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Programming Elixir

Functional |> Concurrent |> Pragmatic |> Fun

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The
Pragmatic
Programmers

Programming Elixir

Functional

|> Concurrent

|> Pragmatic

|> Fun

Dave Thomas

Foreword by
José Valim,
Creator of Elixir

edited by Lynn Beighley



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Printed in the United States of America.

ISBN-13: 978-1-937785-58-1

Encoded using the finest acid-free high-entropy binary digits.

Book version: P1.0—October, 2014

A Vain Attempt at a Justification

I'm a language nut. I love trying languages out, and I love thinking about their design and implementation. (I know; it's sad.)

I came across Ruby in 1998 because I was an avid reader of `comp.lang.misc` (ask your parents). I downloaded it, compiled it, and fell in love. As with any time you fall in love, it's difficult to explain why. It just worked the way I work, and it had enough depth to keep me interested.

Fast-forward 15 years. All that time I'd been looking for something new that gave me the same feeling.

I came across Elixir a while back, but for some reason never got sucked in. But a few months before starting this book, I was chatting with Corey Haines. I was bemoaning the fact that I wanted a way to show people functional programming concepts without the academic trappings those books seem to attract. He told me to look again at Elixir. I did, and I felt the same way I felt when I first saw Ruby.

So now I'm dangerous. I want other people to see just how great this is. I want to evangelize. So my first step is to write a book.

But I don't want to write another 900-page Pickaxe book. I want this book to be short and exciting. So I'm not going into all the detail, listing all the syntax, all the library functions, all the OTP options, or....

Instead, I want to give you an idea of the power and beauty of this programming model. I want to inspire you to get involved, and then point to the online resources that will fill in the gaps.

But mostly, I want you to have fun.

Acknowledgments

It seems to be a common thread—the languages I fall in love with are created by people who are both clever and extremely nice. José Valim, the creator of Elixir, takes both of these adjectives to a new level. I owe him a massive thank-you for giving me so much fun over the last 18 months. Along with him, the whole Elixir core team has done an amazing job of cranking out an entire ecosystem that feels way more mature than its years. Thank you, all.

A conversation with Corey Haines reignited my interest in Elixir—thank you, Corey, for good evenings, some interesting times in Bangalore, and the inspiration.

Bruce Tate is always an interesting sounding board, and his comments on early drafts of the book made a big difference. And I've been blessed with an incredible number of active and insightful beta readers who have made literally hundreds of suggestions for improvements. Thank you, all.

A big tip of the hat to Jessica Kerr, Anthony Eden, and Chad Fowler for letting me steal their tweets.

Candace Cunningham copy edited the book. Among the hundreds of grammatical errors she also found errors in some of the code. Bless her.

The crew at Potomac did their customary stellar job of indexing.

Susannah Pfalzer was a voice of sanity throughout the project (as she is in so many of our Bookshelf projects), and Janet Furlow kept us all honest.

Finally, this is the first time I've written a book with an editor who works down at the prose level. It's been a fantastic experience, as Lynn Beighley has taken what I felt was finished text and systematically shown me the error of my assumptions. The book is way better for her advice. Thank you.

Dave Thomas

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Dallas, TX, October 2014

Take the Red Pill

The Elixir programming language wraps functional programming with immutable state and an actor-based approach to concurrency in a tidy, modern syntax. And it runs on the industrial-strength, high-performance, distributed Erlang VM. But what does all that mean?

It means you can stop worrying about many of the difficult things that currently consume your time. You no longer have to think too hard about protecting your data consistency in a multithreaded environment. You worry less about scaling your applications. And, most importantly, you can think about programming in a different way.

Programming Should Be About Transforming Data

If you come from an object-oriented world, then you are used to thinking in terms of classes and their instances. A class defines behavior, and objects hold state. Developers spend time coming up with intricate hierarchies of classes that try to model their problem, much as Victorian gentleman scientists created taxonomies of butterflies.

When we code with objects, we're thinking about state. Much of our time is spent calling methods in objects and passing them other objects. Based on these calls, objects update their own state, and possibly the state of other objects. In this world, the class is king—it defines what each instance can do, and it implicitly controls the state of the data its instances hold. Our goal is data-hiding.

But that's not the real world. In the real world, we don't want to model abstract hierarchies (because in reality there aren't that many true hierarchies). We want to get things done, not maintain state.

Right now, for instance, I'm taking empty computer files and transforming them into files containing text. Soon I'll transform those files into a format you can read. A web server somewhere will transform your request to download the book into an HTTP response containing the content.

I don't want to hide data. I want to transform it.

Combine Transformations with Pipelines

Unix users are used to the philosophy of small, focused command-line tools that can be combined in arbitrary ways. Each tool takes an input, transforms it, and writes the result in a format that the next tool (or a human) can use.

This philosophy is incredibly flexible and leads to fantastic reuse. The Unix utilities can be combined in ways undreamed of by their authors. And each one multiplies the potential of the others.

It's also highly reliable—each small program does one thing well, which makes it easier to test.

There's another benefit. A command pipeline can operate in parallel. If I write

```
$ grep Elixir *.pml | wc -l
```

the word-count program, `wc`, runs at the same time as the `grep` command. Because `wc` consumes `grep`'s output as it is produced, the answer is ready with virtually no delay once `grep` finishes.

Just to give you a taste of this kind of thing, here's an Elixir function called `pmap`. It takes a collection and a function, and returns the list that results from applying that function to each element of the collection. But...it runs a separate process to do the conversion of each element. Don't worry about the details for now.

```
spawn/pmap1.exs
defmodule Parallel do
  def pmap(collection, func) do
    collection
    |> Enum.map(&(Task.async(fn -> func.(&1) end)))
    |> Enum.map(&Task.await/1)
  end
end
```

We could run this function to get the squares of the numbers from 1 to 1000.

```
result = Parallel.pmap 1..1000, &(&1 * &1)
```

And, yes, I just kicked off 1,000 background processes, and I used all the cores and processors on my machine.

The code may not make much sense, but by about halfway through the book, you'll be writing this kind of thing for yourself.

Functions Are Data Transformers

Elixir lets us solve the problem in the same way the Unix shell does. Rather than have command-line utilities, we have functions. And we can string them together as we please. The smaller—more focused—those functions, the more flexibility we have when combining them.

If we want, we can make these functions run in parallel—Elixir has a simple but powerful mechanism for passing messages between them. And these are not your father's boring old processes or threads—we're talking about the potential to run millions of them on a single machine and have hundreds of these machines interoperating. Bruce Tate commented on this paragraph with this thought: "Most programmers treat threads and processes as a necessary evil; Elixir developers feel they are an important simplification." As we get deeper into the book, you'll start to see what he means.

This idea of transformation lies at the heart of functional programming: a function transforms its inputs into its output. The trigonometric function \sin is an example—give it $\pi/4$, and you'll get back 0.7071.... An HTML templating system is a function; it takes a template containing placeholders and a list of named values, and produces a completed HTML document.

But this power comes at a price. You're going to have to unlearn a whole lot of what you *know* about programming. Many of your instincts will be wrong. And this will be frustrating, because you're going to feel like a total n00b.

Personally, I feel that's part of the fun.

You didn't learn, say, object-oriented programming overnight. You are unlikely to become a functional programming expert by breakfast, either.

But at some point things will click. You'll start thinking about problems in a different way, and you'll find yourself writing code that does amazing things with very little effort on your part. You'll find yourself writing small chunks of code that can be used over and over, often in unexpected ways (just as `wc` and `grep` can be).

Your view of the world may even change a little as you stop thinking in terms of responsibilities and start thinking in terms of getting things done.

And just about everyone can agree that will be fun.

Installing Elixir

The most up-to-date instructions for installing Elixir are available at http://elixir-lang.org/getting_started/1.html. Go install it now.

Running Elixir

In this book, I show a terminal session like this:

```
$ echo Hello, World
Hello, World
```

The terminal prompt is the dollar sign, and the stuff you type follows. (On your system, the prompt will likely be different.) Output from the system is shown without highlighting.

iex—Interactive Elixir

To test that your Elixir installation was successful, let's start an interactive Elixir session. At your regular shell prompt, type iex.

```
$ iex
Erlang/OTP 17 [erts-6.0] [source] [64-bit] [smp:4:4] [async-threads:10]
      [hipe] [kernel-poll:false]

Interactive Elixir (x.y.z) - press Ctrl+C to exit (type h() ENTER for help)
iex(1)>
```

(The various version numbers you see will likely be different—I won't bother to show them on subsequent examples.)

Once you have an iex prompt, you can enter Elixir code and you'll see the result. If you enter an expression that continues over more than one line, iex will prompt for the additional lines with an ellipsis (...).

```
iex(1)> 3 + 4
7
iex(2)> String.reverse "madamimadam"
"madamimadam"
iex(3)> 5 *
...(3)> 6
30
iex(4)>
```

The number in the prompt increments for each complete expression executed. I'll omit the number in most of the examples that follow.

There are several ways of exiting from iex—none are tidy. The easiest two are typing **Ctrl-C** twice or typing **Ctrl-G** followed by **q** and **Return**.

IEx Helpers

iex has a number of helper functions. Type `h` (followed by return) to get a list:

```
iex> h
```

```
# IEx.Helpers
```

```
Welcome to Interactive Elixir. You are currently seeing the documentation
for the module IEx.Helpers which provides many helpers to make Elixir's
shell more joyful to work with.
```

```
This message was triggered by invoking the helper `h()`, usually referred
as `h/0` (since it expects 0 arguments).
```

There are many other helpers available:

```
* `c/2`      - compiles a file at the given path
* `cd/1`     - changes the current directory
* `clear/0`  - clears the screen
* `flush/0`  - flushes all messages sent to the shell
* `h/0`      - prints this help
* `h/1`      - prints help for the given module, function or macro
* `l/1`      - loads the given module's beam code and purges the current version
* `ls/0`     - lists the contents of the current directory
* `ls/1`     - lists the contents of the specified directory
* `pwd/0`    - prints the current working directory
* `r/0`      - recompile and reload all modules that were previously reloaded
* `r/1`      - recompiles and reloads the given module's source file
* `respawn/0` - respawns the current shell
* `s/1`      - prints spec information
* `t/1`      - prints type information
* `v/0`      - prints the history of commands evaluated in the session
* `v/1`      - retrieves the nth value from the history
* `import_file/1` - evaluates the given file in the shell's context
```

Help for functions in this module can be consulted directly from the command line, as an example, try:

```
h(c/2)
```

You can also retrieve the documentation for any module or function. Try these:

```
h(Enum)
h(Enum.reverse/1)
```

In the list of helper functions, the number following the slash is the number of arguments the helper expects.

Probably the most useful is `h` itself. With an argument, it gives you help on Elixir modules or individual functions in a module. This works for any modules

loaded into iex (so when we talk about projects later on, you'll see your own documentation here, too).

For example, the IO module performs common I/O functions. For help on the module, type `h(IO)` or `h IO`.

```
iex> h IO      # or...
iex> h(IO)
```

Functions handling IO.

Many functions in this module expects an IO device as argument. An IO device must be a PID or an atom representing a process. For convenience, Elixir provides `:stdio` and `:stderr` as shortcuts to Erlang's `:standard_io` and `:standard_error`....

This book frequently uses the `puts` function in the IO module, which in its simplest form writes a string to the console. Let's get the documentation.

```
iex> h IO.puts

* def puts(device \\ group_leader(), item)
```

Writes the argument to the device, similarly to `write` but adds a new line at the end. The argument is expected to be a `chardata`.

iex is a surprisingly powerful tool. You can use it to compile and execute entire projects, log in to remote machines, and access already-running Elixir applications.

Customizing iex

You can customize iex by setting options. For example, I like showing the results of evaluations in bright cyan. To find out how to do that, I used this:

```
iex> h IEx.configure
def configure(options)
```

Configures IEx.

The supported options are: `:colors`, `:inspect`, `:default_prompt`, `:alive_prompt` and `:history_size`.

Colors

A keyword list that encapsulates all color settings used by the shell. See documentation for the `IO.ANSI` module for the list of supported colors and attributes.

The value is a keyword list. List of supported keys:

- `:enabled` - boolean value that allows for switching the coloring on and off
- `:eval_result` - color for an expression's resulting value
- `:eval_info` - ... various informational messages
- `:eval_error` - ... error messages
- `:stack_app` - ... the app in stack traces
- `:stack_info` - ... the remaining info in stack traces
- `:ls_directory` - ... for directory entries (ls helper)
- `:ls_device` - ... device entries (ls helper)

This is an aggregate option that encapsulates all color settings used by the shell. See documentation for the `IO.ANSI` module for the list of supported colors and attributes.

. . .

I then created a file called `.iex.exs` in my home directory, containing:

```
IEx.configure colors: [ eval_result: [ :cyan, :bright ] ]
```

If your `iex` session looks messed up (and things such as `[33m` appear in the output), it's likely your console does not support ANSI escape sequences. In that case, disable colorization using

```
IEx.configure colors: [enabled: false]
```

You can put any Elixir code into `.iex.exs`.

Compile and Run

Once you tire of writing one-line programs in `iex`, you'll want to start putting code into source files. These files will typically have the extension `.ex` or `.exs`. This is a convention—files ending in `.ex` are intended to be compiled into bytecodes and then run, whereas those ending in `.exs` are more like programs in scripting languages—they are effectively interpreted at the source level. When we come to write tests for our Elixir programs, you'll see that the application files have `.ex` extensions, whereas the tests have `.exs` because we don't need to keep compiled versions of the tests lying around.

Let's write the classic first program. Go to a working directory and create a file called `hello.exs`.

```
intro/hello.exs
```

```
IO.puts "Hello, World!"
```

The previous example shows how most of the code listings in this book are presented. The bar before the code itself shows the path and file name that contains the code. If you're reading an ebook, you'll be able to click on this

to download the source file. You can also download all the code by visiting the book's page on our site and clicking on the *Source Code* link.¹



Source file names are written in lowercase with underscores. They will have the extension `.ex` for programs that you intend to compile into binary form, and `.exs` for scripts that you want to run without compiling. Our “Hello, World” example is essentially throw-away code, so we used the `.exs` extension for it.

Having created our source file, let's run it. In the same directory where you created the file, run the `elixir` command:

```
$ elixir hello.exs
Hello, World!
```

We can also compile and run it inside `iex` using the `c` helper:

```
$ iex
iex> c "hello.exs"
Hello, World!
[]
iex>
```

The `c` helper compiled and executed the source file. (The `[]` that follows the output is the return value of the `c` function—if the source file had contained any modules, their names would have been listed here.)

The `c` helper compiled the source file as freestanding code. You can also load a file as if you'd typed each line into `iex` using `import_file`. In this case, local variables set in the file are available in the `iex` session.

As some folks fret over such things, the Elixir convention is to use two-column indentation and spaces (not tabs).

Suggestions for Reading the Book

This book is not a top-to-bottom reference guide to Elixir. Instead, it is intended to give you enough information to know what questions to ask and when to ask them. So approach what follows with a spirit of adventure. Try the code as you read, and don't stop there. Ask yourself questions and then try to answer them, either by coding or searching the Web.

1. <http://pragprog.com/titles/elixir>

Participate in the book's discussion forums and consider joining the Elixir mailing list.^{2,3}

You're joining the Elixir community while it is still young. Things are exciting and dynamic, and there are plenty of opportunities to contribute.

Exercises

You'll find exercises sprinkled throughout the book. If you're reading an ebook, then each exercise will link directly to a topic in our online forums. There you'll find an initial answer, along with discussions of alternatives from readers of the book.

If you're reading this book on paper, visit the forums to see the list of exercise topics.⁴

Think Different(ly)

This is a book about thinking differently; about accepting that some of the things folks say about programming may not be the full story:

- Object orientation is not the only way to design code.
- Functional programming need not be complex or mathematical.
- The foundations of programming are not assignments, if statements, and loops.
- Concurrency does not need locks, semaphores, monitors, and the like.
- Processes are not necessarily expensive resources.
- Metaprogramming is not just something tacked onto a language.
- Even if it is work, programming should be fun.

Of course, I'm not saying Elixir is a magic potion (well, technically it is, but you know what I mean). There isn't the *one true way* to write code. But Elixir is different enough from the mainstream that learning it will give you more perspective and it will open your mind to new ways of thinking about programming.

So let's start.

And remember to make it fun.

2. <http://forums.pragprog.com/forums/elixir>

3. <https://groups.google.com/forum/?fromgroups#!forum/elixir-lang-talk>

4. <http://forums.pragprog.com/forums/322>