
Hymn Documentation

Release 0.3

Philip Xu

January 01, 2016

1	Hy Monad Notation - a monad library for Hy	3
1.1	Introduction	3
1.2	Requirements	7
1.3	Installation	7
1.4	License	7
1.5	Links	7
2	Examples	9
2.1	Calculating Pi with Monte Carlo Method	9
2.2	Calculating Sum	10
2.3	Dependency Handling with Lazy Monad	10
2.4	The FizzBuzz Test	11
2.5	Interactive Greeting	12
2.6	Greatest Common Divisor	13
2.7	Project Euler Problem 9	13
2.8	Project Euler Problem 29	14
2.9	Solving 24 Game	14
3	API Reference	17
3.1	The Monoid Class	17
3.2	The Monad Class	18
3.3	The MonadPlus Class	18
3.4	The Continuation Monad	19
3.5	The Either Monad	20
3.6	The Identity Monad	23
3.7	The Lazy Monad	24
3.8	The List Monad	26
3.9	The Maybe Monad	28
3.10	The Reader Monad	32
3.11	The State Monad	33
3.12	The Writer Monad	37
3.13	Mixin Class	40
3.14	Monad Operations	40
3.15	Utility Functions and Types	44
3.16	DSL	45
4	Changelog	47
5	Indices and tables	49
	Python Module Index	51

Contents:

HY MONAD NOTATION - A MONAD LIBRARY FOR HY

1.1 Introduction

Hymn is a monad library for Hy/Python, with do notation for monad comprehension.

Code are better than words.

The continuation monad

```
=> (require hymn.dsl)
=> (import [hymn.types.continuation [cont-m call-cc]])
=> ;; computations in continuation passing style
=> (defn double [x] (cont-m.unit (* x 2)))
=> (def length (cont-m.monadic len))
=> ;; chain with bind
=> (.run (>> (cont-m.unit [1 2 3]) length double))
6
=> (defn square [n] (call-cc (fn [k] (k (** n 2)))))
=> (.run (square 12))
144
=> (.run (square 12) inc)
145
=> (.run (square 12) str)
'144'
=> (.run (do-monad [sqr (square 42)] (.format "answer^2 = {}" sqr)))
'answer^2 = 1764'
```

The either monad

```
=> (require hymn.dsl)
=> (import [hymn.types.either [Left Right either failsafe]])
=> ;; do notation with either monad
=> (do-monad [a (Right 1) b (Right 2)] (/ a b))
Right(0.5)
=> (do-monad [a (Right 1) b (Left 'nan)] (/ a b))
Left(nan)
=> ;; failsafe is a function decorator that wraps return value into either
=> (def safe-div (failsafe /))
=> ;; returns Right if nothing wrong
=> (safe-div 4 2)
Right(2.0)
=> ;; returns Left when bad thing happened, like exception being thrown
=> (safe-div 1 0)
Left(ZeroDivisionError('division by zero',))
=> ;; function either tests the value and call functions accordingly
```

```
=> (either print inc (safe-div 4 2))
3.0
=> (either print inc (safe-div 1 0))
division by zero
```

The identity monad

```
=> (require hymn.dsl)
=> (import [hymn.types.identity [identity-m]])
=> ;; do notation with identity monad is like let binding
=> (do-monad [a (identity-m 1) b (identity-m 2)] (+ a b))
Identity(3)
```

The lazy monad

```
=> (require hymn.dsl)
=> (import [hymn.types.lazy [force]])
=> ;; lazy computation implemented as monad
=> ;; macro lazy create deferred computation
=> (def a (lazy (print "evaluate a") 42))
=> ;; the computation is deferred, notice the value is shown as '_'
=> a
Lazy(_)
=> ;; evaluate it
=> (.evaluate a)
evaluate a
42
=> ;; now the value is cached
=> a
Lazy(42)
=> ;; evaluate again will not trigger the computation
=> (.evaluate a)
42
=> (def b (lazy (print "evaluate b") 21))
=> b
Lazy(_)
=> ;; force evaluate the computation, same as calling .evaluate on the monad
=> (force b)
evaluate b
21
=> ;; force on values other than lazy return the value unchanged
=> (force 42)
42
=> ;; do notation with lazy monad
=> (def c (do-monad [x (lazy (print "get x") 1) y (lazy (print "get y") 2)] (+ x y)))
=> ;; the computation is deferred
=> c
Lazy(_)
=> ;; do it!
=> (force c)
get x
get y
3
=> ;; again
=> (force c)
3
```

The list monad


```

=> (require hymn.dsl)
=> (import [hymn.types.list [list-m]])
=> ;; use list-m constructor to turn sequence into list monad
=> (def xs (list-m (range 2)))
=> (def ys (list-m (range 3)))
=> ;; do notation with list monad is list comprehension
=> (list (do-monad [x xs y ys :when (not (zero? y))] (/ x y)) )
[0.0, 0.0, 1.0, 0.5]
=> ;; * is the reader macro for list-m
=> (list (do-monad [x #*(range 2) y #*(range 3) :when (not (zero? y))] (/ x y)) )
[0.0, 0.0, 1.0, 0.5]

```

The maybe monad

```

=> (require hymn.dsl)
=> (import [hymn.types.maybe [Just Nothing maybe]])
=> ;; do notation with maybe monad
=> (do-monad [a (Just 1) b (Just 1)] (/ a b))
Just(1.0)
=> ;; Nothing yields Nothing
=> (do-monad [a Nothing b (Just 1)] (/ a b))
Nothing
=> ;; maybe is a function decorator that wraps return value into maybe
=> ;; a safe-div with maybe monad
=> (def safe-div (maybe /))
=> (safe-div 42 42)
Just(1.0)
=> (safe-div 42 'answer)
Nothing
=> (safe-div 42 0)
Nothing

```

The reader monad

```

=> (require hymn.dsl)
=> (import [hymn.types.reader [lookup]])
=> ;; do notation with reader monad, lookup assumes the environment is subscriptable
=> (def r (do-monad [a (lookup 'a) b (lookup 'b)] (+ a b)))
=> ;; run reader monad r with environment
=> (.run r {'a 1 'b 2})
3

```

The state monad

```

=> (require hymn.dsl)
=> (import [hymn.types.state [lookup set-value]])
=> ;; do notation with state monad, set-value sets the value with key in the state
=> (def s (do-monad [a (lookup 'a) _ (set-value 'b (inc a))] a))
=> ;; run state monad s with initial state
=> (.run s {'a 1})
(, 1 {'a 1 'b 2})

```

The writer monad

```

=> (require hymn.dsl)
=> (import [hymn.types.writer [tell]])
=> ;; do notation with writer monad
=> (do-monad [_ (tell "hello") _ (tell " world")] nil)
StrWriter((None, 'hello world'))

```

```
=> ;; int is monoid, too
=> (.execute (do-monad [_ (tell 1) _ (tell 2) _ (tell 3)] nil))
6
```

Operations on monads

```
=> (require hymn.dsl)
=> (import [hymn.operations [lift]])
=> ;; lift promotes function into monad
=> (def m+ (lift +))
=> ;; lifted function can work on any monad
=> ;; on the maybe monad
=> (import [hymn.types.maybe [Just Nothing]])
=> (m+ (Just 1) (Just 2))
Just(3)
=> (m+ (Just 1) Nothing)
Nothing
=> ;; on the either monad
=> (import [hymn.types.either [Left Right]])
=> (m+ (Right 1) (Right 2))
Right(3)
=> (m+ (Left 1) (Right 2))
Left(1)
=> ;; on the list monad
=> (import [hymn.types.list [list-m]])
=> (list (m+ (list-m "ab") (list-m "123")))
['a1', 'a2', 'a3', 'b1', 'b2', 'b3']
=> (list (m+ (list-m "+") (list-m "123") (list-m "xy")))
['+1x', '+1y', '+2x', '+2y', '+3x', '+3y', '-1x', '-1y', '-2x', '-2y', '-3x', '-3y']
=> ;; can be used as normal function
=> (reduce m+ [(Just 1) (Just 2) (Just 3)])
Just(6)
=> (reduce m+ [(Just 1) Nothing (Just 3)])
Nothing
=> ;; <- is an alias of lookup
=> (import [hymn.types.reader [<-]])
=> ;; ^ is the reader macro for lift
=> (def p (#^print (<- 'message) :end (<- 'end)))
=> (.run p {'message "Hello world" 'end "!\n"})
Hello world!
=> ;; random number - linear congruential generator
=> (import [hymn.types.state [get-state set-state]])
=> (def random (>> get-state (fn [s] (-> s (* 69069) inc (% (** 2 32)) set-state))))
=> (.run random 1234)
(1234, 85231147)
=> ;; random can be even shorter by using modify
=> (import [hymn.types.state [modify]])
=> (def random (modify (fn [s] (-> s (* 69069) inc (% (** 2 32)))))
=> (.run random 1234)
(1234, 85231147)
=> ;; use replicate to do computation repeatedly
=> (import [hymn.operations [replicate]])
=> (.evaluate (replicate 5 random) 42)
[42, 2900899, 2793697416, 2186085609, 1171637142]
=> ;; sequence on writer monad
=> (import [hymn.operations [sequence]])
=> (import [hymn.types.writer [tell]])
=> (.execute (sequence (map tell (range 1 101))))
5050
```

Using Hymn in Python

```
>>> from hymn.dsl import *
>>> sequence(map(tell, range(1, 101))).execute()
5050
>>> msum = lift(sum)
>>> msum(sequence(map(maybe(int), "12345")))
Just(15)
>>> msum(sequence(map(maybe(int), "12345a")))
Nothing
>>> @failsafe
... def safe_div(a, b):
...     return a / b
...
>>> safe_div(1.0, 2)
Right(0.5)
>>> safe_div(1, 0)
Left(ZeroDivisionError(...))
```

1.2 Requirements

- hy \geq 0.11.0

1.3 Installation

Install from PyPI:

```
pip install hymn
```

Install from source, download source package, decompress, then `cd` into source directory, run:

```
make install
```

1.4 License

BSD New, see LICENSE for details.

1.5 Links

Documentation: <http://hymn.readthedocs.org/>

Issue Tracker: <https://github.com/pyx/hymn/issues/>

Source Package @ PyPI: <https://pypi.python.org/pypi/hymn/>

Mercurial Repository @ bitbucket: <https://bitbucket.org/pyx/hymn/>

Git Repository @ Github: <https://github.com/pyx/hymn/>

EXAMPLES

2.1 Calculating Pi with Monte Carlo Method

Pseudo-random number generator with *State* monad:

```
(import
  [collections [Counter]]
  [time [time]]
  [hymn.dsl [get-state replicate set-state]])

(require hymn.dsl)

;;; Knuth!
(def a 6364136223846793005)
(def c 1442695040888963407)
(def m (** 2 64))

;;; linear congruential generator
(def random
  (do-monad
    [seed get-state
     _ (set-state (-> seed (* a) (+ c) (% m)))
     new-seed get-state]
    (/ new-seed m)))

(def random-point (do-monad [x random y random] (, x y)))

(defn points [seed]
  "stream of random points"
  (while true
    ;; NOTE:
    ;; limited by the maximum recursion depth, we take 150 points each time
    (setv [random-points seed] (.run (replicate 150 random-point) seed))
    (for [point random-points]
      (yield point))))

(defn monte-carlo [number-of-points]
  "use monte carlo method to calculate value of pi"
  (def samples (take number-of-points (points (int (time)))))
  (def result
    (Counter (genexpr (>= 1.0 (+ (** x 2) (** y 2))) [[x y] samples])))
  (-> result (get true) (/ number-of-points) (* 4)))

(defmain [&rest args]
  (if (-> args len (!= 2))
```

```
(print "usage:" (first args) "number-of-points")
(print "the estimate for pi =" (-> args second int monte-carlo)))
```

Example output:

```
$ ./monte_carlo.hy 50000
the estimate for pi = 3.14232
```

2.2 Calculating Sum

Wicked sum function with *Writer* monad:

```
(import [hymn.dsl [sequence tell]])
(require hymn.dsl)

(defn wicked-sum [numbers]
  (.execute (sequence (map tell numbers))))

(defmain [&rest args]
  (if (-> args len (= 1))
    (print "usage:" (first args) "number1 number2 .. numberN")
    (print "sum:" (-> args rest (map int) wicked-sum))))
```

Example output:

```
$ ./sum.hy 123 456 789
sum: 1368
```

2.3 Dependency Handling with Lazy Monad

Actions with the *Lazy* monad can be used to handle dependencies:

```
(import [hymn.dsl [const force lift]])

(require hymn.dsl)

(def depends (lift (const nil)))

(defmacro deftask [n &rest actions]
  `(def ~n
     (depends (lazy (print "(started" '~n))
              ~@actions
              (lazy (print " finished " '~n " " :sep " "))))))

(deftask a)
(deftask b)
(deftask c)
(deftask d)
(deftask e)
(deftask f (depends c a))
(deftask g (depends b d))
(deftask h (depends g e f))
```

```
(defmain [&rest args]
  (force h))
```

Example output:

```
$ ./deps.hy
(started h
(started g
(started b
  finished b)
(started d
  finished d)
  finished g)
(started e
  finished e)
(started f
(started c
  finished c)
(started a
  finished a)
  finished f)
  finished h)
```

2.4 The FizzBuzz Test

The possibly over-engineered FizzBuzz solution:

```
;;; The fizzbuzz test, in the style inspired by c_wraith on Freenode #haskell

(import [hymn.dsl [<> from-maybe maybe-m]])

(require hymn.dsl)

(defn fizzbuzz [i]
  (from-maybe
    (<>
      (do-monad-with maybe-m [:when (zero? (% i 3))] "fizz")
      (do-monad-with maybe-m [:when (zero? (% i 5))] "buzz"))
    (str i)))

;;; using monoid operation, it is easy to add new case, just add one more line
;;; in the append (<>) call. e.g
(defn fizzbuzzbazz [i]
  (from-maybe
    (<>
      (do-monad-with maybe-m [:when (zero? (% i 3))] "fizz")
      (do-monad-with maybe-m [:when (zero? (% i 5))] "buzz")
      (do-monad-with maybe-m [:when (zero? (% i 7))] "bazz"))
    (str i)))

(defn format [seq]
  (.join "" (interleave seq (cycle "\t\t\t\t\n"))))

(defmain [&rest args]
  (if (-> args len (= 1))
    (print "usage:" (first args) "up-to-number"))
```

```
(print (->> args second int inc (range 1) (map fizzbuzz) format)))
```

Example output:

```
$ ./fizzbuzz.hy 100
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
fizz   52     53     fizz   buzz
56     fizz  58     59     fizzbuzz
61     62     fizz   64     buzz
fizz   67     68     fizz   buzz
71     fizz  73     74     fizzbuzz
76     77     fizz   79     buzz
fizz   82     83     fizz   buzz
86     fizz  88     89     fizzbuzz
91     92     fizz   94     buzz
fizz   97     98     fizz   buzz
```

2.5 Interactive Greeting

Greeting from *Continuation* monad:

```
(import [hymn.dsl [cont-m call-cc]])
(require hymn.dsl)

(defn validate [name exit]
  (with-monad cont-m
    (m-when (not name) (exit "Please tell me your name!"))))

(defn greeting [name]
  (.run (call-cc
    (fn [exit]
      (do-monad
        [_ (validate name exit)]
        (+ "Welcome, " name "!"))))))))

(defmain [&rest args]
  (print (greeting (input "Hi, what is your name? "))))
```

Example output:

```
$ ./greeting.hy
Hi, what is your name?
Please tell me your name!
$ ./greeting.hy
Hi, what is your name? Marvin
Welcome, Marvin!
```


2.6 Greatest Common Divisor

Logging with *Writer* monad:

```
(import [hymn.dsl [tell]])

(require hymn.dsl)

(defn gcd [a b]
  (if (zero? b)
    (do-monad
      [_ (tell (.format "the result is: {} \n" (abs a)))]
      (abs a))
    (do-monad-m
      [_ (tell (.format "{} mod {} = {} \n" a b (% a b)))]
      (gcd b (% a b)))))

(defmain [&rest args]
  (if (-> args len (!= 3))
    (print "usage:" (first args) "number1 number2")
    (let [[a (int (get args 1))]
          [b (int (get args 2))]]
      (print "calculating the greatest common divisor of" a "and" b)
      (print (.execute (gcd a b))))))
```

Example output:

```
$ ./gcd.hy 24680 1352
calculating the greatest common divisor of 24680 and 1352
24680 mod 1352 = 344
1352 mod 344 = 320
344 mod 320 = 24
320 mod 24 = 8
24 mod 8 = 0
the result is: 8
```

2.7 Project Euler Problem 9

Solving problem 9 with *List* monad

```
(require hymn.dsl)

(def total 1000)
(def limit (-> total (** 0.5) int inc))

(def triplet
  (do-monad
    [m #*(range 2 limit)
     n #*(range 1 m)
     :let [[a (- (** m 2) (** n 2))]
           [b (* 2 m n)]
           [c (+ (** m 2) (** n 2))]]
          :when (-> (+ a b c) (= total))]
    [a b c]))

(defmain [&rest args])
```

```
(print "Project Euler Problem 9 - list monad example"
      "https://projecteuler.net/problem=9"
      "There exists exactly one Pythagorean triplet"
      "for which a + b + c = 1000. Find the product abc."
      (->> triplet first (reduce *))
      :sep "\n"))
```

Example output:

```
$ ./euler9.hy
Project Euler Problem 9 - list monad example
https://projecteuler.net/problem=9
There exists exactly one Pythagorean triplet
for which a + b + c = 1000. Find the product abc.
31875000
```

2.8 Project Euler Problem 29

Solving problem 29 with *lift()* and *List* monad

```
(require hymn.dsl)

(defmain [&rest args]
  (print "Project Euler Problem 29 - lift and list monad example"
        "https://projecteuler.net/problem=29"
        "How many distinct terms are in the sequence generated by"
        "a to the power of b for 2 <= a <= 100 and 2 <= b <= 100?"
        (-> (#^pow #*(range 2 101) #*(range 2 101)) distinct list len)
        :sep "\n"))
```

Example output:

```
$ ./euler29.hy
Project Euler Problem 29 - lift and list monad example
https://projecteuler.net/problem=29
How many distinct terms are in the sequence generated by
a to the power of b for 2 <= a <= 100 and 2 <= b <= 100?
9183
```

2.9 Solving 24 Game

Nondeterministic computation with *List* monad and error handling with *Maybe* monad:

```
(import
  [functools [partial]]
  [itertools [permutations]])

(require hymn.dsl)

(def ops [+ - * /])

(defmacro infix-repr [fmt]
  `(.format ~fmt :a a :b b :c c :d d :op1 (. op1 --name--)
           :op2 (. op2 --name--) :op3 (. op3 --name--)))
```

```

;;; use maybe monad to handle division by zero
(defmacro safe [expr] `(fn [] ~expr))

(defn template [[a b c d]]
  (do-monad-m
   [op1 #*ops
    op2 #*ops
    op3 #*ops]
   ;; (, result infix-representation)
   [(, (safe (op1 (op2 a b) (op3 c d)))
      (infix-repr "{a} {op2} {b}) {op1} ({c} {op3} {d})"))
    (, (safe (op1 a (op2 b (op3 c d)))
      (infix-repr "{a} {op1} ({b} {op2} ({c} {op3} {d})))"))
    (, (safe (op1 (op2 (op3 a b) c) d)
      (infix-repr "({a} {op3} {b}) {op2} {c} {op1} {d}")))]))

(defn combinations [numbers]
  (do-monad
   [:let [[seemed (set)]]
    [a b c d] #*(permutations numbers 4)
    :when (not-in (, a b c d) seemed)]
   (do
    (.add seemed (, a b c d)
     [a b c d])))

;;; In python, 8 / (3 - (8 / 3)) = 23.999999999999999, it should be 24 in fact,
;;; so we have to use custom comparison function like this
(defn close-enough [a b] (< (abs (- a b)) 0.0001))

(defn solve [numbers]
  (do-monad
   [[result infix-repr] (<< template (combinations numbers))
    :when (>> result (partial close-enough 24))]
   infix-repr))

(defmain [&rest args]
  (if (-> args len (!= 5))
    (print "usage:" (first args) "number1 number2 number3 number4")
    (->> args rest (map int) solve (.join "\n") print)))

```

Example output:

```

$ ./solve24.hy 2 3 8 8
((2 * 8) - 8) * 3
(3 / 2) * (8 + 8)
3 / (2 / (8 + 8))
((8 - 2) - 3) * 8
((8 * 2) - 8) * 3
((8 - 3) - 2) * 8
8 * (8 - (2 + 3))
((8 + 8) / 2) * 3
(8 + 8) / (2 / 3)
(8 + 8) * (3 / 2)
8 * (8 - (3 + 2))
((8 + 8) * 3) / 2

```


API REFERENCE

3.1 The Monoid Class

class `hymn.types.monoid.Monoid`
Bases: `object`
the monoid class
types with an associative binary operation that has an identity
append (*other*)
an associative operation for monoid
classmethod concat (*seq*)
fold a list using the monoid
empty
the identity of `append()`
`hymn.types.monoid.append(*monoids)`
the associative operation of monoid

3.1.1 Hy Specific API

Functions

`<>`
alias of `append()`

3.1.2 Examples

`append()` adds up the values, while handling `empty` gracefully, `<>` is an alias of `append()`

```
=> (import [hymn.types.maybe [Just Nothing]])
=> (import [hymn.types.monoid [<> append]])
=> (append (Just "Cuddles ") Nothing (Just "the ") Nothing (Just "Hacker"))
Just('Cuddles the Hacker')
=> (<> (Just "Cuddles ") Nothing (Just "the ") Nothing (Just "Hacker"))
Just('Cuddles the Hacker')
```

3.2 The Monad Class

class `hymn.types.monad.Monad` (*value*)

Bases: `object`

the monad class

Implements bind operator `>>` and inverted bind operator `<<` as syntactic sugar. It is equivalent to `(>>=)` and `(=<<)` in haskell, not to be confused with `(>>)` and `(<<)` in haskell.

As python treats assignments as statements, there is no way we can overload `>>=` as a chainable bind, be it directly overloaded through `__irshift__`, or derived by python itself through `__rshift__`.

The default implementations of `bind()`, `fmap()` and `join()` are mutual recursive, subclasses should at least either override `bind()`, or `fmap()` and `join()`, or all of them for better performance.

bind (*f*)

the bind operation

f is a function that maps from the underlying value to a monadic type, something like signature `f :: a -> M a` in haskell's term.

The default implementation defines `bind()` in terms of `fmap()` and `join()`.

fmap (*f*)

the fmap operation

The default implementation defines `fmap()` in terms of `bind()` and `unit()`.

join ()

the join operation

The default implementation defines `join()` in terms of `bind()` and identity function.

classmethod monadic (*f*)

decorator that turn *f* into monadic function of the monad

classmethod unit (*value*)

the unit of monad

3.3 The MonadPlus Class

`hymn.types.monadplus` - base monadplus class

class `hymn.types.monadplus.MonadPlus` (*value*)

Bases: `hymn.types.monad.Monad`

the monadplus class

Monads that also support choice and failure.

plus (*other*)

the associative operation

zero

the identity of `plus()`.

It should satisfy the following law, left zero (notice the bind operator is haskell's `>>=` here):

<code>zero >>= f = zero</code>

3.4 The Continuation Monad

class `hymn.types.continuation.Continuation` (*value*)

Bases: `hymn.types.monad.Monad`

the continuation monad

bind (*f*)

the bind operation of `Continuation`

run (*k*=<function identity>)

run the continuation

classmethod **unit** (*value*)

the unit of continuation monad

`hymn.types.continuation.call_cc` (*f*)

call with current continuation

`hymn.types.continuation.cont_m`

alias of `Continuation`

`hymn.types.continuation.continuation_m`

alias of `Continuation`

`hymn.types.continuation.unit` ()

alias of `Continuation.unit` ()

`hymn.types.continuation.run` ()

alias of `Continuation.run` ()

3.4.1 Hy Specific API

cont-m

continuation-m

alias of `Continuation`

Reader Macro

< [**v**]

create a `Continuation` of *v*

Functions

call-cc

alias of `call_cc` ()

3.4.2 Examples

Do Notation

```
=> (require hymn.dsl)
=> (import [hymn.types.continuation [cont-m]])
=> (.run (do-monad [a (cont-m.unit 1)] (inc a)))
2
```

Operations

`call-cc()` - call with current continuation

```
=> (require hymn.dsl)
=> (import [hymn.types.continuation [call-cc cont-m]])
=> (defn search [n seq]
...   (call-cc
...     (fn [exit]
...       (do-monad-with cont-m
...         [_ (m-when (in n seq) (exit (.index seq n))])
...         "not found."))))
=> (.run (search 0 [1 2 3 4 5]))
'not found.'
=> (.run (search 0 [1 2 3 0 5]))
3
```

Reader Macro

```
=> (require hymn.dsl)
=> (require hymn.types.continuation)
=> (#<42)
42
=> (.run (do-monad [a #<25 b #<17] (+ a b)))
42
```

3.5 The Either Monad

```
class hymn.types.either.Either (value)
  Bases: hymn.types.monadplus.MonadPlus, hymn.mixins.Ord
  the either monad
  computation with two possibilities
  bind (f)
    the bind operation of Either
    apply function to the value if and only if this is a Right.
  classmethod from_value (value)
    wrap value in an Either monad
    return a Right if the value is evaluated as true. Left otherwise.
  unit
    alias of Right
class hymn.types.either.Left (value)
  Bases: hymn.types.either.Either
```


left of *Either*

class `hymn.types.either.Right` (*value*)
 Bases: `hymn.types.either.Either`

right of *Either*

`hymn.types.either.either` (*handle_left, handle_right, m*)
 case analysis for *Either*

apply either `handle_left` or `handle_right` to `m` depending on the type of it, raise `TypeError` if `m` is not an *Either*

`hymn.types.either.either_m`
 alias of *Either*

`hymn.types.either.failsafe` (*func*)
 decorator to turn `func` into monadic function of *Either* monad

`hymn.types.either.is_left` (*m*)
 return True if `m` is a *Left*

`hymn.types.either.is_right` (*m*)
 return True if `m` is a *Right*

`hymn.types.either.unit`
 alias of *Right*

`hymn.types.either.zero = Left(u'unknown error')`
 left of *Either*

`hymn.types.either.to_either` ()
 alias of `from_value()`

3.5.1 Hy Specific API

either-m
 alias of *Either*

Reader Macro

| [**f**]
 turn `f` into monadic function with `failsafe()`

Functions

->either

to-either
 alias of `Either.from_value()`

left?
 alias of `is_left()`

right?
 alias of `is_right()`

3.5.2 Examples

Comparison

Either are comparable if the wrapped values are comparable. *Right* is greater than *Left* in any case.

```
=> (import [hymn.types.either [Left Right]])
=> (> (Right 2) (Right 1))
True
=> (< (Left 2) (Left 1))
False
=> (> (Left 2) (Right 1))
False
```

Do Notation

```
=> (require hymn.dsl)
=> (import [hymn.types.either [Left Right]])
=> (do-monad [a (Right 1) b (Right 2)] (+ a b))
Right(3)
=> (do-monad [a (Left 1) b (Right 2)] (+ a b))
Left(1)
```

Do Notation with :when

```
=> (require hymn.dsl)
=> (import [hymn.types.either [either-m]])
=> (defn safe-div [a b]
...   (do-monad-with either-m [:when (not (zero? b))] (/ a b)))
=> (safe-div 1 2)
Right(0.5)
=> (safe-div 1 0)
Left('unknown error')
```

Operations

Use `->either` to create an *Either* from a value

```
=> (import [hymn.types.either [->either]])
=> (->either 42)
Right(42)
=> (->either nil)
Left(None)
```

Use `left?()` and `right?()` to test the type

```
=> (import [hymn.types.either [Left Right left? right?]])
=> (right? (Right 42))
True
=> (left? (Left nil))
True
```

`either()` applies function to value in the monad depending on the type

```
=> (import [hymn.types.either [Left Right either]])
=> (either print inc (Left 1))
1
=> (either print inc (Right 1))
2
```

`failsafe()` turns function into monadic one

```
=> (import [hymn.types.either [failsafe]])
=> (with-decorator failsafe (defn add1 [n] (inc (int n))))
=> (add1 "41")
Right(42)
=> (add1 "nan")
Left(ValidationError("invalid literal for int() with base 10: 'nan'",))
=> (def safe-div (failsafe /))
=> (safe-div 1 2)
Right(0.5)
=> (safe-div 1 0)
Left(ZeroDivisionError('division by zero',))
```

Reader Macro

```
=> (require hymn.types.either)
=> (#|int "42")
Right(42)
=> (#|int "nan")
Left(ValidationError("invalid literal for int() with base 10: 'nan'",))
=> (def safe-div #|/)
=> (safe-div 1 2)
Right(0.5)
=> (safe-div 1 0)
Left(ZeroDivisionError('division by zero',))
```

3.6 The Identity Monad

`hymn.types.identity` - the identity monad

```
class hymn.types.identity.Identity(value)
  Bases: hymn.types.monad.Monad, hymn.mixins.Ord
```

the identity monad

```
hymn.types.identity.identity_m
  alias of Identity
```

```
hymn.types.identity.unit()
  alias of Identity.unit()
```

3.6.1 Hy Specific API

```
identity-m
  alias of Identity
```

3.6.2 Examples

```
=> (require hymn.dsl)
=> (import [hymn.types.identity [identity-m]])
=> (do-monad [a (identity-m.unit 1) b (identity-m.unit 2)] (+ a b))
Identity(3)
```

Identity monad is comparable as long as what's wrapped inside are comparable.

```
=> (> (identity-m.unit 2) (identity-m.unit 1))
True
=> (= (identity-m.unit 42) (identity-m.unit 42))
True
```

3.7 The Lazy Monad

class `hymn.types.lazy.Lazy` (*value*)
Bases: `hymn.types.monad.Monad`

the lazy monad

lazy computation as monad

bind (*f*)
the bind operator of *Lazy*

evaluate ()
evaluate the lazy monad

evaluated
return True if this computation is evaluated

classmethod unit (*value*)
the unit of lazy monad

`hymn.types.lazy.force` (*m*)
force the deferred computation *m* if it is a *Lazy*, act as function `identity` otherwise, return the result

`hymn.types.lazy.is_lazy` (*v*)
return True if *v* is a *Lazy*

`hymn.types.lazy.lazy_m`
alias of *Lazy*

`hymn.types.lazy.unit` ()
alias of *Lazy.unit* ()

`hymn.types.lazy.evaluate` ()
alias of *Lazy.evaluate* ()

3.7.1 Hy Specific API

lazy-m
alias of *Lazy*

Macro

lazy [&rest exprs]

create a *Lazy* from expressions, the expressions will not be evaluated until being forced by *force()* or *evaluate()*

Function

lazy?

alias of *is_lazy()*

3.7.2 Examples

Do Notation

```

=> (require hymn.dsl)
=> (require hymn.types.lazy)
=> (def two (do-monad [x (lazy (print "evaluate two") 2)] x))
=> two
Lazy(_)
=> (.evaluate two)
evaluate two
2

```

Operations

Use macro *lazy()* to create deferred computation from expressions, the computation will not be evaluated until asked explicitly

```

=> (require hymn.dsl)
=> (require hymn.types.lazy)
=> (def answer (lazy (print "the answer is ...") 42))
=> answer
Lazy(_)
=> (.evaluate answer)
the answer is ...
42
=> (.evaluate answer)
42

```

Deferred computation can also be created with expressions wrapped in a function

```

=> (import [hymn.types.lazy [lazy-m]])
=> (def a (lazy-m (fn [] (print "^^") 42)))
=> (.evaluate a)
^^
42

```

Use *evaluate()* to evaluate the computation, the result will be cached

```

=> (require hymn.types.lazy)
=> (def who (lazy (input "enter your name? ")))
=> who
Lazy(_)
=> (.evaluate who)

```

```
enter your name? Marvin
'Marvin'
=> who
Lazy('Marvin')
=> (import [hymn.operations [lift]])
=> (def m+ (lift +))
=> (def x (lazy (print "get x") 2))
=> x
Lazy(_)
=> (def x3 (m+ x x x))
=> x3
Lazy(_)
=> (.evaluate x3)
get x
6
=> x
Lazy(2)
=> x3
Lazy(6)
```

Use `force()` to evaluate `Lazy` as well as other values

```
=> (require hymn.types.lazy)
=> (import [hymn.types.lazy [force]])
=> (force (lazy (print "yes") 1))
yes
1
=> (force 1)
1
=> (def a (lazy (print "Stat!") (+ 1 2 3)))
=> a
Lazy(_)
=> (force a)
Stat!
6
=> a
Lazy(6)
```

`lazy?()` returns `True` if the object is a `Lazy` value

```
=> (import [hymn.types.lazy [lazy-m lazy?]])
=> (lazy? 1)
False
=> (lazy? (lazy-m.unit 1))
True
```

3.8 The List Monad

class `hymn.types.list.List` (*value*)

Bases: `hymn.types.monadplus.MonadPlus`, `hymn.types.monoid.Monoid`

the list monad

nondeterministic computation

append (*other*)

the append operation of `List`

classmethod concat (*list_of_list*)
the concat operation of *List*

fmap (*f*)
return list obtained by applying *f* to each element of the list

join ()
join of list monad, concatenate list of list

plus (*other*)
concatenate two list

classmethod unit (**values*)
the unit, create a *List* from values

`hymn.types.list.fmap` (*f, iterable*)
fmap works like the builtin map, but return a *List* instead of list

`hymn.types.list.list_m`
alias of *List*

`hymn.types.list.zero`
the zero of list monad, an empty list

3.8.1 Hy Specific API

list-m
alias of *List*

Reader Macro

* **[seq]**
turn iterable *seq* into a *List*

3.8.2 Examples

Do Notation

```
=> (require hymn.dsl)
=> (import [hymn.types.list [list-m]])
=> (list (do-monad [a (list-m [1 2 3])] (inc a)))
[2, 3, 4]
=> (list (do-monad [a (list-m [1 2 3]) b (list-m [4 5 6])] (+ a b)))
[5, 6, 7, 6, 7, 8, 7, 8, 9]
=> (list (do-monad [a (list-m "123") b (list-m "xy")] (+ a b)))
['1x', '1y', '2x', '2y', '3x', '3y']
```

Do Notation with :when

```
=> (require hymn.dsl)
=> (import [hymn.types.list [list-m]])
=> (list (do-monad
...     [a (list-m [1 2 4])
...     b (list-m [1 2 4])
```

```
...           :when (!= a b)]
...           (/ a b)))
[0.5, 0.25, 2.0, 0.5, 4.0, 2.0]
```

Operations

`unit` accepts any number of initial values

```
=> (list (list-m.unit))
[]
=> (list (list-m.unit 1))
[1]
=> (list (list-m.unit 1 3))
[1, 3]
=> (list (list-m.unit 1 3 5))
[1, 3, 5]
```

`fmap()` works like the builtin `map` function, but creates `List` instead of the builtin `list`

```
=> (require hymn.dsl)
=> (import [hymn.types.list [fmap list-m]])
=> (instance? list-m (fmap inc [0 1 2]))
True
=> (for [e (fmap inc [0 1 2])] (print e))
1
2
3
```

Reader Macro

```
=> (require hymn.types.list)
=> (import [hymn.types.list [list-m]])
=> (instance? list-m #[0 1 2])
True
=> (list (do-monad [a #*(range 10) :when (odd? a)] (* a 2)))
[2, 6, 10, 14, 18]
```

3.9 The Maybe Monad

class `hymn.types.maybe.Just` (*value*)
Bases: `hymn.types.maybe.Maybe`
Just of the `Maybe`

class `hymn.types.maybe.Maybe` (*value*)
Bases: `hymn.types.monadplus.MonadPlus`, `hymn.types.monoid.Monoid`,
`hymn.mixins.Ord`
the maybe monad
computation that may fail
append (*other*)
the append operation of `Maybe`

bind (*f*)
 the bind operation of *Maybe*
 apply function to the value if and only if this is a *Just*.

from_maybe (*default*)
 return the value contained in the *Maybe*
 if the *Maybe* is *Nothing*, it returns the default values.

classmethod from_value (*value*)
 wrap *value* in a *Maybe* monad
 return a *Just* if the value is evaluated as true. *Nothing* otherwise.

unit
 alias of *Just*

`hymn.types.maybe.is_nothing` (*m*)
 return True if *m* is *Nothing*

`hymn.types.maybe.maybe` (*func=None, predicate=None, nothing_on_exceptions=None*)
 decorator to turn *func* into monadic function of the *Maybe* monad

`hymn.types.maybe.maybe_m`
 alias of *Maybe*

`hymn.types.maybe.unit`
 alias of *Just*

`hymn.types.maybe.Nothing = Nothing`
 the *Maybe* that represents nothing, a singleton, like `None`

`hymn.types.maybe.zero = Nothing`
 the *Maybe* that represents nothing, a singleton, like `None`

`hymn.types.maybe.from_maybe` ()
 alias of `from_maybe` ()

`hymn.types.maybe.to_maybe` ()
 alias of `from_value` ()

3.9.1 Hy Specific API

maybe-m
 alias of *Maybe*

Reader Macro

? [**f**]
 turn *f* into monadic function with `maybe` ()

Functions

<-maybe

from-maybe
 alias of `Maybe.from_maybe` ()

->maybe

to-maybe

alias of `Maybe.from_value()`

nothing?

alias of `is_nothing()`

3.9.2 Examples

Comparison

Maybes are comparable if the wrapped values are comparable. `Just` is greater than `Nothing` in any case.

```
=> (import [hymn.types.maybe [Just Nothing]])
=> (> (Just 2) (Just 1))
True
=> (= (Just 1) (Just 2))
False
=> (= (Just 2) (Just 2))
True
=> (= Nothing Nothing)
True
=> (= Nothing (Just 1))
False
=> (< (Just -1) Nothing)
False
```

Do Notation

```
=> (require hymn.dsl)
=> (import [hymn.types.maybe [Just Nothing]])
=> (do-monad [a (Just 1) b (Just 2)] (+ a b))
Just(3)
=> (do-monad [a (Just 1) b Nothing] (+ a b))
Nothing
```

Do Notation with :when

```
=> (require hymn.dsl)
=> (import [hymn.types.maybe [maybe-m]])
=> (defn safe-div [a b]
... (do-monad-with maybe-m [:when (not (zero? b))] (/ a b)))
=> (safe-div 1 2)
Just(0.5)
=> (safe-div 1 0)
Nothing
```

Operations

Use `->maybe()` to create a `Maybe` from value

```
=> (import [hymn.types.maybe [->maybe]])
=> (->maybe 42)
Just(42)
```

```
=> (->maybe nil)
Nothing
```

`nothing?()` returns True if the value is *Nothing*

```
=> (import [hymn.types.maybe [Just Nothing nothing?]])
=> (nothing? Nothing)
True
=> (nothing? (Just 1))
False
```

`<-maybe()` returns the value in the monad, or a default value if it is *Nothing*

```
=> (import [hymn.types.maybe [<-maybe ->maybe]])
=> (nothing? (->maybe nil))
True
=> (def answer (->maybe 42))
=> (def nothing (->maybe nil))
=> (<-maybe answer "not this one")
42
=> (<-maybe nothing "I got nothing")
"I got nothing"
```

`append()` adds up the values, handling *Nothing* gracefully

```
=> (import [hymn.types.maybe [Just Nothing]])
=> (.append (Just 42) Nothing)
Just(42)
=> (.append (Just 42) (Just 42))
Just(84)
=> (.append Nothing (Just 42))
Just(42)
```

`maybe()` turns a function into monadic one

```
=> (import [hymn.types.maybe [maybe]])
=> (with-decorator maybe (defn add1 [n] (inc (int n))))
=> (add1 "41")
Just(42)
=> (add1 "nan")
Nothing
=> (def safe-div (maybe /))
=> (safe-div 1 2)
Just(0.5)
=> (safe-div 1 0)
Nothing
```

Reader Macro

```
=> (require hymn.types.maybe)
=> (#?int "42")
Just(42)
=> (#?int "not a number")
Nothing
=> (def safe-div #?/)
=> (safe-div 1 2)
Just(0.5)
```

```
=> (safe-div 1 0)
Nothing
```

3.10 The Reader Monad

class `hymn.types.reader.Reader` (*value*)

Bases: `hymn.types.monad.Monad`

the reader monad

computations which read values from a shared environment

bind (*f*)

the bind operation of *Reader*

local (*f*)

return a reader that execute computation in modified environment

run (*e*)

run the reader and extract the final vaule

classmethod **unit** (*value*)

the unit of reader monad

`hymn.types.reader.asks` (*f*)

create a simple reader action from *f*

`hymn.types.reader.local` (*f*)

executes a computation in a modified environment, $f :: e \rightarrow e$

`hymn.types.reader.lookup` (*key*)

create a lookup reader of *key* in the environment

`hymn.types.reader.reader` (*f*)

create a simple reader action from *f*

`hymn.types.reader.reader_m`

alias of *Reader*

`hymn.types.reader.unit` ()

alias of *Reader.unit* ()

`hymn.types.reader.run` ()

alias of *Reader.run* ()

`hymn.types.reader.ask`

fetch the value of the environment

3.10.1 Hy Specific API

reader-m

alias of *Reader*

Function

<-

alias of *lookup* ()

3.10.2 Examples

Do Notation

```
=> (require hymn.dsl)
=> (import [hymn.types.reader [ask]])
=> (.run (do-monad [e ask] (inc e)) 41)
42
```

Operations

asks() creates a reader with a function, *reader()* is an alias of *asks()*

```
=> (require hymn.dsl)
=> (import [hymn.types.reader [asks reader]])
=> (.run (do-monad [h (asks first)] h) [5 4 3 2 1])
5
=> (.run (do-monad [h (reader second)] h) [5 4 3 2 1])
4
```

Use *ask()* to fetch the environment

```
=> (require hymn.dsl)
=> (import [hymn.types.reader [ask]])
=> (.run ask 42)
42
=> (.run (do-monad [e ask] (inc e)) 42)
43
```

local() runs the reader with modified environment

```
=> (import [hymn.types.reader [ask local]])
=> (.run ask 42)
42
=> (.run ((local inc) ask) 42)
43
```

Use *lookup()* to get the value of key in environment, *<-* is an alias of *lookup()*

```
=> (require hymn.dsl)
=> (import [hymn.types.reader [lookup <-]])
=> (.run (lookup 1) [1 2 3])
2
=> (.run (lookup 'b) {'a 1 'b 2})
2
=> (.run (<- 1) [1 2 3])
2
=> (.run (<- 'b) {'a 1 'b 2})
2
=> (.run (do-monad [a (<- 'a) b (<- 'b)] (+ a b)) {'a 25 'b 17})
42
```

3.11 The State Monad

```
class hymn.types.state.State(value)
  Bases: hymn.types.monad.Monad
```

the state monad

computation with a shared state

bind (*f*)

the bind operation of *State*

use the final state of this computation as the initial state of the second

evaluate (*s*)

evaluate state monad with initial state and return the result

execute (*s*)

execute state monad with initial state, return the final state

run (*s*)

evaluate state monad with initial state, return result and state

classmethod unit (*a*)

the unit of state monad

`hymn.types.state.state_m`

alias of *State*

`hymn.types.state.lookup` (*key*)

return a monadic function that lookup the vaule with key in the state

`hymn.types.state.modify` (*f*)

maps the current state with *f* to a new state inside a state monad

`hymn.types.state.set_state` (*s*)

replace the current state and return the previous one

`hymn.types.state.set_value` (*key, value*)

return a monadic function that set the vaule of key in the state

`hymn.types.state.set_values` (***keys/values*)

return a monadic function that set the vaules of keys in the state

`hymn.types.state.update` (*key, f*)

return a monadic function that update the vaule by f with key in the state

`hymn.types.state.update_value` (*key, value*)

return a monadic function that update the vaule with key in the state

`hymn.types.state.unit` ()

alias of *State.unit* ()

`hymn.types.state.evaluate` ()

alias of *State.evaluate* ()

`hymn.types.state.execute` ()

alias of *State.execute* ()

`hymn.types.state.run` ()

alias of *State.run* ()

`hymn.types.state.get_state`

return the current state

`hymn.types.state.gets` (*f*)

gets specific component of the state, using a projection function *f*

3.11.1 Hy Specific API

state-m
alias of *State*

Functions

<-
alias of *lookup()*

<-state

get-state
alias of *get_state()*

state<-

set-state
alias of *set_state()*

set-value
alias of *set_value()*

set-values
alias of *set_values()*

update-value
alias of *update_value()*

3.11.2 Examples

Do Notation

```
=> (require hymn.dsl)
=> (import [hymn.types.state [gets]])
=> (.run (do-monad [a (gets first)] a) [1 2 3])
(1, [1, 2, 3])
```

Operations

Use *get-state()* to fetch the shared state, *<-state* is an alias of *get-state()*

```
=> (import [hymn.types.state [get-state <-state]])
=> (.run get-state [1 2 3])
([1, 2, 3], [1, 2, 3])
=> (.run <-state [1 2 3])
([1, 2, 3], [1, 2, 3])
```

Use *lookup()* to get the value of key in the shared state, *<-* is an alias of *lookup()*

```
=> (import [hymn.types.state [lookup <-]])
=> (.run (lookup 1) [1 2 3])
(2, [1, 2, 3])
=> (.evaluate (lookup 1) [1 2 3])
2
=> (.evaluate (lookup 'a) {'a 1 'b 2})
```

```
1
=> (.run (<- 1) [1 2 3])
(2, [1, 2, 3])
=> (.evaluate (<- 1) [1 2 3])
2
=> (.evaluate (<- 'a') {'a 1 'b 2})
1
```

gets() uses a function to fetch value of shared state

```
=> (import [hymn.types.state [gets]])
=> (.run (gets first) [1 2 3])
(1, [1, 2, 3])
=> (.run (gets second) [1 2 3])
(2, [1, 2, 3])
=> (.run (gets len) [1 2 3])
(3, [1, 2, 3])
```

modify() changes the current state with a function

```
=> (import [hymn.types.state [modify]])
=> (.run (modify inc) 41)
(41, 42)
=> (.evaluate (modify inc) 41)
41
=> (.execute (modify inc) 41)
42
=> (.run (modify str) 42)
(42, '42')
```

set-state() replaces the current state and returns the previous one, *state<-* is an alias of *set-state()*

```
=> (import [hymn.types.state [set-state state<-]])
=> (.run (set-state 42) 1)
(1, 42)
=> (.run (state<- 42) 1)
(1, 42)
```

set-value() sets the value in the state with the key

```
=> (import [hymn.types.state [set-value]])
=> (.run (set-value 2 42) [1 2 3])
([1, 2, 3], [1, 2, 42])
```

set-values() sets multiple values at once

```
=> (import [hymn.types.state [set-values]])
=> (.run (set-values :a 1 :b 2) {})
(, {} {"b" 2 "a" 1})
```

update() changes the value with the key by applying a function to it

```
=> (import [hymn.types.state [update]])
=> (.run (update 0 inc) [0 1 2])
(0, [1, 1, 2])
```

update-value() sets the value in the state with the key

```
=> (import [hymn.types.state [update-value]])
=> (.run (update-value 0 42) [0 1 2])
(0, [42, 1, 2])
```


3.12 The Writer Monad

```

class hymn.types.writer.Writer (value)
    Bases: hymn.types.monad.Monad
    the writer monad
    computation which accumulate output along with result

    bind (f)
        the bind operation of Writer

    execute ()
        extract the output of the writer

    run ()
        unwrap the writer computation

    classmethod unit (value)
        the unit of writer monad

hymn.types.writer.cancel (f, m)
    apply f to the output

hymn.types.writer.listen (m)
    execute m and adds its output to the value of computation

hymn.types.writer.tell (message)
    log the message

hymn.types.writer.writer (value, message)
    embed a writer action with value and message

hymn.types.writer.writer_m
    alias of Writer

hymn.types.writer.writer_with_type (t)
    create a writer for type t

hymn.types.writer.writer_with_type_of (message)
    create a writer of type of message

hymn.types.writer.execute ()
    alias of Writer.execute ()

hymn.types.writer.run ()
    alias of Writer.run ()

```

3.12.1 Predefined Writers

```

class hymn.types.writer.ComplexWriter (value)
class hymn.types.writer.DecimalWriter (value)
class hymn.types.writer.FloatWriter (value)
class hymn.types.writer.FractionWriter (value)
class hymn.types.writer.ListWriter (value)

```

```
class hymn.types.writer.IntWriter (value)
hymn.types.writer.StringWriter
    alias of StreamWriter
class hymn.types.writer.TupleWriter (value)
```

3.12.2 Hy Specific API

```
writer-m
    alias of Writer
```

Functions

```
writer-with-type
    alias of writer_with_type ()
writer-with-type-of
    alias of writer_with_type_of ()
```

Reader Macro

```
+ [w]
    create a writer that logs w
```

Writers

```
complex-writer-m
    alias of ComplexWriter
decimal-writer-m
    alias of DecimalWriter
float-writer-m
    alias of FloatWriter
fraction-writer-m
    alias of FractionWriter
list-writer-m
    alias of ListWriter
int-writer-m
    alias of IntWriter
string-writer-m
    alias of StreamWriter
tuple-writer-m
    alias of TupleWriter
```

3.12.3 Examples

Do Notation

```
=> (require hymn.dsl)
=> (import [hymn.types.writer [tell]])
=> (do-monad [_ (tell 1) _ (tell 2)] nil)
IntWriter((None, 3))
=> (do-monad [_ (tell "hello ") _ (tell "world!")] nil)
StrWriter((None, 'hello world!'))
```

Operations

writer() creates a *Writer*

```
=> (import [hymn.types.writer [writer]])
=> (writer nil 1)
IntWriter((None, 1))
```

tell() adds message into accumulated values of writer

```
=> (import [hymn.types.writer [tell writer]])
=> (.run (tell 1))
(None, 1)
=> (.run (>> (writer 1 1) tell))
(None, 2)
```

tell() and *writer()* are smart enough to create writer of appropriate type

```
=> (import [hymn.types.writer [tell writer]])
=> (writer nil "a")
StrWriter((None, 'a'))
=> (writer nil 1)
IntWriter((None, 1))
=> (writer nil 1.0)
FloatWriter((None, 1.0))
=> (writer nil (, 1))
TupleWriter((None, (1,)))
=> (writer nil [1])
ListWriter((None, [1]))
=> (tell "a")
StrWriter((None, 'a'))
=> (tell 1)
IntWriter((None, 1))
=> (tell 1.0)
FloatWriter((None, 1.0))
=> (tell (, 1))
TupleWriter((None, (1,)))
=> (tell [1])
ListWriter((None, [1]))
```

Use *listen()* to get the value of the writer

```
=> (import [hymn.types.writer [listen writer]])
=> (listen (writer "value" 42))
IntWriter((('value', 42), 42))
```

Use `censor ()` to apply function to the output

```
=> (import [hymn.types.writer [censor tell]])
=> (require hymn.dsl)
=> (def logs (do-monad [_ (tell [1]) _ (tell [2]) _ (tell [3])] nil))
=> (.execute logs)
[1, 2, 3]
=> (.execute (censor sum logs))
6
```

Reader Macro

```
=> (require hymn.dsl)
=> (require hymn.types.writer)
=> ;; reader macro + works like tell
=> #+1
IntWriter((None, 1))
=> (.execute #+1)
1
=> (do-monad [_ #+1 _ #+2 _ #+4] 42)
IntWriter((42, 7))
```

3.13 Mixin Class

class `hymn.mixins.Ord`

Bases: `object`

mixin class that implements rich comparison ordering methods

3.14 Monad Operations

`hymn.operations` provide operations and macros for monad computations

3.14.1 Macros

do-monad [**binding-forms** **expr**]

macro for sequencing monadic computations, with automatic return

```
=> (require hymn.operations)
=> (import [hymn.types.maybe [Just]])
=> (do-monad [a (Just 41)] (inc a))
Just(42)
```

do-monad-m [**binding-forms** **expr**]

macro for sequencing monadic computations, a.k.a do notation in haskell

```
=> (require hymn.operations)
=> (import [hymn.types.maybe [Just]])
=> (do-monad [a (Just 41)] (m-return a))
Just(42)
```

do-monad-with [monad binding-forms expr]

macro for sequencing monadic composition, with said monad as default.

useful when the only binding form is `:when`, we do not know which monad we are working with otherwise

```
=> (require hymn.operations)
=> (import [hymn.types.maybe [maybe-m]])
=> (do-monad-with maybe-m [:when true] 42)
Just(42)
=> (do-monad-with maybe-m [:when false] 42)
Nothing
```

All do monad macros support `:let` binding, like this:

```
=> (require hymn.operations)
=> (import [hymn.types.maybe [Just]])
=> (defn half [x]
... (do-monad
... [:let [[two 2]]
... a x
... :let [[b (/ a two)]]]
... b))
=> (half (Just 42))
Just(21.0)
```

All do monad macros support `:when` if the monad is of type *MonadPlus*.

```
=> (require hymn.operations)
=> (import [hymn.types.maybe [maybe-m]])
=> (defn div [a b] (do-monad-with maybe-m [:when (not (zero? b))] (/ a b)))
=> (div 1 2)
Just(0.5)
=> (div 1 0)
Nothing
```

m-for [[n seq] &rest expr]

macro for sequencing monadic actions

```
=> (require hymn.operations)
=> ;; with simple monad, e.g. maybe
=> (import [hymn.types.maybe [maybe-m]])
=> (m-for [a (range 3)] (maybe-m.unit a))
Just([0, 1, 2])
=> ;; with reader monad
=> (import [hymn.types.reader [<-]])
=> (def readers
... (m-for [a (range 5)]
... (print "create reader" a)
... (<- a)))
create reader 0
create reader 1
create reader 2
create reader 3
create reader 4
=> (.run readers [11 12 13 14 15 16])
[11, 12, 13, 14, 15]
=> (.run readers "abcdefg")
['a', 'b', 'c', 'd', 'e']
=> ;; with writer monad
=> (import [hymn.types.writer [tell]])
```

```
=> (.execute (m-for [a (range 1 101)] (tell a)))
5050
```

m-when [test mexpr]

conditional execution of monadic expressions

with-monad [monad &rest exprs]

provide default function m-return as the unit of the monad

```
=> (require hymn.operation)
=> (import [hymn.types.maybe [maybe-m]])
=> (with-monad maybe-m (m-when (even? 1) (m-return 42)))
Just (None)
=> (with-monad maybe-m (m-when (even? 2) (m-return 42)))
Just (42)
```

monad-comp [expr binding-forms &optional condition]different syntax for do-monad, in the style of list/dict/set comprehensions, the condition part is optional and can only be used with *MonadPlus* as in do-monad

```
=> (require hymn.operations)
=> (import [hymn.types.maybe [Just]])
=> (monad-comp (+ a b) [a (Just 1) b (Just 2)])
Just (3)
=> (monad-comp (/ a b) [a (Just 1) b (Just 0)] (not (zero? b)))
Nothing
=> (import [hymn.types.list [list-m]])
=> (list (monad-comp (/ a b) [a (list-m [1 2]) b (list-m [4 8])]))
[0.25, 0.125, 0.5, 0.25]
=> (list (monad-comp (/ a b) [a (list-m [1 2]) b (list-m [0 1])]) (not (zero? b)))
[1.0, 2.0]
```

3.14.2 Reader Macros

^ [f]*lift()* reader macro, `#^f` is expanded to `(lift f)`

```
=> (require hymn.operations)
=> (import [hymn.types.maybe [Just Nothing]])
=> (#^+ (Just 1) (Just 2))
Just (3)
=> (#^+ (Just 1) Nothing)
Nothing
```

= [value]reader macro for m-return, the unit inside do-monad macros, `#=v` is expanded to `(m-return v)`

```
=> (require hymn.operations)
=> (import [hymn.types.maybe [Just maybe-m]])
=> (do-monad-with maybe-m [a #=1 b #=2] (+ a b))
Just (3)
=> (do-monad-m [a (Just 1)] #=(inc a))
Just (2)
```

3.14.3 Operation on Monads

`hymn.operations.k_compose` (**monadic_funcs*)
right-to-left Kleisli composition of monads.

`<=<`
alias of `k_compose` ()

```
=> (import [hymn.operations [k-compose <=<]])
=> (import [hymn.types.maybe [Just Nothing]])
=> (defn m-double [x] (if (numeric? x) (Just (* x 2)) Nothing))
=> (defn m-inc [x] (if (numeric? x) (Just (inc x)) Nothing))
=> (def +1*2 (k-compose m-double m-inc))
=> (+1*2 1)
Just (4)
=> (def *2+1 (<=< m-inc m-double))
=> (*2+1 2)
Just (5)
=> (*2+1 "two")
Nothing
```

`hymn.operations.k_pipe` (**monadic_funcs*)
left-to-right Kleisli composition of monads.

`>=>`
alias of `k_compose` ()

```
=> (import [hymn.operations [k-pipe >=>]])
=> (import [hymn.types.maybe [Just Nothing maybe]])
=> (def m-int (maybe int))
=> (defn m-array [n] (if (> n 0) (Just (* [0] n)) Nothing))
=> (def make-array (k-pipe m-int m-array))
=> (make-array 0)
Nothing
=> (make-array 3)
Just ([0, 0, 0])
=> (def make-array (>=> m-int m-array))
=> (make-array 2)
Just ([0, 0])
```

`hymn.operations.lift` (*f*)
promote a function to a monad

```
=> (import [hymn.operations [lift]])
=> (import [hymn.types.maybe [Just]])
=> (def m+ (lift +))
=> (m+ (Just 1) (Just 2))
Just (3)
```

`hymn.operations.m_map` (*mf, seq*)
map monadic function *mf* to a sequence, then execute that sequence of monadic values

`m-map`
alias of `m_map` ()

```
=> (import [hymn.operations [m-map]])
=> (import [hymn.types.maybe [maybe-m]])
=> (m-map maybe-m.unit (range 5))
Just ([0, 1, 2, 3, 4])
=> (m-map (maybe-m.monadic inc) (range 5))
```

```
Just([1, 2, 3, 4, 5])
=> (import [hymn.types.writer [tell]])
=> (.execute (m-map tell (range 1 101)))
5050
```

`hymn.operations.replicate` (*n*, *m*)
perform the monadic action *n* times, gathering the results

```
=> (import [hymn.operations [replicate]])
=> (import [hymn.types.list [list-m]])
=> (list (replicate 2 (list-m [0 1])))
[[0, 0], [0, 1], [1, 0], [1, 1]]
```

`hymn.operations.sequence` (*m_values*)
evaluate each action in the sequence, and collect the results

```
=> (import [hymn.operations [sequence]])
=> (import [hymn.types.writer [tell]])
=> (.execute (sequence (map tell (range 1 101))))
5050
```

3.15 Utility Functions and Types

3.15.1 Helper Classes

`class` `hymn.utils.CachedSequence` (*iterable*)
Bases: `object`
sequence wrapper that is lazy while keeps the items

`class` `hymn.utils.SuppressContextManager` (*exceptions*)
Bases: `object`
context manager that suppress specified exceptions

3.15.2 Helper Functions

`hymn.utils.compose` (**fs*)
function composition

`<|`
alias of `compose()`

Note: `<|` cannot be used as `hy` and `python` already using it, `<|` was chosen because we use `|>` as alias of `pipe()` function

`hymn.utils.const` (*value*)
constant function

`hymn.utils.suppress` (**exceptions*)
suppress specified exceptions

`hymn.utils.pipe` (**fs*)
reversed function composition

|>
alias of `pipe()`

Note: |> is different from the same function in *OCaml* and *F#*, which is more like the threading macro `->>` in *hy*

3.16 DSL

The module `hymn.dsl` provides types and functions from other modules of this package, so that they can be imported all at once easily.

Python

```
from hymn.dsl import *
```

Hy

```
(import [hymn.dsl [*]])
```

This module also provides all the macros defined in other modules,

```
(require hymn.dsl)
```

is all you need to use any macro defined in `Hymn`

Note: Some of the function are renamed to more descriptive one to avoid name clash, examples are `hymn.types.reader.lookup()` and `hymn.types.state.lookup()`

The entire source code of this module is listed here for reference:

```
(import
[hymn.types.monoid [<> append]]
[hymn.types.continuation
 [Continuation cont-m continuation-m
 call-cc
 run :as run-cont]]
[hymn.types.either
 [Either either-m
 Left Right left? right? either failsafe]]
[hymn.types.lazy [Lazy lazy-m evaluate :as evaluate-lazy force lazy?]]
[hymn.types.list [List fmap list-m]]
[hymn.types.maybe
 [Maybe maybe-m
 Just Nothing <-maybe ->maybe from-maybe maybe nothing? to-maybe]]
[hymn.types.reader
 [Reader reader-m
 reader
 <- :as <-r
 ask ask :as get-env
 asks asks :as get-env-with
 local local :as use-env-with
 lookup :as lookup-reader
 run :as run-reader]]
[hymn.types.state
 [State state-m
 <-state get-state set-state state<-
 <- :as <-s
```

```
evaluate :as evaluate-state
execute :as execute-state
gets gets :as get-state-with
lookup :as lookup-state
modify modify :as modify-state-with
run :as run-state
set-value set-value :as set-state-value
set-values set-values :as set-state-values
update update :as update-state-value-with
update-value update-value :as update-state-value]]
[hymn.types.writer
 [ComplexWriter complex-writer-m
  DecimalWriter decimal-writer-m
  FloatWriter float-writer-m
  FractionWriter fraction-writer-m
  ListWriter list-writer-m
  IntWriter int-writer-m
  StringWriter string-writer-m
  TupleWriter tuple-writer-m
  censor listen tell writer
  writer-with-type
  writer-with-type-of
  run :as run-writer
  execute :as execute-writer]]
[hymn.operations
 [k-compose <=< k-pipe >=> lift m-map replicate sequence]]
[hymn.utils [compose <| const pipe |>]]

;;; reader macro for the continuation monad
(require hymn.types.continuation)

;;; reader macro for the either monad
(require hymn.types.either)

;;; macros for the lazy monad
(require hymn.types.lazy)

;;; reader macro for the list monad
(require hymn.types.list)

;;; reader macro for the maybe monad
(require hymn.types.maybe)

;;; reader macro for the writer monad
(require hymn.types.writer)

;;; macros for monad operations
(require hymn.operations)
```

CHANGELOG

- 0.3
 - New operation: m-map
 - New macros: m-for, monad-comp
 - New type: deferred computation implemented as the Lazy monad
 - Improved documentation
- 0.2
 - List.unit now support any number of initial values
 - Maybe and List are instances of Monoid
- 0.1

First public release.

INDICES AND TABLES

- genindex
- modindex
- search

h

hymn.mixins, 40
hymn.operations, 40
hymn.types.continuation, 19
hymn.types.either, 20
hymn.types.identity, 23
hymn.types.lazy, 24
hymn.types.list, 26
hymn.types.maybe, 28
hymn.types.monad, 18
hymn.types.monadplus, 18
hymn.types.monoid, 17
hymn.types.reader, 32
hymn.types.state, 33
hymn.types.writer, 37

A

append() (hymn.types.list.List method), 26
 append() (hymn.types.maybe.Maybe method), 28
 append() (hymn.types.monoid.Monoid method), 17
 append() (in module hymn.types.monoid), 17
 ask (in module hymn.types.reader), 32
 asks() (in module hymn.types.reader), 32

B

bind() (hymn.types.continuation.Continuation method), 19
 bind() (hymn.types.either.Either method), 20
 bind() (hymn.types.lazy.Lazy method), 24
 bind() (hymn.types.maybe.Maybe method), 28
 bind() (hymn.types.monad.Monad method), 18
 bind() (hymn.types.reader.Reader method), 32
 bind() (hymn.types.state.State method), 34
 bind() (hymn.types.writer.Writer method), 37

C

CachedSequence (class in hymn.utils), 44
 call_cc() (in module hymn.types.continuation), 19
 censor() (in module hymn.types.writer), 37
 ComplexWriter (class in hymn.types.writer), 37
 compose() (in module hymn.utils), 44
 concat() (hymn.types.list.List class method), 26
 concat() (hymn.types.monoid.Monoid class method), 17
 const() (in module hymn.utils), 44
 cont_m (in module hymn.types.continuation), 19
 Continuation (class in hymn.types.continuation), 19
 continuation_m (in module hymn.types.continuation), 19

D

DecimalWriter (class in hymn.types.writer), 37

E

Either (class in hymn.types.either), 20
 either() (in module hymn.types.either), 21
 either_m (in module hymn.types.either), 21
 empty (hymn.types.monoid.Monoid attribute), 17
 evaluate() (hymn.types.lazy.Lazy method), 24
 evaluate() (hymn.types.state.State method), 34

evaluate() (in module hymn.types.lazy), 24
 evaluate() (in module hymn.types.state), 34
 evaluated (hymn.types.lazy.Lazy attribute), 24
 execute() (hymn.types.state.State method), 34
 execute() (hymn.types.writer.Writer method), 37
 execute() (in module hymn.types.state), 34
 execute() (in module hymn.types.writer), 37

F

failsafe() (in module hymn.types.either), 21
 FloatWriter (class in hymn.types.writer), 37
 fmap() (hymn.types.list.List method), 27
 fmap() (hymn.types.monad.Monad method), 18
 fmap() (in module hymn.types.list), 27
 force() (in module hymn.types.lazy), 24
 FractionWriter (class in hymn.types.writer), 37
 from_maybe() (hymn.types.maybe.Maybe method), 29
 from_maybe() (in module hymn.types.maybe), 29
 from_value() (hymn.types.either.Either class method), 20
 from_value() (hymn.types.maybe.Maybe class method), 29

G

get_state (in module hymn.types.state), 34
 gets() (in module hymn.types.state), 34

H

hymn.mixins (module), 40
 hymn.operations (module), 40
 hymn.types.continuation (module), 19
 hymn.types.either (module), 20
 hymn.types.identity (module), 23
 hymn.types.lazy (module), 24
 hymn.types.list (module), 26
 hymn.types.maybe (module), 28
 hymn.types.monad (module), 18
 hymn.types.monadplus (module), 18
 hymn.types.monoid (module), 17
 hymn.types.reader (module), 32
 hymn.types.state (module), 33
 hymn.types.writer (module), 37

I

Identity (class in `hymn.types.identity`), 23
 identity_m (in module `hymn.types.identity`), 23
 IntWriter (class in `hymn.types.writer`), 38
 is_lazy() (in module `hymn.types.lazy`), 24
 is_left() (in module `hymn.types.either`), 21
 is_nothing() (in module `hymn.types.maybe`), 29
 is_right() (in module `hymn.types.either`), 21

J

join() (`hymn.types.list.List` method), 27
 join() (`hymn.types.monad.Monad` method), 18
 Just (class in `hymn.types.maybe`), 28

K

k_compose() (in module `hymn.operations`), 43
 k_pipe() (in module `hymn.operations`), 43

L

Lazy (class in `hymn.types.lazy`), 24
 lazy_m (in module `hymn.types.lazy`), 24
 Left (class in `hymn.types.either`), 20
 lift() (in module `hymn.operations`), 43
 List (class in `hymn.types.list`), 26
 list_m (in module `hymn.types.list`), 27
 listen() (in module `hymn.types.writer`), 37
 ListWriter (class in `hymn.types.writer`), 37
 local() (`hymn.types.reader.Reader` method), 32
 local() (in module `hymn.types.reader`), 32
 lookup() (in module `hymn.types.reader`), 32
 lookup() (in module `hymn.types.state`), 34

M

m_map() (in module `hymn.operations`), 43
 Maybe (class in `hymn.types.maybe`), 28
 maybe() (in module `hymn.types.maybe`), 29
 maybe_m (in module `hymn.types.maybe`), 29
 modify() (in module `hymn.types.state`), 34
 Monad (class in `hymn.types.monad`), 18
 monadic() (`hymn.types.monad.Monad` class method), 18
 MonadPlus (class in `hymn.types.monadplus`), 18
 Monoid (class in `hymn.types.monoid`), 17

N

Nothing (in module `hymn.types.maybe`), 29

O

Ord (class in `hymn.mixins`), 40

P

pipe() (in module `hymn.utils`), 44
 plus() (`hymn.types.list.List` method), 27
 plus() (`hymn.types.monadplus.MonadPlus` method), 18

R

Reader (class in `hymn.types.reader`), 32
 reader() (in module `hymn.types.reader`), 32
 reader_m (in module `hymn.types.reader`), 32
 replicate() (in module `hymn.operations`), 44
 Right (class in `hymn.types.either`), 21
 run() (`hymn.types.continuation.Continuation` method), 19
 run() (`hymn.types.reader.Reader` method), 32
 run() (`hymn.types.state.State` method), 34
 run() (`hymn.types.writer.Writer` method), 37
 run() (in module `hymn.types.continuation`), 19
 run() (in module `hymn.types.reader`), 32
 run() (in module `hymn.types.state`), 34
 run() (in module `hymn.types.writer`), 37

S

sequence() (in module `hymn.operations`), 44
 set_state() (in module `hymn.types.state`), 34
 set_value() (in module `hymn.types.state`), 34
 set_values() (in module `hymn.types.state`), 34
 State (class in `hymn.types.state`), 33
 state_m (in module `hymn.types.state`), 34
 StringWriter (in module `hymn.types.writer`), 38
 suppress() (in module `hymn.utils`), 44
 SuppressContextManager (class in `hymn.utils`), 44

T

tell() (in module `hymn.types.writer`), 37
 to_either() (in module `hymn.types.either`), 21
 to_maybe() (in module `hymn.types.maybe`), 29
 TupleWriter (class in `hymn.types.writer`), 38

U

unit (`hymn.types.either.Either` attribute), 20
 unit (`hymn.types.maybe.Maybe` attribute), 29
 unit (in module `hymn.types.either`), 21
 unit (in module `hymn.types.maybe`), 29
 unit() (`hymn.types.continuation.Continuation` class method), 19
 unit() (`hymn.types.lazy.Lazy` class method), 24
 unit() (`hymn.types.list.List` class method), 27
 unit() (`hymn.types.monad.Monad` class method), 18
 unit() (`hymn.types.reader.Reader` class method), 32
 unit() (`hymn.types.state.State` class method), 34
 unit() (`hymn.types.writer.Writer` class method), 37
 unit() (in module `hymn.types.continuation`), 19
 unit() (in module `hymn.types.identity`), 23
 unit() (in module `hymn.types.lazy`), 24
 unit() (in module `hymn.types.reader`), 32
 unit() (in module `hymn.types.state`), 34
 update() (in module `hymn.types.state`), 34
 update_value() (in module `hymn.types.state`), 34

W

Writer (class in `hymn.types.writer`), 37
writer() (in module `hymn.types.writer`), 37
writer_m (in module `hymn.types.writer`), 37
writer_with_type() (in module `hymn.types.writer`), 37
writer_with_type_of() (in module `hymn.types.writer`), 37

Z

zero (`hymn.types.monadplus.MonadPlus` attribute), 18
zero (in module `hymn.types.either`), 21
zero (in module `hymn.types.list`), 27
zero (in module `hymn.types.maybe`), 29