GTask

Developing asynchronous applications for multi-core efficiency

February 2009
SCALE 7x
Los Angeles

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What Is It?

GTask is a “mini-framework” to help you write asynchronous code.

Dependencies

GLib and GObject

Platforms

Linux, BSD, and OpenSolaris have been tested

x86, x86_64, and ARM

Probably others

The Application Stack

C | Python | Vala | JS | C# | C++

Your Application

Configuration
GConf

IO
GIO

Multi-Core
GTask

User Interface
GTK+

Multimedia
GStreamer

Portability and Object Orientation
GLib / GObject

#include <glib.h>

Useful routines for C

Portable fundamental types (gint, gfloat, gint64, ...)

Portable atomic operations (g_atomic_int_inc, ...)

HashTable, Queue, Lists, Trees

Locks and Conditions

Errors (like exceptions)

UTF-8, various encodings, and conversions

etc ...

#include <glib-object.h>

Object oriented programming for C

Dynamic type system

Objects, Interfaces, Polymorphism

Properties

Signals (aka, “events”)

Closures

Automatic API bindings to compiled and interpreted languages (Java, Python, Ruby, JS, C++, C#, and more)

Memory management with reference counting

GTask

#include <gtask/gtask.h>

- Abstracts closures one more level
- Single shot execution (only executed once)
- Ability to respond to execution results/errors
- Using callback chains, you can emulate features like try/catch/finally
- Cancellation of tasks
- Task dependencies to prevent premature execution
- Custom schedulers for the problem domain

I Think I've Seen This Before?

- Python Twisted
- Microsoft's CCR
- Apple's NSOperation (OS X 10.5)
- Intel's Threading Building Blocks

- GTask is probably best described as a blend of Python Twisted and NSOperation
- Unlike twisted, you do not need radical changes to your application

Also,

Removes concept of the Stack

The Basics

1. Create a task
   g_task_new (...);

2. Add a callback
   g_task_add_callback (...);

3. Schedule the task
   g_task_scheduler_schedule (...);

Task Phases

WAITING – Waiting on dependent tasks

READY – Ready for execution by scheduler

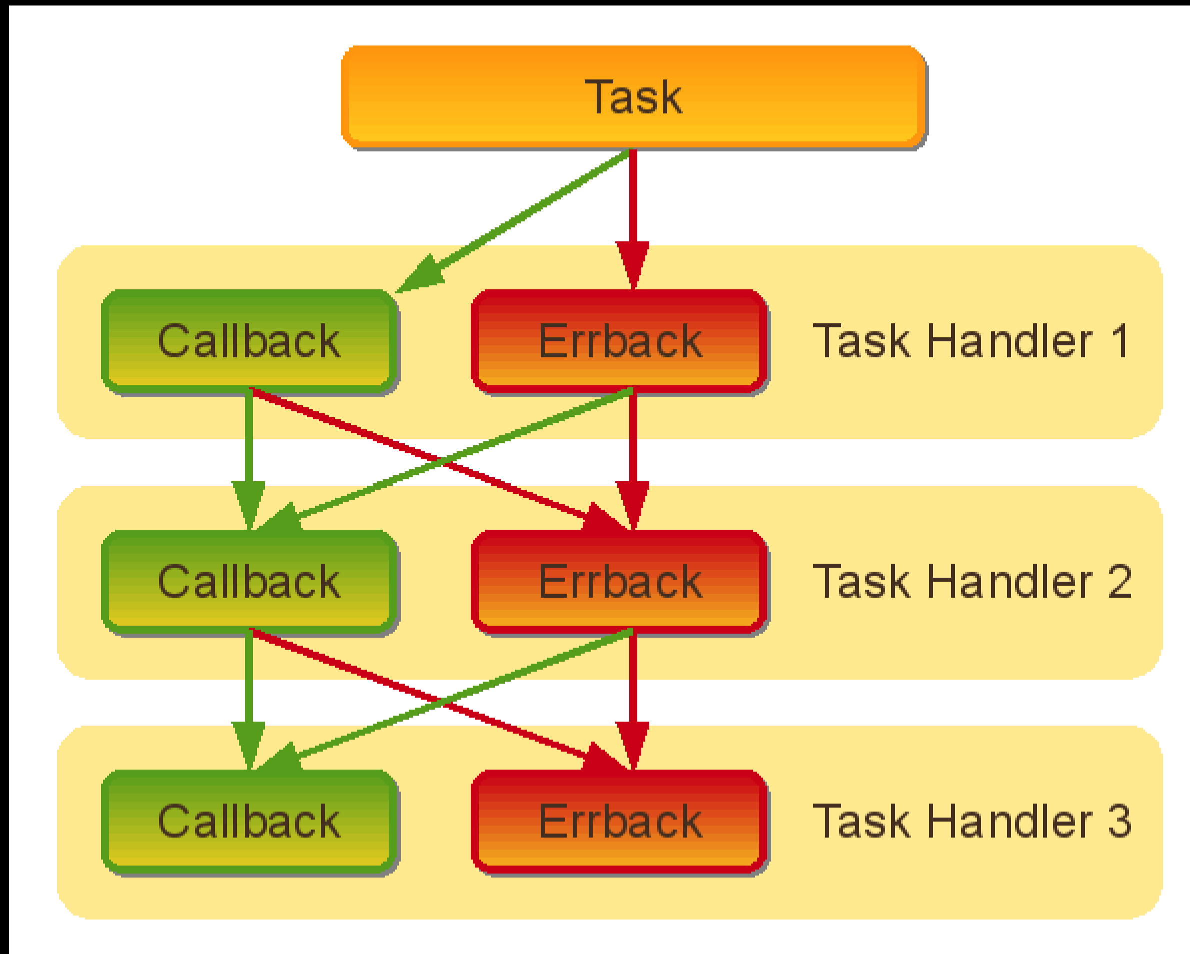
EXECUTING – Currently executing by scheduler

CALLBACKS – Handling post execution callbacks/errbacks

FINISHED – Execution and callbacks have completed

CANCELED – Task was canceled during execution

Callbacks and Errbacks



Function Prototypes

```
/* Task Execution Method */
typedef GTask* (*GTaskFunc) (GTask    *task,
                             GValue   *result,
                             gpointer  data);

/* Callback (After Successful Execution) */
typedef GTask* (*GTaskCallback) (GTask    *task,
                                 GValue   *result,
                                 gpointer  data);

/* Errback (After Errored Execution or Callback) */
typedef GTask* (*GTaskErrback) (GTask    *task,
                                const GError *error,
                                GValue   *result,
                                gpointer  data);
```

Our First Task

```
#include <gtask/gtask.h>
#define SCHEDULER (g_task_scheduler_get_default ())

static void
do_something (void)
{
   GTask *task;

   task = g_task_new (lsdir_cb, "/usr/bin", NULL);
   g_task_scheduler_schedule (SCHEDULER, task);

   g_object_unref (task);
}
```

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   g_task_scheduler_schedule (SCHEDULER, task);

   g_object_unref (task);
}
```

```
static void
lsdir_cb (GTask    *task,
          GValue   *result,
          gpointer  user_data)
{
   const gchar *path = user_data;
   const gchar *name;
   GDir        *dir;

   dir = g_dir_open (path, 0, NULL);
   while ((name = g_dir_read_name (dir) != NULL)
      g_print (“%s\n”, name);
}
```

Remember the Result Parameter?

Each prototype has access to current “result”.

Great for passing state between
Callbacks and Errbacks.

Feels like “functional” programming.

“Throwing” an Error

```
GError *error = g_error_new_literal (
      SOME_ERROR_DOMAIN,
      SOME_ERROR_CODE,
      “An error occured”));

/* steal our reference to the error */
g_task_take_error (task, error);

/* Or, instead copy the error */
g_task_set_error (task, error);
g_error_free (error);
```

“Catching” an Error

```
static void
resolve_error (GTask        *task,
               const GError *error,
               GValue       *result,
               gpointer      user_data)
{
    /* unsetting error allows further callbacks */
    g_task_set_error (task, NULL);
}

g_task_add_errback (task, resolve_error, NULL, NULL);
```

Try/Catch/Finally

We can emulate try/catch/finally using Callbacks and Errbacks!

```
/* the catch */
g_task_add_errback (task, task_errorback1, NULL);

/* the finally */
g_task_add_both (task, task_callback2, task_errback2, NULL);
```

Scheduling

- Provides default scheduler, accessible as g_task_scheduler_get_default()
- Default scheduler is very simple
- Thread pool growth size defaults to 10 * N_CPU
- If implementing a scheduler, watch out for the bumper-to-bumper effect!

Scheduling (Continued)

Currently working on a Work Stealing Scheduler

Also a tertiary scheduler providing "tagged" tasks to pin to a given cpu (increase cpu cache hits).

Work Stealing Scheduler

Each thread has a local (double sided) queue of work items.

If no more work, I'll see if my neighbor thread has work left.

“Local” pop of work item occurs from tail.

“Steal” pop of work item occurs from head.

Local pops attempt lockless for fast-path, uses lock if failed.

Steal requires lock.

... Waiting on scheduler revamp.

Scheduler Revamp

Currently threads are managed by the scheduler.

No real reason for that, its lots of tedious code added to writing custom schedulers.

Often times causes lots of extra threads.

Pull thread management out into global controller.

Schedulers are given threads as needed, based on their MIN, MAX, and DESIRED thread count.

Achieving Higher Concurrency

Use Asynchronous tasks when necessary (and possible).

Try to avoid shared state. This isn't just related to gtask, but in general. The result field is a great place to store what state you need.

Async Tasks

g_task_set_async (task, TRUE);

Tasks that do not finish during g_task_execute().

Best way to achieve higher concurrency.

Good example would be using Async IO from within a task. (GIO, part of Glib)

Task is responsible for moving task to the callbacks phase.

g_task_set_state (task, G_TASK_CALLBACKS)

Main Dispatch

User interfaces such as gtk+ are not thread safe.

Callbacks and Errbacks are performed from within the default main loop.

Requires the use of a Main Loop such as GMainLoop or gtk_main().

This allows you to perform work as tasks, and update the user interface seamlessly within a callback or errback.

Enabling Main Dispatch

```
g_object_set (g_task_scheduler_get_default (),
              “main-dispatch”, TRUE,
              NULL);
```

Language Bindings

Python and Vala currently supported

.NET (via Mono) soon

JavaScript soon (requires gobject-introspection)

C++ soon, needs someone familiar with gtkmm

Python

Simple wrapper around the GTask library

```
import gtask, urllib
URL = “http://audidude.com”
task = gtask.Task(lambda: urllib.urlopen(URL).read())
task.add_callback(lambda data: file(“/tmp/data”,”w”).write(data))
gtask.schedule(task)
```

Python (continued)

Start by rapidly prototyping your code in Python using Tasks.

Optimize as needed simply by implementing your Task in C and calling from Python.

Vala

Vala provides a modern language on top of GLib and GObject.

Syntax very similar to C#.

Compiles to C, no runtime required.

Generics, Lambdas, Properties, Signals, all supported.

You can write implicitly asynchronous code.

Implicitly Asynchronous

```
void do_something () yields
{
    var task = new Task (_ => {
        return some_sync_operation ();
    });

    /* execution suspends at task.run(). *
     * result is filled upon completion  */
    var result = task.run ();
    stdout.printf ("Result was %s\n",
                   (string)result);
}
```

The Future

- Parallel Constructs (foreach, sort, ...)
- Local map/reduce
- Work Stealing and Rate-Limiting Schedulers
- Auto marshaling of task results (for intra-language task execution)
- Integrated Profiling
- Debugging helpers for visualizing “virtual stack”

The Future (continued)

Concurrency Helpers

g_task_n_of(...)
g_task_all_of(...)
g_task_any_of(...)

Helps solve the problem of needing to finish a set of tasks before processing can continue.

Think about multiple database queries in parallel.

Fin

GTask website: http://chergert.github.com/gtask
GTask documentation: http://docs.dronelabs.com/gtask
GTask API Reference: http://docs.dronelabs.com/gtask/api