Building Apps & Libraries with Λrrow

Who am I?

@raulraja
@47deg

- Co-Founder and CTO at 47 Degrees
- Typed FP advocate (regardless of language)

Started as learning Exercise to learn FP in the spanish Android Community Slack

...then KΛTEGORY was born: Solution for Typed FP in Kotlin

KΛTEGORY + Funktionale = Λrrow

Type classes

Arrow contains many FP related type classes

Error Handling	ApplicativeError, MonadError
Computation	Functor, Applicative, Monad, Bimonad, Comonad
Folding	Foldable, Traverse
Combining	Semigroup, SemigroupK, Monoid, MonoidK
Effects	MonadDefer, Async, Effect
Recursion	Recursive, BiRecursive,...
MTL	FunctorFilter, MonadState, MonadReader, MonadWriter, MonadFilter, ...

Data types

Arrow contains many data types to cover general use cases.

Error Handling	Option,Try, Validated, Either, Ior
Collections	ListK, SequenceK, MapK, SetK
RWS	Reader, Writer, State
Transformers	ReaderT, WriterT, OptionT, StateT, EitherT
Evaluation	Eval, Trampoline, Free, FunctionN
Effects	IO, Free, ObservableK
Optics	Lens, Prism, Iso,...
Recursion	Fix, Mu, Nu,...
Others	Coproduct, Coreader, Const, ...

Let's build a simple library

Requirements

1. **Fetch Gists** information **given a github user**
2. **Immutable** model
   - Allow easy in memory updates
   - Support deeply nested relationships without boilerplate
3. Support **async non-blocking** data types:
   - Observable, Flux, Deferred and IO
   - Allow easy access to nested effects
4. **Pure:**
   - Never throw exceptions
   - Defer effects evaluation

Fetch Gists information given a github user

```
fun publicGistsForUser(userName: String): List<Gist> = TODO()
```

Immutable model

- Allow easy in memory updates
- Support deeply nested relationships without boilerplate

```kotlin
data class Gist(
  val files: Map<String, GistFile>,
  val description: String?,
  val comments: Long,
  val owner: GithubUser) {

  override fun toString(): String =
    "Gist($description, ${owner.login}, file count: ${files.size})"

}

data class GithubUser(val login: String)

data class GistFile(val fileName: String?)
```

Immutable model

- Allow easy in memory updates
- Support deeply nested relationships without boilerplate

```
import arrow.intro.*

val gist =
  Gist(
    files = mapOf(
      "typeclassless_tagless_extensions.kt" to GistFile(
        fileName = "typeclassless_tagless_extensions.kt"
      )
    ),
    description = "Tagless with Arrow & typeclassless using extension functions and instances",
    comments = 0,
    owner = GithubUser(login = "-__unkown_user1__-")
  )
```

Immutable model

The data class synthetic copy is fine for simple cases

```
gist.copy(description = gist.description?.toUpperCase())
// Gist(TAGLESS WITH ΛRROW & TYPECLASSLESS USING EXTENSION FUNCTIONS AND INSTANCES, -__unkown_user1__-, file count: 1)
```

Immutable model

As we dive deeper to update nested data the levels of nested copy increases

```
gist.copy(
  owner = gist.owner.copy(
    login = gist.owner.login.toUpperCase()
  )
)
// Gist(Tagless with Λrrow & typeclassless using extension functions and instances, -__UNKOWN_USER1__-, file count: 1)
```

Immutable model

In Typed FP immutable updates is frequently done with Optics like Lens

```kotlin
import arrow.optics.*

val ownerLens: Lens<Gist, GithubUser> =
  Lens(
    get = { gist -> gist.owner },
    set = { value -> { gist: Gist -> gist.copy(owner = value) }}
  )

val loginLens: Lens<GithubUser, String> =
  Lens(
    get = { user -> user.login },
    set = { value -> { user -> user.copy(login = value) }}
  )

val ownerLogin = ownerLens compose loginLens

ownerLogin.modify(gist, String::toUpperCase)
// Gist(Tagless with Arrow & typeclassless using extension functions and instances, -__UNKOWN_USER1__-, file count: 1)
```

Immutable model

Updating arbitrarily nested data with Λrrow is a piece of cake

```kotlin
@optics
data class Gist(
  val url: String,
  val id: String,
  val files: Map<String, GistFile>,
  val description: String?,
  val comments: Long,
  val owner: GithubUser
) {
  companion object
}
```

Provide an immutable data model and means to update it

Updating arbitrarily nested data with Λrrow is a piece of cake

```
- val ownerLens: Lens<Gist, GithubUser> =
-  Lens(
-    get = { gist -> gist.owner },
-    set = { value -> { gist: Gist -> gist.copy(owner = value) }}
-  )
- val loginLens: Lens<GithubUser, String> =
-  Lens(
-    get = { user -> user.login },
-    set = { value -> { user -> user.copy(login = value) }}
-  )
- val ownerLogin = ownerLens compose loginLens
- ownerLogin.modify(gist, String::toUpperCase)
+ import arrow.optics.dsl.*
+ Gist.owner.login.modify(gist, String::toUpperCase)
```

Let's build a simple library

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Support Async/Non-Blocking Popular data types

A initial impure implementation that blocks and throws exceptions

```kotlin
import arrow.intro.Gist
import arrow.data.*
import com.squareup.moshi.*
import com.github.kittinunf.fuel.httpGet
import com.github.kittinunf.result.Result

fun publicGistsForUser(userName: String): ListK<Gist> {
  val (_,_, result) = "https://api.github.com/users/$userName/gists".httpGet().responseString() // blocking IO
  return when (result) {
    is Result.Failure -> throw result.getException() // blows the stack
    is Result.Success -> fromJson(result.value)
  }
}
```

Let's build a simple library

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Don't throw exceptions

When learn FP we usually start with exception-free but synchronous Try and Either like types.

```
import arrow.core.*

fun publicGistsForUser(userName: String): Either<Throwable, ListK<Gist>> {
  val (_,_, result) = "https://api.github.com/users/$userName/gists".httpGet().responseString() // blocking IO
  return when (result) {
    is Result.Failure -> result.getException().left() //exceptions as a value
    is Result.Success -> fromJson(result.value).right()
  }
}

publicGistsForUser("-__unkown_user__-")
// Left(a=com.github.kittinunf.fuel.core.HttpException: HTTP Exception 404 Not Found)
```

Let's build a simple library

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Support Async/Non-Blocking Popular data types

Many choose to go non-blocking with Kotlin Coroutines, a great and popular kotlin async framework

```kotlin
import kotlinx.coroutines.experimental.*

fun publicGistsForUser(userName: String): Deferred<Either<Throwable, ListK<Gist>>> =
  async {
    val (_, _, result) = "https://api.github.com/users/$userName/gists".httpGet().responseString()
    when (result) {
      is Result.Failure -> result.getException().left()
      is Result.Success -> fromJson(result.value).right()
    }
  }

//by default `async` when constructed runs and does not suspend effects
publicGistsForUser("-__unkown_user1__-")
// DeferredCoroutine{Active}@514149e1
```

Let's build a simple library

Requirements

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4. **Pure:**
   - ~~Never throw exceptions~~
   - Defer effects evaluation

Support Async/Non-Blocking Popular data types

But now we have to dive deep into the Deferred and Either effects to get to the value we care about

```kotlin
suspend fun allGists(): List<Gist> {
  val result1: Either<Throwable, ListK<Gist>> = publicGistsForUser("-__unkown_user1__-").await()
  val result2: Either<Throwable, ListK<Gist>> = publicGistsForUser("-__unkown_user2__-").await()
  return when {
    result1 is Either.Right && result2 is Either.Right ->
      result1.b + result2.b
    else ->
      emptyList<Gist>()
  }
}
```

Support Async/Non-Blocking Popular data types

Arrow Monad Transformers help with syntax in the world of nested effects.

```
import arrow.effects.*
import arrow.instances.*
import arrow.typeclasses.*
import arrow.effects.typeclasses.*

fun allGists(): DeferredK<Either<Throwable, List<Gist>>> =
  EitherT
    .monad<ForDeferredK, Throwable>(DeferredK.monad())
    .binding {
       val result1 = EitherT(publicGistsForUser("-__unkown_user1__-").k()).bind()
       val result2 = EitherT(publicGistsForUser("-__unkown_user2__-").k()).bind()
       result1 + result2
   }.value().fix()

// Arrow's delegation to `async` is always lazy
allGists()
// DeferredK(deferred=LazyDeferredCoroutine{New}@5113d1f2)
```

Let's build a simple library

Requirements

1. ~~**Fetch Gists** information **given a github user**~~
2. ~~**Immutable** model~~
   - ~~Allow easy in memory updates~~
   - ~~Support deeply nested relationships without boilerplate~~
3. Support **async non-blocking** data types:
   - Observable, Flux, ~~Deferred~~ and IO <- What about all other data types?
   - ~~Allow easy access to nested effects~~
4. ~~**Pure:**~~
   - ~~Never throw exceptions~~
   - ~~Defer effects evaluation~~

Support Async/Non-Blocking Popular data types

Turns out we don't need concrete data types if we use Type classes and Polymorphism

Support Async/Non-Blocking Popular data types

Arrow can abstract away the computational container type emulating **higher kinded types.**

Kind<F, A> denotes an A value inside an F type contructor:
Ex: List<A>, Deferred<A>, IO<A>, Observable<A>

```kotlin
import arrow.Kind

interface GistApiDataSource<F> {
  fun publicGistsForUser(userName: String): Kind<F, ListK<Gist>>
}
```

Support Async/Non-Blocking Popular data types

Emulating **higher kinded types** is based on defunctionalization
Lightweight higher-kinded polymorphism
by Jeremy Yallop and Leo White

```
+ @higherkind
+ class Option<A> : OptionOf<A>
- class ForOption private constructor() { companion object }
- typealias OptionOf<A> = arrow.Kind<ForOption, A>
- inline fun <A> OptionOf<A>.fix(): Option<A> =
-   this as Option<A>
```

Support Async/Non-Blocking Popular data types

How can we implement a computation in the context of F if we don't know what F is?

```kotlin
class DefaultGistApiDataSource<F> : GistApiDataSource<F> {
  override fun publicGistsForUser(userName: String): Kind<F, ListK<Gist>> = TODO()
}
```

Support Async/Non-Blocking Popular data types

Ad-Hoc Polymorphism and type classes!

A type class is a generic interface that describes behaviors that concrete types can support

```
interface Functor<F> {
  // Arrow projects type class behaviors as static or extension functions over kinded values
  fun <A, B> Kind<F, A>.map(f: (A) -> B): Kind<F, B>
  fun <A, B> lift(f: (A) -> B): (Kind<F, A>) -> Kind<F, B> =
      { fa: Kind<F, A> -> fa.map(f) }
}
```

Support Async/Non-Blocking Popular data types

Ad-Hoc Polymorphism and type classes!

A data type may be able to implement such abstract interfaces

```
@extension interface DeferredFunctor : Functor<ForDeferredK> {
  override fun <A, B> Kind<ForDeferredK, A>.map(f: (A) -> B): DeferredK<B> =
    fix().map(f)
}
```

Support Async/Non-Blocking Popular data types

Ad-Hoc Polymorphism and type classes!

A data type may be able to implement such abstract interfaces

```
@extension interface IOFunctor : Functor<ForIO> {
  override fun <A, B> Kind<ForIO, A>.map(f: (A) -> B): IO<B> =
    fix().map(f)
}
```

Support Async/Non-Blocking Popular data types

Ex. Functor allows us to transform the contents regardless of the concrete data type.

```
listOf(1).map { it + 1 }
// [2]

Option(1).map { it + 1 }
// Some(2)

Try { 1 }.map { it + 1 }
// Success(value=2)

Either.Right(1).map { it + 1 }
// Right(b=2)
```

Support Async/Non-Blocking Popular data types

Arrow includes a comprehensive list of type classes

Type class	Combinator
Semigroup	combine
Monoid	empty
Functor	map, lift
Foldable	foldLeft, foldRight
Traverse	traverse, sequence
Applicative	just, ap
ApplicativeError	raiseError, catch
Monad	flatMap, flatten
MonadError	ensure, rethrow
MonadDefer	delay, suspend
Async	async
Effect	runAsync

Λrrow includes a comprehensive list of type classes

Data types may support all or a subset of type classes based on capabilities:

Type class	Combinators	List
Functor	map, lift	✓
Applicative	just, ap	✓
ApplicativeError	raiseError, catch	✕
Monad	flatMap, flatten	✓
MonadError	ensure, rethrow	✕
MonadDefer	delay, suspend	✕
Async	async	✕
Effect	runAsync	✕

Arrow includes a comprehensive list of type classes

Data types may support all or a subset of type classes based on capabilities:

Type class	Combinators	List	Either	Deferred	IO
Functor	map, lift	✓	✓	✓	✓
Applicative	pure, ap	✓	✓	✓	✓
ApplicativeError	raiseError, catch	✕	✓	✓	✓
Monad	flatMap, flatten	✓	✓	✓	✓
MonadError	ensure, rethrow	✕	✓	✓	✓
MonadDefer	delay, suspend	✕	✕	✓	✓
Async	async	✕	✕	✓	✓
Effect	runAsync	✕	✕	✓	✓

Support Async/Non-Blocking Popular data types

We can use the Async type class to lift async computations into the abstract context of F

```
class DefaultGistApiDataSource<F>(private val async: Async<F>) : GistApiDataSource<F>, Async<F> by async {
  override fun publicGistsForUser(userName: String): Kind<F, ListK<Gist>> =
    async { proc: (Either<Throwable, ListK<Gist>>) -> Unit ->
      "https://api.github.com/users/$userName/gists".httpGet().responseString { _, _, result ->
        when (result) {
          is Result.Failure -> proc(result.getException().left())
          is Result.Success -> proc(fromJson(result.value).right())
         }
      }
    }
}
```

Support Async/Non-Blocking Popular data types

If we have more than one logical services we can group them into a module

```
abstract class Module<F>(
  val async: Async<F>,
  val logger: Logger<F> = DefaultConsoleLogger(async),
  private val dataSource: GistApiDataSource<F> = DefaultGistApiDataSource(async, logger),
  val api: GistsApi<F> = DefaultGistApi(dataSource)
)
```

Support Async/Non-Blocking Popular data types

Our library now supports all data types that provide a type class instance for Async.
This pattern allow you to keep code in a single place while providing

```
compile "com.biz:mylib-coroutines:$version"
```

```
object KotlinCoroutinesRuntime : Module<ForDeferredK>(DeferredK.async())
```

```
import arrow.intro.runtime.*
KotlinCoroutinesRuntime.api.publicGistsForUser("-__unkown_user1__-")
// DeferredK(deferred=LazyDeferredCoroutine{New}@2e2d965)
```

Support Async/Non-Blocking Popular data types

Our library now supports all data types that provide a type class instance for Async.
This pattern allow you to keep code in a single place while providing

```
compile "com.biz:mylib-reactor:$version"
```

```
object ReactorRuntime : Module<ForFluxK>(FluxK.async())
```

```
import arrow.intro.runtime.*
ReactorRuntime.api.publicGistsForUser("-__unkown_user1__-")
// FluxK(flux=FluxFlatMap)
```

Support Async/Non-Blocking Popular data types

Our library now supports all data types that provide a type class instance for Async.
This pattern allow you to keep code in a single place while providing

```
compile "com.biz:mylib-arrow-io:$version"
```

```
object IORuntime : Module<ForIO>(IO.async())
```

```
import arrow.intro.runtime.*
IORuntime.api.publicGistsForUser("-__unkown_user1__-")
// Bind(cont=Suspend(thunk=() -> arrow.effects.IO.Pure<A>), g=(A) -> arrow.effects.IO<B>)
```

Support Async/Non-Blocking Popular data types

Our library now supports all data types that provide a type class instance for Async.
This pattern allow you to keep code in a single place while providing

```
compile "com.biz:mylib-rx2:$version"
```

```
object Rx2Runtime : Module<ForObservableK>(ObservableK.async())
```

```
import arrow.intro.runtime.Rx2Runtime
Rx2Runtime.api.publicGistsForUser("-__unkown_user1__-")
// ObservableK(observable=io.reactivex.internal.operators.observable.ObservableFlatMap@fb152c5)
```

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   - ~~Observable, Flux, Deferred and IO~~
   - ~~Allow easy access to nested effects~~
4. ~~**Pure:**~~
   - ~~Never throw exceptions~~
   - ~~Defer effects evaluation~~

Recap

Requirements

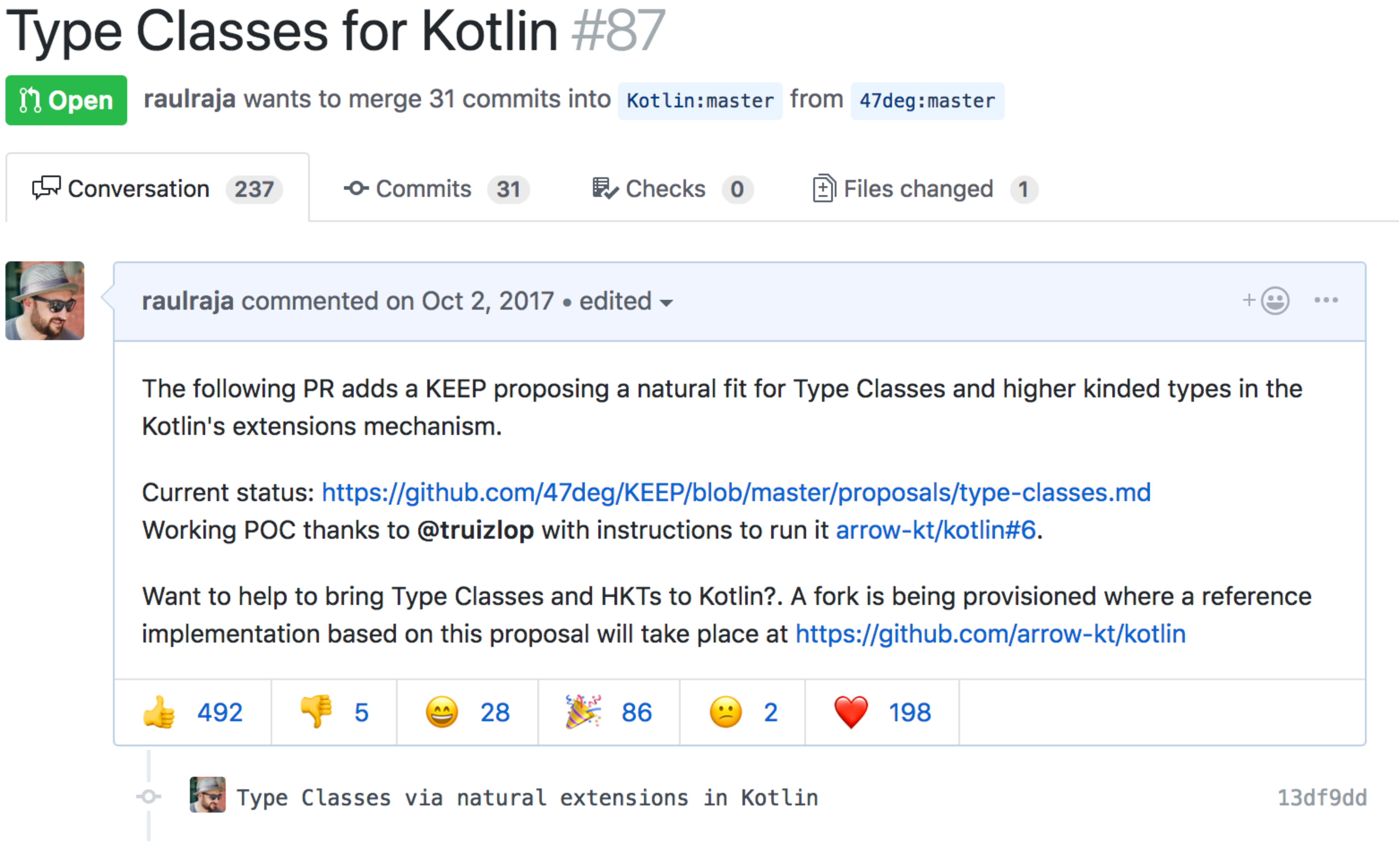
1. FUNC REQ ~~**Fetch Gists** information **given a github user**~~
2. OPTICS ~~**Immutable** model~~
    - ~~Allow easy in memory updates~~
    - ~~Support deeply nested relationships without boilerplate~~
3. POLYMORPHISM ~~Support **async non-blocking** data types:~~
    - ~~Observable, Flux, Deferred and IO~~
    - ~~Allow easy access to nested effects~~
4. EFFECT CONTROL ~~**Pure:**~~
    - ~~Never throw exceptions~~
    - ~~Defer effects evaluation~~

Arrow is modular

Pick and choose what you'd like to use.

Module	**Contents**
typeclasses	Semigroup, Monoid, Functor, Applicative, Monad...
core/data	Option, Try, Either, Validated...
effects	Async, MonadDefer, Effect, IO...
effects-rx2	ObservableK, FlowableK, MaybeK, SingleK
effects-coroutines	DeferredK
mtl	MonadReader, MonadState, MonadFilter,...
free	Free, FreeApplicative, Trampoline, ...
recursion-schemes	Fix, Mu, Nu
optics	Prism, Iso, Lens, ...
meta	@higherkind, @deriving, @extension, @optics

We want to make Typed FP in Kotlin even easier



Type Classes for Kotlin #87

Open **raulraja** wants to merge 31 commits into `Kotlin:master` from `47deg:master`

raulraja commented on Oct 2, 2017 • edited

The following PR adds a KEEP proposing a natural fit for Type Classes and higher kinded types in the Kotlin's extensions mechanism.

Current status: https://github.com/47deg/KEEP/blob/master/proposals/type-classes.md
Working POC thanks to **@truizlop** with instructions to run it arrow-kt/kotlin#6.

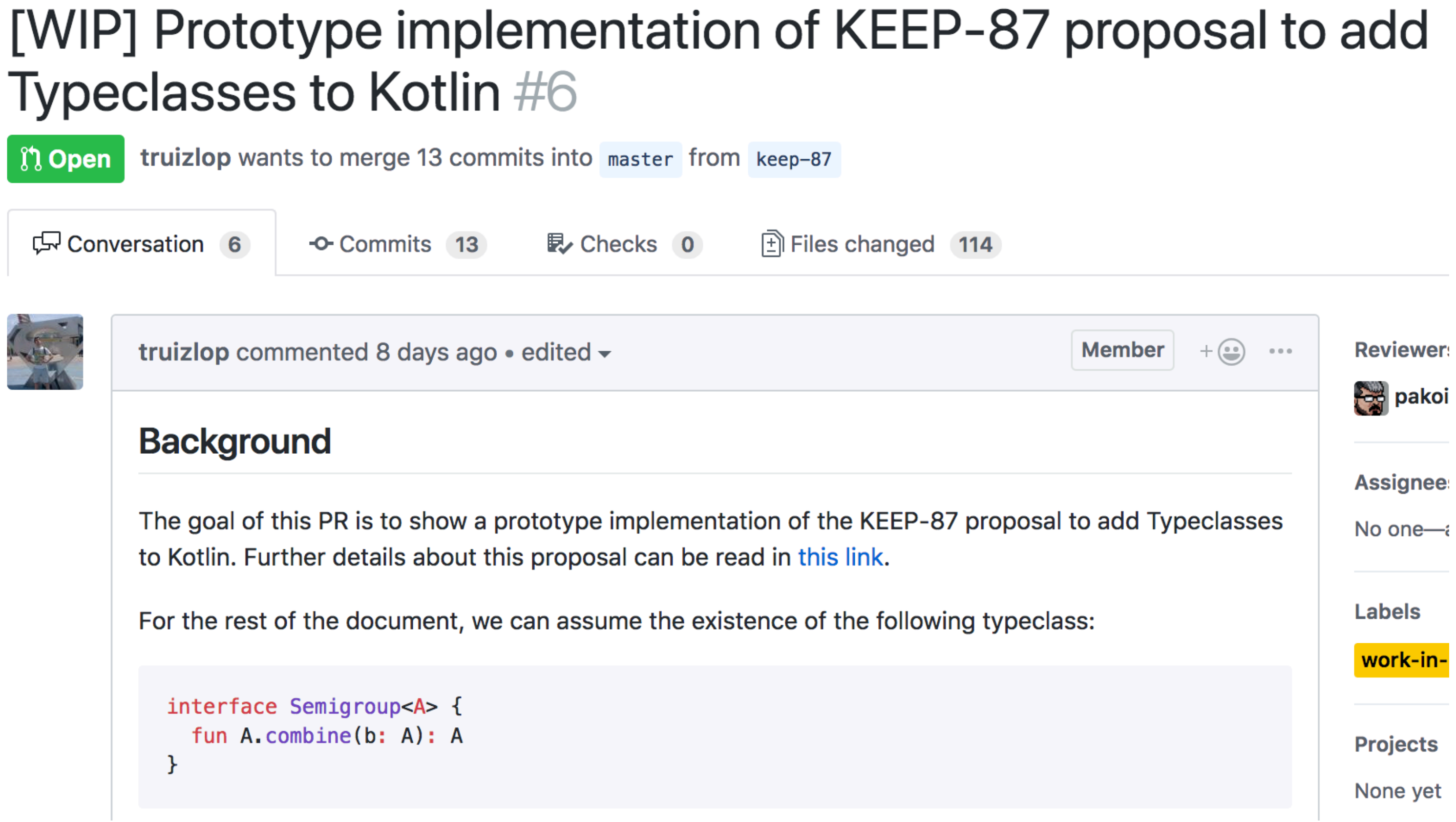
Want to help to bring Type Classes and HKTs to Kotlin?. A fork is being provisioned where a reference implementation based on this proposal will take place at https://github.com/arrow-kt/kotlin

👍 492 👎 5 😄 28 🎉 86 😕 2 ❤️ 198

`Type Classes via natural extensions in Kotlin` 13df9dd

Thanks to @tomasruizlopez we have a POC for KEEP-87:

https://github.com/arrow-kt/kotlin/pull/6



[WIP] Prototype implementation of KEEP-87 proposal to add Typeclasses to Kotlin #6

Open truizlop wants to merge 13 commits into `master` from `keep-87`

truizlop commented 8 days ago • edited

Background

The goal of this PR is to show a prototype implementation of the KEEP-87 proposal to add Typeclasses to Kotlin. Further details about this proposal can be read in this link.

For the rest of the document, we can assume the existence of the following typeclass:

```
interface Semigroup<A> {
  fun A.combine(b: A): A
}
```

KEEP-87 Proposes the following changes to Kotlin

Type class declarations are simple plain interfaces and have a expanded usage beyond FP

```kotlin
interface Repository<A> {
  fun A.save(): A
  fun cache(): List<A>
}
```

KEEP-87 Proposes the following changes to Kotlin

Multiple data types can implement the behavior without resorting to inheritance

```kotlin
extension object UserRepository : Repository<User> {
  fun User.save(): User = TODO()
  fun cache(): List<User> = TODO()
}
```

KEEP-87 Proposes the following changes to Kotlin

We can write polymorphic code with compile time verified dependencies

```
fun <A> persistCache(with R: Repository<A>): List<A> =
  cache().map { it.save() }

persistCache<User>() // compiles and runs because there is a [Repository<User>]
persistCache<Invoice>() // fails to compile: No `extension` [Repository<Invoice>] found
persistCache(UserRepository) // java compatible
persistCache(InvoiceRepository) // compiles and runs because extension context is provided explicitly
```

KEEP-87

The Λrrow team plans to submit this proposal once it's solid and it has properly addressed feedback from the community and the jetbrains compiler team.

Credits

Λrrow is inspired in great libraries that have proven useful to the FP community:

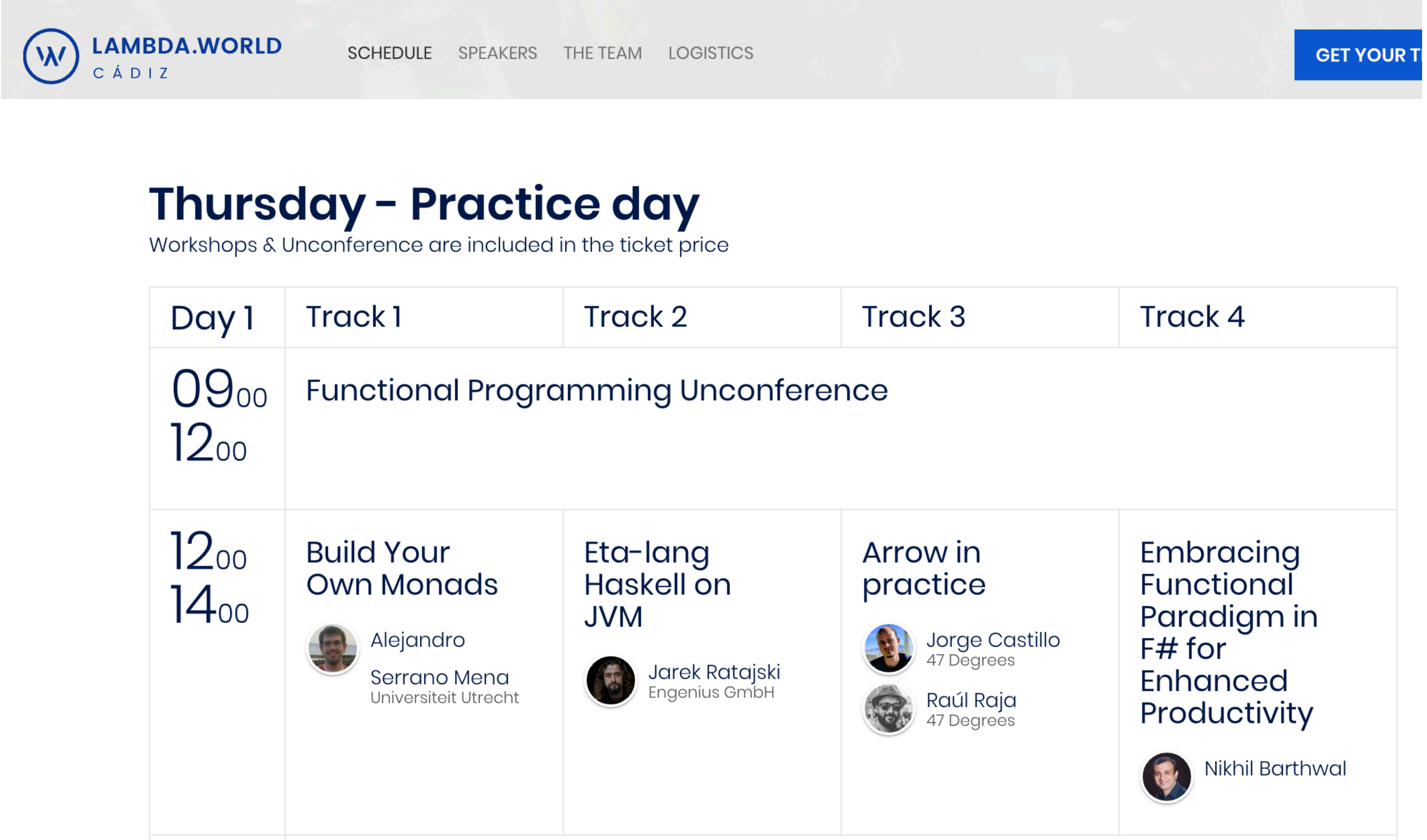
- Cats
- Scalaz
- Freestyle
- Monocle
- Funktionale

Join us!

Github	https://github.com/arrow-kt/arrow
Slack	https://kotlinlang.slack.com/messages/C5UPMM0A0
Gitter	https://gitter.im/arrow-kt/Lobby

We are beginner friendly and provide 1:1 mentoring for both users & new contributors!
+90 Contributors and growing!

Join us at lambda.world for more FP in Kotlin!



Thursday - Practice day

Workshops & Unconference are included in the ticket price

Day 1	Track 1	Track 2	Track 3	Track 4
0900 1200	Functional Programming Unconference			
1200 1400	Build Your Own Monads Alejandro Serrano Mena Universiteit Utrecht	Eta-lang Haskell on JVM Jarek Ratajski Engenius GmbH	Arrow in practice Jorge Castillo 47 Degrees Raúl Raja 47 Degrees	Embracing Functional Paradigm in F# for Enhanced Productivity Nikhil Barthwal

Thanks!

Thanks to everyone that makes Arrow possible!