

Programare funcțională

Introducere în programarea funcțională folosind Haskell
C10

Claudia Chiriță

Denisa Diaconescu

Departamentul de Informatică, FMI, UB

Monade - recap

Functor, Applicative, Monad

```
class Functor f where
```

```
  fmap :: (a -> b) -> f a -> f b
```

```
class Functor m => Applicative m where
```

```
  pure :: a -> m a
```

```
  (<*>) :: m (a -> b) -> m a -> m b
```

```
class Applicative m => Monad m where
```

```
  (>=)  :: m a -> (a -> m b) -> m b
```

```
  (>>)  :: m a -> m b -> m b
```

```
  return :: a -> m a
```

```
ma >> mb = ma >= \_ -> mb
```

Notăția **do** pentru monade

$(\gg=) :: m\ a \rightarrow (a \rightarrow m\ b) \rightarrow m\ b$

$(\gg) :: m\ a \rightarrow m\ b \rightarrow m\ b$

Notăția cu operatori	Notăția do
$e \gg= \backslash x \rightarrow \text{rest}$	$x \leftarrow e$ rest
$e \gg= \backslash _ \rightarrow \text{rest}$	e rest
$e \gg \text{rest}$	e rest

De exemplu

$e1 \gg= \backslash x1 \rightarrow e2 \gg e3$

devine

do

$x1 \leftarrow e1$

$e2$

$e3$

Exemple de efecte laterale

I/O	Monada IO
Parțialitate	Monada Maybe
Excepții	Monada Either
Nedeterminism	Monada [] (listă)
Logging	Monada Writer
Stare	Monada State
Memorie read-only	Monada Reader

Monada List

Monada Listă (nedeterminism)

O computație care întoarce un rezultat nedeterminist nu este o funcție pură.

Poate fi transformată într-o funcție pură transformând rezultatul său din tipul `a` în tipul `[a]`.

În esență, construim o funcție care returnează toate rezultatele posibile în același timp.

Monada Listă (nedeterminism)

Funcțiile din clasa **Monad** specializate pentru liste:

```
(>>=)  :: [a] -> (a -> [b]) -> [b]  
return :: a -> [a]
```

```
instance Monad [] where  
  return x = [x]  
  xs >>= f = concat (map f xs)
```

```
concat :: [[a]] -> [a]
```


Monada Listă – exemplu

```
twiceWhenEven :: [Integer] -> [Integer]
twiceWhenEven xs = do
  x <- xs
  if even x
    then [x*x, x*x]
    else [x*x]
```

Monada Maybe

Monada Maybe (a funcțiilor parțiale)

```
data Maybe a = Nothing | Just a
```

```
(>>=) :: Maybe a -> (a -> Maybe b) -> Maybe b  
return :: a -> Maybe a
```

```
instance Monad Maybe where  
    return = Just
```

```
    Just va >>= f = f va  
    Nothing >>= _ = Nothing
```

Monada Maybe – exemplu

```
radical :: Float -> Maybe Float
```

```
radical x
```

```
    | x >= 0 = return (sqrt x)
```

```
    | x < 0  = Nothing
```

```
-- a * x^2 + b * x + c = 0
```

```
solEq2 :: Float -> Float -> Float -> Maybe Float
```

```
solEq2 0 0 0 = return 0
```

```
solEq2 0 0 c = Nothing
```

```
solEq2 0 b c = return (negate c / b)
```

```
solEq2 a b c = do
```

```
    rDelta <- radical (b * b - 4 * a * c)
```

```
    return ((negate b + rDelta) / (2 * a))
```

Monada Maybe – exemplu

```
-- a * x^2 + b * x + c = 0
solEq2All :: Float -> Float -> Float -> Maybe [Float]
solEq2All 0 0 0 = return [0]
solEq2All 0 0 c = Nothing
solEq2All 0 b c = return [negate c / b]
solEq2All a b c = do
    rDelta <- radical (b * b - 4 * a * c)
    let s1 = (negate b + rDelta) / (2 * a)
    let s2 = (negate b - rDelta) / (2 * a)
    return [s1,s2]
```

Monada Either

Monada Either (a excepțiilor)

```
data Either err a = Left err | Right a
```

```
(>>=) :: Either err a -> (a -> Either err b) ->  
      Either err b
```

```
return :: a -> Either err a
```

```
instance Monad (Either err) where  
  return = Right
```

```
    Right va >>= f = f va
```

```
    err >>= _ = err
```

```
-- Left verr >>= _ = Left verr
```

Monada Either – exemplu

```
radical :: Float -> Either String Float
radical x
  | x >= 0 = return (sqrt x)
  | x < 0  = Left "radical: argument negativ"

-- a * x^2 + b * x + c = 0
solEq2 :: Float -> Float -> Float -> Either String Float
solEq2 0 0 0 = return 0
solEq2 0 0 c = Left "ecuatie: fara solutie"
solEq2 0 b c = return (negate c / b)
solEq2 a b c = do
  rDelta <- radical (b * b - 4 * a * c)
  return ((negate b + rDelta) / (2 * a))
```


Monada Writer

Monada Writer (variantă simplificată)

```
newtype Writer log a = Writer {runWriter :: (a, log)}  
-- a este parametru de tip
```

Funcțiile din clasa **Monad** specializate pentru **Writer**:

```
(>=>) :: Writer log a -> (a -> Writer log b) ->  
      Writer log b  
return :: a -> Writer log a
```

```
instance Monad (Writer String) where  
  return va = Writer (va, "")  
  ma >=> f = let (va, log1) = runWriter ma  
               (vb, log2) = runWriter (f va)  
               in Writer (vb, log1 ++ log2)
```

Monada Writer - exemplu

```
newtype Writer log a = Writer {runWriter :: (a, log)}
```

```
tell :: log -> Writer log ()
```

```
tell msg = Writer ((), msg)
```

```
logIncrement :: Int -> Writer String Int
```

```
logIncrement x = do
```

```
    tell ("increment:" ++ show x ++ "--")
```

```
    return (x + 1)
```

```
logIncrement2 :: Int -> Writer String Int
```

```
logIncrement2 x = do
```

```
    y <- logIncrement x
```

```
    logIncrement y
```

```
> runWriter (logIncrement2 13)
```

```
(15,"increment:13--increment:14")
```

Monada Reader

Monada Reader (stare nemodificabilă)

```
newtype Reader env a = Reader {runReader :: env -> a}  
-- runReader :: Reader env a -> env -> a
```

```
instance Monad (Reader env) where  
  return = Reader const  
  -- return x = Reader (\_ -> x)
```

```
ma >>= k = Reader f  
  where  
    f env = let va = runReader ma env  
            in runReader (k va) env
```

Monada Reader - exemplu

```
newtype Reader env a = Reader {runReader :: env -> a}  
-- runReader :: Reader env a -> env -> a
```

```
ask :: Reader env env  
ask = Reader id
```

```
tom :: Reader String String  
tom = do  
  env <- ask -- gives the environment (here a String)  
  return (env ++ "␣This␣is␣Tom.")
```

```
jerry :: Reader String String  
jerry = do  
  env <- ask  
  return (env ++ "␣This␣is␣Jerry.")
```

Monada Reader - exemplu

```
tomAndJerry :: Reader String String
tomAndJerry = do
  t <- tom
  j <- jerry
  return (t ++ "\n" ++ j)

runJerryRun :: String
runJerryRun = runReader tomAndJerry "Who_is_this?"
```

Se dă tipul de date

```
data Fuel a = Fuel {getFuel :: Integer -> Integer ->  
    Maybe (Integer, a)}
```

Să se scrie instanța clasei **Monad** pentru tipul `Fuel`, ținând cont că în timpul computațiilor se consumă câte o unitate din resursă (`fuel`), iar computațiile pot fi efectuate cât timp resursa nu este 0.

Exemplu:

```
test :: Fuel Int
```

```
test = pure 0 >>= pure . (+1) >>= pure . (+1)
```

```
failEx = getFuel test 1      -- Nothing
```

```
sucEx = getFuel test 2      -- Just (0,2)
```

```
instance Functor Fuel where  
  fmap f (Fuel m) =  
    Fuel (\i -> case m i of  
      Nothing -> Nothing  
      Just (i', a) -> Just (i'  
        ', f a)  
    )
```

```
instance Applicative Fuel where
  pure x = Fuel (\i -> Just (i, x))
  (Fuel mf) <*> (Fuel af) =
    Fuel (\i -> case mf i of
      Nothing -> Nothing
      Just (i', f) ->
        if i' <= 0
        then Nothing
```

```
else case af (i' - 1) of
  Nothing -> Nothing
  Just (i'', a) ->
    if i'' <= 0
    then Nothing
    else Just (i'' - 2, f a)
)
```

Succes la examen!