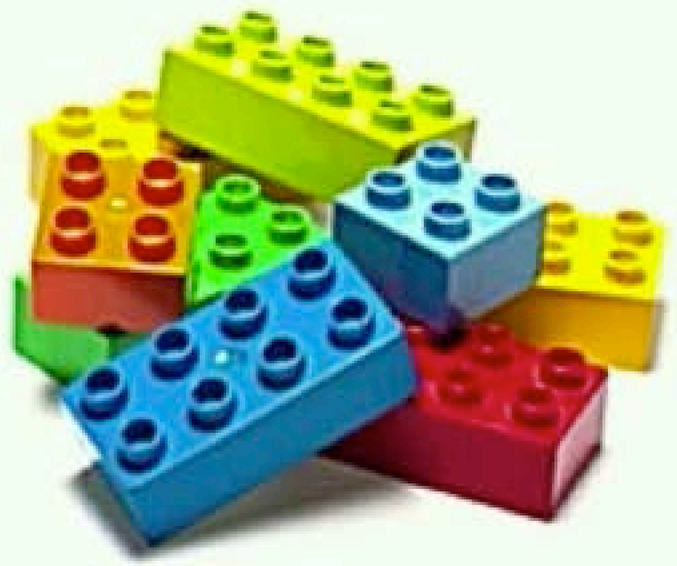
Metaprogramming Elixir

@chris_mccord

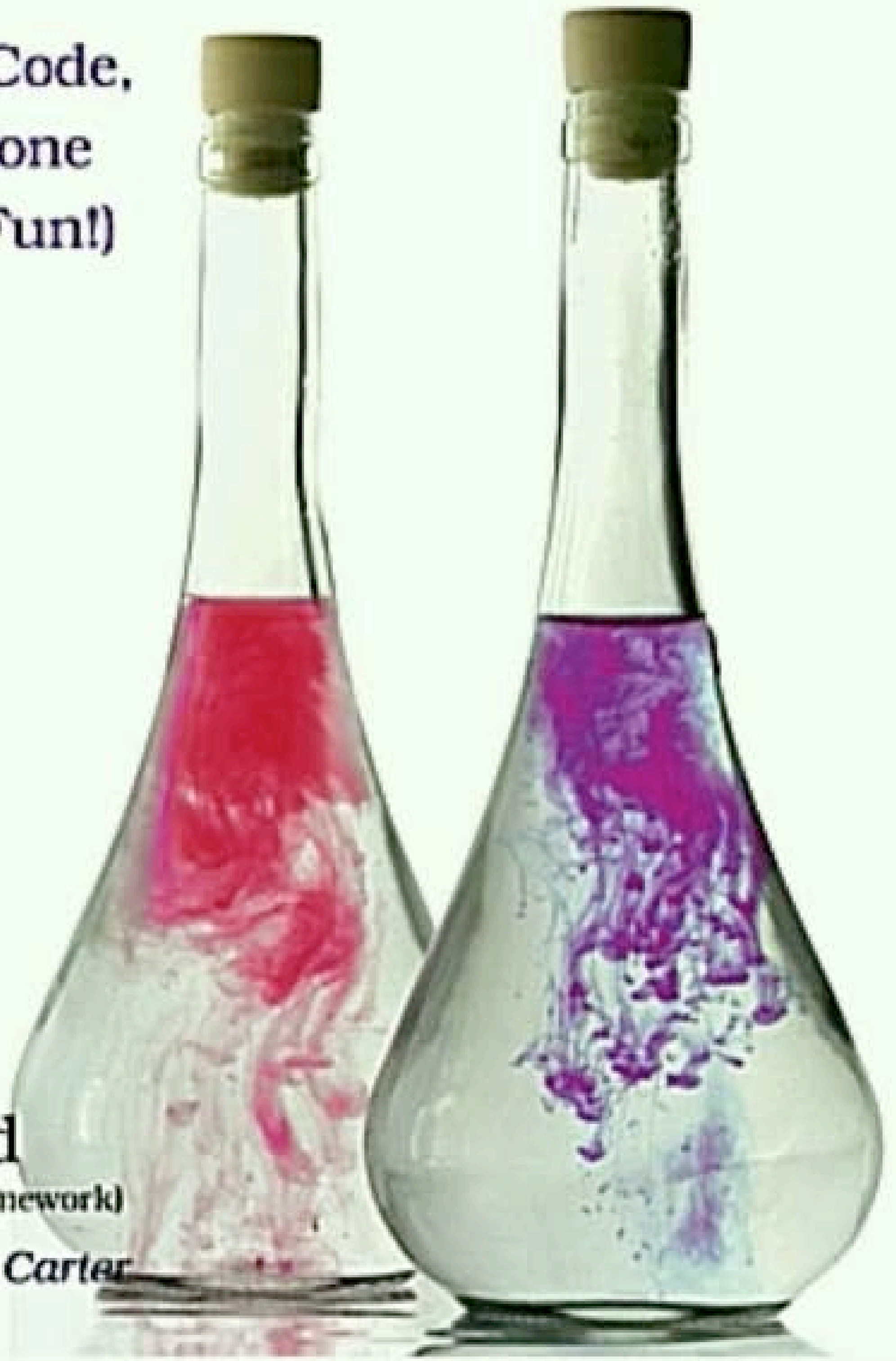


The Pragmatic Programmers

Pragmatic exPress

Metaprogramming Elixir

Write Less Code, Get More Done (and Have Fun!)



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The rules of macros

#1 Don’t write macros.

#2 Use macros gratuitously

Topics

- What is metaprogramming / macros
- What makes Elixir different
- Real-world usecases
  - Phoenix
  - Ecto
  - String.Unicode
  - MIME type matching

Metaprogramming in Elixir

- Code that writes code at compile time, with macros
- Inspects and generates Elixir code representation
- "code representation" - Abstract Syntax Tree (AST)

What is it good for?

- Extending the language to your needs
- Optimizations
  - Performance
  - Boilerplate removal
- DSLs - Domain Specific Languages

Macros

- Carry out metaprogramming in Elixir
- Produce Elixir ASTs

```elixir
defmodule Notifier do

  def ping(pid) do
    if Process.alive?(pid) do
      Logger.debug "Sending ping!"
      send pid, :ping
    end
  end

end
```

Elixir's AST

- Represented as a tree of three element tuples
  - First element is an atom representing a function, or another tuple
  - Second element is metadata
  - Third element is the arguments to the function
- `quote` returns AST of any expression

```
quote do: 5 + 2

{:+, _, [5, 2]}
```

Function Metadata Arguments

```
quote do: 5 + 2

{:+, _, [5, 2]}
(+ 5 2)
```

```
quote do: (5 * 2) - 1 + 7
```

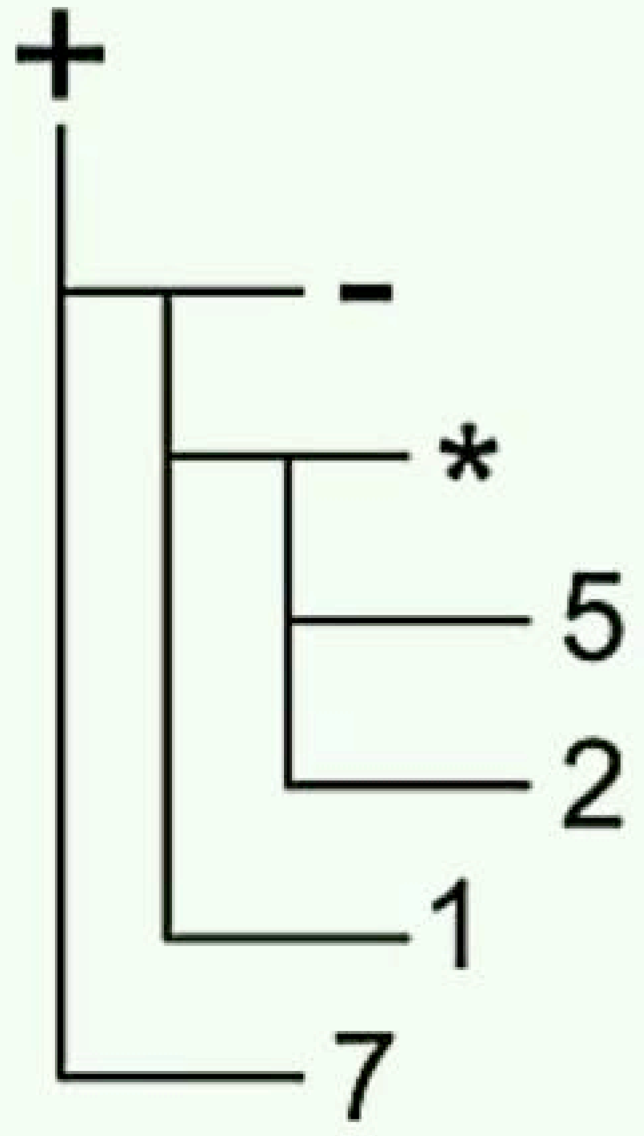
```
{:+, [],
 [{:-, [],
   [{:*, [], [5, 2]}, 1]}, 7]}
```

```
quote do: (5 * 2) - 1 + 7
```

```
{:+, [],
 [{:-, [],
   [{:*, [], [5, 2]}, 1]}, 7]}
```

```
(+ (- (* 5 2) 1) 7)
```

```elixir
quote do: (5 * 2) - 1 + 7
```



```
{:+, […],
  [{:-, […],
    [{:*, […], [5,
                2]},
    1]},
  7]}
```

```
defmodule MathTest do
  use ExUnit.Case

  test "maths" do
    assert 1 + 2 == 5
  end
end
```

```
quote do: 1 == 2
```

```
{:==, _, [1, 2]}
```

```
1) test maths (MathTest)
   iex:20
   Assertion with == failed
   code: 1 == 2
   lhs:  1
   rhs:  2
```

```
quote do: 1 == 2
{:==, _, [1, 2]}

quote do: 5 > 10
{:> _, [5, 10]}
```

```
{operator, _meta, [lhs, rhs]}
```

```elixir
defmodule Assertion do
  defmacro assert({op _, [lhs, rhs]}) do
    quote do
      Assertion.__perform__(unquote(op),
                            unquote(lhs),
                            unquote(rhs))
    end
  end

  def __perform__(:==, lhs, rhs) when lhs == rhs do
    IO.write "."
  end
  def __perform__(:==, lhs, rhs) do
    IO.puts """
    FAILURE:
      expected: #{inspect lhs}
      to equal: #{inspect lhs}
    """
  end
  # ...
end
```

```
defmodule MathTest do
  import Assertion

  def run do
    assert 5 > 2
    assert 1 + 1 == 2
    assert 5 == 6
  end
end

iex> MathTest.run()
..FAILURE:
  expected: 5
  to equal: 6
```

Macro Expansion

```
assert 5 > 2
assert 1 + 1 == 2
assert 5 == 6
```

$$\downarrow$$

```
Assertion.__perform__(:>, 5, 2)
Assertion.__perform__(:==, 1 + 1, 2)
Assertion.__perform__(:==, 5, 6)
```

```
unless user.banned? do
  deliver_message()
end
```

expand ↓

```
if(user.banned?) do
  nil
else
  deliver_message()
end
```

expand ↓

```
case user.banned? do
  x when x in [false, nil] ->
    deliver_message()
  _ ->
    nil
end
```

	Macro?
unless	✓
if	✓
case	✗

Language Extension

Parallel for comprehension

```
for user <- users do
  calculate_user_salary(user)
end

parallel(for user <- users do
  calculate_user_salary(user)
end)
```

```elixir
quote do
  for user <- users do
    calculate_user_salary(user)
  end
end

{:for, [],
 [{:<-, [], [{:user, [], Elixir},
             {:users, [], Elixir}]},
  [do: {:calculate_user_salary, [],
    [{:user, [], Elixir}]}]]}
```

Real-world usecases

Ecto

```
from u in User,
    where: u.age > ^min_age,
order_by: [asc: u.age],
   limit: 10,
  select: u
```

```elixir
defmodule User do
  use Ecto.Model

  schema "users" do
    field :age,  :integer
    field :name, :string
  end
end
```

Phoenix Framework

Routing DSL

```elixir
defmodule Router do
  scope "/" do
    get "/", PageController, :index
    get "/pages/:page", PageController, :show
    post "/files/", FilesController, :create
    resources "/messages", MessageController
  end
end
```

Pattern-matched Route Dispatch

```
defmodule Router do
  def match(conn, "GET", [])
  def match(conn, "GET", ["pages", page])
  def match(conn, "POST", ["files"])
  def match(conn, "GET", ["messages"])
  def match(conn, "GET", ["messages", "new"])
  def match(conn, "GET", ["messages", id, "edit"])
  def match(conn, "POST", ["messages"])
  def match(conn, "PUT", ["messages", id])
  def match(conn, "DELETE", ["messages", id])
end
```

Generated Route Helpers

```
get "/", PageController, :index
get "/pages/:page", PageController, :show
post "/files/", FilesController, :create
resources "/messages", MessageController
```

```
iex> Router.Helpers.page_path(Endpoint, :show, "about")
"/pages/about"

iex> Router.Helpers.page_url(Endpoint, :show, "about")
"http://example.com/pages/about"

iex> Router.Helpers.message_path(Endpoint, :show, 123)
"/messages/123"
```

Precompiled Views

```
defmodule Chat.MessageView do
  use Chat.Web, :view

  def render("show.html", %{msg: msg}) do
    "Showing a message! ..."
  end
end
```

```
iex> View.render(MessageView, "show.html", %{msg: msg})
"Showing a message!"
```

web/templates/message/index.html.eex

```
<h1>Listing Messages</h1>

<%= for msg <- @messages do %>
<tr>
  <td><%= msg.body %></td>
  <td><%= msg.room_id %></td>
  <td>
    <%= link "Show", to: msg_path(@conn, :show, msg) %>
    <%= link "Edit", to: msg_path(@conn, :edit, msg) %>
  </td>
</tr>
<% end %>
```

Advanced Code Generation

- Turn datasets into code
- Eliminate Boilerplate
- Optimize Performance

String.Unicode

```
irb> "José".upcase
"JOSé"

iex> String.upcase("José")
"JOSÉ"
```

/lib/elixir/unicode/UnicodeData.txt

```
0041;LATIN CAPITAL LETTER A;Lu;0;L;;;;;N;;;
0042;LATIN CAPITAL LETTER B;Lu;0;L;;;;;N;;;
0043;LATIN CAPITAL LETTER C;Lu;0;L;;;;;N;;;
0044;LATIN CAPITAL LETTER D;Lu;0;L;;;;;N;;;
1F680;ROCKET;So;0;ON;;;;;N;;;;;
1F681;HELICOPTER;So;0;ON;;;;;N;;;;;
1F682;STEAM LOCOMOTIVE;So;0;ON;;;;;N;;;;;
1F683;RAILWAY CAR;So;0;ON;;;;;N;;;;;
1F684;HIGH-SPEED TRAIN;So;0;ON;;;;;N;;;;;
```

27,000 lines of unicode mappings

```elixir
defmodule String.Unicode do

  data_path = Path.join(__DIR__, "UnicodeData.txt")

  {codes, whitespace} = Enum.reduce File.stream!(data_path),
    #...
  end

  def upcase(string), do: upcase(string, "")

  for {codepoint, upper, _lower, _title} <- codes,
    upper && upper != codepoint do
    defp upcase(unquote(codepoint) <> rest, acc) do
      upcase(rest, acc <> unquote(upper))
    end
  end

  defp upcase(<<char, rest :: binary>>, acc) do
    upcase(rest, <<acc::binary, char>>)
  end
  defp upcase("", acc), do: acc
  # ...
end
```

```
defp upcase("é" <> rest, acc) do
  upcase(rest, acc <> "É")
end

defp upcase("ć" <> rest, acc) do
  upcase(rest, acc <> "Ć")
end

defp upcase("🚀" <> rest, acc) do
  upcase(rest, acc <> "🚀")
end
```

MIME-Type conversion in 10 LOC

mimes.txt

```
application/javascript  .js
application/json              .json
image/jpeg          .jpeg, .jpg
video/jpeg          .jpgv
```

~ 685 mime types

MIME-Type conversion in 10 LOC

```elixir
defmodule MIME do
  for line <- File.stream!(Path.join([__DIR__, "mimes.txt"]), [], :line) do
    [type, rest] = line |> String.split("\t") |> Enum.map(&String.strip(&1))
    extensions = String.split(rest, ~r/,\s?/)

    def exts_from_type(unquote(type)), do: unquote(extensions)
    def type_from_ext(ext) when ext in unquote(extensions), do: unquote(type)
  end

  def exts_from_type(_type), do: []
  def type_from_ext(_ext), do: nil
  def valid_type?(type), do: exts_from_type(type) |> Enum.any?
end
```

```
iex> MIME.exts_from_type("image/jpeg")
[".jpeg", ".jpg"]

iex> MIME.type_from_ext(".jpg")
"image/jpeg"

iex> MIME.valid_type?("text/html")
true

iex> MIME.valid_type?("text/emoji")
false
```

HTML DSL

```
markup do
  div do
    h1 "Latest Post"
  end
  div class: "row" do
    p post.body
    if post.published? do
      span "Posted #{post.publish_date}"
    end
  end
end
"<div><h1>Latest Post</h1></div>
<div class=\"row\"><p></p></div>"
```

```elixir
defmodule Hub do
  "https://api.github.com/users/chrismccord/repos"
  |> HTTPotion.get(["User-Agent": "Elixir"])
  |> Map.get(:body)
  |> Poison.decode!()
  |> Enum.each(fn repo ->
    def unquote(String.to_atom(repo["name"]))() do
      unquote(Macro.escape(repo))
    end
  end)

  def go(repo) do
    url = apply(__MODULE__, repo, [])["html_url"]
    System.cmd("open", [url])
  end
end
```

Recap

- ~~Don't write macros~~
- Use macros responsibly
- Don't be afraid to be a little irresponsible why you're learning
- Extend the language
- Have fun.

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#elixir-lang freenode

www.elixir-lang.org

https://pragprog.com/book/cmelixir/metaprogramming-elixir