lume

Lua Mutitasking Environment

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Motivation

Writing Lua applications...

- Used for fast prototyping of networked applications...
  - ...extended to control / sensor interaction
- Must be highly portable
- Running on embedded / low power hardware

Applications naturally grow up to need concurrence

- Performance: blocking on I/O is bad
- Some tasks are naturally concurrent: serializing them is a loss/loss

Concurrence

Preemptive

- Controlled by OS: Transparent for the applications
- Implemented at the hardware level
- Example: UNIX, *

Cooperative

- Controlled by apps: Explicit in the source code
- Implemented in user space
- Example: RISC OS, Windows 3.1

Concurrence

Message Passing

- “Processes”
- Examples: UNIX pipes, web services
- API model:
  serialization (e.g. JSON) +
  messaging (e.g. Sockets)
- Pros: robust, easily distributable
- Cons: serialization&messaging overhead, hard to design

Shared State

- “Threads”
- Examples: pthreads, [*obligatorios del curso de redes*]
- API model:
  access control (e.g. semaphors)
- Pros: no data copying
- Cons: high contact surface, error prone, hard to track bugs (when preemptive)

Sierra Wireless luasched

Scheduling

- Create or kill a task: `t=sched.run(function()…end)`, `sched.kill(t)`
- Send a signal: `sched.signal(emitter, event, [args…])`
  - Used for low level I/O
  - For inter-tasks synchronization
  - For extensibility
- Wait for a signal: `sched.wait(emitter, [timeout], events…)`
- React to signals: `sched.sighook()`, `sched.sigrun()`, `sched.sigrunonce()`

Written in pure Lua, with current state accessible as proc.tasks (never needed to convert to C).

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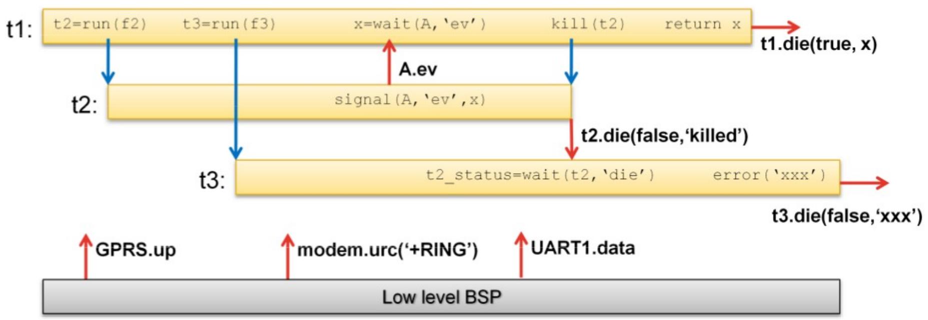
Scheduling



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SIERRA WIRELESS

http://www.lua.org/wshop11/m2m-embedded-development-with-lua.pdf

Luasched vs Lumen

- Sierra Wireless
- Enterprise grade M2M development and tooling
- Modified Lua + modified luasocket
- Tooling modules in C (shell, LTN12)

- jvisca@fing.edu.uy
- “API changes and other random breakages occur”
- Plain lua + luasocket & nixio backends
- All tooling in pure Lua+lumen sched.

Lumen scheduler

- Inspired in Sierra Wireless luasched.
- Cooperative
- Message passing and shared memory supported
    - Messaging trough signals and pipes/streams
    - Access control trough critical section marking
- Pure Lua, no external dependencies: runs on Lua 5.1, 5.2, 5.3 LuaJIT
- Implemented using coroutines
- Runs in a single VM instance (state), available as a Lua module
  ```
  local sched = require 'sched'
  ```
- MIT licence

Lumen vs Others

- Pros
  - Lightweight
  - Pure Lua: Hardware & OS-independent
  - Simple usage model
  - Well suited for I/O bound logic
  - Tools available: logging, remote shell, webserver...
- Cons
  - Single Lua state – single core.
    (Multiple States can interchange messages, tough)
  - Slow context switching (compared to preemptive), not well suited to CPU-bound logic

Lumen scheduler

```lua
local sched=require 'sched'

-- task emits signals
sched.run(function()
    for i = 1, 10 do
        sched.signal('an_event', i)
        sched.sleep(1)
    end
end)

-- task receives signals
sched.run(function()
    local waitd = {'an_event'}
    while true do
        local ev, data = sched.wait(waitd)
        print (data)
    end
end)

sched.go()
```

Lumen tasks

- Create and run a task

```lua
local f = function(...)
   -- blabla
end
local taskd = sched.run( f, ... )
```

- Create a task, run later

```lua
local taskd = sched.new_task( f )
taskd:run(...) --start
```

- Current task

```lua
local my_taskd = sched.running_task
```

Tasks control

- Pause tasks

```
taskd:set_pause(true)  --pause
taskd:set_pause(false) --unpause
```

- Yielding and waiting

```
taskd:wait()
taskd:sleep(1.5)
```

- Finishing a task == finishing the function

```
local f = function(...)
   error ...  --here
   return ... --here
end --here
```

- Killing a task

```
taskd:kill()
```

Lumen signals - emitting

- Tasks emit signals
- A signals is a *event*, plus *parameters*
  - The event can be of any type
  - Parameters in any number, of any type
- Tasks should emit signals for everything that could be interesting to other tasks
- Examples:

```
sched.signal( 'new client', skt )
local EVENT_DIE = {}
sched.signal(EVENT_DIE, true, 10, 10)
sched.signal(EVENT_DIE, false, 'div by 0')
```

Lumen signals - receiving

- Tasks can wait for signals. Waiting for a signal is the main method for synchronization.
- Wait descriptors define a list of event(s) (can be '*')
- The wait call returns the signal's parameters
- Examples:

```
local waitd = {
    EVENT_DIE,
    EVENT_FINISH,
    timeout = 10 --optional
}
local event, p1, p2, p3 = sched.wait(waitd)
```

Lumen signals - receiving

- There are some useful shortcuts for handling signals in a event-like manner

```
sched.sigrun(waitd, f)
sched.new_sigrun_task(waitd, f)
sched.sigrunonce(waitd, f)
sched.new_sigrunonce_task(waitd, f)
```

- They are implemented in plain wait calls

```
sched.new_sigrun_task = function ( waitd, f )
   return M.new_task (function()
      while true do
         f(M.wait(waitd))
      end
   end)
end
```

Lumen signals - buffering

- Signals are like UDP: if nobody is waiting for them, they get lost.

```
while true do
    sched.wait(waitd1)
    --do something
    sched.wait(waitd2) --events for waitd1 can get missed
    --do something
end
```

- Sometimes this is the right thing. When not:

```
local waitd = sched.new_waitd({
    '*',
    buff_mode='drop_last', --or 'drop_first'
})
```

- Still, this is not enough sometimes (faster emitter than receiver).

Signal alternatives: pipes & streams

Signals never block the emitter. Not useful on a producer – consumer scheme.

Pipes

```lua
local pipes=require 'pipes'
local p=pipes.new(10)

--one task
p:write(a, b)

--other task
local ok,a,b=p:read()
```

Streams

```lua
local stream=require 'stream'
local s=stream.new(1000)

--one task
s:write('####')

--other task
local text=s:read()
```

- Implemented using plain signals
- Pipes and streams allow timeouts

Resource sharing and access

- A catalog allows to publish objects under a well known name, and wait for them to appear.

```
local catalogs = require 'catalog'
local tasks = catalogs.get_catalog('tasks')

--in one task
tasks:register('consumer', taskd)

--in another task
local consumer = tasks:waitfor('consumer', 60)
```

- Some ideas for catalogs are 'events', 'pipes', 'devices'

Mutexes

Needed only seldom, because scheduling is non-preemptive: only needed if task yields control explicitly inside critical section.

```
local mutex = require 'mutex'

local n = 0

local critical = function ()
    print( 'before', n )
    n = n + 1
    sched.wait()
    n = n - 1
    print( 'after', n )
end

local mx = mutex.new()
local synched = mx:synchronized(critical)
```

Other method:

```
local function critical()
  mx:acquire()
  -- do stuff
  mx:release()
end
```

I/O: selector module

- Basic POSIX support
  - Sockets (TCP&UDP)
  - Files
  - Piping-in output from programs
- Data can be obtained in several ways, depending on its nature
  - Signals on data arrival
  - Callback to a provided function on data arrival
  - Stream
- Sending can be synchronous or asynchronous.
- Nixio and luasocket as backends

```
local selector = require 'tasks/selector'
selector.init({service='nixio'})
```

I/O: selector module

- Send a UDP Packet

```
local udpsend = selector.new_udp("127.0.0.1", 8888)
udpsend:send('data!')
```

- Start a TCP Server, a handler read lines

```
local tcp_server = selector.new_tcp_server("127.0.0.1", 8888, 'line',,
function(sktd, data, err)
    print ('arrived:', sktd, data)
    return true
end)
```

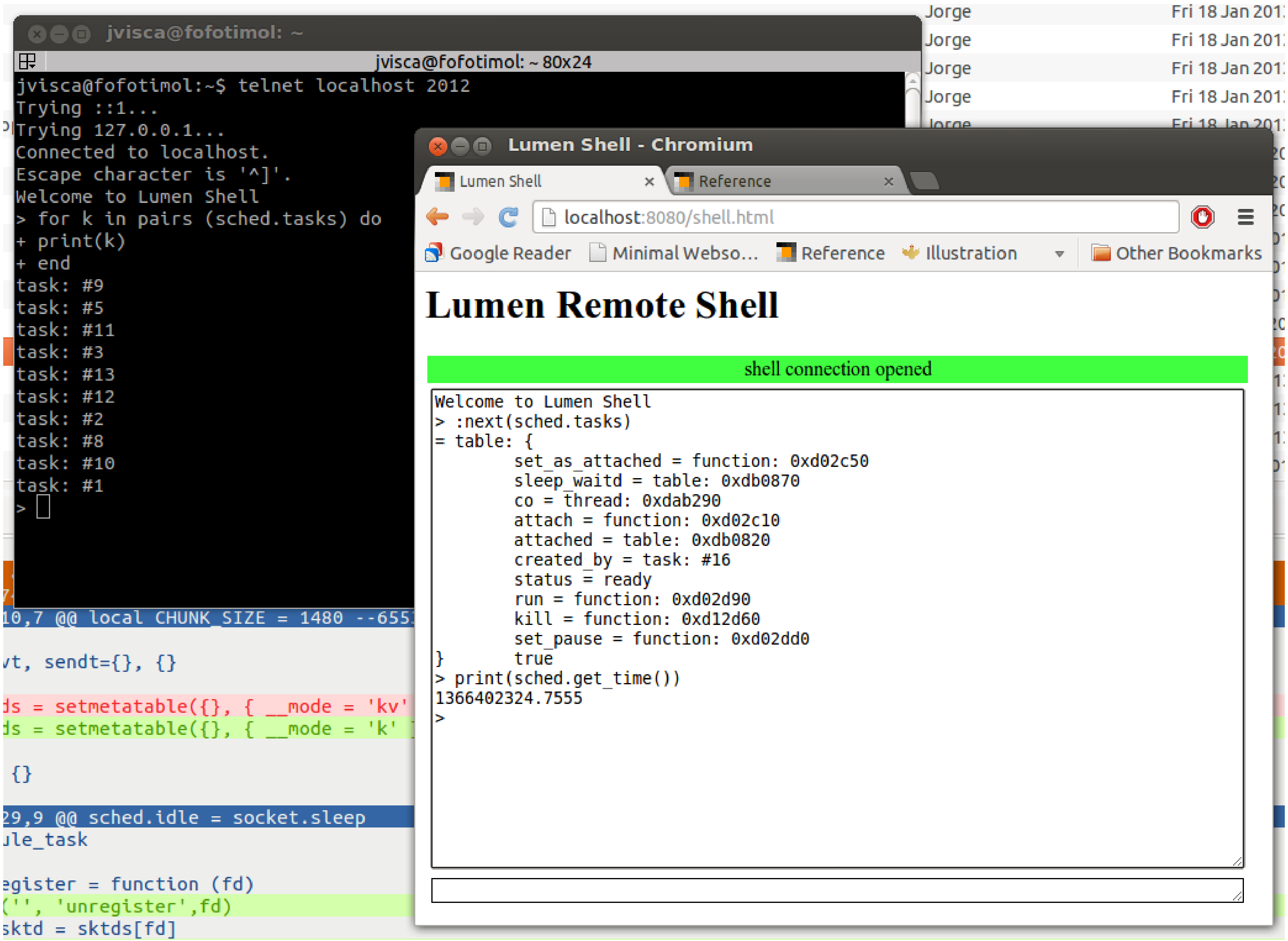
- Receive UDP trough signals

```
local udprecv = selector.new_udp(nil, nil, "127.0.0.1", 8888)
sched.sigrun(
    {udprecv.events.data, timeout=60},
    function(_, _, ...) print("arrived:", ...) end
)
```

- Read from file trough a stream

```
local fs = stream.new(buffer_size)
local fd, err = selector.new_fd ('/dev/tty0', {"rdonly"}, nil, fs)
while true do print( fs:read() ) end
```

Tooling



jvisca@fofotimol: ~
jvisca@fofotimol: ~ 80x24
jvisca@fofotimol:~$ telnet localhost 2012
Trying ::1...
Trying 127.0.0.1...
Connected to localhost.
Escape character is '^]'.
Welcome to Lumen Shell
> for k in pairs (sched.tasks) do
+ print(k)
+ end
task: #9
task: #5
task: #11
task: #3
task: #13
task: #12
task: #2
task: #8
task: #10
task: #1
>
Lumen Shell - Chromium
Lumen Shell
Reference
localhost:8080/shell.html
Google Reader
Minimal Webso...
Reference
Illustration
Other Bookmarks
Lumen Remote Shell
shell connection opened
Welcome to Lumen Shell
> :next(sched.tasks)
= table: {
set_as_attached = function: 0xd02c50
sleep_waitd = table: 0xdb0870
co = thread: 0xdab290
attach = function: 0xd02c10
attached = table: 0xdb0820
created_by = task: #16
status = ready
run = function: 0xd02d90
kill = function: 0xd12d60
set_pause = function: 0xd02dd0
}   true
> print(sched.get_time())
1366402324.7555
>
Jorge
Fri 18 Jan 201

References

- Lumen sources:
  https://github.com/xopxe/Lumen
- Lumen API:
  http://xopxe.github.com/Lumen/

End