dist✪ge

Modern Staged Dependency Injection for Scala

Modular Functional Programming
with
Context Minimization
through
Garbage Collection

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DI is outdated and doesn't compose with FP?

Many Scala folks think that:

1. DI is heavy and slow
   - *"tests initialize longer than they execute"*
2. DI is unsafe
   - *"my program may compile but fail on startup after a huge delay"*
3. DI doesn't work for modern FP code
   - *"we cannot inject* `IO[_, _]` *into* `Repository[_[_, _]]`*"*
4. DI is full of magic and error-prone
   - *"I've read 80% out of 5000-page Spring manual but still don't understand why do I need to put these twelwe annotations here. Also I've tried Guice but it failed with 10-megabytes stack after five minutes and 300 retries of database connection instantiation"*

TLDR

```scala
import distage._, scalaz.zio.IO

trait Repository[F[_, _]] {}
class ProductionRepository[F[_, _]]() extends Repository[F]
class DummyRepository[F[_, _]]() extends Repository[F]
class App[F[_, _]](repository: Repository[F]) { def run = ??? }

class MyAppProd[F[_, _]] extends PluginDef {
  make[Repository[F]].from[ProductionRepository[F]]
  make[App[F]]
}
class Main[F[_, _]] { def main(args: Array[String]): Unit = {
  Injector()
    .produce(MyAppProd[F], roots = Set(DIKey.get[App[F]]))
    .run { app: App[F] => app.run() }
}}
object Main[IO]
```

distage: overview

1. Staged Model: *plans the job first then do*,
2. Garbage Collection: *instantiates reachable instances only*,
3. Higher-Kinded Types support: *injects typeclass instances*,
4. Path-Dependent Types support,
5. Plan introspection: *dumps, graphviz, dependency trees*,
6. Plan rewriting,
7. Roles: *multiple services in one process*,
8. Dynamic Plugins[2] and Testkit,
9. Circular Dependencies[1],
10. Trait Augmentation and Assisted Injection[1],
11. Automatic Sets: *prepopulated sets all the instances of a class*

[1] Both run-time and compile-time support
[2] Run-time with compile-time verification

Garbage Collection for better and faster tests

1. Define all your test and production dependencies as a flat list,
2. Put discrimination tags on test-specific definitions,
3. Only the instances required for your tests will be instantiated,
4. It takes just milliseconds, not like in Spring,
5. $\Rightarrow$ Significant savings on test startup time.
6. You don't need to setup your context, it's done automatically by Plugin Loader and Garbage Collector,
7. $\Rightarrow$ Substantial savings on test context configuration.

Example: Garbage Collection and tests

```scala
import distage._, scalaz.zio.IO

trait Repository[F[_, _]] {}
class ProductionRepository[F[_, _]]() extends Repository[F]
class DummyRepository[F[_, _]]() extends Repository[F]

class MyAppDef[F[_, _]] extends PluginDef {
  make[Repository[F]].from[ProductionRepository[F]]
  make[Repository[F]].tagged("test").from[DummyRepository[F]]
}

object MyApp extends MyApp[IO]

class RepoTest extends DistagePluginSpec { "repository" must {
"do something" in di {
  (repository: Repository[IO]) => // repository is a GC root
    // ProductionRepository will not be instantiated!
} } }
```

Garbage Collection for deployment: flexible monoliths

We may fuse Microservices with Monoliths keeping *all* their benefits:

1. Develop software components (*Roles*[1]) as usual[2],
2. Each Role is a Garbage Collection Root,
3. Build one Docker image with multiple Roles in it,
4. Define Roles you want to start as commandline parameters,
5. $\Rightarrow$ higher computational density, savings on infrastructure,
6. $\Rightarrow$ *substantial* development simplification: full environment may be started on a low-end machine with one command,

```
server1# docker run company/product +analytics
server2# docker run company/product +accounting +users
developer1# docker run company/product +*
developer2# docker run company/product --dummy-repositories +*
```

[1]Slides with more details: https://goo.gl/iaMt43
[2]You are not prohibited from using multirepo layout

Config support

distage has HOCON configuration extension.

```scala
case class HostPort(host: String, port: Int)

class HttpServer(@ConfPath("http.listen") listenOn: HostPort) {
  // ...
}
```

The extension:

1. Enumerates all the missing references in a Plan,
2. Searches them for a specific @ConfPath annotation,
3. Tries to find corresponding sections in config source,
4. Extends plan with config values,
5. ⇒ Config values are being resolved before instantiation begins,
6. ⇒ problems are being shown quickly and all at once.

Dynamic Plugins

Just drop your modules into your classpath:

```
class AccountingModule extends PluginDef {
  make[AccountingService].from[AccountingServiceImpl]
  // ...
}
```

Then you may pick up all the modules and build your context:

```
val plugins = new PluginLoaderDefaultImpl(
  PluginConfig(Seq("com.company.plugins"))
).load()
// ... pass to an Injector
```

1. Useful while you are prototyping your app,
2. In maintenance phase you may switch to static configuration.

Circular dependencies

1. Supported, `Proxy` concept used,
2. Optional: you may turn Circular Dependency support off.
3. By-name parameters (`class C(param: => P)`) supported, without run-time code-generation,
4. Compile-time and run-time code-generation for other cases,

Limitations:

1. You cannot use an injected parameter immediately in a constructor,
2. you cannot have circular non-by-name dependencies with final classes,

Trait Completion

```
trait UsersService {
  protected def repository: UsersRepo
  def add(user: User): Unit = {
    repository.put(user.id, user)
    ???
  }
}
```

We may bind this trait directly, without an implementation class:

```
make[UsersService]
```

1. Corresponding class will be generated[1] by `distage`,
2. Null-arg abstract methods will be wired with context values,

[1] both runtime and compile-time cogen supported

Assisted Injection (Factory Methods)

```scala
class UserActor(sessionId: UUID, sessionRepo: SessionRepo)

trait ActorFactory {
  def createActor(sessionId: UUID): UserActor
}
```

1. `createActor` is a factory method,
2. `createActor` will be generated by `distage`,
3. non-null-arg abstract methods are treated as factory methods,
4. Non-invasive *assisted injection*: `sessionId: UUID` will be taken from method parameter, `sessionRepo: SessionRepo` will be wired from context,
5. Useful for `Akka`, lot more convenient than Guice,
6. Works in both runtime and compile-time.

Extension: Automatic Sets

1. All instances of type `T` (like `AutoCloseable`) as a `Set[T]`,
2. Strong and Weak References:
   - GC collects weak referenced members with no more references

Example: free-of-charge basic resource support:

```scala
trait Resource {
  def start(): Unit
  def stop(): Unit
}
trait App { def main(): Unit }
locator.run { (resources: Set[Resource], app: App) =>
  try {
    resources.foreach(_.start())
    app.main()
  } finally { resources.foreach(_.close()) }
}
```

How it works: Plans

`distage` takes your bindings and then:

1. represents each binding as an operation of simple Turing-incomplete DSL (like `make`, `reference`, etc.),
2. uses dependency information to build turn the operations list into Directed Acyclic Graph, breaking circular dependencies if any,
3. resolves conflicts — when one DAG node has several associated operations,
4. performs garbage collection,
5. applies other transformations (like resolves config usages),
6. applies topological sorting to represent the DAG as a sequence of operations — a Plan,
7. the Plan may be introspected, printed, executed during compile-time by code generator or executed in run-time.

Plan Introspection: example context

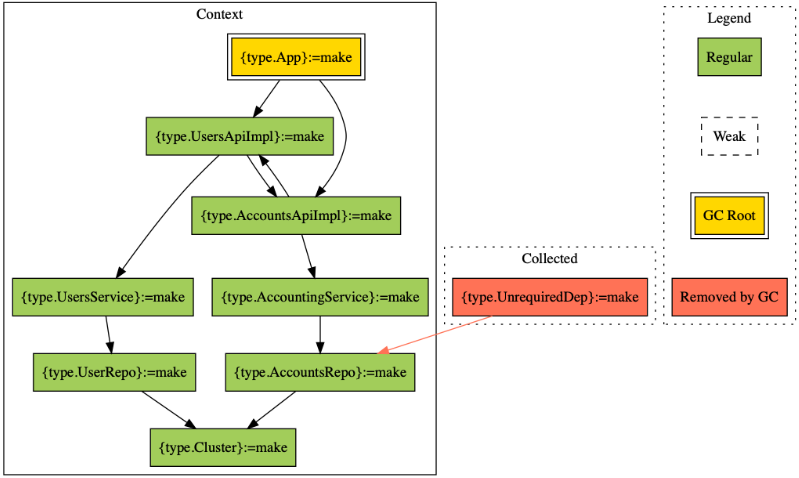
```scala
class Cluster
trait UsersService
trait AccountingService
trait UserRepo
trait AccountsRepo

class UserRepoImpl(cluster: Cluster) extends UserRepo
class AccountsRepoImpl(cluster: Cluster) extends AccountsRepo
class UserServiceImpl(userRepo: UserRepo) extends UsersService
class AccountingServiceImpl(accountsRepo: AccountsRepo)
    extends AccountingService

class UsersApiImpl(service: UsersService
    , accountsApi: AccountsApiImpl)
class AccountsApiImpl(service: AccountingService
    , usersApi: UsersApiImpl) // circular dependency
class App(uapi: UsersApiImpl, aapi: AccountsApiImpl)
```

Plan Introspection: example bindings[1]

```scala
val definition = new ModuleDef {
    make[Cluster]
    make[UserRepo].from[UserRepoImpl]
    make[AccountsRepo].from[AccountsRepoImpl]
    make[UsersService].from[UserServiceImpl]
    make[AccountingService].from[AccountingServiceImpl]
    make[UsersApiImpl]
    make[AccountsApiImpl]
    make[App]
}
val injector = Injector()
val plan = injector.plan(definition)
```

[1]Full code example: https://goo.gl/7ZwHfX

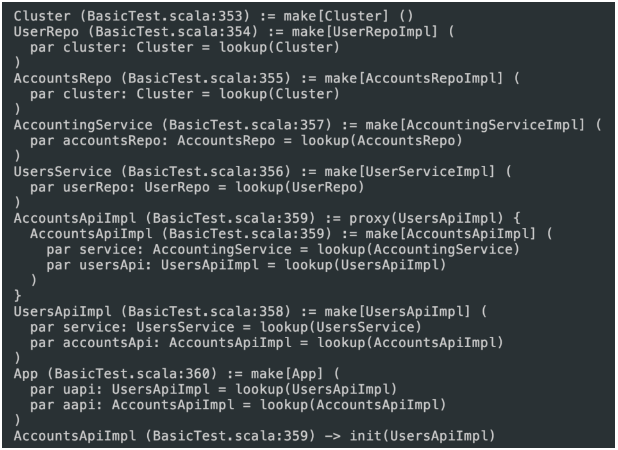
Plan Introspection: graphviz dumps[1]


Context
{type.App}:=make
{type.UsersApiImpl}:=make
{type.AccountsApiImpl}:=make
{type.UsersService}:=make
{type.AccountingService}:=make
{type.UserRepo}:=make
{type.AccountsRepo}:=make
{type.Cluster}:=make
Collected
{type.UnrequiredDep}:=make
Legend
Regular
Weak
GC Root
Removed by GC

[1]This picture has been generated automatically by distage extension

Plan Introspection: plan dumps

```scala
println(plan.render) // look for the circular dependency!
```

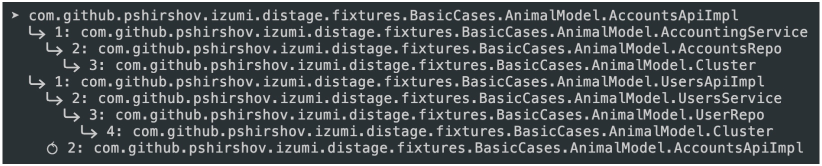


```
Cluster (BasicTest.scala:353) := make[Cluster] ()
UserRepo (BasicTest.scala:354) := make[UserRepoImpl] (
  par cluster: Cluster = lookup(Cluster)
)
AccountsRepo (BasicTest.scala:355) := make[AccountsRepoImpl] (
  par cluster: Cluster = lookup(Cluster)
)
AccountingService (BasicTest.scala:357) := make[AccountingServiceImpl] (
  par accountsRepo: AccountsRepo = lookup(AccountsRepo)
)
UsersService (BasicTest.scala:356) := make[UserServiceImpl] (
  par userRepo: UserRepo = lookup(UserRepo)
)
AccountsApiImpl (BasicTest.scala:359) := proxy(UsersApiImpl) {
  AccountsApiImpl (BasicTest.scala:359) := make[AccountsApiImpl] (
    par service: AccountingService = lookup(AccountingService)
    par usersApi: UsersApiImpl = lookup(UsersApiImpl)
  )
}
UsersApiImpl (BasicTest.scala:358) := make[UsersApiImpl] (
  par service: UsersService = lookup(UsersService)
  par accountsApi: AccountsApiImpl = lookup(AccountsApiImpl)
)
App (BasicTest.scala:360) := make[App] (
  par uapi: UsersApiImpl = lookup(UsersApiImpl)
  par aapi: AccountsApiImpl = lookup(AccountsApiImpl)
)
AccountsApiImpl (BasicTest.scala:359) -> init(UsersApiImpl)
```

Plan Introspection: dependency trees

You may explore dependencies of a component:

```scala
val dependencies = plan.topology.dependencies
println(dependencies.tree(DIKey.get[AccountsApiImpl]))
```



```
➤ com.github.pshirshov.izumi.distage.fixtures.BasicCases.AnimalModel.AccountsApiImpl
  ↳ 1: com.github.pshirshov.izumi.distage.fixtures.BasicCases.AnimalModel.AccountingService
    ↳ 2: com.github.pshirshov.izumi.distage.fixtures.BasicCases.AnimalModel.AccountsRepo
      ↳ 3: com.github.pshirshov.izumi.distage.fixtures.BasicCases.AnimalModel.Cluster
  ↳ 1: com.github.pshirshov.izumi.distage.fixtures.BasicCases.AnimalModel.UsersApiImpl
    ↳ 2: com.github.pshirshov.izumi.distage.fixtures.BasicCases.AnimalModel.UsersService
      ↳ 3: com.github.pshirshov.izumi.distage.fixtures.BasicCases.AnimalModel.UserRepo
        ↳ 4: com.github.pshirshov.izumi.distage.fixtures.BasicCases.AnimalModel.Cluster
    ⥀ 2: com.github.pshirshov.izumi.distage.fixtures.BasicCases.AnimalModel.AccountsApiImpl
```

Circular dependencies are specifically marked.

Compile-Time and Runtime DI

A Plan:

```
myRepository := create[MyRepository]()
myservice    := create[MyService](myRepository)
```

May be interpreted as:

Code tree (compile-time):

```
val myRepository =
    new MyRepository()
val myservice =
    new MyService(myRepository)
```

Set of instances (runtime):

```
plan.foldLeft(Context.empty) {
case (ctx, op) =>
    ctx.withInstance(
        op.key
        , interpret(action)
    )
}
```

distage

7mind Stack

distage: status and things to do

distage is:

1. ready to use,
2. in real production,
3. all Run-time features are available,
4. all Compile-time features except of full Producer are available.

Our plans:

1. `ProducerF[_]` — Producer within a monad,
2. New Roles API,
3. Scala.js support,
4. Compile-time Producer,
5. Isolated Classloaders for Roles (in future),
6. Check our GitHub: https://github.com/pshirshov/izumi-r2.

distage is just a part of our stack

We have a vision backed by our tools:

1. Idealingua: transport and codec agnostic gRPC alternative with rich modeling language,
2. LogStage: zero-cost logging framework,
3. *Fusional Programming and Design* guidelines. We love both FP and OOP,
4. *Continous Delivery* guidelines for Role-based process,
5. *Percept-Plan-Execute* Generative Programming approach, abstract machine and computational model. Addresses Project Planning (see Operations Research). Examples: orchestration, build systems.

Altogether these things already allowed us to significantly reduce development costs and delivery time for our client.

More slides to follow.

You use Guice?
Switch to distage!

Teaser: LogStage

A log call ...

```
log.info(s"$user logged in with $sessionId!")
```

...may be rendered as a text like `17:05:18 UserService.login user=John Doe logged in with sessionId=DEADBEEF!`
...or a structured JSON:

```
{
  "user": "John Doe",
  "sessionId": "DEADBEEF",
  "_template": "$user logged in with $sessionId!",
  "_location": "UserService.scala:265",
  "_context": "UserService.login",
}
```

Teaser: Idealingua

```
id UserId { uid: str }
data User {  name: str /* ... more fields */ }
data PublicUser {
 + InternalUser
 - SecurityAttributes
}
adt Failure = NotFound | UnknownFailure
service Service {
  def getUser(id: UserId): User !! Failure
}
```

1. Convenient Data and Interface Definition Language,
2. Extensible, transport-agnostic, abstracted from wire format,
3. JSON + HTTP / WebSocket at the moment,
4. C#, go, Scala, TypeScript at the moment,
5. Better than gRPC / REST / Swagger/ etc.

Thank you for your attention

distage website: https://izumi.7mind.io/
We're looking for clients, contributors, adopters and colleagues ;)

About the author:

1. coding for 18 years, 10 years of hands-on commercial engineering experience,
2. has been leading a cluster orchestration team in Yandex, "the Russian Google",
3. implemented "*Interstellar Spaceship*" – an orchestration solution to manage 50K+ physical machines across 6 datacenters,
4. Owns an Irish R&D company, https://7mind.io,
5. Contact: team@7mind.io,
6. Github: https://github.com/pshirshov
7. Download slides: https://github.com/7mind/slides/

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