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Introduction to Monads in Ruby

Do not fear, Monads are here

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Functors

Functors

Functor is simply something that can be mapped over and returns something else of the same type.

Functors

Ruby's example of Functor is an Array.

```ruby
[1,2,3,4,5].map { |i| i.to_s } # => ['1','2','3','4','5']
```

Mapping over array returns new array with computed values.

```
[Integer] -> [String]
```

In more generic way we can read this as *"apply a function from x to y, to an array of x, which will result in array of y"*

```
[x] -> [y]

(x -> y) -> [x] - [y]
```

Functors

`Hash` in Ruby on the other hand is **not** a `Functor` as it may return other data type.

```ruby
id = -> x { x }

hash = { dog_age: 3, cat_age: 6 }

hash.map(&id) # => [[:dog_age, 3], [:cat_age, 6]]

hash.map(&id) == hash # => false

Hash -> Array
```

This time given `Hash` class `Array` is returned instead

```
Hash -> Array
```

Identity law

Mapping an identity function (function that returns value passed to it) over a Functor should not change the data Functor encapsulates.

In Ruby example of identity function is method itself.

```ruby
[1,2,3].map(&:itself) # => [1,2,3]

Array -> Array # Array is a functor!
```

```ruby
{ dog_age: 3, cat_age: 6 }.map(&:itself) # => [[:dog_age, 3], [:cat_age, 6]]

Hash -> Array # Hash is not a functor
```

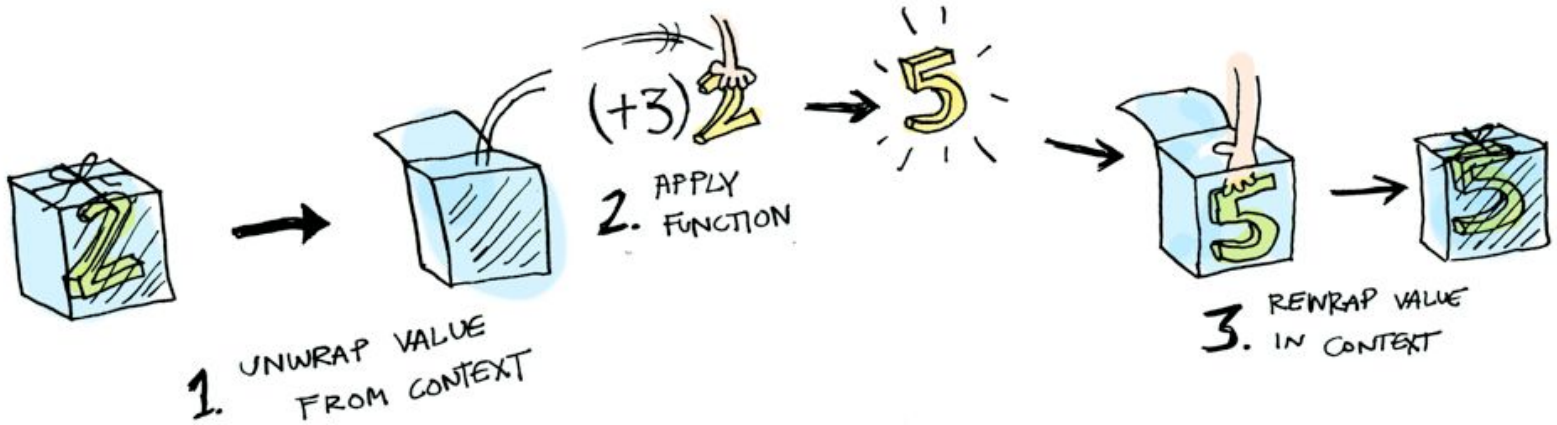
Associative law

Mapping f (g (x)) over a Functor should give the same result as mapping g (x) followed by f (x) over the Functor (function composition).

```ruby
array = [1, 2, 3]

f = -> (x) { x + 1 }
g = -> (x) { x * 2 }

array.map(&f).map(&g)                # => [4, 6, 8]

array.map { |x| g.call(f.call(x)) } # => [4, 6, 8]
array.map { |x| g.(f.(x)) }          # => [4, 6, 8]
```

Functors

All that comes down to with Functors is that they always should stay that same type of Functor.



http://adit.io/posts/2013-04-17-functors,_applicatives,_and_monads_in_pictures.html

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Monads

Monads

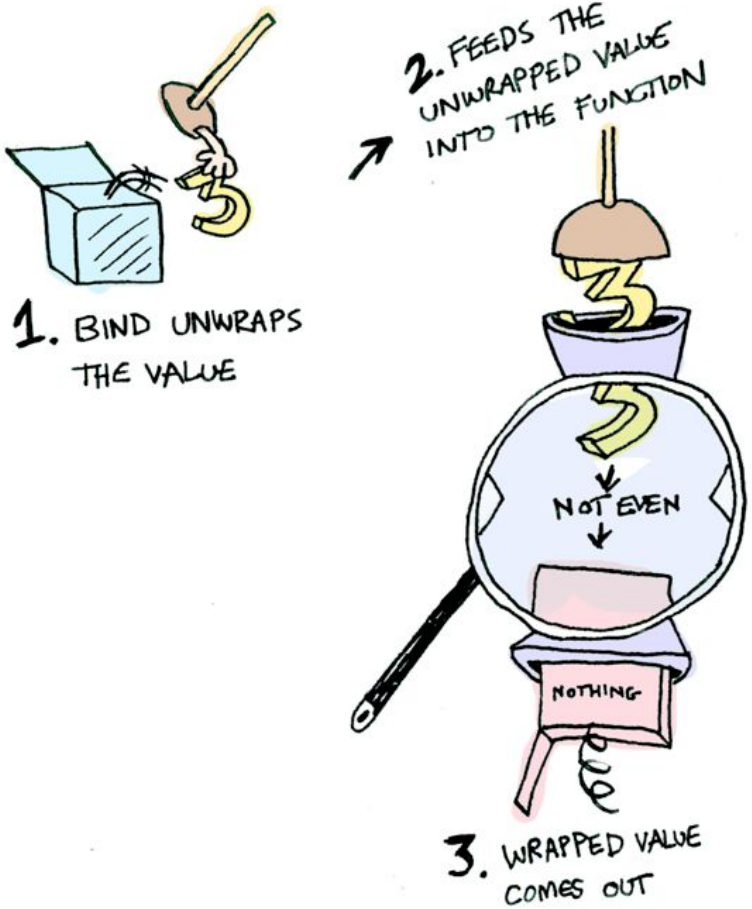
“A monad is just a monoid in the category of endofunctors, what's the problem?” - James Iry

Monads

Monads apply a function that returns a wrapped value to a wrapped value.

Monads have a function >>= (bind) that allows to do that.

Monads



http://adit.io/posts/2013-04-17-functors,_applicatives,_and_monads_in_pictures.html

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Maybe Monad

Maybe

Maybe addresses very common pattern where a given method call might return a value or may return a nil.

```
def lowest_number(array)
  sorted = array.sort { |x, y| x <=> y }
  sorted.first
end

[Comparable] -> Maybe Comparable
```

Maybe


```ruby
class Maybe
  def initialize(value)
    @value = value
  end

  # Unwraps the value if it's not nil, does some work and return
  # result wrapped in new context
  def fmap
    return self if @value.nil?
    self.class.new(yield @value)
  end

  # Unwraps the value if not nil, does some work and return the
  # result itself (without context). Block passed to bind have to
  # wrap result in new context
  def bind
    return self if @value.nil?
    yield @value
  end

  # Useful method for irb/pry to print Some/None
  def inspect
    return 'None' if @value.nil?
    'Some ' + @value.inspect
  end
end
```

Maybe

Simple Maybe implementation in action:

```ruby
Maybe.new(1).fmap { |x| x + 1 }   # => Some 2

Maybe.new(1).bind { |x| x + 1 }   # => 2

Maybe.new(nil).bind { |x| x + 1 } # => None

Maybe.new(nil).fmap { |x| x + 1 } # => None
```

Monads

- fmap is similar to map in ruby - unwraps, applies block (function) and wrapps again
- bind like fmap unwraps, applies block but it returns unwrapped value (so other bind cannot be chained on to it)

Monads

In order for a data type to be a Monad it has to obey three "*monad laws*":

- Left identity: `return a >>= f ≡ f a`
- Right identity `m >>= return ≡ m`
- Associativity: `(m >>= f) >>= g ≡ m >>= ( \x -> f x >>= g)`

Left identity

```
return a >>= f ≡ f a
```

Putting a value in the default context (e.g. Maybe) and feeding it to a function is the same as applying the function to the value.

```ruby
f = -> (x) { Maybe(x ** 3) }

Maybe(2).bind(&f) #=> Some(8)

f.(2) #=> Some(8)

Maybe(2).bind(&f) == f.(2) # => true
```

Right identity

```
m >>= return ≡ m
```

If we have a Maybe object and try to bind it to another Maybe, this operation will not change anything

```ruby
Maybe(5).bind(&method(:Maybe)) # => Maybe(5)
```

Associativity

```
(m >>= f) >>= g ≡ m >>= ( \x -> f x >>= g)
```

```ruby
a = Maybe(4)

f = -> (x) { Maybe(x ** 3) }
g = -> (x) { x > 10 ? Maybe(x) : None() }

# (m >>= f) >>= g

(a.bind(&f)).bind(&g) # => Some(64)

# m >>= ( \x -> f x >>= g)

a.bind { |x| f.(x).bind(&g) } # => Some(64)
```

Given a chain of computations it does not matter how they are nested - the outcome must always be the same.

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dry-monads

dry-monads

`dry-monads` is a set of common monads for Ruby that helps execute code in more elegant, free of if/else way.

`dry-monads` are a basis for some other gems implemented by `dry` team.

`gem install dry-monads` (or add `gem 'dry-monads'` to gemfile and bundle)

dry-monads

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Monads implemented by dry-monads gem:

- Maybe
- Result
- Try
- List
- Task

Dry::Monads::Maybe

The `Maybe` monad is used when a series of computations could return `nil` at any point, returning `Some(value)` or `None()`.

Methods:

- `bind`
- `fmap`
- `value!`
- `value_or`
- `or`

Dry::Monads::Maybe


```ruby
require 'dry/monads/maybe'

M = Dry::Monads

maybe_company = M.Maybe(company).bind do |company|
  M.Maybe(company.address).bind do |address|
    M.Maybe(address.street)
  end
end

# If company with address exists
# => Some("Street Address")
# If company or address is nil
# => None()
```

Dry::Monads::Result

The Result monad is used when a series of computations might return an error object with additional data. Result uses two constructors Success(value) and Failure(value).

Methods:

- bind
- fmap
- value!
- value_or
- or
- failure
- failure?
- success
- success?
- to_maybe

Dry::Monads::Result


```ruby
require 'dry/monads/result'

class SimpleCalculator
  include Dry::Monads::Result::Mixin

  attr_accessor :integer


  def calc
    i = Integer(integer)

    Success(i).bind do |val|
      if val >= 0
        Success(val + 1)
      else
        Failure(:value_less_than_zero)
      end
    end.bind do |val|
      if val % 2 != 0
        Success(val * 3)
      else
        Failure(:value_should_be_odd)
      end
    end
  end
end
```

Dry::Monads::Result


```ruby
# instantiate new SimpleCalculator
calculator = SimpleCalculator.new

# full Success path
c.integer = 2
calculator.calc # => Success(9)

# first Failure
c.integer = -1
calculator.calc # => Failure(:value_less_than_zero)

# second Failure
c.integer = 3
calculator.calc # => Failure(:value_should_be_odd)
```

Dry::Monads::Try

The Try monads rescues a block from an exception. Useful to wrap code that might raise an exception like HTTP requests or queries to DB.

Methods:

- bind
- fmap
- value! / value?
- exception / error?
- to_result / to_maybe

Dry::Monads::Try


```ruby
require 'dry/monads/try'

module CatchExceptions
  extend Dry::Monads::Try::Mixin

  res = Try() { 6 / 3 }
  res.value! if res.value?
  # => 2

  res = Try() { 6 / 0 }
  res.exception if res.error?
  # => #<ZeroDivisionError: divided by 0>

  # By default Try catches all exceptions inherited from StandardError.
  # However you can catch only certain exceptions like this
  Try(NoMethodError, NotImplementedError) { 10 / 0 }
  # => raised ZeroDivisionError: divided by 0 exception
end
```

Dry::Monads::Task

The Task monad is used for asynchronous computations. It can be used to wrap side-effectful actions (IO). Internally uses Promise from concurrent-ruby gem.

Methods:

- bind
- fmap
- or / or_fmap
- value!
- wait (optional_timeout)
- to_result / to_maybe

Dry::Monads::Task


```ruby
require 'dry/monads/task'

class GetCompaniesWithEmployees
  include Dry::Monads::Task::Mixin

  def call
    # Start two concurent tasks
    companies = Task { fetch_companies }
    employees = Task { fetch_employees }

    # Combine two tasks
    companies.bind { |comp| employees.fmap { |empl| [comp, empl] } }
  end

  def fetch_companies
    sleep 3
    [{ id: 1, name: 'Solid Inc.' }, { id: 2, name: 'Rigid Inc.' }]
  end

  def fetch_employees
    sleep 2
    [
      { id: 2, employee_id: 2, name: 'Norville' },
      { id: 1, employee_id: 1, name: 'Jake' },
    ]
  end
end
```

Dry::Monads::Task


```ruby
# GetCompaniesWithEmployees instance
get = GetCompaniesWithEmployees.new

# Spin up two tasks
task = get.call

task.fmap do |companies, employees|
  puts "Companies: #{ companies.inspect }"
  puts "Employees: #{ employees.inspect }"
end

# => Task(?)

# => Companies: [{:id=>1, :name=>"Solid Inc."}, {:id=>2, :name=>"Rigid Inc."}]
# => Employees: [{:id=>2, :employee_id=>2, :name=>"Norville"}, {:id=>1, :employee_id=>1, :name=>"Jake"}]
```

Dry::Monads::List

The List monad allows us to wrap multiple values/objects in a list.

Methods:

- bind
- fmap
- value
- concatenation (+)
- head/tail
- traverse

Dry::Monads::List


```ruby
require 'dry/monads/list'

M = Dry::Monads

M::List[3, 4].bind { |x| [x + 1] } # => List[4, 5]
M::List[3, 4].bind(-> x { [x, x + 1] }) # => List[3, 4, 4, 5]

M::List[3, nil].bind { |x| [x + 1] } # => error

M::List[3, 4].fmap { |x| x + 1 } # => List[4, 5]

M::List[3, 4].value # => [3, 4]

M::List[1, 2] + M::List[3, 4] # => List[1, 2, 3, 4]

M::List[1, 2, 3, 4].head # => Some(1)
M::List[1, 2, 3, 4].tail # => List[2, 3, 4]
```

Summary

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“A change of perspective is worth 80 IQ points”

- Alan Kay

Summary

“In addition to it begin useful, it is also cursed and the curse of the monad is that once you get the epiphany, once you understand - ‘oh that's what it is’ - you lose the ability to explain it to anybody.”

Douglas Crockford

Summary

Monad:

- A thing that contains one or more other things
- Used to define a pipeline, series of computational steps
- Allows to reuse code and write composable parts
- Programmable semicolons
- Controls code complexion

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