Fizz buzz - LuaX demo

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Contents

Chapter 1

Disclaimer

This document is not about Fizzbuzz. This document is a suggestion to simplify the build process of software projects, a demo of an **homogeneous and consistent** development and documentation environment. Fizzbuzz is just an application example.

Chapter 2

Links

- fizzbuzz_slideshow.pdf: PDF slideshow
- fizzbuzz.pdf: PDF demonstration (specification, implementation, tests, test report, documentation generator, ...)
- github.com/CDSoft/fizzbuzz: Sources

Chapter 3

Introduction

Lots of software projects involve various tools, free as well as commercial, to build the software, run the tests, produce the documentation, ... These tools use different data formats and scripting languages, which makes the projects less scalable and harder to maintain.

Sharing data between configuration files, documentations, tests results can then be painful and counter productive (the necessary glue is often more complex than the tools themselves).

Usually people script their build systems and processes with languages like Bash, Python, Javascript and make them communicate with plain text, YAML, JSON, XML, CSV, INI, TOML. Every script shall rely on specific (existing or not) libraries to read and write these data formats.

This document presents a commun and powerful data format and some tools to script the build process of a project and generate documentation.

To sum up the suggested solution is:

- a **single data format**
- and a **reduced set of highly configurable tools**.

Chapter 4

Lua[1]

Lua is the perfect candidate for both a common data format and a script language.

4.1 What is Lua?

Lua is a powerful, efficient, lightweight, embeddable scripting language. It supports procedural programming, object-oriented programming, functional programming, data-driven programming, and data description.

Lua combines simple procedural syntax with powerful data description constructs based on associative arrays and extensible semantics. Lua is dynamically typed, runs by interpreting bytecode with a register-based virtual machine, and has automatic memory management with incremental garbage collection, making it ideal for configuration, scripting, and rapid prototyping.

4.2 Why choose Lua?

Lua is a proven, robust language

Lua has been used in many industrial applications (e.g., Adobe's Photoshop Lightroom), with an emphasis on embedded systems (e.g., the Ginga middleware for digital TV in Brazil) and games (e.g., World of Warcraft and Angry Birds). Lua is currently the leading scripting language in games. Lua has a solid reference manual and there are several books about it. Several versions of Lua have been released and used in real applications since its creation in 1993. Lua featured in HOPL III, the Third ACM SIGPLAN History of Programming Languages Conference, in 2007. Lua won the Front Line Award 2011 from the Game Developers Magazine.

[1] from https://www.lua.org/about.html

Lua is fast

Lua has a deserved reputation for performance. To claim to be "as fast as Lua" is an aspiration of other scripting languages. Several benchmarks show Lua as the fastest language in the realm of interpreted scripting languages. Lua is fast not only in fine-tuned benchmark programs, but in real life too. Substantial fractions of large applications have been written in Lua.

Lua is portable

Lua is distributed in a small package and builds out-of-the-box in all platforms that have a standard C compiler. Lua runs on all flavors of Unix and Windows, on mobile devices (running Android, iOS, BREW, Symbian, Windows Phone), on embedded microprocessors (such as ARM and Rabbit, for applications like Lego MindStorms), on IBM mainframes, etc.

Lua is powerful (but simple)

A fundamental concept in the design of Lua is to provide meta-mechanisms for implementing features, instead of providing a host of features directly in the language. For example, although Lua is not a pure object-oriented language, it does provide meta-mechanisms for implementing classes and inheritance. Lua's meta-mechanisms bring an economy of concepts and keep the language small, while allowing the semantics to be extended in unconventional ways.

Lua is small

Adding Lua to an application does not bloat it. The tarball for Lua 5.4, which contains source code and documentation, takes 353K compressed and 1.3M uncompressed. The source contains around 30000 lines of C. Under 64-bit Linux, the Lua interpreter built with all standard Lua libraries takes 281K and the Lua library takes 468K.

Lua is free

Lua is free open-source software, distributed under a very liberal license (the well-known MIT license). It may be used for any purpose, including commercial purposes, at absolutely no cost. Just download it and use it.

Chapter 5

LuaX

LuaX is a Lua interpreter and REPL based on Lua 5.4, augmented with some useful packages. LuaX can also produce standalone executables from Lua scripts.

LuaX runs on several platforms with no dependency:

- Linux (x86_64, i386, aarch64)
- MacOS (x86_64, aarch64)
- Windows (x86_64, i386)

LuaX can cross-compile scripts from and to any of these platforms.

LuaX comes with a standard Lua interpreter and provides some libraries (embedded in a single executable, no external dependency required):

- LuaX interactive usage: improved Lua REPL
- F: functional programming inspired functions
- fs: file system management
- sh: shell command execution
- mathx: complete math library for Lua
- imath: arbitrary precision integer and rational arithmetic library
- qmath: rational number library
- complex: math library for complex numbers based on C99
- ps: Process management module
- sys: System module
- crypt: cryptography module
- lz4: Extremely Fast Compression algorithm
- lpeg: Parsing Expression Grammars For Lua
- linenoise: light readline alternative
- luasocket: Network support for the Lua language
- inspect: Human-readable representation of Lua tables

More information here: http://cdelord.fr/luax

Chapter 6

Scripting with LuaX

LuaX can be used as a general programming language. There are plenty of good documentations for Lua and LuaX.

A big advantage of Lua is the usage of Lua tables as a common data format usable by various tools. It is Human-readable and structured. It can be generated by Lua scripts but also by any software producing text files.

Typical usages are:

- project/software configuration
  - a Lua table can be used to describe a project or a software configuration
    - read by an embedded Lua interpreter
    - used to generate documentation or source code
- tests results
  - a test suite can generate test results as a Lua table
  - tests results can be used to render documentation (tests reports) and compute a test coverage

The next chapters present some tools written in Lua/LuaX or using Lua as a scripting engine.

Chapter 7

Bang

Bang is a ninja file generator scriptable in LuaX, a Lua interpreter with a bunch of useful modules (file management, functional programming module, basic cryptography, ...). It takes a build description (a LuaX script) and generates a Ninja file.

Bang provides functions to generate ninja primitives (variables, rules, build statements, ...) and some extra features:

- rule/build statement pairs described in a single function call
- file listing and filenames list management using LuaX modules (e.g. F and fs)
- pipe simulation using rule composition
- "clean", "install" and "help" targets

Bang comes with an example that shows how to use bang and LuaX functions to:

- discover source files actually present in the repository: no redundant hard coded file lists (redundancy means painful maintenance)
- cross-compile the same sources for multiple platforms: compilation for several platforms without any dirty copy/paste
- describe static libraries: in the `lib` directory, each sub-directory is a library compiled and archived in its own `.a` file
- describe executables: in the `bin` directory, each C source file is the main file of a binary containing this C file as well as libraries from the `lib` directory.

Bang is currently used to build bang itself but also LuaX and some projects available on my GitHub.

Chapter 8

Ypp

Ypp is a minimalist and generic text preprocessor using Lua macros.

Ypp is compiled by LuaX, i.e. Lua and LuaX functions and modules are available in macros.

More information here: http://cdelord.fr/ypp

Ypp is pretty simple. It searches for Lua expressions and replaces macros with their results.

Macro	Result
`@(...)`	Evaluates the Lua expression `...` and replaces the macro by its result
`@@(...)`	Executes the Lua chunk `...` and replaces the macro by its result (if not `nil`)

Some expression do not require parentheses (function calls).

8.1 Example

```
$$
\sum_{i=1}^{100} i^2 = @F.range(100):map(function(x) return x*x end):sum()
$$
```

is rendered as

$$\sum_{i=1}^{100} i^2 = 338350$$

Macros can also define variables reusable later by other macros.

```
@@[[
    local foo = 42
    N = foo * 23 + 34
    local function sq(x) return x*x end
    function sumsq(n) return F.range(N):map(sq):sum() end
]]
```

defines `N` ($N = 1000$) which can be read in a Lua expression or with `@N` and `sumsq` which computes the sum of squares.

Then

```
$$
\sum_{i=1}^{@N} i^2 = @sumsq(N)
$$
```

becomes

$$\sum_{i=1}^{1000} i^2 = 333833500$$

Chapter 9

Pandoc

Pandoc is a swiss-army knife to convert from and to a bunch of document formats.

A big advantage of Pandoc is the ability to use Lua scripts to define custom readers and writers for unsupported formats and also Lua filters to manipulate the pandoc abstract syntax tree (AST). This is the main pandoc feature exercised in this document.

Pandoc has an excellent documentation:

- main pandoc documentation: https://pandoc.org/MANUAL.html
- Lua filter documentation: https://pandoc.org/lua-filters.html

Fizzbuzz uses pandoc Lua filters with Panda (see next chapter) which bundles some useful filters in a single script.

Chapter 10

Panda

Panda is a Pandoc Lua filter that works on internal Pandoc's AST.

It provides several interesting features:

- variable expansion (minimalistic templating)
- conditional blocks
- file inclusion (e.g. for source code examples)
- script execution (e.g. to include the result of a command)
- diagrams (Graphviz, PlantUML, ditaa, Asymptote, blockdiag, mermaid...)

The documentation of Panda is here: http://cdelord.fr/panda

10.1 Examples

There are lots of examples in the documentation of panda. We will see here two of them.

Documentation extraction from source code

The source code can be documented by adding special marks in comments. The documentation shall be written in Markdown. The default mark is `@@@` and can be customized.

For instance, the following C source contains documentation that can be extracted and included to a Pandoc document.

```
/*@@@
**`answer`** takes any question
and returns the most relevant answer.

Example:
``` c
```
```

```
    const char *meaning
        = answer("What's the meaning of life?");
```
```
@@@*/

const char *answer(const char *question)
{
    return "42";
}
```

To extract the documentation, panda provides a macro to replace a `div` element by the documentation chunks from a file. E.g.:

```
:::{doc=deep_thought.c}
:::
```

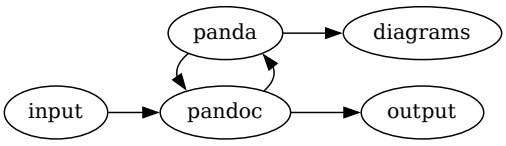
will be replaced by:

> **answer** takes any question and returns the most relevant answer.
>
> Example:
>
> ```
>     const char *meaning
>         = answer("What's the meaning of life?");
> ```

Diagrams

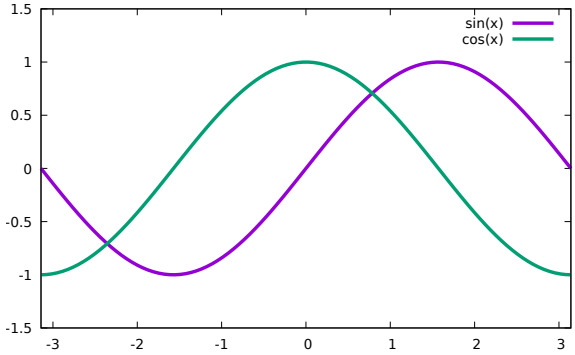
Diagrams can be embedded in Pandoc documents. Diagrams are specified as code blocks and are replaced by an image by panda.

```
```{.dot render="{{dot}}" width=67%}
digraph {
    rankdir=LR;
    input -> pandoc -> output
    pandoc -> panda -> {pandoc, diagrams}
    { rank=same; pandoc, panda }
    { rank=same; diagrams, output }
}
```
```




```
```{render="{{gnuplot}}" width=67%}
```
```

```
set xrange [-pi:pi]
set yrange [-1.5:1.5]
plot sin(x) lw 4, cos(x) lw 4
```



Chapter 11

hey

`hey` is a shell script. It is intended to easily install some tools based on LuaX and Pandoc to pre-process files and generate documents, using Lua as a common, simple and powerful scripting language.

11.1 Example

Easy installation, only `hey` is needed:

```
wget https://raw.githubusercontent.com/CDSoft/hey/master/hey
```

Its usage is very similar to `apt` or `dnf`:

```
$ hey list
all     install all packets

======== CDSoft softwares ========================================================
bang    Ninja file generator scriptable in LuaX
calculadoira
        simple yet powerful calculator
lsvg    LuaX interpreter specialized to generate SVG images
luax    Lua eXtended, a Lua interpreter with a better REPL and useful libraries
panda   Pandoc Lua filter that works on internal Pandoc's AST
tagref  Maintain cross-references in your code
ypp     Yet another preprocessor, scriptable in LuaX

======== Other softwares =========================================================
ditaa   DIagrams Through Ascii Art
pandoc  Swiss-army knife to convert from and to a bunch of document formats
pandoc-latex-template
        Clean pandoc LaTeX template to convert your markdown files to PDF or LaTeX
```

```
pandoc-panam-css
        Pan Am: Simple CSS for Pandoc
plantuml
        PlantUML
typst   Focus on your text and let Typst take care of layout and formatting
```

```
$ hey install all
...
```

Chapter 12

Fizzbuzz

Fizzbuzz is a concrete example of the usage of LuaX/ypp/pandoc/panda to specify and test a software.

12.1 Specification

From Wikipedia:

> Fizz buzz is a group word game for children to teach them about division. Players take turns to count incrementally, replacing any number divisible by three with the word "fizz", and any number divisible by five with the word "buzz".

`fizzbuzz` is a function that returns `"fizz"`, `"buzz"`, `"fizzbuzz"` or `n` for any positive integer `n`.

$$fizzbuzz : \mathbb{N}^+ \to \{fizz, buzz, fizzbuzz\} \cup \mathbb{N}^+$$

$$fizzbuzz(n) = \begin{cases} \text{"fizzbuzz"} & \text{if } (3|n) \wedge (5|n) \\ \text{"fizz"} & \text{if } (3|n) \wedge \neg(5|n) \\ \text{"buzz"} & \text{if } (5|n) \wedge \neg(3|n) \\ n & \text{if } \neg(3|n) \wedge \neg(5|n) \end{cases}$$

12.1.1 Requirements

`SPEC_API`: fizzbuzz command line argument

The fizzbuzz program takes one argument that specify the number for fizzbuzz values to generate.

`SPEC_OUT`: fizzbuzz output on stdout

The fizzbuzz program emits fizzbuzz values on the standard output. Each line contains `n` and `fizzbuzz(n)`.

e.g.:

```
$ fizzbuzz 6
1   1
2   2
3   fizz
4   4
5   buzz
6   fizz
```

`SPEC_FIZZ`: **fizz when n is a multiple of 3 but not 5**

If `n` is a multiple of 3 but not 5, then `fizzbuzz(n)` is `"fizz"`.

`SPEC_BUZZ`: **buzz when n is a multiple of 5 but not 3**

If `n` is a multiple of 5 but not 3, then `fizzbuzz(n)` is `"buzz"`.

`SPEC_FIZZBUZZ`: **fizzbuzz n is a when multiple of 3 and 5**

If `n` is a multiple of 3 and 5, then `fizzbuzz(n)` is `"fizzbuzz"`.

`SPEC_NUM`: **n when n is a not a multiple of 3 and 5**

If `n` is a multiple of 3 and 5, then `fizzbuzz(n)` is `"fizzbuzz"`.

12.1.2 Examples

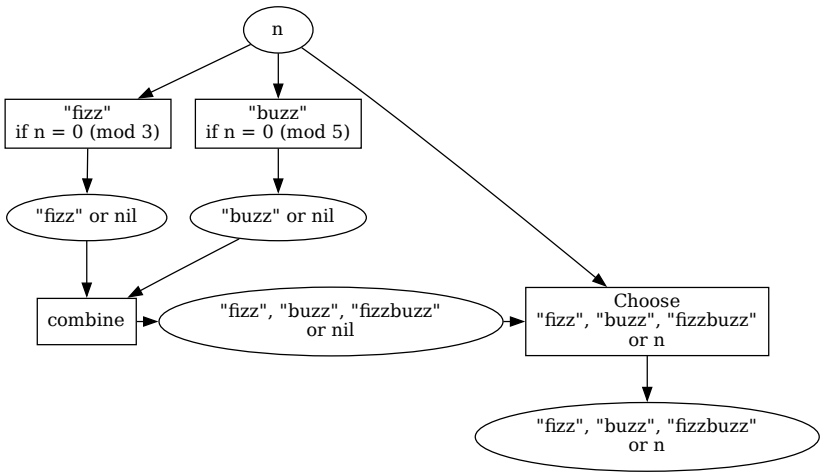
n	fizzbuzz(n)	n	fizzbuzz(n)	n	fizzbuzz(n)	n	fizzbuzz(n)
1	1	6	fizz	11	11	16	16
2	2	7	7	12	fizz	17	17
3	fizz	8	8	13	13	18	fizz
4	4	9	fizz	14	14	19	19
5	buzz	10	buzz	15	fizzbuzz	20	buzz

12.2 Implementation

12.2.1 Lua implementation

The Lua implementation of Fizzbuzz is based on a functional style, using function compositions.

It computes the `"fizz"` and `"buzz"` parts and return them if at least one of them is not `nil`. Otherwise it returns its argument unchanged.




```
local function div(d, s, n)
    return n % d == 0 and s or nil
end

local fizz = F.partial(div, 3, "fizz")
local buzz = F.partial(div, 5, "buzz")

local function combine(a, b)
    return a and (a..(b or "")) or b
end

local function fizzbuzz(n)
    return combine(fizz(n), buzz(n)) or n
end
```

12.2.2 C implementation

The C implementation of Fizzbuzz uses an array of string formats used by `sprintf` to produce `"fizz"`, `"buzz"`, `"fizzbuzz"` or the function argument.

The array index is a 2-bit integer, each bit being the divisilibity of the argument by 3 or 5.

```
const char *fizzbuzz(int i, char *s)
{
    static const char *fmt[] = {
        [0|(0<<1)] = "%d",
        [1|(0<<1)] = "fizz",
```

```
        [0|(1<<1)] = "buzz",
        [1|(1<<1)] = "fizzbuzz",
    };
    const int fizz = (i%3 == 0) << 0;
    const int buzz = (i%5 == 0) << 1;
    sprintf(s, fmt[fizz|buzz], i);
    return s;
}
```

12.2.3 Haskell implementation

The Haskell implementation of Fizzbuzz builds infinite lists of fizzes, buzzes and integers.

The functions `fizzbuzz` builds three infinite lists and combine them.

ns	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	...
fizzes	.	.	fizz	.	.	fizz	.	.	fizz	.	.	fizz	.	.	fizz	...
buzzes	.	.	.	.	buzz	.	.	.	.	buzz	.	.	.	.	buzz	...

$$fizzbuzz(n) = \begin{cases} fizz + buzz & \text{if } fizz \neq Nothing \vee buzz \neq Nothing \\ n & \text{if } fizz = buzz = Nothing \end{cases}$$

```
fizzbuzz :: [String]
fizzbuzz = zipWith3 combine fizzes buzzes ns
    where
        ws d w = cycle $ replicate (d-1) Nothing ++ [Just w]
        fizzes = ws 3 "fizz"
        buzzes = ws 4 "buzz" -- bug that shall be detected by the tests
        ns = show <$> [1..]
        combine f b n = fromMaybe n (f<>b)
```

12.3 Tests

The results of the Fizzbuzz executables are checked by the test script `fizzbuzz_test.lua`. This script check the fizzbuzz results and produces a Lua table with the test results. This script will later be used to build the test reports.

12.3.1 Test plan

Each fizzbuzz implementation is executed (with 50 values). The results are checked by `fizzbuzz_test.lua` and stored in a Lua table.

The fizzbuzz values are recorded in the `fizzbuzz` field of the test result table.

`TEST_API`: **number of fizzbuzz values**

`SPEC_API`: fizzbuzz command line argument

The fizzbuzz list contains 50 values.

The result of this test is recorded in the `valid_number_of_lines` field of the test result table.

`TEST_OUT`: **output on stdout**

`SPEC_OUT`: fizzbuzz output on stdout

The fizzbuzz list is emitted on stdout.

`TEST_FIZZ`: **"fizz" values**

`SPEC_FIZZ`: fizz when n is a multiple of 3 but not 5

All multiples of 3 but not 5 are `"fizz"`.

The result of this test is recorded in the `valid_fizz` field of the test result table.

`TEST_BUZZ`: **"buzz" values**

`SPEC_BUZZ`: buzz when n is a multiple of 5 but not 3

All multiples of 5 but not 3 are `"buzz"`.

The result of this test is recorded in the `valid_buzz` field of the test result table.

`TEST_FIZZBUZZ`: **"fizzbuzz" values**

`SPEC_FIZZBUZZ`: fizzbuzz n is a when multiple of 3 and 5

All multiples of 3 and 5 are `"fizzbuzz"`.

The result of this test is recorded in the `valid_fizzbuzz` field of the test result table.

`TEST_NUM`: **integral values**

`SPEC_NUM`: n when n is a not a multiple of 3 and 5

All non multiples of 3 and 5 are themselves.

The result of this test is recorded in the `valid_numbers` field of the test result table.

12.4 Test reports

12.4.1 Lua implementation

The Lua fizzbuzz function returns:

1, 2, fizz, 4, buzz, fizz, 7, 8, fizz, buzz, 11, fizz, 13, 14, fizzbuzz, 16, 17, fizz, 19, buzz, fizz, 22, 23, fizz, buzz, 26, fizz, 28, 29, fizzbuzz, 31, 32, fizz, 34, buzz, fizz, 37, 38, fizz, buzz, 41, fizz, 43, 44, fizzbuzz, 46, 47, fizz, 49, buzz

`RES_LUA_API`: **number of fizzbuzz values** [PASS]

`TEST_API`: number of fizzbuzz values

`RES_LUA_OUT`: **output on stdout** [PASS]

`TEST_OUT`: output on stdout

`RES_LUA_FIZZ`: **"fizz" values** [PASS]

`TEST_FIZZ`: "fizz" values

`RES_LUA_BUZZ`: **"buzz" values** [PASS]

`TEST_BUZZ`: "buzz" values

`RES_LUA_FIZZBUZZ`: **"fizzbuzz" values** [PASS]

`TEST_FIZZBUZZ`: "fizzbuzz" values

`RES_LUA_NUM`: **integral values** [PASS]

`TEST_NUM`: integral values

Summary: 5 / 5 tests passed

12.4.2 C implementation

The C fizzbuzz function returns:

1, 2, fizz, 4, buzz, fizz, 7, 8, fizz, buzz, 11, fizz, 13, 14, fizzbuzz, 16, 17, fizz, 19, buzz, fizz, 22, 23, fizz, buzz, 26, fizz, 28, 29, fizzbuzz, 31, 32, fizz, 34, buzz, fizz, 37, 38, fizz, buzz, 41, fizz, 43, 44, fizzbuzz, 46, 47, fizz, 49, buzz

`RES_C_API`: **number of fizzbuzz values** [PASS]

`TEST_API`: number of fizzbuzz values

`RES_C_OUT`: **output on stdout** [PASS]

`TEST_OUT`: output on stdout

`RES_C_FIZZ`: **"fizz" values** [PASS]

`TEST_FIZZ`: "fizz" values

`RES_C_BUZZ`: **"buzz" values** [PASS]

`TEST_BUZZ`: "buzz" values

`RES_C_FIZZBUZZ`: **"fizzbuzz" values** [PASS]

`TEST_FIZZBUZZ`: "fizzbuzz" values

`RES_C_NUM`: **integral values** [PASS]

`TEST_NUM`: integral values

Summary: 5 / 5 tests passed

12.4.3 Haskell implementation

The Haskell fizzbuzz function returns:

1, 2, fizz, buzz, 5, fizz, 7, buzz, fizz, 10, 11, fizzbuzz, 13, 14, fizz, buzz, 17, fizz, 19, buzz, fizz, 22, 23, fizzbuzz, 25, 26, fizz, buzz, 29, fizz, 31, buzz, fizz, 34, 35, fizzbuzz, 37, 38, fizz, buzz, 41, fizz, 43, buzz, fizz, 46, 47, fizzbuzz, 49, 50

`RES_HS_API`: **number of fizzbuzz values** [PASS]

`TEST_API`: number of fizzbuzz values

`RES_HS_OUT`: **output on stdout** [PASS]

`TEST_OUT`: output on stdout

`RES_HS_FIZZ`: **"fizz" values** [FAIL]

`TEST_FIZZ`: "fizz" values

`RES_HS_BUZZ`: **"buzz" values** [FAIL]

`TEST_BUZZ`: "buzz" values

`RES_HS_FIZZBUZZ`: **"fizzbuzz" values** [FAIL]

`TEST_FIZZBUZZ`: "fizzbuzz" values

`RES_HS_NUM`: **integral values** [FAIL]

`TEST_NUM`: integral values

Summary: 1 / 5 tests passed

12.4.4 Lua / C / Haskell comparison

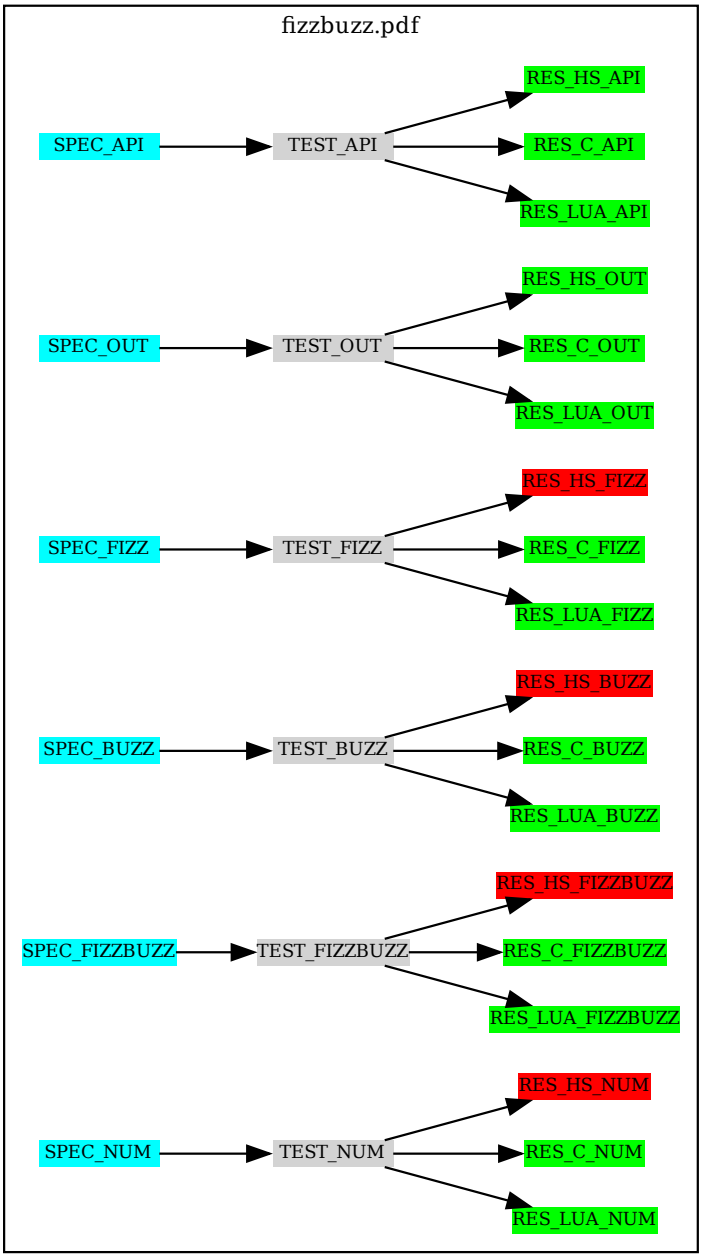
n	Lua	C	Haskell	Comparison
1	1	1	1	*OK*
2	2	2	2	*OK*
3	fizz	fizz	fizz	*OK*
4	4	4	buzz	**FAIL**
5	buzz	buzz	5	**FAIL**
6	fizz	fizz	fizz	*OK*
7	7	7	7	*OK*
8	8	8	buzz	**FAIL**
9	fizz	fizz	fizz	*OK*
10	buzz	buzz	10	**FAIL**

n	Lua	C	Haskell	Comparison
11	11	11	11	*OK*
12	fizz	fizz	fizzbuzz	**FAIL**
13	13	13	13	*OK*
14	14	14	14	*OK*
15	fizzbuzz	fizzbuzz	fizz	**FAIL**
16	16	16	buzz	**FAIL**
17	17	17	17	*OK*
18	fizz	fizz	fizz	*OK*
19	19	19	19	*OK*
20	buzz	buzz	buzz	*OK*
21	fizz	fizz	fizz	*OK*
22	22	22	22	*OK*
23	23	23	23	*OK*
24	fizz	fizz	fizzbuzz	**FAIL**
25	buzz	buzz	25	**FAIL**
26	26	26	26	*OK*
27	fizz	fizz	fizz	*OK*
28	28	28	buzz	**FAIL**
29	29	29	29	*OK*
30	fizzbuzz	fizzbuzz	fizz	**FAIL**
31	31	31	31	*OK*
32	32	32	buzz	**FAIL**
33	fizz	fizz	fizz	*OK*
34	34	34	34	*OK*
35	buzz	buzz	35	**FAIL**
36	fizz	fizz	fizzbuzz	**FAIL**
37	37	37	37	*OK*
38	38	38	38	*OK*
39	fizz	fizz	fizz	*OK*
40	buzz	buzz	buzz	*OK*
41	41	41	41	*OK*
42	fizz	fizz	fizz	*OK*
43	43	43	43	*OK*
44	44	44	buzz	**FAIL**
45	fizzbuzz	fizzbuzz	fizz	**FAIL**
46	46	46	46	*OK*
47	47	47	47	*OK*
48	fizz	fizz	fizzbuzz	**FAIL**
49	49	49	49	*OK*
50	buzz	buzz	50	**FAIL**

12.5 Coverage matrix

File	fizzbuzz.pdf
SPEC_API	fizzbuzz command line argument
SPEC_OUT	fizzbuzz output on stdout
SPEC_FIZZ	fizz when n is a multiple of 3 but not 5
SPEC_BUZZ	buzz when n is a multiple of 5 but not 3
SPEC_FIZZBUZZ	fizzbuzz n is a when multiple of 3 and 5
SPEC_NUM	n when n is a not a multiple of 3 and 5
TEST_API	number of fizzbuzz values • *SPEC_API*: fizzbuzz command line argument
TEST_OUT	output on stdout • *SPEC_OUT*: fizzbuzz output on stdout
TEST_FIZZ	"fizz" values • *SPEC_FIZZ*: fizz when n is a multiple of 3 but not 5
TEST_BUZZ	"buzz" values • *SPEC_BUZZ*: buzz when n is a multiple of 5 but not 3
TEST_FIZZBUZZ	"fizzbuzz" values • *SPEC_FIZZBUZZ*: fizzbuzz n is a when multiple of 3 and 5
TEST_NUM	integral values • *SPEC_NUM*: n when n is a not a multiple of 3 and 5
RES_LUA_API	number of fizzbuzz values [PASS] • *TEST_API*: number of fizzbuzz values
RES_LUA_OUT	output on stdout [PASS] • *TEST_OUT*: output on stdout
RES_LUA_FIZZ	"fizz" values [PASS] • *TEST_FIZZ*: "fizz" values
RES_LUA_BUZZ	"buzz" values [PASS] • *TEST_BUZZ*: "buzz" values
RES_LUA_FIZZBUZZ	"fizzbuzz" values [PASS] • *TEST_FIZZBUZZ*: "fizzbuzz" values
RES_LUA_NUM	integral values [PASS] • *TEST_NUM*: integral values
RES_C_API	number of fizzbuzz values [PASS] • *TEST_API*: number of fizzbuzz values
RES_C_OUT	output on stdout [PASS] • *TEST_OUT*: output on stdout
RES_C_FIZZ	"fizz" values [PASS] • *TEST_FIZZ*: "fizz" values
RES_C_BUZZ	"buzz" values [PASS] • *TEST_BUZZ*: "buzz" values

File	`fizzbuzz.pdf`
`RES_C_FIZZBUZZ`	"fizzbuzz" values [PASS] • *`TEST_FIZZBUZZ`*: "fizzbuzz" values
`RES_C_NUM`	integral values [PASS] • *`TEST_NUM`*: integral values
`RES_HS_API`	number of fizzbuzz values [PASS] • *`TEST_API`*: number of fizzbuzz values
`RES_HS_OUT`	output on stdout [PASS] • *`TEST_OUT`*: output on stdout
`RES_HS_FIZZ`	"fizz" values [FAIL] • *`TEST_FIZZ`*: "fizz" values
`RES_HS_BUZZ`	"buzz" values [FAIL] • *`TEST_BUZZ`*: "buzz" values
`RES_HS_FIZZBUZZ`	"fizzbuzz" values [FAIL] • *`TEST_FIZZBUZZ`*: "fizzbuzz" values
`RES_HS_NUM`	integral values [FAIL] • *`TEST_NUM`*: integral values


fizzbuzz.pdf
SPEC_API
TEST_API
RES_HS_API
RES_C_API
RES_LUA_API
SPEC_OUT
TEST_OUT
RES_HS_OUT
RES_C_OUT
RES_LUA_OUT
SPEC_FIZZ
TEST_FIZZ
RES_HS_FIZZ
RES_C_FIZZ
RES_LUA_FIZZ
SPEC_BUZZ
TEST_BUZZ
RES_HS_BUZZ
RES_C_BUZZ
RES_LUA_BUZZ
SPEC_FIZZBUZZ
TEST_FIZZBUZZ
RES_HS_FIZZBUZZ
RES_C_FIZZBUZZ
RES_LUA_FIZZBUZZ
SPEC_NUM
TEST_NUM
RES_HS_NUM
RES_C_NUM
RES_LUA_NUM

Chapter 13

References

Fizzbuzz repository: https://github.com/CDSoft/fizzbuzz

This document is not about Fizzbuzz. This document is a suggestion to simplify the build process of software projects. Fizzbuzz is just an application example.

Lua: https://www.lua.org

Lua is a powerful, efficient, lightweight, embeddable scripting language. It supports procedural programming, object-oriented programming, functional programming, data-driven programming, and data description.

Lua documentation: https://www.lua.org/manual/5.4/

The reference manual is the official definition of the Lua language.

LuaX: https://github.com/CDSoft/luax

LuaX is a Lua interpreter and REPL based on Lua 5.4, augmented with some useful packages. LuaX can also produce standalone executables from Lua scripts.

bang: https://github.com/CDSoft/bang

Bang is a Ninja file generator scriptable in LuaX.

ypp: https://github.com/CDSoft/ypp

Ypp is a minimalist and generic text preprocessor using Lua macros.

Pandoc: https://pandoc.org

Pandoc is a universal document converter. If you need to convert files from one markup format into another, pandoc is your swiss-army knife.

Pandoc manual: https://pandoc.org/MANUAL.html

Pandoc User's Guide

Pandoc's Markdown: https://pandoc.org/MANUAL.html#pandocs-markdown

Pandoc understands an extended and slightly revised version of John Gruber's Markdown syntax. This document explains the syntax, noting differences from original Markdown.

Pandoc Lua filters: https://pandoc.org/lua-filters.html

Pandoc has long supported filters, which allow the pandoc abstract syntax tree (AST) to be manipulated between the parsing and the writing phase. Traditional pandoc filters accept a JSON representation of the pandoc AST and produce an altered JSON representation of the AST. They may be written in any programming language, and invoked from pandoc using the `--filter` option.

Although traditional filters are very flexible, they have a couple of disadvantages. First, there is some overhead in writing JSON to stdout and reading it from stdin (twice, once on each side of the filter). Second, whether a filter will work will depend on details of the user's environment. A filter may require an interpreter for a certain programming language to be available, as well as a library for manipulating the pandoc AST in JSON form. One cannot simply provide a filter that can be used by anyone who has a certain version of the pandoc executable.

Starting with version 2.0, pandoc makes it possible to write filters in Lua without any external dependencies at all. A Lua interpreter (version 5.3) and a Lua library for creating pandoc filters is built into the pandoc executable. Pandoc data types are marshaled to Lua directly, avoiding the overhead of writing JSON to stdout and reading it from stdin.

Panda: https://github.com/CDSoft/panda

Panda is a Pandoc Lua filter that works on internal Pandoc's AST.

Chapter 14

Appendices

This chapter contains the sources of this document.

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<program> Copyright (C) <year> <name of author>
This program comes with ABSOLUTELY NO WARRANTY; for details type `show w'.
This is free software, and you are welcome to redistribute it under certain conditions; type `show c' for details.

```
The hypothetical commands `show w' and `show c' should show the appropriate
parts of the General Public License.  Of course, your program's commands
might be different; for a GUI interface, you would use an "about box".

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Public License instead of this License.  But first, please read
<https://www.gnu.org/licenses/why-not-lgpl.html>.
```

14.2 fizzbuzz.md

```
---
title: Fizz buzz - LuaX demo
date: @DATE
author: @AUTHOR
keywords:
    - Lua
    - Script
    - Documentation
    - Tests
    - Build system

titlepage: true

caption-justification: raggedright

toc-own-page: true

listings-disable-line-numbers: false
listings-no-page-break: true
disable-header-and-footer: false

footnotes-pretty: true
footnotes-disable-backlinks: true

book: true
```

```
classoption: oneside

titlepage-logo: "{{logo}}"
logo-width: 60mm

table-use-row-colors: true

code-block-font-size: "\\small"
---

```meta
logo = os.getenv "LOGO"
```

Disclaimer

This document is not about [Fizzbuzz](https://en.wikipedia.org/wiki/Fizz_buzz).
This document is a suggestion to simplify the build process of software
projects, a demo of an **homogeneous and consistent** development and
documentation environment. Fizzbuzz is just an application example.

Links

- [fizzbuzz_slideshow.pdf](http://cdelord.fr/fizzbuzz/fizzbuzz_slideshow.pdf): PDF slidesho
- [fizzbuzz.pdf](http://cdelord.fr/fizzbuzz/fizzbuzz.pdf): PDF demonstration (specification
- github.com/CDSoft/fizzbuzz: Sources

{width=50%}

Introduction

Lots of software projects involve various tools, free as well as commercial, to
build the software, run the tests, produce the documentation, ... These tools
use different data formats and scripting languages, which makes the projects
less scalable and harder to maintain.

Sharing data between configuration files, documentations, tests results can
then be painful and counter productive (the necessary glue is often more
complex than the tools themselves).

Usually people script their build systems and processes with languages like
Bash, Python, Javascript and make them communicate with plain text, YAML, JSON,
XML, CSV, INI, TOML. Every script shall rely on specific (existing or not)
libraries to read and write these data formats.
```

```
This document presents a commun and powerful data format and some tools to
script the build process of a project and generate documentation.

To sum up the suggested solution is:

- a **single data format**
- and a **reduced set of highly configurable tools**.

# Lua[^lua]

[Lua](https://www.lua.org) is the perfect candidate for both a
common data format and a script language.

## What is Lua?

Lua is a powerful, efficient, lightweight, embeddable scripting language. It
supports procedural programming, object-oriented programming, functional
programming, data-driven programming, and data description.

Lua combines simple procedural syntax with powerful data description constructs
based on associative arrays and extensible semantics. Lua is dynamically typed,
runs by interpreting bytecode with a register-based virtual machine, and has
automatic memory management with incremental garbage collection, making it
ideal for configuration, scripting, and rapid prototyping.

[^lua]: from <https://www.lua.org/about.html>

## Why choose Lua?

**Lua is a proven, robust language**

Lua has been used in many industrial applications (e.g., Adobe's Photoshop
Lightroom), with an emphasis on embedded systems (e.g., the Ginga middleware
for digital TV in Brazil) and games (e.g., World of Warcraft and Angry Birds).
Lua is currently the leading scripting language in games. Lua has a solid
reference manual and there are several books about it. Several versions of Lua
have been released and used in real applications since its creation in 1993.
Lua featured in HOPL III, the Third ACM SIGPLAN History of Programming
Languages Conference, in 2007. Lua won the Front Line Award 2011 from the Game
Developers Magazine.

**Lua is fast**

Lua has a deserved reputation for performance. To claim to be "as fast as Lua"
is an aspiration of other scripting languages. Several benchmarks show Lua as
```

```
the fastest language in the realm of interpreted scripting languages. Lua is
fast not only in fine-tuned benchmark programs, but in real life too.
Substantial fractions of large applications have been written in Lua.

**Lua is portable**

Lua is distributed in a small package and builds out-of-the-box in all
platforms that have a standard C compiler. Lua runs on all flavors of Unix and
Windows, on mobile devices (running Android, iOS, BREW, Symbian, Windows
Phone), on embedded microprocessors (such as ARM and Rabbit, for applications
like Lego MindStorms), on IBM mainframes, etc.

**Lua is powerful (but simple)**

A fundamental concept in the design of Lua is to provide meta-mechanisms for
implementing features, instead of providing a host of features directly in the
language. For example, although Lua is not a pure object-oriented language, it
does provide meta-mechanisms for implementing classes and inheritance. Lua's
meta-mechanisms bring an economy of concepts and keep the language small, while
allowing the semantics to be extended in unconventional ways.

**Lua is small**

Adding Lua to an application does not bloat it. The tarball for Lua 5.4,
which contains source code and documentation, takes 353K compressed and 1.3M
uncompressed. The source contains around 30000 lines of C. Under 64-bit Linux,
the Lua interpreter built with all standard Lua libraries takes 281K and the
Lua library takes 468K.

**Lua is free**

Lua is free open-source software, distributed under a very liberal license (the
well-known MIT license). It may be used for any purpose, including commercial
purposes, at absolutely no cost. Just download it and use it.

# LuaX

[LuaX](https://github.com/CDSoft/luax) is a Lua interpreter and REPL based on
Lua 5.4, augmented with some useful packages. LuaX can also produce
standalone executables from Lua scripts.

LuaX runs on several platforms with no dependency:

- Linux (x86_64, i386, aarch64)
- MacOS (x86_64, aarch64)
```

```
- Windows (x86_64, i386)

LuaX can cross-compile scripts from and to any of these platforms.

LuaX comes with a standard Lua interpreter and provides some libraries (embedded
in a single executable, no external dependency required):

- [LuaX interactive usage](https://github.com/CDSoft/luax/blob/master/doc/repl.md): improve
- [F](https://github.com/CDSoft/luax/blob/master/doc/F.md): functional programming inspired
- [fs](https://github.com/CDSoft/luax/blob/master/doc/fs.md): file system management
- [sh](https://github.com/CDSoft/luax/blob/master/doc/sh.md): shell command execution
- [mathx](https://github.com/CDSoft/luax/blob/master/doc/mathx.md): complete math library f
- [imath](https://github.com/CDSoft/luax/blob/master/doc/imath.md): arbitrary precision int
- [qmath](https://github.com/CDSoft/luax/blob/master/doc/qmath.md): rational number library
- [complex](https://github.com/CDSoft/luax/blob/master/doc/complex.md): math library for co
- [ps](https://github.com/CDSoft/luax/blob/master/doc/ps.md): Process management module
- [sys](https://github.com/CDSoft/luax/blob/master/doc/sys.md): System module
- [crypt](https://github.com/CDSoft/luax/blob/master/doc/crypt.md): cryptography module
- [lz4](https://github.com/CDSoft/luax/blob/master/doc/lz4.md): Extremely Fast Compression
- [lpeg](https://github.com/CDSoft/luax/blob/master/doc/lpeg.md): Parsing Expression Gramma
- [linenoise](https://github.com/CDSoft/luax/blob/master/doc/linenoise.md): light readline
- [luasocket](https://github.com/CDSoft/luax/blob/master/doc/luasocket.md): Network support
- [inspect](https://github.com/CDSoft/luax/blob/master/doc/inspect.md): Human-readable repr

More information here: <http://cdelord.fr/luax>

# Scripting with LuaX

LuaX can be used as a general programming language.
There are plenty of [good documentations for Lua](https://www.lua.org/docs.html)
and [LuaX](http://cdelord.fr/luax).

A big advantage of Lua is the usage of Lua tables as a common data format usable by various
It is Human-readable and structured. It can be generated by Lua scripts but also by any soft

Typical usages are:

- project/software configuration
    - a Lua table can be used to describe a project or a software configuration
        - read by an embedded Lua interpreter
        - used to generate documentation or source code
- tests results
    - a test suite can generate test results as a Lua table
    - tests results can be used to render documentation (tests reports) and compute a test c
```

```
The next chapters present some tools written in Lua/LuaX or using Lua as a scripting engine.

# Bang

[Bang](https://github.com/CDSoft/bang) is a ninja file generator scriptable in
LuaX, a Lua interpreter with a bunch of useful modules (file management,
functional programming module, basic cryptography, ...). It takes a build
description (a LuaX script) and generates a Ninja file.

Bang provides functions to generate ninja primitives (variables, rules, build
statements, ...) and some extra features:

- rule/build statement pairs described in a single function call
- file listing and filenames list management using LuaX modules (e.g. F and fs)
- pipe simulation using rule composition
- "clean", "install" and "help" targets

Bang comes with an example that shows how to use bang and LuaX functions to:

- discover source files actually present in the repository: no redundant hard
  coded file lists (redundancy means painful maintenance)
- cross-compile the same sources for multiple platforms: compilation for several
  platforms without any dirty copy/paste
- describe static libraries: in the `lib` directory, each sub-directory is
  a library compiled and archived in its own `.a` file
- describe executables: in the `bin` directory, each C source file is the main
  file of a binary containing this C file as well as libraries from the `lib`
  directory.

Bang is currently used to build bang itself but also LuaX and some projects
available on my [GitHub](https://github.com/CDSoft).

# Ypp

Ypp is a minimalist and generic text preprocessor using Lua macros.

Ypp is compiled by LuaX, i.e. Lua and LuaX functions and modules are available
in macros.

More information here: <http://cdelord.fr/ypp>

Ypp is pretty simple. It searches for Lua expressions and replaces macros with their results

?(false)
```

````
Macro       Result
----------- ------------------------------------------------------------------------
`@(...)`    Evaluates the Lua expression `...` and replaces the macro by its result
`@@(...)`   Executes the Lua chunk `...` and replaces the macro by its result (if not `nil`

Some expression do not require parentheses (function calls).

?(true)

## Example

?(false)

``````{.markdown}
$$
\sum_{i=1}^{100} i^2 = @F.range(100):map(function(x) return x*x end):sum()
$$
``````

?(true)

is rendered as

> $$
> \sum_{i=1}^{100} i^2 = @F.range(100):map(function(x) return x*x end):sum()
> $$

Macros can also define variables reusable later by other macros.

?(false)
``````{.markdown}
@@[[
    local foo = 42
    N = foo * 23 + 34
    local function sq(x) return x*x end
    function sumsq(n) return F.range(N):map(sq):sum() end
]]
``````
?(true)

@@[[
    local foo = 42
    N = foo * 23 + 34
    local function sq(x) return x*x end
    function sumsq(n) return F.range(N):map(sq):sum() end
````

```
]]

defines `N` ($N = @N$) which can be read in a Lua expression or with ?(false)`@N`?(true)
and `sumsq` which computes the sum of squares.

Then

?(false)

``````{.markdown}
$$
\sum_{i=1}^{@N} i^2 = @sumsq(N)
$$
``````

?(true)

becomes

> $$
> \sum_{i=1}^{@N} i^2 = @sumsq(N)
> $$

Pandoc

[Pandoc](https://pandoc.org/) is a swiss-army knife to convert from and to a
bunch of document formats.

A big advantage of Pandoc is the ability to use Lua scripts to define custom
readers and writers for unsupported formats and also Lua filters to manipulate
the pandoc abstract syntax tree (AST). This is the main pandoc feature
exercised in this document.

Pandoc has an excellent documentation:

- main pandoc documentation: <https://pandoc.org/MANUAL.html>
- Lua filter documentation: <https://pandoc.org/lua-filters.html>

Fizzbuzz uses pandoc Lua filters with Panda (see next chapter) which bundles
some useful filters in a single script.

Panda

Panda is a [Pandoc Lua filter](https://pandoc.org/lua-filters.html) that works
on internal Pandoc's AST.
```

````
It provides several interesting features:

- variable expansion (minimalistic templating)
- conditional blocks
- file inclusion (e.g. for source code examples)
- script execution (e.g. to include the result of a command)
- diagrams (Graphviz, PlantUML, ditaa, Asymptote, blockdiag, mermaid...)

The documentation of Panda is here: <http://cdelord.fr/panda>

## Examples

There are lots of examples in the documentation of panda. We will see here two of them.

**Documentation extraction from source code**

The source code can be documented by adding special marks in comments. The documentation sha

For instance, the following C source contains documentation that can be extracted and includ

``````{.c include=deep_thought.c}

``````

To extract the documentation, panda provides a macro to replace a `div` element by the docu

`````` markdown
:::{doc=deep_thought.c}
:::
``````

will be replaced by:

> :::{doc=deep_thought.c}
> :::

Diagrams

Diagrams can be embedded in Pandoc documents. Diagrams are specified as code
blocks and are replaced by an image by panda.

``` meta
_dot = "{{dot}}"
_gnuplot = "{{gnuplot}}"
```
````

````
    ```{.dot render="{{_dot}}" width=67%}
    digraph {
        rankdir=LR;
        input -> pandoc -> output
        pandoc -> panda -> {pandoc, diagrams}
        { rank=same; pandoc, panda }
        { rank=same; diagrams, output }
    }
    ```

```{.dot render="{{dot}}" name=example-graphviz width=67%}
digraph {
    rankdir=LR;
    input -> pandoc -> output
    pandoc -> panda -> {pandoc, diagrams}
    { rank=same; pandoc, panda }
    { rank=same; diagrams, output }
}
```

    ```{render="{{_gnuplot}}" width=67%}
    set xrange [-pi:pi]
    set yrange [-1.5:1.5]
    plot sin(x) lw 4, cos(x) lw 4
    ```

```{render="{{gnuplot}}" name=example-gnuplot width=67%}
set xrange [-pi:pi]
set yrange [-1.5:1.5]
plot sin(x) lw 4, cos(x) lw 4
```

# hey

`hey` is a shell script. It is intended to easily install some tools based on
LuaX and Pandoc to pre-process files and generate documents, using Lua as a
common, simple and powerful scripting language.

## Example

Easy installation, only `hey` is needed:

``` sh
wget https://raw.githubusercontent.com/CDSoft/hey/master/hey
```
````

````
Its usage is very similar to `apt` or `dnf`:

``` sh
$ hey list
@sh "hey list"
```

``` sh
$ hey install all
...
```

# Fizzbuzz

Fizzbuzz is a concrete example of the usage of LuaX/ypp/pandoc/panda to specify
and test a software.

## Specification

From [Wikipedia](https://en.wikipedia.org/wiki/Fizz_buzz):

> Fizz buzz is a group word game for children to teach them about division.
> Players take turns to count incrementally, replacing any number divisible by
> three with the word "fizz", and any number divisible by five with the word
> "buzz".

`fizzbuzz` is a function that returns `"fizz"`, `"buzz"`, `"fizzbuzz"` or `n` for any posit

$$
    fizzbuzz : \mathbb{N}^+ \to \{fizz, buzz, fizzbuzz\} \cup \mathbb{N}^+
$$
$$
    fizzbuzz(n) =
        \begin{cases}
            \text{"fizzbuzz" }  & \text{if } (3|n) \land (5|n) \\
            \text{"fizz" }      & \text{if } (3|n) \land \lnot (5|n) \\
            \text{"buzz" }      & \text{if } (5|n) \land \lnot (3|n) \\
            n                   & \text{if } \lnot (3|n) \land \lnot (5|n) \\
        \end{cases}
$$

@@[[
    function fizzbuzz(n)
        if n % 15 == 0 then return "fizzbuzz" end
        if n % 3 == 0 then return "fizz" end
````

```
        if n % 5 == 0 then return "buzz" end
        return n
    end
]]

### Requirements

@req "SPEC_API: fizzbuzz command line argument"

The fizzbuzz program takes one argument that specify the number for fizzbuzz
values to generate.

@req "SPEC_OUT: fizzbuzz output on stdout"

The fizzbuzz program emits fizzbuzz values on the standard output.
Each line contains `n` and `fizzbuzz(n)`.

e.g.:

```
$ fizzbuzz 6
@F.range(6):map(function(n) return F{n, fizzbuzz(n)}:str "\t" end)
```

@req "SPEC_FIZZ: fizz when n is a multiple of 3 but not 5"

If `n` is a multiple of 3 but not 5, then `fizzbuzz(n)` is `"fizz"`.

@req "SPEC_BUZZ: buzz when n is a multiple of 5 but not 3"

If `n` is a multiple of 5 but not 3, then `fizzbuzz(n)` is `"buzz"`.

@req "SPEC_FIZZBUZZ: fizzbuzz n is a when multiple of 3 and 5"

If `n` is a multiple of 3 and 5, then `fizzbuzz(n)` is `"fizzbuzz"`.

@req "SPEC_NUM: n when n is a not a multiple of 3 and 5"

If `n` is a multiple of 3 and 5, then `fizzbuzz(n)` is `"fizzbuzz"`.

Examples

@[[
    {
        "n | fizzbuzz(n) | n | fizzbuzz(n) | n | fizzbuzz(n) | n | fizzbuzz(n) ",
```

```
        "---|-------------|---|-------------|---|-------------|---|-------------",
    }
    ..
    F.range(5):map(function(n)
        return F{
            n,      fizzbuzz(n),
            n+5,    fizzbuzz(n+5),
            n+10,   fizzbuzz(n+10),
            n+15,   fizzbuzz(n+15),
        }:str "|"
    end)
]]

## Implementation

### Lua implementation

:::{doc=fizzbuzz.lua shift=3}
:::

### C implementation

:::{doc=fizzbuzz.c shift=3}
:::

### Haskell implementation

:::{doc=fizzbuzz.hs shift=3}
:::

## Tests

The results of the Fizzbuzz executables are checked by the test script `fizzbuzz_test.lua`.
This script check the fizzbuzz results and produces a Lua table with the test results.
This script will later be used to build the test reports.

### Test plan

@@( test_cfg = require "test_config" )

Each fizzbuzz implementation is executed (with @test_cfg.N values). The results are
checked by `fizzbuzz_test.lua` and stored in a Lua table.

The fizzbuzz values are recorded in the `fizzbuzz` field of the test result table.
```

```
@req "TEST_API: number of fizzbuzz values" {
    refs = "SPEC_API",
}

The fizzbuzz list contains @test_cfg.N values.

The result of this test is recorded in the `valid_number_of_lines` field of the test result

@req "TEST_OUT: output on stdout" {
    refs = "SPEC_OUT",
}

The fizzbuzz list is emitted on stdout.

@req "TEST_FIZZ: \"fizz\" values" {
    refs = "SPEC_FIZZ",
}

All multiples of 3 but not 5 are `"fizz"`.

The result of this test is recorded in the `valid_fizz` field of the test result table.

@req "TEST_BUZZ: \"buzz\" values" {
    refs = "SPEC_BUZZ",
}

All multiples of 5 but not 3 are `"buzz"`.

The result of this test is recorded in the `valid_buzz` field of the test result table.

@req "TEST_FIZZBUZZ: \"fizzbuzz\" values" {
    refs = "SPEC_FIZZBUZZ",
}

All multiples of 3 and 5 are `"fizzbuzz"`.

The result of this test is recorded in the `valid_fizzbuzz` field of the test result table.

@req "TEST_NUM: integral values" {
    refs = "SPEC_NUM",
}

All non multiples of 3 and 5 are themselves.

The result of this test is recorded in the `valid_numbers` field of the test result table.
```

```
## Test reports

### Lua implementation

@@(lua_tests = require "result_lua")

The Lua fizzbuzz function returns:

@F.str(lua_tests.fizzbuzz, ", ")

@req.test "RES_LUA_API: number of fizzbuzz values" {
    refs = "TEST_API",
    status = lua_tests.valid_number_of_lines,
}

@req.test "RES_LUA_OUT: output on stdout" {
    refs = "TEST_OUT",
    status = lua_tests.valid_number_of_lines,
}

@req.test "RES_LUA_FIZZ: \"fizz\" values" {
    refs = "TEST_FIZZ",
    status = lua_tests.valid_fizz,
}

@req.test "RES_LUA_BUZZ: \"buzz\" values" {
    refs = "TEST_BUZZ",
    status = lua_tests.valid_buzz,
}

@req.test "RES_LUA_FIZZBUZZ: \"fizzbuzz\" values" {
    refs = "TEST_FIZZBUZZ",
    status = lua_tests.valid_fizzbuzz,
}

@req.test "RES_LUA_NUM: integral values" {
    refs = "TEST_NUM",
    status = lua_tests.valid_numbers,
}

**Summary**: @lua_tests.nb_pass / @lua_tests.nb tests passed

### C implementation

@@(c_tests = require "result_c")
```

```
The C fizzbuzz function returns:

@F.str(c_tests.fizzbuzz, ", ")

@req.test "RES_C_API: number of fizzbuzz values" {
    refs = "TEST_API",
    status = c_tests.valid_number_of_lines,
}

@req.test "RES_C_OUT: output on stdout" {
    refs = "TEST_OUT",
    status = c_tests.valid_number_of_lines,
}

@req.test "RES_C_FIZZ: \"fizz\" values" {
    refs = "TEST_FIZZ",
    status = c_tests.valid_fizz,
}

@req.test "RES_C_BUZZ: \"buzz\" values" {
    refs = "TEST_BUZZ",
    status = c_tests.valid_buzz,
}

@req.test "RES_C_FIZZBUZZ: \"fizzbuzz\" values" {
    refs = "TEST_FIZZBUZZ",
    status = c_tests.valid_fizzbuzz,
}

@req.test "RES_C_NUM: integral values" {
    refs = "TEST_NUM",
    status = c_tests.valid_numbers,
}

**Summary**: @c_tests.nb_pass / @c_tests.nb tests passed

### Haskell implementation

@@(hs_tests = require "result_hs")

The Haskell fizzbuzz function returns:

@F.str(hs_tests.fizzbuzz, ", ")

@req.test "RES_HS_API: number of fizzbuzz values" {
```

```
    refs = "TEST_API",
    status = hs_tests.valid_number_of_lines,
}

@req.test "RES_HS_OUT: output on stdout" {
    refs = "TEST_OUT",
    status = hs_tests.valid_number_of_lines,
}

@req.test "RES_HS_FIZZ: \"fizz\" values" {
    refs = "TEST_FIZZ",
    status = hs_tests.valid_fizz,
}

@req.test "RES_HS_BUZZ: \"buzz\" values" {
    refs = "TEST_BUZZ",
    status = hs_tests.valid_buzz,
}

@req.test "RES_HS_FIZZBUZZ: \"fizzbuzz\" values" {
    refs = "TEST_FIZZBUZZ",
    status = hs_tests.valid_fizzbuzz,
}

@req.test "RES_HS_NUM: integral values" {
    refs = "TEST_NUM",
    status = hs_tests.valid_numbers,
}

**Summary**: @hs_tests.nb_pass / @hs_tests.nb tests passed

### Lua / C / Haskell comparison

@[[
    {
        "n  | Lua | C | Haskell | Comparison",
        "---|-----|---|---------|-----------",
    } .. F.zip {
        lua_tests.fizzbuzz,
        c_tests.fizzbuzz,
        hs_tests.fizzbuzz,
    }:mapi(function (i, res)
        local expected = tostring(fizzbuzz(i))
        local ok = res:all(F.partial(F.op.eq, expected))
        return ({i}..res..{ok and "*OK*" or "**FAIL**"}):str "|"
```

```
    end)
]]

## Coverage matrix

@req.matrix "g"

```{.dot render="{{dot}}" name=coverage-matrix}
@req.dot()
```

References

@@[[
    link = F.curry(function(name, url)
        return F.I{name=name, url=url}"[**$(name)**]($(url)): <$(url)>\n"
    end)
]]

@link "Fizzbuzz repository" "https://github.com/CDSoft/fizzbuzz"
> This document is not about Fizzbuzz. This document is a suggestion to
> simplify the build process of software projects. Fizzbuzz is just an
> application example.

@link "Lua" "https://www.lua.org"
> Lua is a powerful, efficient, lightweight, embeddable scripting language. It
> supports procedural programming, object-oriented programming, functional
> programming, data-driven programming, and data description.

@link "Lua documentation" "https://www.lua.org/manual/5.4/"
> The reference manual is the official definition of the Lua language.

@link "LuaX" "https://github.com/CDSoft/luax"
> LuaX is a Lua interpreter and REPL based on Lua 5.4, augmented with some
> useful packages. LuaX can also produce standalone executables from Lua
> scripts.

@link "bang" "https://github.com/CDSoft/bang"
> Bang is a Ninja file generator scriptable in LuaX.

@link "ypp" "https://github.com/CDSoft/ypp"
> Ypp is a minimalist and generic text preprocessor using Lua macros.

@link "Pandoc" "https://pandoc.org"
> Pandoc is a universal document converter. If you need to convert files from
```

```
> one markup format into another, pandoc is your swiss-army knife.

@link "Pandoc manual" "https://pandoc.org/MANUAL.html"
> Pandoc User's Guide

@link "Pandoc's Markdown" "https://pandoc.org/MANUAL.html#pandocs-markdown"
> Pandoc understands an extended and slightly revised version of John Gruber's
> Markdown syntax. This document explains the syntax, noting differences from
> original Markdown.

@link "Pandoc Lua filters" "https://pandoc.org/lua-filters.html"
> Pandoc has long supported filters, which allow the pandoc abstract syntax
> tree (AST) to be manipulated between the parsing and the writing phase.
> Traditional pandoc filters accept a JSON representation of the pandoc AST and
> produce an altered JSON representation of the AST. They may be written in any
> programming language, and invoked from pandoc using the `--filter` option.
>
> Although traditional filters are very flexible, they have a couple of
> disadvantages. First, there is some overhead in writing JSON to stdout and
> reading it from stdin (twice, once on each side of the filter). Second,
> whether a filter will work will depend on details of the user's environment.
> A filter may require an interpreter for a certain programming language to be
> available, as well as a library for manipulating the pandoc AST in JSON form.
> One cannot simply provide a filter that can be used by anyone who has a
> certain version of the pandoc executable.
>
> Starting with version 2.0, pandoc makes it possible to write filters in Lua
> without any external dependencies at all. A Lua interpreter (version 5.3) and
> a Lua library for creating pandoc filters is built into the pandoc
> executable. Pandoc data types are marshaled to Lua directly, avoiding the
> overhead of writing JSON to stdout and reading it from stdin.

@link "Panda" "https://github.com/CDSoft/panda"
> Panda is a Pandoc Lua filter that works on internal Pandoc's AST.

::::::{.if output_file=".build/fizzbuzz.pdf"}

# Appendices

This chapter contains the sources of this document.

## LICENSE

```{.markdown include=LICENSE}
```
```

````
## fizzbuzz.md

```{.markdown include=fizzbuzz.md}
```

## project_data.lua

```{.lua include=project_data.lua}
```

## fizzbuzz.lua

```{.lua include=fizzbuzz.lua}
```

## fizzbuzz.c

```{.c include=fizzbuzz.c}
```

## fizzbuzz.hs

```{.hs include=fizzbuzz.hs}
```

## test_config.lua

```{.lua include=test_config.lua}
```

## fizzbuzz_test.lua

```{.lua include=fizzbuzz_test.lua}
```

## build.lua

```{.lua include=build.lua}
```

::::::
````

14.3 project_data.lua

```
AUTHOR = "Christophe Delord - <http://cdelord.fr/fizzbuzz>"
DATE = os.date("%a %b %e, %Y", sh "git log -1 --format=%ct")
```

14.4 fizzbuzz.lua

```
#!/usr/bin/env luax

--[[@@@

The Lua implementation of Fizzbuzz is based on a functional style,
using function compositions.

It computes the `"fizz"` and `"buzz"` parts and return them
if at least one of them is not `nil`{.lua}.
Otherwise it returns its argument unchanged.

```{ .dot render="{{dot}}" name=fizzbuzz-lua width=100% }
digraph {

n [label="n" shape=oval]

compute_fizz [label="\"fizz\"\nif n = 0 (mod 3)" shape=box]
compute_buzz [label="\"buzz\"\nif n = 0 (mod 5)" shape=box]
combine [label="combine" shape=box]
select [label="Choose\n\"fizz\", \"buzz\", \"fizzbuzz\"\nor n" shape=box]

fizz [label="\"fizz\" or nil" shape=oval]
buzz [label="\"buzz\" or nil" shape=oval]
fizzbuzz [label="\"fizz\", \"buzz\", \"fizzbuzz\"\nor nil" shape=oval]
fizzbuzz_n [label="\"fizz\", \"buzz\", \"fizzbuzz\"\nor n" shape=oval]

n -> compute_fizz -> fizz -> combine
n -> compute_buzz -> buzz -> combine
n -> select
combine -> fizzbuzz -> select
select -> fizzbuzz_n

{ rank=same; combine, fizzbuzz, select }

}
```
```

```
```{.lua include="fizzbuzz.lua" pattern="%-%-%s*fizzbuzz%s*{%s*(.-)%s*%-%-%s*}" format="%1"}
```
@@@]]

local F = require "F"

-- fizzbuzz {

local function div(d, s, n)
    return n % d == 0 and s or nil
end

local fizz = F.partial(div, 3, "fizz")
local buzz = F.partial(div, 5, "buzz")

local function combine(a, b)
    return a and (a..(b or "")) or b
end

local function fizzbuzz(n)
    return combine(fizz(n), buzz(n)) or n
end

-- }

local n = tonumber(arg[1])
assert(n, tostring(arg[1])..": not a number")

F.range(n)
    : map(fizzbuzz)
    : foreachi(print)
```

14.5 fizzbuzz.c

```
/*@@@

The C implementation of Fizzbuzz uses an array of string formats
used by `sprintf`{.c} to produce `"fizz"`, `"buzz"`, `"fizzbuzz"`
or the function argument.

The array index is a 2-bit integer, each bit being the divisilibity
of the argument by 3 or 5.

```{.c include="fizzbuzz.c" pattern="[c]onst.-%b{}"}
```
```

```
```
@@@*/

#include <stdio.h>
#include <stdlib.h>
#include <string.h>

static const char *fizzbuzz(int i, char *s)
{
    static const char *fmt[] = {
        [0|(0<<1)] = "%d",
        [1|(0<<1)] = "fizz",
        [0|(1<<1)] = "buzz",
        [1|(1<<1)] = "fizzbuzz",
    };
    const int fizz = (i%3 == 0) << 0;
    const int buzz = (i%5 == 0) << 1;
    sprintf(s, fmt[fizz|buzz], i);
    return s;
}

int main(int argc, const char *argv[])
{
    if (argc != 2)
    {
        fprintf(stderr, "argument expected\n");
        exit(1);
    }
    const int n = atoi(argv[1]);
    char s[64];
    for (int i = 1; i <= n; i++)
    {
        printf("%d\t%s\n", i, fizzbuzz(i, s));
    }
    return EXIT_SUCCESS;
}
```

## 14.6 fizzbuzz.hs

```
{-@@@

The Haskell implementation of Fizzbuzz builds infinite lists
of fizzes, buzzes and integers.
```
```

```
The functions `fizzbuzz` builds three infinite lists and combine them.

ns      1     2     3     4     5     6     7     8     9     10    11    12    13    14
------- ----- ----- ----- ----- ----- ----- ----- ----- ----- ----- ----- ----- ----- -----
fizzes  .     .     fizz  .     .     fizz  .     .     fizz  .     .     fizz  .     .
buzzes  .     .     .     .     buzz  .     .     .     .     buzz  .     .     .     .

$$
fizzbuzz(n) =
    \begin{cases}
        fizz + buzz     & \text{if } fizz \ne Nothing \lor buzz \ne Nothing \\
        n               & \text{if } fizz = buzz = Nothing \\
    \end{cases}
$$

```{.hs include="fizzbuzz.hs" pattern="%-%-%s*fizzbuzz%s*{%s*(.-)%s*%-%-%s*}" format="%1"}
```
@@@-}

import Control.Monad
import Data.Maybe
import System.Environment

-- fizzbuzz {

fizzbuzz :: [String]
fizzbuzz = zipWith3 combine fizzes buzzes ns
    where
        ws d w = cycle $ replicate (d-1) Nothing ++ [Just w]
        fizzes = ws 3 "fizz"
        buzzes = ws 4 "buzz" -- bug that shall be detected by the tests
        ns = show <$> [1..]
        combine f b n = fromMaybe n (f<>b)

-- }

main :: IO ()
main = do
    n <- read . head <$> getArgs
    forM_ (zip [1..n] fizzbuzz) $ \(i, s) ->
        putStrLn $ show i ++ "\t" ++ s
```

14.7 test_config.lua

```
return {
    N = 50, -- number of fizzbuzz values to test
}
```

14.8 fizzbuzz_test.lua

```
#!/usr/bin/env luax

local F = require "F"
local fs = require "fs"

local result_file = arg[1]
local N = tonumber(arg[2])

assert(result_file and N, "Wrong arguments")

local indices, fizzbuzzes = fs.read(result_file)
    : lines()
    : map(string.words)
    : unzip()
indices = indices:map(tonumber)

local tests = F{}

-- fizzbuzz list used to render the test results
tests.fizzbuzz = fizzbuzzes

-------------------------------------------------------------------------------
-- The number of line shall be N
-------------------------------------------------------------------------------

tests.valid_number_of_lines =
    #indices == N and #fizzbuzzes == N
    and F.op.ueq(indices, F.range(N))

-------------------------------------------------------------------------------
-- Multiples of 3 but not 5 are "fizz"
-------------------------------------------------------------------------------

tests.valid_fizz =
    fizzbuzzes
        : filteri(function(i, _) return i%3 == 0 and i%5 ~= 0 end)
```

```
        : all(F.partial(F.op.eq, "fizz"))

-------------------------------------------------------------------------------
-- Multiples of 5 but not 3 are "buzz"
-------------------------------------------------------------------------------

tests.valid_buzz =
    fizzbuzzes
        : filteri(function(i, _) return i%3 ~= 0 and i%5 == 0 end)
        : all(F.partial(F.op.eq, "buzz"))

-------------------------------------------------------------------------------
-- Multiples of 3 and 5 are "fizzbuzz"
-------------------------------------------------------------------------------

tests.valid_fizzbuzz =
    fizzbuzzes
        : filteri(function(i, _) return i%3 == 0 and i%5 == 0 end)
        : all(F.partial(F.op.eq, "fizzbuzz"))

-------------------------------------------------------------------------------
-- Non multiples of 3 and 5 are themselves
-------------------------------------------------------------------------------

tests.valid_numbers =
    fizzbuzzes
        : mapi(function(i, s)
            return i%3 == 0 or i%5 == 0 or F.read(s) == i
        end)
        : land()

-------------------------------------------------------------------------------
-- Statistics
-------------------------------------------------------------------------------

local results = tests
    : filtert(function(res) return type(res) == "boolean" end)
    : values()

tests.nb = #results
tests.nb_pass = #results:filter(F.partial(F.op.eq, true))
tests.nb_fail = #results:filter(F.partial(F.op.eq, false))

-------------------------------------------------------------------------------
-- Format test results
```

```
-------------------------------------------------------------------------------

print("--[[ Fizzbuzz output")
print("indices", F.show(indices))
print("fizzbuzzes", F.show(fizzbuzzes))
print("]]")

print("return", F.show(tests, {indent=4}))
```

14.9 build.lua

```
local F = require "F"

-------------------------------------------------------------------------------
section "Project directories"
-------------------------------------------------------------------------------

var "builddir" ".build"
var "img" "img"

clean "$builddir"

local all = {}
require "atexit"(function() default(all) end)

-------------------------------------------------------------------------------
section "Help"
-------------------------------------------------------------------------------

help.description "Fizzbuzz build system"
help "all" "compile, test and document FizzBuzz"

-------------------------------------------------------------------------------
section "Tests"
-------------------------------------------------------------------------------

local test_config = require "test_config"

rule "run_test" {
    command = { "$in", test_config.N, "> $out" }
}

section "Lua test"
```

```
acc(all) {
    build "$builddir/tests/fizzbuzz_lua" { "fizzbuzz.lua",
        command = "luax -q -o $out $in",
    },
    build "$builddir/tests/fizzbuzz_lua.txt" {
        "run_test", "$builddir/tests/fizzbuzz_lua",
    },
}

section "C test"

acc(all) {
    build "$builddir/tests/fizzbuzz_c" { "fizzbuzz.c",
        command = "gcc $in -o $out",
    },
    build "$builddir/tests/fizzbuzz_c.txt" {
        "run_test", "$builddir/tests/fizzbuzz_c",
    },
}

section "Haskell test"

acc(all) {
    build "$builddir/tests/fizzbuzz_hs" { "fizzbuzz.hs",
        command = "ghc -outputdir ${out}_tmp $in -o $out",
    },
    build "$builddir/tests/fizzbuzz_hs.txt" {
        "run_test", "$builddir/tests/fizzbuzz_hs",
    },
}

section "Test results"

rule "check" {
    command = { "luax", "$in", test_config.N, "> $out" }
}

acc(all) {
    F"lua c hs":words():map(function(lang)
        return build("$builddir/tests/result_"..lang..".lua") { "check",
            "fizzbuzz_test.lua",
            "$builddir/tests/fizzbuzz_"..lang..".txt",
        }
    end)
}
```

```
-------------------------------------------------------------------------------
section "Documentation"
-------------------------------------------------------------------------------

local env = {
    'export LUA_PATH="$builddir/tests/?.lua;./?.lua";',
    'export REQDB="$builddir/reqdb.lua";',
    'export REQTARGET="fizzbuzz.pdf";',
}

local ypp_flags = {
    "-p .",
    "-l project_data",
    "-l req",
}

rule "ypp" {
    command = { env, "ypp", ypp_flags, "--MD --MF $depfile", "$in -o $out" },
    depfile = "$builddir/dependencies/$out.d",
}

local pandoc_flags = {
    "--table-of-content",
}

local html_flags = {
    pandoc_flags,
    "--to html5",
    "--css", "$$PANDOC_USER_DATA_DIRECTORY/panam.css",
    "--embed-resources --standalone",
    "--mathml",
}

rule "panda_html" {
    command = {
        env,
        "export PANDA_TARGET=$out;",
        "export PANDA_DEP_FILE=$depfile;",
        "export LOGO=$logo_html;",
        "export PANDOC_USER_DATA_DIRECTORY=`pandoc -v | awk -F': *' '$$1==\"User data direct
        "panda", html_flags, "$in -o $out",
    },
    depfile = "$builddir/dependencies/$out.d",
    implicit_in = {
        "$logo_html",
```

```
    },
}

local pdf_flags = {
    pandoc_flags,
    "--number-sections",
    "--highlight-style tango",
    "--top-level-division=chapter",
}

rule "panda_pdf" {
    command = {
        env,
        "export PANDA_TARGET=$out;",
        "export PANDA_DEP_FILE=$depfile;",
        "export LOGO=$logo_pdf;",
        "panda", pdf_flags, "$in -o $out",
    },
    depfile = "$builddir/dependencies/$out.d",
    implicit_in = {
        "$logo_pdf",
    },
}

local markdown_flags = {
    pandoc_flags,
    "--to gfm",
    "--number-sections",
    "--highlight-style tango",
    "--top-level-division=chapter",
}

rule "panda_gfm" {
    command = {
        env,
        "export PANDA_TARGET=$out;",
        "export PANDA_DEP_FILE=$depfile;",
        "export LOGO=$logo_html;",
        "panda", markdown_flags, "$in -o $out",
    },
    depfile = "$builddir/dependencies/$out.d",
    implicit_in = {
        "$logo_html",
    },
}
```

```
local beamer_flags = {
    "--to beamer",
    "-V theme:Madrid",
    "-V colortheme:default",
}

rule "panda_beamer" {
    command = {
        env,
        "export PANDA_TARGET=$out;",
        "export PANDA_DEP_FILE=$depfile;",
        "export LOGO=$logo_pdf;",
        "panda", beamer_flags, "$in -o $out",
    },
    depfile = "$builddir/dependencies/$out.d",
    implicit_in = {
        "$logo_pdf",
    },
}

var "logo_pdf" "$builddir/logo.pdf"
var "logo_html" "$img/logo.svg"

rule "lsvg" { command = "lsvg $in $out" }

acc(all) {
    build "$logo_pdf"  { "lsvg", "logo.lua" },
    build "$logo_html" { "lsvg", "logo.lua" },
}

local fizzbuzz_md = build "$builddir/fizzbuzz.md" { "ypp", "fizzbuzz.md",
    implicit_in = {
        "$builddir/tests/result_lua.lua",
        "$builddir/tests/result_c.lua",
        "$builddir/tests/result_hs.lua",
    },
}
acc(all) {
    build "$builddir/fizzbuzz.html" { "panda_html", fizzbuzz_md },
    build "$builddir/fizzbuzz.pdf"  { "panda_pdf",  fizzbuzz_md },
    build "README.md"               { "panda_gfm",  fizzbuzz_md },
}

acc(all) {
    build("$builddir/fizzbuzz_slideshow.pdf") { "panda_beamer",
```

```
        build "$builddir/fizzbuzz_slideshow.md" { "ypp", "fizzbuzz_slideshow.md" }
    }
}
```