an overview

Alceste Scalas

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Programming languages reading group

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Scala: what's the hype about?

- **Object oriented** *and* **functional** programming language
- Runs on the **JVM**...
  - **interoperability with Java** and other languages
  - **influence** on Java 8/9 (lambdas)
- ...and also compiles as:
  - **Javascript** (Scala.js)
  - **native code** (Scala Native)
- Powerful **types**, with **innovations** (path-dependent types)

Object-Oriented Programming

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abstract class Pet(val name: String) {
  val scratches: Boolean // Abstract, immutable
}
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trait Tricks {
  var sitting = false // Concrete, mutable
  def sit   = { sitting = true }
  def stand = { sitting = false }
  def speak: Unit // Abstract
}
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trait Tricks {
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```
class Cat(name: String) extends Pet(name) {
  override val scratches = true
}
```

Object-Oriented Programming

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abstract class Pet(val name: String) {
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```
trait Tricks {
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  def sit   = { sitting = true }
  def stand = { sitting = false }
  def speak: Unit // Abstract
}
```

```
class Cat(name: String) extends Pet(name) {
  override val scratches = true
}
```

```
class Dog(name: String) extends Pet(name) with Tricks {
  override val scratches = false
  override def speak = println("Woof!")
}
```

Value semantics

```
class Pumpkin(val ripeness: Int,
              val weight: Int)

val p1 = new Pumpkin(10, 5)
val p2 = new Pumpkin(10, 5)

p1 == p2 // false
```

Value semantics

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              val weight: Int)

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p1 == p2 // false
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```
case class Pumpkin(ripeness: Int,
                   weight: Int)

val p1 = Pumpkin(10, 5)
val p2 = Pumpkin(10, 5)

p1 == p2 // true
```

Algebraic data types

```
sealed abstract class Term
case class Const(value: Int)       extends Term
case class Neg(t: Term)            extends Term
case class Sum(t1: Term, t2: Term) extends Term

val t = Neg( Sum( Const(1), Const(2) ) )
```

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```

```
def eval(t: Term): Int = t match {
  case Const(value) => value
  case Neg(t)       => -eval(t)
  case Sum(t1, t2)  => eval(t1) + eval(t2)
}
eval(t) // Returns: -3
```

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}
eval(t) // Returns: -3
```

```
def str(t: Term): String = t match {
  case Const(value) => f"${value}"
  case Neg(t)       => f"-(${str(t)})"
  case Sum(t1, t2)  => f"${str(t1)} + ${str(t2)}"
}
str(t) // Returns: "-(1 + 2)"
```

Functional programming (https://alvinalexander.com/scala/...)

```
val chars = 'a' to 'z'

// All pairs of different chars
val perms = chars.map { a =>
  chars.filter { b =>
    a != b
  }.map { b =>
    f"${a}${b}"
  }
}.flatten
```

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// All pairs of different chars
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    a != b
  }.map { b =>
    f"${a}${b}"
  }
}.flatten
```

```
// Syntactic sugar: for-comprehension
val perms2 = for {
  a <- chars
  b <- chars if (a != b)
} yield f"${a}${b}"

perms == perms2 // true
```

Monads (http://scabl.blogspot.co.uk/2013/02/monads-in-scala-1.html)

```
sealed abstract class MMaybe[+A] {
  // flatMap corresponds to >>= in Haskell
  def flatMap[B](f: A => MMaybe[B]): MMaybe[B]

  // map corresponds to >> in Haskell
  def map[B](f: A => B): MMaybe[B] = {
    flatMap { a => MJust(f(a)) }
} }

case class MJust[+A](a: A) extends MMaybe[A] {
  override def flatMap[B](f: A => MMaybe[B]) = f(a)
}

case object MNothing extends MMaybe[Nothing] {
  override def flatMap[B](f: Nothing => MMaybe[B]) = MNothing
}
```

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case class MJust[+A](a: A) extends MMaybe[A] {
  override def flatMap[B](f: A => MMaybe[B]) = f(a)
}

case object MNothing extends MMaybe[Nothing] {
  override def flatMap[B](f: Nothing => MMaybe[B]) = MNothing
}
```

```
for { x <- MJust(1); y <- MJust(2) } yield (x,y) // MJust((1,2))
for { x <- MJust(1); y <- MNothing } yield (x,y) // MNothing
```

Implicit parameters

```
def pat(implicit d: Dog) = {
  println(f"Good ${d.name}!")
}

implicit val dog = new Dog("Rex")
pat
pat
// Prints: Good Rex! (2 times)
```

Implicit parameters and conversions

```
def pat(implicit d: Dog) = {
  println(f"Good ${d.name}!")
}

implicit val dog = new Dog("Rex")
pat
pat
// Prints: Good Rex! (2 times)
```

```
def says(d: Dog) = {
  println(f"${d.name} says:"); d.speak
}

implicit def toDog(name: String) = new Dog(name)

says("Rocky")
// Rocky says:
// Woof!
```

Path-dependent types (http://danielwestheide.com/blog/2013/02/13/...)

```
case class Franchise(title: String) {
  case class Character(name: String)
  def friends(c1: Character, c2: Character) = (c1, c2)
}
```

Path-dependent types (http://danielwestheide.com/blog/2013/02/13/...)

```
case class Franchise(title: String) {
  case class Character(name: String)
  def friends(c1: Character, c2: Character) = (c1, c2)
}
```

```
val starTrek = Franchise("Star Trek")
val kirk =  starTrek.Character("James T. Kirk")
val spock = starTrek.Character("Spock")

val starWars = Franchise("Star Wars")
val luke = starWars.Character("Luke Skywalker")
val yoda = starWars.Character("Yoda")
```

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val luke = starWars.Character("Luke Skywalker")
val yoda = starWars.Character("Yoda")
```

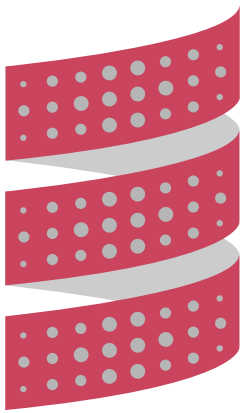
```
starTrek.friends(kirk, spock) // OK
starWars.friends(luke, yoda)  // OK

starTrek.friends(kirk, yoda)
// error: type mismatch;
// found   : starWars.Character
// required: starTrek.Character
```

The future: Dotty

A **reimplementation of Scala** with:

- a cleaner **theoretical basis** (the DOT calculus)
- **advanced features** (e.g., intersection and union types)



`http://dotty.epfl.ch/`

Protocols as types: in research

`[START]`

A client program can request *either*:

- the **Trans**actions for a certain date
  - then, the bank can *either*:
    - reply with a **Report**, and the session goes back to `[START]`
    - *or*, reply **Bye** with the report, and the session ends
- or **Quit**:
  - then, the session ends

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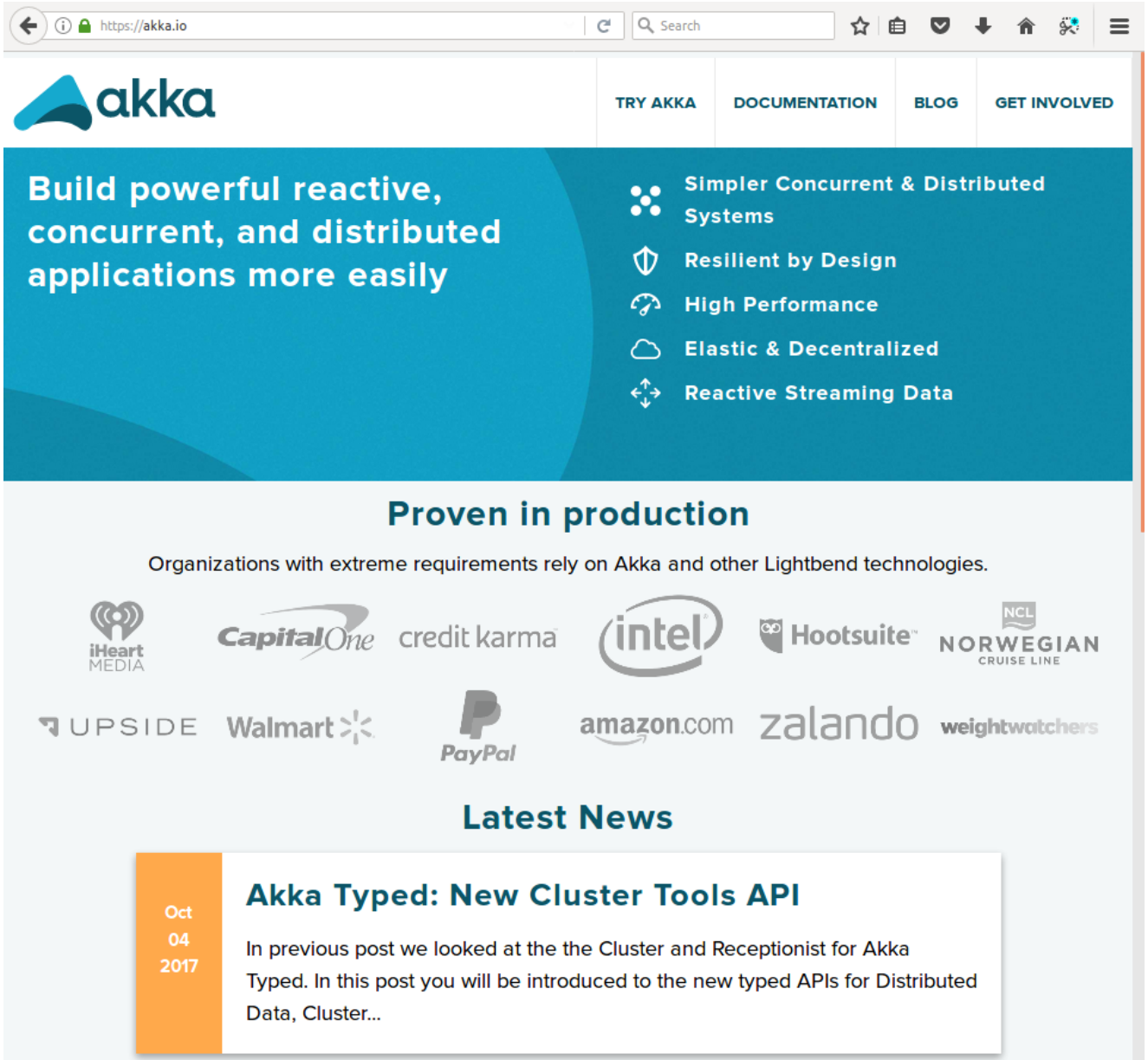
Scala + `lchannels` (ECOOP'16)

```
def client(b: Out[Start]): Unit = {
  if (...) {
    val b2 = b !! Trans("08-10-2017")_

    b2 ? {
      case m @ Report(txt) => client(m.cont)
      case Bye(txt)        => return
    }
  } else {
    b ! Quit()
  }
}
```

Protocols as types: in industry



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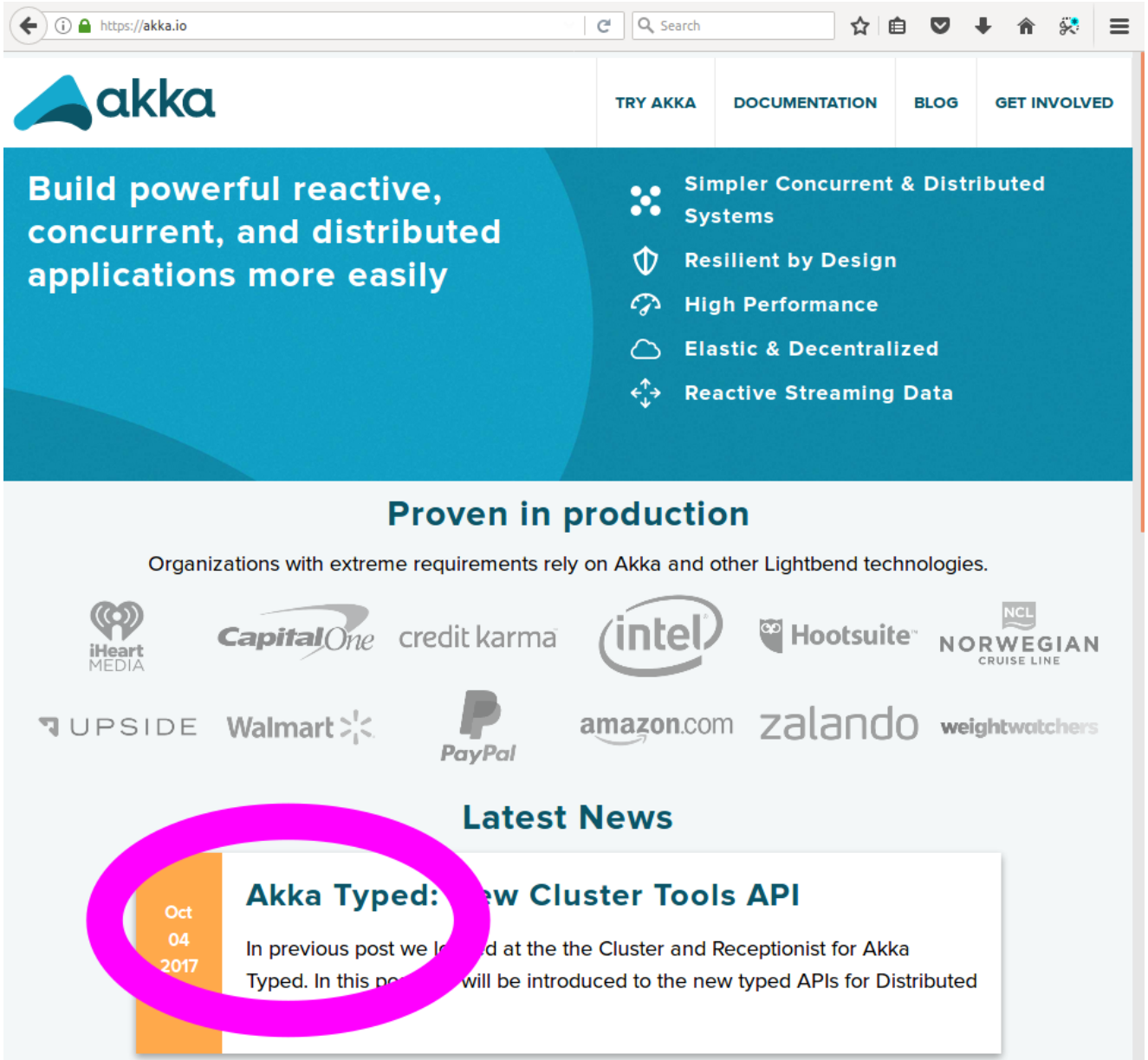

Conclusions

Scala combines **object-oriented** and **functional** programming

Scala is **interoperable with Java**, and reuses its software libraries

Interest on **type-safe concurrent programming**. See:

http://alcestes.github.io/lchannels

(Library for type-safe distributed applications)

Paper: **"Lightwight session programming in Scala"**

(by A. Scalas and N. Yoshida; 30th European Conference on Object-Oriented Programming, 2016)