Essential Scala

Six Core Concepts for Learning Scala

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underscore

Introduction

Overview

Essential Scala

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underscore

1. Expressions, types, & values
2. Objects and classes
3. Algebraic data types
4. Structural recursion
5. Sequencing computation
6. Type classes

1. Expressions, types, & values
2. Objects and classes
3. Algebraic data types
4. Structural recursion
5. Sequencing computation
6. Type classes

Motivation

There are simple patterns in effective use of Scala

Improve the teaching of Scala

Huge thanks to the PLT team

http://racket-lang.org/people.html

Expressions, Types, and Values

Goal: model of evaluation

1 + 1 Expression

Int

Type

1 + 1 Expression

Int Type

1 + 1 Expression

2 Value

Types exist at compile-time, values at run-time

Basic language features, syntax

Objects and Classes

Goal: familiarity with syntax

Objects and classes!

Case classes and pattern matching

Largely practicing syntax

Algebraic Data Types

Goal: translate data descriptions into code

Model data with logical *ors* and logical *ands*

A website visitor is:

- logged in; *or*
- anonymous

A logged in user has:

- an ID; *and*
- an email address

Structure of the code follows the structure of the data

Two patterns:

- product types (*and*)
- sum types (*or*)

Product type:

A has a *B* *and* *C*

```
final case class A(b: B, c: C)
```

A has a *B* *and* *C*

```
final case class A(b: B, c: C)
```

A has a *B and C*

```
final case class A(b: B, c: C)
```

A has a *B* *and* *C*

```scala
final case class A(b: B, c: C)
```

A has a *B and* C

Sum type:

A is a *B* *or* *C*

```
sealed trait A
final case class B() extends A
final case class C() extends A
```

A is a *B* *or* *C*

```
sealed trait A
final case class B() extends A
final case class C() extends A
```

A is a *B or C*

```
sealed trait A
final case class B() extends A
final case class C() extends A
```

A is a *B or C*

```
sealed trait A
final case class B() extends A
final case class C() extends A
```

A is a *B or* C

Sum and product together make algebraic data types

Examples

A website visitor is:

- logged in; *or*
- anonymous

```
sealed trait Visitor
final case class Anonymous()
  extends Visitor
final case class User()
  extends Visitor
```

A logged in user has:

- an ID; *and*
- an email address

An anonymous has:

- an ID

```scala
sealed trait Visitor {
  id: Id
}
final case class Anonymous(id: Id)
  extends Visitor
final case class User(id: Id, email: Email)
  extends Visitor
```

A calculation is a success *or* failure

```
sealed trait Calculation
final case class Success()
  extends Calculation
final case class Failure()
  extends Calculation
```

A success has an value.

A failure has an error message

```scala
sealed trait Calculation
final case class Success(value: Int)
  extends Calculation
final case class Failure(msg: String)
  extends Calculation
```

Summary

- Structure data with logical ands and ors
- These are called algebraic data types
- Code follows immediately from structure of the data

Structural Recursion

Goal: transform algebraic data types

```scala
sealed trait Calculation
final case class Success(value: Int)
  extends Calculation
final case class Failure(msg: String)
  extends Calculation
```

Implement on Calculation

```
def add(value: Int): Calculation = ???
```

Structure of the code follows structure of the data

Two (sub-)patterns: pattern matching and polymorphism

A is a *B* *or* *C*

B has a *D* *and* *E*

C has a *F* *and* *G*

```scala
sealed trait A
final case class B(d: D, e: E) extends A
final case class C(f: F, g: G) extends A
```

Pattern matching

```scala
sealed trait A {
  def doSomething: H = {
    this match {
      case B(d, e) => doB(d, e)
      case C(f, g) => doC(f, g)
    }
  }
}
final case class B(d: D, e: E) extends A
final case class C(f: F, g: G) extends A
```

Polymorphism

```scala
sealed trait A {
  def doSomething: H
}
final case class B(d: D, e: E) extends A {
  def doSomething: H =
    doB(d, e)
}
final case class C(f: F, g: G) extends A {
  def doSomething: H =
    doC(f, g)
}
```

Example

```scala
sealed trait Calculation
final case class Success(value: Int)
  extends Calculation
final case class Failure(msg: String)
  extends Calculation
```

Add an Int to a Calculation

```scala
sealed trait Calculation {
  def add(value: Int): Calculation = ???
}

final case class Success(value: Int)
  extends Calculation

final case class Failure(msg: String)
  extends Calculation
```

```scala
sealed trait Calculation {
  def add(value: Int): Calculation =
    this match {
      case Success(v) => ???
      case Failure(msg) => ???
    }
}

final case class Success(value: Int)
  extends Calculation

final case class Failure(msg: String)
  extends Calculation
```

```scala
sealed trait Calculation {
  def add(value: Int): Calculation =
    this match {
      case Success(v) =>
        Success(v + value)
      case Failure(msg) =>
        Failure(msg)
    }
}

final case class Success(value: Int)
  extends Calculation

final case class Failure(msg: String)
  extends Calculation
```

Summary

- Processing algebraic data types immediately follows from the structure of the data
- Can choose between pattern matching and polymorphism
- Pattern matching (within the base trait) is usually preferred

Sequencing Computation

Goal: patterns for sequencing computations

Functional programming is about transforming values

That is all you can do without introducing side-effects

A => B => C

This is sequencing computations

Three patterns: fold, map, and flatMap

Fold

A => B

Abstraction over structural recursion

```scala
sealed trait A {
  def doSomething: H = {
    this match {
      case B(d, e) => doB(d, e)
      case C(f, g) => doC(f, g)
    }
  }
}
final case class B(d: D, e: E) extends A
final case class C(f: F, g: G) extends A
```

```scala
sealed trait A {
  def doSomething: H = {
    this match {
      case B(d, e) => doB(d, e)
      case C(f, g) => doC(f, g)
    }
  }
}
final case class B(d: D, e: E) extends A
final case class C(f: F, g: G) extends A
```

```scala
sealed trait A {
  def fold(doB: (D, E) => H, doC: (F, G)
=> H): H = {
    this match {
      case B(d, e) => doB(d, e)
      case C(f, g) => doC(f, g)
    }
  }
}
final case class B(d: D, e: E) extends A
final case class C(f: F, g: G) extends A
```

Example

A Result is a Success or Failure

```scala
sealed trait Result
final case class Success() extends Result
final case class Failure() extends Result
```

Success contains a value of type A

```scala
sealed trait Result[A]

final case class Success[A](value: A)
  extends Result[A]

final case class Failure[A]()
  extends Result[A]
```

(This just an invariant Option)

Implement fold

Start with structural recursion pattern

```scala
sealed trait Result[A] {
  def fold[B]: B =
    this match {
      Success(v) => ???
      Failure()  => ???
    }
}
final case class Success[A](value: A)
  extends Result[A]
final case class Failure[A]()
  extends Result[A]
```

Abstract out arguments

```scala
sealed trait Result[A] {
  def fold[B](s: A => B, f: B): B =
    this match {
      Success(v) => s(v)
      Failure()  => f
    }
}
final case class Success[A](value: A)
  extends Result[A]
final case class Failure[A]()
  extends Result[A]
```

Fold is a generic transform for any algebraic data type

Fold is not always the best choice

Not all data is an algebraic data type

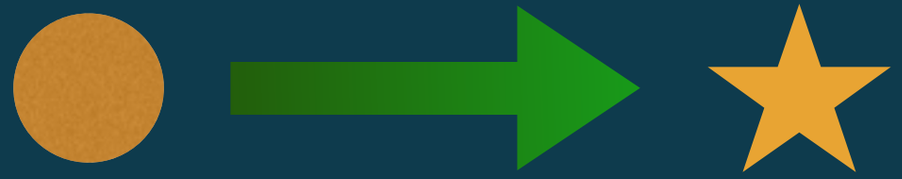
Sometimes other methods are easier to use

Result[A]

Get user from database
(might not be a user)

Convert user to JSON

Result[User]



User => Json

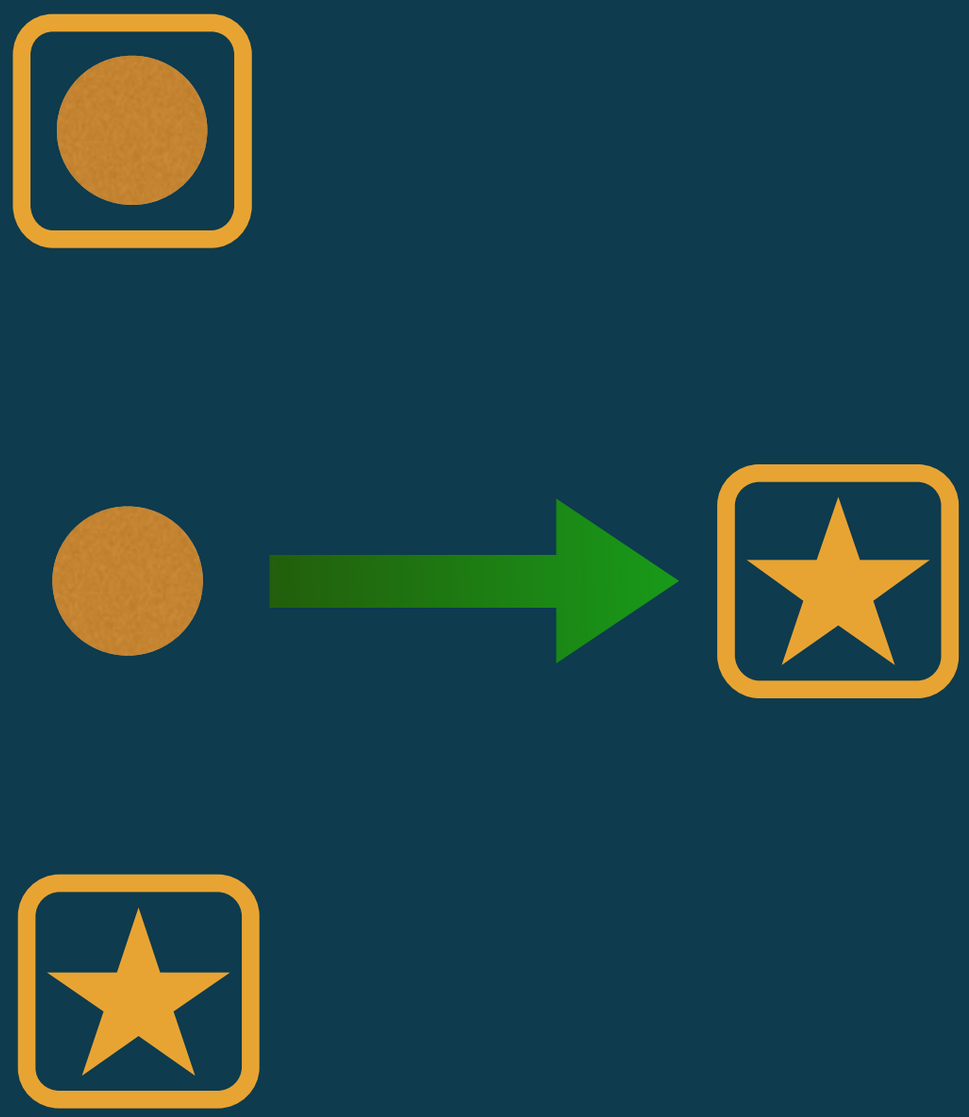
Result[Json]

Map

F[A] A => B F[B]

Get user from database
(might not be a user)

Get order for user (might not be an order)



Result[User]

User =>
Result[Order]

Result[Order]

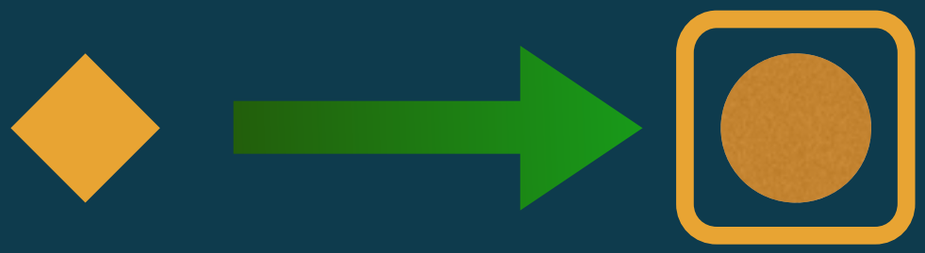
FlatMap

F[A] A => F[B] F[B]

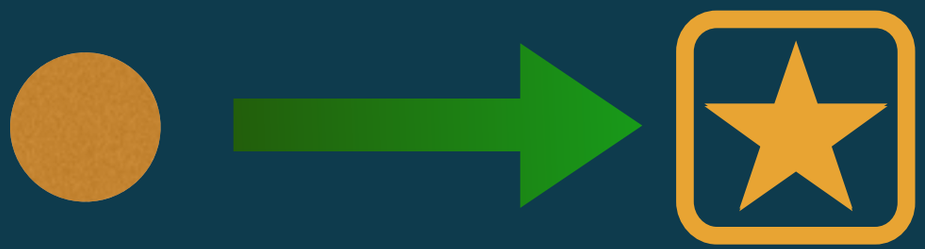
Example

getOrder(id: UserId):
HttpResponse

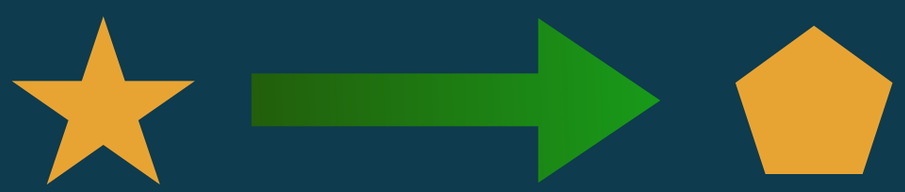
UserId



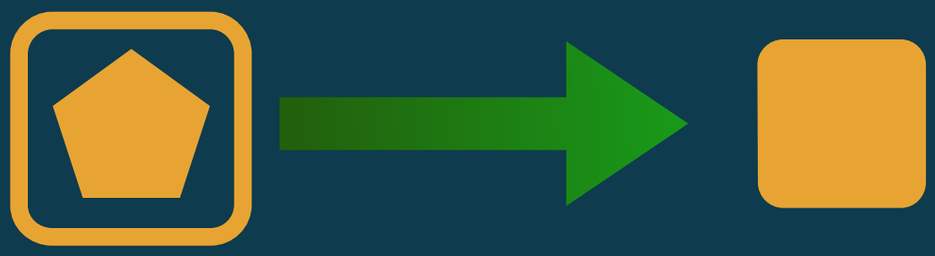
UserId => Result[User]



User => Result[Order]

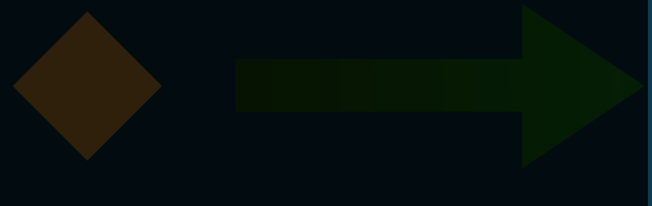


Order => Json



Result[Json] =>
HttpResponse

UserId



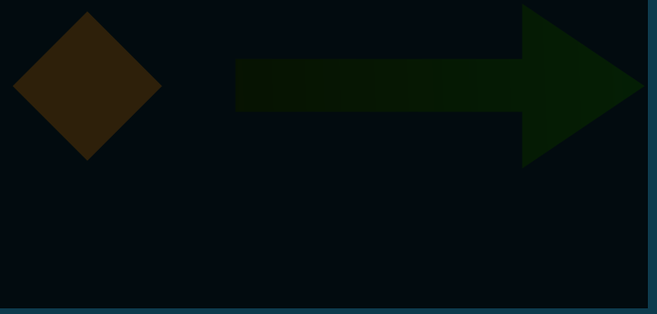
UserId => Result[User]

User => Result[Order]

Order => Json

Result[Json] =>
HttpResponse

UserId



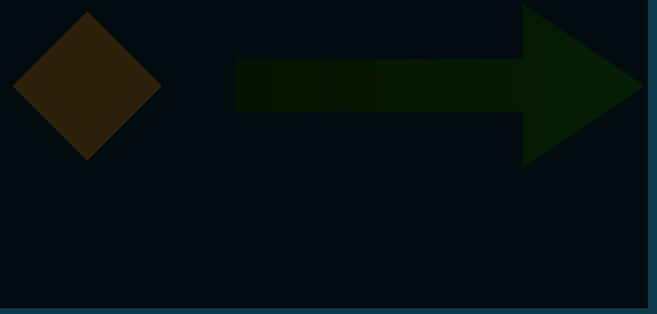
UserId => Result[User]

User => Result[Order]

Order => Json

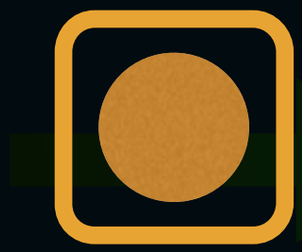
Result[Json] =>
HttpResponse

UserId



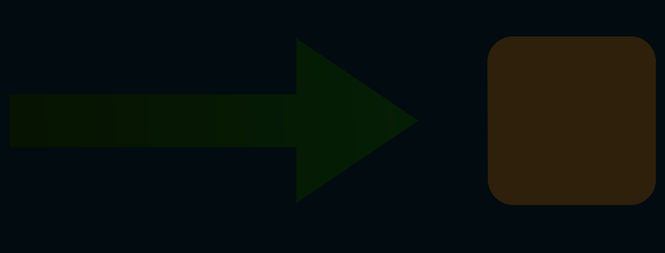
UserId => Result[User]

User => Result[Order]

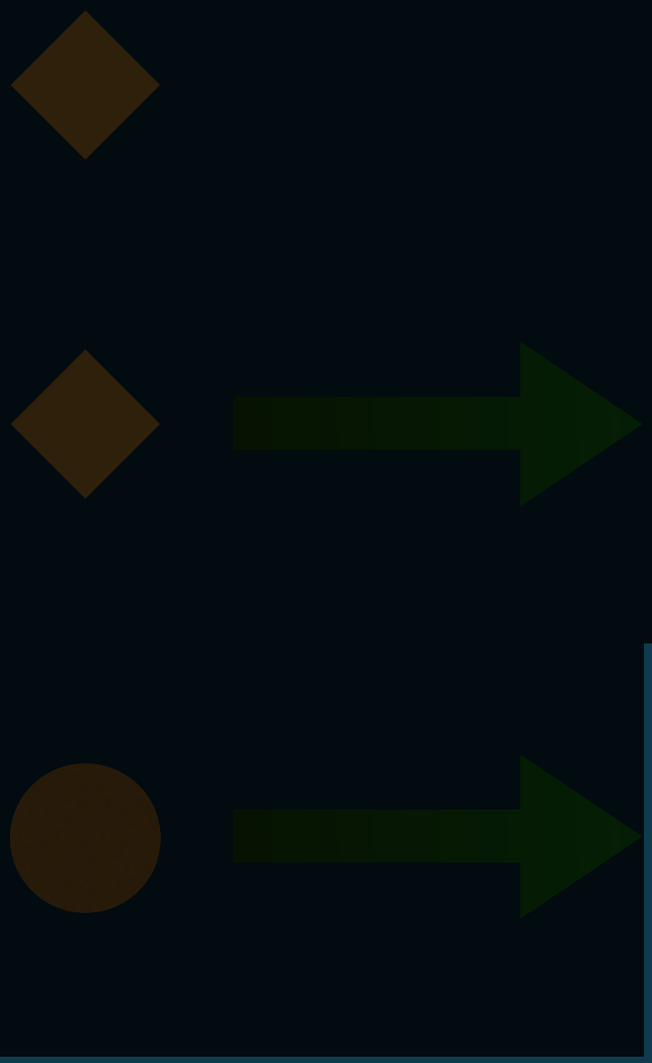


flatMap

Order => Json



Result[Json] =>
HttpResponse



UserId

UserId => Result[User]

User => Result[Order]

Order => Json

Result[Json] =>
HttpResponse

UserId

UserId => Result[User]

User => Result[Order]

Order => Json

Result[Json] =>
HttpResponse

UserId

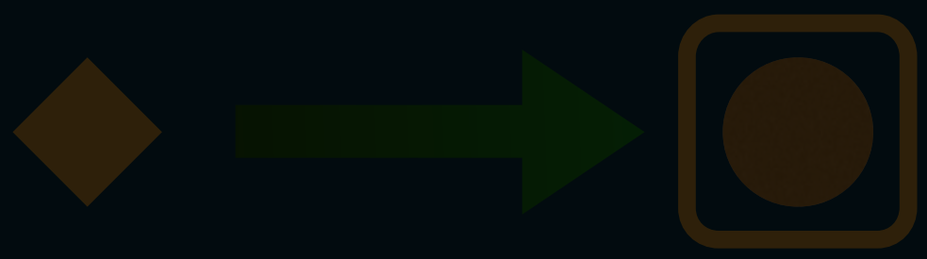
UserId => Result[User]

User => Result[Order]

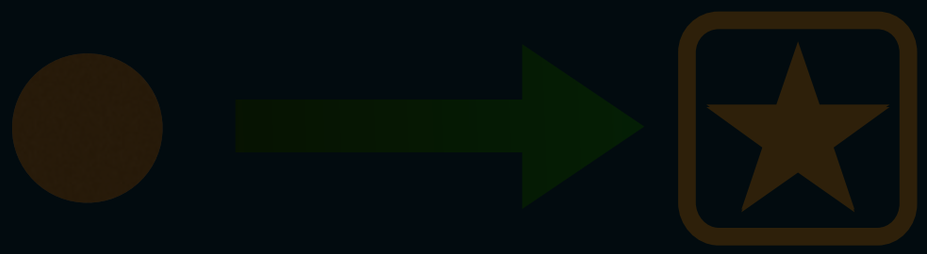
Order => Json

Result[Json] =>
HttpResponse

UserId

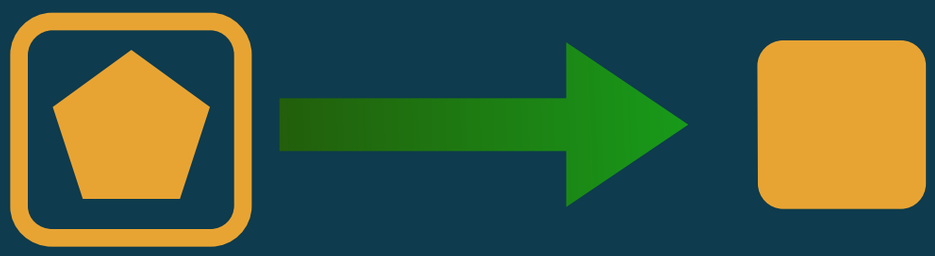


UserId => Result[User]



User => Result[Order]

Order => Json



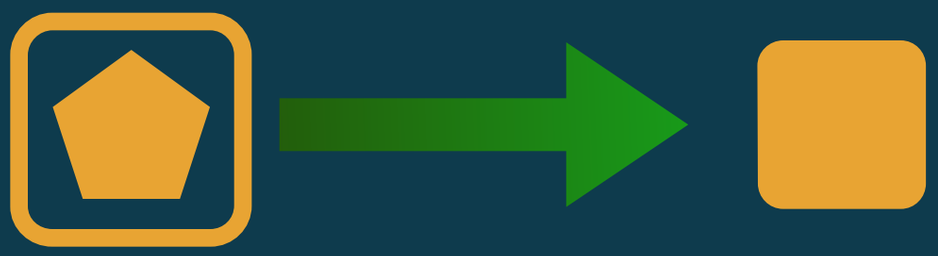
Result[Json] =>
HttpResponse

UserId

UserId => Result[User]

User => Result[Order]

Order => Json



Result[Json] =>
HttpResponse

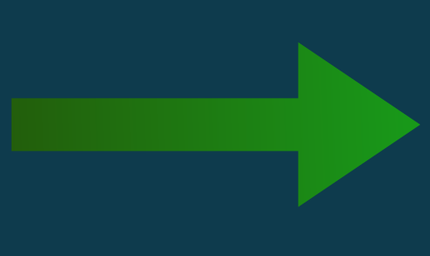
UserId

fold

UserId => Result[User]

User => Result[Order]

Order => Json



Result[Json] =>
HttpResponse

Summary

- Standard patterns for sequencing computations
- F[A] **map** (A => B) = F[B]
- F[A] **flatMap** (A => F[B]) = F[B]
- **fold** is general transformation for algebraic data types
- You can teach monads in an introductory course!

Type Classes

Ad-hoc polymorphism

Break free from your class oppressors!

Conclusions

Scala is simple

3 patterns are 90% of code

4 patterns are 99% of code

Program design in Scala is systematic

Be like keyboard cat!

underscore.io/training/courses/essential-scala/