How GNOME supports multiple programming languages

(The story of GObject-Introspection)

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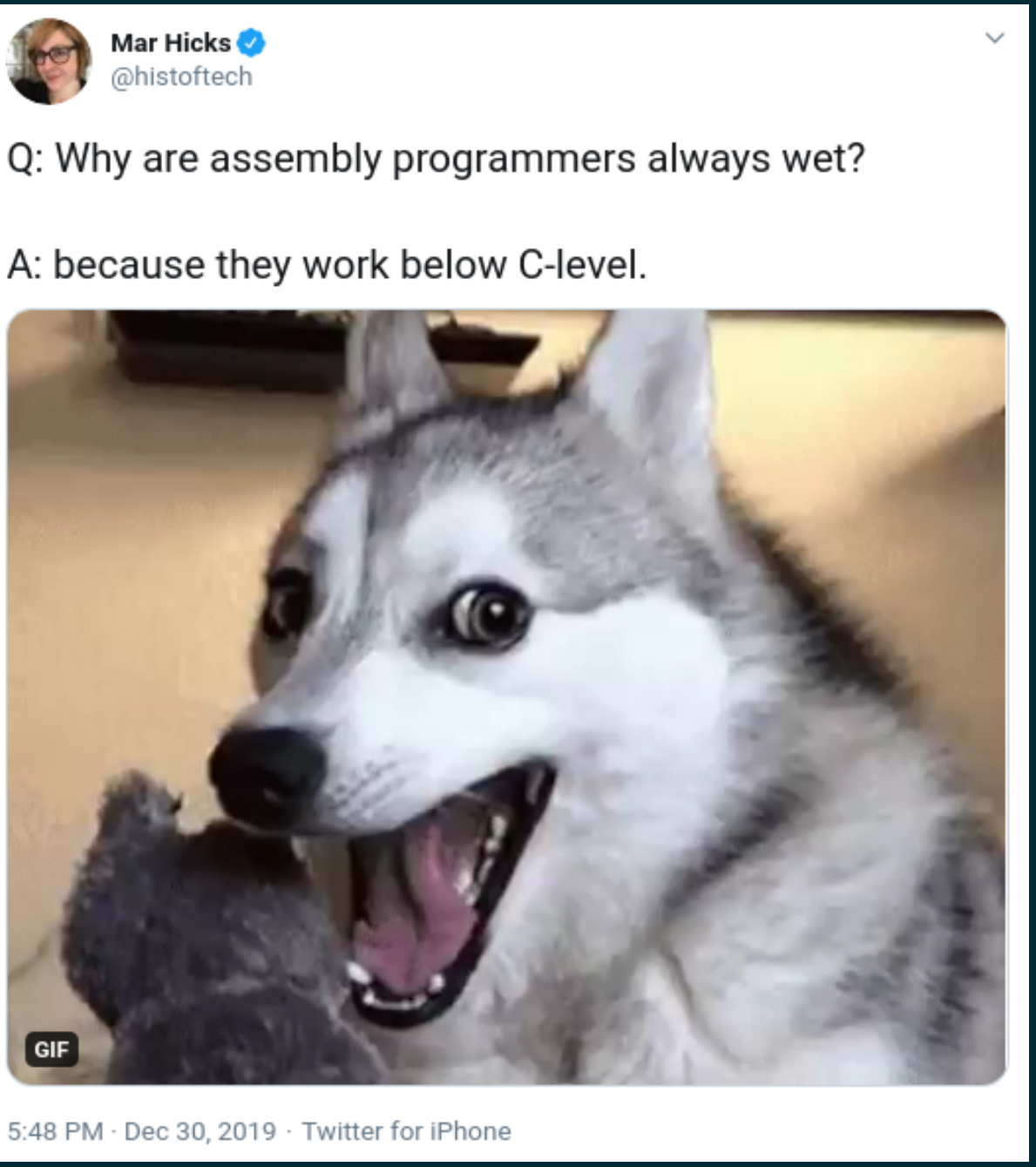
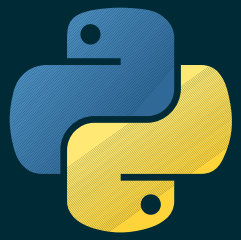
GNOME Onboard
Africa Virtual 2020



https://twitter.com/histoftech/status/1211796118973100032



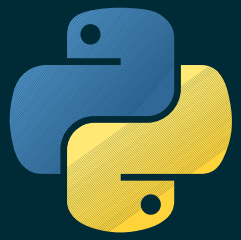
Python

```
import gi
gi.require_version('Gtk', '3.0')
from gi.repository import Gtk

win = Gtk.Window()
win.set_title("Hello World")

label = Gtk.Label.new("I am written in Python")
win.add(label);

win.show_all()
Gtk.main()
```



Python

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win.add(label);

win.show_all()
Gtk.main()
```

Javascript

```
imports.gi.versions.Gtk = "3.0";
const Gtk = imports.gi.Gtk;

Gtk.init(null);

let win = new Gtk.Window();
win.set_title("Hello World");

let label = Gtk.Label.new("I am written in Javascript")
win.add(label);

win.show_all();
Gtk.main();
```

Javascript

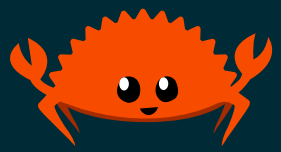
```
imports.gi.versions.Gtk = "3.0";
const Gtk = imports.gi.Gtk;

Gtk.init(null);

let win = new Gtk.Window();
win.set_title("Hello World");

let label = Gtk.Label.new("I am written in Javascript")
win.add(label);

win.show_all();
Gtk.main();
```



Rust

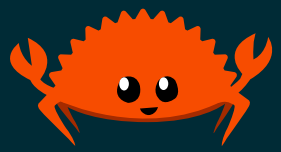
```
use gtk::{self, prelude::*, Label, Window, WindowType};

fn main() {
    gtk::init().unwrap();

    let win = Window::new(WindowType::Toplevel);
    win.set_title("Hello World");

    let label = Label::new(Some("I am written in Rust"));
    win.add(&label);

    win.show_all();
    gtk::main();
}
```



Rust

```
use gtk::{self, prelude::*, Label, Window, WindowType};

fn main() {
    gtk::init().unwrap();

    let win = Window::new(WindowType::Toplevel);
    win.set_title("Hello World");

    let label = Label::new(Some("I am written in Rust"));
    win.add(&label);

    win.show_all();
    gtk::main();
}
```

But GTK is written in C

```
GtkWidget*
gtk_window_new (GtkWindowType type)
{
    ...
}


void
gtk_window_set_title (GtkWindow   *window,
                      const gchar *title)
{
    ...
}
```

Object-oriented programming in C

```
void
gtk_widget_show_all (GtkWidget *widget)
{
  GtkWidgetClass *class;

  class = GTK_WIDGET_GET_CLASS (widget);

  if (class->show_all)
    class->show_all (widget);
}
```

```
class GtkWidget:
    def show_all(self):
        ...
```

```
void
gtk_container_add (GtkContainer *container,
                   GtkWidget    *widget)
{
    ...
}
```

```
class GtkContainer:
    def add(self, widget):
        ...
```

Object-oriented programming in C

```
void
gtk_widget_show_all (GtkWidget *widget)
{
  GtkWidgetClass *class;

  class = GTK_WIDGET_GET_CLASS (widget);

  if (class->show_all)
    class->show_all (widget);
}
```

Get the class structure

```
void
gtk_container_add (GtkContainer *container,
                   GtkWidget    *widget)
{
    ...
}
```

Object-oriented programming in C

```
void
gtk_widget_show_all (GtkWidget *widget)
{
  GtkWidgetClass *class;

  class = GTK_WIDGET_GET_CLASS (widget);

  if (class->show_all)
    class->show_all (widget);
}
```

If the method is implemented
call the method

```
void
gtk_container_add (GtkContainer *container,
                   GtkWidget    *widget)
{
    ...
}
```

Extending Python from C

```
static PyObject *
say_hello(PyObject *self, PyObject *args)
{
    const char *name;

    if (!PyArg_ParseTuple(args, "s", &name))
        return NULL;

    printf("hello %s\n", name);

    Py_INCREF(Py_None);
    return Py_None;
}
```

everything is a PyObject

```
static PyObject *
say_hello(PyObject *self, PyObject *args)
{
    const char *name;

    if (!PyArg_ParseTuple(args, "s", &name))
        return NULL;

    printf("hello %s\n", name);

    Py_INCREF(Py_None);
    return Py_None;
}
```

parse a string from args and put it in name

```
static PyObject *
say_hello(PyObject *self, PyObject *args)
{
    const char *name;

    if (!PyArg_ParseTuple(args, "s", &name))
        return NULL;

    printf("hello %s\n", name);

    Py_INCREF(Py_None);
    return Py_None;
}
```

do whatever in C

```
static PyObject *
say_hello(PyObject *self, PyObject *args)
{
    const char *name;

    if (!PyArg_ParseTuple(args, "s", &name))
        return NULL;

    printf("hello %s\n", name);

    Py_INCREF(Py_None);
    return Py_None;
}
```

build a Python return value and return it

```
class Label(Widget):
    def set_text(self, text):
        ...

label.set_text(“hello”)
```

A hand-written wrapper for gtk_label_set_text()

```
static PyObject *
wrap_label_set_text(PyObject *self, PyObject *args)
{
    GtkLabel *label;
    const char *text;

    label = get_gtklabel_from_self(self);

    if (!PyArg_ParseTuple(args, "s", &text))
        return NULL;

    gtk_label_set_text(label, text);

    Py_INCREF(Py_None);
    return Py_None;
}
```

What is a language binding?

- A language-specific wrapper for a library.
- Ideally make it feel like a library written for that language.

Back in 1997

- Hand-written bindings.
- C++, Objective-C, Python (?), Perl
- Wrap each function by hand, as needed.
- Error-prone, lots of duplication.

1998 / 1999

- Red Hat rewrites their installer in Python.
- With a GTK interface.
- Lots of work put into PyGTK.

Machine-readable descriptions

```
(class GtkWidget
       ;;; void gtk_widget_show (GtkWidget *widget);
       (method show
               (args nil)
               (retval nil))

       ;;; void gtk_widget_hide (GtkWidget *widget);
       (method hide
               (args nil)
               (retval nil)))
```

A method with one argument

```
(class GtkContainer
    ;;; void gtk_container_add (GtkContainer *container,
    ;;;                         GtkWidget    *child);

    (method add
            (args GtkWidget)
            (retval nil)))
```

Describe all the C types!

```
typedef struct {
    guchar r;
    guchar g;
    guchar b;
} GdkColor;
```

```
(struct GdkColor
        (field r (type 'guchar))
        (field g (type 'guchar))
        (field b (type 'guchar)))
```

GObject

- An object and type system for C.
- Register types at runtime.
- Lots of things for memory management.
  - How does a value for a type get copied?
  - Are values reference-counted?
  - Etc.

Example:
Signals and their argument types

```
g_signal_new ("button-press-event",
    gtk_widget_get_type(), /* type of object for which this
                            * signal is being created
                            */
    ...
    G_TYPE_BOOLEAN,  /* type of return value */
    1,               /* number of arguments */
    GDK_TYPE_EVENT); /* type of first and only argument */
```

```
g_signal_query(class, signal)
```

Static vs. Dynamic

- Static languages (Rust, C++)
  - Cannot g_signal_query() and construct classes at runtime
  - Everything needs to be pre-generated
- Dynamic languages (Python, Javascript)
  - Can generate new classes and methods at runtime

GNOME 2

- Lots of machine-readable descriptions of APIs.
- Cut&paste from binding to binding.
- Lots of manual work on top of automation.

GNOME 3

- GObject-Introspection.
- Write a library in C.
- Generate a machine-readable API/ABI description from it.
- Bindings are language-specific glue from the machine-readable descriptions to the C library.

Annotations

```
/**
 * gtk_widget_get_parent:
 * @widget: a #GtkWidget
 *
 * Returns the parent container of @widget.
 *
 * Returns: (transfer none) (nullable): the parent
 *          container of @widget, or %NULL
 **/
GtkWidget *
gtk_widget_get_parent (GtkWidget *widget)
{
    ...
}
```

```
/**
 * gtk_widget_get_parent:
 * @widget: a #GtkWidget
 *
 * Returns the parent container of @widget.
 *
 * Returns: (transfer none) (nullable): the parent
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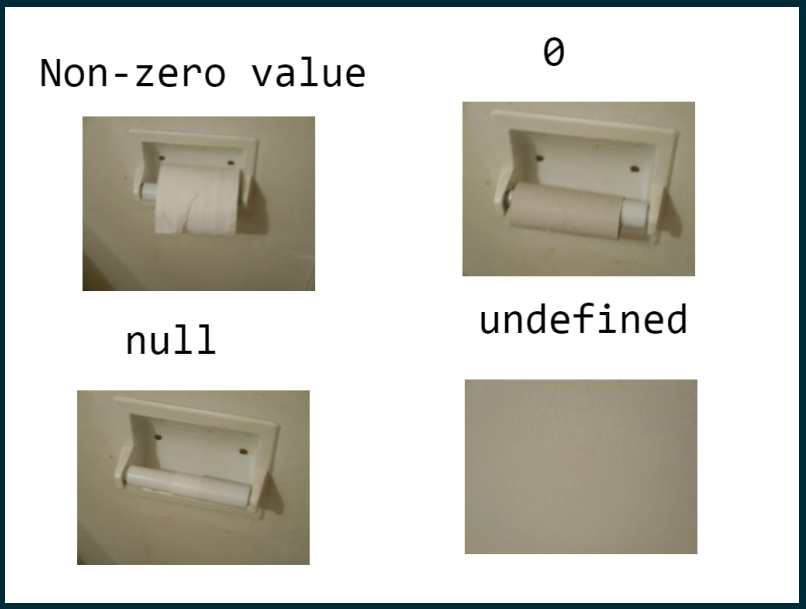
 **/
GtkWidget *
gtk_widget_get_parent (GtkWidget *widget)
{
    ...
}
```

Inline documentation written in comments

```
/**
 * gtk_widget_get_parent:
 * @widget: a #GtkWidget
 *
 * Returns the parent container of @widget.
 *
 * Returns: (transfer none) (nullable): the parent
 *          container of @widget, or %NULL
 **/
GtkWidget *
gtk_widget_get_paren  (GtkWidget *widget)
{
    ...
}
```

(transfer none) - no extra reference count
is added to the returned object

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 * Returns the parent container of @widget.
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 * Returns: (transfer none) (nullable): the parent
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 **/
GtkWidget *
gtk_widget_get_parent (GtkWidget *widget)
{
    ...
}
```

(nullable) - may return NULL

https://ach-te-internety.pl/wp-content/uploads/2019/03/null-undefined-roznice-ach-te-itnernety.png

Gtk-3.0.gir

```
<repository version="1.2" ...>

  <namespace name="Gtk"
             version="3.0"
             shared-library="libgtk-3.so.0,libgdk-3.so.0"
             c:identifier-prefixes="Gtk"
             c:symbol-prefixes="gtk">
```

GtkEntry class

```
<class name="Entry"
       c:symbol-prefix="entry"
       c:type="GtkEntry"
       parent="Widget"
       glib:type-name="GtkEntry"
       glib:get-type="gtk_entry_get_type"
       glib:type-struct="EntryClass">

  <doc>
    The #GtkEntry widget is a single line text entry
    widget. A fairly large set of key bindings are supported
    by default. If the entered text is longer than the
    ...
   </doc>
```

What does GtkEntry implement?

```
<implements name="Atk.ImplementorIface"/>
<implements name="Buildable"/>
<implements name="CellEditable"/>
<implements name="Editable"/>
```

One method of GtkEntry

```
const gchar*
gtk_entry_get_text (GtkEntry *entry);
```

```
<method name="get_text" c:identifier="gtk_entry_get_text">
  <doc>Retrieves the contents of the entry widget. ... </doc>

  <return-value transfer-ownership="none">
    <type name="utf8" c:type="const gchar*"/>
  </return-value>

  <parameters>
    <instance-parameter name="entry" transfer-ownership="none">
      <type name="Entry" c:type="GtkEntry*"/>
    </instance-parameter>
  </parameters>
</method>
```

Description of a struct

```
typedef struct
{
    int x, y;
    int width, height;
} GdkRectangle;
```

```
    <record name="Rectangle"
            c:type="GdkRectangle"
            glib:type-name="GdkRectangle"
            glib:get-type="gdk_rectangle_get_type"
            c:symbol-prefix="rectangle">

      <field name="x" writable="1">
        <type name="gint" c:type="int"/>
      </field>
      <field name="y" writable="1">
        <type name="gint" c:type="int"/>
      </field>
      ... etc ...
    </record>
```

Compiled descriptions

- .gir files are huge XML files!
  - Look in /usr/share/gir-1.0/
- Don’t want to parse megabytes at startup of every application.
- *.gir -> compiled to *.typelib
  - Look in /usr/lib64/girepository-1.0/
  - can be memory-mapped and shared across processes

The Unwritten Future

James Munns
@bitshiftmask

Here's a rant (opinion?) that I'll turn in to a blog post soon.

I think Rust should have a third ABI, not repr(C) or repr(Rust), and it should be used to slowly phase out the C ABI for a better one. Want to hear more of my unreasonable thoughts about ABIs? Read on.

4:22 PM · Jul 23, 2020 · Twitter Web App

https://twitter.com/bitshiftmask/status/1286411475658178561

GNOME already has part of this!

James Munns
@bitshiftmask

Fifth: The ABI should include the ability to encode information about types and layouts, not just function names. This should be used at compile/runtime to provide type information. Compilers should be able to import ABI libraries directly, or provide codegen tools to get headers

4:35 PM · Jul 23, 2020 · Twitter Web App

Work on tools, save the world!

Thanks

- federico@gnome.org