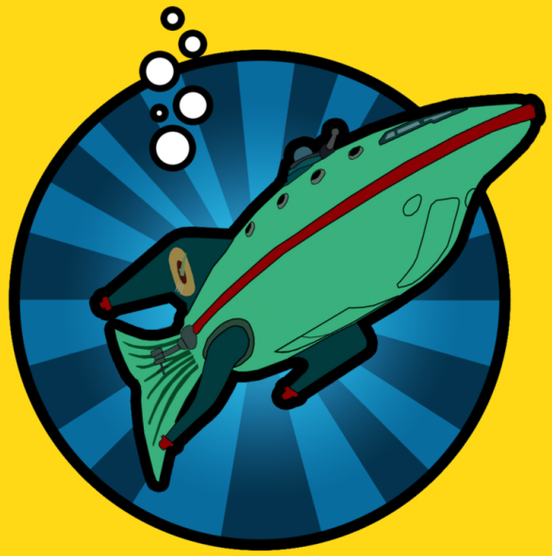
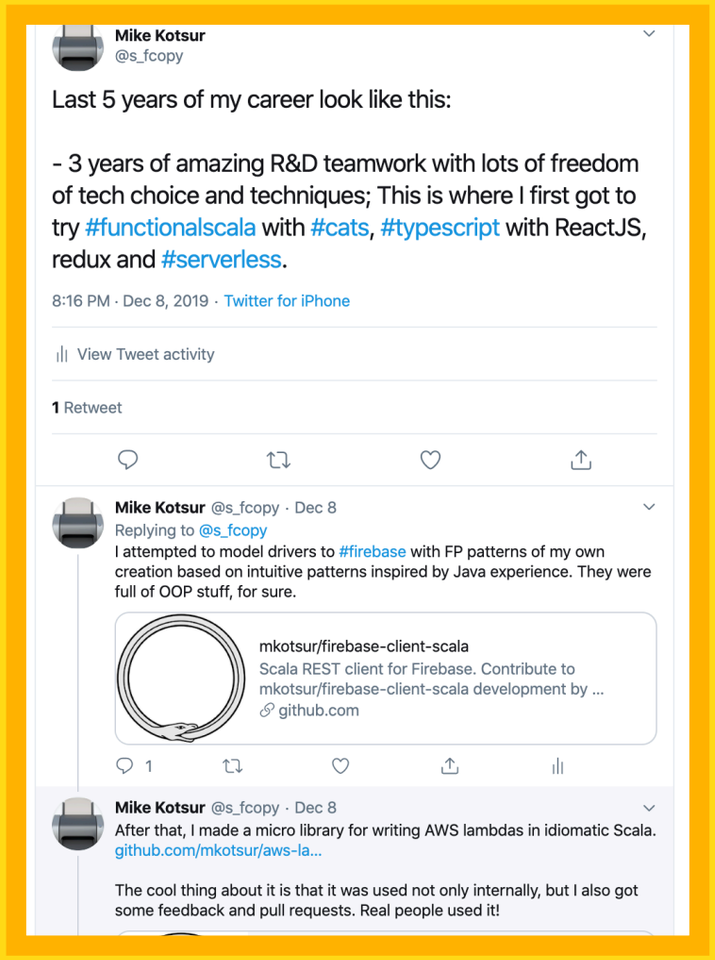
Prototyping the Future with Functional Scala



Mike Kotsur

ScalaUA 2020

“Becomes very happy up in the mountains or writing nice and stable code in a functional language without runtime bugs.”



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We’ll cover

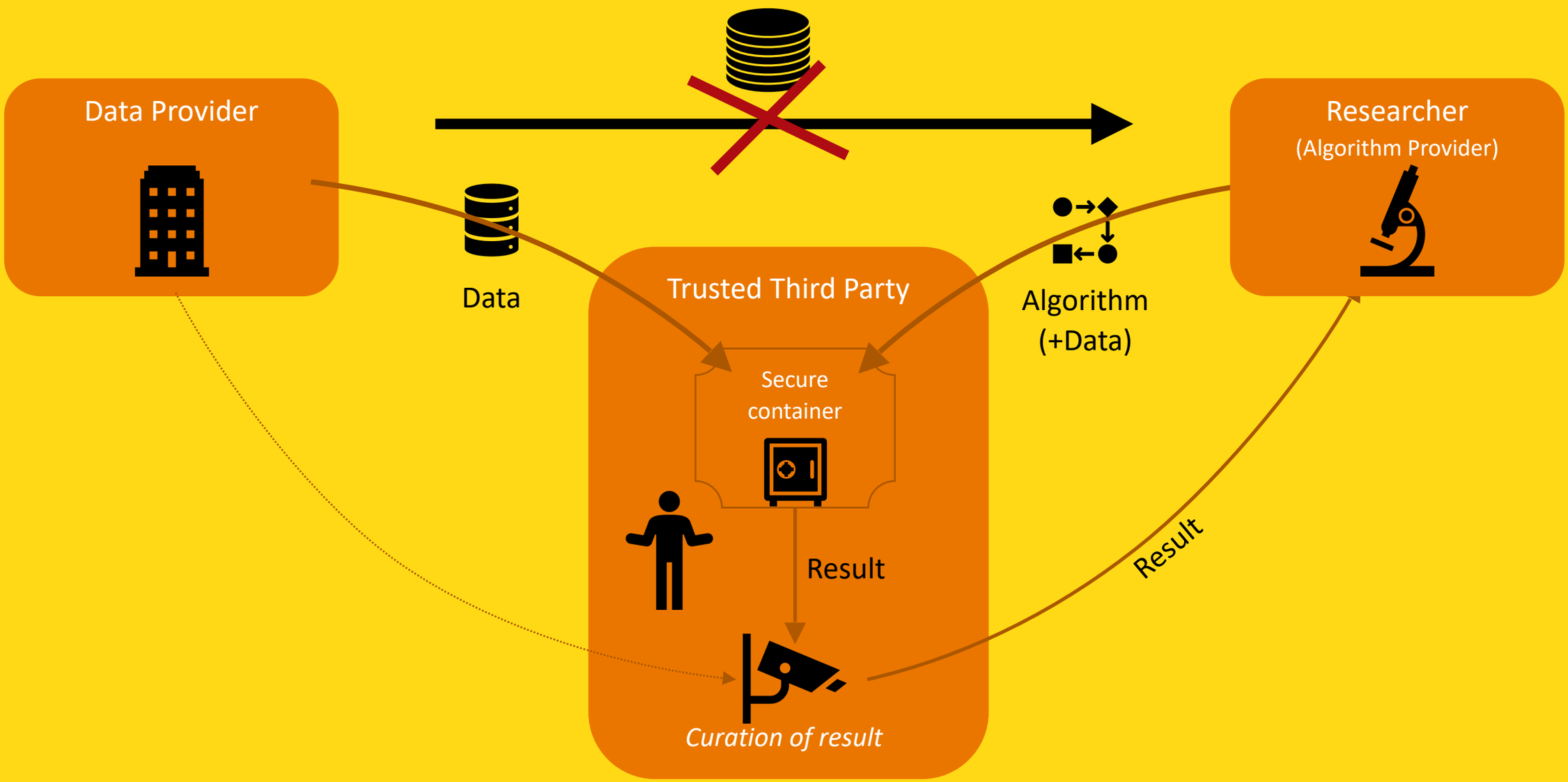
- 🚲 What prototyping is all about;
- 🅾️1️⃣ Data Exchange project challenges;
- 🥳☠️ 9 Lessons learned;
- 💪 How modern FP Scala libs help.

Software Prototyping

- Testing a business idea with the minimal functionality;
- Trying to make as much **Feedback => Improvement** iterations as possible within limited time;

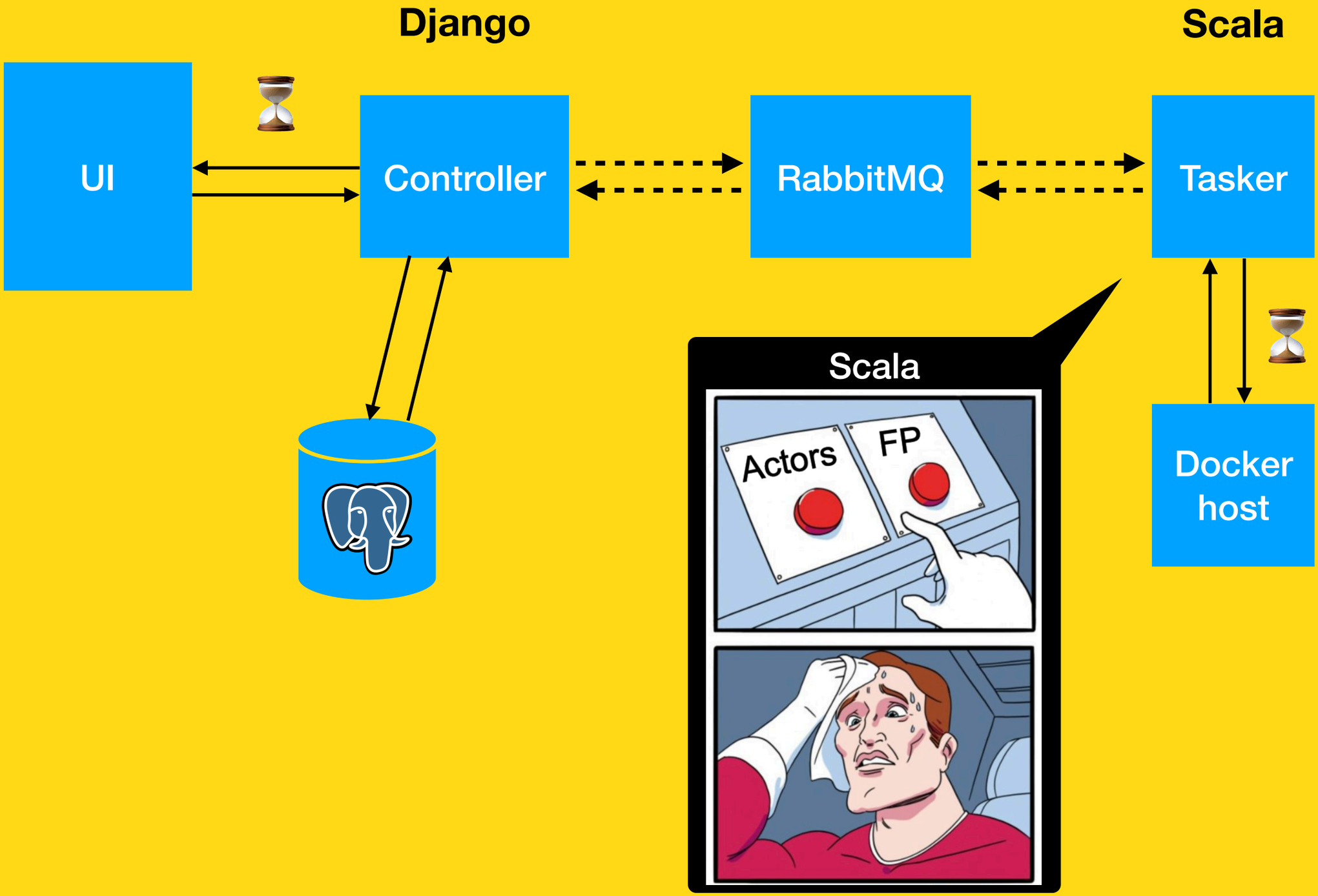
- Difficult tech choices: quality / speed.

Data Exchange



More info:
https://www.surf.nl/en/data-exchange-trusted-data-sharing

Architecture v0.2



Lesson 1:

Future[T] is a thing of the past

```scala
val f0: Future[Int] = Future { ??? }
def times2(i: Int): Int = ???

//   times2(f0) doesn't compile

f0.map(times2)(ec)

f0.onComplete {
  case Failure(exception) ⇒ ???
  case Success(value)     ⇒ ???
}

f0.recover {
  case e: Throwable ⇒ ???
}

Await.ready(f0, Duration.Inf)

// Do other things
```

Lesson 1:

Future[T] is a thing of the past

```scala
val f: Future[Int] = Future { 1 }
val g: Future[Int] = Future { 2 }
for {
  i ← f
  j ← g
} yield i + j
```

```scala
for {
  i ← Future { 1 }
  j ← Future { 2 }
} yield i + j
```

Lesson 1:

Future[T] is a thing of the past

```
type Name = String
type Price = Int
type Importance = Int
type Activity[T] = (Name, Price, Importance, Future[T])

def doCheapFirst[T](aa: List[Activity[T]]) = ???
def doImportantFirst[T](aa: List[Activity[T]]) = ???
```

Eagerly evaluated

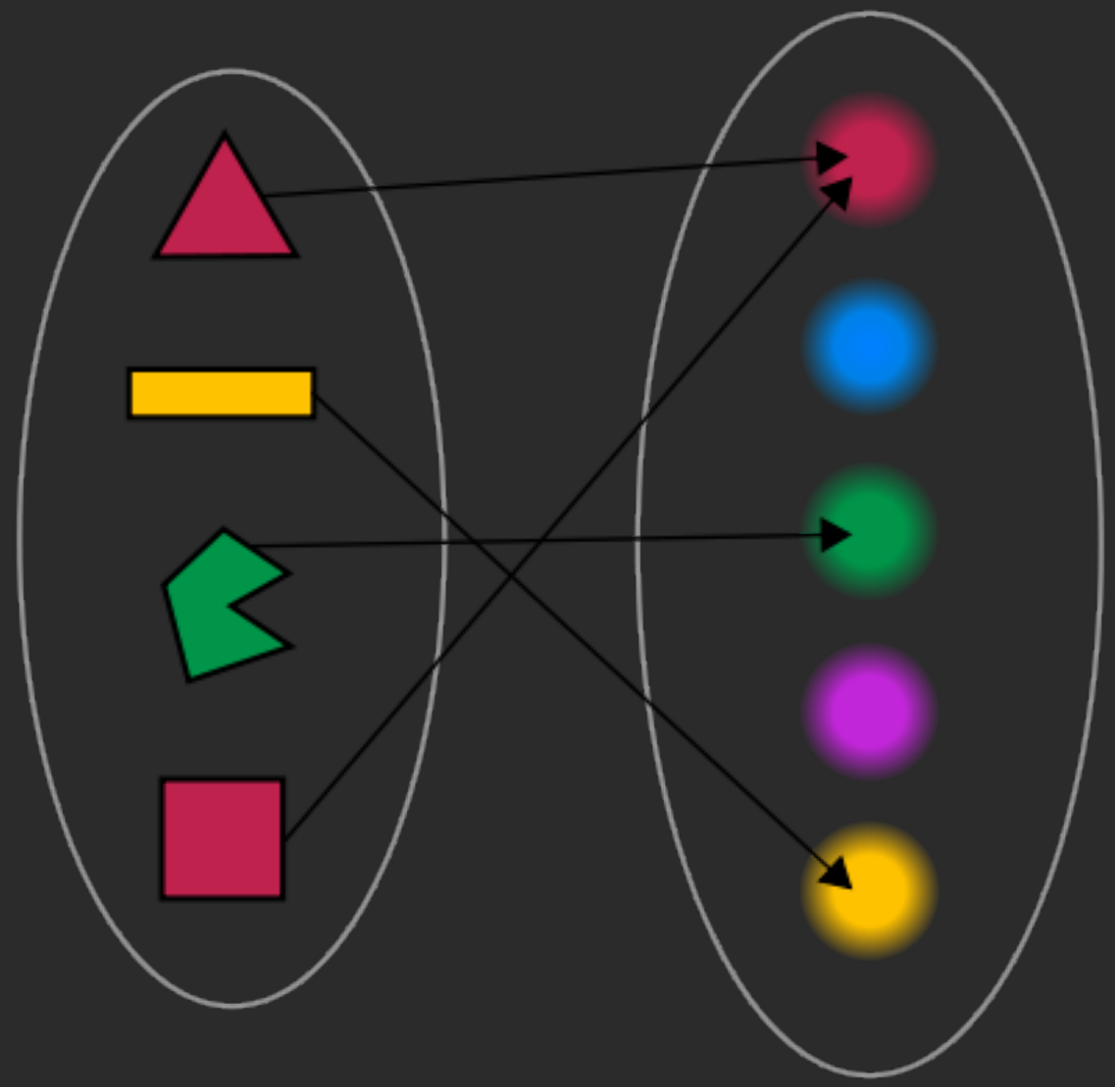
Lesson 2:

FP

is not

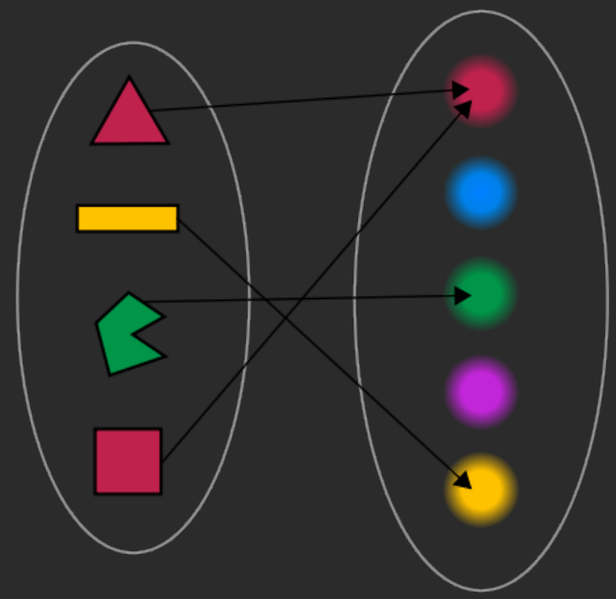
all or

nothing

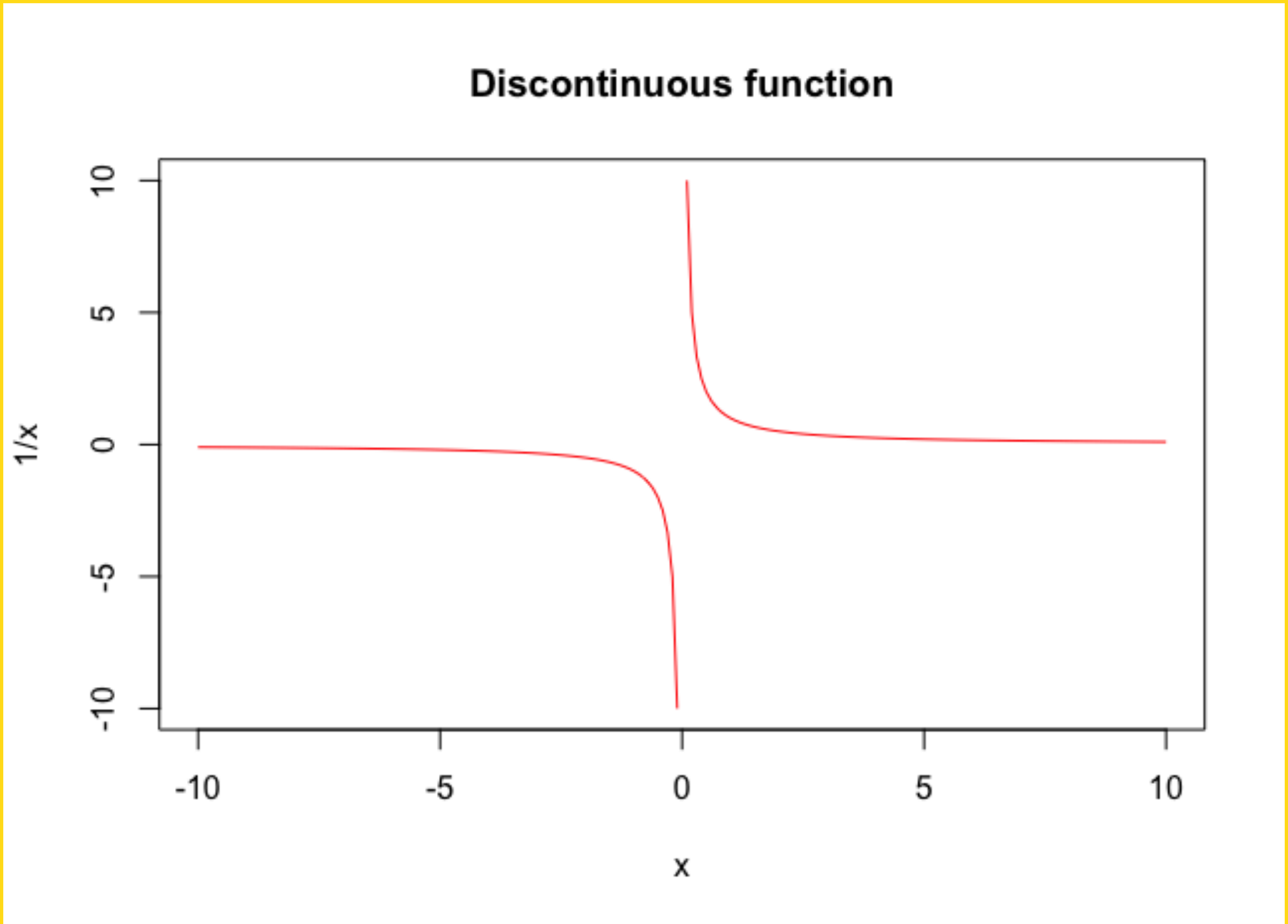


```
//  Math function:
// - relation between sets that;
// - associates to every element of a first set;
// - exactly one element of the second set.
```

```scala
sealed trait Shape
case object Circle extends Shape
case object Polygon extends Shape
case object Rectangle extends Shape
case object Hexagon extends Shape

sealed trait Color
case object Red extends Color
case object Yellow extends Color
case object Green extends Color
case object Purple extends Color
case object Blue extends Color

def shapeColour(shape: Shape): Color = ???


//  CS pure function:
//  - return value is the same for the same args;
//  - its evaluation has no side effects.
```



$f(x) = 1/x$



$$f(x) = 1/x$$

$$f: X \to Y$$

Set X - **domain**;

Set Y - **co-domain**;

X = R / {0}
* or “plug the gap” to keep it R

Y ⊇ R / {0}
** trait Function1[-T1, +R]

```scala
// Not pure!
def getUserName(uid: String): String
```

_

```scala
// User may not exist
def getUserName(uid: String): Option[String]
```

_ || nothing

```scala
// + there may be an error
def getUserName(uid: String):
                        Try[Option[String]]
```

_ || {<: Throwable}

```scala
// There may be an error
// + it may not exist
// + we don't know when it's done
def getUserName(uid: String):
                      Future[Option[String]]
```

_ || {<: Throwable} *

* asynchrony

Functional Effect. A functional effect is an **immutable** **data type** that **describes** (or models) the computation of one or more values, where the computation may require an **additional feature** like optionality, logging, access to context (like configuration), errors, state, or input/output. Using effect-specific operations, functional effects can be transformed

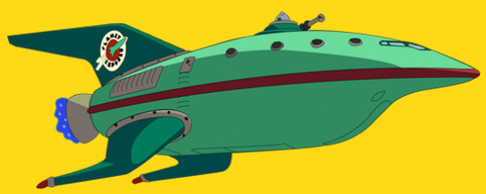
— John A De Goes, A Glossary of Functional Programming

cats-effect

IO, SyncIO	A data type for encoding side effects as pure values, capable of expressing both synchronous and asynchronous computations.
Resource	Effectfully allocates and releases a resource.
Fiber	It represents the (pure) result of an Async data type (e.g. IO) being started concurrently and that can be either joined or canceled.
Timer	It is a scheduler of tasks.
…	

Lesson 3:

IO is good for evolutionary development



Case: a java library, which does what you need, but not how you want it to be done.

```
object Jackpot

def javaGamble: Jackpot.type = {
  Thread.sleep(1000)
  if (System.currentTimeMillis() % 2 == 0) {
    Jackpot
  } else {
    throw new RuntimeException(
          "Sorry, no jackpot this time :-(“
    )
  }
}
```

Unwrap at the
“end of the world”

```
object SimpleGambleApp extends IOApp {

  private def gamble: IO[Jackpot.type] = IO(javaGamble)

  override def run(args: List[String]): IO[ExitCode] = {
    for {
      _ ← IO(println("Started"))
      jackpot ← gamble
      _ ← IO(println(jackpot))
    } yield ExitCode.Success
  }


}
```

Delay[+A](thunk: () ⇒ A) extends IO[A]

(⇒ T) ⇒ IO[T]

IO is a monad, hence
`flatMap` and `for`.

```scala
object GentleGambleApp extends IOApp {

  private def gamble: IO[Jackpot.type] = IO(javaGamble)

  def gambleGentle: IO[Option[Jackpot.type]] =
    gamble.attempt.map {
      case Right(x) ⇒ x.some
      case Left(_)  ⇒ None
    }

  override def run(args: List[String]): IO[ExitCode] = {
    for {
      _ ← IO(println("Started"))
      jackpot ← gambleGentle
      _ ← IO(println(jackpot))
    } yield ExitCode.Success
  }

}
```

Let combinators do their thing 🏋

Always get a result!

Defining new in terms of old 📖

```
private def gambleUntilWin(attempts: Int = 100): IO[Jackpot.type] =
  gambleGentle.flatMap {
    case Some(x) ⇒
      x.pure[IO]
    case None if attempts > 0 ⇒
      IO(println(s"Retrying. ${attempts - 1} attempts left")) *>
        gambleUntilWin(attempts - 1)
    case None ⇒ IO.raiseError(new RuntimeException("Out of attempts"))
  }
```

Recursion without stack

Or use `cats-retry` lib

https://typelevel.org/cats-effect/datatypes/io.html

```scala
private def parGamble: IO[scala.Option[Jackpot.type]] =
  List.fill(10)(gambleGentle).parSequence.flatMap {
    _.count(_.isDefined) match {
      case 0 ⇒ None.pure[IO]
      case _ ⇒ Jackpot.some.pure[IO]
    }
}
```

List[IO[T]] ⇒ IO[List[T]]

Lesson 4:

Keep your configs pure

```
object MyConf {

  object mymodule {
    val awakeInterval: FiniteDuration = 30.seconds
    val jdbcUrl = sys.env
      .getOrElse("DB_JDBC_URL",
                 "jdbc:postgresql://xxxxx")
    val dbUser = sys.env.getOrElse("DB_USER", "user")
    val dbPassword = sys.env.getOrElse("DB_PASS", "")
  }
}
```

```
watcher {

  awakeInterval = 30 seconds

  db {
    jdbcUrl = "jdbc:postgresql://localhost:5432/surfsara"
    jdbcUrl = ${DB_JDBC_URL}

    user = "surfsara"
    user = ${DB_USER}

    password = ""
    password = ${DB_PASSWORD}
  }

}
```

```scala
case class WatcherConf(db: DbConf,
                       awakeInterval: FiniteDuration)

object WatcherConf {

  case class DbConf(jdbcUrl: String,
                    username: String,
                    password: String)

}
```

```scala
case class WatcherConf(db: DbConf,
                       awakeInterval: FiniteDuration)


object WatcherConf {

 case class DbConf(jdbcUrl: String,
                   username: String,
                   password: String)

  implicit def hint[T]: ProductHint[T] =
    ProductHint[T](ConfigFieldMapping(CamelCase, CamelCase))

  def loadF: IO[WatcherConf] =
    ConfigSource.default.at("watcher").loadF[IO, WatcherConf]
}
```

```
// build.sc
object watcher extends ScalaModule with ScalafmtModule {

  override def moduleDeps = Seq(researchdrive)

}



// Loading configs per module
conf   ← WatcherConf.loadF
rdConf ← ResearchDriveConf.loadF
da     ← ResearchDriveDA.create(rdConf)
_      ← scheduleWatcher(conf, da)
```

Lesson 5:

At least two thread pools

```
val f = Future {
  Thread.sleep(1000)
} (? ExecutionContext)
```

```
val io = IO {
  Thread.sleep(1000)
  42
}
```

```
import cats.implicits._
List.fill(10)(io).parSequence(? ContextShift)
```

```
// An execution context that is safe to use for
blocking operations.
class Blocker(blockingContext: ExecutionContext)
```

Two thread pools

1. Async code
    - Usually fixed thread pool, e.g. `**ExecutionContext.global**`
    - Default: amount of CPUs
2. Blocking tasks that need to hold the thread
    - Cached unbounded thread pool.
    - In cats-effect normally wrapped into `**Blocker(bc: ExecutionContext)**`

`parGamble` needs this

… or what?

- Fixed for blocking tasks may cause deadlock;
- Cached for async code will cause performance issues by spawning too many threads too quickly;
- You may see the problem only in production.

More about thread pools:

- https://typelevel.org/cats-effect/concurrency/basics.html
- http://degoes.net/articles/zio-threads
- https://docs.scala-lang.org/overviews/core/futures.html

Lesson 6:
[Un]recoverable errors

```
private def verifyETag(path: WebdavPath, expectedETag: ETag):
IO[Boolean] = ???

for {
  eTagValidOrError ← verifyETag(WebdavPath(codePath), eTag).attempt
  doneMsg ← eTagValidOrError match {
    case Right(true)  ⇒ processMessage(msg)
    case Right(false) ⇒ TaskProgress.rejectedEtag(taskId).pure[IO]
    case Left(ex)     ⇒ TaskProgress.rejected(taskId, ex).pure[IO]
  }
  _ ← logger.info(s"The state of Done message is ${doneMsg.state}")
  _ ← publisher(doneMsg)
} yield ()
```

Lesson 7: Data model FTW

```
object Artifact {

  case class Location(localHome: Path,
                      containerHome: Path,
                      userPath: String)

}
```

Path on the host of JVM process

Path in the container

Relative path to the file

Lesson 8:

Make illegal state **un-**representable

```
//  Resource is a data structure that
//  captures the effectful allocation (acquire),
//  along with its finalizer (release).


abstract class Resource[F[_], A] {
  def use[B](f: A ⇒ F[B]): F[B]
}
```

```scala
val ec = Resource
  .make(
    acquire = IO(Executors.newCachedThreadPool()))(
    release = tp ⇒ IO(tp.shutdown())
  ).evalMap(executor ⇒
            IO(ExecutionContext.fromExecutor(executor))
  )


 // You can't use it nor here
```

```scala
ec.use { implicit ec ⇒
  //  ...  only here
  IO(Future(42))
}

//  ...  neither here
```

ContainerEnv

How do I know if all files are in place and safe to use?

```
case class ContainerEnv(algorithm: Algorithm,
                        input: InputData,
                        output: OutputData)
```

Model it as a Resource!

```scala
def containerEnv(
    startContainerCmd: Messages.StartContainer
): Resource[IO, ContainerEnv] =
  tempDirResource.evalMap { tempHome ⇒

    val algorithmLocation = ???
    val inputLocation = ???
    val outputLocation = ???
    val downloads = ???

    for {
      _ ← Webdav.downloadToHost(downloads)
      algorithm ← Artifact.algorithm(algorithmLocation)
      input ← Artifact.data(inputLocation)
      output ← Artifact.output(outputLocation)
    } yield ContainerEnv(algorithm, input, output)
  }
```

Applies an effectful transformation to the allocated resource.

`V1 ⇒ IO[V2]`

Lesson 9:
Module sandwiching

```scala
object Apps extends IOApp {

  override def run(args: List[String]): IO[ExitCode] =
    for {
      f1 ← App1.run(args).start
      f2 ← App2.run(args).start
      e1 ← f1.join
      e2 ← f2.join
    } yield ExitCode(e1.code + e2.code)
}
```

Start execution of the source suspended in the `IO` context

Uses implicit ContextShift

📖

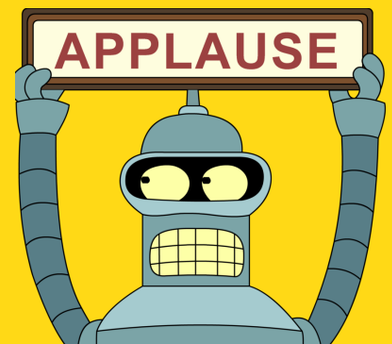
Lessons learned

- Future[T] is a thing of the past
- FP is not all or nothing
- IO is good for evolutionary development
- Keep your configs pure
- At least two thread pools
- [Un]-recoverable errors
- Data model FTW
- Make illegal state unrepresentable

📖

Scala ecosystem
is great for prototyping!

- Scala - easy data modelling;
- Cats Effect - IO, Resource, parSequence(), attempt(), Fibers;
- Libs: Pureconfig, FS2, HTTP4S, Odin (logging);



Thank you! Questions?

mkotsur/aws-lambda-scala

Writing AWS Lambdas in Scala

Scala ★ 118 Updated Mar 25

mkotsur/conf-2020-scalaua

Code snippets for my ScalaUA 2020 talk

Scala Updated 3 days ago

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A useful AppleScript snipped that makes a PDF snapshot of your active keynote presentation without annoying menu clicking:

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How should the config of your Scala app be designed

That's, perhaps, a very good question to ask early in the project because eventually parts of the config will trickle down to many...

★ Published on Mar 27 · 2 min read