Lua – The Next Generation

Moonshine

As a scripting language, Lua is fairly unique. It has a strong following from two niche markets: Linux users, and computer game programmers. What is it about this language that appeals? What is so special? Steven Goodwin investigates.

BY STEVEN GOODWIN

From a linguistics point of view, Lua could be considered fairly ordinary! It has all the necessary features to make it a usable language, but lacks any strong selling points in the vein of Perl's regular expressions, or C's speed of execution. Its strengths do not lie with individual parts of the language, but how it functions as a whole, and how well it connects with the outside world.

We shall be looking at Lua as a customization and configuration tool, showing how the end user can customize particular software (using *elinks* as an example), and what steps must be taken in order to implement such functionality in their own applications.

The Whole Of The Moon

Lua began in 1993 as a language for Brazilian academics at Tecgraf, in the Pontifical Catholic University of Rio de Janeiro (PUC-Rio). Its purpose was to provide a simple method of extending applications through a basic procedural language, traditional datatypes, and a virtual machine. All these features have remained a fundamental part of *Lua* to the present day, with the release of version 5.0.2 (for minor bug fixes) on March 17, 2004. Its uptake has been as steady (some would say slow) as its update cycle; just 12 public releases in its entire 11 year history. However, as a compensation, there is little chance of code breaking overnight, and every release so far has been incredibly stable.

The basic structure of Lua (pronounced LOO-ah, and whose name means *moon* in Portuguese) is that of a language interpreter (the program, *lua*) which generates and runs byte code, a set of optional basic libraries (for input and output, maths, and so on, all written in standard C), and a compiler (*luac*) to generate byte code offline. Because of the highly standard nature of the Lua code base, it works on almost any platform that sports a C compiler. The Linux version clocks in at just over 100K, with the combined set of default libraries taking a further 72K. Many embedded projects have taken advantage of its small size (and its ability to build anywhere), as have several games companies, such as Criterion Studios, LucasArts (Grim Fandango), and BioWare (with MDK2 and Baldur's Gate). For a longer list of uses visit [1].

Harvest Moon

As a language, it has all the features you'd expect from a functional scripting language, including the obligatory online manual, available at [2]. First off, we have the data types. These may not be plentiful (see Table 1: Lua Types), but they are capable of satisfying a programmers usual desires. The variables themselves follow the ideals of a loosely-typed language, and so can hold any type it pleases, at any particular time. Attempting to use undefined variables causes them to have the type *nil*, which can cause some operations (for example, string concatenation) to fail. The Lua concept of a 'number' is equivalent to the C type *double*. However, performance junkies (using version 5) can change this to *float* (or even *int*) and recompile *Lua*. Just add

```
#define LUA_NUMBER  float
```

before *#include*ing *lua.h*. Anyone using version 4, or earlier, will need to manually modify the code a little further.

There is also a range of flow control statements, that fit the following:

- *do* block *end*
- *while* exp *do* block *end*
- *repeat* block *until* exp
- *if* exp *then* block *end*
- *if* exp *then* block *else* otherblock *end*
- *if* exp *then* block *elseif* exp *then* otherblock *end* [and so on…]
- *for* var = start,end[,step] *do* block *end*
- *for* var *in* iterator *do* block *end*

Table 1: Lua Types

Type	Identifier	Name for lua_*istype* etc
Nil	LUA_TNIL	nil
Number	LUA_TNUMBER	number
Bool	LUA_TBOOLEAN	boolean
String	LUA_TSTRING	string
Table	LUA_TTABLE	table
Function	LUA_TFUNCTION	cfunction
Userdata	LUA_TUSERDATA	userdata

Notes

The identifier can be used to translate the constant into a string inside C, using *lua_typename(lua_State *L, int type)*

lua_isnumber accepts both numbers (123) and numerical strings ("123")

lua_toboolean returns 0 for *false* and *nil*, and 1 for everything else

Listing 1: hello.lua

```
A comment, about a wry comment,
commenting about programmer
originality!
function hello()
write("Hello, Lua!")
end
hello()
```

Nothing unusual there, although C programmers should be aware that the ‘end’ value is also evaluated in the *for* loop. Note that all statements use the word *end* as a block terminator, instead of the more traditional brace. This simplicity is a very obvious attempt to coax non-programmers into the world of scripting. The preference of words over symbols is also apparent when you realize the operators !, && and || have been replaced with their alphabetic counterparts, *not*, *and*, and *or*.

The syntax also removes some of the restrictions found in other languages. For example, two (or more) parameters can be returned from functions, without any problem or esoteric magic.

```
function onetwo()
return 1,2
end
one,two = onetwo()
```

Finally, Lua contains local and anonymous functions. Taking these in order, a local function is one that can only be called from within the function it is declared in. This is uncommon to C programmers, but fairly familiar to everybody else. Secondly, anonymous functions mean we can embed an entire function in the place we would place a callback. This prevents additional, arbitrary, functions within the code.

For more detailed information on the syntax, you’d do well to read the original version available at [2]. For an interactive experience, the message boards at [3] are available.

However, Lua’s features as a language are not what sells it to developers. It is more its use as a configuration tool that is considered its killer app. It is so easy for an application developer to add Lua scripting support that one wonders why it’s not more prevalent. It can be used to create plug-in modules for software, or as a configuration file. This need not be a static configuration, like most other applications. You can create something much more powerful and flexible. Something dynamic!

Dynamic configurations have been something of a rarity. Only the more complex applications, such as Apache, have them. Even then, directives such as *IfModule* are fairly minimal, and have limited scope. A truly dynamic configuration can ease the install process by preparing itself when the program is run, and adapt itself according the directory structure, number of users, current bandwidth, processor load, and so on.

Lua also provides a method to add hooks into software for customization. We shall look at this, adding some simple hooks into the text-browser *elinks*.

Dancing in the Moonlight

Hooks are a method whereby a program (in this case, *elinks*) calls a special function every time it is about to do something important. This ‘something important’ might be when jumping to a URL, or downloading a page of HTML from the server. Under normal, non-hooked, circumstances, this special function will do nothing! Nada. Zip. It will simply return control back to the main program and let it jump to the URL it was going to jump to in the first place.

However, when a hook is placed into this special function, control is passed out of the main program into the hook function. At this point, the hook function has control of the data and can re-write the URL, for instance. As these hooks are programmed from a Lua program – *our* Lua program – we can re-write them according to our personal preferences.

For example, I may wish to visit one of my own web sites, *www.BlueDust.com*, by typing *bd*. I could do this by creating a simple hook into the ‘jump to URL’ routine with:

```
if (url == “bd“) then
return “www.bluedust.com“
end
```

Lo and behold, instant configuration!

The demonstration program for this article, *elinks*, has a number of different hooks, and these are given in Table 2: Hooks and Crannies. We can use some of these to customize the application.

As well as *elinks* calling our script, it is possible for our script to call *elinks* through callbacks. This lets us retrieve information, such as the title page, that isn’t passed through as a parameter. This is useful with key shortcuts as what parameters should be passed in to them? URLs? Bookmark lists? This is where the callback functions come into play.

These callbacks are specific functions that *elinks* has decided that we (as a script) may use. It allows us to call them as if they were part of the Lua script itself. They include functions such as *current_url* and *current_title*. A list is

Listing 2: *goto_url_hook*

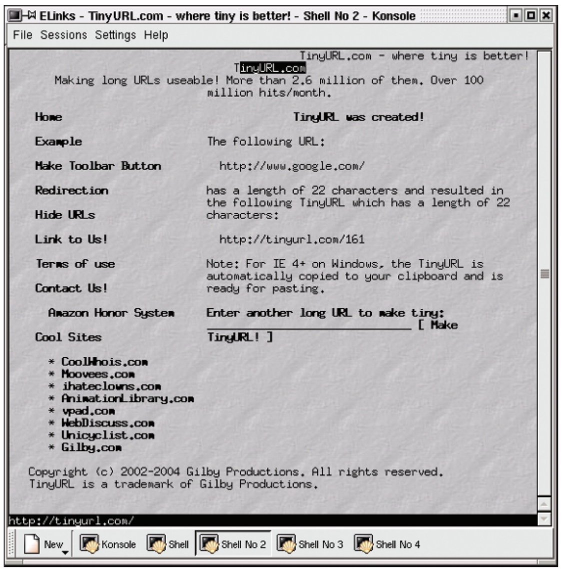
```
function goto_url_hook (url,
current_url)
if url == “tiny“ then
  return
“http://tinyurl.com/create.php?ur
l=“..current_url
end
return url
end
```

Listing 3: *bind_key* function

```
bind_key (“main“, “Ctrl-T“,
  function ()
    return “goto_url“,
“http://tinyurl.com/create.php?ur
l=“..current_url()
  end
  )
```

Table 2: Hooks and Crannies

Hook function	Called when...	Should return...	Notes
goto_url_hook(url,current_url)	A URL is entered in the “Go to URL” dialog	A new URL, or nil to cancel	
follow_url_hook(url)	A URL has been selected	A new URL, or nil to cancel	
pre_format_html_hook(url,html)	Document has been downloaded	Modified string, or nil if no changes were made	Can remove adverts/junk from badly designed web pages
lua_console_hook(string)	Something is entered into the Lua console (type , in *elinks*)	A command (run, eval, goto-url, or nil) followed by an appropriate argument (the program to run, Lua code to evaluate, a URL to go to, or nil, respectively)	
quit_hook()	*elinks* is about to exit	Nothing	For tidying up resources


ELinks - TinyURL.com - where tiny is better! - Shell No 2 - Konsole
File Sessions Settings Help
New
Konsole
Shell
Shell No 2
Shell No 3
Shell No 4

```
                              TinyURL.com - where tiny is better!
                        TinyURL.com
   Making long URLs useable! More than 2.6 million of them. Over 100
                        million hits/month.

 Home                              TinyURL was created!

 Example                  The following URL:

 Make Toolbar Button        http://www.google.com/

 Redirection              has a length of 22 characters and resulted in
                          the following TinyURL which has a length of 22
 Hide URLs                characters:

 Link to Us!                http://tinyurl.com/161

 Terms of use             Note: For IE 4+ on Windows, the TinyURL is
                          automatically copied to your clipboard and is
 Contact Us!              ready for pasting.

   Amazon Honor System    Enter another long URL to make tiny:
                          _________________________________ [ Make
 Cool Sites               TinyURL! ]

   * CoolWhois.com
   * Moovees.com
   * ihateclowns.com
   * AnimationLibrary.com
   * vpad.com
   * WebDiscuss.com
   * Unicyclist.com
   * Gilby.com

 Copyright (c) 2002-2004 Gilby Productions. All rights reserved.
 TinyURL is a trademark of Gilby Productions.
http://tinyurl.com/
```

Figure 1: The result of our hook function.

given in Table 3: Odds and Sods. We shall now employ both ideas to create a simple hook for *elinks* that creates a tiny url for the current page.

Moondance

Our first task (to save headaches later) is to make sure *elinks* has actually been compiled with Lua scripting support. You can check this by opening the *About* box by pressing *Alt+H* (to open the help menu), followed by the letter *A*. Here should be the words,

```
Scripting (Lua)
```

This is included by default with most distros (and downloadable from [4]), if not, it can be rectified by a simple,

```
$./configure —with-lua
$ make
# make install
```

This will also create a sample *hooks.lua* file in the *elinks/contrib/lua* directory.

We then need to create a script for *elinks* to run when it starts. This is placed in *~/.elinks/hooks.lua* and is run in its entirety at startup. So provided all our code is contained within *functions*, nothing should appear to happen on screen.

The first of our functions will include the code for *goto_url_hook*. As previously mentioned, this gets called whenever the user hits ‘g’ to change web page. It is therefore a simple matter to write Listing 2.

It really is as easy as that! Reload *elinks* and visit your least unfavorite web site. Then press ‘g’, followed by the keyword *tiny*, and return. If you’re like me and chose Google as your test site, you’ll be taken to a web page at *tinyurl.com*, as shown in figure 1.

We can see the new url given as *http://tinyurl.com/161*, which can then be copied, pasted, emailed, and generally misused. If we knew how to add shortcuts to *elinks* we could save ourselves four keystrokes. Those of you who read Table 3: Odds and Sods earlier, already know about the function called *bind_key*. Yes! It is the right one, so we can add the code as in Listing 3.

This example demonstrates the usefulness of anonymous functions, and the ease by which two values can be returned from a function. In this case, the command *goto_url*, and the URL parameter for that command.

To add some final polish we will eradicate the duplicate URL information by writing our *hooks.lua* file as Listing 4.

As you can see, Lua makes it very easy for the end user to add functionality to a piece of software. You need nothing more than the methods provided here, and a little imagination, to add a whole host of other functionality. Generally speaking, adding flexibility for the end user means complexity for the programmer. With Lua, this is not the case! Let’s look at why…

Moonraker

In any extensible system like this, there are three basic components. The initialization (and de-initialization), the communication in (where the script talks to our C program), and the communication out (where C talks to the script).

Box 1: enable_systems_functions

openfile, closefile, readfrom, writeto, appendto, pipe_read, remove, rename, flush, seek, tmpname, read, write execute, exit, clock, date, getenv, setlocale.

Listing 4: *hooks.lua* file

```
function get_tiny(url)
  return
"http://tinyurl.com/create.php?ur
l=“..url
end
function goto_url_hook (url,
current_url)
if url == “tiny“ then
  return get_tiny(current_url)
end
return url
end
bind_key (“main“, “Ctrl-T“,
function () return “goto_url“,
get_tiny( current_url() ) end )
```

All three areas are very simple, and can use the basic templates presented here. This simplicity has kept the Lua interpreter small, and encouraged programmers to use it for configuration.

Let us start at the beginning,

```
#include <lua.h>
int main(int argc, char *argv[])
{
lua_State *pLua;
  pLua = lua_open();
  printf(“Hello, World!“);
  lua_close(pLua);
return 0;
}
```

Listing 5: *factorial* routine

```
int compute(int n) { return
n<2?1:n*compute(n-1); }
int c_factorial(lua_State *pLua)
{
int params = lua_gettop(pLua);
int n, result;
int answers = 0;
  for(n=1; n<=params; n++) {
    if (lua_isnumber(pLua, n)) {
      result = compute(
lua_tonumber(pLua, n) );
      lua_pushnumber(pLua,
result);
      answers++;
    } else {
      // Error!
      break;
    }
  }
  return answers;
}
```

The first thing to note is that I'm running Lua 5. This can lead to minor compatibility issues, since *lua_open* takes a stack size parameter under version 4. Version 4 users will note that the header file must be changed to *lua40/lua.h*. These are two of the backwardly-incompatible changes made to version 5. When compiling, we must link with the Lua library:

```
$ gcc -llua mycode.c
```

If you are using Lua on its own, you will need some form of input and output. This is not included as standard, since most applications provide their own I/O. To allow Lua code access to its standard libraries, include the following:

```
lua_baselibopen(pLua);
lua_iolibopen(pLua);
lua_strlibopen(pLua);
lua_mathlibopen(pLua);
```

Which libraries you need is, obviously, up to you. However, including any of them requires linkage with the *lualib* library. Use of the maths library requires C's own math library (which is not included as standard), to make the compile line look more akin to this,

```
$ gcc -llua -llualib ⮐
-lm mycode.c
```

pLua holds the state of the entire Lua system. Since Lua is re-entrant, we can call *lua_open* as many times as we want, and neither state will conflict with the other.

This allows us to use Lua as part of a threaded system. Whenever interacting with Lua, we must use this pointer, which is conventionally labeled *L*, although I am using *pLua* to increase its visibility in the examples.

Having got the Lua state, we can feed Lua code to it, and the inbuilt interpreter will process it as normal.

```
lua_dostring(pLua, ⮐
"number=12345");
// other code
lua_dostring(pLua, ⮐
"print(number)");
```

Table 3: Odds and Sods

Function name	Purpose
enable_systems_functions()	Allows certain functions (e.g. openfile) to be used. See Box 1.
current_url()	Retrieves the URL of the current *elinks* page
current_link()	Retrieves the link that is currently selected (or *nil* if none)
current_title()	Retrieves the title from the page
current_document()	Retrieves the HTML page, as a string
current_document_formatted([width])	Retrieves the HTML page, formatted to the optional width
pipe_read(command)	Executes the *command* given and reads data
execute(command)	Executes the *command* given under a shell (using *sh -c*)
bind_key (keymap, keystroke, function)	Executes the *function* whenever the *key stroke* is made. Should return a command and parameter, like *lua_console_hook*

As long as we keep hold of *pLua*, any variables set will remain in the Lua state. Any time we call a function (like *print*), Lua will evaluate it with whatever functions have been declared, and return any results to the state held in *pLua*.

You can probably see how easy it would be to build your own interpreter and debugger with just this simple function, and you'd be right! However, such a function has already been written for us. It's called *dofile*. It executes the code within the file, as if it were running from the command line: that is, executing only those statements that are global. However, unlike the command line, once the file has been run, the state remains in *pLua*. These variables, along with any declared functions, can now be accessed by the C code. Or another Lua file, loaded with *lua_dofile*. Or code evaluated with *lua_dostring*.

```
int result;
result = lua_dofile➘
(pLua, “config.lua“);
```

In this case *result* returns the effect of the last chunk, which depends on whether the script executed successfully or not.

Moonlight on Vermont

Let us now write something useful in our *config.lua* script that calls a function in our C program. This would act like the *current_url* function in *elinks*, for example.

To do this, we need to register one of our C functions with Lua. This ties the two languages together. We give it the name that Lua should use, followed by the name of our actual function in C.

```
lua_register(pLua, “factorial“,➘
 c_factorial);
```

From here, we can get Lua to take over. It will organize all the function calling, parameter passing, and the returning of the results. All we need to do is retrieve the parameters in the correct order, and pass the correct result back.

Since Lua supports multiple return parameters (and arguments of any arbitrary type), we can not use any particular C prototype to manage it. Instead, all parameters are pushed on (and pulled off) a stack. We can then query the stack to tell us how many items are on it, and what type these items are. The stack, like variables, can hold any supported data type. It is therefore up to us (as the C programmer) to correctly request the appropriate type when removing data from the stack. This has the added bonus of making sure that every C function has the same signature, or prototype, when used with Lua.

If our *factorial* routine could take an arbitrary number of integers, and return the factorial of each one, we'd retrieve the number of arguments, and compute the result for each one – provided it was numeric. Our code would look something like Listing 5.

Note the stack indices are counted from 1 (not 0), and that we need to return the number of parameters that are pushed on the return stack. That's all there is to writing your own functions. The types may vary, so *lua_isnumber* might become *lua_isbool* (see Table 1), but the principles are the same.

Clouds across the Moon

Calling a Lua function from C is no more difficult, once you know the pattern. It works on the same principle as before where you push data onto the stack. In this case we must place the function name on first, followed by each of the arguments in order. Since the types vary between C and Lua, you need to use the correct function to push the appropriate type onto the stack. See Listing 6.

Listing 6: Calling Lua

```
// The function name is a global
symbol: we must use that instead
of a string containing the
function name
lua_getglobal(pLua,
“swap_greeting“);
// Our first parameter
lua_pushstring(pLua, “Steev“);
// Our second parameter
lua_pushstring(pLua, “Hello“);
// The call itself
lua_call(pLua, 2/*number of input
args*/, 2/*number of result
args*/);
// Retrieve results into Lua-
variables
lua_setglobal(pLua, “result2“);
lua_setglobal(pLua, “result1“);
```

This would have the same effect of Lua calling its own function thus,

```
result1, result2 = ➘
swap_greeting(“Steev“, “Hello“);
```

Note the order of the parameters is reversed to cope with their removal from the stack in first in-last out, order.

It we had wanted the results of this function in the C code, we would read the data from the stack ourselves, and then have to explicitly remove it. Like so,

```
pResult2 = lua_tostring➘
(pLua, -1);
pResult1 = lua_tostring➘
(pLua, -2);
lua_pop(L, 2);
```

Notice the reverse order here, too, and the use of negative stack indices.

Shepherd Moons

As you can see in these few pages, we have been able to learn the basics of a new language, upgrade a web browser, and find a way to supplement our own projects with dynamic configuration scripts! This has all been possible because of the power and flexibility of Lua. I'm sure you'll have your own ideas for projects: perhaps you'll add the ability to email pages (or links) directly from Mutt, or open a secondary browser (for brain-dead sites that require Mozilla), or remove adverts from particular web sites, or… something else… Go on! Have a play! ■

INFO

[1] Lua uses: *http://www.lua.org/uses.html*

[2] Lua documentation: *http://www.lua.org/manual/5.0/*

[3] Lua forums: *http://archive.neotonic.com/archive/lua-l*

[4] elinks program: *http://elinks.or.cz/download.html*

THE AUTHOR

When builders go down the pub they talk about football. Presumably therefore, when footballers go down the pub they talk about builders! When Steven Goodwin goes down the pub he doesn't talk about football, or builders. He talks about computers. Constantly...