free for anyone to include with their application.

Raph Levien, author of libart_lgpl and the GdkRGB module, tells me that still faster routines could be written; if you need more speed, consider this a challenge.

The Draw Method (GDK Mode)

Drawing with GDK is much less complicated than drawing with libart_lgpl, though it is also less flexible and produces lower-quality results. Here is the GnomeCanvasRect implementation of the draw method:

```
static void
gnome_canvas_rect_draw (GnomeCanvasItem *item, GdkDrawable *drawable,
                        int x, int y, int width, int height)
{
  GnomeCanvasRE *re;
  double i2w[6], w2c[6], i2c[6];
  int x1, y1, x2, y2;
  ArtPoint i1, i2;
  ArtPoint c1, c2;

  re = GNOME_CANVAS_RE (item);

  /* Get canvas pixel coordinates */

  gnome_canvas_item_i2w_affine (item, i2w);
  gnome_canvas_w2c_affine (item->canvas, w2c);
  art_affine_multiply (i2c, i2w, w2c);

  i1.x = re->x1;
  i1.y = re->y1;
  i2.x = re->x2;
  i2.y = re->y2;
  art_affine_point (&c1, &i1, i2c);
  art_affine_point (&c2, &i2, i2c);
  x1 = c1.x;
  y1 = c1.y;
  x2 = c2.x;
  y2 = c2.y;

  if (re->fill_set) {
    if (re->fill_stipple)
      gnome_canvas_set_stipple_origin (item->canvas, re->fill_gc);

    gdk_draw_rectangle (drawable,
                        re->fill_gc,
                        TRUE,
                        x1 - x,
                        y1 - y,
                        x2 - x1 + 1,
                        y2 - y1 + 1);
  }

  if (re->outline_set) {
    if (re->outline_stipple)
      gnome_canvas_set_stipple_origin (item->canvas, re->outline_gc);

    gdk_draw_rectangle (drawable,
                        re->outline_gc,
                        FALSE,
                        x1 - x,
                        y1 - y,
                        x2 - x1,
                        y2 - y1);
  }
}
```

The draw method receives a drawable (the buffer), the buffer offsets (x and y---the canvas pixel coordinates of the buffer), and the buffer's size (width and height). GnomeCanvasRect's draw method obtains the item-to-world and world-to-canvas affines, then composes (multiplies) them to create an item-to-canvas affine. (See the section called *Affine Transformations* in the chapter called *GnomeCanvas* for more on affines.) Using this affine, it converts the rectangle's corner points to canvas pixel coordinates; then it draws the rectangle, converting the canvas coordinates to buffer coordinates by subtracting the buffer offsets.

Other Methods

This section describes the remaining GnomeCanvasItem methods, including event, point, bounds, realize, unrealize, map, and unmap.

Events

The GnomeCanvasItem class has a slot in its vtable called event; this is the only GnomeCanvasItem class function associated with a signal. None of the stock canvas items implement a default handler for event, but of course your own canvas item could.

The return value of event works just like the GtkWidget "event" signal; if the last signal handler returns FALSE, the event is propagated to the item's parent item (by emitting the event signal on the parent), if TRUE propagation ends.

Point

The point method is used to determine which canvas item is located at a given point. The canvas uses this information to decide which item should receive events. A point method calculates the distance from some point to the canvas item. Canvas items *must* correctly report a distance of 0 if the point is on the canvas item, or they will not receive events; they *must* report non-zero if the point is not on the item, or they will receive too many events. The exact value returned is not nearly as important as the zero/non-zero distinction.

For convenience, the point method receives the same point pre-translated into both item and canvas pixel coordinates.

The point method also receives a pointer to a pointer to a GnomeCanvasItem; non-group canvas items should store a pointer to themselves in this space. Groups store the *actual_item received from the topmost child which returns 0 from its point method. If you think about it for a while, you will see the implication: the root canvas group's point method stores a pointer to the deepest child in the item tree at the point in question. The canvas sends events occurring at that point to this most-junior child. Note that the canvas item tree corresponds to the item stacking order (i.e. the root group is on the bottom), so events go to the topmost items, as you might expect. Remember that events are then propagated up the item tree hierarchy.

Here is the point method for GnomeCanvasRect:

```
static double
gnome_canvas_rect_point (GnomeCanvasItem *item,
                         double x, double y, int cx, int cy,
                         GnomeCanvasItem **actual_item)
{
  GnomeCanvasRE *re;
  double x1, y1, x2, y2;
  double hwidth;
  double dx, dy;
  double tmp;
  re = GNOME_CANVAS_RE (item);

  *actual_item = item;

  /* Find the bounds for the rectangle plus its outline width */

  x1 = re->x1;
  y1 = re->y1;
  x2 = re->x2;
  y2 = re->y2;

  if (re->outline_set) {
    if (re->width_pixels)
      hwidth = (re->width / item->canvas->pixels_per_unit) / 2.0;
    else
      hwidth = re->width / 2.0;

    x1 -= hwidth;
    y1 -= hwidth;
    x2 += hwidth;
    y2 += hwidth;
  } else
    hwidth = 0.0;

  /* Is point inside rectangle (which can be hollow if it has no fill set)?
*/

  if ((x >= x1) && (y >= y1) && (x <= x2) && (y <= y2)) {
    if (re->fill_set || !re->outline_set)
      return 0.0;

    dx = x - x1;
    tmp = x2 - x;
    if (tmp < dx)
      dx = tmp;

    dy = y - y1;
    tmp = y2 - y;
    if (tmp < dy)
      dy = tmp;

    if (dy < dx)
      dx = dy;
    dx -= 2.0 * hwidth;

    if (dx < 0.0)
      return 0.0;
    else
      return dx;
  }

  /* Point is outside rectangle */

  if (x < x1)
    dx = x1 - x;
  else if (x > x2)
    dx = x - x2;
  else
    dx = 0.0;

  if (y < y1)
    dy = y1 - y;
  else if (y > y2)
    dy = y - y2;
  else
    dy = 0.0;

  return sqrt (dx * dx + dy * dy);
}
```

It should be obvious how this function works; it is simple geometry. Again, notice the line:

```
  *actual_item = item;
```

If your item isn't receiving any events, make sure you included a similar statement.

Bounds

The bounds method computes the approximate bounding box of a canvas item. In Gnome 1.0, this method is only used in gnome_canvas_item_get_bounds(), a user-visible function to return the bounds of a canvas item. The canvas does not use it at all internally, and most likely you could get away without implementing it, though all the stock items do.

The function should return an item's bounding box in item coordinates; here is the GnomeCanvasRE version:

```
static void
gnome_canvas_re_bounds (GnomeCanvasItem *item,
                        double *x1, double *y1,
                        double *x2, double *y2)
{
  GnomeCanvasRE *re;
  double hwidth;

  re = GNOME_CANVAS_RE (item);

  if (re->width_pixels)
    hwidth = (re->width / item->canvas->pixels_per_unit) / 2.0;
  else
    hwidth = re->width / 2.0;

  *x1 = re->x1 - hwidth;
  *y1 = re->y1 - hwidth;
  *x2 = re->x2 + hwidth;
  *y2 = re->y2 + hwidth;
}
```

Realizing and Mapping

Canvas items are realized and mapped just as widgets are. These methods play the same role they do for widgets; realizing a canvas item allocates any GDK resources it plans to use, unrealizing it deallocates the same resources. Mapping a canvas item shows its GdkWindow, unmapping it hides the GdkWindow. Very few canvas items have a GdkWindow (GnomeCanvasWidget is the big exception), so most canvas items will not even implement map and unmap methods. GnomeCanvasRect does not. It does have realize and unrealize methods, however.

Here is its realize method:

```
static void
gnome_canvas_re_realize (GnomeCanvasItem *item)
{
  GnomeCanvasRE *re;

  re = GNOME_CANVAS_RE (item);

  if (re_parent_class->realize)
    (* re_parent_class->realize) (item);

  if (!item->canvas->aa) {
    re->fill_gc = gdk_gc_new (item->canvas->layout.bin_window);
    re->outline_gc = gdk_gc_new (item->canvas->layout.bin_window);
  }
}
```

And unrealize:

```
static void
gnome_canvas_re_unrealize (GnomeCanvasItem *item)
{
  GnomeCanvasRE *re;

  re = GNOME_CANVAS_RE (item);

  if (!item->canvas->aa) {
    gdk_gc_unref (re->fill_gc);
    gdk_gc_unref (re->outline_gc);
  }

  if (re_parent_class->unrealize)
    (* re_parent_class->unrealize) (item);
}
```

Note that your realize and unrealize methods are unlikely to have anything to do in antialiased mode, since there won't be any GDK resources to worry about.

GtkObject Methods

Of course, any canvas item subclass must implement the usual GtkObject methods, including destroy if the object allocates resources that need cleaning up, and a get_arg/set_arg pair if the object defines any arguments. The only canvas-item-specific concern is that you must schedule an update or redraw as needed if set_arg changes the properties of the canvas item. These functions are quite long due to the number of arguments, but not very interesting, so they are omitted here. See the full GnomeCanvasRect source code if you're curious.

IV. Appendices

Appendix A describes the GTK+/Gnome object hierarchy; it should help you find the widget you need for a given application. Appendix B is a guide to the GTK+ and Gnome header files. Appendix C answers some frequently asked questions; Appendix D points you to some useful online resources; and Appendix E contains code listings for examples used in the book.

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GTK+/Gnome Object Hierarchy

Table of Contents

This appendix is a quick tour of the GTK+ and Gnome object hierarchy. It includes GtkObject and all subclasses from both libraries, a brief description of each, and the header files the objects are found in. It also includes screen shots of widgets, to help you find the correct widget for a given task. The testgtk and test-gnome programs that come with the GTK+ and Gnome libraries are also a good way to find widgets; many of the screenshots in this appendix are from those programs.

The specific header file containing each object is listed; however, all GTK+ header files can be included with the gtk/gtk.h convenience header. All GTK+ and Gnome headers can be included with the gnome.h header.

Some objects are described as "abstract base classes"---this means that only the subclasses of the object can be instantiated, but all of the subclasses can be manipulated through the base class's interface.

As a general rule, you should try to use *the most specific object possible*. That is, you could use GtkWindow for your main application window, but GnomeApp is a better choice; you could roll your own about dialog from GnomeDialog, but GnomeAbout is a better choice. This maximizes UI consistency and minimizes your effort.

Both GTK+ and Gnome come with "test" programs, called testgtk and test-gnome, respectively. These programs are used to test the widgets and other features in each library. They're also an excellent source of sample code, and a good way to browse the available widgets and find the one you need.

Hierarchy Summary

```
GtkBin
 |
 +GtkButton
   |
   +GnomeColorPicker
   |
   +GnomeFontPicker
   |
   +GnomeHRef
   |
   +GtkToggleButton
   |
   +GtkOptionMenu
```

This would be for GtkButton. The parent of the object (if any) is shown, then the object itself (possibly highlighted or in bold), then the *immediate* children of the object, if any. The second element that might be nice: some of the objects are "immature" or "unstable", which is a sort of mild warning suggesting to programmers that they may not want to use the object. It might be nice to have some sort of icon or margin text used to mark those objects.

```
GtkObject
 |
 +GtkWidget
 | |
 | +GtkContainer
 | | |
 | | +GtkBin
 | | | |
 | | | +GtkWindow
 | | | | |
 | | | | +GnomeDialog
 | | | | | |
 | | | | | +GnomeAbout
 | | | | | |
 | | | | | +GnomeMessageBox
 | | | | | |
 | | | | | +GnomePropertyBox
 | | | | | |
 | | | | | `GnomeScores
 | | | | |
 | | | | +GnomeApp
 | | | | |
 | | | | +GtkDialog
 | | | | | |
 | | | | | +GnomeFontSelector
 | | | | | |
 | | | | | `GtkInputDialog
 | | | | |
 | | | | +GtkColorSelectionDialog
 | | | | |
 | | | | +GtkFileSelection
 | | | | |
 | | | | +GtkFontSelectionDialog
 | | | | |
 | | | | `GtkPlug
```

```
  | | | |
  | | | +GtkButton
  | | | | |
  | | | | +GnomeColorPicker
  | | | | |
  | | | | +GnomeFontPicker
  | | | | |
  | | | | +GnomeHRef
  | | | | |
  | | | | +GtkToggleButton
  | | | | | |
  | | | | | `GtkCheckButton
  | | | | |   |
  | | | | |   `GtkRadioButton
  | | | | |
  | | | | `GtkOptionMenu
  | | | |
  | | | +GnomeDockItem
  | | | |
  | | | +GtkAlignment
  | | | |
  | | | +GtkFrame
  | | | | |
  | | | | `GtkAspectFrame
  | | | |
  | | | +GtkItem
  | | | | |
  | | | | +GtkMenuItem
  | | | | | |
  | | | | | +GtkCheckMenuItem
  | | | | | | |
  | | | | | | `GtkRadioMenuItem
  | | | | | |
  | | | | | +GtkPixmapMenuItem
  | | | | | |
  | | | | | `GtkTearoffMenuItem
  | | | | |
  | | | | +GtkListItem
  | | | | |
  | | | | `GtkTreeItem
  | | | |
  | | | +GtkEventBox
  | | | |
  | | | +GtkHandleBox
```

```
 | | | |
 | | | +GtkScrolledWindow
 | | | |
 | | | `GtkViewport
 | | |
 | | +GtkBox
 | | | |
 | | | +GtkHBox
 | | | | |
 | | | | +GnomeAppBar
 | | | | |
 | | | | +GnomeDateEdit
 | | | | |
 | | | | +GtkCombo
 | | | | | |
 | | | | | `GnomeEntry
 | | | | |
 | | | | +GnomeFileEntry
 | | | | |
 | | | | +GnomeNumberEntry
 | | | | |
 | | | | +GnomeProcBar
 | | | | |
 | | | | `GtkStatusbar
 | | | |
 | | | +GtkVBox
 | | | | |
 | | | | +GnomeCalculator
 | | | | |
 | | | | +GnomeGuru
 | | | | |
 | | | | +GnomeIconEntry
 | | | | |
 | | | | +GnomeIconSelection
 | | | | |
 | | | | +GnomeLess
 | | | | |
 | | | | +GnomePaperSelector
 | | | | |
 | | | | +GnomePixmapEntry
 | | | | |
 | | | | +GnomeSpell
 | | | | |
 | | | | +GtkColorSelection
```

```
| | | | |
| | | | `GtkGammaCurve
| | | |
| | | `GtkButtonBox
| | |   |
| | |   +GtkHButtonBox
| | |   |
| | |   `GtkVButtonBox
| | |
| | +GtkLayout
| | | |
| | | `GnomeCanvas
| | |   |
| | |   `GnomeIconList
| | |
| | +GnomeDockBand
| | |
| | +GnomeDock
| | |
| | +GtkCList
| | | |
| | | `GtkCTree
| | |
| | +GtkFixed
| | |
| | +GtkNotebook
| | | |
| | | `GtkFontSelection
| | |
| | +GtkPaned
| | | |
| | | +GtkHPaned
| | | |
| | | `GtkVPaned
| | |
| | +GtkList
| | |
| | +GtkMenuShell
| | | |
| | | +GtkMenuBar
| | | |
| | | `GtkMenu
| | |
| | +GtkPacker
```

```
  | | |
  | | +GtkSocket
  | | |
  | | +GtkTable
  | | | |
  | | | `GtkTed
  | | |
  | | +GtkToolbar
  | | |
  | | `GtkTree
  | |
  | +GnomeAnimator
  | |
  | +GnomePixmap
  | | |
  | | `GnomeStock
  | |
  | +GtkMisc
  | | |
  | | +GtkLabel
  | | | |
  | | | +GtkAccelLabel
  | | | |
  | | | +GtkClock
  | | | |
  | | | `GtkTipsQuery
  | | |
  | | +GtkArrow
  | | |
  | | +GtkImage
  | | |
  | | `GtkPixmap
  | |
  | +GtkCalendar
  | |
  | +GtkDrawingArea
  | | |
  | | `GtkCurve
  | |
  | +GtkDial
  | |
  | +GtkEditable
  | | |
  | | +GtkEntry
```

```
| | | |
| | | `GtkSpinButton
| | |
| | `GtkText
| |
| +GtkRuler
| | |
| | +GtkHRuler
| | |
| | `GtkVRuler
| |
| +GtkRange
| | |
| | +GtkScale
| | | |
| | | +GtkHScale
| | | |
| | | `GtkVScale
| | |
| | `GtkScrollbar
| |   |
| |   +GtkHScrollbar
| |   |
| |   `GtkVScrollbar
| |
| +GtkSeparator
| | |
| | +GtkHSeparator
| | |
| | `GtkVSeparator
| |
| +GtkPreview
| |
| +GtkProgress
| | |
| | `GtkProgressBar
| |
| `ZvtTerm
|
+GnomeCanvasItem
| |
| +GnomeCanvasRE
| | |
| | +GnomeCanvasEllipse
| | |
| | `GnomeCanvasRect
| |
| +GnomeCanvasGroup
| |
| +GnomeCanvasImage
| |
| +GnomeCanvasLine
| |
| +GnomeCanvasPolygon
| |
| +GnomeCanvasText
| |
| +GnomeCanvasWidget
| |
| `GnomeIconTextItem
|
+GnomeClient
|
+GnomeDEntryEdit
|
+GnomeDockLayout
|
+GnomeMDIChild
| |
| `GnomeMDIGenericChild
|
+GnomeMDI
|
+GtkData
| |
| +GtkAdjustment
| |
| `GtkTooltips
|
`GtkItemFactory
```

GtkObject

GtkObject

Library

GTK+

Header File

gtk/gtkobject.h

Description

GtkObject is the base of GTK+'s object hierarchy. It is not a graphical component; it implements interfaces for reference counting, attaching key-value pairs to objects and object destruction ("virtual destructors" in C++ terms). GtkObject itself makes heavy use of the GTK+ type system. The signal/callback infrastructure of GTK+ works in terms of GtkObject---that is, signals are emitted from a particular GtkObject, and callbacks are connected to a particular object and signal.

the chapter called *The GTK+ Object and Type System* covers GtkObject in detail.

GtkObject

GtkObject

Library

GTK+

Header File

gtk/gtkobject.h

Description

GtkObject is the base of GTK+'s object hierarchy. It is not a graphical component; it implements interfaces for reference counting, attaching key-value pairs to objects and object destruction ("virtual destructors" in C++ terms). GtkObject itself makes heavy use of the GTK+ type system. The signal/callback infrastructure of GTK+ works in terms of

GtkObject---that is, signals are emitted from a particular GtkObject, and callbacks are connected to a particular object and signal.

the chapter called *The GTK+ Object and Type System* covers GtkObject in detail.

Widgets

Widgets are the reason for GTK+'s existence. Widgets are subclasses of GtkWidget, which is in turn a subclass of GtkObject. A widget represents a rectangular region on the screen, and may be purely decorative, an interactive control, or a container controlling the arrangement of child widgets. the chapter called *GTK+ Basics* introduces GTK+ and thus widgets; the chapter called *Writing a GtkWidget* covers widget implementation and concepts in more detail.

GtkWidget

Library

GTK+

Header File

gtk/gtkwidget.h

Description

GtkWidget is the parent class of all widgets. Chapters the chapter called *GTK+ Basics* and the chapter called *Writing a GtkWidget* describe widgets in general terms.

GtkWidget is an abstract base class.

GtkContainer

Library

GTK+

Header File

gtk/gtkcontainer.h

Description

GtkContainer is the abstract base class for widgets that can contain other widgets. the section called *Containers And Widget Layout* in the chapter called *GTK+ Basics* describes containers in some detail; the chapter called *Writing a GtkWidget* includes information on container widget implementation.

GtkBin

Library

GTK+

Header File

gtk/gtkbin.h

Description

GtkBin is an abstract base class for containers with one child. It provides default implementions of the GtkContainer interface, so it is very easy to subclass. the chapter called *Writing a GtkWidget* describes how to implement a GtkBin subclass.

GtkWindow

Library

GTK+

Header File

gtk/gtkwindow.h

Description

GtkWindow represents a toplevel dialog or application window. As the primary toplevel widget in GTK+, it has many special responsibilities; for example, it maintains the current keyboard focus and determines its own size allocation (rather than receiving one from a parent widget).

Gnome applications typically use GnomeApp for main application windows, to take advantage of its added features; for dialogs, you should use GnomeDialog with Gnome and GtkDialog with GTK+. Of course there are several specialized dialog subclasses available as well. If none of GtkWindow's subclasses seem appropriate to your application, GtkWindow can also be used directly.

A danger worthy of note: GtkWindow is automatically destroyed if it receives a "delete_event" signal. To prevent this, you must install the *last* signal handler to run, and your signal handler must return TRUE. This is a very common GTK+ programming mistake; see the section called *Window Change Events* in the chapter called *GDK Basics* for details. GnomeDialog will help you handle this situation; see the chapter called *User Communication: Dialogs*.

It is a good idea to make GtkWindow the last container you call gtk_widget_show() on. Most widgets are not actually mapped (placed onscreen) until their parent container is; but GtkWindow has no parent, and appears immediately. So if you show its children after you've shown the window, you will see some flicker.

GnomeDialog

Library

Gnome

Header File

libgnomeui/gnome-dialog.h

Description

GnomeDialog (or a subclass) should be used for all dialogs in a Gnome program. the chapter called *User Communication: Dialogs* describes the GnomeDialog interface.

If you aren't using Gnome, GnomeDialog is still useful --- because it implements all the basic features a dialog really must have. Studying the GnomeDialog source is highly recommended (you can even cut-and-paste if your application is under the GPL).

GnomeAbout

Library

Gnome

Header File

libgnomeui/gnome-about.h

Description

GnomeAbout is an about dialog, giving Gnome about dialogs a consistent look-and-feel. the section called *GnomeAbout* in the chapter called *User Communication: Dialogs* covers the interface.

GnomeMessageBox

Library

Gnome

Header File

libgnomeui/gnome-messagebox.h

Description

GnomeMessageBox is simply a GnomeDialog with a label and a small icon pre-packed inside. The icon corresponds to a "message box type," such as a warning message, an error, or a question. This helps users rapidly determine the dialog's purpose. the section called *GnomeMessageBox* in the chapter called *User Communication: Dialogs* explains the use of this widget.

GnomePropertyBox

Library

Gnome

Header File

libgnomeui/gnome-propertybox.h

Description

GnomePropertyBox is a dialog for application preferences or the properties of some user-visible object in your program. It has "apply", "OK", "close", and "help" buttons; "OK" is equivalent to "apply" followed by "close." the section called *GnomePropertyBox* in the chapter called *User Communication: Dialogs* describes it in more detail.

GnomeScores

Library

Gnome

Header File

libgnomeui/gnome-scores.h

Description

GnomeScores keeps track of and displays a high scores list. Most Gnome games use it.

GnomeApp

Library

Gnome

Header File

libgnomeui/gnome-app.h

Description

GnomeApp is a GtkWidget subclass specialized for main application windows. It has spaces for an optional toolbar, menubar, and statusbar. The application's "document" goes in a special slot in the center of the widget. the section called *The GnomeApp Widget* in the chapter called *The Main Window: GnomeApp* describes this widget.

GtkDialog

Library

GTK+

Header File

gtk/gtkdialog.h

Description

GtkDialog is a GtkWindow with three widgets pre-packed: a GtkVBox for the dialog contents, a GtkSeparator, and a GtkHBox for the dialog's buttons. GtkDialog is not very useful; all Gnome programs should use GnomeDialog instead.

GnomeFontSelector

Library

Gnome

Header File

libgnomeui/gnome-font-selector.h

Description

GnomeFontSelector is an obsolete font selection dialog, replaced by GtkFontSelectionDialog. GtkFontSelectionDialog contains a GtkFontSelection. Gnome programs should really use a GtkFontSelection inside a GnomeDialog, because GtkFontSelectionDialog does not use GnomeDialog and thus its look-and-feel is slightly wrong. GnomeFontSelector should not be used.

GtkInputDialog

Library

GTK+

Header File

gtk/gtkinputdialog.h

Description

GtkInputDialog is a dialog for selecting and setting up devices that use the X Input Extension (such as drawing tablets). It predates Gnome and is not a GnomeDialog so it looks a little funny in Gnome applications, but there is no reasonable workaround without rewriting the widget.

GtkColorSelectionDialog

Library

GTK+

Header File

gtk/gtkcolorsel.h

Description

GtkColorSelectionDialog is a dialog containing a GtkColorSelection. Gnome applications should manually place the GtkColorSelection in a GnomeDialog, or use GnomeColorPicker.

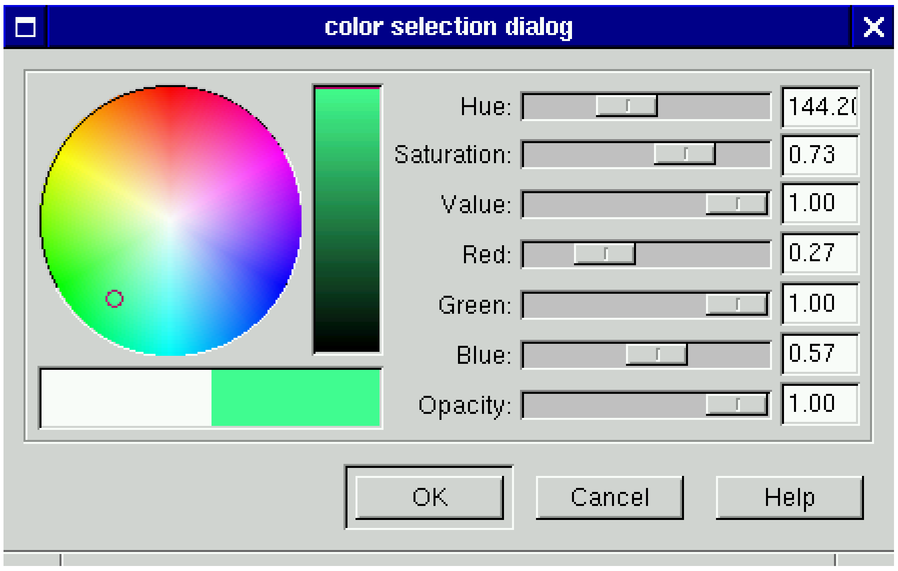


Figure 1. GtkColorSelectionDialog

GtkFileSelection

Library

GTK+

Header File

gtk/gtkfilesel.h

Description

GtkFileSelection is a file selection dialog (unlike most of the other widgets ending in "Selection", which are composite widgets meant to be placed inside a dialog). Unfortunately, there is no Gnome replacement for this dialog, so Gnome applications typically use it, despite its somewhat inconsistent look.

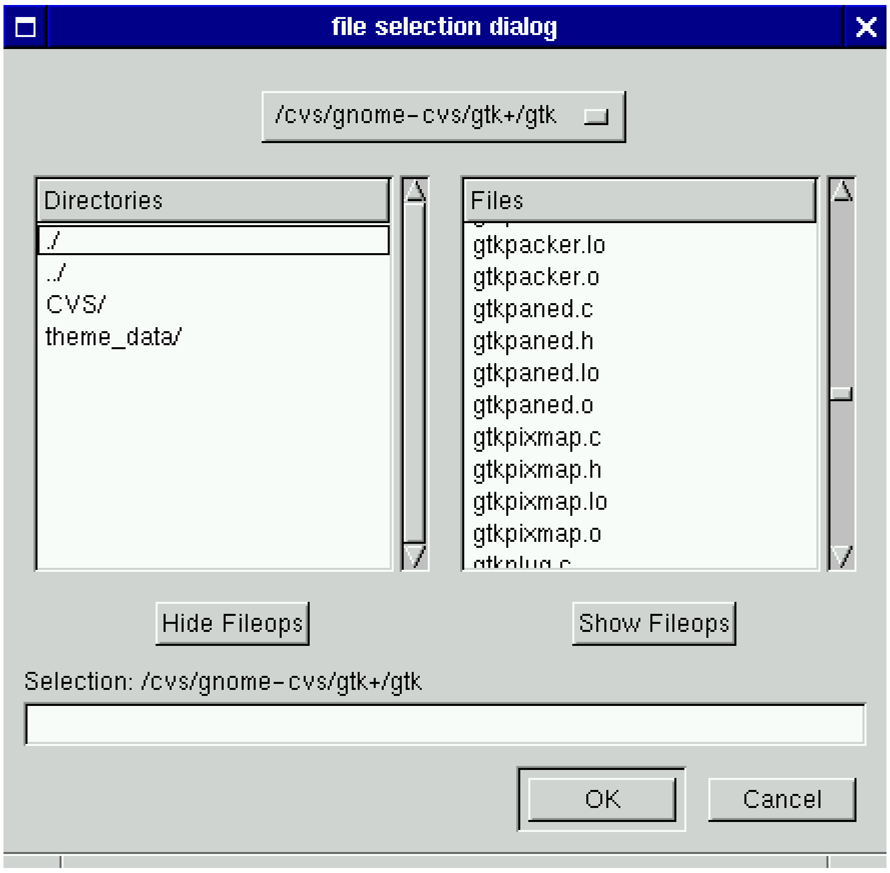


Figure 2. GtkFileSelection

GtkFontSelectionDialog

Library

GTK+

Header File

gtk/gtkfontsel.h

Description

GtkFontSelectionDialog is a dialog containing a GtkFontSelection. Gnome applications should use a GnomeDialog containing a GtkFontSelection instead.

Figure 3. GtkFontSelectionDialog

GtkPlug

Library

GTK+

Header File

gtk/gtkplug.h

Description

GtkPlug is a toplevel window that can be embedded in a GtkSocket widget running in a separate application. In other words, GtkSocket is a "hole" in one process that can contain a GtkPlug widget from another.

GtkButton

Library

GTK+

Header File

gtk/gtkbutton.h

Description

GtkButton is a simple rectangular button. It's a container with one child; usually it contains text or a pixmap, but it can contain any widget.

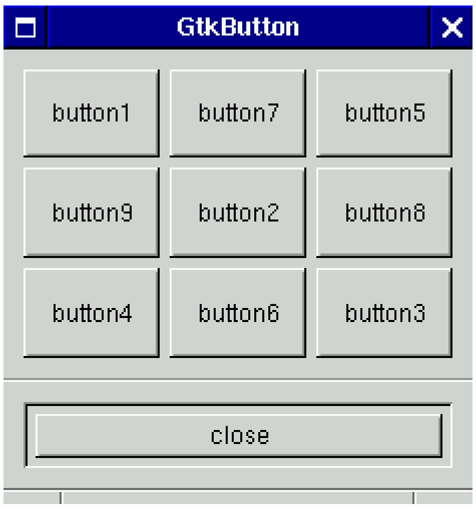


Figure 4. A dialog filled with GtkButtons

GnomeColorPicker

Library

Gnome

Header File

libgnomeui/gnome-color-picker.h

Description

GnomeColorPicker is a button containing a small colored square indicating the currently selected color. When clicked, it creates a color selection dialog to change the selected color.

GnomeFontPicker

Library

Gnome

Header File

libgnomeui/gnome-font-picker.h

Description

GnomeFontPicker is analagous to GnomeColorPicker; it's a button showing the currently selected font, which pops up a font selection dialog when clicked.

GnomeHRef

Library

Gnome

Header File

libgnomeui/gnome-href.h

Description

GnomeHRef is a borderless button with a hyperlink displayed on it. When the button is clicked, Gnome points the user's browser at the hyperlink's target URL, or launches a new browser instance. The command used to go to the URL is globally configurable from the Gnome control center.

GtkToggleButton

Library

GTK+

Header File

gtk/gtktogglebutton.h

Description

GtkToggleButton looks much like a regular GtkButton. However, it is intended to reflect a toggleable state; when the toggle is "active," the button appears to be depressed. GtkCheckButton should often be used instead of the toggle button; the check button usually looks nicer than GtkToggleButton, and gives the user a better idea that the button represents a toggleable state.

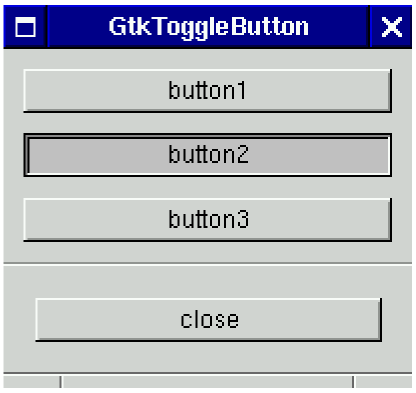


Figure 5. Three GtkToggleButton widgets; the center one is "active."

GtkCheckButton

Library

GTK+

Header File

gtk/gtkcheckbutton.h

Description

The GtkCheckButton widget works just like the GtkToggleButton, but looks different (it looks like a label with a small button to the left). In most cases, the check button is a better choice than the toggle button, because the toggle button does not give the user a visual hint that it represents a toggleable state.

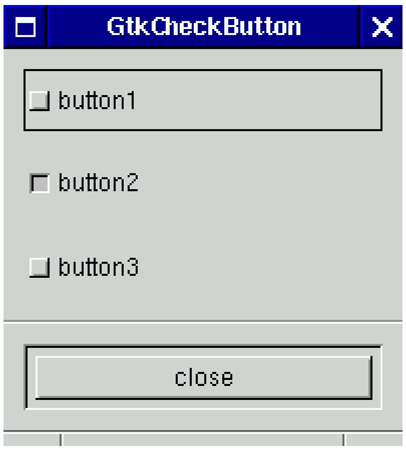


Figure 6. Three GtkCheckButton widgets; the center one is "active."

GtkRadioButton

Library

GTK+

Header File

gtk/gtkradiobutton.h

Description

A radio button represents one of several mutually-exclusive options. Radio buttons are placed in "groups"; only one button in a group can be active at a given time. GtkOptionMenu can also be used to represent mutually exclusive options; an option menu is typically a better choice if there are more than a few options. A GtkList or GtkCList might be appropriate if there are a truly large number of options.

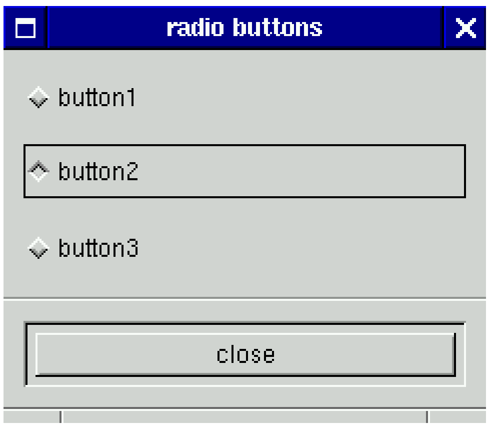


Figure 7. A group of three GtkRadioButtons

GtkOptionMenu

Library

GTK+

Header File

gtk/gtkoptionmenu.h

Description

GtkOptionMenu displays the currently active item from among a number of options; when clicked, it pops up a menu to allow the user to make a new item active. The option menu is slightly broken; it does not take the size of the menu items into account when requesting its size. If you have menu items containing labels in the option menu, the labels will often be truncated. The best workaround is to give the option menu more space than it requests, by setting appropriate options on its parent container.

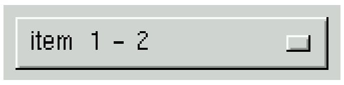


Figure 8. GtkOptionMenu

GnomeDockItem

Library

Gnome

Header File

libgnomeui/gnome-dock-item.h

Description

GnomeDockItem is a container that allows its child to appear on a GnomeDock. Dock items can be detached from their parent window and placed anywhere on the desktop; they can also be moved around within the dock. GnomeDock lets users rearrange Gnome toolbars. GnomeDockItem provides the "handle" for dragging its child. GnomeApp uses GnomeDock internally, so Gnome toolbars are all repositionable.

Figure 9. GnomeDock, with several GnomeDockItems.

GtkAlignment

Library

GTK+

Header File

gtk/gtkalignment.h

Description

GtkAlignment is an invisible container used to align a child widget within some space. It lets you set two factors, each in both the X and Y direction;

the *alignment* is 0.0 for left-justified (or top-justified) and 1.0 for right-justified (or bottom-justified). An alignment of 0.5 centers the child in that direction. The *scale* factor determines how the child fills extra space it did not request; if 0.0, the child fills only its requisition. A scale of 1.0 means that the child always expands to fill all the available space. (Clearly, a 1.0 scale factor makes the alignment factor irrelevant.)

GtkFrame

Library

GTK+

Header File

gtk/gtkframe.h

Description

The frame widget draws a decorative frame around its child. It has an optional title describing the contents of the frame. To turn off the title, set it to NULL. It also has a configurable shadow style; the four possibilities are shown in Figure 10. GTK_SHADOW_NONE is a fifth acceptable value for the shadow type; it turns the shadow off.

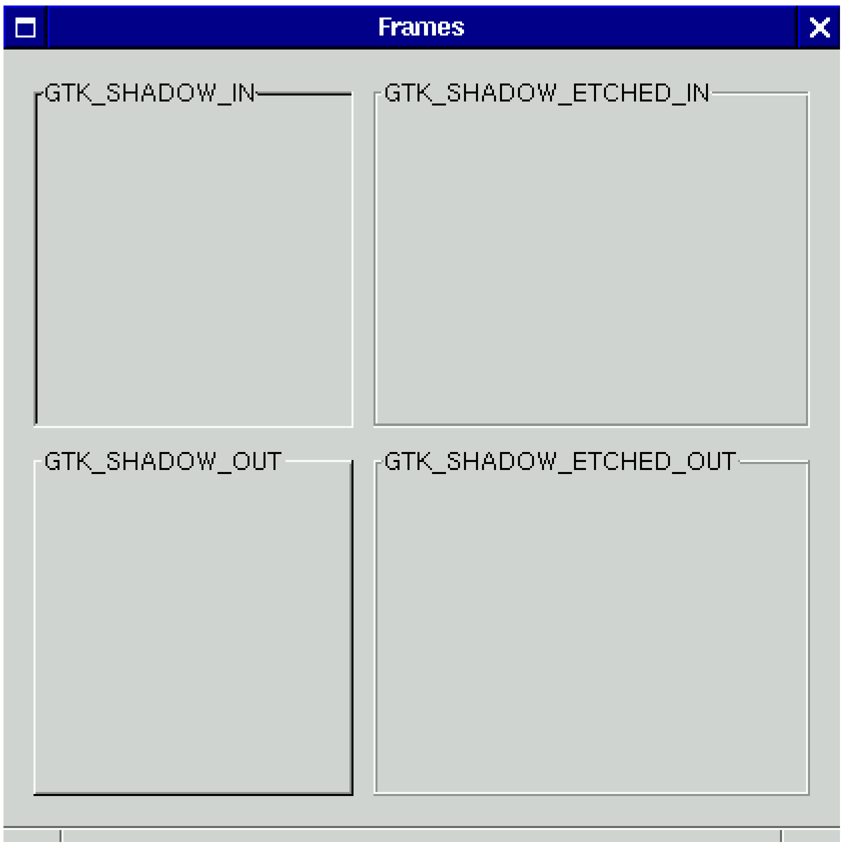


Figure 10. GtkFrame, with the four shadow types.

GtkAspectFrame

Library

GTK+

Header File

gtk/gtkaspectframe.h

Description

GtkAspectFrame is used to control the aspect ratio of its child. It also allows you to justify the child in both directions, similar to GtkAlignment. You can specify an aspect ratio, or require that the ratio of the child's size request be preserved. Visually, GtkAspectFrame looks exactly like GtkFrame.

GtkItem

Library

GTK+

Header File

gtk/gtkitem.h

Description

GtkItem is an abstract base class for list items, tree items, and menu items. Items are widgets that can be ″selected,″ ″deselected,″ and ″toggled.″

GtkMenuItem

Library

GTK+

Header File

gtk/gtkmenuitem.h

Description

A menu item is an invisible container; it is the only kind of widget that can appear in a GtkMenu. Typically, a label or a label and a pixmap are placed in the menu item to indicate its function. If a menu item has no child widget, it draws a separator line instead. This saves the overhead of adding a GtkSeparator to the menu item.

GtkCheckMenuItem

Library

GTK+

Header File

gtk/gtkcheckmenuitem.h

Description

GtkCheckMenuItem is a menu item that works like a GtkCheckButton; it has a small button next to its child widget, which is either "active" or "inactive." Because it's a subclass of GtkMenuItem, it can appear in menus.

GtkRadioMenuItem

Library

GTK+

Header File

gtk/gtkradiomenuitem.h

Description

A radio menu item works like GtkRadioButton; it allows the user to choose from a set of mutually exclusive options. Because it's a subclass of GtkMenuItem, it can appear in menus.

GtkPixmapMenuItem

Library

Gnome

Header File

libgnomeui/gtkpixmapmenuitem.h

Description

GtkPixmapMenuItem is a Gnome widget despite its name. This widget solves a very specific problem: namely, if a menu contains check or radio menu items, GTK+ indents the child widget of all the menu items in the menu to make room for the check or radio buttons. Gnome uses pixmaps next to some menu items; GtkPixmapMenuItem indents pixmaps in the same way GTK+ indents check or radio buttons. If you simply added a pixmap and a label to a GtkMenuItem, the pixmap would be incorrectly aligned with the plain labels in other menu items. This widget is not really pixmap-specific; any widget can be placed in the unindented "pixmap" slot. Usually GtkPixmapMenuItem is created implicitly with the Gnome menu creation functions.

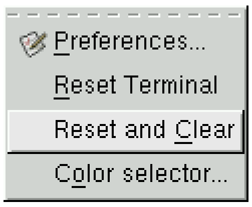


Figure 11. GtkPixmapMenuItem correctly positions pixmaps in a separate column to the left of the menu item texts.

GtkTearoffMenuItem

Library

GTK+

Header File

gtk/gtktearoffmenuitem.h

Description

GtkTearoffMenuItem is a "perforation" representing a spot where a menu can be "torn off" (kept visible in a toplevel window for easy access). Gnome menus all include a tearoff menu item by default, but users can globally disable them using the Gnome control center.

GtkListItem

Library

GTK+

Header File

gtk/gtklistitem.h

Description

GtkListItem is an invisible container that allows its child to appear in a GtkList. That is, only list items can appear in a list.

GtkTreeItem

Library

GTK+

Header File

gtk/gtktreeitem.h

Description

GtkTreeItem is an invisible container that gives its child the ability to appear in a GtkTree. Only tree items can be placed in the tree widget.

GtkEventBox

Library

GTK+

Header File

gtk/gtkeventbox.h

Description

The event box widget may be the simplest container in GTK+; its only purpose is to have a GdkWindow. Certain operations only work on widgets with windows (such as setting the background color, or capturing events); if you want to perform these operations on a windowless widget, you can place the widget in an event box and perform the operations on the event box, achieving much the same effect.

GtkHandleBox

Library

GTK+

Header File

gtk/gtkhandlebox.h

Description

The handle box widget can be adds a handle to a child widget; by dragging on the handle, the child can be removed from the window and positioned elsewhere on the user's desktop. The handle box is often used for toolbars. GnomeDock and GnomeDockItem offer a more flexible (but more elaborate) alternative.

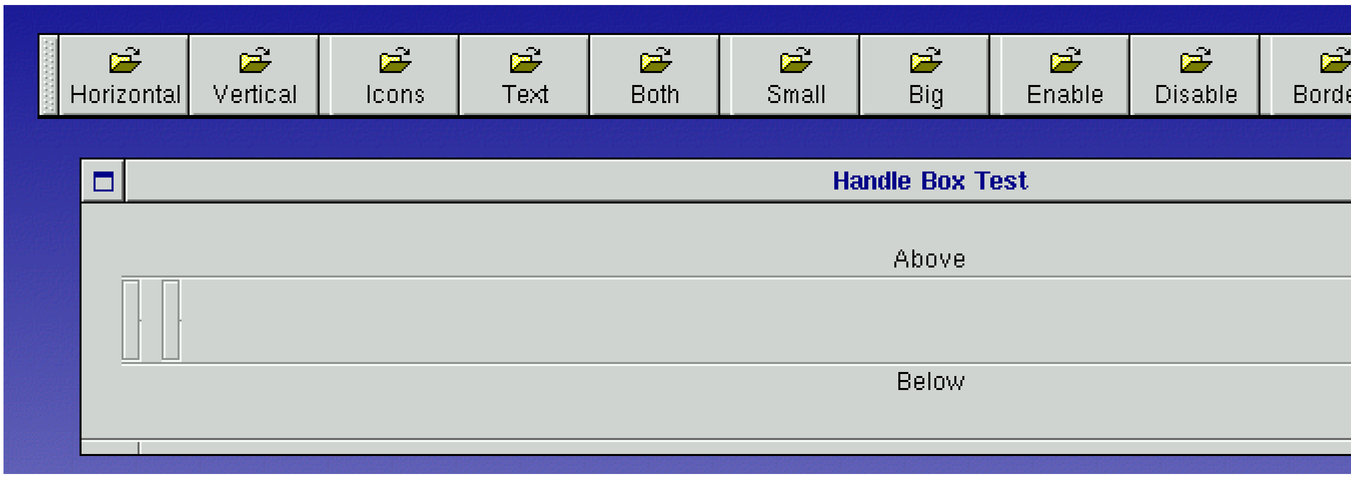


Figure 12. A torn-off GtkHandleBox containing a toolbar, alongside its original parent window.

GtkScrolledWindow

Library

GTK+

Header File

gtk/gtkscrolledwindow.h

Description

GtkScrolledWindow provides horizontal and vertical scrollbars for its child widget. Optionally, the scrollbars are hidden when the entire child is visible. If a child widget has a set_scroll_adjustments_signal in its GtkWidgetClas (see the section called *Overridable Signals* in the chapter called *Writing a GtkWidget*), the scrolled window uses them as the adjustments for the scrollbars. Otherwise, the scrolled window scrolls the entire widget using a GtkViewport. (Consider GtkCList for example; the column titles aren't scrolled, only the list contents. Thus GtkCList provides scroll adjustment signals.)

GtkViewport

Library

GTK+

Header File

gtk/gtkviewport.h

Description

GtkViewport is more or less an implementation detail of GtkScrolledWindow. It contains a widget that does not provide a set_scroll_adjustments_signal, and provides such a signal on the child widget's behalf. See GtkScrolledWindow for more details.

GtkBox

Library

GTK+

Header File

gtk/gtkbox.h

Description

GtkBox is an abstract base class for GtkVBox, GtkHBox, and GtkButtonBox. It's an invisible layout container; the chapter called *GTK+ Basics* describes it in some detail.

GtkHBox

Library

GTK+

Header File

gtk/gtkhbox.h

Description

GtkHBox is a GtkBox that packs widgets from left to right. The left side is considered the "start" of the box.

GnomeAppBar

Library

Gnome

Header File

libgnomeui/gnome-appbar.h

Description

GnomeAppBar is a simple status bar with an optional progress meter. It does not have "contexts" like GtkStatusbar. the section called *GnomeAppBar* in the chapter called *The Main Window: GnomeApp* gives more details.

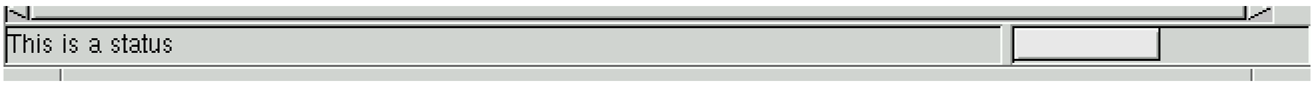


Figure 13. GnomeAppBar with the optional progress bar turned on.

GnomeDateEdit

Library

Gnome

Header File

libgnomeui/gnome-dateedit.h

Description

GnomeDateEdit allows the user to edit a date and time. The time-editing part can be turned off if you are only interested in the date.

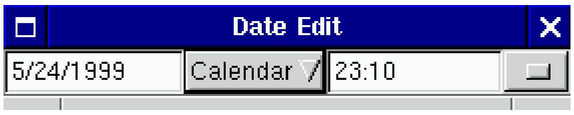


Figure 14. GnomeDateEdit

GtkCombo

Library

GTK+

Header File

gtk/gtkcombo.h

Description

GtkCombo is a text entry box with a drop-down menu "quick choices." If you want to limit the user to a fixed set of options, a GtkOptionMenu is more appropriate. GtkCombo allows the user to type in anything, but offers some suggestions as well. GnomeEntry is a combo box that adds items the user types in to the list of choices in the drop-down menu, and automatically remembers the list from session to session.

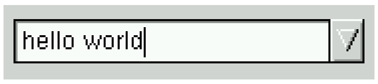


Figure 15. GtkCombo

GnomeEntry

Library

Gnome

Header File

libgnomeui/gnome-entry.h

Description

GnomeEntry is a GtkCombo extension that uses the drop-down menu as a history. If the user types something which isn't in the history already, GnomeEntry adds it and saves it in a configuration file to be loaded next time the application starts up.

GnomeFileEntry

Library

Gnome

Header File

libgnomeui/gnome-file-entry.h

Description

GnomeFileEntry is a GnomeEntry that keeps file names in its history. It also has a "Browse" button which pops up a GtkFileSelection. It has a "directories only" mode as well.

GnomeNumberEntry

Library

Gnome

Header File

libgnomeui/gnome-number-entry.h

Description

GnomeNumberEntry allows the user to enter a number; it keeps a history of numbers entered in its drop-down menu. It also has a "Calculator" button to pop up a GnomeCalculator.

GnomeProcBar

Library

Gnome

Header File

libgnomeui/gnome-procbar.h

Description

GnomeProcBar is used in a Gnome panel applet that displays CPU and memory load, and in the GTop application (a graphical top clone). It displays a colored bar that can change length; it could be used to display any kind of constantly-changing value.

GtkStatusbar

Library

GTK+

Header File

gtk/gtk.h

Description

GtkStatusbar is described in the section called *GtkStatusbar* in the chapter called *The Main Window: GnomeApp*. It's a status bar widget; it displays a line of text at the bottom of a window.

GtkVBox

Library

GTK+

Header File

gtk/gtkvbox.h

Description

GtkVBox is a GtkBox that packs widgets from top to bottom. The top is considered the "start" of the box.

GnomeCalculator

Library

Gnome

Header File

libgnomeui/gnome-calculator.h

Description

GnomeCalculator is a simple calculator, implemented as a GtkWidget.

Figure 16. GnomeCalculator

GnomeGuru

Library

Gnome

Header File

libgnomeui/gnome-guru.h

Description

GnomeGuru was an attempt to implement a "wizard" widget (a series of pages representing steps in a task that the user can step through). It is an immature interface and should not be used; at press time, it appears that a new widget called GnomeDruid will replace it in the next version of Gnome. GnomeDruide will most likely be available as an add-on module before that, so look for it if you need a wizard widget.

GnomeIconEntry

Library

Gnome

Header File

libgnomeui/gnome-icon-entry.h

Description

GnomeIconEntry is similar to GnomeColorPicker and GnomeFontPicker. It's a button displaying a currently-selected icon; when the button is clicked, an icon browser dialog allows the user to set a new icon. The widget used to have a text entry for typing an icon filename, thus it is called GnomeIconEntry rather than GnomeIconPicker.

GnomeIconSelection

Library

Gnome

Header File

libgnomeui/gnome-icon-sel.h

Description

GnomeIconSelection browses icon files; it's used by GnomeIconEntry but can also be used directly.

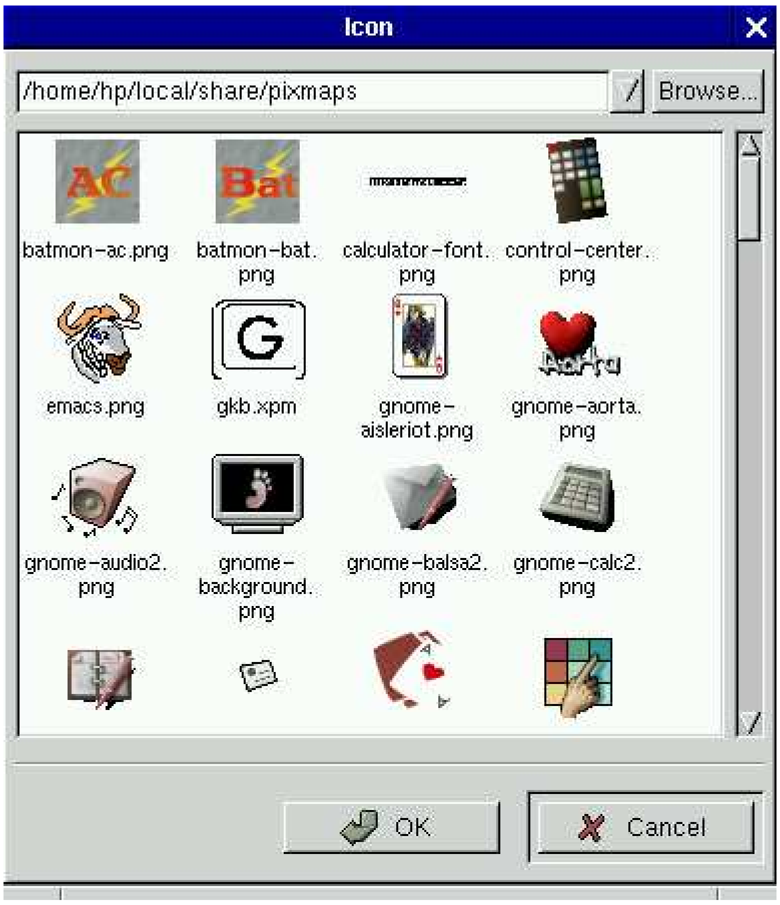


Figure 17. GnomeIconSelection

GnomeLess

Library

Gnome

Header File

libgnomeui/gnome-less.h

Description

GnomeLess is a simple extension of GtkText that loads text from a file or file descriptor and displays it. It is probably a good idea to avoid this widget; because it isn't very useful, it is likely to disappear from future versions of Gnome.

GnomePaperSelector

Library

Gnome

Header File

libgnomeui/gnome-paper-selector.h

Description

GnomePaperSelector is another widget worth avoiding; in the 1.0 release, it is strictly experimental. It allows the user to select the paper size for printing.

GnomePixmapEntry

Library

Gnome

Header File

libgnomeui/gnome-pixmap-entry.h

Description

GnomePixmapEntry has essentially the same purpose as GnomeIconEntry; it allows the user to select a pixmap. The only reason you might prefer one to the other is that GnomeIconEntry scales images to the standard Gnome icon size.

GnomeSpell

Library

Gnome

Header File

libgnomeui/gnome-spell.h

Description

GnomeSpell is a spell-checker interface; it uses the ispell program internally. This widget should be considered experimental and avoided in production code.

GtkColorSelection

Library

GTK+

Header File

gtk/gtkcolorsel.h

Description

GtkColorSelection allows the user to specify a color, using a color wheel or sliders. It makes up the contents of GtkColorSelectionDialog (Figure 1 in the section called *Description*).

GtkGammaCurve

Library

GTK+

Header File

gtk/gtkgamma.h

Description

GtkGammaCurve allows the user to edit a curve; it's a very specialized widget used in the Gimp. Few applications will have a use for it.

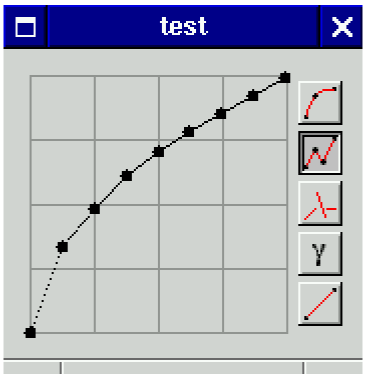


Figure 18. GtkGammaCurve

GtkButtonBox

Library

GTK+

Header File

gtk/gtkbbox.h

Description

GtkButtonBox is a special kind of GtkBox designed to store the buttons of a dialog. It has horizontal and vertical variants. GnomeDialog creates a button box for you, so there is no need to use this widget directly when programming with Gnome.

GtkHButtonBox

Library

GTK+

Header File

gtk/gtkhbbox.h

Description

GtkHButtonBox is the horizontal variant of GtkButtonBox.

GtkVButtonBox

Library

GTK+

Header File

gtk/gtk.h

Description

GtkVButtonBox is the vertical variant of GtkButtonBox.

GtkLayout

Library

GTK+

Header File

gtk/gtklayout.h

Description

GtkLayout creates the illusion of a container with infinite size. Because X windows are limited to 32,768 pixels in size (2^15), most widgets also have a 32,768-pixel size limit (and child widgets must be positioned within the parent's X window). Naive widgets scroll by simply moving their GdkWindow. GtkLayout is more intelligent about this.

GnomeCanvas

Library

Gnome

Header File

libgnomeui/gnome-canvas.h

Description

GnomeCanvas is extensively discussed in the chapter called *GnomeCanvas*. It renders flicker-free structured graphics, and is ideal for custom displays.

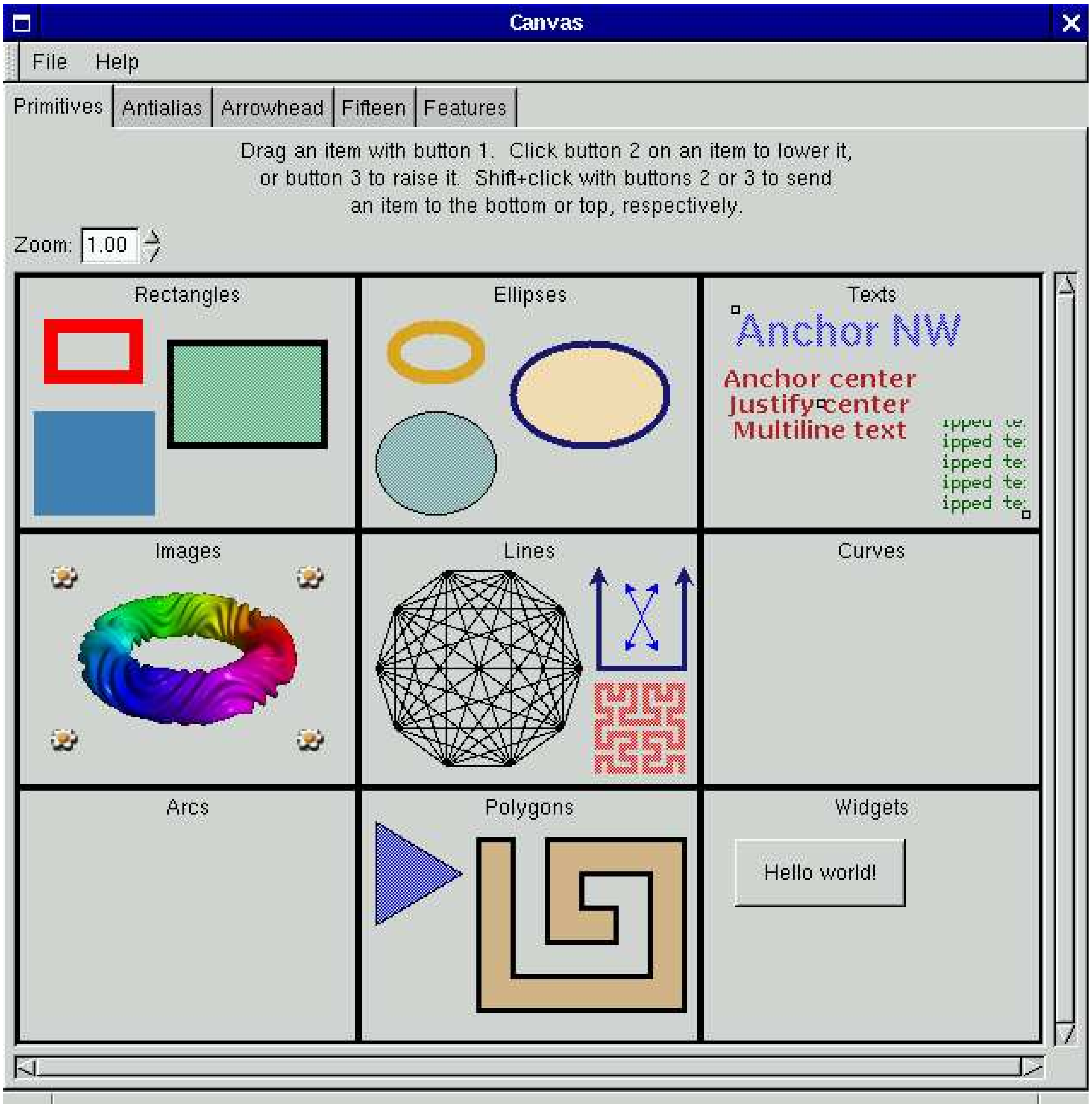

Canvas
File Help
Primitives Antialias Arrowhead Fifteen Features
Drag an item with button 1. Click button 2 on an item to lower it, or button 3 to raise it. Shift+click with buttons 2 or 3 to send an item to the bottom or top, respectively.
Zoom: 1.00
Rectangles
Ellipses
Texts
Anchor NW
Anchor center
Justify center
Multiline text
Images
Lines
Curves
Arcs
Polygons
Widgets
Hello world!

Figure 19. GnomeCanvas

GnomeIconList

Library

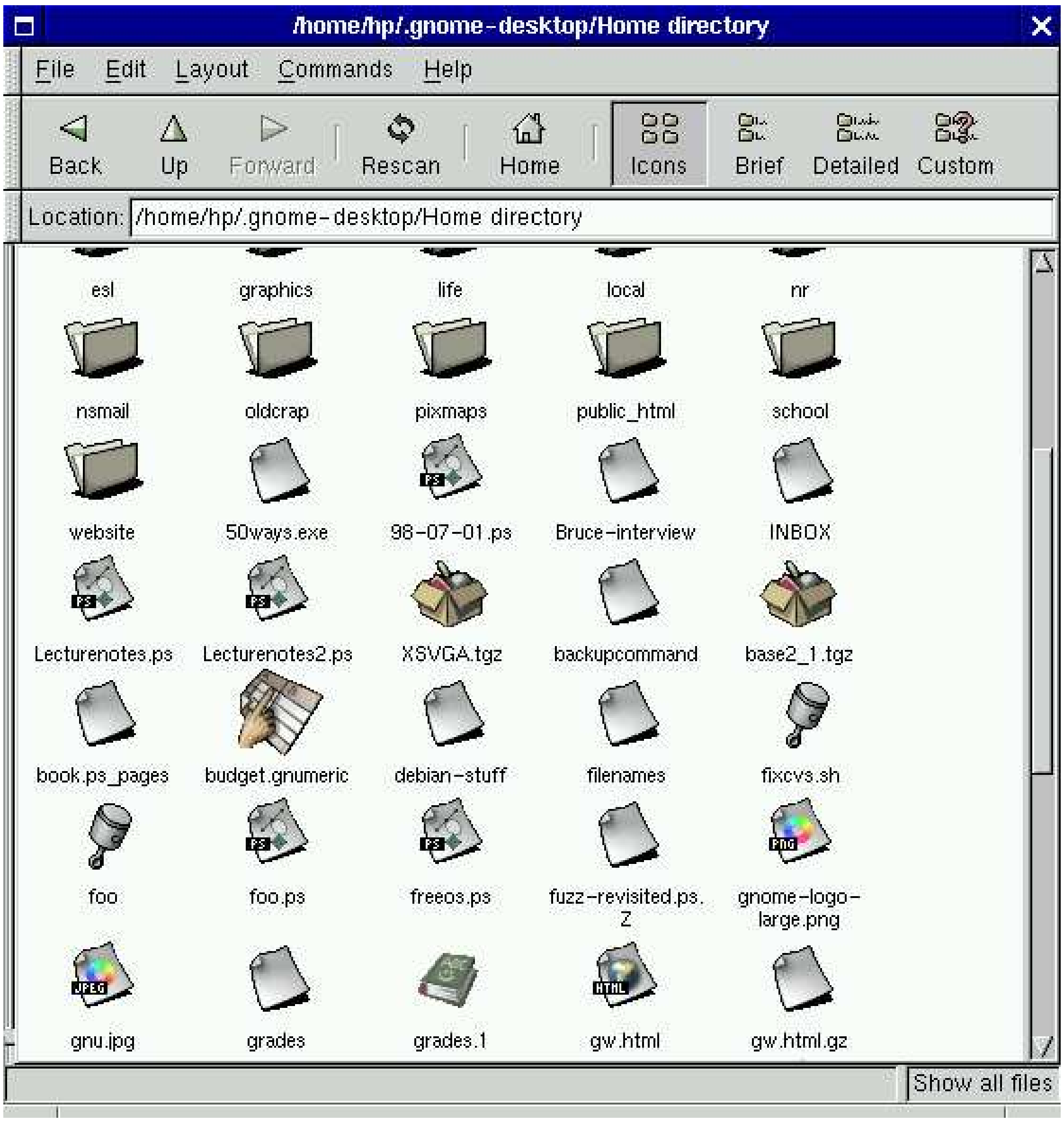
Gnome

Header File

libgnomeui/gnome-icon-list.h

Description

GnomeIconList is used in the Gnome file manager. It displays icons and their names; users can select groups of icons by rubberbanding.



Location: /home/hp/.gnome-desktop/Home directory

Figure 20. Gnome file manager, demonstrating GnomeIconList

GnomeDockBand

Library

Gnome

Header File

libgnomeui/gnome-dock-band.h

Description

GnomeDockBand contains one row or column of GnomeDockItems; a GnomeDock in turn contains one or more GnomeDockBands. See the GnomeDockItem entry for details and a screenshot.

GnomeDock

Library

Gnome

Header File

libgnomeui/gnome-dock.h

Description

GnomeDock collects GnomeDockBands which in turn hold GnomeDockItems. GnomeDock allows users to reposition toolbars and other application components. See the GnomeDockItem entry for details and a screenshot.

GtkCList

Library

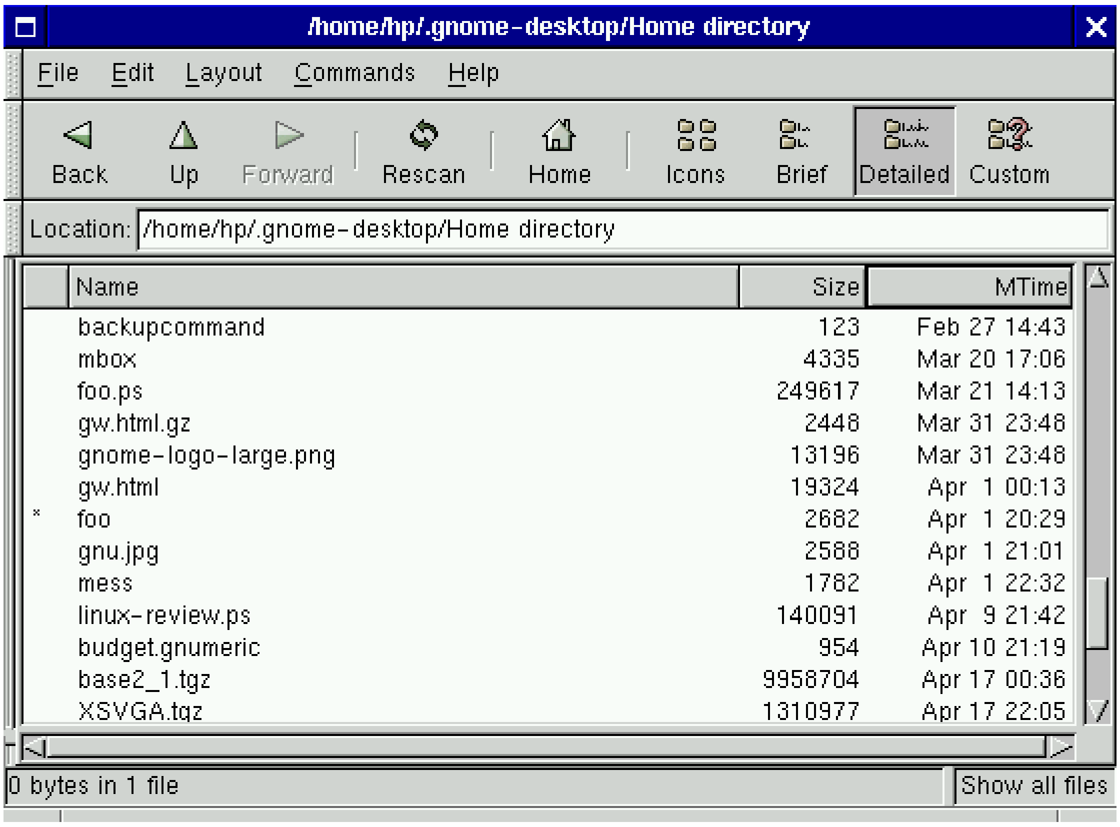
GTK+

Header File

gtk/gtkclist.h

Description

GtkCList is a list-with-columns widget; it is also the base class for GtkCTree. GtkCList displays text and/or a pixmap in each cell; it *cannot* hold child widgets in its cells. GtkCList is only a container because it uses widgets for the column headings. You may prefer GtkList, which can have child widgets as list items, but is less efficient and has a maximum list size of 32,768 pixels.



```
Location: /home/hp/.gnome-desktop/Home directory

   Name                              Size        MTime
   backupcommand                      123   Feb 27 14:43
   mbox                              4335   Mar 20 17:06
   foo.ps                          249617   Mar 21 14:13
   gw.html.gz                        2448   Mar 31 23:48
   gnome-logo-large.png             13196   Mar 31 23:48
   gw.html                          19324    Apr  1 00:13
*  foo                               2682    Apr  1 20:29
   gnu.jpg                           2588    Apr  1 21:01
   mess                              1782    Apr  1 22:32
   linux-review.ps                 140091    Apr  9 21:42
   budget.gnumeric                    954   Apr 10 21:19
   base2_1.tgz                    9958704   Apr 17 00:36
   XSVGA.tgz                      1310977   Apr 17 22:05

0 bytes in 1 file
```

Figure 21. The Gnome file manager's list view uses GtkCList

GtkCTree

Library

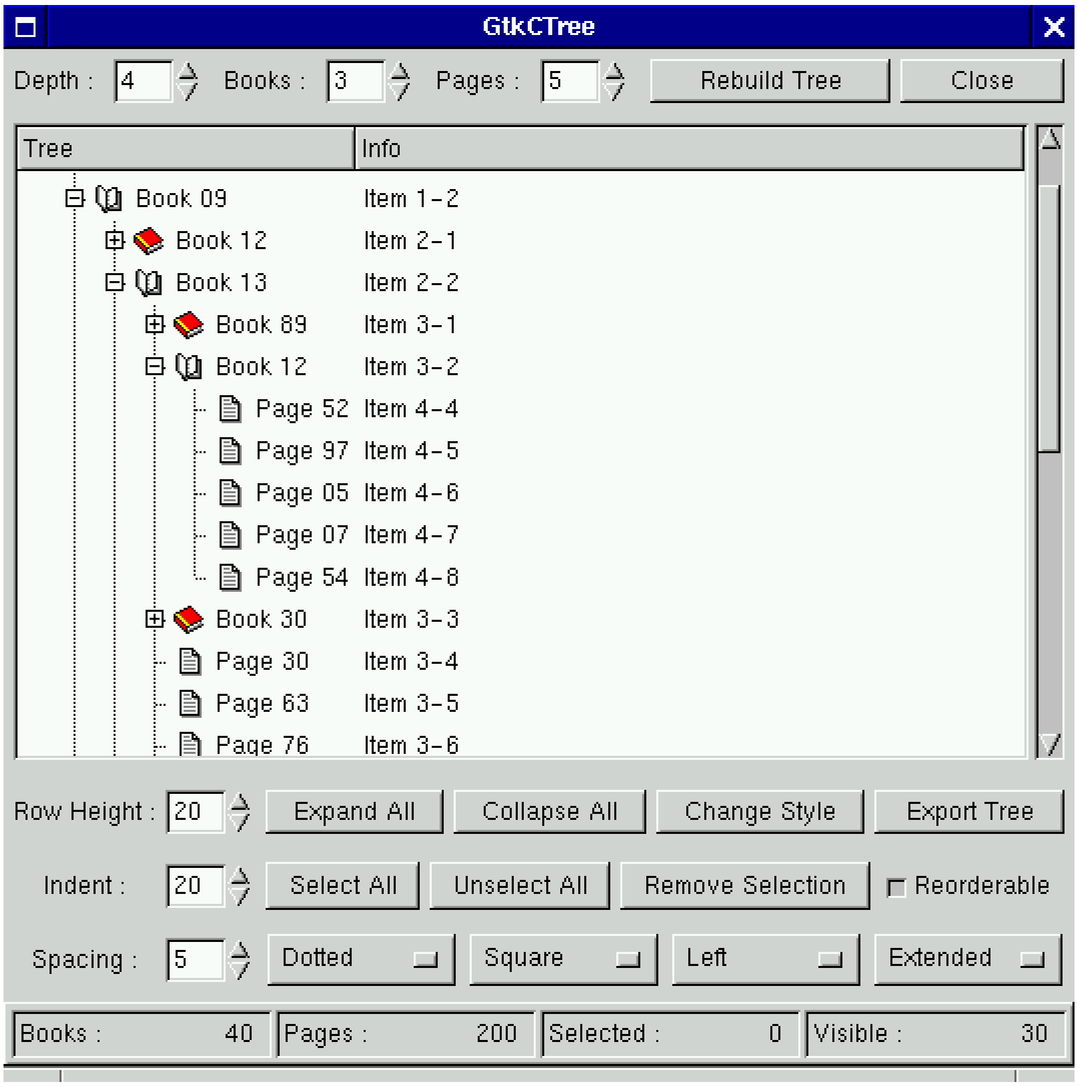
GTK+

Header File

gtk/gtkctree.h

Description

GtkCTree is similar to GtkCList, but (unsurprisingly) displays a tree with expandable nodes instead of a simple list. GtkTree is a more flexible tree widget (it can have arbitrary widgets in the tree cells), but it is less efficient and limited to 32,768 pixels.



Depth : 4 Books : 3 Pages : 5

Tree	Info
Book 09	Item 1-2
Book 12	Item 2-1
Book 13	Item 2-2
Book 89	Item 3-1
Book 12	Item 3-2
Page 52	Item 4-4
Page 97	Item 4-5
Page 05	Item 4-6
Page 07	Item 4-7
Page 54	Item 4-8
Book 30	Item 3-3
Page 30	Item 3-4
Page 63	Item 3-5
Page 76	Item 3-6

Row Height : 20

Indent : 20

Spacing : 5 Dotted Square Left Extended

Books : 40 Pages : 200 Selected : 0 Visible : 30

Figure 22. GtkCTree

GtkFixed

Library

GTK+

Header File

gtk/gtkfixed.h

Description

The GtkFixed container allows you to position child widgets at absolute coordinates, and always gives child widgets exactly their requested size. This widget is for masochists; it doesn't do anything automatically. You should almost always use another layout widget instead (if you think you need the fixed widget, consider asking for help; most likely a real layout widget can be made to work better).

GtkNotebook

Library

GTK+

Header File

gtk/gtknotebook.h

Description

A notebook widget presents the user with several "pages"; the user can move a page to the top by selecting its "tab." Each child added to GtkNotebook becomes a page; you can also specify widgets to use for the tab labels. It is generally considered bad practice to have more than a single row of tabs, but GtkNotebook does allow it. It is also possible to position the tabs on the left, right, or bottom of the notebook, but you should always leave them on top for interface consistency.

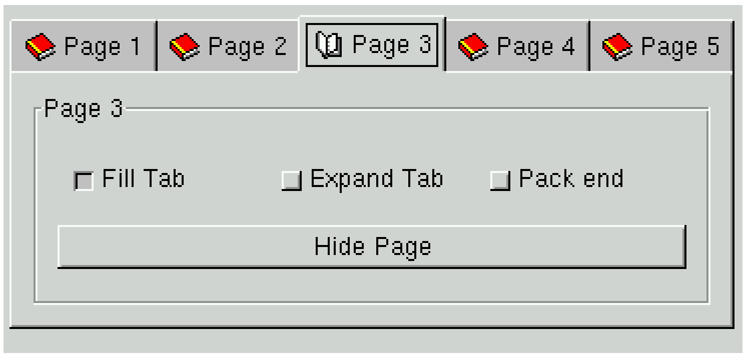


Figure 23. GtkNotebook

GtkFontSelection

Library

GTK+

Header File

gtk/gtkfontsel.h

Description

GtkFontSelection is a composite widget that allows the user to select a font from among the fonts available on the system. GtkFontSelectionDialog contains an instance of GtkFontSelection. Gnome applications should place a GtkFontSelection in a GnomeDialog.

GtkPaned

Library

GTK+

Header File

gtk/gtkpaned.h

Description

The GtkPaned widget divides an area into two user-resizable sections. It has horizontal and vertical variants.

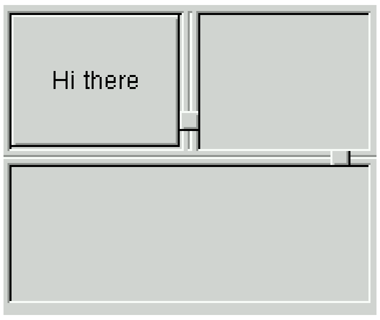


Figure 24. Horizontal and vertical GtkPaned widgets

GtkHPaned

Library

GTK+

Header File

gtk/gtkhpaned.h

Description

GtkHPaned is the horizontal variant of GtkPaned; it allows the user to divide a horizontal space between the GtkHPaned's two child widgets.

GtkVPaned

Library

GTK+

Header File

gtk/gtkvpaned.h

Description

GtkVPaned is the vertical variant of GtkPaned; it allows the user to divide a vertical space between the GtkVPaned's two child widgets.

GtkList

Library

GTK+

Header File

gtk/gtklist.h

Description

GtkList displays a list of items. Each item is a GtkListItem; GtkListItem is a container that can hold any kind of widget. The size of a GtkList is limited, because list items are placed at fixed coordinates in the list's GdkWindow, and scrolling is achieved by moving the GdkWindow; GdkWindow has a maximum size of 32,768 pixels, and any list item positioned outside that range is invisible. GtkCList overcomes this limitation, but is unable to contain arbitrary widgets.

GtkMenuShell

Library

GTK+

Header File

gtk/gtkmenushell.h

Description

GtkMenuShell is an abstract base class for widgets that contain GtkMenuItems. Its two subclasses are GtkMenu and GtkMenuBar.

GtkMenuBar

Library

GTK+

Header File

gtk/gtkmenubar.h

Description

GtkMenuBar is a menu bar. It contains one or more menu items; normally, each menu item will have a submenu (i.e., a GtkMenu with more menu items). For example, the menu bar might have a menu item called "File," with a submenu containing the menu items "Open" and "Quit."

GtkMenu

Library

GTK+

Header File

gtk/gtkmenu.h

Description

GtkMenu contains menu items. GtkMenu is unique because it should not be shown (with gtk_widget_show()) by the programmer; menus are popped up in response to user actions.

GtkPacker

Library

GTK+

Header File

gtk/gtkpacker.h

Description

GtkPacker is a layout container inspired by the Tk toolkit. If you're familiar with that toolkit, you may find it easier to use than the standard GTK+ layout containers.

GtkSocket

Library

GTK+

Header File

gtk/gtksocket.h

Description

GtkSocket is a "hole" in one application that allows a GtkPlug from a second application to be embedded.

GtkTable

Library

GTK+

Header File

gtk/gtktable.h

Description

the section called *GtkTable* in the chapter called *GTK+ Basics* desribes GtkTable in some detail. It's one of the most important GTK+ layout widgets.

GtkTed

Library

Gnome

Header File

libgnomeui/gtk-ted.h

Description

GtkTed is a relic from the early days of Gnome; "ted" stands for "table editor." It's a kind of primitive GUI builder. There are at least two advanced projects to write good GUI builders (Glade and GLE), so this widget should be ignored and will disappear in a future version of libgnomeui.

GtkToolbar

Library

GTK+

Header File

gtk/gtktoolbar.h

Description

No surprises here: GtkToolbar is a toolbar widget. Gnome applications will usually use the Gnome helper functions instead of creating a toolbar directly, as described in the chapter called *The Main Window: GnomeApp*.

GtkTree

Library

GTK+

Header File

gtk/gtktree.h

Description

GtkTree is to GtkCTree as GtkList is to GtkCList. That is, GtkTree is more flexible than GtkCTree---tree items can contain any widget--- but it's also a bit slower than GtkCTree and holds only a limited number of items. The maximum number of items depends on the height of the rows; the total row height must fit inside a GdkWindow, which means 32,768 pixels.

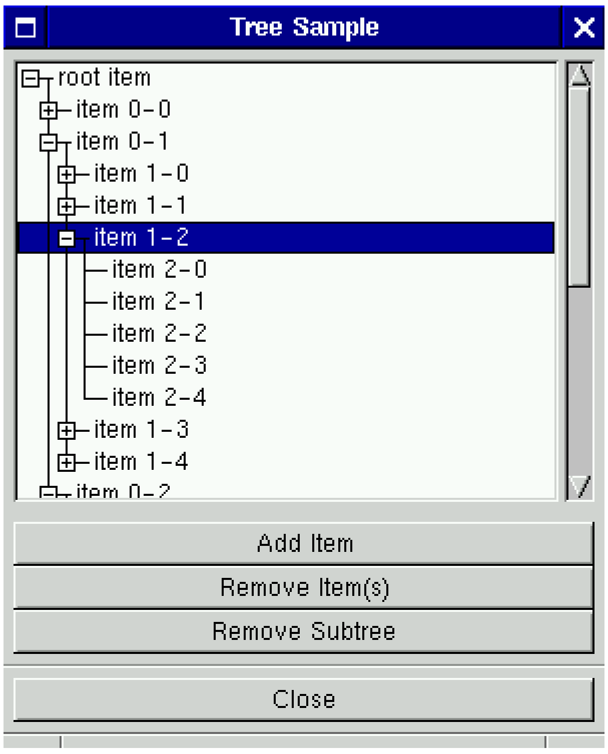


Figure 25. GtkTree

GnomeAnimator

Library

Gnome

Header File

libgnomeui/gnome-animator.h

Description

GnomeAnimator displays a series of images, creating an animation. It has a "loop mode" and a "play once" mode. The GnomeAnimator API is marked "immature" in Gnome 1.0 and may change incompatibly in future versions; this is an experimental widget.

GnomePixmap

Library

Gnome

Header File

libgnomeui/gnome-pixmap.h

Description

GnomePixmap should be preferred to GtkPixmap, though it has the same purpose. GnomePixmap is a bit smarter about visuals. It can also load images from many different formats, using Imlib, so it's more convenient to use.

GnomeStock

Library

Gnome

Header File

libgnomeui/gnome-stock.h

Description

GnomeStock is a container that wraps a GnomePixmap; it automatically creates "insensitive" and "focused" copies of the pixmap to reflect the widget state. It can be set to one of the Gnome stock pixmap macros, such as GNOME_STOCK_PIXMAP_CUT (small picture of scissors), GNOME_STOCK_PIXMAP_PRINT (a little printer), etc. You can also register new stock pixmaps specific to your application at runtime. Gnome uses this widget internally when creating menus and toolbars using a GnomeUIInfo template (see the section called *Menus and Toolbars with GnomeUIInfo* in the chapter called *The Main Window: GnomeApp*).

GtkMisc

Library

GTK+

Header File

gtk/gtkmisc.h

Description

The descriptively-named (or not) GtkMisc abstract base class allows you to set the "alignment" and "padding" of its subclasses. *Alignment* is a float between 0.0 and 1.0, where 0.0 is left-justified, 0.5 is centered, and 1.0 is right-justified. Alignment only matters if a GtkMisc receives a size allocation larger than its size request; the alignment locates the natural bounding box of the widget within its actual bounding box. *Padding* is a number of pixels to add to the widget's size request. The widget will then leave those pixels blank.

Widgets that do not derive from GtkMisc can be made "alignable" in the same way by placing them in a GtkAlignment container.

GtkLabel

Library

GTK+

Header File

gtk/gtklabel.h

Description

GtkLabel simply displays a text string. If the text string contains newlines, GtkLabel displays multiple lines. Labels honor the alignment parameter from their parent class (GtkMisc); you can use this to center the text, or move it to the left or right. Alignment is not the same as justification. Justification defines the position of multiple lines with respect to each other. Left-justified means each line starts in the same place, right-justified means each ends in the same place, center-justified means each is centered around the same imaginary line. Justification has no meaning for one-line labels. Alignment set with gtk_misc_set_alignment() positions the entire block of text within its size allocation; alignment only matters if the label receives more space than it requested (it will request just enough to hold the text block). Labels are GTK_NO_WINDOW widgets (which means they don't receive events and draw on their parent's background).

GtkAccelLabel

Library

GTK+

Header File

gtk/gtkaccellabel.h

Description

GtkAccelLabel is associated with some other widget, and displays the accelerator key for that widget as part of the label.

GtkClock

Library

Gnome

Header File

libgnomeui/gtk-clock.h

Description

GtkClock is a label that displays a time. It can optionally update the time periodically (just like a clock!).

GtkTipsQuery

Library

GTK+

Header File

gtk/gtktipsquery.h

Description

GtkTipsQuery is a label that displays tooltips. It also has "What's This?" functionality. You call gtk_tips_query_start() to switch to "query mode." In query mode, the cursor is changed to a question mark; as the mouse moves over widgets in the application, the GtkTipsQuery displays their tooltips. GtkTipsQuery emits a "widget_selected" signal if the user clicks on a widget; you can use this to display more extensive help for that widget. You might store the more extensive help as the "private" component of a GtkTooltip, or you might use gtk_object_set_data() to store some kind of application-specific help information.

GtkArrow

Library

GTK+

Header File

gtk/gtkarrow.h

Description

GtkArrow displays an arrow. It's a very simple GTK_NO_WINDOW widget and doesn't even receive events. In the default theme, an arrow is simply a triangle.

GtkImage

Library

GTK+

Header File

gtk/gtkimage.h

Description

GtkImage displays a GdkImage in a widget. It's only useful if you already have a GdkImage; to display a fixed image you usually want GnomePixmap.

GtkPixmap

Library

GTK+

Header File

gtk/gtkpixmap.h

Description

GtkPixmap displays a GdkPixmap. If you're using Gnome, prefer GnomePixmap for the reasons given in its description.

GtkCalendar

Library

GTK+

Header File

gtk/gtkcalendar.h

Description

GtkCalendar displays a calendar page (one month). It allows users to select a date. GnomeDateEdit uses GtkCalendar in a popup menu.

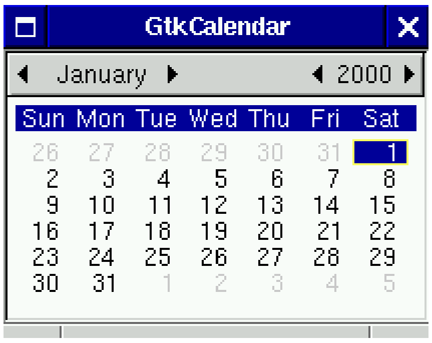


Figure 26. GtkCalendar is Y2K compliant!

GtkDrawingArea

Library

GTK+

Header File

gtk/gtkdrawingarea.h

Description

GtkDrawingArea is a thin wrapper around GdkWindow; it gives you a blank area to draw on. Normally, you would connect to its "configure_event" signal to catch changes in the size of the area, and do your drawing in an "expose_event" handler. To eliminate flicker, you might keep a GdkPixmap equal in size to the drawing area, and draw to the pixmap; in your ″expose_event″ handler, simply copy the exposed region from the pixamp to the drawing area.

For high-level graphics, GnomeCanvas can be much more convenient to use.

GtkCurve

Library

GTK+

Header File

gtk/gtkcurve.h

Description

GtkCurve is used to display the curve in the GtkGammaCurve widget. It's a drawing area extension with curve-drawing abilities. Most likely you won't find a use for this widget.

GtkDial

Library

GTK+

Header File

gtk/gtkdial.h

Description

GtkDial is a ″speedometer″ display. By default, the user can drag the ″needle″ around, changing the dial's value. GtkDial also has a ″view only″ mode.

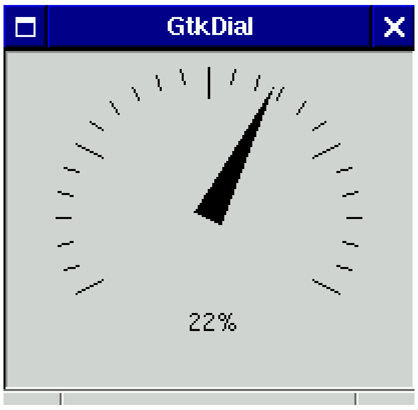


Figure 27. The GtkDial widget

GtkEditable

Library

GTK+

Header File

gtk/gtkeditable.h

Description

GtkEditable is an abstract base class for widgets that allow the user to edit text. The base class interface allows cursor positioning, retrieving characters, and so on. It also includes the "changed" signal, which you can use to detect user input.

GtkEntry

Library

GTK+

Header File

gtk/gtkentry.h

Description

GtkEntry allows the user to enter a single line of text. It has a "password" mode; in "password" mode the text in the entry is replaced by asterisks.

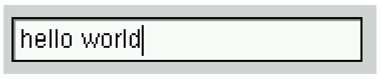

hello world

Figure 28. GtkEntry allows the user to enter a line of text

GtkSpinButton

Library

GTK+

Header File

gtk/gtkspinbutton.h

Description

GtkSpinButton is a GtkEntry customized to allow the user to enter a number. Spin buttons add up and down arrows to the entry, so the user can rapidly spin through the possible values.

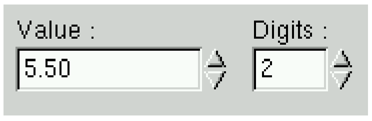

Value : 5.50
Digits : 2

Figure 29. >GtkSpinButton

GtkText

Library

GTK+

Header File

gtk/gtktext.h

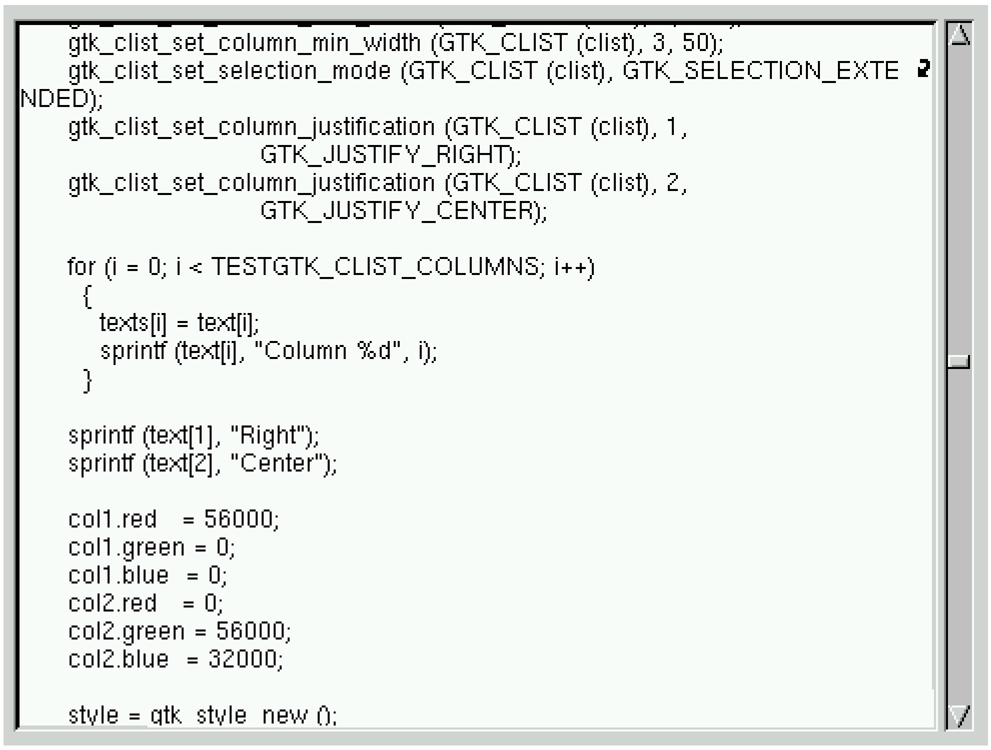
Description

GtkText is a text widget. It can display text, and offers simple text-editing facilities.

Two questions about the text widget are *very* frequently asked on the GTK+ mailing lists. These are:

- Does the text widget support horizontal scrolling?
- The text widget doesn't seem to be very powerful. Are there plans to replace it?

The text widget does not support horizontal scrolling; instead, it wraps lines. It is not very powerful, and the code is difficult to maintain; it will most likely be replaced in Gtk 1.4 as part of the move to Unicode.



```
    gtk_clist_set_column_min_width (GTK_CLIST (clist), 3, 50);
    gtk_clist_set_selection_mode (GTK_CLIST (clist), GTK_SELECTION_EXTE
NDED);
    gtk_clist_set_column_justification (GTK_CLIST (clist), 1,
                                        GTK_JUSTIFY_RIGHT);
    gtk_clist_set_column_justification (GTK_CLIST (clist), 2,
                                        GTK_JUSTIFY_CENTER);

    for (i = 0; i < TESTGTK_CLIST_COLUMNS; i++)
      {
        texts[i] = text[i];
        sprintf (text[i], "Column %d", i);
      }

    sprintf (text[1], "Right");
    sprintf (text[2], "Center");

    col1.red   = 56000;
    col1.green = 0;
    col1.blue  = 0;
    col2.red   = 0;
    col2.green = 56000;
    col2.blue  = 32000;

    style = gtk_style_new ();
```

Figure 30. GtkText

GtkRuler

Library

GTK+

Header File

gtk/gtkruler.h

Description

GtkRuler is an abstract base class for the horizontal and vertical ruler widgets. The ruler widgets are used in the GIMP to display image dimensions.

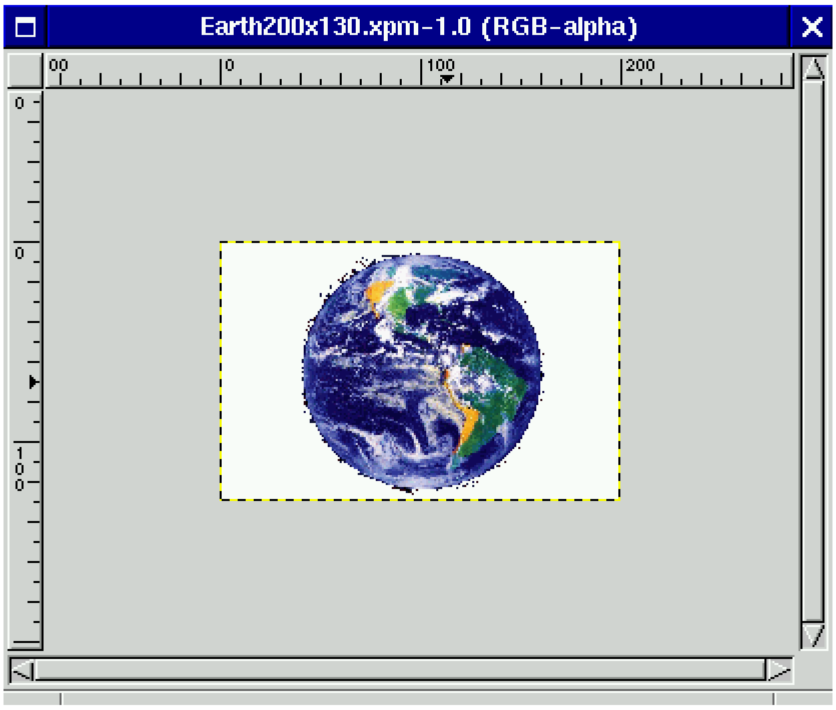


Figure 31. GtkHRuler and GtkVRuler, as used in the GIMP

GtkHRuler

Library

GTK+

Header File

gtk/gtkhruler.h

Description

Horizontal variant of GtkRuler.

GtkVRuler

Library

GTK+

Header File

gtk/gtkvruler.h

Description

Vertical variant of GtkRuler.

GtkRange

Library

GTK+

Header File

gtk/gtkrange.h

Description

GtkRange is an abstract base class for "slider" widgets. These widgets modify some numeric value as a "slider" is moved in a "trough." The two subclasses of GtkRange are GtkScale, used to allow the user to enter a numeric value, and GtkScrollbar, the GTK+ scrollbar widget.

GtkScale

Library

GTK+

Header File

gtk/gtkscale.h

Description

GtkScale allows the user to enter a numeric value by moving a slider. It can display the current value above the slider; you can turn this off if the exact value isn't relevant, or you want to provide feedback in some other way. GtkScale is an abstract base class; you must instantiate its vertical or horizontal variant.

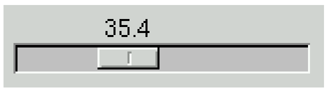


Figure 32. The GtkScale widget

GtkHScale

Library

GTK+

Header File

gtk/gtkhscale.h

Description

GtkHScale is the horizontal variant of GtkScale.

GtkVScale

Library

GTK+

Header File

gtk/gtkvscale.h

Description

GtkVScale is the vertical variant of GtkScale.

GtkScrollbar

Library

GTK+

Header File

gtk/gtkscrollbar.h

Description

GtkScrollbar is an abstract base class, giving horizontal and vertical scrollbars a common interface.

GtkHScrollbar

Library

GTK+

Header File

gtk/gtkhscrollbar.h

Description

A horizontal scrollbar.

GtkVScrollbar

Library

GTK+

Header File

gtk/gtkvscrollbar.h

Description

A vertical scrollbar.

GtkSeparator

Library

GTK+

Header File

gtk/gtkseparator.h

Description

The GtkSeparator widget is a divider line you can use to make your interface more attractive. For example, a GtkHSeparator is used to divide the contents of a GnomeDialog from its buttons.

GtkHSeparator

Library

GTK+

Header File

gtk/gtkhseparator.h

Description

Horizontal GtkSeparator.

GtkVSeparator

Library

GTK+

Header File

gtk/gtkvseparator.h

Description

Vertical GtkSeparator.

GtkPreview

Library

GTK+

Header File

gtk/gtkpreview.h

Description

GtkPreview displays an RGB image; the GIMP uses it to display a preview of the effects of an image transformation.

GtkProgress

Library

GTK+

Header File

gtk/gtkprogress.h

Description

GtkProgress is an abstract base class for progress displays. In GTK+ 1.2 only one concrete subclass exists (GtkProgressBar). Future versions of GTK+ may add additional progress widgets.

GtkProgressBar

Library

GTK+

Header File

gtk/gtkprogressbar.h

Description

GtkProgressBar is a flexible progress bar widget. It can display text over the progress bar, and has an "activity" mode to indicate "activity, but unknown total task size." In "activity" mode a small block moves back and forth. GtkProgressBar is probably excessively configurable; you should try to use its default look-and-feel, for consistency with other applications.

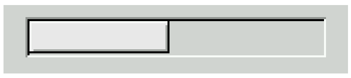


Figure 33. GtkProgressBar

ZvtTerm

Library

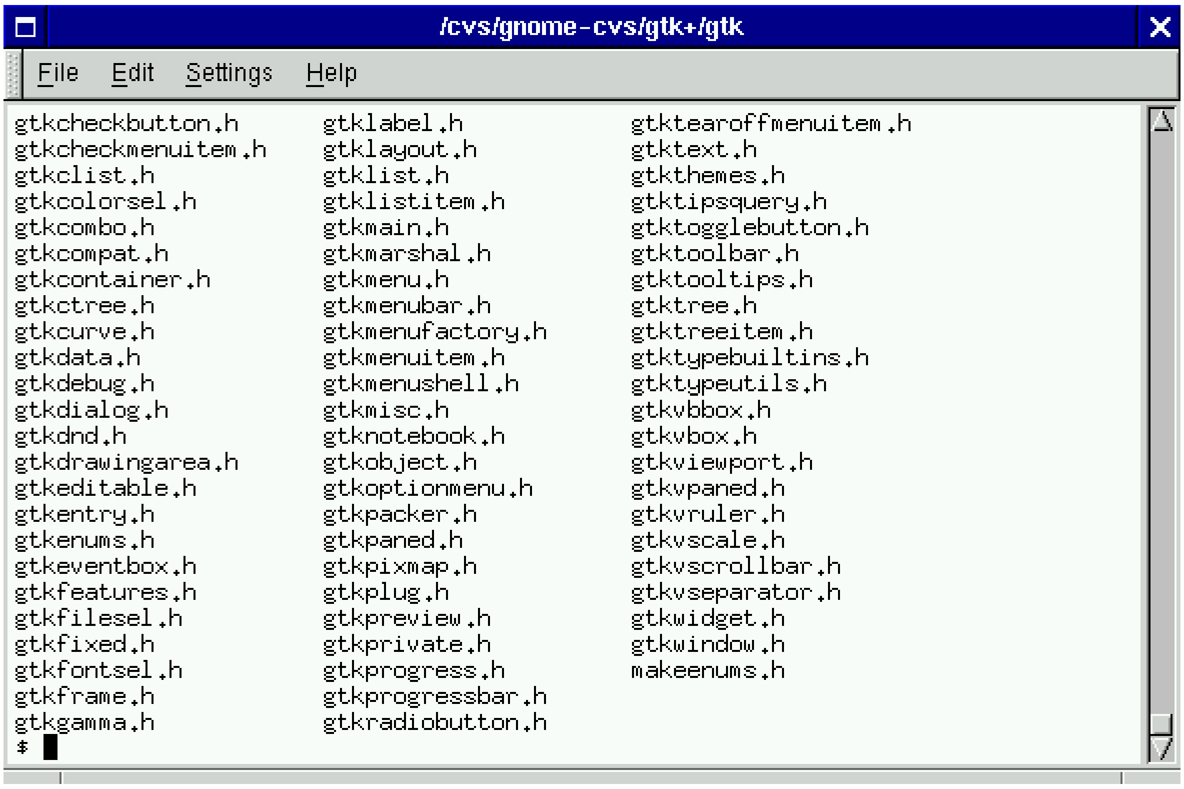
Zvt

Header File

zvt/zvtterm.h

Description

ZvtTerm comes with gnome-libs but is not in libgnomeui. It's in a separate libzvt. ZvtTerm is simply a terminal emulator; you can spawn a child process to run inside the widget and interact with the user. ZvtTerm provides all the functionality of the gnome-terminal program that comes with the Gnome desktop environment.



```
gtkcheckbutton.h      gtklabel.h          gtktearoffmenuitem.h
gtkcheckmenuitem.h    gtklayout.h         gtktext.h
gtkclist.h            gtklist.h           gtkthemes.h
gtkcolorsel.h         gtklistitem.h       gtktipsquery.h
gtkcombo.h            gtkmain.h           gtktogglebutton.h
gtkcompat.h           gtkmarshal.h        gtktoolbar.h
gtkcontainer.h        gtkmenu.h           gtktooltips.h
gtkctree.h            gtkmenubar.h        gtktree.h
gtkcurve.h            gtkmenufactory.h    gtktreeitem.h
gtkdata.h             gtkmenuitem.h       gtktypebuiltins.h
gtkdebug.h            gtkmenushell.h      gtktypeutils.h
gtkdialog.h           gtkmisc.h           gtkvbbox.h
gtkdnd.h              gtknotebook.h       gtkvbox.h
gtkdrawingarea.h      gtkobject.h         gtkviewport.h
gtkeditable.h         gtkoptionmenu.h     gtkvpaned.h
gtkentry.h            gtkpacker.h         gtkvruler.h
gtkenums.h            gtkpaned.h          gtkvscale.h
gtkeventbox.h         gtkpixmap.h         gtkvscrollbar.h
gtkfeatures.h         gtkplug.h           gtkvseparator.h
gtkfilesel.h          gtkpreview.h        gtkwidget.h
gtkfixed.h            gtkprivate.h        gtkwindow.h
gtkfontsel.h          gtkprogress.h       makeenums.h
gtkframe.h            gtkprogressbar.h
gtkgamma.h            gtkradiobutton.h
$ 
```

Figure 34. gnome-terminal uses the ZvtTerm widget

Canvas Items

GnomeCanvasItem

Library

Gnome

Header File

libgnomeui/gnome-canvas.h

Description

GnomeCanvasItem is the abstract base class for canvas items. the chapter called *GnomeCanvas* and the chapter called *Writing a GnomeCanvasItem* describe it in detail.

GnomeCanvasRE

Library

Gnome

Header File

libgnomeui/gnome-canvas-rect-ellipse.h

Description

GnomeCanvasRE is the base class for the rectangle and ellipse canvas items. In the future, it may also be the base class for a GnomeCanvasArc item. the section called *Rectangle and Ellipse Items* in the chapter called *GnomeCanvas* details this canvas item.

GnomeCanvasEllipse

Library

Gnome

Header File

libgnomeui/gnome-canvas-rect-ellipse.h

Description

GnomeCanvasEllipse renders an ellipse on the canvas; see the section called *Rectangle and Ellipse Items* in the chapter called *GnomeCanvas* for more details.

GnomeCanvasRect

Library

Gnome

Header File

libgnomeui/gnome.h

Description

GnomeCanvasRect renders a rectangle on the canvas; see the section called *Rectangle and Ellipse Items* in the chapter called *GnomeCanvas* for more details.

GnomeCanvasGroup

Library

Gnome

Header File

libgnomeui/gnome-canvas.h

Description

GnomeCanvasGroup is a GnomeCanvasItem that contains other GnomeCanvasItems. It creates the hierarchical tree structure of the items on a GnomeCanvas. The GnomeCanvas creates a special GnomeCanvasGroup, called the *root*; all user-created canvas items must be added below the root group. See the chapter called *GnomeCanvas* for more details.

GnomeCanvasImage

Library

Gnome

Header File

libgnomeui/gnome-canvas-image.h

Description

GnomeCanvasImage displays an image on the canvas (specifically, a GdkImlibImage). See the section called *Image Item* in the chapter called *GnomeCanvas* for details.

GnomeCanvasLine

Library

Gnome

Header File

libgnomeui/gnome.h

Description

GnomeCanvasLine displays a line segment or series of line segments on the canvas; it can also be used to display an unfilled polygon, by joining the end of the last segment to the start of the first. Optionally, the line can have arrowheads at either end. See the section called *Line Item* in the chapter called *GnomeCanvas*.

GnomeCanvasPolygon

Library

Gnome

Header File

libgnomeui/gnome-canvas-polygon.h

Description

GnomeCanvasPolygon displays a filled polygon. Use GnomeCanvasLine for hollow polygons. See the section called *Polygon Item* in the chapter called *GnomeCanvas* for more details.

GnomeCanvasText

Library

Gnome

Header File

libgnomeui/gnome-canvas-text.h

Description

GnomeCanvasText displays some text on the canvas; see the section called *Text Item* in the chapter called *GnomeCanvas* for more information.

GnomeCanvasWidget

Library

Gnome

Header File

libgnomeui/gnome-canvas-widget.h

Description

GnomeCanvasWidget emulates a GtkContainer; it holds a child widget and displays it on the canvas. See the section called *Widget Item* in the chapter called *GnomeCanvas* for details.

GnomeCanvasTextItem

Library

Gnome

Header File

libgnomeui/gnome-icon-item.h

Description

GnomeCanvasTextItem is used internally by the GnomeIconList widget. You should never use it directly; it's considered an implementation detail and subject to change in future versions of the library.

Miscellaneous Objects

GnomeClient

Library

Gnome

Header File

libgnomeui/gnome-client.h

Description

GnomeClient is a GtkObject which conceals the details of session management and provides a nice session management API for Gnome applications. See the section called *Session Management* in the chapter called *Gnome Application Basics* for more information.

GnomeDEntryEdit

Library

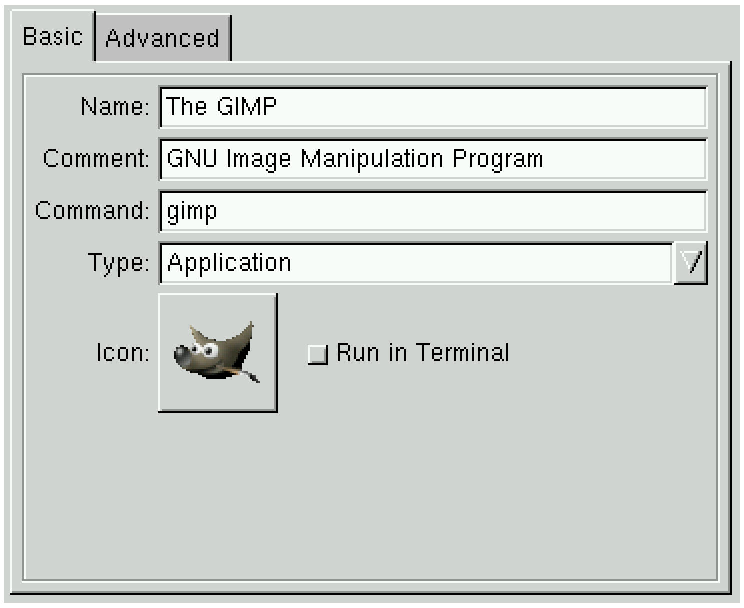
Gnome

Header File

libgnomeui/gnome-dentry-edit.h

Description

GnomeDEntryEdit is a very specialized object; it is a sort of "widget manager" that creates and keeps track of two child widgets, an "easy" and an "advanced" page. The two pages combine to let the user edit a Gnome .desktop entry, as described in the section called *.desktop Entries* in the chapter called *Creating Your Source Tree*. GnomeDEntryEdit is intended to be used in conjunction with a preexisting GtkNotebook. It isn't a GtkNotebook subclass itself, because you might want to use the GtkNotebook in a GnomePropertyBox. The Gnome panel and the Gnome menu editor use this widget.



Name: The GIMP
Comment: GNU Image Manipulation Program
Command: gimp
Type: Application
Run in Terminal

Figure 35. The GnomeDEntryEdit object created the two widgets in this notebook

GnomeDockLayout

Library

Gnome

Header File

libgnomeui/gnome-dock-layout.h

Description

GnomeDockLayout maintains information about the current position of items in a GnomeDock. It can load and save this information; GnomeDock uses this functionality to save and load toolbar positions. Recall that GnomeApp uses the GnomeDock widget for its layout.

GnomeMDIChild

Library

Gnome

Header File

libgnomeui/gnome-mdi-child.h

Description

GnomeMDIChild is an abstract interface; you must derive your own subclass or use GnomeMDIGenericChild in order to take advantage of the GnomeMDI object. GnomeMDI is a "multiple document interface" manager.

GnomeMDIGenericChild

Library

Gnome

Header File

libgnomeui/gnome-mdi-generic-child.h

Description

A generic implementation of GnomeMDIChild. For complex applications, you may need to write a custom implementation.

GnomeMDI

Library

Gnome

Header File

libgnomeui/gnome-mdi.h

Description

GnomeMDI keeps track of multiple documents. Users can configure how the documents are arranged in the application; they might be placed in a GtkNotebook in the same GtkWindow, or each document might have its own GtkWindow. Also, users can drag the notebook pages out of the GtkWindow, and they will be reparented into their own toplevel window.

GtkData

Library

GTK+

Header File

gtk/gtkdata.h

Description

GtkData is an abstract base class for a piece of data that might be shared between multiple objects. Right now its interface is empty; in the future, there may be generic operations for all GtkData objects.

GtkAdjustment

Library

GTK+

Header File

gtk/gtkadjustment.h

Description

GtkAdjustment represents a numeric value. It can also store a maximum and minimum value, a "step increment," a "page increment," and a "page size." Some objects don't use all the fields in the adjustment, and some interpret them slightly differently. A GtkRange (including its GtkScale and GtkScrollbar subclasses) will allow the user to move the slider between the minimum and maximum values. Clicking the arrows on the end of a GtkScrollbar nudges the scroll bar by one "step increment"; clicking them with the middle button moves one "page increment." The "page size" determines the size of the scrollbar slider (it's the length of the "visible" page in the same units as the overall range). GtkAdjustment emits signals when its values change.

GtkTooltips

Library

GTK+

Header File

gtk/gtktooltips.h

Description

GtkTooltips associates some help text with a widget. If the user holds the mouse pointer still over the widget for a short time, a tooltip will appear displaying the help text. GtkTooltips can also store some "private" text; you might use this with a GtkTipsQuery to display more extensive help. the section called *Tooltips* in the chapter called *The Main Window: GnomeApp* has more information on tooltips.

GtkItemFactory

Library

GTK+

Header File

gtk/gtkitemfactory.h

Description

GtkItemFactory is intended to simplify menu creation; Gnome applications should use GnomeUIInfo templates instead (see the section called *Menus and Toolbars with GnomeUIInfo* in the chapter called *The Main Window: GnomeApp*).

Table of Header Files

This appendix lists most of the header files in GTK+ and Gnome, in alphabetical order, with a brief description of each one. Remember that the previous appendix gives a slightly longer description of each widget and GtkObject.

Table 1. glib, GTK+, and Gnome Header Files

Header	Description
art_affine.h	Affine operations
art_alphagamma.h	Alphagamma tables
art_bpath.h	Bezier paths
art_filterlevel.h	"Filter levels" for image rendering
art_gray_svp.h	Rendering sorted vector paths to a grayscale buffer
art_misc.h	Miscellaneous libart declarations
art_pathcode.h	Path operators (moveto, lineto, etc.)
art_pixbuf.h	Pixel buffers
art_point.h	Point data types (i.e. X,Y coordinate pairs)
art_rect.h	Rectangle data types
art_rect_svp.h	Bounding box computation for sorted vector paths
art_rect_uta.h	Bounding rectangles from a microtile array

art_rgb.h	Basic RGB drawing primitives (run-filling)
art_rgb_affine.h	Affine transformation of RGB buffers
art_rgb_bitmap_affine.h	Affine transformation of bitmaps
art_rgb_pixbuf_affine.h	Affine transformation of generic pixel buffers
art_rgb_rgba_affine.h	Affine transformation of RGBA buffers
art_rgb_svp.h	Rendering sorted vector paths to RGB buffers
art_svp.h	Sorted vector path data type
art_svp_ops.h	Sorted vector path set operations (union, intersection, etc.)
art_svp_render_aa.h	Antialiased sorted vector path rendering
art_svp_vpath.h	Sorting an unsorted vector path
art_svp_vpath_stroke.h	"Strokes" a vector path yielding a sorted vector path
art_svp_wind.h	Winding rules for sorted vector paths
art_uta.h	Microtile array data type
art_uta_ops.h	Microtile array set operations (union, etc.)
art_uta_rect.h	Conversion from a rectangle to a microtile array
art_uta_svp.h	Conversion from a sorted vector path to a microtile array
art_uta_vpath.h	Conversion from a vector path to a microtile array
art_vpath.h	Vector path data type
art_vpath_bpath.h	Bezier path to vector path conversion
art_vpath_svp.h	Sorted vector path to vector path conversion
gdk.h	GDK function declarations
gdkcursors.h	GDK builtin cursor IDs
gdki18n.h	Portability wrappers for iswalnum() and iswspace()

gdkkeysyms.h	GDK keysym names (GDK_space, GDK_Up, etc.)
gdkprivate.h	Private GDK types
gdkrgb.h	GDK's GdkRGB module
gdktypes.h	GDK type declarations
gdkx.h	Declarations for GDK-to-X mapping
glib.h	glib header
gnome-about.h	GnomeAbout widget
gnome-animator.h	GnomeAnimator widget
gnome-app-helper.h	GnomeApp add-ons, including GnomeUIInfo menu/toolbar generation
gnome-app-util.h	User messages, via dialog or statusbar
gnome-app.h	GnomeApp widget
gnome-appbar.h	GnomeAppBar widget
gnome-calculator.h	GnomeCalculator widget
gnome-canvas-image.h	GnomeCanvasImage canvas item
gnome-canvas-line.h	GnomeCanvasLine canvas item
gnome-canvas-load.h	Routine to load a PNG with alpha transparency
gnome-canvas-polygon.h	GnomeCanvasPolygon canvas item
gnome-canvas-rect-ellipse.h	GnomeCanvasRect and GnomeCanvasEllipse canvas items
gnome-canvas-text.h	GnomeCanvasText canvas item
gnome-canvas-util.h	Miscellaneous canvas-related routines
gnome-canvas-widget.h	GnomeCanvasWidget canvas item
gnome-canvas.h	GnomeCanvas widget, GnomeCanvasItem base class and GnomeCanvasGroup item
gnome-client.h	GnomeClient session management interface
gnome-color-picker.h	GnomeColorPicker widget
gnome-config.h	Configuration file API
gnome-dateedit.h	GnomeDateEdit widget
gnome-defs.h	Miscellaneous libgnome macros

gnome-dentry-edit.h	GnomeDEntryEdit object
gnome-dentry.h	.desktop file handling
gnome-dialog-util.h	Dialog convenience functions
gnome-dialog.h	GnomeDialog widget
gnome-dns.h	Asynchronous DNS lookups
gnome-dock-band.h	GnomeDockBand widget
gnome-dock-item.h	GnomeDockItem widget
gnome-dock-layout.h	GnomeDockLayout object
gnome-dock.h	GnomeDock widget
gnome-entry.h	GnomeEntry widget
gnome-exec.h	Convenience wrappers to exec child processes
gnome-file-entry.h	GnomeFileEntry widget
gnome-fileconvert.h	Routine that attempts to convert between MIME types
gnome-font-picker.h	GnomeFontPicker widget
gnome-font-selector.h	GnomeFontSelector widget
gnome-geometry.h	Convenience functions for geometry strings (e.g. 1000x1000+0+0)
gnome-guru.h	Obsolete "wizard" widget
gnome-help.h	gnome_help_goto() and friends
gnome-history.h	Recently-used-file history
gnome-href.h	GnomeHRef widget
gnome-i18n.h	Gnome internationalization macros
gnome-i18nP.h	Library-internal internationalization (private)
gnome-ice.h	Code to handle an ICE connection
gnome-icon-entry.h	GnomeIconEntry widget
gnome-icon-item.h	GnomeIconTextItem canvas item (don't use; library-private)
gnome-icon-list.h	GnomeIconList widget

gnome-icon-sel.h	GnomeIconSelection widget
gnome-init.h	gnome_init() and variants
gnome-less.h	GnomeLess widget
gnome-mdi-child.h	GnomeMDIChild object
gnome-mdi-generic-child.h	GnomeMDIGenericChild object
gnome-mdi-session.h	Session management support for GnomeMDI
gnome-mdi.h	GnomeMDI object
gnome-messagebox.h	GnomeMessageBox widget
gnome-metadata.h	Facilities for associating data with files
gnome-mime-info.h	Get information about registered MIME types
gnome-mime.h	Determine MIME type of a file
gnome-number-entry.h	GnomeNumberEntry widget
gnome-paper-selector.h	GnomePaperSelector widget
gnome-paper.h	Deprecated interface for paper size configuration (use gnome-print instead)
gnome-pixmap-entry.h	GnomePixmapEntry widget
gnome-pixmap.h	GnomePixmap widget
gnome-popt.h	Argument-parsing-related declarations
gnome-popup-help.h	Routine to add popup help to a widget
gnome-popup-menu.h	Convenience routines to create right-click popup menus
gnome-preferences.h	Routines to load and save certain Gnome-wide preferences
gnome-procbar.h	GnomeProcBar widget
gnome-properties.h	Experimental interface for handling preferences
gnome-property-entries.h	Auxiliary routines for experimental gnome-properties.h interface
gnome-propertybox.h	GnomePropertyBox widget
gnome-regex.h	Wrapper for regcomp() that caches compiled regular expressions
gnome-remote.h	Remote command execution (user configures

	the remote execution command on a per-host basis)
gnome-score.h	Routines to load and save high scores
gnome-scores.h	GnomeScores widget
gnome-sound.h	Routines to play sounds
gnome-spell.h	GnomeSpell widget
gnome-startup.h	Routines to allow "locking" during session startup
gnome-stock.h	Gnome stock pixmap widgets and declarations
gnome-triggers.h	Register events and actions to trigger when the events happen
gnome-types.h	Assorted type declarations
gnome-uidefs.h	Assorted macros
gnome-url.h	gnome_url_show() to display an URL using a user-configured method
gnome-util.h	Lots of useful utility functions
gnome-winhints.h	Gnome window manager hints
gnome.h	Includes all the public libgnome and libgnomeui headers
gnorba.h	libgnorba header file
gtk-clock.h	GtkClock widget
gtk-ted.h	GtkTed widget
gtk.h	Includes the public GTK+ headers and gdk.h
gtkaccelgroup.h	Accelerator key support
gtkaccellabel.h	GtkAccelLabel widget
gtkadjustment.h	GtkAdjustment object
gtkalignment.h	GtkAlignment widget
gtkarg.h	GtkArg type
gtkarrow.h	GtkArrow widget
gtkaspectframe.h	GtkAspectFrame widget
gtkbbox.h	GtkButtonBox widget

gtkbin.h	GtkBin widget
gtkbindings.h	Keybinding support for GTK_RUN_ACTION signals)
gtkbox.h	GtkBox widget
gtkbutton.h	GtkButton widget
gtkcalendar.h	GtkCalendar widget
gtkcauldron.h	Experimental dialog-creation routines
gtkcheckbutton.h	GtkCheckButton widget
gtkcheckmenuitem.h	GtkCheckMenuItem widget
gtkclist.h	GtkCList widget
gtkcolorsel.h	GtkColorSelection widget
gtkcombo.h	GtkCombo widget
gtkcompat.h	Compatibility macros for renamed or removed functions
gtkcontainer.h	GtkContainer widget
gtkctree.h	GtkCTree widget
gtkcurve.h	GtkCurve widget
gtkdata.h	GtkData object
gtkdial.h	GtkDial widget
gtkdialog.h	GtkDialog widget
gtkdnd.h	GTK+ drag-and-drop interface
gtkdrawingarea.h	GtkDrawingArea widget
gtkeditable.h	GtkEditable widget
gtkentry.h	GtkEntry widget
gtkenums.h	Enumerations used in GTK+
gtkeventbox.h	GtkEventBox widget
gtkfeatures.h	Macros to identify GTK+ library version
gtkfilesel.h	GtkFileSelection widget
gtkfixed.h	GtkFixed widget
gtkfontsel.h	GtkFontSelection widget

gtkframe.h	GtkFrame widget
gtkgamma.h	GtkGammaCurve widget
gtkgc.h	Graphics context cache interface
gtkhandlebox.h	GtkHandleBox widget
gtkhbbox.h	GtkHButtonBox widget
gtkhbox.h	GtkHBox widget
gtkhpaned.h	GtkHPaned widget
gtkhruler.h	GtkHRuler widget
gtkhscale.h	GtkHScale widget
gtkhscrollbar.h	GtkHScrollbar widget
gtkhseparator.h	GtkHSeparator widget
gtkimage.h	GtkImage widget
gtkinputdialog.h	GtkInputDialog widget
gtkintl.h	GTK+ internationalization
gtkitem.h	GtkItem widget
gtkitemfactory.h	GtkItemFactory object
gtklabel.h	GtkLabel widget
gtklayout.h	GtkLayout widget
gtklist.h	GtkList widget
gtklistitem.h	GtkListItem widget
gtkmain.h	GTK+ main loop
gtkmarshal.h	GTK+ signal marshallers
gtkmenu.h	GtkMenu widget
gtkmenubar.h	GtkMenuBar widget
gtkmenufactory.h	GtkMenuFactory (use item factory instead)
gtkmenuitem.h	GtkMenuItem widget
gtkmenushell.h	GtkMenuShell widget
gtkmisc.h	GtkMisc widget
gtknotebook.h	GtkNotebook widget
gtkobject.h	GtkObject base class

gtkoptionmenu.h	GtkOptionMenu widget
gtkpacker.h	GtkPacker widget
gtkpaned.h	GtkPaned widget
gtkpixmap.h	GtkPixmap widget
gtkpixmapmenuitem.h	GtkPixmapMenuItem widget
gtkplug.h	GtkPlug widget
gtkpreview.h	GtkPreview widget
gtkprogress.h	GtkProgress widget
gtkprogressbar.h	GtkProgressBar widget
gtkradiobutton.h	GtkRadioButton widget
gtkradiomenuitem.h	GtkRadioMenuItem widget
gtkrange.h	GtkRange widget
gtkrc.h	GTK+ rc file parsing
gtkruler.h	GtkRuler widget
gtkscale.h	GtkScale widget
gtkscrollbar.h	GtkScrollbar widget
gtkscrolledwindow.h	GtkScrolledWindow widget
gtkselection.h	Selection-handling routines
gtkseparator.h	GtkSeparator widget
gtksignal.h	Signal-related declarations
gtksocket.h	GtkSocket widget
gtkspinbutton.h	GtkSpinButton widget
gtkstatusbar.h	GtkStatusbar widget
gtkstyle.h	GtkStyle type and themed drawing routines
gtktable.h	GtkTable widget
gtktearoffmenuitem.h	GtkTearoffMenuItem widget
gtktext.h	GtkText widget
gtkthemes.h	Theme engine data type
gtktipsquery.h	GtkTipsQuery widget
gtktogglebutton.h	GtkToggleButton widget

gtktoolbar.h	GtkToolbar widget
gtktooltips.h	GtkTooltips object
gtktree.h	GtkTree widget
gtktreeitem.h	GtkTreeItem widget
gtktypebuiltins.h	GTK+ builtin type IDs
gtktypeutils.h	GTK+ type system routines
gtkvbbox.h	GtkVButtonBox widget
gtkvbox.h	GtkVBox widget
gtkviewport.h	GtkViewport widget
gtkvpaned.h	GtkVPaned widget
gtkvruler.h	GtkVRuler widget
gtkvscale.h	GtkVScale widget
gtkvscrollbar.h	GtkVScrollbar widget
gtkvseparator.h	GtkVSeparator widget
gtkwidget.h	GtkWidget base class
gtkwindow.h	GtkWindow widget
libgnome.h	Includes all public libgnome headers
libgnomeui.h	Includes all public libgnomeui headers
zvtterm.h	ZvtTerm widget

Frequently Asked Questions

This chapter contains some commonly-asked questions, and answers, with references to the rest of the book. See the table of contents for a summary of the questions.

Questions, with Answers

How do I make my application beep?

Call the gdk_beep() function.

When do I need to destroy my widgets?

See the section called *Widget Life Cycle* in the chapter called *GTK+ Basics* for the simple answer, and the section called *Object Finalization* in the chapter called *The GTK+ Object and Type System* for more details.

When I turn on memory profiling in glib, my application becomes unstable. What gives?

Normally g_malloc() and g_free() are just wrappers around malloc() and free(), with a couple of extra features described in the section called *Memory* in the chapter called *glib: Portability and Utility*. However, when you turn on memory profiling, they are no longer interchangeable with malloc() and free(). So anytime you incorrectly mix the two pairs of functions, your program will crash.

If you're using the GNU C library, which comes with nearly all Linux distributions, it has a special feature which can help you debug this. Set the MALLOC_CHECK_ environment variable to 2 before running your program, then run the program in gdb. As soon as free() gets a pointer not created by malloc(), abort() will be called.

To create a custom display, I want to place widgets in arbitrary locations, or move them around rapidly, or draw to them directly. How?

You are probably fighting a losing battle. Widgets really aren't what you want, most likely. Consider using a GtkDrawingArea or the GnomeCanvas to create your custom display.

If you really need interactive widgets, such as a GtkEntry or GtkButton, you can try to use GtkLayout or GtkFixed.

If you have very specialized needs, you probably need to write your own widget. the chapter called *Writing a GtkWidget* tells you how to do so.

Why does my memory debugging tool show memory leaks in glib?

glib does not call malloc() every time it needs a new node in a data structure. If it did, building linked lists (for example) would be substantially slower. Instead, glib caches pools of equal-sized "memory chunks" for use in these data structures. Since the chunks are still available for recycling when your program exits, they are never free()d. (Of course, the operating system will reclaim the memory, but tools such as ccmalloc and Purify will report it as a memory leak.)

To get around this, you can plug a new GAllocator into most of the data structures. A GAllocator is a pool of memory as described above. Just create an allocator manually, so you have a pointer to it; you can then free the allocator when you are finished. Figure 1 summarizes the relevant functions for GList. A quick glance through glib.h will reveal the corresponding functions for other data structures.

The name argument to g_allocator_new() is used in debugging messages; the n_preallocs argument is passed through to g_mem_chunk_new().

```
#include <glib.h>
```

```
void g_list_push_allocator(GAllocator* allocator);

void g_list_pop_allocator(void);

GAllocator* g_allocator_new(gchar* name, guint n_preallocs);

void g_allocator_free(GAllocator* allocator);
```

Figure 1. Functions for replacing the GList memory allocator

I get a bunch of "assertion failed" warnings from GTK+. What causes these?

These come from the g_return_if_fail() checks at the beginning of many GTK+ functions. (They will only appear if your copy of GTK+ was compiled with debugging turned on---and hopefully it was if you are writing an application.) You will need to look at the exact assertion that failed to see what causes the warning. A common one: if you accidentally access a destroyed widget or object, you will have a pointer to memory garbage. Among other things, this means the type tag will be invalid; so GTK+'s runtime type checks will fail.

Why are some things in Gnome rather than GTK+?

Historical accident, mostly. Sometimes there is a reason; for example, GTK+ does not include gdk_imlib, so does not include any widgets that rely on it. In very general terms, GTK+ imposes less "policy" than Gnome; some Gnome widgets are deliberately inflexible to keep people from creating an inconsistent user interface. GTK+ does not take this approach. Finally, some of the Gnome widgets were considered too "experimental" to go in GTK+ at the time. However, the core Gnome widgets discussed in this book are not in this category.

How can I center a window on the screen?

If the window is a GnomeDialog, this is user-configurable and you should not do it. In most other cases it would be a bit strange; but there are exceptions, such as splash screens. The function you want is gtk_window_set_position(); you can leave the window's position up to the window manager (the default), ask to have it centered, or ask to have it appear wherever the mouse pointer is. There is an enumeration which corresponds to these settings: GTK_WIN_POS_NONE, GTK_WIN_POS_CENTER, GTK_WIN_POS_MOUSE. For example:

```
gtk_window_set_position(GTK_WINDOW(window), GTK_WIN_POS_CENTER);
```

You should do this *before* calling gtk_widget_show(), because the function affects where the window appears when it is first placed on-screen.

Is there a widget that does printing?

No. When people ask this question they are usually looking for an abstract interface that draws either to the screen or to a printer. There is nothing like that in GTK+ right now. GnomeCanvas will probably have a feature like this in a future version.

There is a gnome-print library available, which handles many unpleasant low-level details when dealing with fonts and PostScript. It also comes with a printer-selection dialog.

When I `fork()`, I get a bunch of warnings and my program crashes. What's going on?

There are two things to remember:

1. The child process must not try to use the GUI; since it shares file descriptors with the parent, including GTK+'s connection to the X server, GTK+ will become very confused.
2. The child process must be terminated with _exit() rather than exit(); calling exit() will shut down GTK+ and confuse the parent process. (GTK+ registers a "cleanup" function using atexit().)

When do I need to call `gtk_widget_realize()` vs. `gtk_widget_show()`?

the section called *Realizing, Mapping, and Showing* in the chapter called *GTK+ Basics* goes into some detail on this. But here is a brief summary.

Showing a widget implies mapping it eventually (to be precise, it schedules the widget to be mapped when its parent widgets are mapped). Mapping a widget means calling gdk_window_show() to display the widget's GdkWindow on the screen (if it has a GdkWindow, some widgets don't). To map a widget you must first realize it. Therefore showing a widget implies realizing it. Therefore if you show a widget you don't need to explicitly realize it with gtk_widget_realize() because it will be realized eventually anyway.

There's one exception, however. To *realize* a widget means to allocate X server resources for it, most notably a GdkWindow. Some things you might want to do require the GdkWindow to exist, so you might want to force a widget to be realized immediately. gtk_widget_realize() does this. Since parent widgets must be realized before their children, gtk_widget_realize() will immediately realize all of a widget's parents as well. One of these parents must be a toplevel window, or realization will not be possible.

If you force-realize a widget, you still have to call gtk_widget_show() since realization does not map the widget.

A good but not foolproof rule of thumb: if you are using GTK_WIDGET(widget)->window, you will need widget to be realized.

However, it should be noted that force-realizing a widget is always a mildly bad idea; it is inefficient and uncomfortably low-level. In many cases you can work around the need to do so.

When creating a pixmap, I get the warning: `Creating pixmap from xpm with NULL window and colormap`. What's wrong?

Creating a pixmap requires a colormap. gdk_pixmap_create_from_xpm_d() requires a GdkWindow argument in order to extract a colormap. You are probably trying to use the window field of an unrealized widget, which is NULL. You might try the newer function, gdk_pixmap_colormap_create_from_xpm_d() which accepts a colormap argument; if you pass in a colormap, its window argument can be NULL. However, using Imlib instead is a still better solution; Imlib's pixmap routines are faster anyway.

How can I separate the GUI from the rest of my application?

For a variety of reasons, an application's graphical interface tends to be an exceptionally volatile and ever-changing piece of software. It's the focus of most user requests for change. It is difficult to plan and execute well the first time around---often you will discover that some aspect of it is unpleasant to use only after you have written it. Making things worse, graphical interfaces are not portable across machines; Gnome works on X windows, but if your application is useful, it won't be long before someone wants to run your application on another system, or have a command-line version, or have a web-based interface. You might even want to have two interfaces in the same version---perhaps the GUI, and a scripting language such as Guile.

In practical terms, this means that any large application should have a radical separation between its various *frontends*, or interfaces, and the *backend*. The backend should contain all the ``hard parts'': your algorithms and data structures, the real work done by the application. Think of it as an abstract ``model'' being displayed to and manipulated by the user.

Each frontend should be a ``view'' and a ``controller.'' As a ``view,'' the frontend must note any changes in the backend, and change the display accordingly. As a ``controller,'' the frontend must allow the user to relay requests for change to the backend (it defines how manipulations of the frontend translate into changes in the model).

There are many ways to discipline yourself to keep your application separated. A couple of useful ideas:

- Write the backend as a library; if this becomes undesirable for any reason, you can always statically link.
- Write at least two frontends from the start; one or both can be ugly prototypes, you just want to get an idea how to structure the backend. Remember, frontends should be easy; the backend has the hard parts.

If one of your frontends is Gnome- or GTK+- based, an excellent choice for the other is an interactive Guile terminal. Your non-expert end users probably won't use it, but it's a great debugging tool; you can prototype and test the backend using easy-to-write Guile bindings, and add the graphical controls only when things are working. When you're done, you'll have a scriptable application almost for free.

If your application can potentially be run in batch mode, command line and web interfaces are also relatively easy to write, useful for debugging, and will keep you disciplined.

Finally, if your project is large enough to justify the bother and complexity, consider using a cross-platform frontend layer to share code between GUI frontends on different platforms. This approach is taken by Mozilla (http://www.mozilla.org), and the AbiSource office suite (http://www.abisource.com). It might be interesting to have a look at their code.

I don't like the default appearance of [some widget]. How do I change its appearance?

Don't program your preferences. GTK+ unfortunately has all sorts of look and feel settings that the programmer can affect. For example, you can change the appearance of the ``expanders'' in a GtkCTree---they can be triangles, squares, or circles. By default they are squares. You change them by calling gtk_ctree_set_expander_style().

There's no good reason to call this function in an application. Ever. Think about why you would call it---because you happen to like that expander style better. It's a purely cosmetic issue. However, if you do call it, you've just made your application's look and feel different from that of every other application. This is *harmful*, because it confuses users and even gives them a sense that your application is ``unprofessional'' or ``not quite right.''

``But I want my favorite expanders!,'' you might whine. Don't despair. There is a correct way to handle this situation. Variable aspects of look and feel should be configurable *at runtime* by *users*. What's more, it should be configurable *globally*, for *all applications at once*. GTK+ provides themes for precisely this purpose.

Unfortunately themes do not yet cover all aspects of look and feel, and so the temptation remains to hard-code these in your application. You must resist. If you are dead-set against the default expander style, or the default dialog position, or whatever, then do the work to make it configurable on the library level and submit that code to the GTK+ or Gnome maintainers.

You have to do this on the library level---think about it. If you provide an application-specific way to configure look and feel, nothing has really been gained; if someone does like a particular expander style, they have to go through each program deciding if and how the style can be changed. Some programs will invariably be ``stuck'' with the default, since the authors of those programs didn't make it configurable. The resulting mess is very annoying to users.

Gnome already has solutions for a number of common cases. For example, GTK+ lets you pop up a dialog at the mouse pointer, in the center of the screen, or wherever the window manager wants; there is no reason you should pick your favorite and use it in your application. Thus GnomeDialog loads a user preference for the dialog's initial position. This preference can be set from the Gnome control center.

Thanks for the lecture, but I have a really good reason to change the appearance of a widget. How do I override the theme?

write this

Why are signals specified as strings rather than integers or some sort of macro?

Strings are nicer. They are easier to type and less headache for GtkObject authors to maintain. They don't clutter the C namespace. Typing a string incorrectly will trigger a runtime error so macros don't improve error checking. Finally, strings are internally converted to a numeric ID so there is no loss in efficiency.

Consider the maintenance headache of using enumerations instead: both enumeration values and their names would have to be unique across GTK+, Gnome, and third-party extensions. A nightmare.

Why is GTK+ written in C?

First and foremost: asking this question in any public forum is *strongly discouraged*. Don't do it. Check the archives for several extended off-topic flamefests if you're interested.

Here are some reasons:

- The original authors wanted to write it in C, and now many C-only applications are based on it. The current authors enjoy C.
- GTK+ handles types and objects much more flexibly than C++; it is runtime-oriented, more like Java or Objective C than C++ system. This is convenient for GUI builders and language bindings.
- C is the lingua franca of UNIX development; most people know how to code in it.
- There are already nice toolkits for languages such as Java and Objective C. There are C++ wrappers for GTK+; several, in fact.
- C is more portable than C++; ANSI C++ is not yet widely implemented, so only an ill-defined subset of C++ can actually be used.
- When GTK+ development first started, there was no free, working C++ compiler.

Again: do not ask this question on any mailing lists, because people will not be amused.

My motion event handler is only invoked once; why is that?

If you specify GDK_POINTER_MOTION_HINT_MASK, you must call gdk_window_get_pointer() to get more motion events. One motion event is sent each time you get the pointer location. See the section called *Mouse Movement Events* in the chapter called *GDK Basics*.

Can I move the mouse pointer myself?

There is an Xlib routine called XWarpPointer() that does this, but GDK does not wrap it. It is almost certainly a bad idea to use this feature (in fact it is intended for window managers only); you might consider writing to one of the GTK+ or Gnome mailing lists to ask for another way to achieve whatever you are trying to achieve. However, you can always use Xlib routines (such as XWarpPointer()) by including gdk/gdkx.h and gdk/gdkprivate.h, then manipulating the private parts of the GDK data structures. If that sounds unsavory, it probably should.

How do I read the pixels out of a GdkPixmap?

First and foremost: remember that a pixmap is a server-side resource, i.e. possibly across a network and *definitely* across some kind of socket. Therefore, you do not want to request its pixels one by one. Iterating over a pixmap that way could easily take many seconds.

GDK wraps an Xlib object called XImage. The wrapper is called GdkImage. A GdkImage is essentially a local copy of the data in a pixmap. You can copy a region of a pixmap or window into a GdkImage with the gdk_image_get() routine, then get and set pixels with gdk_image_get_pixel() and gdk_image_put_pixel(). You can also access the image's data structures directly, but this is quite complicated (due to visuals, depths, differences between host and network byte order, and so on). If you modify the image, you use gdk_draw_image() to copy it back to a server-side drawable.

Copying a pixmap to a GdkImage, or copying a GdkImage to a pixmap, still involves moving quite a bit of data over the network; however, since it's all in one burst the speed can be tolerable in many cases. Also, if the client and the server are on the same machine, and the X shared memory extension is available, GDK will automatikcally set up a shared memory segment to copy the data.

Most of the time, if you plan to do a lot of image manipulation, you are better off using RGB buffers as your primary data structure (see the section called *RGB Buffers* in the chapter called *GDK Basics*). The functions in gdk/gdkrgb.h allow you to copy an RGB buffer to a drawable. These functions use GdkImage internally, but they are tuned to be very fast and handle all the complexities for you.

I'm drawing a lot of points to the screen with `gdk_draw_point()`, and it's unbelievably slow. What's wrong? How can I render image data to the screen?

See the previous question. You should probably use the GDK RGB functions (the section called *RGB Buffers* in the chapter called *GDK Basics*).

I'm trying to set the background of a `GtkLabel`, and it doesn't work.

GtkLabel is a windowless widget; it is "transparent" and draws on its parent container's background. If you want to set the background, place the label in a GtkEventBox. The same answer applies to other windowless widgets, such as GtkImage.

In the GTK+ and Gnome source code, many functions have two variants: one called `gtk_whatever_foo()`, and another called `gtk_whatever_real_foo()`. What's the difference?

gtk_whatever_foo() is typically a public function which emits the "foo" signal, taking care of any necessary details before and after emission (remember that only GTK_RUN_ACTION signals can be emitted without special actions before and after). gtk_whatever_real_foo() will be the default handler for the signal, installed in the object's class struct. the chapter called *Writing a GtkWidget* has many examples of this.

How do I "gray out" a widget, so the user can't select it?

See the section called *Sensitivity* in the chapter called *GTK+ Basics*. Short answer:

```
gtk_widget_set_sensitive(widget, FALSE);
```

I'm connecting to "button_press_event" or some other event signal, but the callback is never invoked.

There are several possibilities:

- The widget has no GdkWindow (i.e. the GTK_NO_WINDOW flag is set), so it does not receive events (other than synthesized expose events).
- The event you're trying to monitor isn't in the event mask for the widget's GdkWindow. Use gtk_widget_add_events() to add more events to the mask.
- The widget is a container, and some child widget is "handling" the event by returning TRUE from the event signal emission. Only "unhandled" events are propagated from child to parent.

See the section called *Receiving GDK Events in GTK+* in the chapter called *GDK Basics* for more details on events and how they are passed to widgets.

I want to use the arrow keys as a control in my application, but GTK+ keeps stealing the key press events to move the focus around.

Key press handling is somewhat complex. You might want to read the section called *Keyboard Focus* in the chapter called *GDK Basics* and the section called *Focus* in the chapter called *GTK+ Basics* for a brief overview. the section called *Receiving GDK Events in GTK+* in the chapter called *GDK Basics* is also relevant.

In short, key events are initially received by a toplevel GtkWindow. GTK+'s key event behavior is more or less defined by default key press event handler in gtkwindow.c (looking at this function is instructive). It works as follows:

- If there's a focus widget, the key event signal is emitted on the focus widget. If this emission returns TRUE, as described in the section called *Receiving GDK Events in GTK+* in the chapter called *GDK Basics*, processing stops.
- If any of the accelerator groups attached to the window contain an accelerator matching the event, then processing stops.
- If the key event hasn't been handled yet, there are some default bindings; the arrow keys move the focus around, for example.

Thus, to override the arrow key behavior, you can return TRUE from the focus widget's signal emission, install an accelerator for the arrow keys, or connect to "key_press_event" on the toplevel window and use gtk_signal_emit_stop_by_name() to end the signal emission before the GtkWindow default handler runs.

Does GTK+ have multiple inheritance?

No, but "interfaces" (in Java terms) or "pure virtual classes" (in C++ terms) are planned for the next version. See the section called *Overridable Signals* in the chapter called *Writing a GtkWidget* for a discussion of an ugly workaround used in GtkWidget to create "activatable" and "scrollable" interfaces.

I'm getting error messages from GDK. How can I determine the cause of these?

First, run your program with the --sync option. This invokes XSynchronize() to turn off event buffering; it slows down the application, but causes errors to be reported as soon as they occur. Alternatively, some Xlib implementations let you turn on synchronization by setting the global variable _Xdebug to TRUE in a debugger.

Once errors are being reported synchronously, just run your app in a debugger and wait for abort() to be called. For warnings, set a breakpoint at g_logv() which is the function called by the g_warning() macro.

How do I update the GUI without returning control to the main loop?

Just do this:

```
while (gtk_events_pending())
  gtk_main_iteration();
```

This code will handle all pending events, then return control to you. You can also run nested instances of gtk_main(); each call to gtk_main_quit() exits one instance. gnome_dialog_run() uses this technique to block waiting for user input.

How should I format code to be included in GTK+ or Gnome?

The GTK+ coding style is basically the GNU coding style (http://www.gnu.org/prep/standards_toc.html). The Gnome libraries are less consistent, but lean toward the Linux kernel coding style (documented in /usr/src/linux/Documentation/CodingStyle on many Linux systems).

The GTK+ style uses two-space indentation, puts all braces on a new line, and leaves one space between identifiers and opening parentheses, like this:

```
if (whatever)
  {
    foo (arg1, arg2);
  }
```

Emacs uses this style by default.

The Gnome style uses eight-space indentation and Kernighan and Ritchie braces, like so:

```
if (whatever) {
        foo (arg1, arg2);
}
```

It also leaves a space between identifiers and opening parentheses. To make Emacs use the Gnome style, add a line like this to the top of your source files:

```

/* -*- Mode: C; indent-tabs-mode: nil; c-basic-offset: 8 c-style: "K&R"
-*- */
```

When preparing a patch for any piece of free software, it's polite the style of the preexisting code. It's customary to include a file called HACKING in source code distributions addressing this and similar issues; read it if it exists.

Is there a GUI builder for GTK+ and Gnome?

A very promising GUI builder called Glade is being developed. Glade can generate source code in several languages, or an XML description of your widgets. An add-on module called libglade loads these XML descriptions at runtime and creates the described widgets. The next release of the Gnome libraries will very likely include or require libglade.

How well do GTK+ and Gnome support internationalization?

GTK+ 1.2 supports most European and Asian languages. GDK contains an API for loading fontsets and rendering multibyte strings, though this book does not cover it. The stock GTK+ widgets that handle text use this API and will deal with multibyte strings correctly. GTK+ also supports input methods for Asian languages. GTK+ 1.2 does *not* support right-to-left scripts, or scripts that require complex ligatures and unusual line breaks. However, support for these languages is a high priority for GTK+ 1.4. For details on future plans, Owen Taylor's white paper at http://developer.gnome.org/doc/whitepapers/gtki18n/ is an excellent resource.

Both GTK+ and Gnome use the gettext message catalog system to translate user-visible strings, so any string the toolkit knows how to render can be translated into foreign languages. the section called

Internationalization in the chapter called *Gnome Application Basics* covers this topic.

Online Resources

Table of Contents

This chapter documents some useful online resources for Gnome programmers.

Obtaining and Compiling the Libraries

Because the exact compilation instructions can change between releases, this book won't attempt to document them precisely. You should obtain the latest stable release of both GTK+ and Gnome from http://www.gtk.org/ and http://www.gnome.org, respectively, and follow the instructions that come with the distribution.

It's a very good idea to compile the GTK+ and Gnome libraries yourself, for several reasons:

- You should have the source code around, to learn from and to refer to when documentation is lacking.
- You should compile with debugging switched on, so preconditions and assertions will be triggered if you try to use the library incorrectly. Most prebuilt binaries will turn these checks off for efficiency.
- You will probably want unstripped libraries, so you can see function names and so on in your debugger.

Web sites

GTK+ and Gnome each have home pages; http://www.gtk.org/ and http://www.gnome.org, respectively.

On the GTK+ site, take special note of these pages:

- http://www.gtk.org/rdp/ is the GTK+ Reference Documentation Project; look here for reference materials on the GTK+ API.
- http://www.gtk.org/faq/ has the GTK+ FAQ; asking these questions on the mailing list is discouraged. Appendix C of this book supplements the official GTK+ FAQ with still more questions; check it out as well.

On the Gnome site, have a look at these pages:

- http://www.gnome.org/lxr/ contains browsable, searchable, hypertext copies of all the code on the GTK+/Gnome CVS server. This includes GTK+ and Gnome, as well as many applications.
- http://bugs.gnome.org/ allows you to browse GTK+ and Gnome bug reports, and submit new ones. If you find a bug, please submit it here so the maintainers can keep track of it.
- http://developer.gnome.org was not yet live at press time, but will be available soon. It will contain comprehensive resources for Gnome developers.

Mailing Lists

Here are some of the mailing lists that cover GTK+ and Gnome development topics:

- gtk-list@redhat.com is appropriate for questions about using GTK+, reading the GTK+ source code, discussion of GTK+ bugs, and so on.
- gnome-list@gnome.org is very high traffic; it is the general Gnome mailing list, for discussion of all things Gnome-related.
- gnome-devel-list@gnome.org is the right list for questions about the Gnome libraries and how to write programs with them. It's also appropriate for discussing the development of the libraries themselves, or submitting patches which modify the libraries.
- gtk-app-devel-list@redhat.com is an alternative to gtk-list more focused on application development. Most things appropriate for this list are also appropriate for gtk-list, but gtk-app-devel-list has less traffic if you're concerned about that.
- gtk-devel-list@redhat.com is for discussion of developing the glib, GDK, and GTK+ libraries. It is *not* for discussion of *using* the libraries to develop applications.

- gnome-announce-list@gnome.org carries announcements related to Gnome and Gnome applications. It is relatively low-traffic.

To subscribe to any of these mailing lists, append -request to the list name and send a message with subscribe my-address@wherever.net in the subject. For example, I would subscribe to gtk-list@redhat.com by sending a message to gtk-list-request@redhat.com with subscribe hp@pobox.com in the subject line.

Please, ask any and all questions about GTK+ and Gnome development on one of the mailing lists or on IRC. It is inappropriate to mail the developers privately, unless you have reason to believe they have special knowledge of some particular section of code. You'll almost certainly get a faster and better response from the list anyway.

Internet Relay Chat

The two main IRC channels related to GTK+ and Gnome development are both on irc.gimp.org; join #gimp or #gnome to ask questions. You can also meet the library developers and other participants in the GTK+/Gnome community.

Code Listings

Table of Contents

This appendix contains complete sample code listings.

The GnomeHello Application

GnomeHello is used as an example in Part 2.

hello.c

```
#include <config.h>
#include <gnome.h>
```

```
#include "app.h"


static void session_die(GnomeClient* client, gpointer client_data);

static gint save_session(GnomeClient *client, gint phase,
                         GnomeSaveStyle save_style,
                         gint is_shutdown, GnomeInteractStyle
interact_style,
                         gint is_fast, gpointer client_data);


static int greet_mode = FALSE;
static char* message  = NULL;
static char* geometry = NULL;

struct poptOption options[] = {
  {
    "greet",
    'g',
    POPT_ARG_NONE,
    &greet_mode,
    0,
    N_("Say hello to specific people listed on the command line"),
    NULL
  },
  {
    "message",
    'm',
    POPT_ARG_STRING,
    &message,
    0,
    N_("Specify a message other than \"Hello, World!\""),
    N_("MESSAGE")
  },
  {
    "geometry",
    '\0',
    POPT_ARG_STRING,
    &geometry,
    0,
    N_("Specify the geometry of the main window"),
    N_("GEOMETRY")
  },
  {
    NULL,
    '\0',
    0,
    NULL,
    0,
    NULL,
    NULL
  }
};

int
main(int argc, char* argv[])
{
  GtkWidget* app;

  poptContext pctx;

  char** args;
  int i;

  GSList* greet = NULL;

  GnomeClient* client;

  bindtextdomain(PACKAGE, GNOMELOCALEDIR);
  textdomain(PACKAGE);

  gnome_init_with_popt_table(PACKAGE, VERSION, argc, argv,
                             options, 0, &pctx);

  /* Argument parsing */

  args = poptGetArgs(pctx);

  if (greet_mode && args)
    {
      i = 0;
      while (args[i] != NULL)
        {
          greet = g_slist_prepend(greet, args[i]);
          ++i;
        }
      /* Put them in order */
      greet = g_slist_reverse(greet);
    }
  else if (greet_mode && args == NULL)
    {
      g_error(_("You must specify someone to greet."));
    }
  else if (args != NULL)
    {
      g_error(_("Command line arguments are only allowed with
--greet."));
    }
  else
    {
      g_assert(!greet_mode && args == NULL);
    }

  poptFreeContext(pctx);

  /* Session Management */

  client = gnome_master_client ();
  gtk_signal_connect (GTK_OBJECT (client), "save_yourself",
                      GTK_SIGNAL_FUNC (save_session), argv[0]);
  gtk_signal_connect (GTK_OBJECT (client), "die",
                      GTK_SIGNAL_FUNC (session_die), NULL);


  /* Main app */

  app = hello_app_new(message, geometry, greet);

  g_slist_free(greet);

  gtk_widget_show_all(app);

  gtk_main();

  return 0;
}

static gint
save_session (GnomeClient *client, gint phase, GnomeSaveStyle
save_style,
              gint is_shutdown, GnomeInteractStyle interact_style,
              gint is_fast, gpointer client_data)
{
  gchar** argv;
  guint argc;

  /* allocate 0-filled, so it will be NULL-terminated */
  argv = g_malloc0(sizeof(gchar*)*4);
  argc = 1;

  argv[0] = client_data;

  if (message)
    {
      argv[1] = "--message";
      argv[2] = message;
      argc = 3;
    }

  gnome_client_set_clone_command (client, argc, argv);
  gnome_client_set_restart_command (client, argc, argv);

  return TRUE;
}

static void
session_die(GnomeClient* client, gpointer client_data)
{
  gtk_main_quit ();
}
```

app.h

```
#ifndef GNOMEHELLO_APP_H
#define GNOMEHELLO_APP_H

#include <gnome.h>

GtkWidget* hello_app_new(const gchar* message,
                         const gchar* geometry,
                         GSList* greet);
```

```
void       hello_app_close(GtkWidget* app);

#endif
```

app.c

```
#include <config.h>
#include "app.h"
#include "menus.h"

/* Keep a list of all open application windows */
static GSList* app_list = NULL;

static gint delete_event_cb(GtkWidget* w, GdkEventAny* e, gpointer
data);
static void button_click_cb(GtkWidget* w, gpointer data);

GtkWidget*
hello_app_new(const gchar* message,
              const gchar* geometry,
              GSList* greet)
{
  GtkWidget* app;
  GtkWidget* button;
  GtkWidget* label;
  GtkWidget* status;
  GtkWidget* frame;

  app = gnome_app_new(PACKAGE, _("Gnome Hello"));

  frame = gtk_frame_new(NULL);

  button = gtk_button_new();

  label  = gtk_label_new(message ? message : _("Hello, World!"));

  gtk_window_set_policy(GTK_WINDOW(app), FALSE, TRUE, FALSE);
  gtk_window_set_default_size(GTK_WINDOW(app), 250, 350);
  gtk_window_set_wmclass(GTK_WINDOW(app), "hello", "GnomeHello");
```

```
gtk_frame_set_shadow_type(GTK_FRAME(frame), GTK_SHADOW_IN);

gtk_container_set_border_width(GTK_CONTAINER(button), 10);

gtk_container_add(GTK_CONTAINER(button), label);

gtk_container_add(GTK_CONTAINER(frame), button);

gnome_app_set_contents(GNOME_APP(app), frame);

status = gnome_appbar_new(FALSE, TRUE, GNOME_PREFERENCES_NEVER);

gnome_app_set_statusbar(GNOME_APP(app), status);

hello_install_menus_and_toolbar(app);


gtk_signal_connect(GTK_OBJECT(app),
                   "delete_event",
                   GTK_SIGNAL_FUNC(delete_event_cb),
                   NULL);

gtk_signal_connect(GTK_OBJECT(button),
                   "clicked",
                   GTK_SIGNAL_FUNC(button_click_cb),
                   label);

if (geometry != NULL)
  {
    gint x, y, w, h;
    if ( gnome_parse_geometry( geometry,
                               &x, &y, &w, &h ) )
      {
        if (x != -1)
          {
            gtk_widget_set_uposition(app, x, y);
          }

        if (w != -1)
          {
            gtk_window_set_default_size(GTK_WINDOW(app), w, h);
          }
      }
      else
        {
          g_error(_("Could not parse geometry string `%s'"), geometry);
        }
    }


  if (greet != NULL)
    {
      GtkWidget* dialog;
      gchar* greetings = g_strdup(_("Special Greetings to:\n"));
      GSList* tmp = greet;

      while (tmp != NULL)
        {
          gchar* old = greetings;

          greetings = g_strconcat(old,
                                  (gchar*) tmp->data,
                                  "\n",
                                  NULL);
          g_free(old);

          tmp = g_slist_next(tmp);
        }

      dialog = gnome_ok_dialog(greetings);

      g_free(greetings);

      gnome_dialog_set_parent(GNOME_DIALOG(dialog), GTK_WINDOW(app));
    }

  app_list = g_slist_prepend(app_list, app);

  return app;
}

void
hello_app_close(GtkWidget* app)
{
  g_return_if_fail(GNOME_IS_APP(app));

  app_list = g_slist_remove(app_list, app);
  gtk_widget_destroy(app);

  if (app_list == NULL)
    {
      /* No windows remaining */
      gtk_main_quit();
    }
}

static gint
delete_event_cb(GtkWidget* window, GdkEventAny* e, gpointer data)
{
  hello_app_close(window);

  /* Prevent the window's destruction, since we destroyed it
   * ourselves with hello_app_close()
   */
  return TRUE;
}

static void
button_click_cb(GtkWidget* w, gpointer data)
{
  GtkWidget* label;
  gchar* text;
  gchar* tmp;

  label = GTK_WIDGET(data);

  gtk_label_get(GTK_LABEL(label), &text);

  tmp = g_strdup(text);

  g_strreverse(tmp);

  gtk_label_set_text(GTK_LABEL(label), tmp);

  g_free(tmp);
}
```

menus.h

```
#ifndef GNOMEHELLO_MENUS_H
#define GNOMEHELLO_MENUS_H

#include <gnome.h>

void hello_install_menus_and_toolbar(GtkWidget* app);

#endif
```

menus.c

```
#include <config.h>
#include "menus.h"
#include "app.h"

static void nothing_cb(GtkWidget* widget, gpointer data);
static void new_app_cb(GtkWidget* widget, gpointer data);
static void close_cb  (GtkWidget* widget, gpointer data);
static void exit_cb   (GtkWidget* widget, gpointer data);
static void about_cb  (GtkWidget* widget, gpointer data);


static GnomeUIInfo file_menu [] = {
  GNOMEUIINFO_MENU_NEW_ITEM(N_("_New Hello"),
                            N_("Create a new hello"),
                            new_app_cb, NULL),

  GNOMEUIINFO_MENU_OPEN_ITEM(nothing_cb, NULL),

  GNOMEUIINFO_MENU_SAVE_ITEM(nothing_cb, NULL),

  GNOMEUIINFO_MENU_SAVE_AS_ITEM(nothing_cb, NULL),

  GNOMEUIINFO_SEPARATOR,

  GNOMEUIINFO_MENU_CLOSE_ITEM(close_cb, NULL),
  GNOMEUIINFO_MENU_EXIT_ITEM(exit_cb, NULL),

  GNOMEUIINFO_END
};

static GnomeUIInfo edit_menu [] = {
  GNOMEUIINFO_MENU_CUT_ITEM(nothing_cb, NULL),
  GNOMEUIINFO_MENU_COPY_ITEM(nothing_cb, NULL),
  GNOMEUIINFO_MENU_PASTE_ITEM(nothing_cb, NULL),
  GNOMEUIINFO_MENU_SELECT_ALL_ITEM(nothing_cb, NULL),
  GNOMEUIINFO_MENU_CLEAR_ITEM(nothing_cb, NULL),
  GNOMEUIINFO_MENU_UNDO_ITEM(nothing_cb, NULL),
  GNOMEUIINFO_MENU_REDO_ITEM(nothing_cb, NULL),
  GNOMEUIINFO_MENU_FIND_ITEM(nothing_cb, NULL),
  GNOMEUIINFO_MENU_FIND_AGAIN_ITEM(nothing_cb, NULL),
  GNOMEUIINFO_MENU_REPLACE_ITEM(nothing_cb, NULL),
  GNOMEUIINFO_MENU_PROPERTIES_ITEM(nothing_cb, NULL),
  GNOMEUIINFO_END
};

static GnomeUIInfo help_menu [] = {
  GNOMEUIINFO_HELP ("gnome-hello"),

  GNOMEUIINFO_MENU_ABOUT_ITEM(about_cb, NULL),

  GNOMEUIINFO_END
};

static GnomeUIInfo menu [] = {
  GNOMEUIINFO_MENU_FILE_TREE(file_menu),
  GNOMEUIINFO_MENU_EDIT_TREE(edit_menu),
  GNOMEUIINFO_MENU_HELP_TREE(help_menu),
  GNOMEUIINFO_END
};

static GnomeUIInfo toolbar [] = {
  GNOMEUIINFO_ITEM_STOCK (N_("New"), N_("Create a new hello"),
nothing_cb, GNOME_STOCK_PIXMAP_NEW),

  GNOMEUIINFO_SEPARATOR,

  GNOMEUIINFO_ITEM_STOCK (N_("Prev"), N_("Previous hello"), nothing_cb,
GNOME_STOCK_PIXMAP_BACK),
  GNOMEUIINFO_ITEM_STOCK (N_("Next"), N_("Next hello"), nothing_cb,
GNOME_STOCK_PIXMAP_FORWARD),

  GNOMEUIINFO_END
};


void
hello_install_menus_and_toolbar(GtkWidget* app)
{
  gnome_app_create_toolbar_with_data(GNOME_APP(app), toolbar, app);
  gnome_app_create_menus_with_data(GNOME_APP(app), menu, app);
  gnome_app_install_menu_hints(GNOME_APP(app), menu);
}

static void
nothing_cb(GtkWidget* widget, gpointer data)
{
  GtkWidget* dialog;
  GtkWidget* app;

  app = (GtkWidget*) data;

  dialog = gnome_ok_dialog_parented(
          _("This does nothing; it is only a demonstration."),
          GTK_WINDOW(app));
}

static void
new_app_cb(GtkWidget* widget, gpointer data)
{
  GtkWidget* app;

  app = hello_app_new(_("Hello, World!"), NULL, NULL);

  gtk_widget_show_all(app);
}

static void
close_cb(GtkWidget* widget, gpointer data)
{
  GtkWidget* app;

  app = (GtkWidget*) data;
  hello_app_close(app);
}

static void
exit_cb(GtkWidget* widget, gpointer data)
{
  gtk_main_quit();
}

static void
about_cb(GtkWidget* widget, gpointer data)
{
  static GtkWidget* dialog = NULL;
  GtkWidget* app;

  app = (GtkWidget*) data;

  if (dialog != NULL)
    {
      g_assert(GTK_WIDGET_REALIZED(dialog));
      gdk_window_show(dialog->window);
      gdk_window_raise(dialog->window);
    }
  else
    {
      const gchar *authors[] = {
        "Havoc Pennington <hp@pobox.com>",
        NULL
      };

      gchar* logo = gnome_pixmap_file("gnome-hello-logo.png");

      dialog = gnome_about_new (_("GnomeHello"), VERSION,
                                "(C) 1999 Havoc Pennington",
                                authors,
                                _("A sample GNOME application."),
                                logo);

      g_free(logo);

      gtk_signal_connect(GTK_OBJECT(dialog),
                         "destroy",
                         GTK_SIGNAL_FUNC(gtk_widget_destroyed),
                         &dialog);
      gnome_dialog_set_parent(GNOME_DIALOG(dialog), GTK_WINDOW(app));

      gtk_widget_show(dialog);
    }
}
```

The `GtkEv` Widget

GtkEv is a widget that reports events on a subwindow, similar to the xev client that comes with X.

gtkev.h

```
#ifndef INC_GTK_EV_H
#define INC_GTK_EV_H

#include <gtk/gtkwidget.h>

#ifdef __cplusplus
extern "C" {
#endif /* __cplusplus */

#define GTK_EV(obj)          GTK_CHECK_CAST (obj, gtk_ev_get_type (),
GtkEv)
#define GTK_EV_CLASS(klass)  GTK_CHECK_CLASS_CAST (klass,
gtk_ev_get_type (), GtkEvClass)
#define GTK_IS_EV(obj)       GTK_CHECK_TYPE (obj, gtk_ev_get_type ())

typedef struct _GtkEv       GtkEv;
typedef struct _GtkEvClass  GtkEvClass;

struct _GtkEv
{
  GtkWidget widget;

  GdkWindow*     event_window;
  GdkRectangle   event_window_rect;

  GdkRectangle   description_rect;

  GList*         buffer;
  GList*         buffer_end;
  gint           buffer_size;
};

struct _GtkEvClass
{
  GtkWidgetClass parent_class;


};



guint           gtk_ev_get_type           (void);
GtkWidget*      gtk_ev_new                (void);


#ifdef __cplusplus
}
#endif /* __cplusplus */

#endif /* __GTK_EV_H__ */
```

gtkev.c

```
#include "gtkev.h"

static void   gtk_ev_class_init    (GtkEvClass  *klass);
static void   gtk_ev_init          (GtkEv       *ev);



/* GtkObject functions */
static void   gtk_ev_destroy       (GtkObject   *object);
```

```
/* GtkWidget functions */

static gint   gtk_ev_event (GtkWidget          *widget,
                            GdkEvent           *event);

static void gtk_ev_realize        (GtkWidget        *widget);
static void gtk_ev_unrealize      (GtkWidget        *widget);
static void gtk_ev_size_request   (GtkWidget        *widget,
                                   GtkRequisition   *requisition);
static void gtk_ev_size_allocate  (GtkWidget        *widget,
                                   GtkAllocation    *allocation);

static void gtk_ev_draw           (GtkWidget        *widget,
                                   GdkRectangle     *area);
static void gtk_ev_draw_focus     (GtkWidget        *widget);

static gint gtk_ev_expose         (GtkWidget        *widget,
                                   GdkEventExpose   *event);
static gint gtk_ev_focus_in       (GtkWidget        *widget,
                                   GdkEventFocus    *event);
static gint gtk_ev_focus_out      (GtkWidget        *widget,
                                   GdkEventFocus    *event);

/* GtkEv-specific functions */

static void gtk_ev_paint          (GtkEv            *ev,
                                   GdkRectangle     *area);

static void gtk_ev_paint_event_window  (GtkEv            *ev,
                                        GdkRectangle     *area);

static void gtk_ev_push_text       (GtkEv            *ev,
                                    const gchar*     text);

/* Utility Functions */

static gchar* event_to_text (GdkEvent* event);

static GtkWidgetClass *parent_class = NULL;

guint
gtk_ev_get_type (void)
{
  static guint ev_type = 0;
  if (!ev_type)
    {
      static const GtkTypeInfo ev_info =
      {
        "GtkEv",
        sizeof (GtkEv),
        sizeof (GtkEvClass),
        (GtkClassInitFunc) gtk_ev_class_init,
        (GtkObjectInitFunc) gtk_ev_init,
        /* reserved_1 */ NULL,
        /* reserved_2 */ NULL,
        (GtkClassInitFunc) NULL,
      };

      ev_type = gtk_type_unique (gtk_widget_get_type (), &ev_info);
    }

  return ev_type;
}

static void
gtk_ev_class_init (GtkEvClass *klass)
{
  GtkObjectClass *object_class;
  GtkWidgetClass *widget_class;

  object_class = (GtkObjectClass*) klass;
  widget_class = (GtkWidgetClass*) klass;

  parent_class = gtk_type_class (gtk_widget_get_type ());

  object_class->destroy = gtk_ev_destroy;

  widget_class->realize = gtk_ev_realize;
  widget_class->unrealize = gtk_ev_unrealize;

  widget_class->size_request = gtk_ev_size_request;

  widget_class->size_allocate = gtk_ev_size_allocate;

  widget_class->draw = gtk_ev_draw;

  widget_class->event = gtk_ev_event;
  widget_class->draw_focus = gtk_ev_draw_focus;

  widget_class->expose_event = gtk_ev_expose;

  widget_class->focus_in_event = gtk_ev_focus_in;
  widget_class->focus_out_event = gtk_ev_focus_out;
}

static void
gtk_ev_init (GtkEv *ev)
{
  GTK_WIDGET_SET_FLAGS (GTK_WIDGET(ev), GTK_CAN_FOCUS);

  ev->event_window = NULL;
  ev->buffer       = NULL;
  ev->buffer_end   = NULL;
  ev->buffer_size  = 0;

  ev->event_window_rect.x = ev->event_window_rect.y = 0;
  ev->event_window_rect.width = ev->event_window_rect.height = 0;

  ev->description_rect.x = ev->description_rect.y = 0;
  ev->description_rect.width = ev->description_rect.height = 0;
}

GtkWidget*
gtk_ev_new (void)
{
  GtkEv *ev;

  ev = gtk_type_new (gtk_ev_get_type ());

  return GTK_WIDGET (ev);
}

/* GtkObject functions */
static void
gtk_ev_destroy       (GtkObject   *object)
{
  GtkEv* ev;
  GList* tmp;

  g_return_if_fail(object != NULL);
  g_return_if_fail(GTK_IS_EV(object));

  ev = GTK_EV(object);

  tmp = ev->buffer;
  while (tmp != NULL)
    {
      g_strfreev((gchar**)tmp->data);

      tmp = g_list_next(tmp);
    }

  g_list_free(ev->buffer);

  ev->buffer = NULL;
  ev->buffer_end = NULL;
  ev->buffer_size = 0;

  /* Chain up */
  if (GTK_OBJECT_CLASS(parent_class)->destroy)
    (* GTK_OBJECT_CLASS(parent_class)->destroy) (object);
}

/* GtkWidget functions */

static gint
gtk_ev_event (GtkWidget        *widget,
              GdkEvent         *event)
{
  GtkEv* ev;

  g_return_val_if_fail(widget != NULL, FALSE);
  g_return_val_if_fail(GTK_IS_EV(widget), FALSE);

  ev = GTK_EV(widget);

  if (event->any.window == widget->window)
    {
      if (GTK_WIDGET_CLASS(parent_class)->event)
        return (* GTK_WIDGET_CLASS(parent_class)->event) (widget,
event);
      else
        return FALSE;
    }
  else
    {
      gchar* text;

      /* The event is either on ev->event_window, or it is a key event
       * passed down to us from the toplevel GtkWindow
       */

      text = event_to_text(event);

      gtk_ev_push_text(ev, text);

      g_free(text);

      /* If it was a motion event, make sure we get more */
      if (event->type == GDK_MOTION_NOTIFY)
        {
          gdk_window_get_pointer(ev->event_window, NULL, NULL, NULL);
        }

      /* We didn't "handle" the event, just listened in on it. */
      return FALSE;
    }
}

static void
gtk_ev_realize        (GtkWidget        *widget)
{
  GdkWindowAttr attributes;
  gint attributes_mask;
  GtkEv* ev;
  GdkCursor* cursor;

  g_return_if_fail(widget != NULL);
  g_return_if_fail(GTK_IS_EV(widget));

  ev = GTK_EV(widget);

  /* Set realized flag */

  GTK_WIDGET_SET_FLAGS (widget, GTK_REALIZED);

  /* Main widget window */
  attributes.window_type = GDK_WINDOW_CHILD;
  attributes.x = widget->allocation.x;
  attributes.y = widget->allocation.y;
  attributes.width = widget->allocation.width;
  attributes.height = widget->allocation.height;
  attributes.wclass = GDK_INPUT_OUTPUT;
  attributes.visual = gtk_widget_get_visual (widget);
  attributes.colormap = gtk_widget_get_colormap (widget);
  attributes.event_mask = gtk_widget_get_events (widget) |
GDK_EXPOSURE_MASK;

  attributes_mask = GDK_WA_X | GDK_WA_Y | GDK_WA_VISUAL |
GDK_WA_COLORMAP;

  widget->window = gdk_window_new (gtk_widget_get_parent_window
(widget),
                                   &attributes, attributes_mask);
  gdk_window_set_user_data (widget->window, widget);

  /* Event window */

  cursor = gdk_cursor_new(GDK_CROSSHAIR);

  attributes.window_type = GDK_WINDOW_CHILD;
  attributes.x = ev->event_window_rect.x;
  attributes.y = ev->event_window_rect.y;
  attributes.width = ev->event_window_rect.width;
  attributes.height = ev->event_window_rect.height;
  attributes.wclass = GDK_INPUT_OUTPUT;
  attributes.visual = gtk_widget_get_visual (widget);
  attributes.colormap = gtk_widget_get_colormap (widget);
  attributes.event_mask = GDK_ALL_EVENTS_MASK;
  attributes.cursor = cursor;

  attributes_mask = GDK_WA_X | GDK_WA_Y | GDK_WA_VISUAL |
    GDK_WA_COLORMAP | GDK_WA_CURSOR;

  ev->event_window = gdk_window_new (widget->window,
                                     &attributes, attributes_mask);
  gdk_window_set_user_data (ev->event_window, widget);

  gdk_window_show(ev->event_window);

  gdk_cursor_destroy(cursor);
  /* Style */

  widget->style = gtk_style_attach (widget->style, widget->window);

  gtk_style_set_background (widget->style, widget->window,
GTK_STATE_NORMAL);

  gdk_window_set_background (ev->event_window,
                             &widget->style->base[GTK_STATE_NORMAL]);
}

static void
gtk_ev_unrealize (GtkWidget        *widget)
{
  GtkEv* ev;

  g_return_if_fail(widget != NULL);
  g_return_if_fail(GTK_IS_EV(widget));

  ev = GTK_EV(widget);

  /* Hide all windows */

  if (GTK_WIDGET_MAPPED (widget))
    gtk_widget_unmap (widget);

  GTK_WIDGET_UNSET_FLAGS (widget, GTK_MAPPED);

  /* Destroy our child window */

  if (ev->event_window)
    {
      gdk_window_set_user_data(ev->event_window, NULL);
      gdk_window_destroy(ev->event_window);
      ev->event_window = NULL;
    }

  /* This destroys widget->window and unsets the realized flag
   */
  if (GTK_WIDGET_CLASS(parent_class)->unrealize)
    (* GTK_WIDGET_CLASS(parent_class)->unrealize) (widget);
}
```

```
static void
gtk_ev_size_request   (GtkWidget        *widget,
                       GtkRequisition   *requisition)
{
  g_return_if_fail(widget != NULL);
  g_return_if_fail(GTK_IS_EV(widget));

  /*
   * GtkEv always wants to be the same fixed size.
   */

  requisition->width  = 450;
  requisition->height = 300;
}

static void
gtk_ev_size_allocate  (GtkWidget        *widget,
                       GtkAllocation    *allocation)
{
  static const gint spacing = 10;
  GtkEv* ev;

  g_return_if_fail(widget != NULL);
  g_return_if_fail(GTK_IS_EV(widget));

  ev = GTK_EV(widget);

  widget->allocation = *allocation;

  ev->event_window_rect.width =
    MAX(allocation->width - spacing*2, 0);
  ev->event_window_rect.height =
    MAX(allocation->height / 5 - spacing / 2, 0);

  ev->event_window_rect.x =
    (allocation->width - ev->event_window_rect.width)/2;
  ev->event_window_rect.y =
    MIN(spacing, allocation->height);

  ev->description_rect.x = ev->event_window_rect.x;
  ev->description_rect.y =
    ev->event_window_rect.y + ev->event_window_rect.height + spacing;
  ev->description_rect.width =
    ev->event_window_rect.width;
  ev->description_rect.height =
    MAX((allocation->height - ev->event_window_rect.height -
spacing*3), 0);

  if (GTK_WIDGET_REALIZED (widget))
    {
      gdk_window_move_resize (widget->window,
                              allocation->x,
                              allocation->y,
                              allocation->width,
                              allocation->height);

      gdk_window_move_resize (ev->event_window,
                              ev->event_window_rect.x,
                              ev->event_window_rect.y,
                              ev->event_window_rect.width,
                              ev->event_window_rect.height);
    }
}

static void
gtk_ev_draw           (GtkWidget        *widget,
                       GdkRectangle     *area)
{
  GdkRectangle event_window_area;
  GdkRectangle intersection;
  GtkEv* ev;

  g_return_if_fail(widget != NULL);
  g_return_if_fail(GTK_IS_EV(widget));

  ev = GTK_EV(widget);

  gtk_ev_paint(ev, area);

  event_window_area = *area;

  if (gdk_rectangle_intersect(area, &ev->event_window_rect,
&intersection))
    {
      /* Make the intersection relative to the event window */
      intersection.x -= ev->event_window_rect.x;
      intersection.y -= ev->event_window_rect.y;
      gtk_ev_paint_event_window(ev, &intersection);
    }
}

static void
gtk_ev_draw_focus     (GtkWidget        *widget)
{
  GdkRectangle rect;
  GtkEv* ev;

  g_return_if_fail(widget != NULL);
  g_return_if_fail(GTK_IS_EV(widget));

  ev = GTK_EV(widget);

  rect.x = 0;
  rect.y = 0;
  rect.width = widget->allocation.width;
  rect.height = widget->allocation.height;

  if (GTK_WIDGET_DRAWABLE (ev))
    gtk_ev_paint(ev, &rect);
}

static gint
gtk_ev_expose         (GtkWidget        *widget,
                       GdkEventExpose   *event)
{
  if (event->window == widget->window)
    gtk_ev_paint(GTK_EV(widget), &event->area);
  else if (event->window == GTK_EV(widget)->event_window)
    gtk_ev_paint_event_window(GTK_EV(widget), &event->area);
  else
    g_assert_not_reached();

  return TRUE;
}

static gint
gtk_ev_focus_in       (GtkWidget        *widget,
                       GdkEventFocus    *event)
{
  g_return_val_if_fail(widget != NULL, FALSE);
  g_return_val_if_fail(GTK_IS_EV(widget), FALSE);
  GTK_WIDGET_SET_FLAGS (widget, GTK_HAS_FOCUS);
  gtk_widget_draw_focus (widget);

  return FALSE;
}

static gint
gtk_ev_focus_out      (GtkWidget        *widget,
                       GdkEventFocus    *event)
{
  g_return_val_if_fail(widget != NULL, FALSE);
  g_return_val_if_fail(GTK_IS_EV(widget), FALSE);

  GTK_WIDGET_UNSET_FLAGS (widget, GTK_HAS_FOCUS);
  gtk_widget_draw_focus (widget);

  return FALSE;
}

/* GtkEv-specific functions */

static void
gtk_ev_paint          (GtkEv            *ev,
                       GdkRectangle     *area)
{
  GtkWidget* widget;

  g_return_if_fail(ev != NULL);
  g_return_if_fail(GTK_IS_EV(ev));

  widget = GTK_WIDGET(ev);

  if (!GTK_WIDGET_DRAWABLE (widget))
    return;

  gdk_window_clear_area (widget->window,
                         area->x,
                         area->y,
                         area->width,
                         area->height);

  gdk_gc_set_clip_rectangle(widget->style->black_gc, area);
```

```
/* Draw a black rectangle around the event window */

gdk_draw_rectangle(widget->window,
                   widget->style->black_gc,
                   FALSE,
                   ev->event_window_rect.x - 1,
                   ev->event_window_rect.y - 1,
                   ev->event_window_rect.width + 2,
                   ev->event_window_rect.height + 2);

gdk_gc_set_clip_rectangle(widget->style->black_gc, NULL);

/* Draw text in the description area, if applicable */

if (ev->buffer)
  {
    GdkRectangle intersection;

    if (gdk_rectangle_intersect(area,
                                &ev->description_rect,
                                &intersection))
      {
        static const gint space = 2;
        gint line;
        gint step;
        gint first_baseline;
        GList* tmp;

        step  = widget->style->font->ascent +
          widget->style->font->descent + space;

        first_baseline = ev->description_rect.y +
          widget->style->font->ascent + space;

        line = 0;

        tmp = ev->buffer;

        while (tmp != NULL)
          {
            gchar** this_event = tmp->data;
            gint i = 0;
            while (this_event[i])
              {
                  gtk_paint_string (widget->style,
                                    widget->window,
                                    widget->state,
                                    &intersection, widget, "ev",
                                    ev->description_rect.x,
                                    first_baseline + line*step,
                                    this_event[i]);
                  ++i;
                  ++line;
                }

              /* Bail out if we're off the bottom; the "- 2*step" is
               *  needed because the next baseline may be outside the
               *  redraw area but we are interested in the whole row of
               *  text, not the baseline. The 2* is because line is one
               *  larger than we've actually drawn.
               */
              if ((first_baseline + line*step - 2*step) >
                  (intersection.y + intersection.height))
                break;

              tmp = g_list_next(tmp);
            }
        }
    }

  if (GTK_WIDGET_HAS_FOCUS (widget))
    {
      gtk_paint_focus (widget->style, widget->window,
                       area, widget, "ev",
                       widget->allocation.x, widget->allocation.y,
                       widget->allocation.width-1,
widget->allocation.height-1);
    }
}

static void
gtk_ev_paint_event_window  (GtkEv            *ev,
                            GdkRectangle     *area)
{
  GtkWidget* widget;
  gint width;
  gint x, y;
  const char* title;
  g_return_if_fail(ev != NULL);
  g_return_if_fail(GTK_IS_EV(ev));

  widget = GTK_WIDGET(ev);

  if (!GTK_WIDGET_DRAWABLE (widget))
    return;

  title = _("Event Window");

  gdk_window_clear_area (ev->event_window,
                         area->x,
                         area->y,
                         area->width,
                         area->height);

  gdk_gc_set_clip_rectangle(widget->style->black_gc, area);

  /* Clearly it would be better to cache this */

  width = gdk_string_width(widget->style->font,
                           title);

  x = (ev->event_window_rect.width - width)/2;
  y = widget->style->font->ascent + 2;

  gdk_draw_string(ev->event_window,
                  widget->style->font,
                  widget->style->black_gc,
                  x, y,
                  title);

  gdk_gc_set_clip_rectangle(widget->style->black_gc, NULL);
}

static void
gtk_ev_push_text (GtkEv            *ev,
                  const gchar*     text)
{
  if (text)
    {
      gchar** event;
      event = g_strsplit(text, "\n", 10);
      ev->buffer = g_list_prepend(ev->buffer, event);
      ev->buffer_size += 1;

      /* See if this was the first one we added */
      if (ev->buffer_end == NULL)
        {
          ev->buffer_end = ev->buffer;
        }

      /* See if we have too many to possibly fit on-screen */
      if (ev->buffer_size > 100)
        {
          GList* prev = ev->buffer_end->prev;

          prev->next = NULL;

          g_strfreev(ev->buffer_end->data);
          g_list_free_1(ev->buffer_end);

          ev->buffer_end = prev;

          ev->buffer_size -= 1;
        }
    }

  if (GTK_WIDGET_DRAWABLE (ev))
    gtk_widget_queue_draw_area(GTK_WIDGET(ev),
                               ev->description_rect.x,
                               ev->description_rect.y,
                               ev->description_rect.width,
                               ev->description_rect.height);
}

static gchar*
event_name_line(GdkEvent* event)
{
  switch (event->type)
    {
    case GDK_NOTHING:
      return g_strdup(_("Invalid event!\n"));
      break;

    case GDK_DELETE:
      return g_strdup(_("Delete\n"));
      break;

    case GDK_DESTROY:
      return g_strdup(_("Destroy\n"));
      break;

    case GDK_EXPOSE:
      return g_strdup(_("Expose\n"));
      break;

    case GDK_MOTION_NOTIFY:
      return g_strdup(_("Motion Notify\n"));
      break;

    case GDK_BUTTON_PRESS:
      return g_strdup(_("Button Press\n"));
      break;

    case GDK_2BUTTON_PRESS:
      return g_strdup(_("2 Button Press\n"));
      break;

    case GDK_3BUTTON_PRESS:
      return g_strdup(_("3 Button Press\n"));
      break;

    case GDK_BUTTON_RELEASE:
      return g_strdup(_("Button Release\n"));
      break;

    case GDK_KEY_PRESS:
      return g_strdup(_("Key Press\n"));
      break;

    case GDK_KEY_RELEASE:
      return g_strdup(_("Key Release\n"));
      break;

    case GDK_ENTER_NOTIFY:
      return g_strdup(_("Enter Notify\n"));
      break;

    case GDK_LEAVE_NOTIFY:
      return g_strdup(_("Leave Notify\n"));
      break;

    case GDK_FOCUS_CHANGE:
      return g_strdup(_("Focus Change\n"));
      break;

    case GDK_CONFIGURE:
      return g_strdup(_("Configure\n"));
      break;

    case GDK_MAP:
      return g_strdup(_("Map\n"));
      break;

    case GDK_UNMAP:
      return g_strdup(_("Unmap\n"));
      break;

    case GDK_PROPERTY_NOTIFY:
      return g_strdup(_("Property Notify\n"));
      break;

    case GDK_SELECTION_CLEAR:
      return g_strdup(_("Selection Clear\n"));
      break;

    case GDK_SELECTION_REQUEST:
      return g_strdup(_("Selection Request\n"));
      break;

    case GDK_SELECTION_NOTIFY:
      return g_strdup(_("Selection Notify\n"));
      break;

    case GDK_PROXIMITY_IN:
      return g_strdup(_("Proximity In\n"));
      break;

    case GDK_PROXIMITY_OUT:
      return g_strdup(_("Proximity Out\n"));
      break;

    case GDK_DRAG_ENTER:
      return g_strdup(_("Drag Enter\n"));
      break;

    case GDK_DRAG_LEAVE:
      return g_strdup(_("Drag Leave\n"));
      break;

    case GDK_DRAG_MOTION:
      return g_strdup(_("Drag Motion\n"));
      break;

    case GDK_DRAG_STATUS:
      return g_strdup(_("Drag Status\n"));
      break;

    case GDK_DROP_START:
      return g_strdup(_("Drop Start\n"));
      break;

    case GDK_DROP_FINISHED:
      return g_strdup(_("Drop Finished\n"));
      break;

    case GDK_CLIENT_EVENT:
      return g_strdup(_("Client Event\n"));
      break;

    case GDK_VISIBILITY_NOTIFY:
      return g_strdup(_("Visibility Notify\n"));
      break;

    case GDK_NO_EXPOSE:
      return g_strdup(_("No Expose\n"));
      break;

    default:
      g_assert_not_reached();
      return NULL;
      break;
    }
}

static gchar*
any_event_line(GdkEvent* event)
{
  guint32 event_time;

  event_time = gdk_event_get_time(event);

  if (event_time != GDK_CURRENT_TIME)
    return g_strdup_printf(_("Window: %p Time: %u send_event: %s\n"),
                           event->any.window,
                           event_time,
                           event->any.send_event ? _("True") :
_("False"));
  else
    return g_strdup_printf(_("Window: %p send_event: %s\n"),
                           event->any.window,
                           event->any.send_event ? _("True") :
_("False"));
}

#define MAX_STATES 30

static gchar*
event_state_line(GdkModifierType state)
{
  gchar** states;
  gint n_active;

  states = g_new(gchar*, MAX_STATES);

  n_active = 0;

  if (state & GDK_SHIFT_MASK)
    {
      states[n_active] = _("Shift");
      ++n_active;
    }
  if (state & GDK_LOCK_MASK)
    {
      states[n_active] = _("Lock");
      ++n_active;
    }
  if (state & GDK_CONTROL_MASK)
    {
      states[n_active] = _("Ctrl");
      ++n_active;
    }
  if (state & GDK_MOD1_MASK)
    {
      states[n_active] = _("Mod1");
      ++n_active;
    }
  if (state & GDK_MOD2_MASK)
    {
      states[n_active] = _("Mod2");
      ++n_active;
    }
  if (state & GDK_MOD3_MASK)
    {
      states[n_active] = _("Mod3");
      ++n_active;
    }
  if (state & GDK_MOD4_MASK)
    {
      states[n_active] = _("Mod4");
      ++n_active;
    }
  if (state & GDK_MOD5_MASK)
    {
      states[n_active] = _("Mod5");
      ++n_active;
    }
  if (state & GDK_BUTTON1_MASK)
    {
      states[n_active] = _("Button1");
      ++n_active;
    }
  if (state & GDK_BUTTON2_MASK)
    {
      states[n_active] = _("Button2");
      ++n_active;
    }
  if (state & GDK_BUTTON3_MASK)
    {
      states[n_active] = _("Button3");
      ++n_active;
    }
  if (state & GDK_BUTTON4_MASK)
    {
      states[n_active] = _("Button4");
      ++n_active;
    }
  if (state & GDK_BUTTON5_MASK)
    {
      states[n_active] = _("Button4");
      ++n_active;
    }
  if (state & GDK_RELEASE_MASK)
    {
      states[n_active] = _("Release");
      ++n_active;
    }

  if (n_active == 0)
    return NULL;
  else
    {
      /* Not efficient, but not important */

      gchar* str = NULL;
      gchar* tmp = NULL;

      guint i = 0;
      while (i < n_active)
        {

          if (str)
            {
              tmp = str;
              str = g_strconcat(str, " | ", states[i], NULL);
              g_free(tmp);
            }
          else
            {
              str = g_strdup(states[i]);
            }

          ++i;
        }

      tmp = str;
      str = g_strconcat(str, "\n", NULL);
      g_free(tmp);

      return str;
    }
}

static gchar*
event_to_text (GdkEvent* event)
{
  gchar* any_line;
  gchar* name_line;
  gchar* entire_line;
  gchar* detail;
  gchar* state;

  name_line = event_name_line(event);
  any_line = any_event_line(event);

  entire_line = NULL;
  detail = NULL;
  state = NULL;

  switch (event->type)
    {
    case GDK_NOTHING:
      break;

    case GDK_DELETE:
      break;

    case GDK_DESTROY:
      break;

    case GDK_EXPOSE:
      detail = g_strdup_printf(_("Area: %d,%d  %dx%d Count: %d\n"),
                               event->expose.area.x,
                               event->expose.area.y,
                               event->expose.area.width,
                               event->expose.area.height,
                               event->expose.count);
      break;

    case GDK_MOTION_NOTIFY:
      detail = g_strdup_printf(_("x: %g y: %g\n"),
                               event->motion.x,
                               event->motion.y);
      state = event_state_line(event->motion.state);
      break;

    case GDK_BUTTON_PRESS:
    case GDK_2BUTTON_PRESS:
    case GDK_3BUTTON_PRESS:
    case GDK_BUTTON_RELEASE:
      detail = g_strdup_printf(_("Button: %d\n"),
                               event->button.button);
      state = event_state_line(event->button.state);
      break;

    case GDK_KEY_PRESS:
    case GDK_KEY_RELEASE:
      detail = g_strdup_printf(_("Keyval: GDK_%s Text: %s\n"),
                               gdk_keyval_name(event->key.keyval),
                               event->key.string);
      state = event_state_line(event->key.state);
      break;

    case GDK_ENTER_NOTIFY:
      break;

    case GDK_LEAVE_NOTIFY:
      break;

    case GDK_FOCUS_CHANGE:
      break;

    case GDK_CONFIGURE:
      break;

    case GDK_MAP:
      break;

    case GDK_UNMAP:
      break;

    case GDK_PROPERTY_NOTIFY:
      break;

    case GDK_SELECTION_CLEAR:
      break;

    case GDK_SELECTION_REQUEST:
      break;

    case GDK_SELECTION_NOTIFY:
      break;

    case GDK_PROXIMITY_IN:
      break;

    case GDK_PROXIMITY_OUT:
      break;

    case GDK_DRAG_ENTER:
      break;

    case GDK_DRAG_LEAVE:
      break;

    case GDK_DRAG_MOTION:
      break;

    case GDK_DRAG_STATUS:
      break;

    case GDK_DROP_START:
      break;

    case GDK_DROP_FINISHED:
      break;

    case GDK_CLIENT_EVENT:
      break;

    case GDK_VISIBILITY_NOTIFY:
      break;

    case GDK_NO_EXPOSE:
      break;

    default:
      g_assert_not_reached();
      break;
    }

  if (entire_line == NULL)
```

```
    {
      /* Assumes we always have a detail if we have a state */

      entire_line = g_strconcat(name_line,
                                "  ", any_line,
                                detail ? "  " : NULL, detail,
                                state ? "  " : NULL, state,
                                NULL);
    }

  g_free(name_line);
  g_free(any_line);
  g_free(detail);
  g_free(state);

  return entire_line;
}
```