Pontifícia Universidade Católica
do Rio de Janeiro

Lua: 20 Years

Roberto Ierusalimschy

Luiz Henrique de Figueiredo

Waldemar Celes

1992-1993: The Beginning

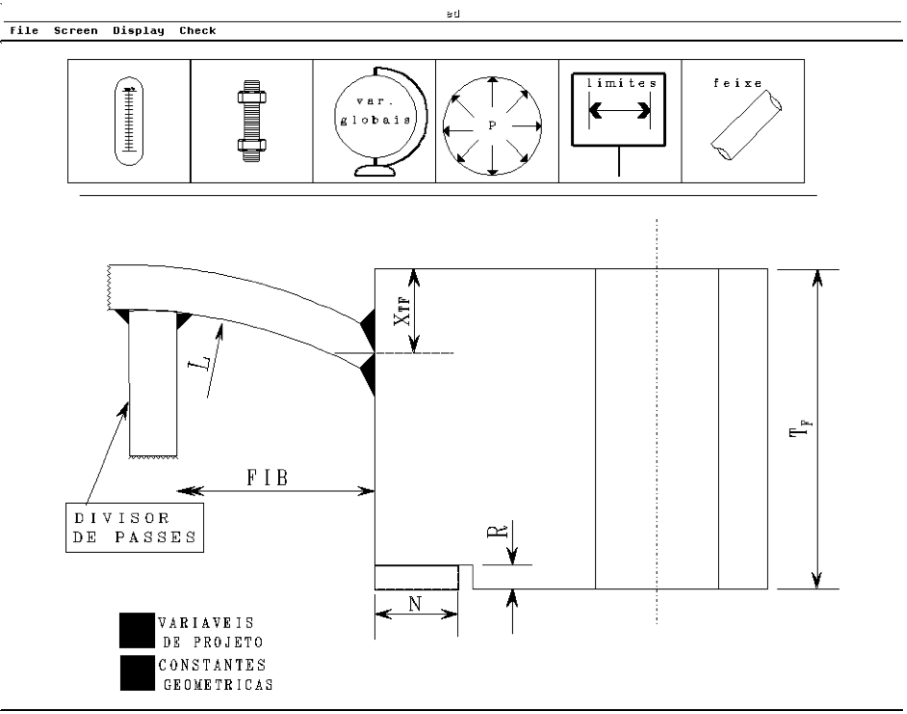
1992: Tecgraf

Partnership between PUC-Rio and Petrobras (the Brazilian Oil Company)

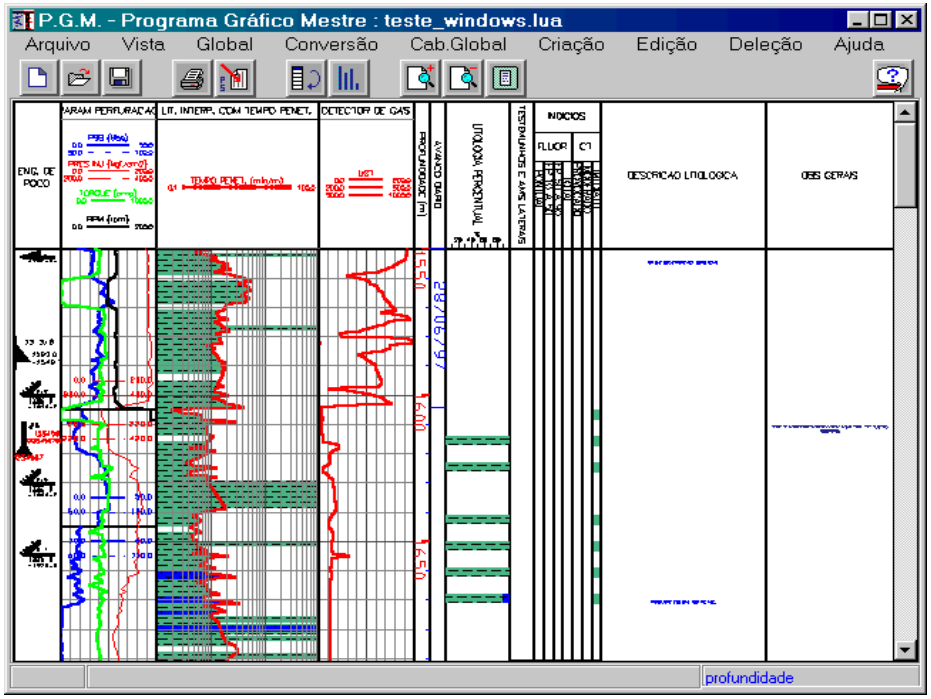
1992: Tecgraf

- Two projects using “little languages”

DEL, for data entry

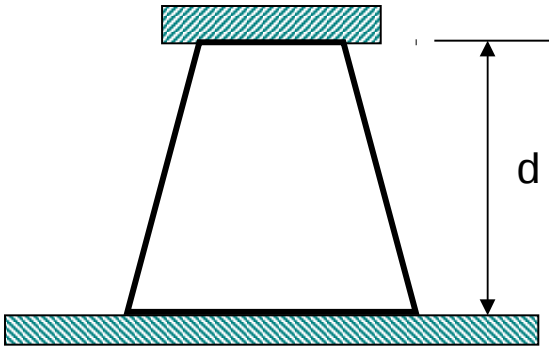


PGM, to visualize geologic profiles



DEL
Data Entry Language

- form definition
  - parameter list
  - types and default values




```
:e gasket "gasket properties"
mat     s               # material
d       f       0       # distance
y       f       0       # settlement stress
t       i       1       # facing type

:p gasket.m>30
gasket.m<3000
gasket.y>335.8
gasket.y<2576.8
```

SOL
Simple Object Language

- data description language
  - not totally unlike XML (with DTD)
  - BibTeX-like syntax

```
type @track {x:number, y:number=23, z}

type @line {t:@track=@track{x=8}, z:number*}

-- create an object 't1', of type 'track'
t1 = @track {y=9, x=10, z="hi!"}

l = @line {t=@track{x=t1.y, y=t1.x}, z=[2,3,4]}
```

1992: Tecgraf

- Both DEL & PGM shared several limitations
  - decision-making facilites
  - arithmetic expressions
  - abstraction mechanisms

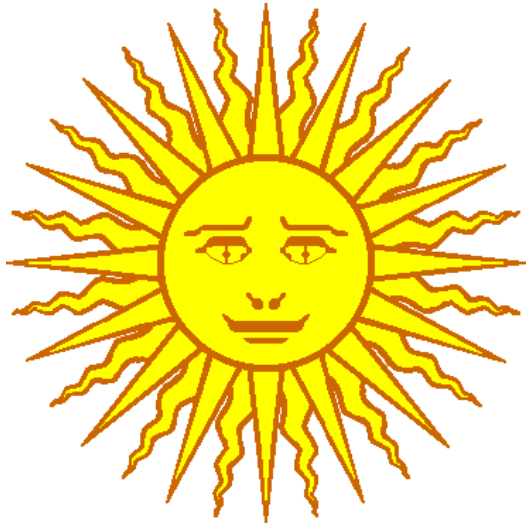
1993

- Roberto (PGM), Luiz (DEL) and Waldemar (PGM) got together to find a common solution to their common problems...

What we needed?

- A “generic configuration language”
- A “complete” language
- Easily embeddable
- Portable
- Non-intimidating syntax
- As simple as possible

As we were giving up Sol,



a friend suggested a new name...

...and Lua was born

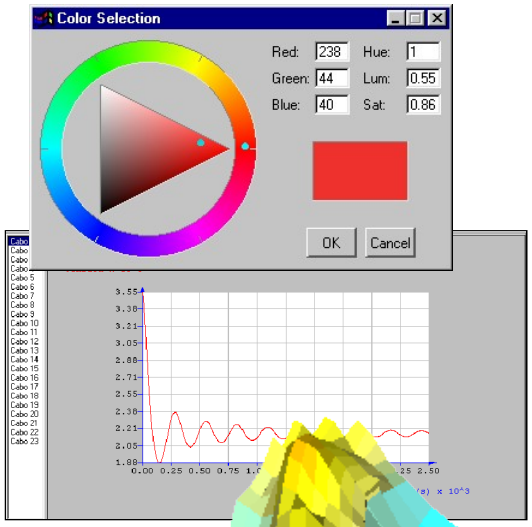
Lua 1.0 (1993)

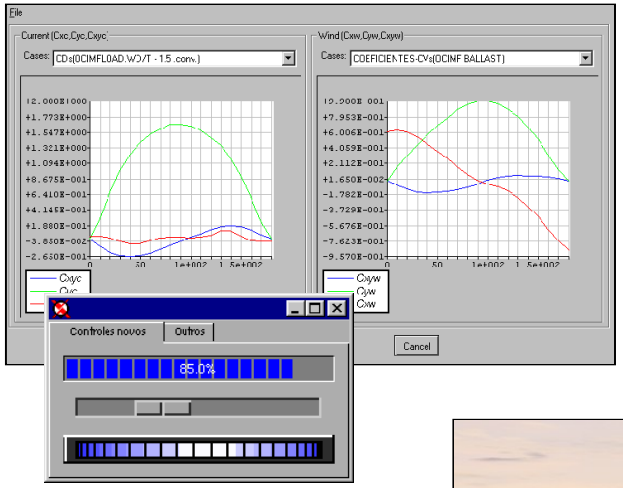
- Called 1.0 a posteriori
- *The simplest thing that could possibly work*
- Standard implementation
  - precompiler with yacc/lex
  - opcodes for a stack-based virtual machine
- Less than 5000 lines of C code

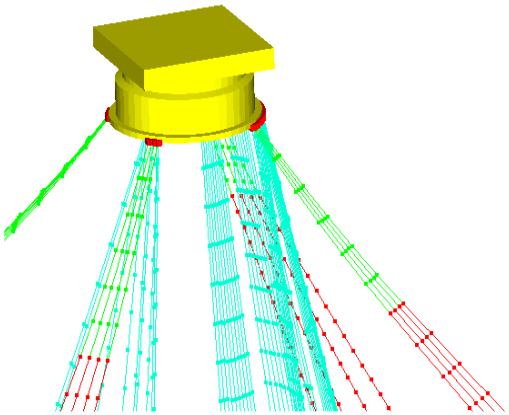
Lua 1.0 (1993)

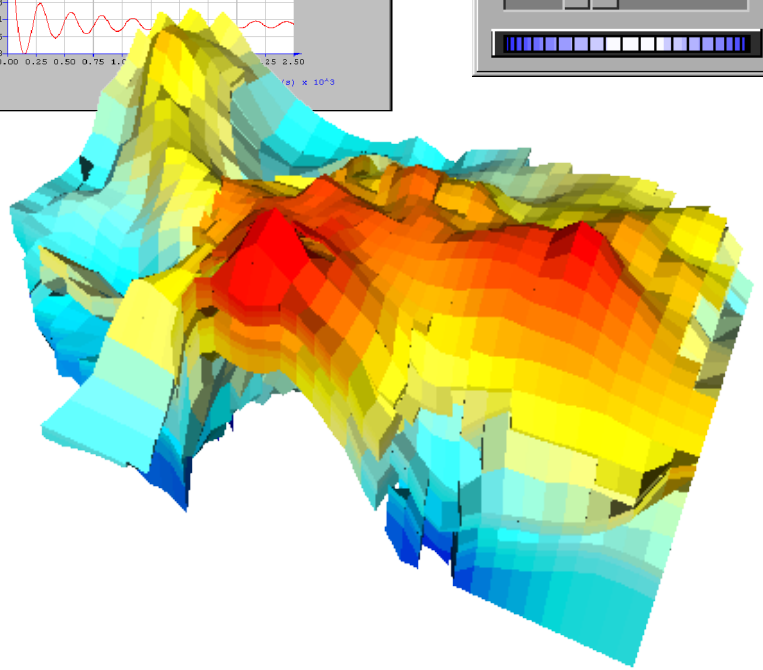
- Requirements:
  - simple, portable, extensible, embeddable, small
- Expectations:
  - to solve our problems with PGM and DEL
  - fulfilled our expectations: both DEL and PGM used Lua successfully
- It was a big success in Tecgraf

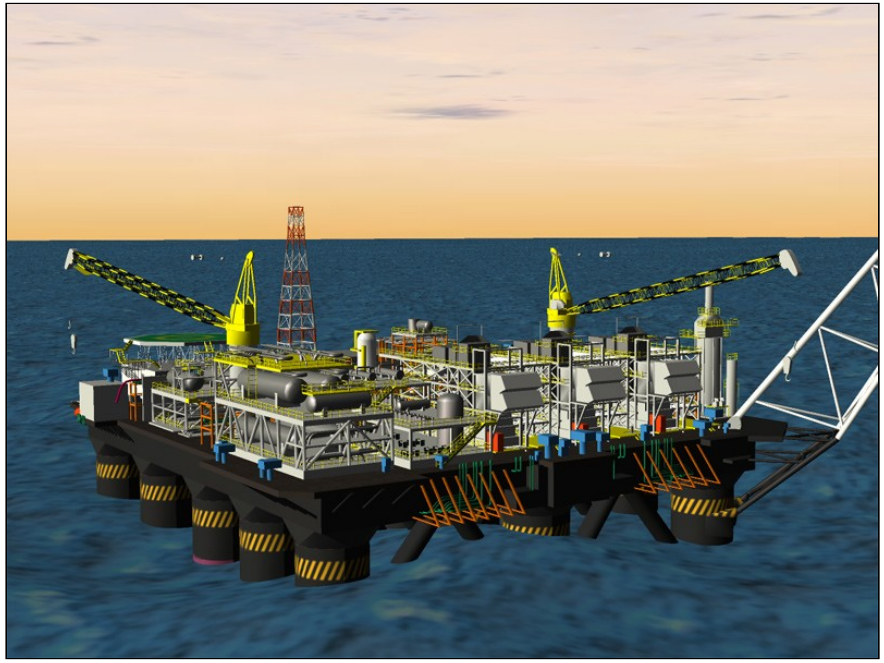
Soon, several projects at Tecgraf were using Lua











Lua 1.1 (1994)

- New users brought new demands
  - several small improvements
  - mainly for performance
- Reference manual
- Well-defined and well-documented C API

License

- First public distribution
  - ftp
  - free for academic uses, but not free for commercial uses
  - after one year, only one unfruitful contact
- Later versions with free license
  - open-source license
  - not “open-source decision making”

How was Lua 1.0?

- Not that different from Sol...

```
t1 = @track{x = 10.3, y = 25.9,
            title = "depth"}
```

How was Lua 1.0?

- But quite different...

```
t1 = @track{x = 10.3, y = 25.9,
            title = "depth"}
```

```
function track (t)
  if not t.x then t.x = 0.0 end
  if type(t.x) ~= "number" then
    error("invalid 'x' value")
  end
  if type(t.y) ~= "number" then
    error("invalid 'y' value")
  end
end
```

Tables in Lua 1.0

- The sole data structure
  - still is
- Constructors:

```
t = @(100)                    -- empty
t = @[a, b, c]                -- list
t = @{x = 10, y = 20} -- record
t = @foo{x=10, y = 20}
```

Tables in Lua 2.1 (1995)

- Any value as index
  - not only numbers and strings
- Simplification
  - Only one constructor + syntactic sugar:

```
t = {}                      -- empty
t = {a, b, c}               -- list
t = {x = 10, y = 20} -- record
t = foo({x=10, y = 20})
```

Lua 2.1 - 2.5 (Feb 95 - Nov 96)

- Fallbacks
  - minimum mechanism to get the label "*OO inside*"
- External precompiler
  - faster load for large programs (metafiles)
- Debug facilities
  - basic mechanisms for external debuggers
- Pattern matching

Tables everywhere

- As Lua evolved, the use of tables only increased
- All data structures
  - arrays, records, sets, lists, etc.
  - objects
  - modules
- Tables also used for several internal structures
  - global variables, metamethods, references (in the API)

International Exposure

Newsgroups:
comp.compilers,comp.lang.misc,comp.programming,comp.lang.c
From: lhf@csg.uwaterloo.ca (Luiz H de Figueiredo)
Organization: Computer Systems Group, University of Waterloo
Keywords: tools, available
Date: Fri, 8 Jul 1994 11:51:45 GMT

This is the first public release of Lua.

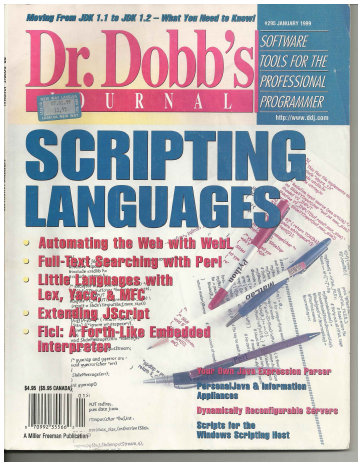
* What is Lua?
Lua is a simple, yet powerful, language for extending applications. Lua has been developed by TeCGraf, the Computer Graphics Technology Group of PUC-Rio, the Catholic University of Rio de Janeiro, Brazil. Dozens of industrial products developed by TeCGraf use Lua.
[…]

International Exposure

- First home page in 1995
  - `http://www.inf.puc-rio.br/~roberto/lua`
- e-mail contact with “far-away” users
- Beginning of 1997 - discussion list
  - to allow users to answer users' questions
  - end of 1997 - more than 100 subscribers, should we try a newsgroup?

International Exposure

- Jun 1996 - paper in S:P&E
  - R. Ierusalimschy, L. H. de Figueiredo, W. Celes, Lua - an extensible extension language, *Software: Practice & Experience* 26(6):635-652, 1996.
- Dec 1996 - article in Dr. Dobb's
  - L. H. de Figueiredo, R. Ierusalimschy, W. Celes, Lua: an extensible embedded language, *Dr. Dobb's Journal* 21(12):26-33, 1996.



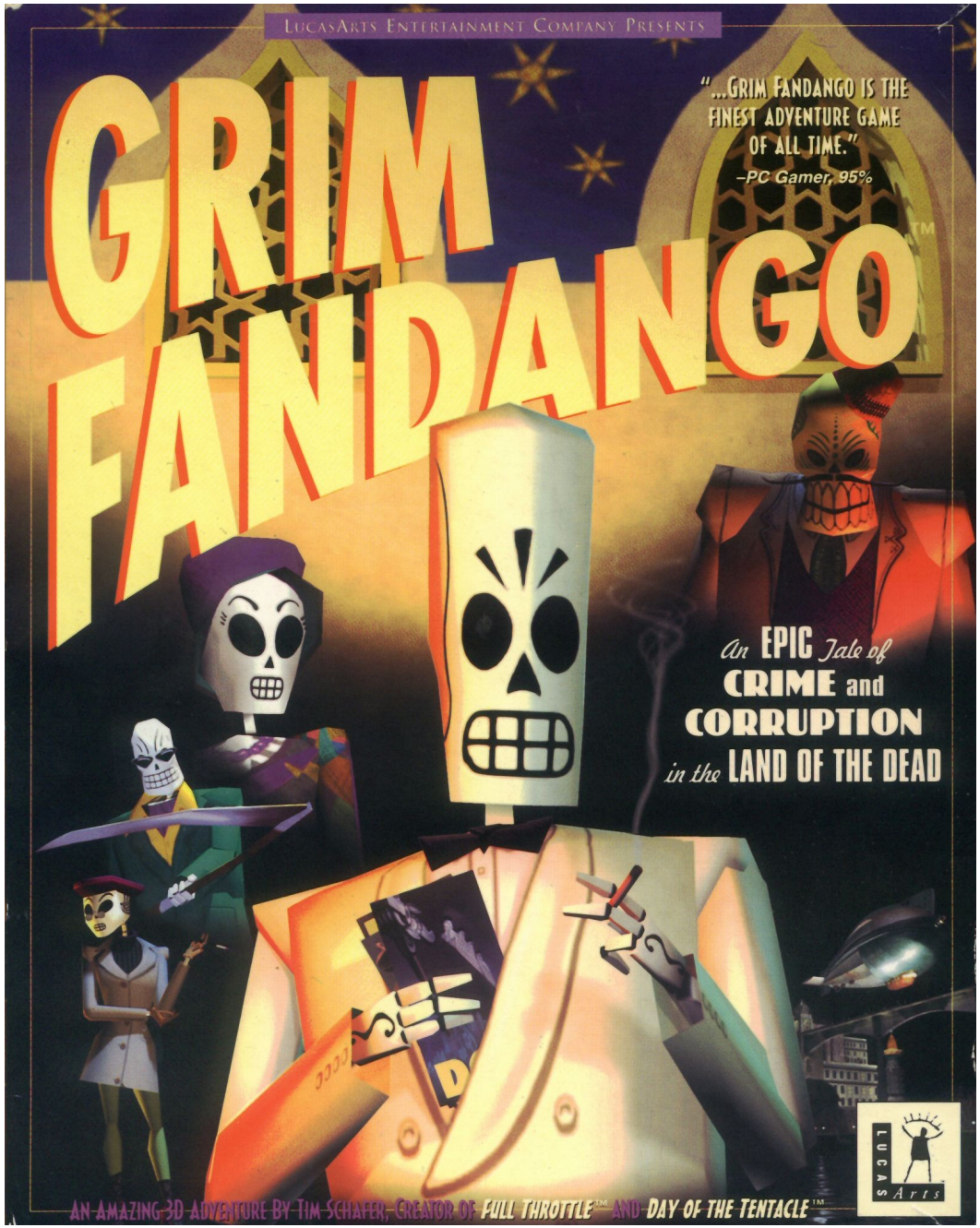
Beachhead in Games

From: Bret Mogilefsky <mogul@lucasarts.com>
To: '"lua@icad.puc-rio.br"' <lua@icad.puc-rio.br>
Subject: LUA rocks! Question, too.
Date: Thu, 9 Jan 1997 13:21:41 -0800

Hi there...

After reading the Dr. Dobbs article on Lua I was very eager to check it out, and so far it has exceeded my expectations in every way! It's elegance and simplicity astound me. Congratulations on developing such a well-thought out language.

Some background: I am working on an adventure game for the LucasArts Entertainment Co., and I want to try replacing our older adventure game scripting language, SCUMM, with Lua.



Lucas Arts, 1998: First AAA game to use Lua

Scripting in Grim Fandango

“[The engine] doesn't know anything about adventure games, or talking, or puzzles, or anything else that makes Grim Fandango the game it is. It just knows how to render a set from data that it's loaded and draw characters in that set.
[…]
“The real heroes in the development of Grim Fandango were the scripters. They wrote everything from how to respond to the controls to dialogs to camera scripts to door scripts to the in-game menus and options screens. […]
“A TREMENDOUS amount of this game is written in Lua. The engine, including the Lua interpreter, is really just a small part of the finished product.”

Bret Mogilefsky

What happened next

- Game of the year...almost
  - Half-Life relegated us the Adventure Game of the Year
- GDC 1999 (2000?)
  - Panel discussion of scripting languages
    - Rob Huebner on embedding Java
    - Kevin Bruner on interpreted C++
    - Seamus McNally on not using a scripting language
  - 200 miserable people
  - “Or you could just use Lua...”
  - Furious scribbling

Bret Mogilefsky, Lua workshop 2005

Escape From Monkey Island Screen Shot Gallery [13 of 24] - Microsoft

1998 - 2002

- User base grows outside Brazil
  - shift from inside PUC to outside
- Development of a virtual community
- Writing of PiL
- Several changes in the language
  - support for larger programs
  - functional facilities
  - several incompatible changes between versions

Lua 3.1 (1998)

- Functional features
  - syntax for anonymous, nested functions
  - since Lua 1.0, `function f ...` was sugar for `f = function ...`, except that the latter was not valid syntax!

iterators

```
foreach(t, function (k, v)
  print(k, v)
end)
```

callbacks

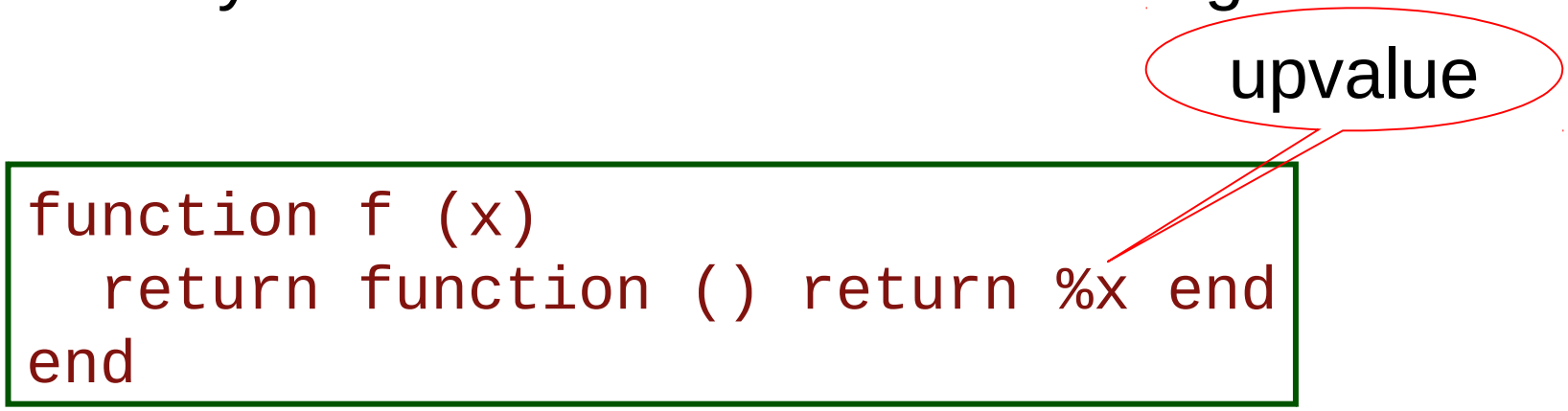
```
button.action = function ... end
```

Lexical scoping

- Functional features
- No simple and efficient way to implement lexical scoping
  - on-the-fly compilation with no intermediate representation + activation records in a stack
  - hindered earlier adoption of nested functions

Upvalues

- “a form of proper lexical scoping”
- The frozen value of an external local variable inside a nested function
- Trick somewhat similar to Java demand for `final` when building nested classes
- Special syntax to avoid misunderstandings



In Aug 1998, Cameron Laird wrote in SunWorld:

“Its user base is also small; there might be only a few tens of thousands of Lua programmers in the world. They're very fond of this language, though, and the imminent explosion of ubiquitous embedded processing (computers in your car, in your plumbing, and in your kitchen appliances) can only work in favor of Lua.”

In Aug 1998, Cameron Laird wrote in SunWorld:

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For us, this “small base” was much larger than we could have imagined!

Lua 3.2 (1999)

- Multithreading?
  - for Web servers

Lua 3.2

- Multithreading?
- Problems with multithreading
  - (preemption + shared memory)
  - not portable
  - no one can write correct programs when `a=a+1` is non deterministic
  - core mechanisms originally proposed to OS programming, not to “normal people”
  - almost impossible to debug

Lua 3.2

- Multithreading?
- Multiple “Lua processes”
  - multiple independent states in an application
  - no shared memory
- Would require major change in the API
  - each function should get the state as an extra argument
  - instead, a single C global variable in the code points to the running state
  - Extra API functions set the running state

Lua 4.0 (2000)

- Major change in the API
  - all functions got a new parameter (the state)
  - no more C global variables in the code
  - libraries should not use C globals, too
  - concurrent C threads can each has its own state
- We took the opportunity and made several other improvements in the API
  - stack oriented

2001

- Several appearances in Brazilian press
- March 2001, new site: www.lua.org
  - gift from a user (Jim Mathies)
- Few months later, lua-users.org
  - kept by Lua users (thanks to John Belmonte)
- Big plans for 4.1

Plans for Lua 4.1

- Multithreading?
  - multiple characters in games

Plans for Lua 4.1

- Multithreading?
- Coroutines!
  - portable implementation
  - deterministic semantics
  - coroutines + scheduler =

    non-preemptive multithreading
  - could be used as a basis for multithreading for those that really wanted it

Plans for Lua 4.1

- New implementation for tables
  - store array part in an actual array
- New implementation for upvales
  - allowed “true” lexical scoping!
- New register-based virtual machine
- Tags replaced by metatables
  - regular tables that store *metamethods* (old *tag methods*) for the object

Plans for Lua 4.1

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  - regular tables that store *metamethods* (old *tag methods*) for the object

Too much for a minor version...

Lua 5.0 (2003)

- Coroutines
- Lexical scoping
- Register-based virtual machine, new implementation for tables
- Metatables, boolean type, weak tables, proper tail calls, ...
- Module system

Lua 5

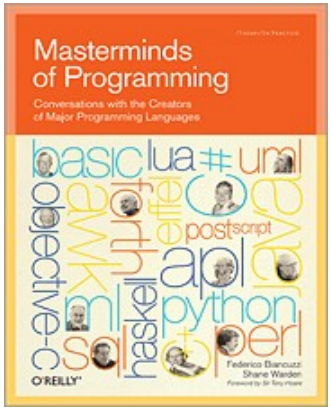
- Dec 2003 - 1st edition of “Programming in Lua”
- Mar 2004 - roundtable about Lua at GDC
- Jul 2005 - 1st Lua workshop
  - San Jose, CA (sponsored by Adobe)
- Mar 2006 - 2nd edition of “Programming in Lua”

Lua 5.1 (2006)

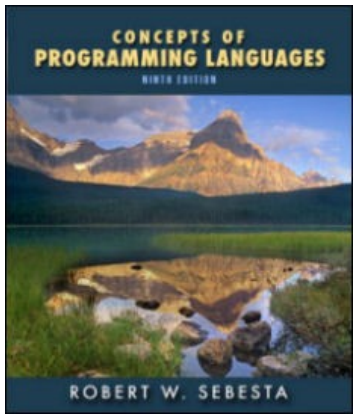
- Incremental garbage collector
  - demand from games
- Better support for modules
  - more policies
  - functions to help following “good practice”
- Support for dynamic C libraries
  - not portable!
  - the mother of all (non portable) libraries

- *2007: III ACM History of Programming Languages.*

- *2009: Masterminds of Programming: Conversations with the Creators of Major Programming Languages.* O'Reilly Media.



- *2009 (2012): Concepts of Programming Languages.* Robert Sebesta, Addison Wesley.

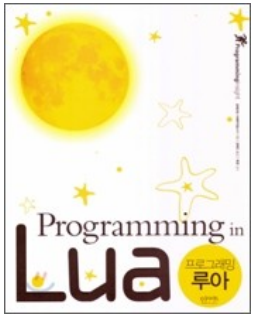


Lua 5.2 (2011)

- Yieldable `pcall` and metamethods
- Emergency collection
- New lexical scheme for global variables (`_ENV`)
- Ephemeron tables
- bitlib library
- Finalizers for tables
- Light C functions

Lua Today


はじめての
Lua
プログラミング
清水 英樹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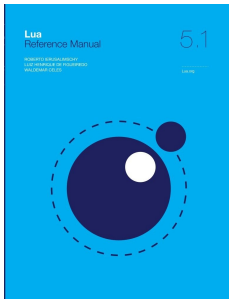
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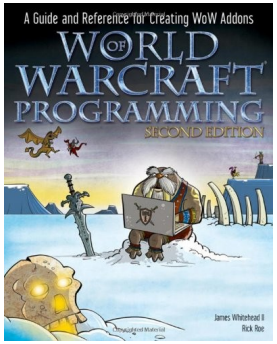
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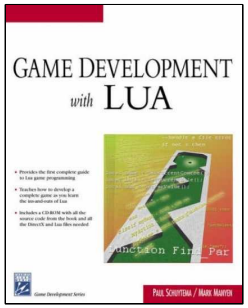
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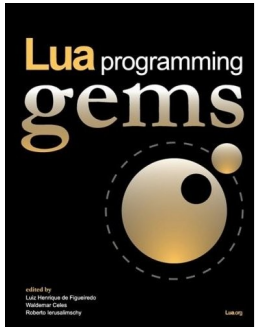
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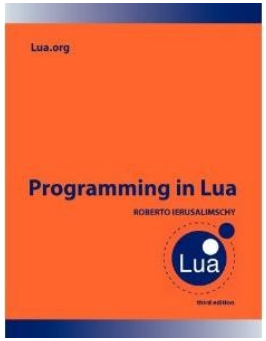
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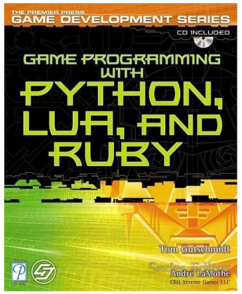
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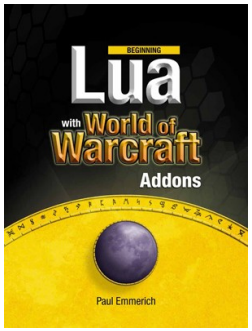
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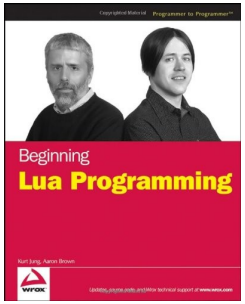
ET SES APPLICATIONS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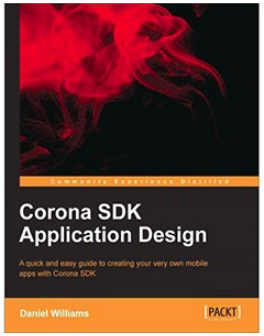
Lua
Programming
By: Brandon LaRouche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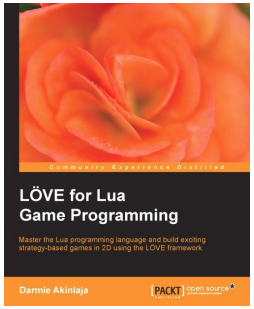
Daniel Williams
PACKT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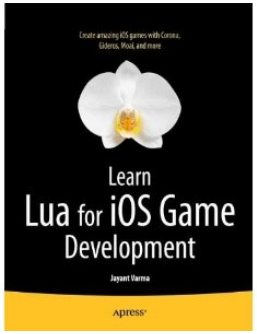
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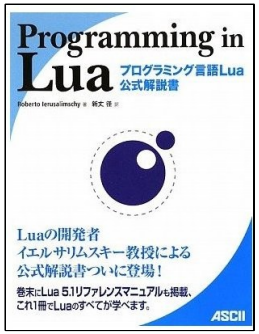
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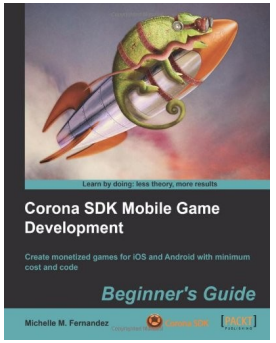
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EDITION

Embedded Systems

Samsung (TVs), Cisco (routers), Logitech (keyboards), Olivetti (printers), Océ (printers), Ginga (Brazilian TV middleware), Verison (set-top boxes), Texas Instruments (calculators Nspire), Huawei (cell phones), Sierra Wireless (M2M devices), Mercedes-Benzs (cars), …

Adobe Lightroom

more than one million lines of Lua code

Slashdot, Feb 1, 2012:

“Wikipedia Chooses Lua As Its New Template Language”

Wired, March 19, 2013:

“Meet Wikipedia, the Encyclopedia Anyone Can Code”

“*As of this weekend, anyone on Earth can use Lua [...] to build material on Wikipedia and its many sister sites, such as Wikiquote and Wiktionary.*”

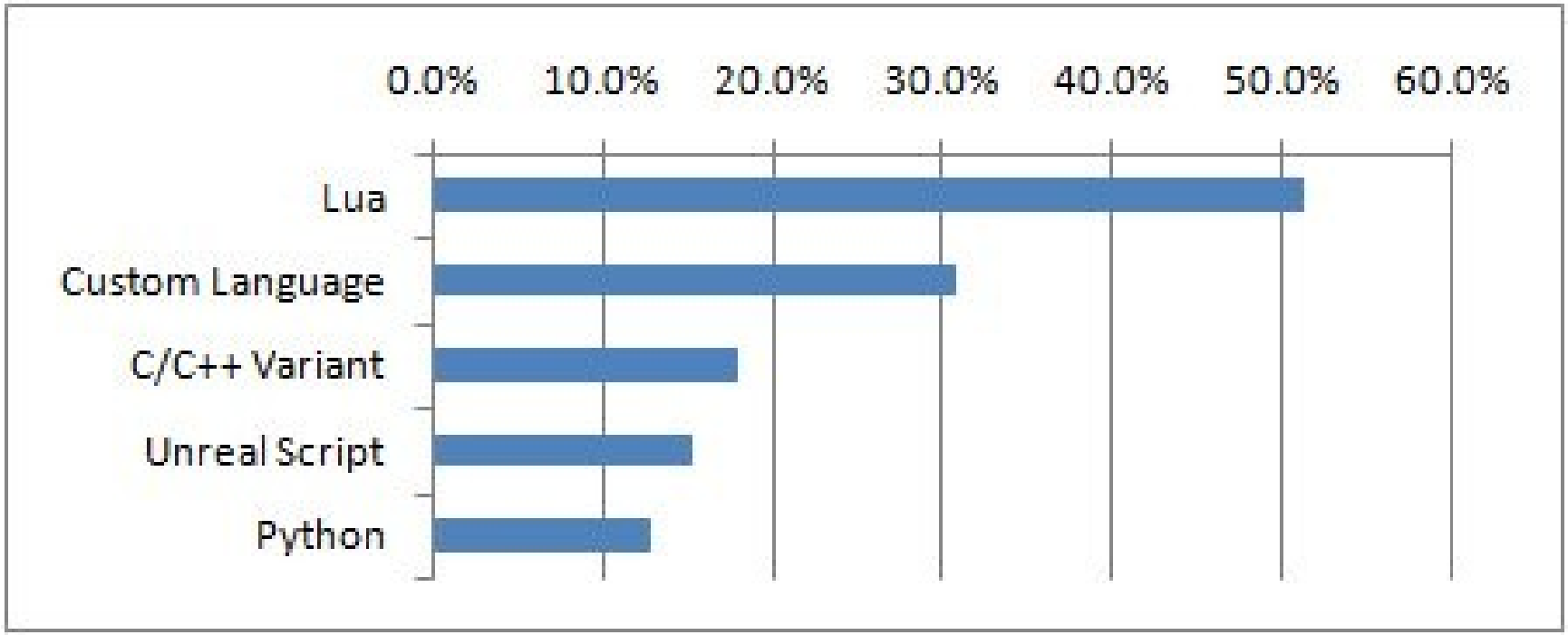
Scripting the Internet of Things

November 2011: “Sierra Wireless, IBM, Eurotech, and the Eclipse Foundation establish an M2M Industry Working Group to ease the development, testing, and deployment of machine-to-machine solutions.”

October 2013: “Wind River Unveils Latest Software Platform for Internet of Things”

Lua in Games

- The Engine Survey (Mark DeLoura, 03/02/09,Gamasutra)
- What script languages are most people using?




Company of Heroes
Universe at War
Dungeons
Tap Tap Revenge
Blitzkrieg
Introducing The World's First Competitive Sim!
Monopoly Tycoon
Driver San Francisco
ROBLOX
Grim Fandango
amped
The Hulk
Destroy All Humans!
Requiem
Memento Mori
Lord of the Rings Online
Shadows of Angmar
Baldur's Gate
Rail Simulator
World of Warcraft
Far Cry
Impossible Creatures
S.T.A.L.K.E.R.
Diner Dash 2
Blossom
NFL Fever
soul ride
Natural Selection 2
Allods Online
There
Brütal Legend
SimCity 4
Angry Birds
Play
SpellForce
Napoleon Total War
Supreme Commander
Fable II
Buzz! Quiz TV
Crimson
Mok 2
Crysis
Supreme Commander Forged Alliance
Homeworld 2
Psychonauts
The Incredibles
When Danger Calls
Top Spin 2
Sonic the Hedgehog
The Witcher
Crackdown
Star Wars Empire at War
PlayStation Home
Links
Dungeons
Bubble Ball
Escape from Monkey Island
Empire Total War
Civilization V
plus+
Crackdown
Heroes V
Might and Magic
Dawn of War
Dark Crusade
You Are Empty

What is Next?

- Integers
  - 64-bit values in “large” machines
  - 32-bit integers and floats in “small” machines
- Extra libraries
  - basic UTF-8 support
  - struct
- Macros
  - how to do it?

Our “Principles”

- It is much easier to add a missing feature than to remove an excessive one
- Implementing is the easiest part of any new feature
  - documentation, maintenance, added complexity
  - it is very hard to anticipate all implications of a new feature
- Stuck to the standard
- Emphasis on embedding

Our “Principles”

- Mechanisms instead of policies
  - type definitions in Sol
  - delegation in Lua 2.1
  - coroutines
  - modules
- Effective way to avoid tough decisions
- This itself is a policy...


20 Years
Lua