Functional Design Patterns in Scala

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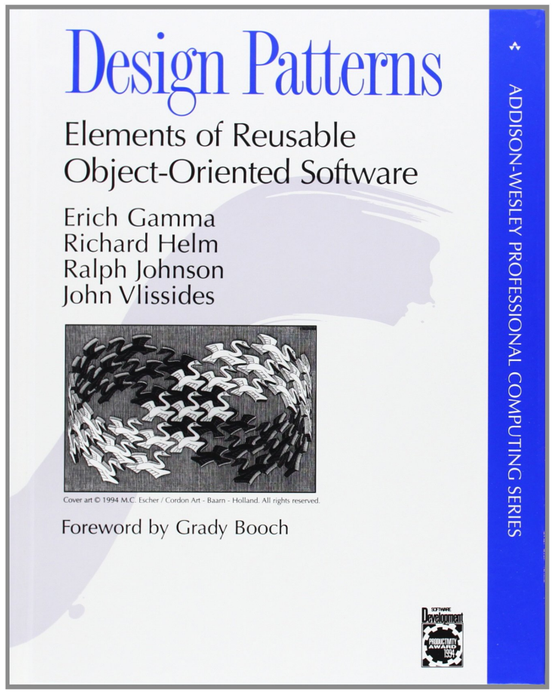
What we'll cover

- What is a functional design pattern?
- Examples
  - ADTs
  - Optics
  - Type Classes
  - Monoids

Design Patterns



THE 23 GANG OF FOUR DESIGN PATTERNS

C	Abstract Factory	S	Facade	S	Proxy
S	Adapter	C	Factory Method	B	Observer
S	Bridge	S	Flyweight	C	Singleton
C	Builder	B	Interpreter	B	State
B	Chain of Responsibility	B	Iterator	B	Strategy
B	Command	B	Mediator	B	Template Method
S	Composite	B	Memento	B	Visitor
S	Decorator	C	Prototype		

Algebraic Data Types

Algebraic Data Types

Sum for `is-a`:

```
sealed trait Language
final case object Java extends Language
final case object Python extends Language
final case object Scala extends Language
```

Product for `has-a`:

```
case class Identity(name: String, address: Address)
case class Address(line1: String, line2: String, postcode: String)
```

Algebraic Data Types

Typically we combine sum and product types in an ADT:

```
sealed trait Employee
final case class Manager(who: Identity, reports: Set[Employee]) extends Employee
final case class Developer(who: Identity, primarySkill: Language) extends Employee
final case class Tester(who: Identity) extends Employee
```

Lenses

Problem: *Manipulate state, while preserving immutability*

```
val addr = Address("10", "Main St", "NW1 6XE")
val rich0 = Developer(Identity("Rich", addr), Java)
```

Case classes provide the `copy` method. Easy enough to use for changing shallow values:

```
val rich1 = rich0.copy(primarySkill = Scala)
```

Lenses

Less readable for values that are deeply nested:

```
val rich2 = rich1.copy(
              who = rich1.who.copy(
                address = rich1.who.address.copy(
                  line1 = "11")))
```

Lenses

We can solve this a Lens!

```
case class Lens[O, V](
  get: O => V,
  set: (O, V) => O
)
```

O = top-level object

V = nested value being accessed or mutated. i.e. O has-a V

Lenses

The most important concept here is that lenses *compose*:

```
case class Lens[O, V](
  get: O => V,
  set: (O, V) => O
)

def compose[O, I, V](firstLens:  Lens[O, I],  secondLens: Lens[I, V]) =
  Lens[O, V](
    get = firstLens.get andThen secondLens.get,
    set = (obj, value) =>
      firstLens.set(obj, secondLens.set(firstLens.get(obj), value))
)
```

Lenses

```
val developerIdentityLens= Lens[Developer, Identity](
  get = _.who,
  set = (o, v) => o.copy(who = v)
)
val identityAddressLens = Lens[Identity, Address](
  get = _.address,
  set = (o, v) => o.copy(address = v)
)
val developerAddressLens = compose(developerIdentityLens, identityAddressLens)

val addressLine1Lens= Lens[Address, String](
  get = _.line1,
  set = (o, v) => o.copy(line1 = v)
)
val developerLine1Lens = compose(developerAddressLens, addressLine1Lens)
```

Lenses

So rather than:

```
val firstLine = rich0.who.address.line1 // 10
val rich1 = rich0.copy(
              who = rich0.who.copy(
                address = rich0.who.address.copy(
                  line1 = "11")))
// Developer(Identity(Rich,Address(11,Main St,NW1 6XE)),Java)
```

... we can now write:

```
val firstLine = developerLine1Lens.get(rich0) // 10
val rich2 = developerLine1Lens.set(rich0, "11")
// Developer(Identity(Rich,Address(11,Main St,NW1 6XE)),Java)
```

Optics

`Lens` is only one pattern in the family

See also: `Optional`, `Prism`, `Iso`, ...

We can reduce boilerplate even further using libraries
- Monocle
- Shapeless
- Scalaz

Type Classes

Problem: *Add behaviours to our data types*

Type Classes

Problem: *Add behaviours to our data types without changing the types*

With subtyping:

```
trait MakesNoise { def sounds: String }

object Dog extends MakesNoise {
  override def sounds = ("bark")
}
object Laptop extends MakesNoise {
  override def sounds = "whirr, beep"
}
```

Type Classes

```
class Dog
class Laptop

trait MakesNoise[T] { def sounds: String }

object MakesNoiseInstances {
  implicit val makeNoiseDog: MakesNoise[Dog] = new MakesNoise[Dog] {
    def sounds = "bark"
  }
  implicit val makeNoiseLaptop: MakesNoise[Laptop] = new MakesNoise[Laptop] {
    def sounds = "whirr, beep"
  }
}
```

Type Classes

Behaviour from the type class is provided to our types through the implicit scope:

```
import MakesNoiseInstances._

implicit val makeNoiseDog: MakesNoise[Dog] = new MakesNoise[Dog] {
  def sounds = "growl"
}

val dogBehaviour = implicitly[MakesNoise[Dog]]
val laptopBehaviour = implicitly[MakesNoise[Laptop]]

println(dogBehaviour.sounds) // growl
println(laptopBehaviour.sounds) // whirr, beep
```

Functional Libraries

Cats provides definitions of a number of common type classes, instances for basic types, and syntax.

Example:

```
trait Show[A] {
  def show(a: A): String
}
```

```scala
import cats.Show
import cats.instances.all._
import cats.syntax.show._

implicitly[Show[Int]].show(42) // 42
42.show                        // 42

sealed abstract class Colour(val name: String)
object Colour {
  implicit val ColourShow = Show.show[Colour](_.name)
  object Red extends Colour("Red")
  object Blue extends Colour("Blue")
}

implicit class ColourExt(c: Colour){
  def show = Colour.ColourShow.show(c)
}

import Colour._
println(Red.show) // Red
```

Monoid

```
trait Semigroup[A] {
  def combine(x: A, y: A): A
}

trait Monoid[A] extends Semigroup[A] {
  def empty: A
}
```

An Example

Problem: *Convert a string of digits into a string representing an LCD display*

```
display("012345")
//  ._.  ...  ._.  ._.  ...  ._.
// |.|  ..|  ._|  ._|  |_|  |_.
// |_|  ..|  |_.  ._|  ..|  ._|
```

```scala
case class LCDDisplay(
  firstRow: String, secondRow: String, thirdRow: String)

object LCDDisplay {
  val digitMapping = Map(
    0 -> LCDDisplay(
    " _ ",
    "| |",
    "|_|"
    ),
    1 -> LCDDisplay("...", "..|", "..|"),
    2 -> LCDDisplay("._.", "._|", "|_."),
    3 -> LCDDisplay("._.", "._|", "._|"),
    4 -> LCDDisplay("...", "|_|", "..|"),
    5 -> LCDDisplay("._.", "|_.", "._|"),
    6 -> LCDDisplay("._.", "|_.", "|_|"),
    7 -> LCDDisplay("._.", "..|", "..|"),
    8 -> LCDDisplay("._.", "|_|", "|_|"),
    9 -> LCDDisplay("._.", "|_|", "..|")
  )
}
```

Add instances for Show and Monoid for our type:

```
object LCDDisplay {
  ...

  implicit val ShowInstance =
    Show.show[LCDDisplay](_.productIterator mkString "\n")

  implicit val ConcatMonoid = new Monoid[LCDDisplay] {
    override def empty = LCDDisplay("", "", "")
    override def combine(l1: LCDDisplay, l2: LCDDisplay): LCDDisplay =
      LCDDisplay(
        l1.firstRow  + " " + l2.firstRow,
        l1.secondRow + " " + l2.secondRow,
        l1.thirdRow  + " " + l2.thirdRow)
  }

  def parse(s: String): Seq[LCDDisplay] =
    s.map(i => digitMapping(i.asDigit))

  def display(s: String) =
    ShowInstance.show(ConcatMonoid.combineAll(parse(s)))
}
```

We can check this works:

```
import LCDDisplay._

println(display("012345"))
//  ._.  ...  ._.  ._.  ...  ._.
// |.|  ..|  ._|  ._|  |_|  |_.
// |_|  ..|  |_.  ._|  ..|  ._|
```

We can check this works:

```
import LCDDisplay._

println(display("012345"))
//  ._. ... ._. ._. ... ._.
// |.| ..| ._| ._| |_| |_.
// |_| ..| |_. ._| ..| ._|

println(display(""))
//
//
//
//
```

More Patterns

- Functional Programming in Scala (the red book)
- Scala with Cats book
- Patterns built on top of these abstractions
  - Free, Tagless Final, etc.

Thank you!