

# Modularity and Backpack

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# MirageOS

TODO picture of unikernel

# MirageOS

TODO picture of HTTP app with dependencies

# Exhibit 1

## MirageOS

*The compiler heavily emphasises static type checking, and the resulting binaries are fast native code with no runtime type information and the module system is among the most powerful in a general-purpose programming language in terms of permitting flexible and safe code reuse and refactoring.*

- Technical Background of MirageOS

# ML Modules

## Structures

```
structure IntInteger =  
  struct  
    type integer = int  
    val zero = 0  
    val succ n = n + 1  
    fun add a b = a + b  
    fun mul a b = a * b  
  end
```

# ML Modules

## Signatures

```
signature INTEGER =  
  sig  
    type integer  
    val zero: integer  
    val succ: integer -> integer  
    fun add: integer -> integer -> integer  
    fun mul: integer -> integer -> integer  
  end
```

# ML Modules

## Functors

```
functor RationalFun(l: INTEGER) =  
  struct  
    type rational = l.integer * l.integer  
    fun nom (n, _) = n  
    fun denom (_, d) = d  
    fun add (n1, d1) (n2, d2) =  
      (l.add (l.mul n1 d2) (l.mul n2 d1),  
       l.mul d1 d2)  
  end  
  
structure IntRational = RationalFun(IntInteger)
```

# ML Modules

TODO: Mirage app diagram



## Exhibit 2

tagstream-conduit

```
data Dec builder string = Dec
{ decToS      :: builder -> string
, decBreak    :: (Char -> Bool) -> string ->
                  (string, string)
, decBuilder  :: string -> builder
, decDrop     :: Int -> string -> string
, decEntity   :: string -> Maybe string
, decUncons   :: string -> Maybe (Char, string)
}
```

# Exhibit 3

tagsoup

```
class (Typeable a, Eq a) => StringLike a where  
  empty      :: a  
  cons       :: Char -> a -> a  
  uncons     :: a -> Maybe (Char, a)  
  toString   :: a -> String  
  fromString :: String -> a  
  — [...] ]
```

# Backpack

## Signatures

```
module IntegerSig where  
  
data Integer  
  
zero  :: Integer  
succ  :: Integer  
add   :: Integer -> Integer -> Integer  
mul   :: Integer -> Integer -> Integer
```

# Backpack

## Modules

```
module Rational where  
  
import qualified IntegerSig as I  
  
data Rational = R I.Integer I.Integer  
  
nom (R n _) = n  
denom (R _ d) = d  
add (R n1 d1) (R n2 d2) =  
  R (I.add (I.mul n1 d2) (I.mul n2 d1))  
    (I.mul d1 d2)
```

# Backpack

Cabal packages

## Integer signature package

name:	integer-sig
version:	1.0
indefinite:	True
exposed-signatures:	IntegerSig

# Backpack

Cabal packages

Integer implementation package

```
name: integer-int  
exposed-modules: IntegerInt
```

# Backpack

Cabal packages

Rational “functor” package

name:	rational
indefinite:	True
build-depends:	integer-sig -1.0
exposed-modules:	Rational

# Backpack

Mixing in

## Rationals based on Integers

```
name: rational-int
build-depends:
  integer (IntegerInt as IntegerSig),
  rational
reexported-modules: Rational
```