# Eff Monad

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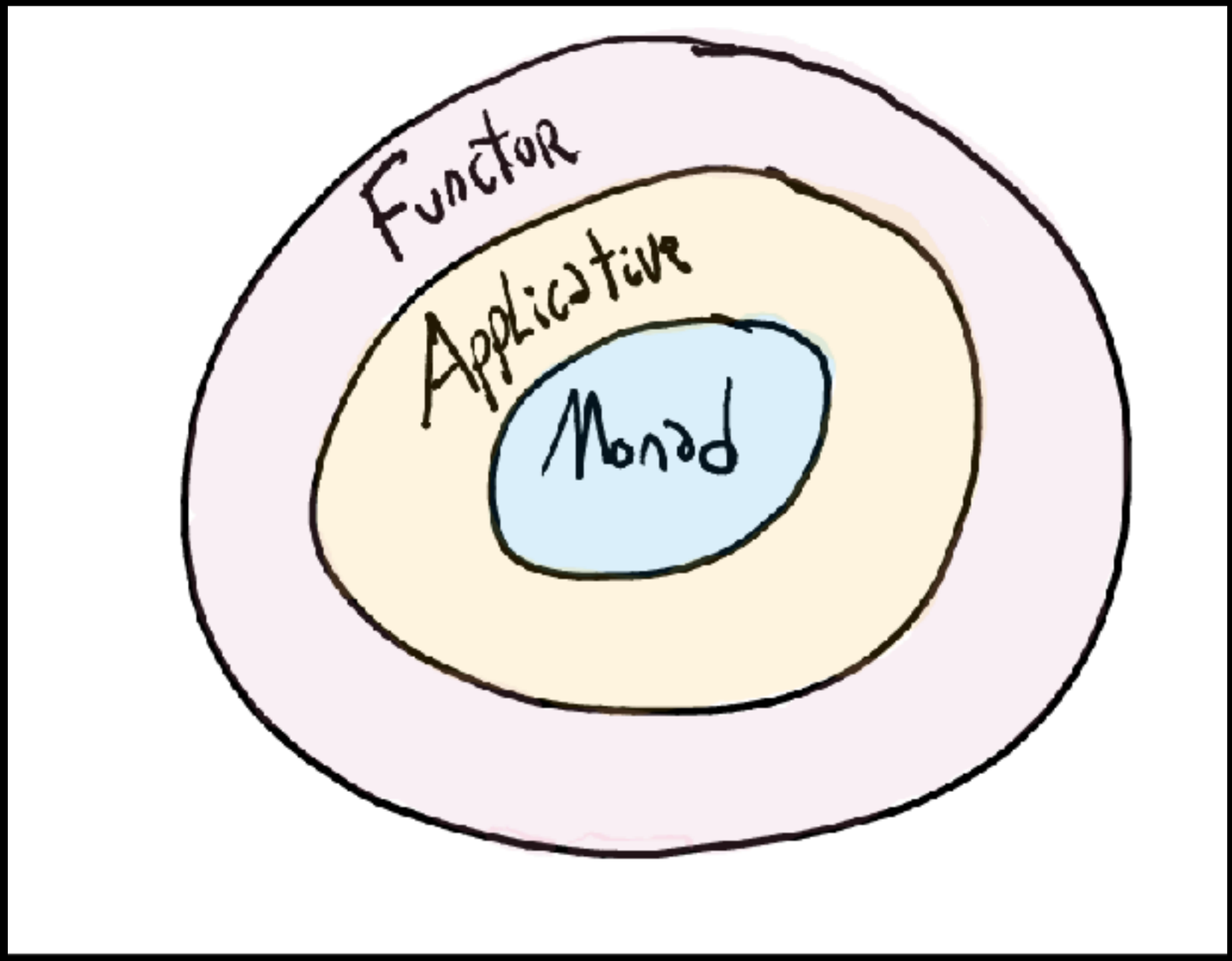
# What is Monad?



# Type classes

| | |
|---|---|
| **Functor** | `def map[A, B](f: A => B): F[A]=>F[B]` |
| **Applicative Functor** | `def apply[A, B] (f: F[A => B]): F[A] => F[B]` |
| **Monad** | `def bind[A, B](f: A => F[B]): F[A] => F[B]` |

# Monad

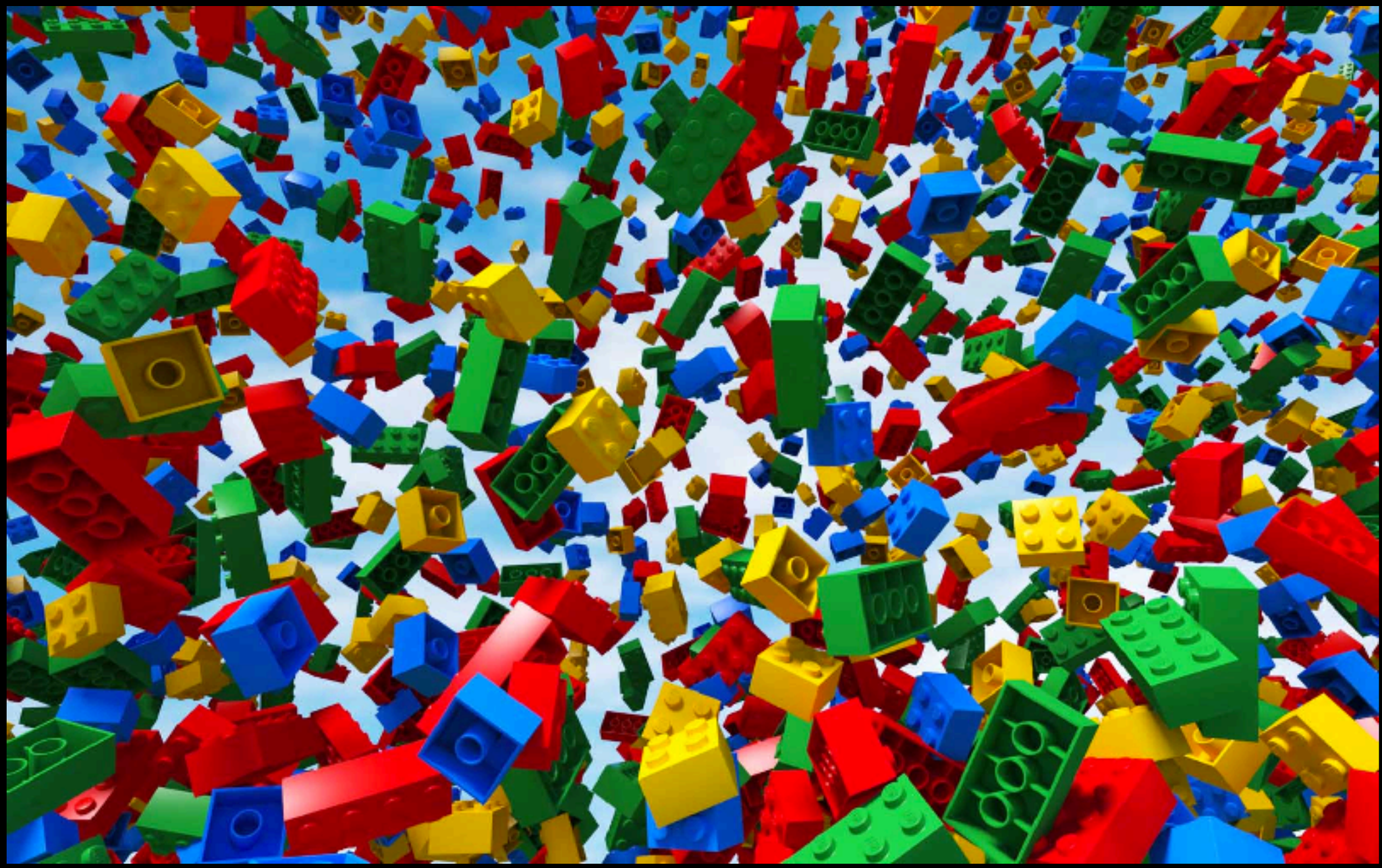
```
import scalaz._
import Scalaz._
val double:Int => Int = 2*
```

```
//Functor
Option(2).map(double)
//Applicative
Option(2) <*> Option(double)
//Monad
Option(2) >>= (double(_).some)
```

# Monads

- List, Option, Future
- Writer[W, A]: A monad for logging
- Reader[E, A]: A monad which reads values
- State[S, A]: A monad for state machine
- ....

# Life is not easy



# Life is beautiful

# Monad Composition

- We always need to compose contexts or effects
- Option+Writer+Reader+…….
- How can I handle this?

# Monad Transformer

- Either + Option
  - *type EOMonad[A] = EitherT[Option, String, A]*
- Either + Option  + List
  - *type EOLMonad[A] = ListT[EitherT[Option, String, ?], A]*
- Either + Option  + List + Reader + Writer????

# Free Monad

- Monads + Interpreters
- Compose various monads via Coproduct
- Interpreters via NaturalTransformation

# Some Helper Code

```
implicit class NaturalTransformationOrOps[F[_], H[_]]
(private val nt: F ~> H) extends AnyVal {
  def or[G[_]](f:G ~> H): Coproduct[F, G, ?] ~> H =
    new (Coproduct[F, G, ?] ~> H) {
      def apply[A](c: Coproduct[F, G, A]): H[A] = c.run match {
        case -\/(fa) => nt(fa)
        case \/-(ga) => f(ga)
      }
  }
type -~>[F[_], G[_]] = Inject[F, G]
object LiftImplicit {
  implicit def lift[F[_], G[_], A](
    fa: F[A]
  )(
  implicit I: F -~> G
): Free.FreeC[G, A] =
    Free liftFC I.inj(fa)
}
```

Monads Composition

Lift to Free Monad

# Program

```
type PRG0[A] = Coproduct[Interact, Crud, A]
type PRG[A] = Coproduct[Log, PRG0, A]
type PRG1[A] = Coproduct[PPLog, PRG, A]
val program: Free[PRG1, Boolean] = prg[PRG1]
val interpreter0: PRG0 ~> Result = (Console andThen Id2Result) or Crudinterpreter
val interpreter: PRG ~> Result = (Printer andThen Id2Result) or interpreter0
val interpreter1: PRG1 ~> Result = (PPPrinter andThen Id2Result) or interpreter
val result0: Result[Boolean] = program.foldMap(interpreter1)
```

Program Stack

Interpreters

# We need more

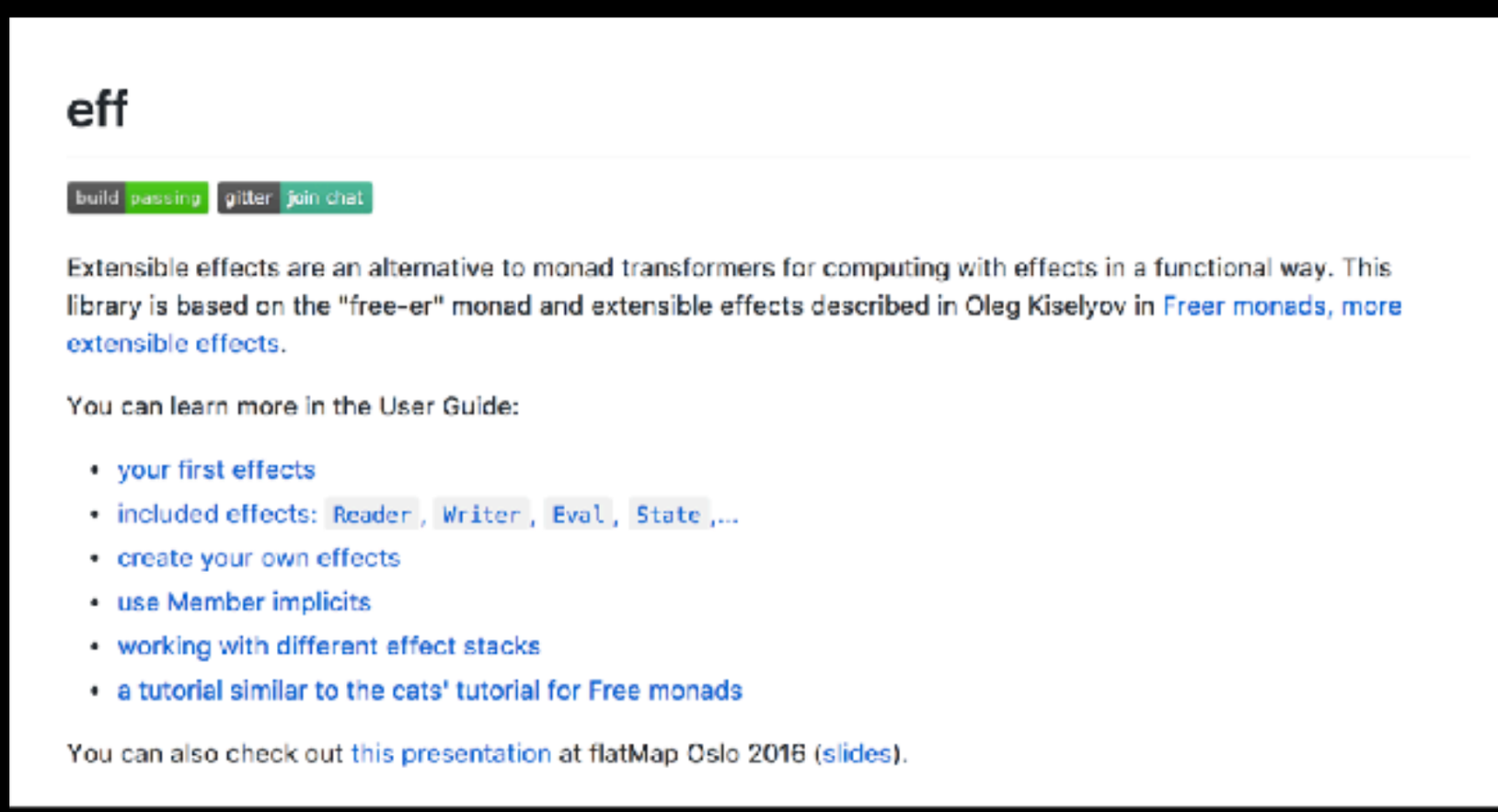
- What if I don’t want to have so much boilerplate code , computer should be cleverer than me
- What if I want to compose, add and remove effects easily in one program
- What if I want to change a behaviour of an effect at run time
- Yes, Eff Monad!

# Eff Monad

- Freer Monad from Haskell
  - http://okmij.org/ftp/Haskell/extensible/more.pdf
- A program is a big effect stack composed of multiple different effects
- An effect is modular and can be added and removed from a big effect stack at run time
- An effect can be translated to other effect
- Less boilerplate code

# Eff Monad library

- https://github.com/atnos-org/eff
- Eric Torreborre
- Author of specs2



## eff

build passing gitter join chat

Extensible effects are an alternative to monad transformers for computing with effects in a functional way. This library is based on the "free-er" monad and extensible effects described in Oleg Kiselyov in Freer monads, more extensible effects.

You can learn more in the User Guide:

- your first effects
- included effects: `Reader`, `Writer`, `Eval`, `State`,...
- create your own effects
- use Member implicits
- working with different effect stacks
- a tutorial similar to the cats' tutorial for Free monads

You can also check out this presentation at flatMap Oslo 2016 (slides).

# A basic sample

Effect Stack

```
type Stack = Fx.fx3[WriterString, ReaderInt, Eval]
```

```
def program[R: _readerInt: _writerString: _eval]: Eff[R, Int] =
  for {
    n <- ask[R, Int]
    _ <- tell("the required power is " + n)
    a <- delay(math.pow(2, n.toDouble).toInt)
    _ <- tell("the result is " + a)
  } yield a
```

Effects

```
println(program[Stack].runReader(6).runWriter.runEval.run)
//(64,List(the required power is 6, the result is 64))
println(program[Stack].runWriter.runReader(6).runEval.run)
//(64,List(the required power is 6, the result is 64))
```

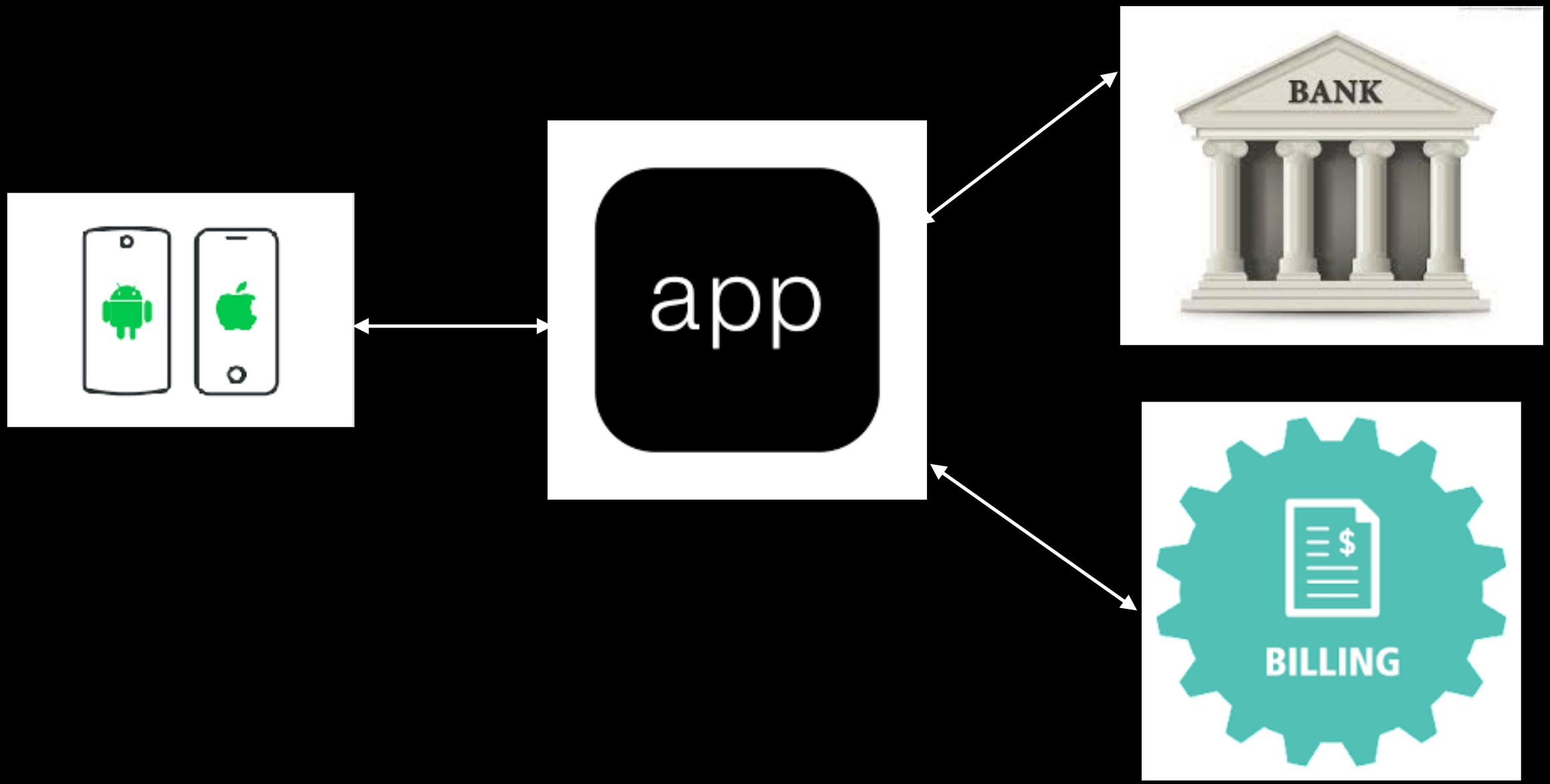
# Out of Box Effects

| Name | Description | Link |
|---|---|---|
| `EvalEffect` | an effect for delayed computations | link |
| `OptionEffect` | an effect for optional computations, stopping when there's no available value | link |
| `EitherEffect` | an effect for computations with failures, stopping when there is a failure | link |
| `ValidateEffect` | an effect for computations with failures, allowing to collect failures | link |
| `ErrorEffect` | a mix of Eval and Either, catching exceptions and returning them as failures | link |
| `ReaderEffect` | an effect for depending on a configuration or an environment | link |
| `WriterEffect` | an effect to log messages | link |
| `StateEffect` | an effect to pass state around | link |
| `ListEffect` | an effect for computations returning several values | link |
| `ChooseEffect` | an effect for modeling non-determinism | link |
| `MemoEffect` | an effect for memoizing values | link |
| `FutureEffect` | an effect for asynchronous computations | link |
| `SafeEffect` | an effect for guaranteeing resource safety | link |

# Eff Step by Step

- Create your ADTs
- Lift your ADT to Eff[R, A] via Eff.send
- Build your program
- Write your interpreters
- Run it

# An IVR Billing App



# ADT

```scala
sealed trait BillOp[A]

case class CheckBill(bill: String) extends BillOp[Boolean]

case class UpdateBill(bill: String, status: String) extends BillOp[Option[String]]
```

```scala
sealed trait BankOp[A]

case class Purchase(bill: String, card: String) extends BankOp[Option[String]]
case class Refund(bill:   String, card: String) extends BankOp[Option[String]]
```

# ADT

```scala
sealed trait IvrOp[A]

sealed trait Result
case object Continue extends Result
case object RequestAgain extends Result
case object Stop extends Result

case class Request(prompt: String) extends IvrOp[String]
case class Response(msg:   String) extends IvrOp[Unit]
case class CheckInput(msg:  String) extends IvrOp[Result]
```

# Lift ADT to Eff

```
type _bankOp[R] = BankOp |= R
def purchase[R: _bankOp](bill: String, card: String): Eff[R, Option[String]] =
  Eff.send[BankOp, R, Option[String]](Purchase(bill, card))
```

Call Eff.send explicitly

```
object EffHelper {
  implicit def liftEff[A, F[_], R: F |= ?](s: F[A]): Eff[R, A] =
    Eff.send[F, R, A](s)
  }
}
```

Call Eff.send implicitly

# The App

```
def program[R: _ivrOp: _billOp: _bankOp]: Eff[R, Unit] =
  for {
    bill      <- Request("Please type in your bill reference ")
    _         <- Response(s"Your bill reference: ${bill}")
    card      <- Request("Please type in your credit card info ")
    _         <- Response(s"Your credit card is : ${card}, we are processing no
    reference <- Purchase(bill, card)
    receipt   <- UpdateBill(bill, "Paid")
    _         <- Response(s"Your payment refrence is ${receipt}")
  } yield ()

type Stack = Fx.fx3[IvrOp, BillOp, BankOp]
program[Stack].runBill.runIvr.runBank.run

// Please type in your bill reference
//1
//Your bill reference: 1
//Please type in your credit card info
//2
//Your credit card is : 2, we are processing now
//Your payment refrence is Some(Ok)
```

The minimum effect stack

# Interpreters

```
trait Recurser[M[_], R, A, B] {
  def onPure(a: A): B
  def onEffect[X](m: M[X]): X Either Eff[R, B]
  def onApplicative[X, T[_]: Traverse](ms: T[M[X]]): T[X] Either M[T[X]]
}

trait Translate[T[_], U] {
  def apply[X](kv: T[X]): Eff[U, X]
}

trait SideEffect[T[_]] {
  def apply[X](tx: T[X]): X
  def applicative[X, Tr[_] : Traverse](ms: Tr[T[X]]): Tr[X]
}
```

# Interpreters

```
type _billOp[R] = BillOp |= R
def runBillOp[R, A](effect: Eff[R, A])(implicit m: BillOp <= R): Eff[m.Out, A] = {
  val memDataSet = new scala.collection.mutable.ListBuffer[String]

  recurse(effect)(new Recurser[BillOp, m.Out, A, A] {
    def onPure(a:      A): A = a
    def payBill(bill: String, card: String) = "Ok".some
    def check(bill:   String) = bill === "1234"

    def onEffect[X](i: BillOp[X]): X Either Eff[m.Out, A] = Left {
      i match {
        case UpdateBill(bill, card) => payBill(bill, card)
        case CheckBill(bill)        => check(bill)
      }
    }

    def onApplicative[X, T[_]: Traverse](ms: T[BillOp[X]]): T[X] Either BillOp[T[X]] =
      Left(ms.map {
        case UpdateBill(bill, card) => payBill(bill, card)
        case CheckBill(bill)        => check(bill)
      })
  })(m)
}
```

The rest of effects stack

Effect Interpreter

# I want to check user's inputs!

```
def checkInput[R: _ivrOp](input: String): Eff[R, Option[String]] =
  (CheckInput(input): Eff[R, Result]) >>= { r =>
    r match {
      case Continue     => Eff.pure(input.some)
      case Stop         => Eff.pure(None)
      case RequestAgain => askForBill[R]
    }
  }

def askForBill[R: _ivrOp]: Eff[R, Option[String]] =
  for {
    input <- Request("Please type in your bill reference or type 0 to stop")
    bill  <- checkInput(input)
  } yield bill
```

Recursive Effect

# Option effect is in !

```
def program[R: _ivrOp: _billOp: _bankOp: _option]: Eff[R, Unit]
  for {
    billOption <- askForBill
    bill       <- fromOption(billOption)
    _          <- Response(s"Your bill reference: ${bill}")
    card       <- Request("Please type in your credit card info ")
    _          <- Response(s"Your credit card is : ${card}, we are processing now")
    reference  <- Purchase(bill, card)
    receipt    <- finishCall(bill, reference)
  } yield ()

type Stack = Fx.fx4[IvrOp, BillOp, BankOp, Option]
program[Stack].runBill.runIvr.runBank.runOption.run
```

Option Effect

# How can I miss logging?

```
type WriterString[A]  = Writer[String, A]
type _writerString[R] = WriterString |= R

def program[R: _ivrOp: _billOp: _bankOp: _option: _writerString]: Eff[R, Unit] =
  for {
    _           <- tell("A customer called in, let's start ")
    billOption  <- askBill
    bill        <- fromOption(billOption)
    _           <- Response(s"Your bill reference: ${bill}")
    card        <- Request("Please type in your credit card info ")
    _           <- Response(s"Your credit card is : ${card}, we are processing now")
    reference   <- Purchase(bill, card)
    receipt     <- finishCall(bill, reference)
    _           <- Response(s"Your payment refrence is ${receipt}")
    _           <- tell("We have finished everyting")
  } yield ()

type Stack = Fx.fx5[IvrOp, BankOp, BillOp, Option, WriterString]
program[Stack].runBill.runIvr.runBank.runOption.runWriter.run
```

Writer Effect

# One More thing

- I have a performance issue and I want to log the time taken for each operation and I hate below code

```scala
def getTimeStamp = s"${new java.util.Date}"
def program[R: _ivrOp: _billOp: _bankOp: _writerString]: Eff[R, Unit] =
  for {
    _         <- tell("<<<${getTimeStamp}>>>:Request for bill reference Start")
    bill      <- Request("Please type in your bill reference ")
    _         <- tell("<<<${getTimeStamp}>>>:Request for bill reference End")
    _         <- tell("<<<${getTimeStamp}>>>:Response for bill reference Start")
    _         <- Response(s"Your bill reference: ${bill}")
    _         <- tell("<<<${getTimeStamp}>>>:Response for bill reference End")
    _         <- tell("<<<${getTimeStamp}>>>:Request for card info Start")
    card      <- Request("Please type in you
    _         <- tell("<<<${getTimeStamp}>>>
    _         <- tell("<<<${getTimeStamp}>>>
    _         <- Response(s"Your credit card
    _         <- tell("<<<${getTimeStamp}>>>
    _         <- tell("<<<${getTimeStamp}>>>
    reference <- Purchase(bill, card)
    _         <- tell("<<<${getTimeStamp}>>>
    _         <- tell("<<<${getTimeStamp}>>>
    receipt   <- UpdateBill(bill, reference.
    _         <- tell("<<<${getTimeStamp}>>>
    _         <- tell("<<<${getTimeStamp}>>>
    _         <- Response(s"Your payment ref
    _         <- tell("<<<${getTimeStamp}>>>
  } yield ()
```

# Eff Translation

```
type WriterString[A] = Writer[String, A]
implicit class LogTimesOps[R, A](e:    Eff[R, A]) {
  def logTimes[T[_]](implicit memberT: MemberInOut[T, R],
                     writer:           MemberIn[WriterString, R]): Eff[R, A] =
    LogHelper.logTimes[R, T, A](e)
}
```

```
def logTimes[R, T[_], A](eff:                    Eff[R, A])(implicit memberT: MemberInOut[T, R]
                                                 writer: MemberIn[WriterString, R]): Eff[R, A] = {

  translateInto(eff)(new Translate[T, R] {
    def apply[X](tx: T[X]): Eff[R, X] =
      for {
        _ <- tell[R, String](s"${new java.util.Date}:$tx start")
        x <- send[T, R, X](tx)
        _ <- tell[R, String](s"${new java.util.Date}:$tx end")
      } yield x
  })
}
```

Writer effect injected

# Eff Translation

```
def program[R: _ivrOp: _billOp: _bankOp: _option]: Eff[R, Unit] =
  for {
    billOption <- askBill
    bill       <- fromOption(billOption)
    cats       <- Response(s"Your bill reference: ${bill}")
    card       <- Request("Please type in your credit card info ")
    cats       <- Response(s"Your credit card is : ${card}, we are processing now")
    reference  <- Purchase(bill, card)
    receipt    <- UpdateBill(bill, "Paid")
    _          <- Response(s"Your payment refrence is ${receipt}")
  } yield ()

type Stack = Fx.fx5[IvrOp, BillOp, BankOp, Writer[String, ?], Option]

val (result, logs) =
  program[Stack].logTimes[BillOp].runBill.runBank.runIvr.runOption.runWriter.run
logs.foreach(println)
```

Writer effect injected

# Eff[R, A]=> Eff[U,A]

| | |
|---|---|
| into | Move current effect to a larger stack |
| transform | Transform an effect into another one by using a natural transformation |
| translate | Translate an effect into other effects in the stack |
| translateInto | Translate one effect of the stack into other effects in a larger stack |

# Monad Loop

```
def program[R: _kvstore]: Eff[R, Unit] =
  for {
    _ <- Put("wild-cats", 2)
    _ <- Put("tame-cats", 5)
    n <- Get("wild-cats")
    r = n.map(_ * 2)
    _ <- Delete("tame-cats")
  } yield ()

def done[R: _kvstore]: Eff[R, Boolean] = Check

type Stack = Fx.fx2[Option, KVStore]

program[Stack].untilM_(done[Stack])
```

Monad with a Control Loop

# Links

- https://github.com/atnos-org/eff
- http://atnos-org.github.io/eff/
- Some other similar libs
  - https://github.com/frees-io/freestyle
  - https://github.com/b-studios/scala-effekt

# Thanks