



Modern Staged Dependency Injection for Scala

Modular Functional Programming
with
Context Minimization
through
Garbage Collection

Septimal Mind Ltd
team@7mind.io

DI is outdated and doesn't compose with FP?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 twelve 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

```
1  import distage._, scalaz.zio.IO
2
3  trait Repository[F[_], _] {}
4  class ProductionRepository[F[_], _]() extends Repository[F]
5  class DummyRepository[F[_], _]() extends Repository[F]
6  class App[F[_], _](repository: Repository[F]) { def run = ??? }
7
8  class MyAppProd[F[_], _] extends PluginDef {
9    make[Repository[F]].from[ProductionRepository[F]]
10   make[App[F]]
11 }
12 class Main[F[_], _] { def main(args: Array[String]): Unit = {
13   Injector()
14   .produce(MyAppProd[F], roots = Set(DIKey.get[App[F]]))
15   .run { app: App[F] => app.run() }
16 }
17 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 Plugins² and Testkit,
9. Circular Dependencies¹,
10. Trait Augmentation and Assisted Injection¹,
11. Automatic Sets: *prepopulated sets all the instances of a class*

¹Both run-time and compile-time support

²Run-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. ⇒ 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. ⇒ Substantial savings on test context configuration.

Example: Garbage Collection and tests

```
1  import distage._, scalaz.zio.IO
2
3  trait Repository[F[_], _] {}
4  class ProductionRepository[F[_], _]() extends Repository[F]
5  class DummyRepository[F[_], _]() extends Repository[F]
6
7  class MyAppDef[F[_], _] extends PluginDef {
8    make[Repository[F]].from[ProductionRepository[F]]
9    make[Repository[F]].tagged("test").from[DummyRepository[F]]
10 }
11
12 object MyApp extends MyApp[IO]
13
14 class RepoTest extends DistagePluginSpec { "repository" must {
15   "do something" in di {
16     (repository: Repository[IO]) => // repository is a GC root
17       // ProductionRepository will not be instantiated!
18   } } }
```

Garbage Collection for deployment: flexible monoliths

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

1. Develop software components (*Roles*¹) as usual²,
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,

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

¹Slides with more details: <https://goo.gl/iaMt43>

²You are not prohibited from using multirepo layout

Config support

dista has HOCON configuration extension.

```
1 case class HostPort(host: String, port: Int)
2
3 class HttpServer(@ConfPath("http.listen") listenOn: HostPort) {
4   // ...
5 }
```

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. \Rightarrow Config values are being resolved before instantiation begins,
6. \Rightarrow problems are being shown quickly and all at once.

Dynamic Plugins

Just drop your modules into your classpath:

```
1 class AccountingModule extends PluginDef {  
2     make[AccountingService].from[AccountingServiceImpl]  
3     // ...  
4 }
```

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

```
1 val plugins = new PluginLoaderDefaultImpl(  
2     PluginConfig(Seq("com.company.plugins"))  
3 ).load()  
4 // ... 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

```
1 trait UserService {  
2   protected def repository: UsersRepo  
3   def add(user: User): Unit = {  
4     repository.put(user.id, user)  
5     ???  
6   }  
7 }
```

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

```
1 | make[UserService]
```

1. Corresponding class will be generated¹ by distage,
2. Null-arg abstract methods will be wired with context values,

¹both runtime and compile-time cogen supported

Assisted Injection (Factory Methods)

```
1 class UserActor(sessionId: UUID, sessionRepo: SessionRepo)
2
3 trait ActorFactory {
4     def createActor(sessionId: UUID): UserActor
5 }
```

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:

```
1  trait Resource {
2      def start(): Unit
3      def stop(): Unit
4  }
5  trait App { def main(): Unit }
6  locator.run { (resources: Set[Resource], app: App) =>
7      try {
8          resources.foreach(_.start())
9          app.main()
10     } finally { resources.foreach(_.close()) }
11 }
```

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

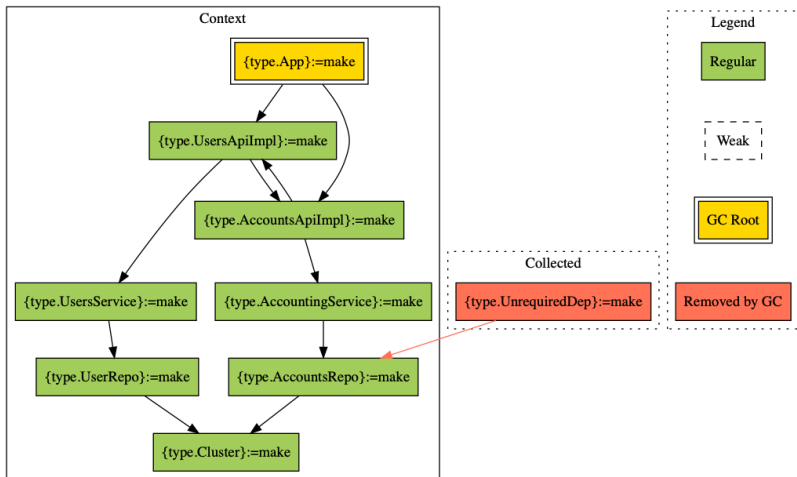
```
1  class Cluster
2  trait UserService
3  trait AccountingService
4  trait UserRepo
5  trait AccountsRepo
6
7  class UserRepoImpl(cluster: Cluster) extends UserRepo
8  class AccountsRepoImpl(cluster: Cluster) extends AccountsRepo
9  class UserServiceImpl(userRepo: UserRepo) extends UserService
10 class AccountingServiceImpl(accountsRepo: AccountsRepo)
11     extends AccountingService
12
13 class UsersApiImpl(service: UserService
14     , accountsApi: AccountsApiImpl)
15 class AccountsApiImpl(service: AccountingService
16     , usersApi: UsersApiImpl) // circular dependency
17 class App(uapi: UsersApiImpl, aapi: AccountsApiImpl)
```

Plan Introspection: example bindings¹

```
1  val definition = new ModuleDef {  
2      make[Cluster]  
3      make[UserRepo].from[UserRepoImpl]  
4      make[AccountsRepo].from[AccountsRepoImpl]  
5      make[UserService].from[UserServiceImpl]  
6      make[AccountingService].from[AccountingServiceImpl]  
7      make[UsersApiImpl]  
8      make[AccountsApiImpl]  
9      make[App]  
10 }  
11 val injector = Injector()  
12 val plan = injector.plan(definition)
```

¹Full code example: <https://goo.gl/7ZwHfX>

Plan Introspection: graphviz dumps¹



¹This picture has been generated automatically by distage extension

Plan Introspection: plan dumps

```
1 | 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)
)
UserService (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: UserService = lookup(UserService)
  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:

```
1 | val dependencies = plan.topology.dependencies  
2 | 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:

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

May be interpreted as:

Code tree (compile-time):

```
1 val myRepository =
2   new MyRepository()
3 val myservice =
4   new MyService(myRepository)
```

Set of instances (runtime):

```
1 plan.foldLeft(Context.empty) {
2   case (ctx, op) =>
3     ctx.withInstance(
4       op.key
5       , interpret(action)
6     )
7 }
```

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 ...

```
1 | 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:

```
1 | {  
2 |   "user": "John Doe",  
3 |   "sessionId": "DEADBEEF",  
4 |   "_template": "$user logged in with $sessionId!",  
5 |   "_location": "UserService.scala:265",  
6 |   "_context": "UserService.login",  
7 | }
```

Teaser: Idealingua

```
1  id UserId { uid: str }
2  data User {  name: str /* ... more fields */ }
3  data PublicUser {
4    + InternalUser
5    - SecurityAttributes
6  }
7  adt Failure = NotFound | UnknownFailure
8  service Service {
9    def getUser(id: UserId): User !! Failure
10 }
```

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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