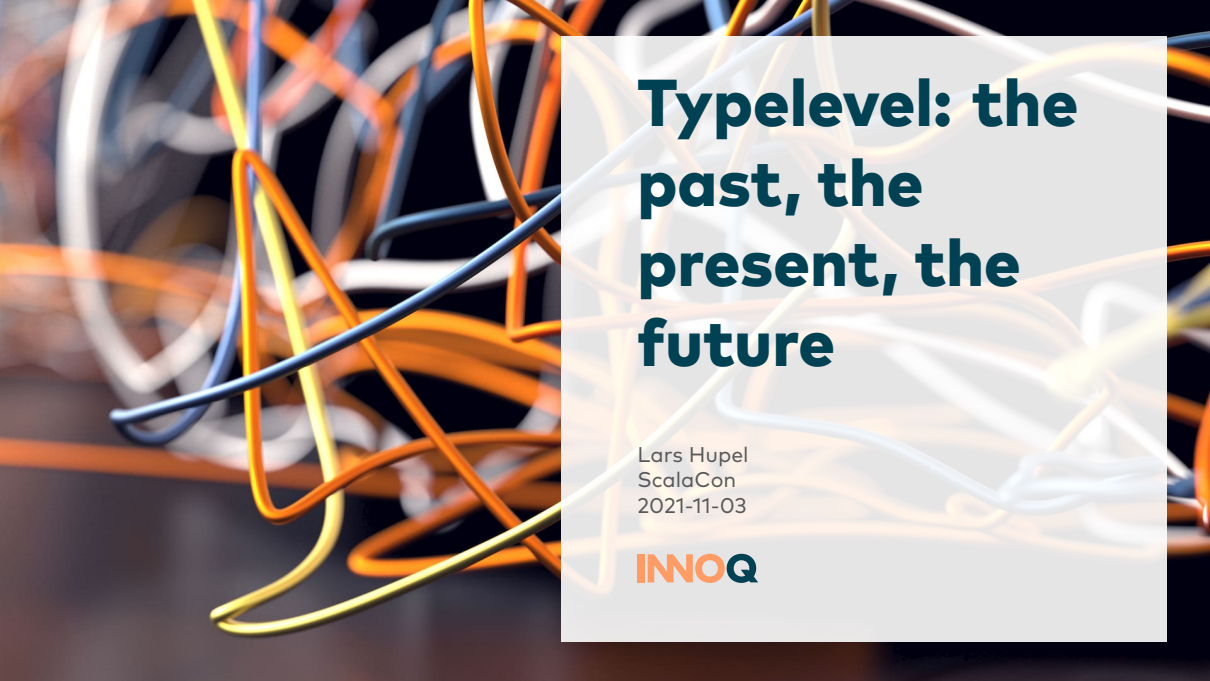

Typelevel: the past, the present, the future

Lars Hupel
ScalaCon
2021-11-03

INNOQ


FLAMMABLE
KEEP FIRE AWAY


FLAMMABLE
KEEP FIRE AWAY


Humble beginnings

Founded in 2013 at Northeast Scala Symposium

TYPELEVEL
SCALA

Humble beginnings

Founded in 2013 at Northeast Scala Symposium

Today: 70+ projects, vibrant ecosystem

TYPELEVEL
SCALA

Typelevel projects

Central theme: Scala-idiomatic Functional Programming

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- ... with as little hassle as possible

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- ... with as little hassle as possible
- ... with as little runtime overhead as possible

Typelevel projects

Central theme: Scala-idiomatic Functional Programming

- … with as little hassle as possible
- … with as little runtime overhead as possible
- … as safe as possible

Adopters


Disney
streaming
services

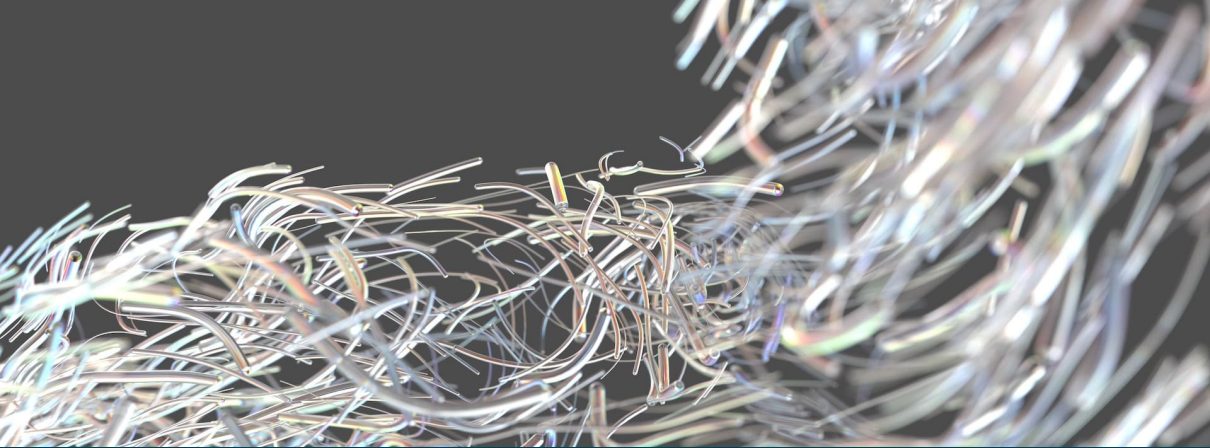

47


itv


COMCAST


PHILIPS


ix
inner-product.com



Cats

Type classes

Supremely useful tool, pioneered in Haskell

Type classes

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```
class Semigroup a => Monoid a where
  mempty :: a
  mconcat :: [a] -> a
  mconcat = foldr mappend mempty
```

Type classes

Supremely useful tool, pioneered in Haskell

```
class Semigroup a => Monoid a where
  mempty :: a
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It Just Works™!


HULK SMASH THE STATE

Type classes in Scala

... now we just need to encode them in Scala

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- multiple inheritance?

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- multiple inheritance?
- syntax??
- global confluence???

The Limitations of Type Classes as Subtyped Implicits (Short Paper)

Adelbert Chang
adelbertc@gmail.com

Abstract

Type classes enable a powerful form of ad-hoc polymorphism which provide solutions to many programming design problems. Inspired by this, Scala programmers have striven to emulate them in the design of libraries like Scalaz and Cats.

The natural encoding of type classes combines subtyping and implicits, both central features of Scala. However, this encoding has limitations. If the type class hierarchy branches, seemingly valid programs can hit implicit resolution failures. These failures must then be solved by explicitly passing the implicit arguments which is cumbersome and negates the advantages of type classes.

In this paper we describe instances of this problem and show that they are not merely theoretical but often arise in practice. We also discuss and compare the space of solutions to this problem in Scala today and in the future.

CCS Concepts • *Software and its engineering* → *Language features*

the type class resolver automatically searches through the dictionary of instances to ensure the appropriate instances are defined.

Scala programmers have sought to emulate type classes to leverage this kind of ad-hoc polymorphism. The natural encoding of type classes uses implicits for instance definition and resolution and subtyping for specifying type class relationships.

As a running example consider the (stubbed) encoding of the `Functor` and `Monad` type classes. Each type class becomes a trait, and relationships between type classes become subtype relationships. For example, every `Monad` gives rise to a `Functor`, so `Monad[F] extends Functor[F]`.

```
trait Functor[F[_]] { }
trait Monad[F[_]] extends Functor[F] { }
```

It is also possible to write functions abstracting over these type classes.

Type classes, encoded

In 2015, Michael Pilquist started *simulacrum*.

Goal: consistent encoding across different projects, 0 boilerplate

Simulacrum

Input

```
import simulacrum._

@typeclass trait Semigroup[A] {
  @op("|+|") def append(x: A, y: A): A
}
```

Simulacrum

Output

```
object Semigroup {
  def apply[A](implicit instance: Semigroup[A]): Semigroup[A] = instance

  // ...
}
```

Simulacrum

More output

```
object Semigroup {
  trait Ops[A] {
    def typeClassInstance: Semigroup[A]
    def self: A
    def |+|(y: A): A = typeClassInstance.append(self, y)
  }
}
```

Simulacrum

Even more output

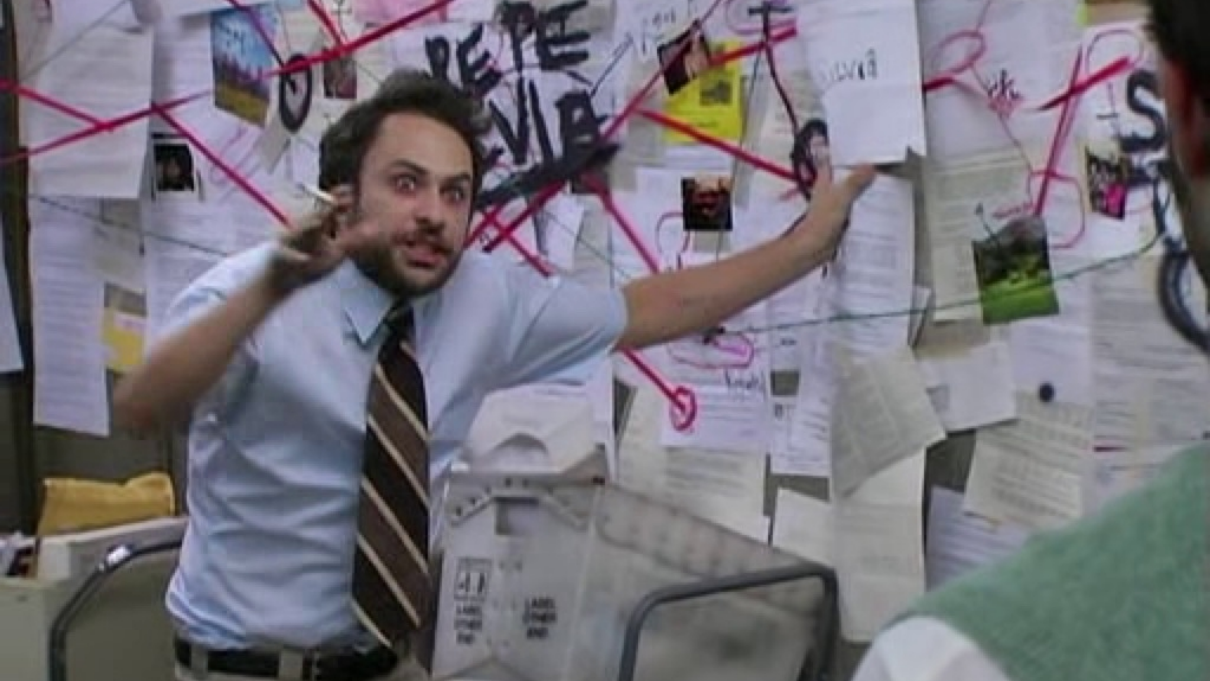
```
object Semigroup {
  trait ToSemigroupOps {
    implicit def toSemigroupOps[A](target: A)(implicit tc: Semigroup[A]): Ops[A]
      val self = target
      val typeClassInstance = tc
    }
  }

  object nonInheritedOps extends ToSemigroupOps
}
```

Simulacrum

Yet more output

```
object Semigroup {
  trait AllOps[A] extends Ops[A] {
    def typeClassInstance: Semigroup[A]
  }
  object ops {
    implicit def toAllSemigroupOps[A](target: A)(implicit tc: Semigroup[A]): AllO
      val self = target
      val typeClassInstance = tc
    }
  }
}
```



But it works!

Simulacrum solved a ton of issues

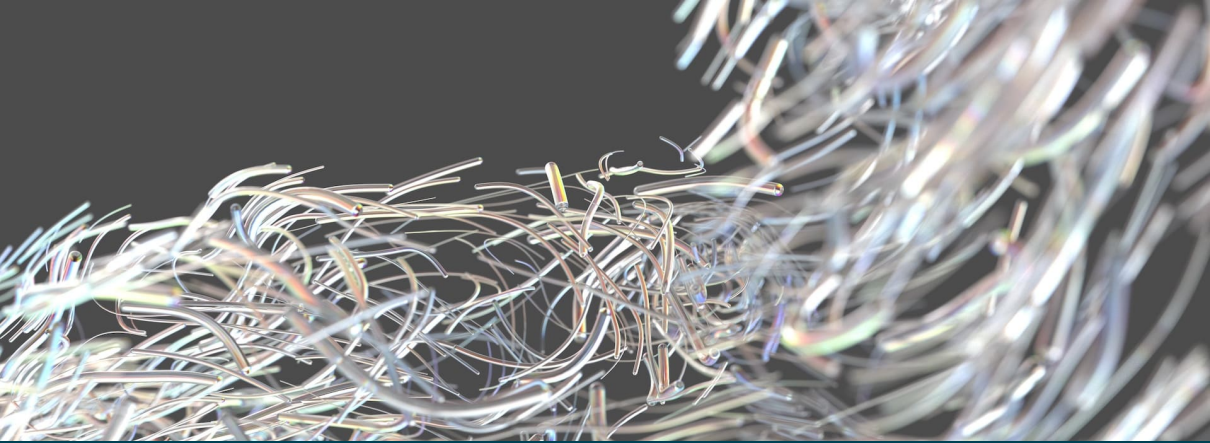
We can write `x |+| y`!

But it works!

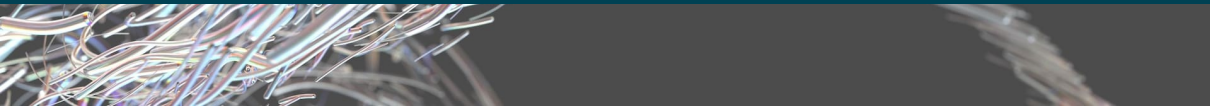
Simulacrum solved a ton of issues

We can write `x |+| y`!

Used by Cats and tons of third-party libraries



Spire



Numerics for Scala

- started out as a SIP in 2011 (!)
- evolved into a dedicated library
- "what if functional but also fast"

What about performance?

Simulacrum didn't solve the performance issue of type classes.

What about performance?

Simulacrum didn't solve the performance issue of type classes.

Input

```
x |+| y
```

What about performance?

Simulacrum didn't solve the performance issue of type classes.

Output

```
Semigroup.ops.toAllSemigroupOps(x).|+|(y)
```

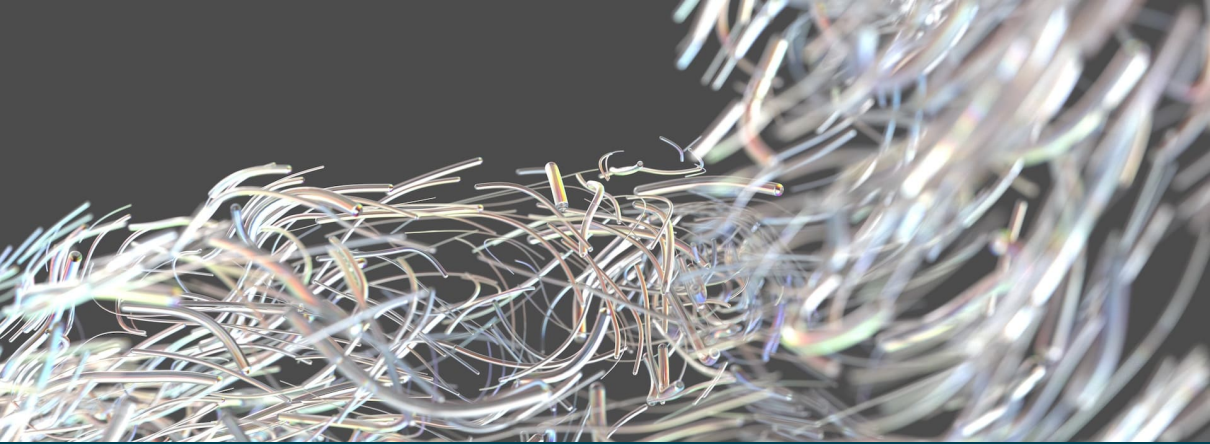
Enter Machinist

Split out of Spire by Erik Osheim in 2014

Enter Machinist

Split out of Spire by Erik Osheim in 2014

Now (2020) archived and re-incorporated into Spire



Shapeless

- started out as a series of talks in 2011 (!)
- scratched an itch: how to abstract over data?
- pioneered “type class derivation”
- many concepts incorporated into Scala 3

Type Class Derivation

Problem: You want to serialize a bunch of case classes to JSON.

Solution: Boilerplate?

Type Class Derivation

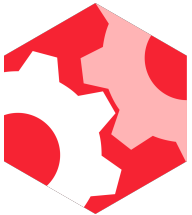
Problem: You want to compare a bunch of case classes.

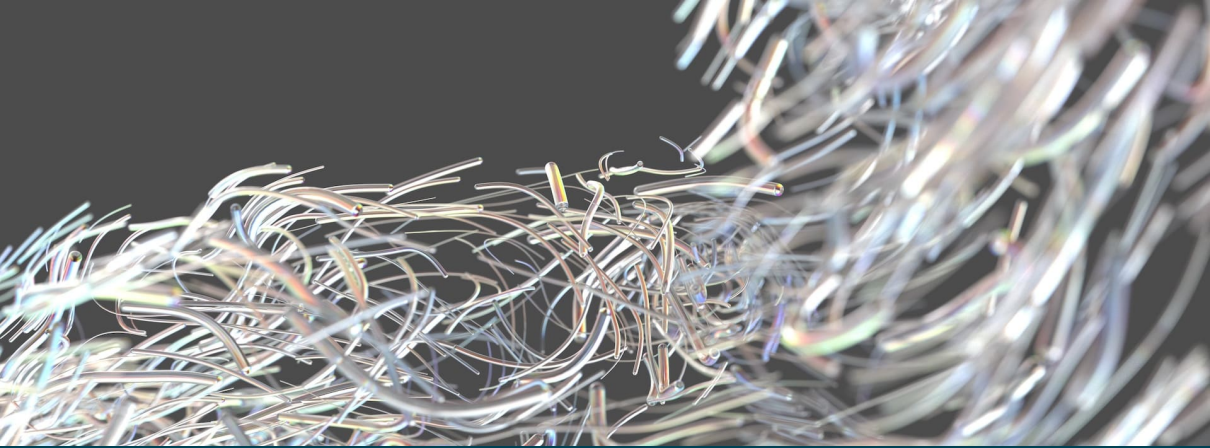
Solution: Boilerplate … again?!

```scala
case class Account(owner: Person, balance: Int)

case class Person(name: String, address: Address)

case class Address(lines: List[String], country: Country)

case class Country(code: String)
```

```
type Account = Person :: Int :: HNil

type Person = String :: Address :: HNil

type Address = List[String] :: Country :: HNil

type Country = String :: HNil
```

In Action

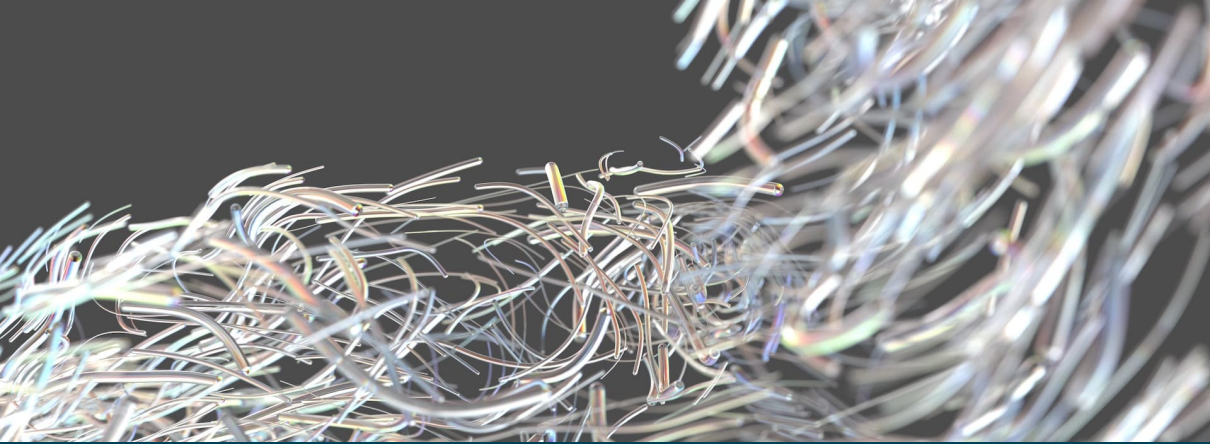




Cats Effect

- full history almost impossible to trace
- draws from multitude of influences
- supports the rise of asynchronous software construction

CATS EFFECT 3



Community

What happened since 2013?

- in 2014, we forked Scala
- in 2015, Erik started Cats
- in 2016, we organized our first conference
- in 2016, Lars joined the Scala Center Advisory Board
- in 2017, we shut down the Scala fork
- in 2017, we released Cats 1.0.0
- in 2019, we launched a donation campaign
- in 2020, Typelevel libraries were at the forefront of Dotty

typelevel.scala

Let the Scala compiler work for you. We provide type classes, instances, conversions, supplements to the standard library, and much more.

Get started

scalaz

Powerful abstractions. Scalaz is a Scala library for functional programming. It provides purely functional data structures and defines a set of foundational type classes (e.g. *Functor* and *Monad*) and corresponding instances for a large number of types.

Learn more »

shapeless

Powerful types. Shapeless is an exploration of generic (aka »polytypic«) programming in Scala derived from the various talks Miles Sabin has given over the course of 2011 on implementing *Scrap your boilerplate* and *higher rank polymorphism* in Scala.

Learn more »

spire

Powerful numerics. Spire is a numeric library for Scala which is intended to be generic, fast, and precise. Using features such as specialization, macros, type classes, and implicits, Spire works hard to allow developers to write efficient numeric code without having to »bake in« particular numeric representations.

Learn more »

2013

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Get started

Argonaut

Purely functional JSON. Argonaut is a JSON library for Scala, providing a rich library for parsing, printing and manipulation as well as convenient codecs for translation to and from scala data types.

Learn more »

discipline

Flexible law checking. Originally intended for internal use in spire, this library helps libraries declaring type classes to precisely state the laws which instances need to satisfy, and takes care of not checking derived laws multiple times.

Learn more »

Monocle

Lenses for Scala. Strongly inspired by Haskell's `lens` library, Monocle is an Optics library where Optics gather the concepts of `Lens`, `Traversal`, `Optional`, `Prism` and `Iso`.

Learn more »

ScalaCheck

…y checking. ScalaCheck is a library for …ed property-based testing. It contains …ors for randomized test data and …tors for properties.

… more »

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Functional programming. Scalaz is a Scala library for functional programming. It provides purely functional data structures and defines a set of foundational type classes (e.g. *Functor* and *Monad*) and corresponding instances for a large number of types.

Learn more »

scalaz-stream

Stream processing scalaz-stream is a streaming I/O library. The design goals are compositionality, expressiveness, resource safety, and speed. The design is meant to supercede or replace older iteratee or iteratee-style libraries.

Learn more »

scodec

Binary serialization. scodec is a combinator library

shapeless

Generic programming. Shapeless is an generic

specs2

Expressive specifications. specs2 is a library for

2014

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Learn more »

ScalaCheck

Property checking. ScalaCheck is a library for automated property-based testing. It contains generators for randomized test data and combinators for properties.

Learn more »

shapeless

… programming. Shapeless is an generic …ming library. Starting with implementations *… your boilerplate* and higher rank …phism in Scala, it quickly grew to provide …d abstract tools like heterogenous lists …matic instance derivation for type classes.

Learn more »

specs2

Expressive specifications. specs2 is a library for writing executable software specifications, aiming for conciseness, readability and extensibility.

Learn more »

spire

Numeric abstractions. Spire is a numeric library for Scala which is intended to be generic, fast, and precise. Using features such as specialization, macros, type classes, and implicits, Spire works hard to allow developers to write efficient numeric code without having to »bake in« particular numeric representations.

Learn more »

*-contrib

Scala

Plugins for scalac

2015

Typelevel.scala

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Upcoming Events

For the first time ever, we are organizing the Typelevel Summits. Join us in the US, Europe or both for our community-based events.

2016

TYPELEVEL SCALA

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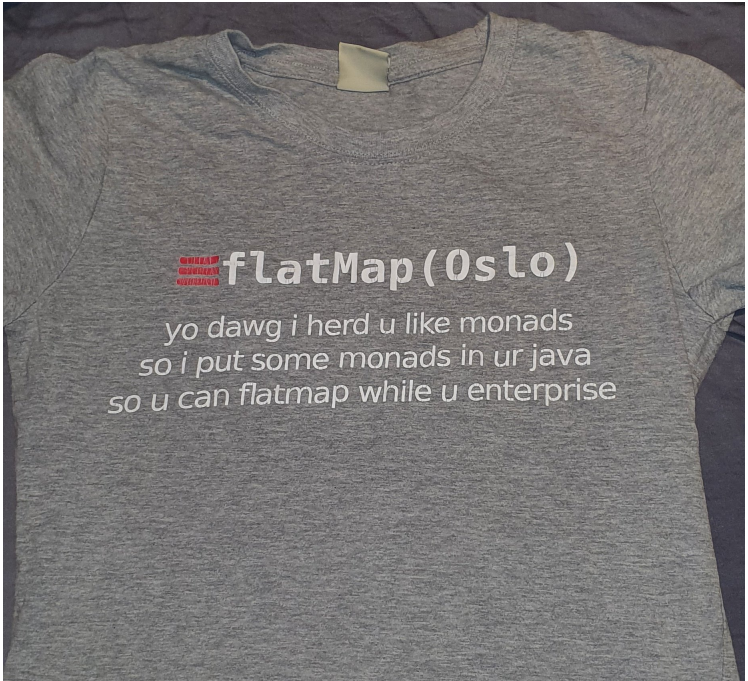
ABOUT

Soon

Future


flatMap(Oslo)
yo dawg i herd u like monads
so i put some monads in ur java
so u can flatmap while u enterprise

seriously the answer is almost always .traverse

So are we not flatmapping that shit any more?

traverse is flatmapping that shit on our behalf

Q & A

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LARS HUPEL

Senior Consultant
innoQ Deutschland GmbH

Lars is known as one of the founders of the Type-level initiative which is dedicated to providing principled, type-driven Scala libraries in a friendly, welcoming environment. A frequent conference speaker, they are active in the open source community, particularly in Scala.

Sources

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