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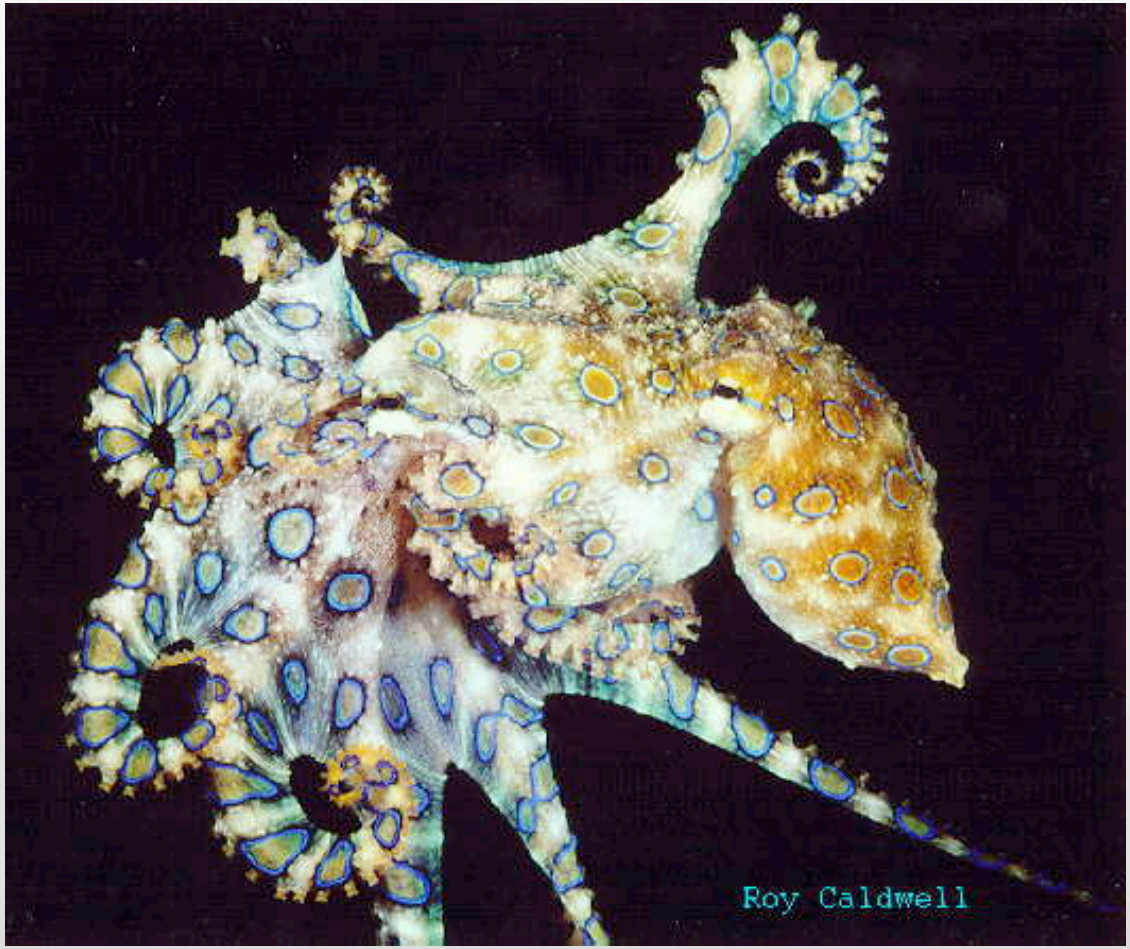
Using Boost.Coroutine to untangle a state machine

What's a Coroutine?



http://hoopermuseum.earthsci.carleton.ca/cephalopoda/octopus.htm

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What's a Coroutine?

```
/* Decompression code */
while (1) {
    c = getchar();
    if (c == EOF)
        break;
    if (c == 0xFF) {
        len = getchar();
        c = getchar();
        while (len--)
            emit(c);
    } else
        emit(c);
}
emit(EOF);
```

```
/* Parser code */
while (1) {
    c = getchar();
    if (c == EOF)
        break;
    if (isalpha(c)) {
        do {
            add_to_token(c);
            c = getchar();
        } while (isalpha(c));
        got_token(WORD);
    }
    add_to_token(c);
    got_token(PUNCT);
}
```

Excerpted from the following page 2012-03-13:
http://www.chiark.greenend.org.uk/~sgtatham/coroutines.html

What's a Coroutine?

```
/* Decompression code */
while (1) {
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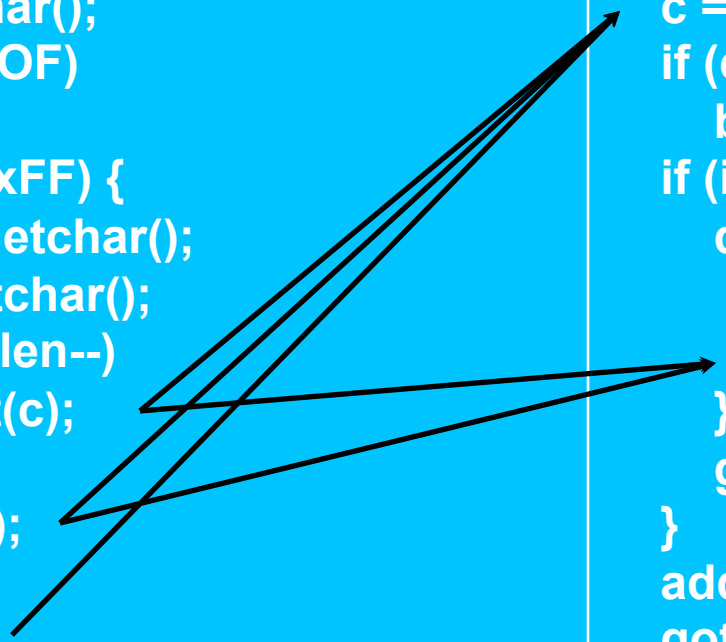
```



Excerpted from the following page 2012-03-13:
http://www.chiark.greenend.org.uk/~sgtatham/coroutines.html

What's a Coroutine?

- Use the IP, Luke
- Control flow > flag variables

http://themoderatevoice.com/101316/can-obama-be-luke-skywalker/

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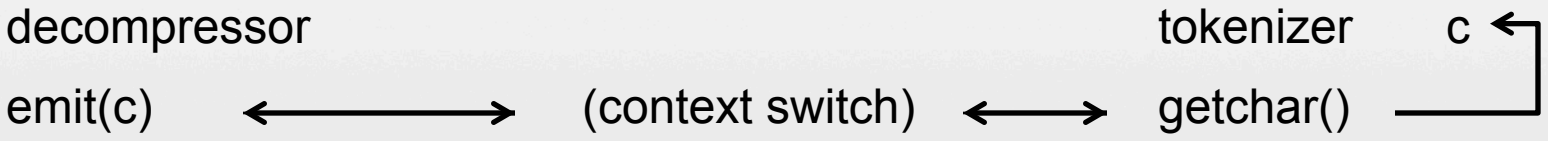
What's a Coroutine?

- **Own call stack**
- **Own local variables**



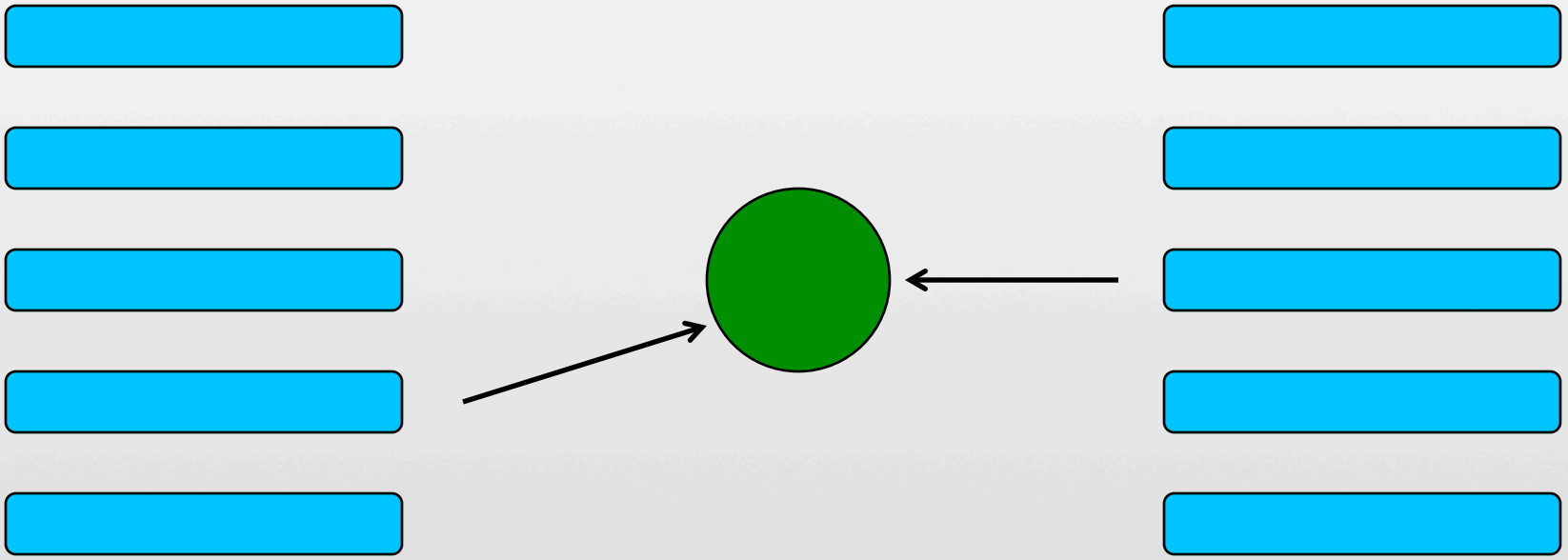
Concurrency Taxonomy

	Data space	CPU	Stack
Processes	separate	separate CPU, real or virtual	separate
Threads	shared	separate CPU, real or virtual	separate
Coroutines	shared	CPU explicitly traded	separate
Flags & gotos	shared	CPU explicitly traded	no (Here There Be Kludges)

Flags & gotos

- Simon Tatham's "Coroutines in C" article: http://www.chiark.greenend.org.uk/~sgtatham/coroutines.html
- Tom Duff on "Duff's Device": http://www.lysator.liu.se/c/duffs-device.html
- Tom Duff on "coroutine" trick: http://brainwagon.org/2005/03/05/coroutines-in-c/#comment-1878
- Protothreads: http://www.sics.se/~adam/pt/expansion.html
- Boost.ASIO example: http://www.boost.org/doc/libs/1_49_0_beta1/doc/html/boost_asio/example/http/server4/coroutine.hpp

Why not threads?



Why not threads?

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            c = getchar();
        } while (isalpha(c));
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    }
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    got_token(PUNCT);
}
```

Excerpted from the following page 2012-03-13:
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Use the right tool

Ian Baker
http://www.flickr.com/photos/raindrift/7095238893/

Via Tsuji
http://www.flickr.com/photos/via/3791253900/

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The Problem at Hand?

Syed Abdul Khaliq
http://www.flickr.com/photos/mixedmedia/2329086736/

Tony Case
http://www.flickr.com/photos/tonyjcase/3409091722/

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The Problem at Hand

HatM
http://www.flickr.com/photos/hatm/5704122117/

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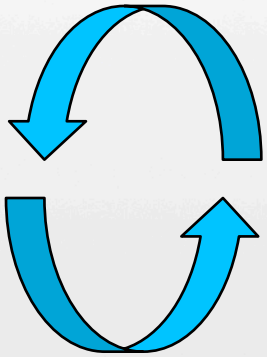
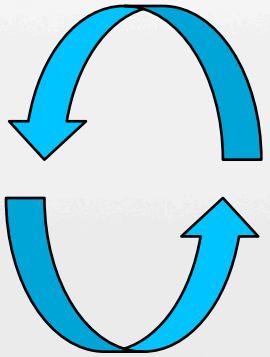
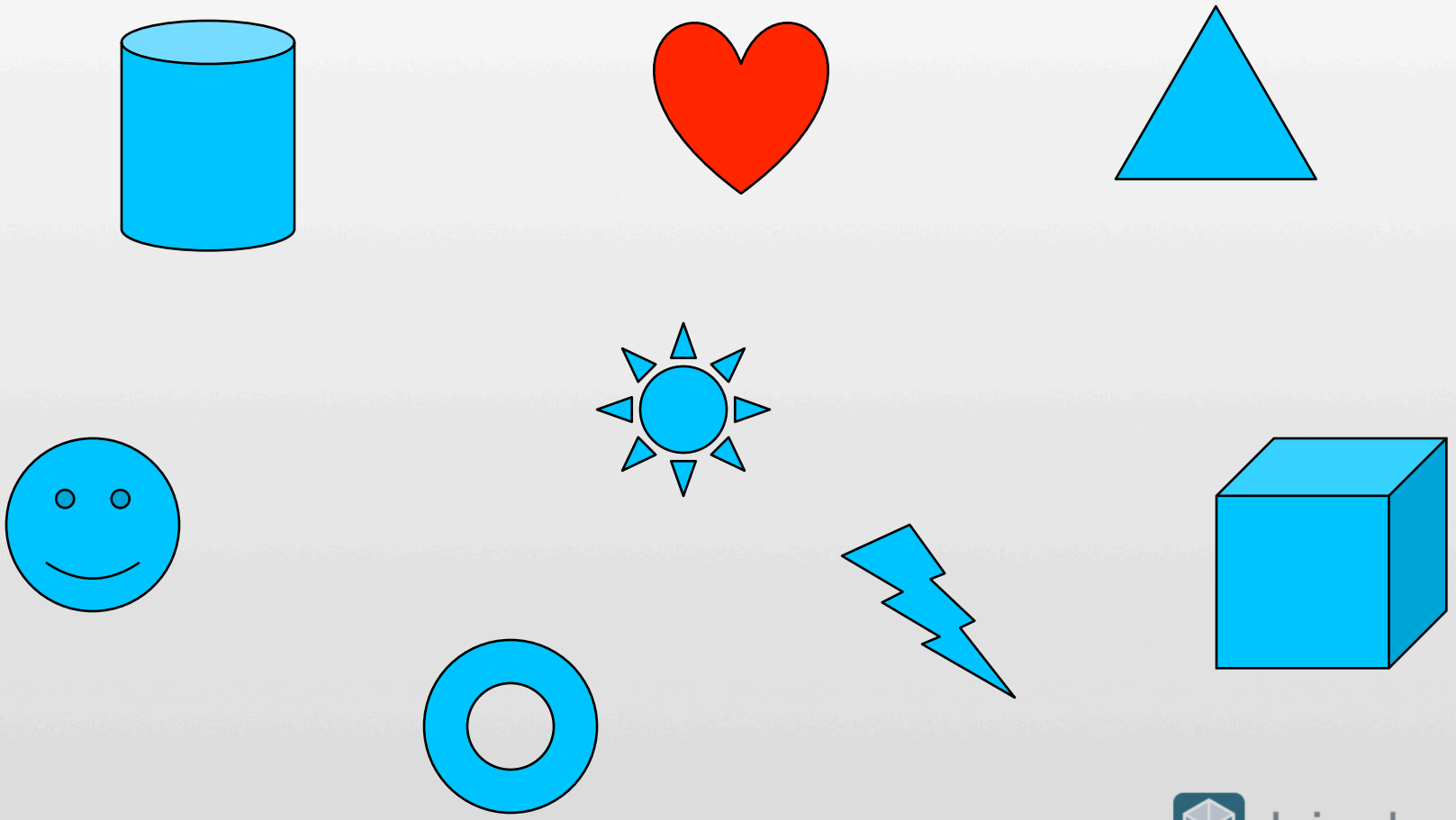
Interactive Code





Where to put it?



Your mission…

- Must not block for *anything*
- Must fetch lots of data from back-end servers
- Must perform long, complex sequences of high-latency requests

Global accesses

http://nishitak.files.wordpress.com/2010/11/gullivers-travels.jpg

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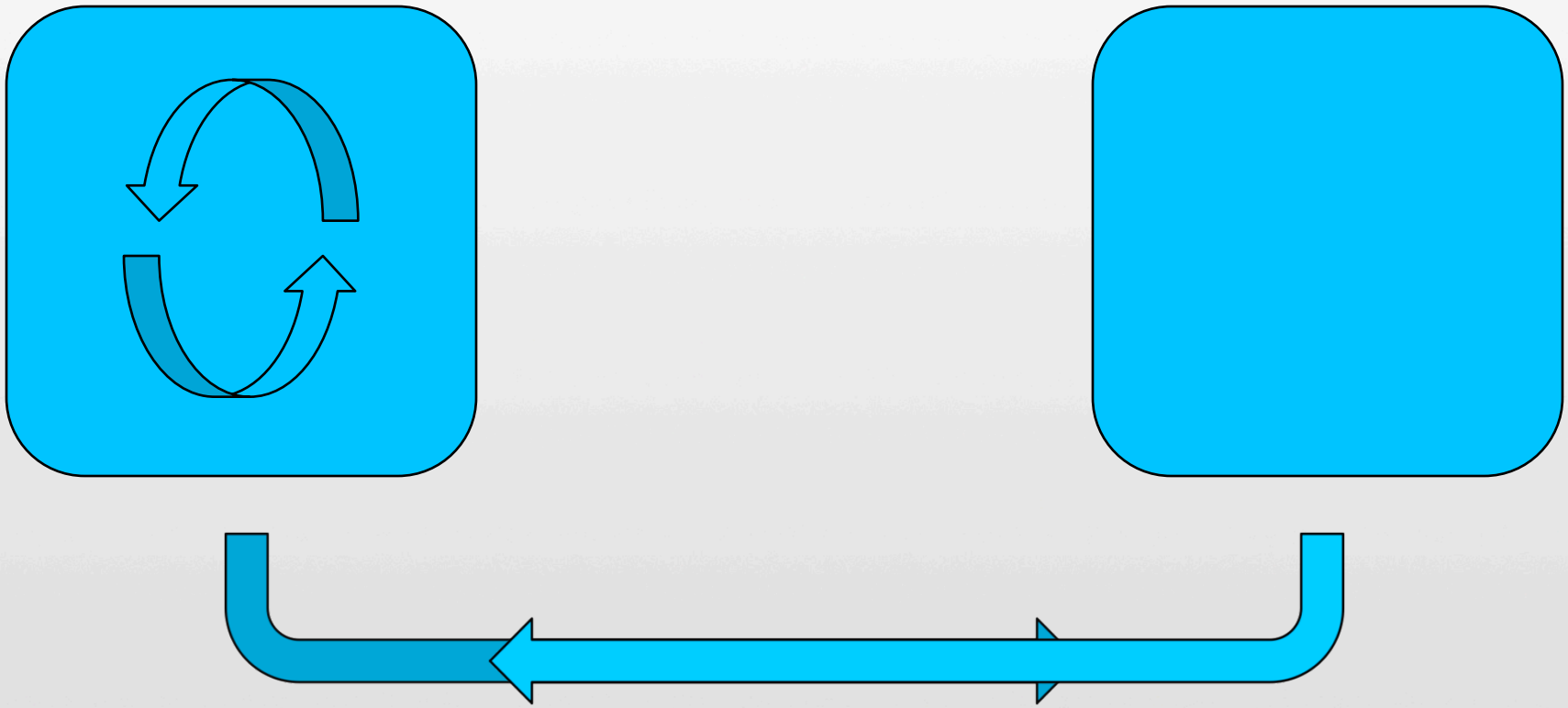
Managing Async



Managing Async: The Big Switch

Claude Robillard
http://www.flickr.com/photos/clauderobillard/6557118865/

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Managing Async: The Big Switch

http://hg.secondlife.com/viewer-release/src/acfb0781d850/indra/newview/llstartup.cpp#cl-361 **(handout pages 1-2)**

```
bool idle_startup()
{
    ...
    if ( STATE_FIRST == LLStartUp::getStartupState() )
    {
        ...
        // Go to the next startup state
        LLStartUp::setStartupState( STATE_BROWSER_INIT );
        return FALSE;
    }
    if (STATE_BROWSER_INIT == LLStartUp::getStartupState())
    {
        ...
        LLStartUp::setStartupState( STATE_LOGIN_SHOW );
        return FALSE;
    }
    ...
}
```

The Big Switch: maintenance

```
If (STATE_LOGIN_AUTH_INIT == LLStartUp::getStartupState())
{
    std::vector<std::string> uris;
    LLViewerLogin::getInstance()->getLoginURIs(uris);
    std::vector<std::string>::const_iterator iter, end;
    for (iter = uris.begin(), end = uris.end(); iter != end; ++iter)
    {
        std::vector<std::string> rewritten;
        rewritten = LLSRV::rewriteURI(*iter);
        sAuthUris.insert(sAuthUris.end(), rewritten.begin(), rewritten.end());
    }
    sAuthUriNum = 0;
    LLStartUp::setStartupState( STATE_LOGIN_AUTHENTICATE );
}
```

Managing Async: preprocessor

```
#define CORO_YIELD_IMPL(n) \
  for (_coro_value = (n);;) \
    if (_coro_value == 0) \
    { \
      case (n): ; \
      break; \
    } \
    else \
      switch (_coro_value ? 0 : 1) \
        for (;;) \
          case -1: if (_coro_value) \
            goto terminate_coroutine; \
          else for (;;) \
            case 1: if (_coro_value) \
              goto bail_out_of_coroutine; \
            else case 0:
```

http://www.boost.org/doc/libs/1_49_0_beta1/doc/html/boost_asio/example/http/server4/coroutine.hpp

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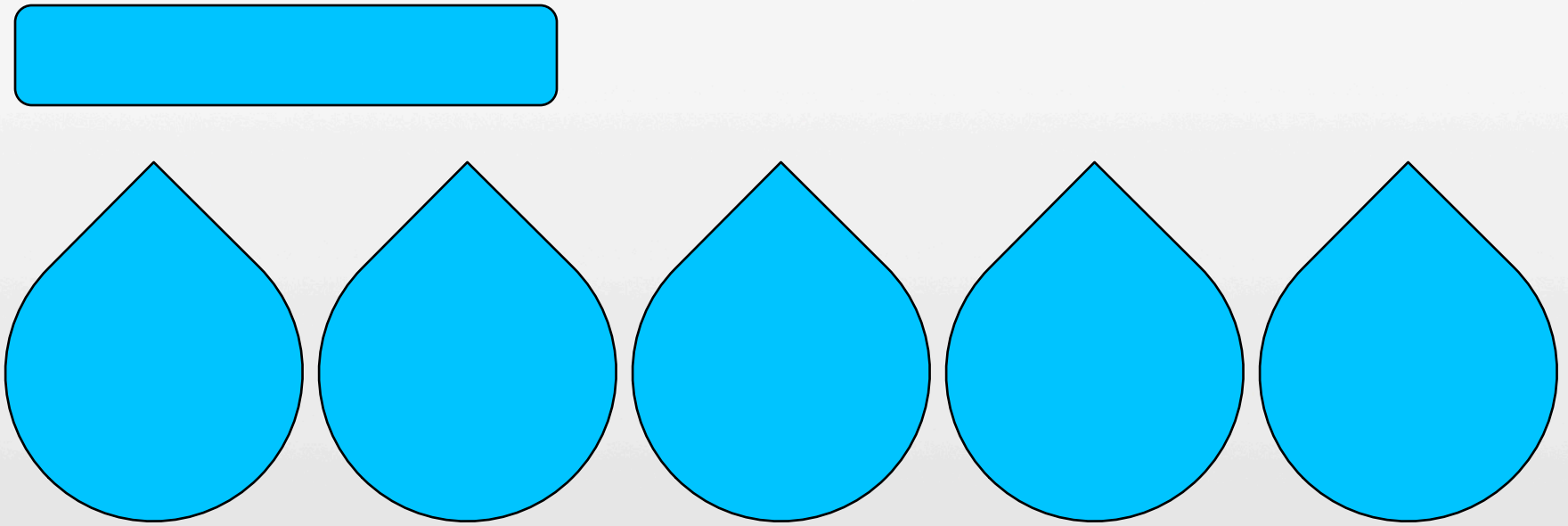
Managing Async: Responder Objects

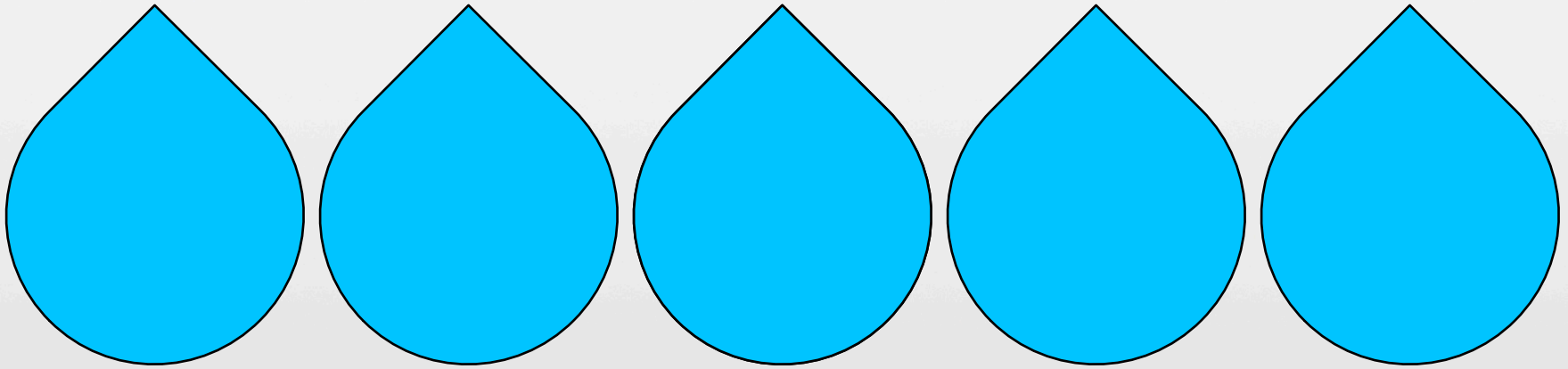
```
class Responder
{
public:
    Responder();
    virtual ~Responder();
    virtual void error(U32 status, const std::string& reason);
    virtual void result(const LLSD& content);
};
...
LLHTTPClient::post(url, capabilityNames,
                           BaseCapabilitiesComplete::build(getHandle(), id),
                           LLSD(), CAP_REQUEST_TIMEOUT);
```

http://hg.secondlife.com/viewer-release/src/3142ebd0bc5a/indra/llmessage/llcurl.h#cl-70
http://hg.secondlife.com/viewer-release/src/3142ebd0bc5a/indra/newview/llviewerregion.cpp#cl-202
http://hg.secondlife.com/viewer-release/src/3142ebd0bc5a/indra/newview/llviewerregion.cpp#cl-1563

Managing Async: Responder Objects



Managing Async: Responder Objects



Managing Async: Boost.Statechart

http://bitbucket.org/nat_linden/coroutines-talk-code/src/tip/lllogin.cpp (handout pages 3-9)

```
SC::result react( const EvAuthResponse& ev )
{
	…
	if(status == "CURLError” || status == "XMLRPCError” || status == "OtherError")
	{
		// Retry if there are any other rewritten uris for this attempt.
		if( ++mURIIndex < (size_t)outermost_context().getRewrittenURIs().size() )
		{
			makeRequest(uri_param);
		}
		else
		{
			post_event( EvAuthFailure() );
		}
	}
	else
	{
		post_event( EvAuthFailure() );
	}
}
```

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Use the right tool

Ian Baker
http://www.flickr.com/photos/raindrift/7095238893/

Via Tsuji
http://www.flickr.com/photos/via/3791253900/

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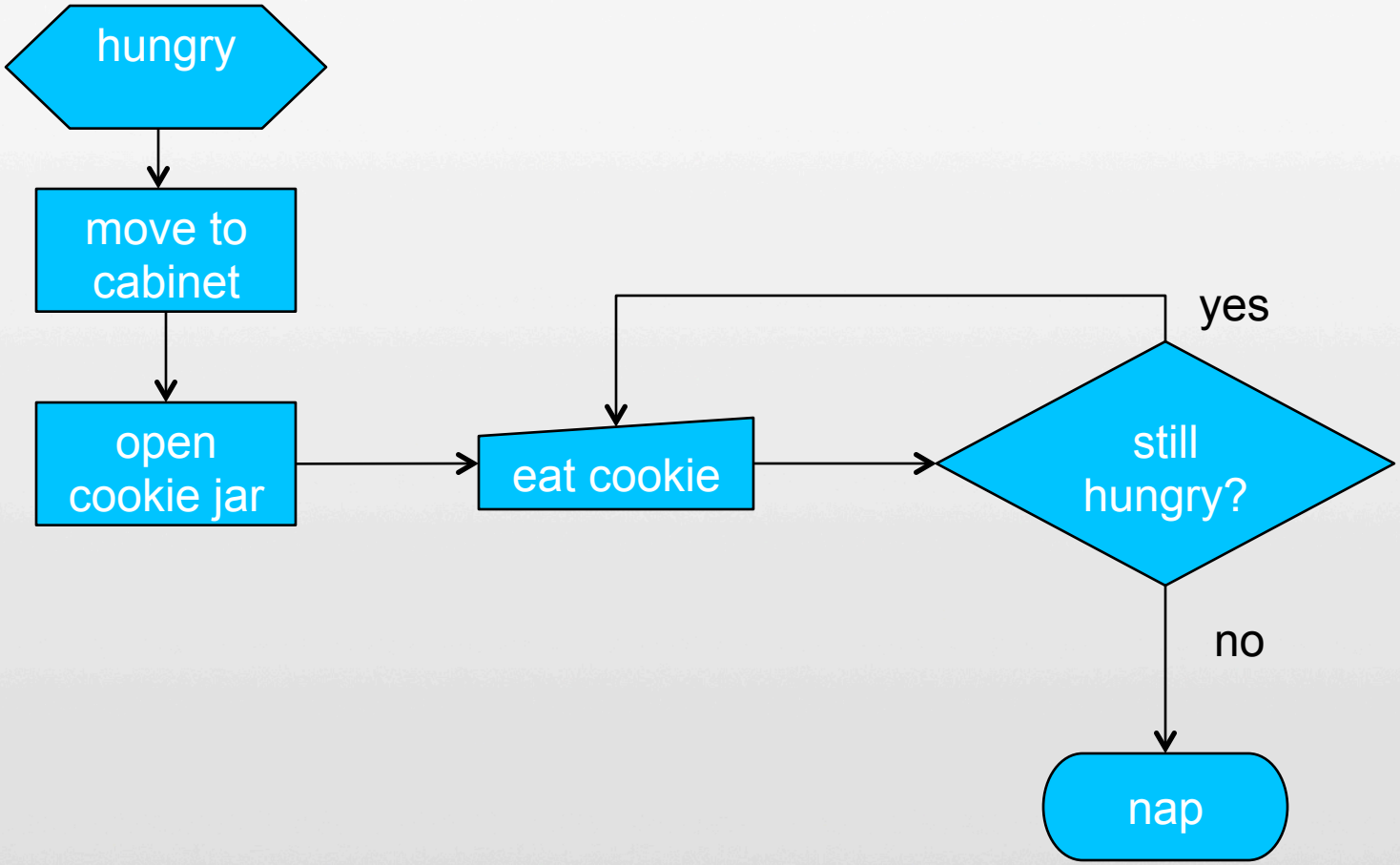
Flowchart



Sequential Code

```
#define WINK 60

void hungry()
{
    move_to_cabinet();
    open_cookie_jar();
    do
    {
        eat_cookie();
    } while (still_hungry());
    sleep(40*WINK);
}
```

Managing Async: Boost.ASIO

A non-static class member function adapted to a read handler using bind():

```
void my_class::read_handler(
    const boost::system::error_code& ec,
    std::size_t bytes_transferred)
{
    ...
}
...
socket.async_read(...,
    boost::bind(&my_class::read_handler, this,
        boost::asio::placeholders::error,
        boost::asio::placeholders::bytes_transferred));
```

http://www.boost.org/doc/libs/1_49_0/doc/html/boost_asio/reference/ReadHandler.html

Sequential Code

```
#define WINK 60

void hungry()
{
    move_to_cabinet();
    open_cookie_jar();
    do
    {
        eat_cookie();
    } while (still_hungry());
    sleep(40*WINK);
}
```

Managing Async: Boost.Coroutine

http://hg.secondlife.com/viewer-release/src/3142ebd0bc5a/indra/viewer_components/login/lllogin.cpp#cl-131
(handout pages 10-12)

```
// We expect zero or more "Downloading" status events, followed by
// exactly one event with some other status.
for (mAuthResponse = validateResponse(loginReplyPump.getName(),
        postAndWait(self, request, xmlrpcPump, loginReplyPump, "reply"));
    mAuthResponse["status"].asString() == "Downloading";
    mAuthResponse = validateResponse(loginReplyPump.getName(),
        waitForEventOn(self, loginReplyPump)))
{
    // Still Downloading -- send progress update.
    sendProgressEvent("offline", "downloading");
}
status = mAuthResponse["status"].asString();
```

Managing Async: Boost.Coroutine

```
rewritten = LLSRV::rewriteURI(*iter);
sAuthUris.insert(sAuthUris.end(), rewritten.begin(), rewritten.end());
```

```
// Make request
LLSD request;
request["op"] = "rewriteURI";
request["uri"] = uri;
request["reply"] = replyPump.getName();
rewrittenURIs = postAndWait(self, request, srv_pump_name, filter);
```

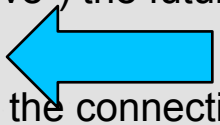
Managing Async: Boost.Coroutine

```
LLSD::Integer attempts = 0;
for (LLSD::array_const_iterator urit(rewrittenURIs.beginArray()),
         urend(rewrittenURIs.endArray());
     urit != urend; ++urit)
{
    ...
    for (;;)
    {
        ++attempts;
        ...
        for (…)
        {
            ...
        }
        ...
    } // loop back to try the redirected URI
    ...
} // Retry if there are any more rewrittenURIs.
```

Context Switch looks like Function Call

http://hg.secondlife.com/viewer-release/src/3142ebd0bc5a/indra/llcommon/lleventcoro.h#cl-204

```
template <typename SELF>
LLSD postAndWait(SELF& self, const LLSD& event,
                 const LLEventPumpOrPumpName& requestPump,
                 const LLEventPumpOrPumpName& replyPump, …)
{
    // declare the future
    boost::coroutines::future<LLSD> future(self);
    // make a callback that will assign a value to the future, and listen on
    // the specified LLEventPump with that callback
    LLTempBoundListener connection(replyPump.getPump().listen(listenerName,
                                   voidlistener(boost::coroutines::make_callback(future))));
    requestPump.getPump().post(modevent);
    // trying to dereference ("resolve") the future makes us wait for it
    LLSD value(*future);
    // returning should disconnect the connection
    return value;
}
```



Context switch

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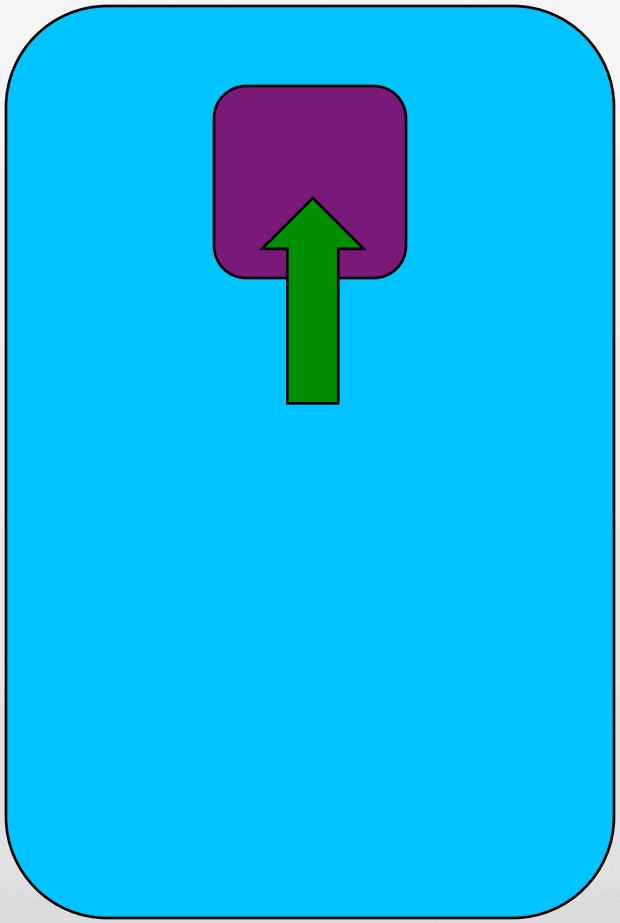
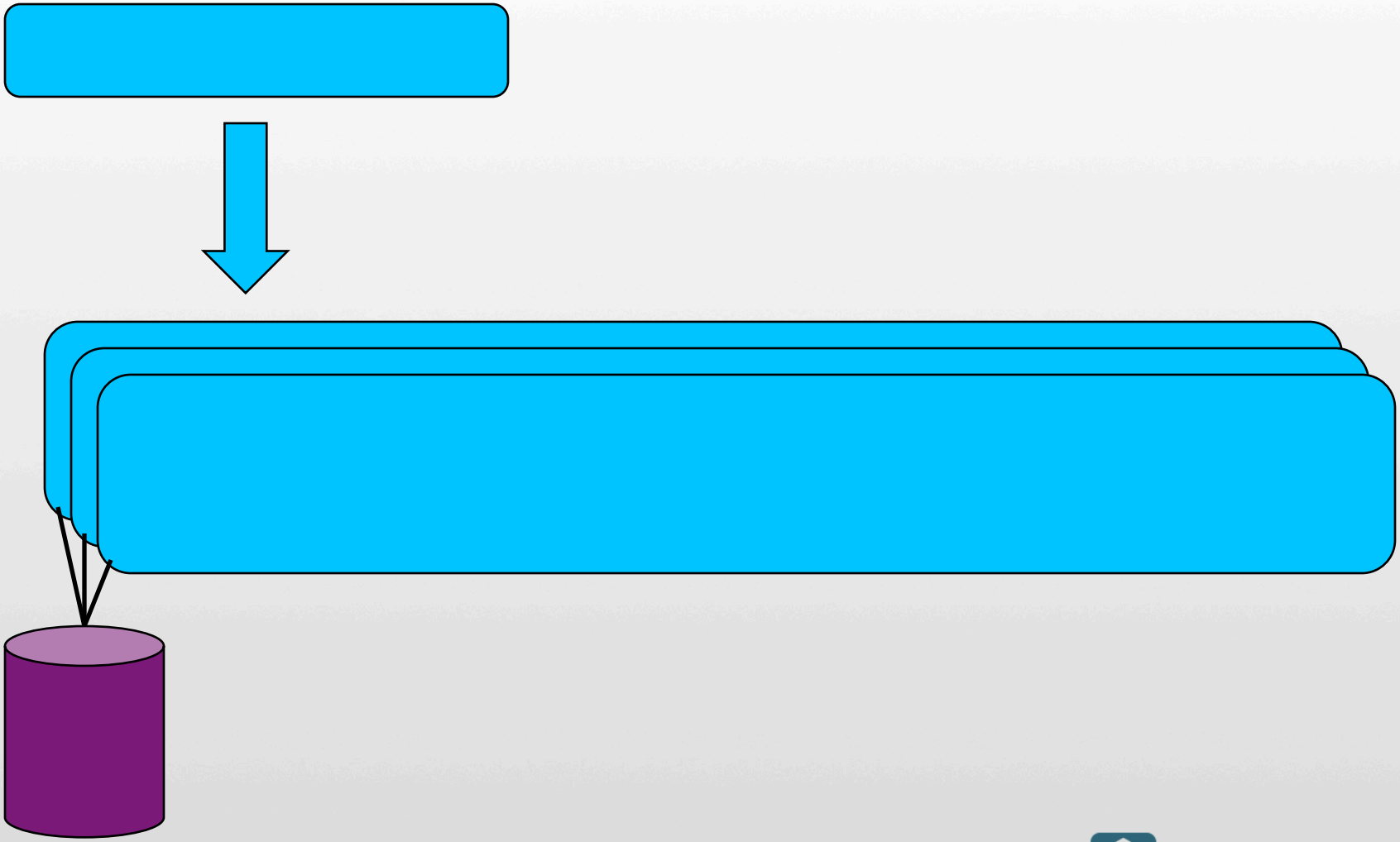
Managing Coroutine Object Lifespan



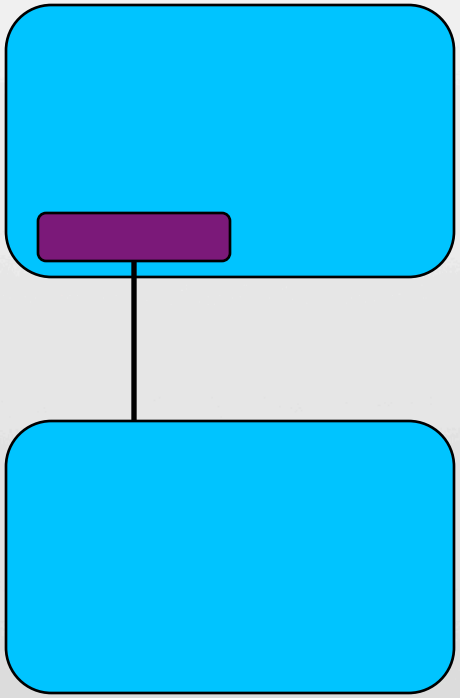
Managing Coroutine Object Lifespan



Parameter Gotcha

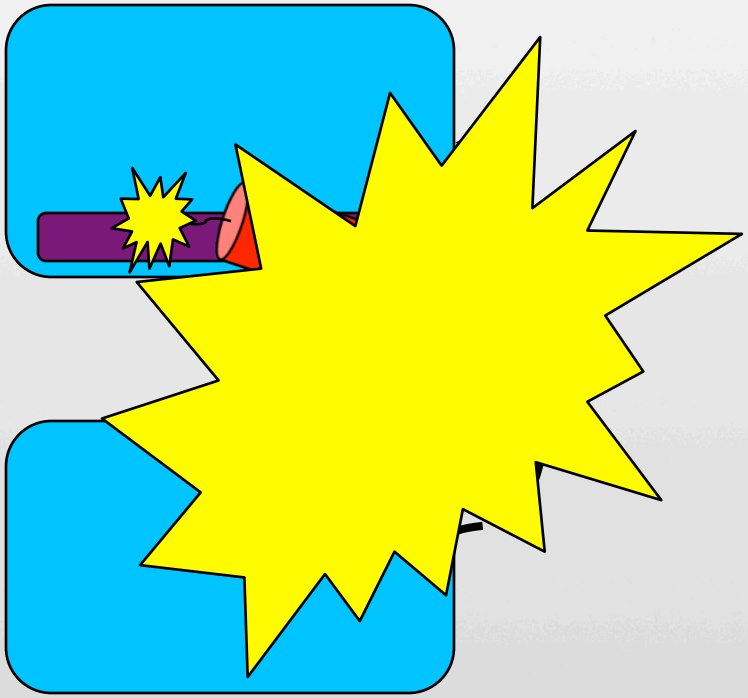
```
void myfunc(const std::string& data);

myfunc("lovely weather");
```



Parameter Gotcha

```
typedef boost::coroutines::coroutine<void()> coro;
void mycoro(coro::self& self, const std::string& data);
LLCoros::instance()::launch(
            boost::bind(mycoro, _1, “love and weather”));
```



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Parameter Gotcha

```
typedef boost::coroutines::coroutine<void()> coro;
void mycoro(coro::self& self, std::string data);
```

Playing with Stacks??

Recipe for disaster?

http://www.empireonline.com/features/50-greatest-animated-characters/default.asp?film=50

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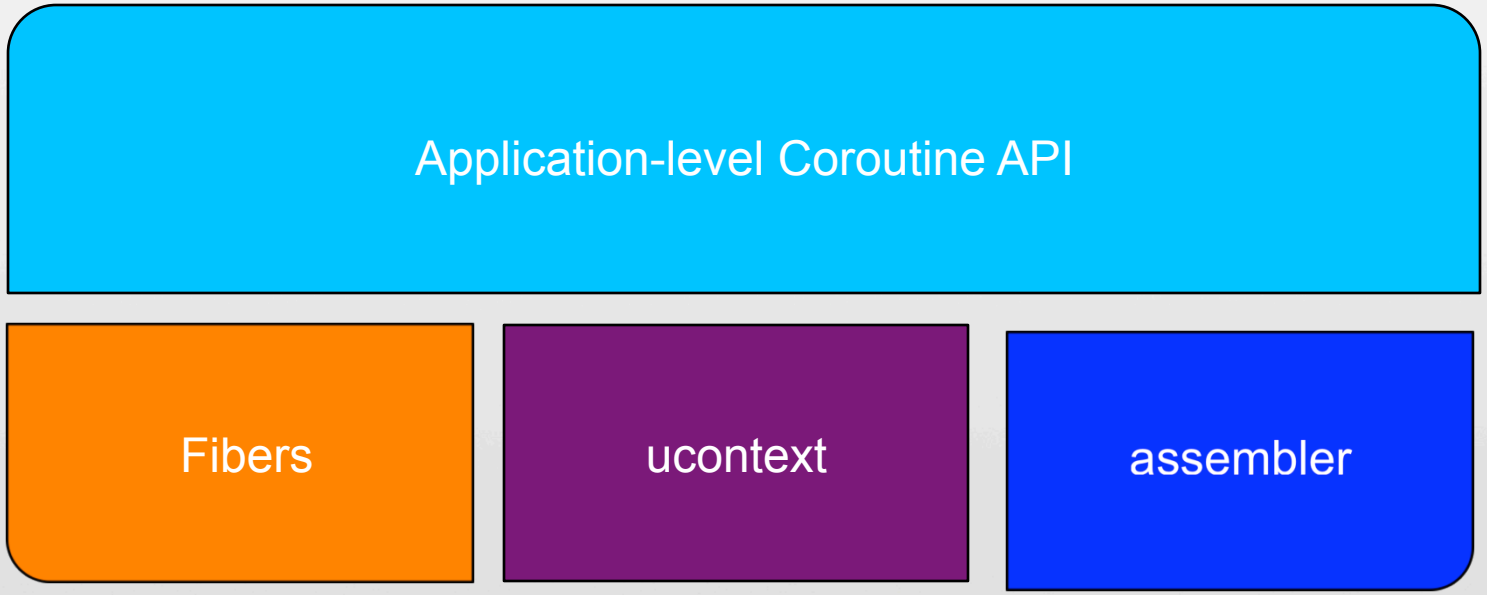
User-Space Context Switching

- **Gnu Pth:** http://www.gnu.org/software/pth/
- **Posix <ucontext.h>:** http://pubs.opengroup.org/onlinepubs/009695399/functions/makecontext.html
- **Windows Fibers:** http://msdn.microsoft.com/en-us/library/windows/desktop/ms682661%28v=vs.85%29.aspx

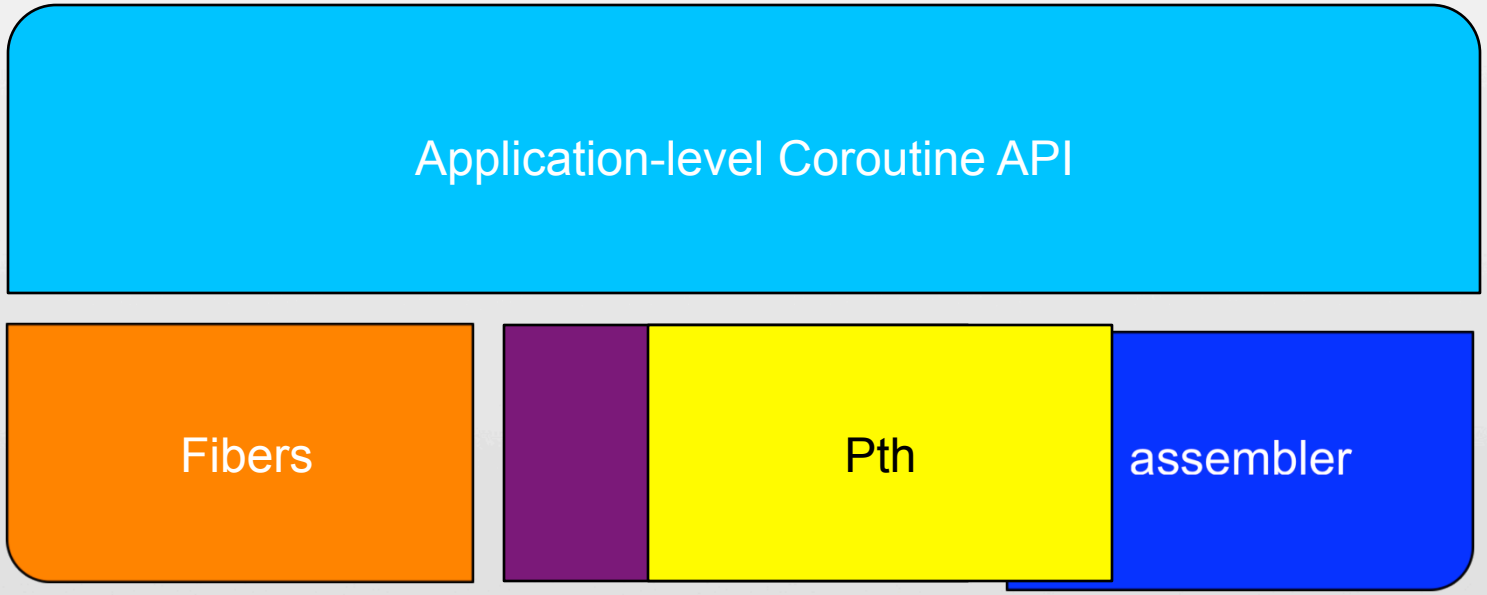
Boost.Coroutine

- **Boost.Coroutine:**
  http://www.crystalclearsoftware.com/soc/coroutine/
  https://github.com/boost-vault/Concurrent-Programming/blob/master/boost-coroutine-2009-12-01.tar.gz



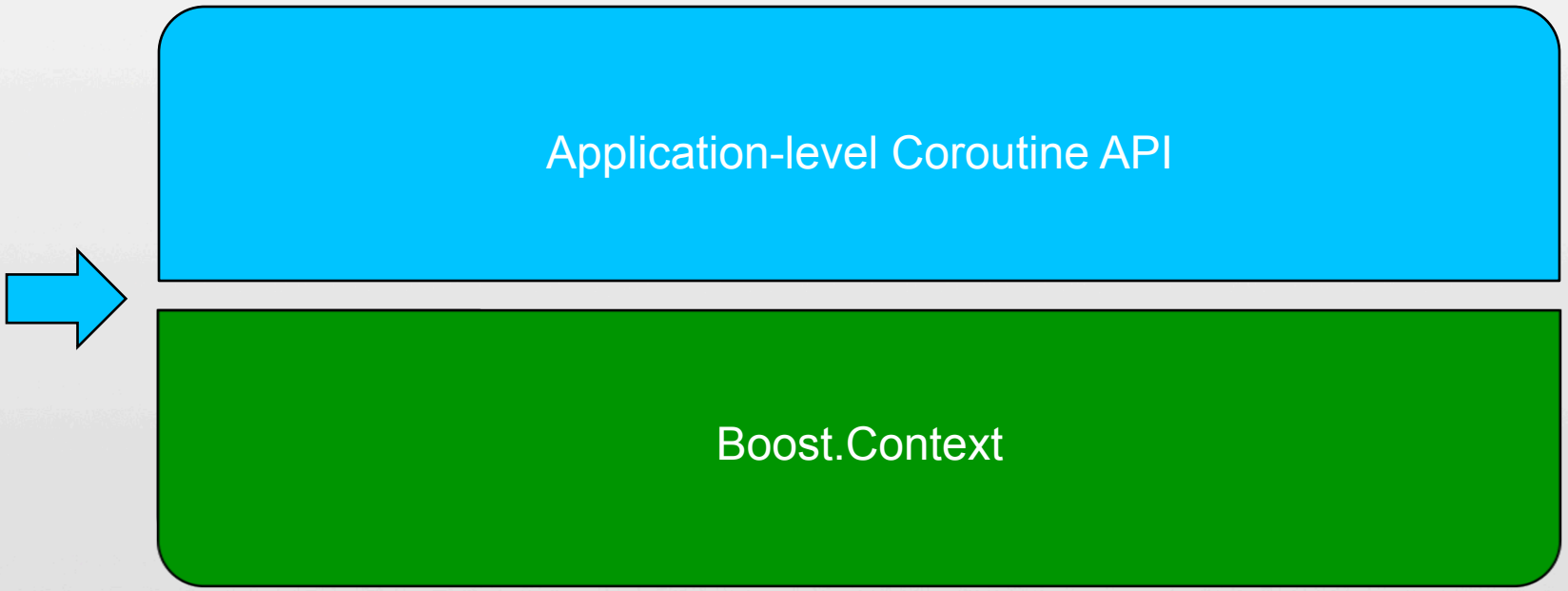
Boost.Coroutine Tweaks

- Bug Fix
- Coroutine Identity
- Pth implementation



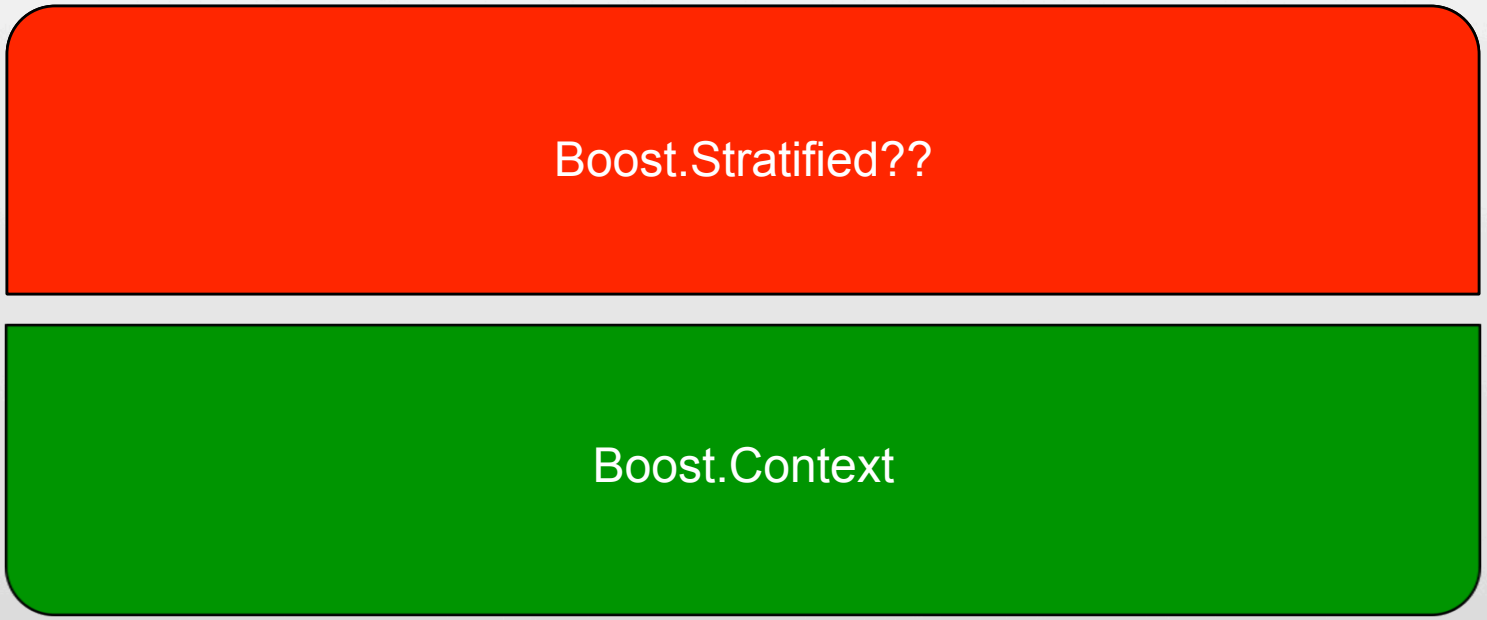
Boost.Coroutine and Boost.Context

- http://svn.boost.org/svn/boost/trunk/boost/context/



The Future of Futures

- http://gitorious.org/boost-dev/boost-dev/archive-tarball/coroutine
- git clone git://gitorious.org/boost-dev/boost-dev.git
- Stratified JavaScript: http://onilabs.com/stratifiedjs



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Questions

- **You know you want to ask...** ☺