# Essential Scala

## Six Core Concepts for Learning Scala

Noel Welsh, @noelwelsh

underscore

# Introduction

# Scala is complex?

Self types
Type bounds
Existential types
Trait stacks
Overloading
Implicit conversions

Is doesn’t have to be this way

# Essential Scala

Noel Welsh and Dave Gurnell

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

Huge thanks to the PLT team
http://racket-lang.org/people.html

# 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*

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

*A* has a *B and* C

Sum type:

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

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

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

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

*A* is a *B or C*

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

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

```scala
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

```scala
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 {
  def 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

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

A success has a 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

# 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

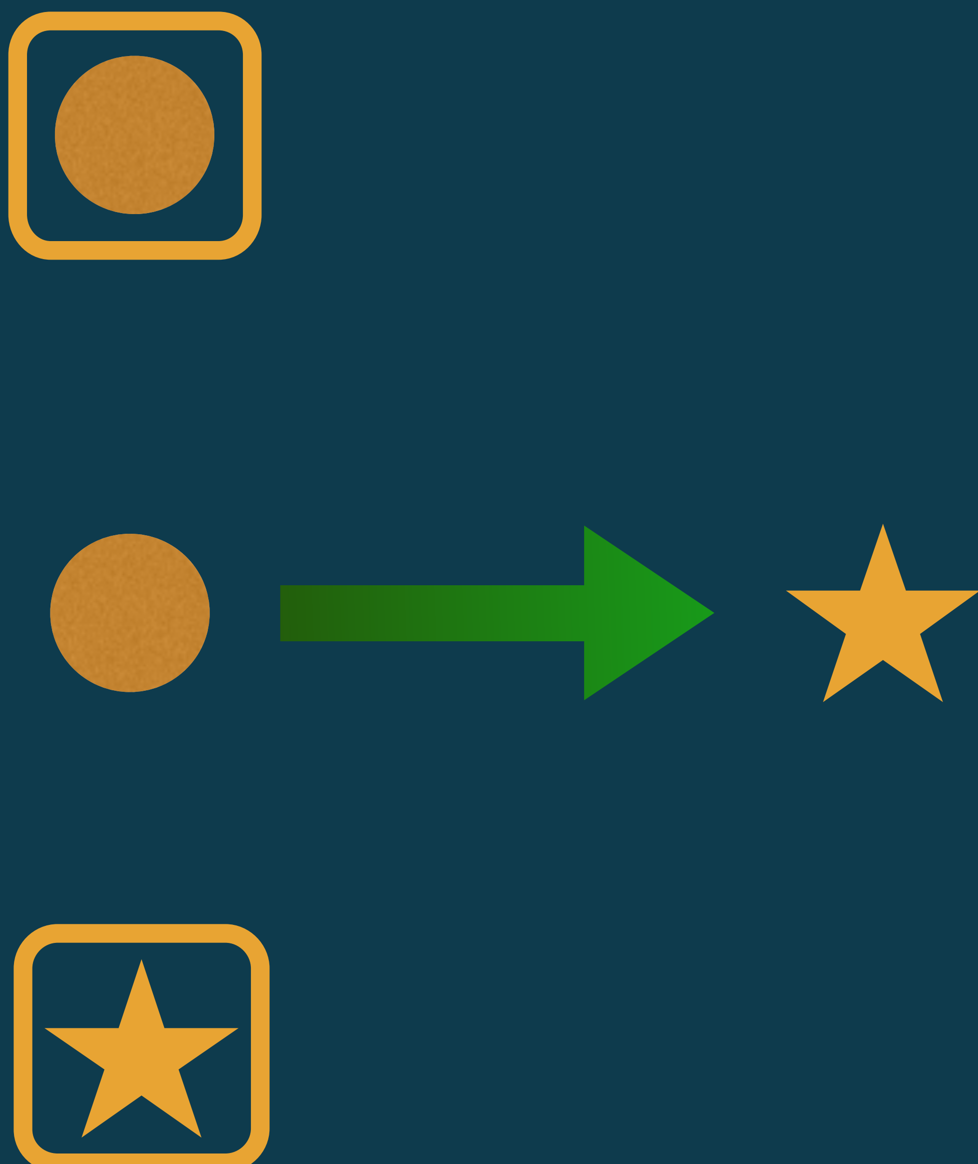
Sometimes other methods are easier to use

# Result[A]

Get user from database
(might not be a user)

Result[User]

Convert user to JSON



Result[User]

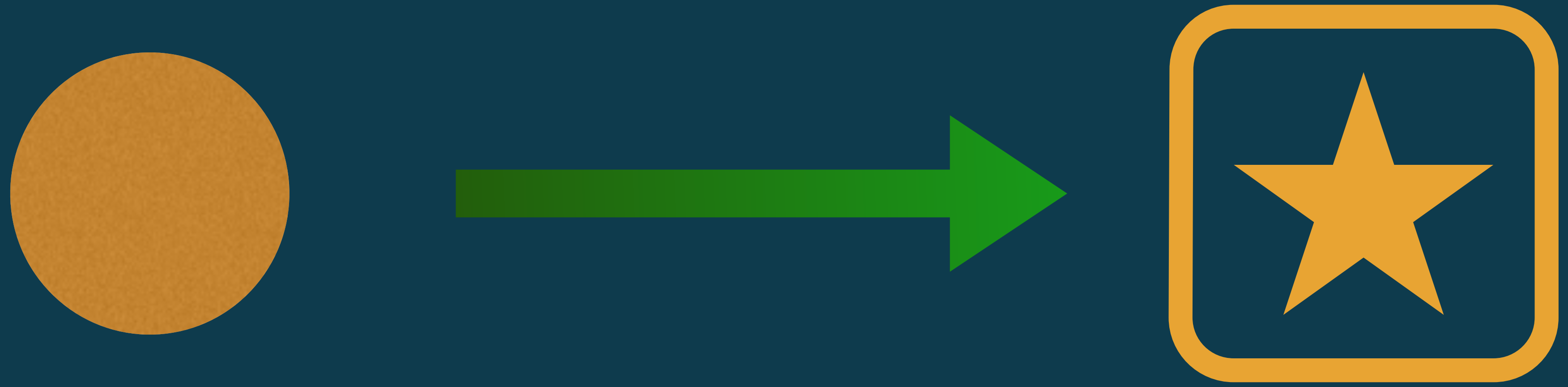
User => Json

Result[Json]

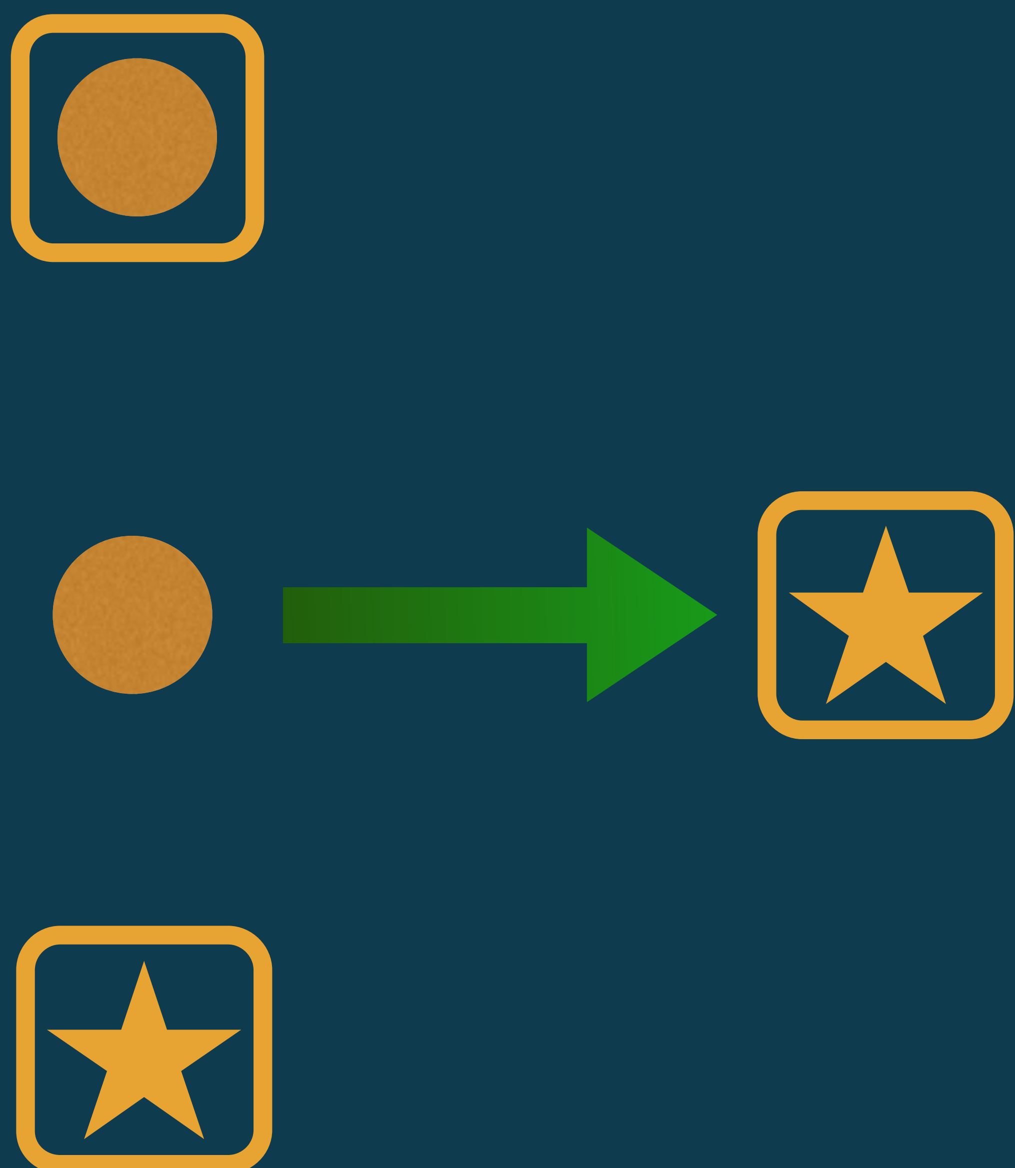
# Map

Get user from database
(might not be a user)

Result[User]



Get order for user (might not be an order)



Result[User]

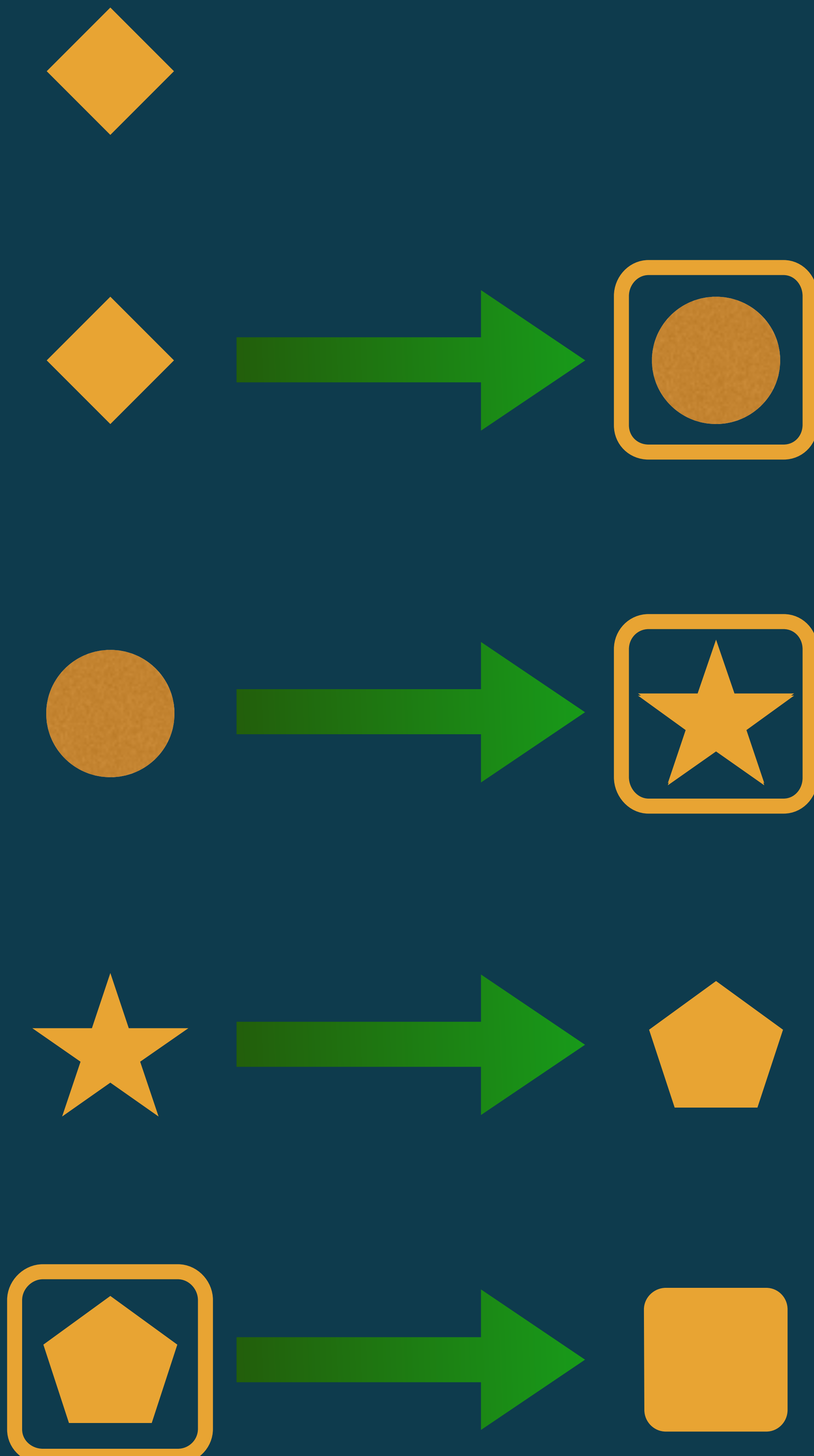
User => Result[Order]

Result[Order]

# FlatMap

# Example

getOrder(id: UserId):
HttpResponse



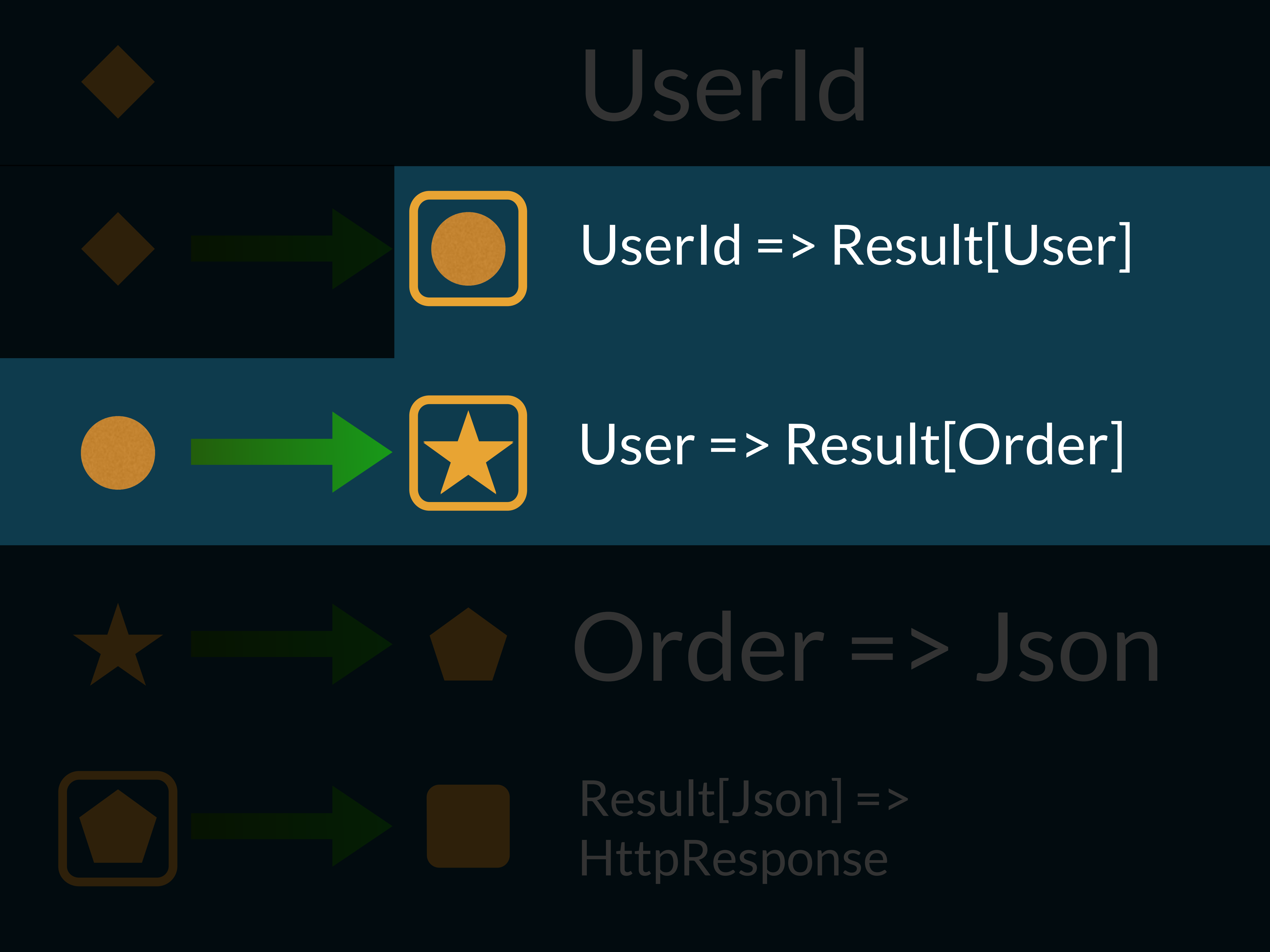
UserId

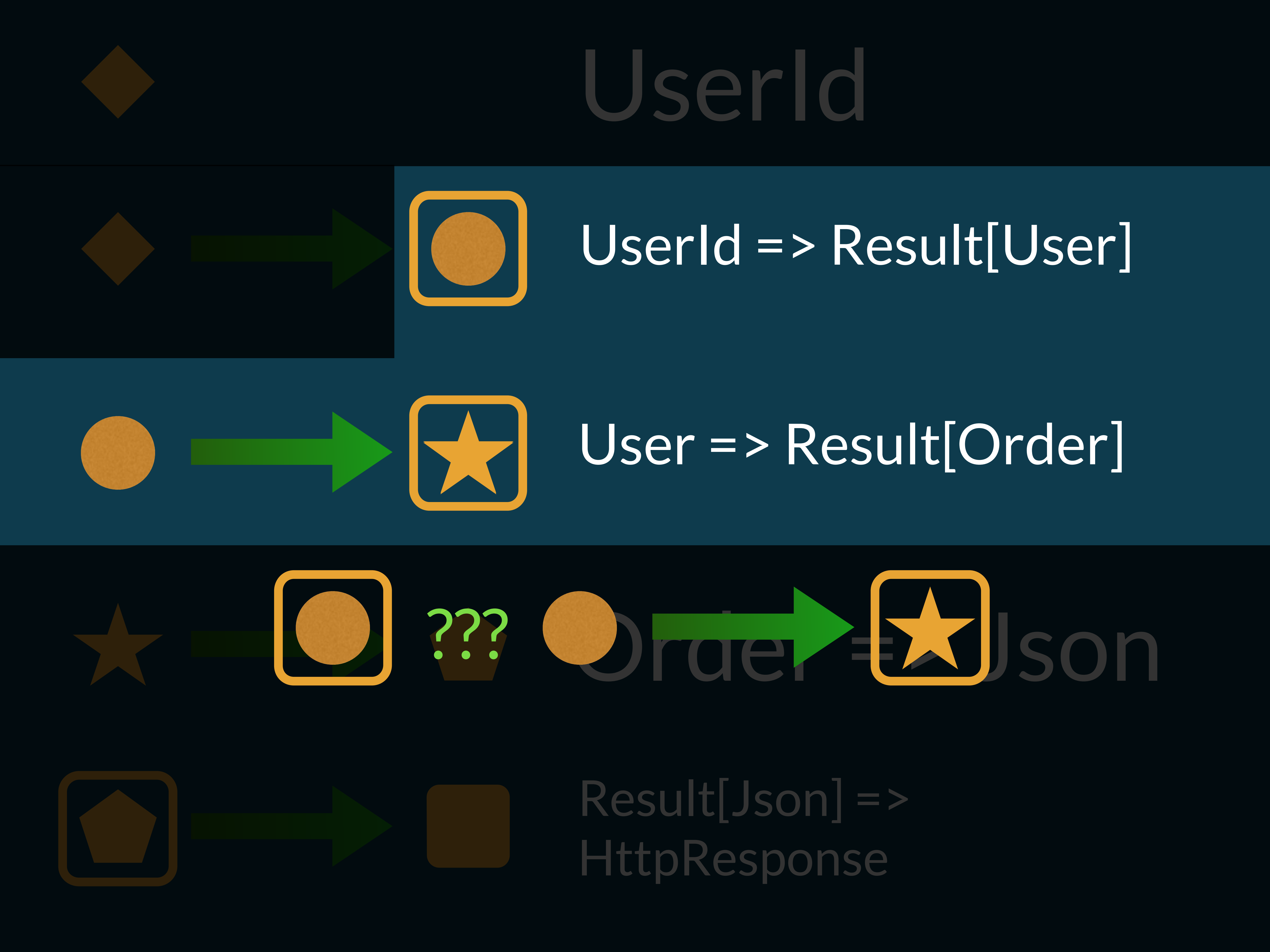
UserId => Result[User]

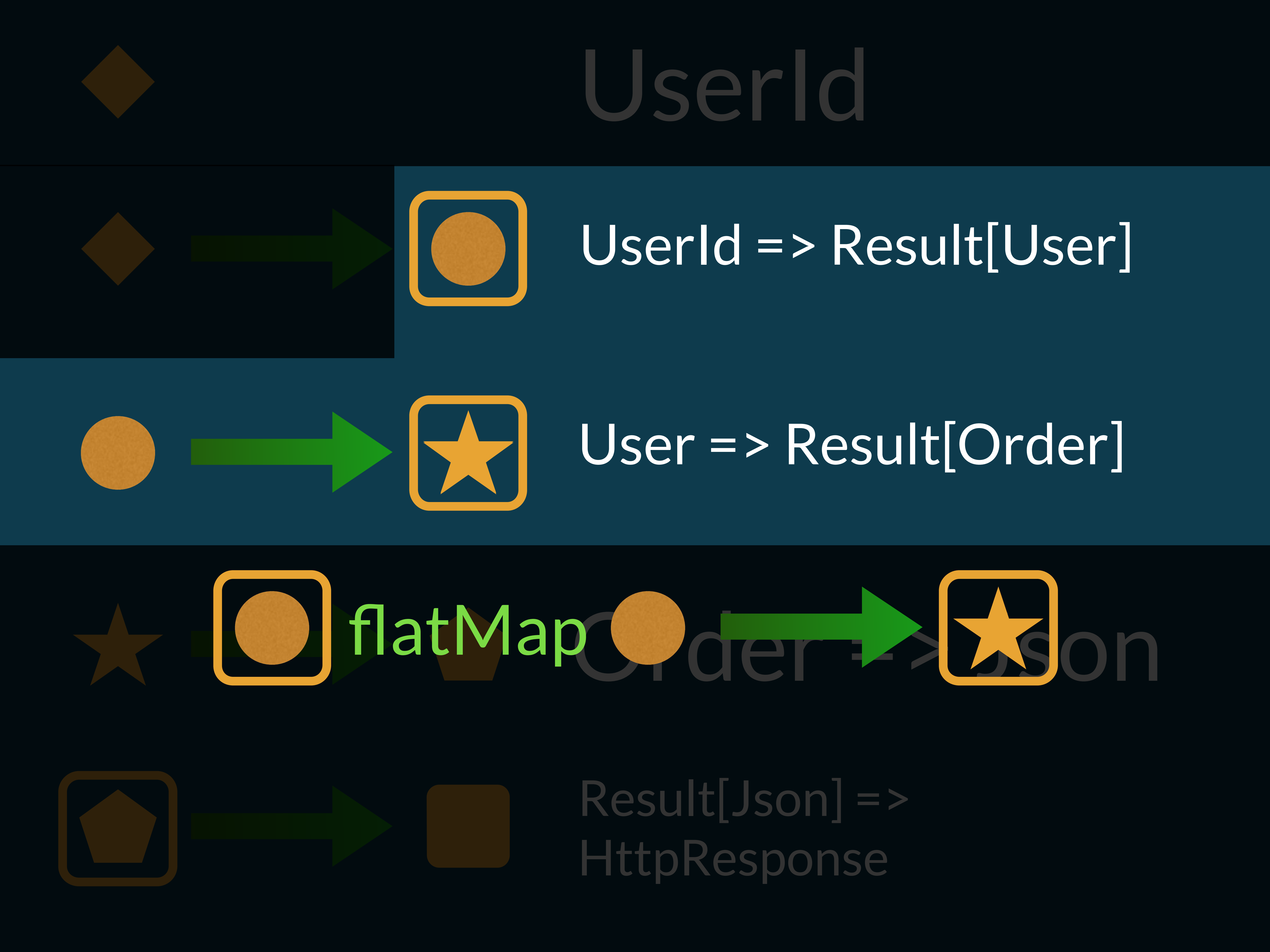
User => Result[Order]

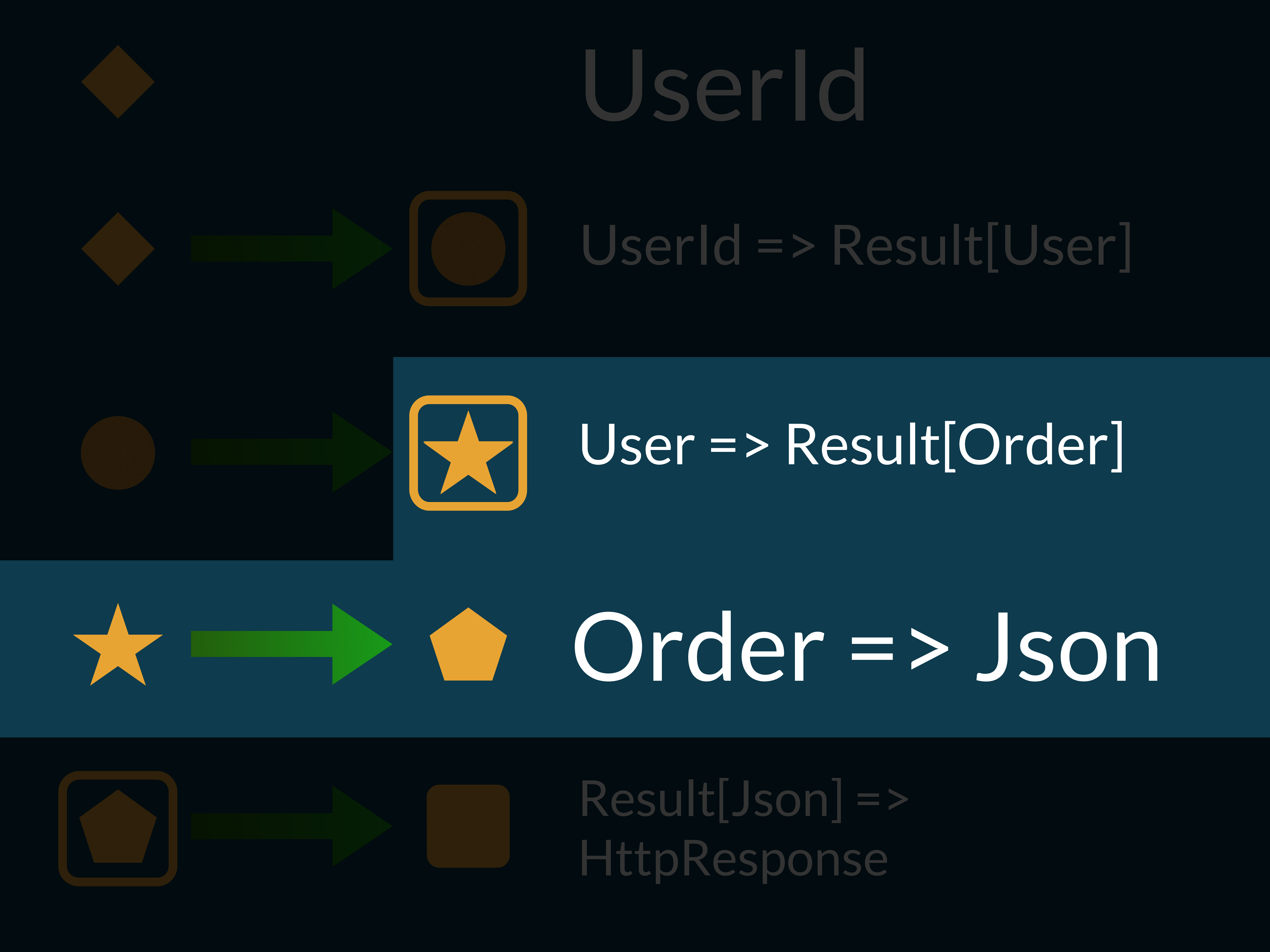
Order => Json

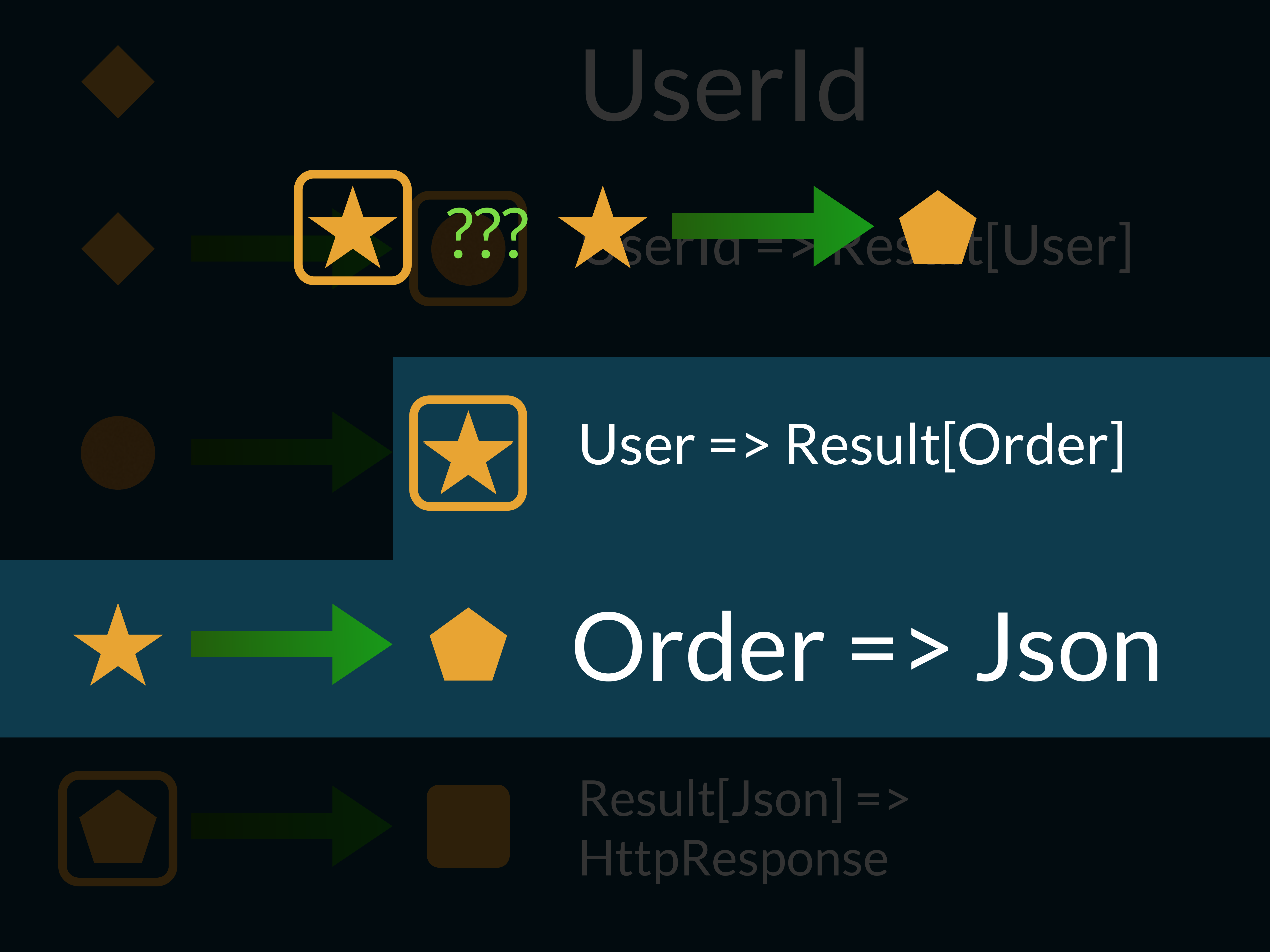
Result[Json] =>
HttpResponse


UserId
UserId => Result[User]
User => Result[Order]
Order => Json
Result[Json] =>
HttpResponse

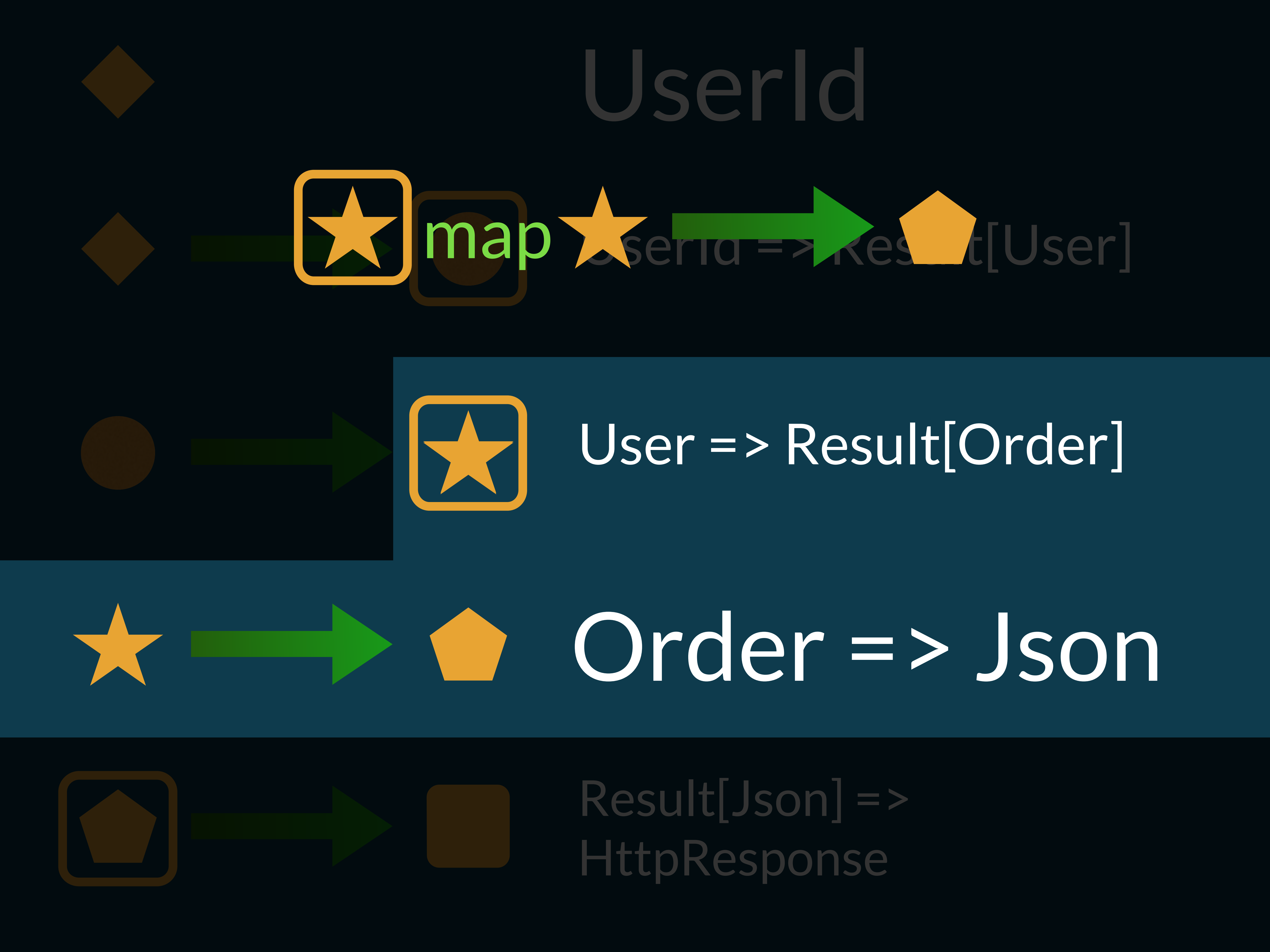

UserId
UserId => Result[User]
User => Result[Order]
???
Result[Json] =>
HttpResponse


UserId
UserId => Result[User]
User => Result[Order]
flatMap
Result[Json] =>
HttpResponse


UserId
UserId => Result[User]
User => Result[Order]
Order => Json
Result[Json] =>
HttpResponse

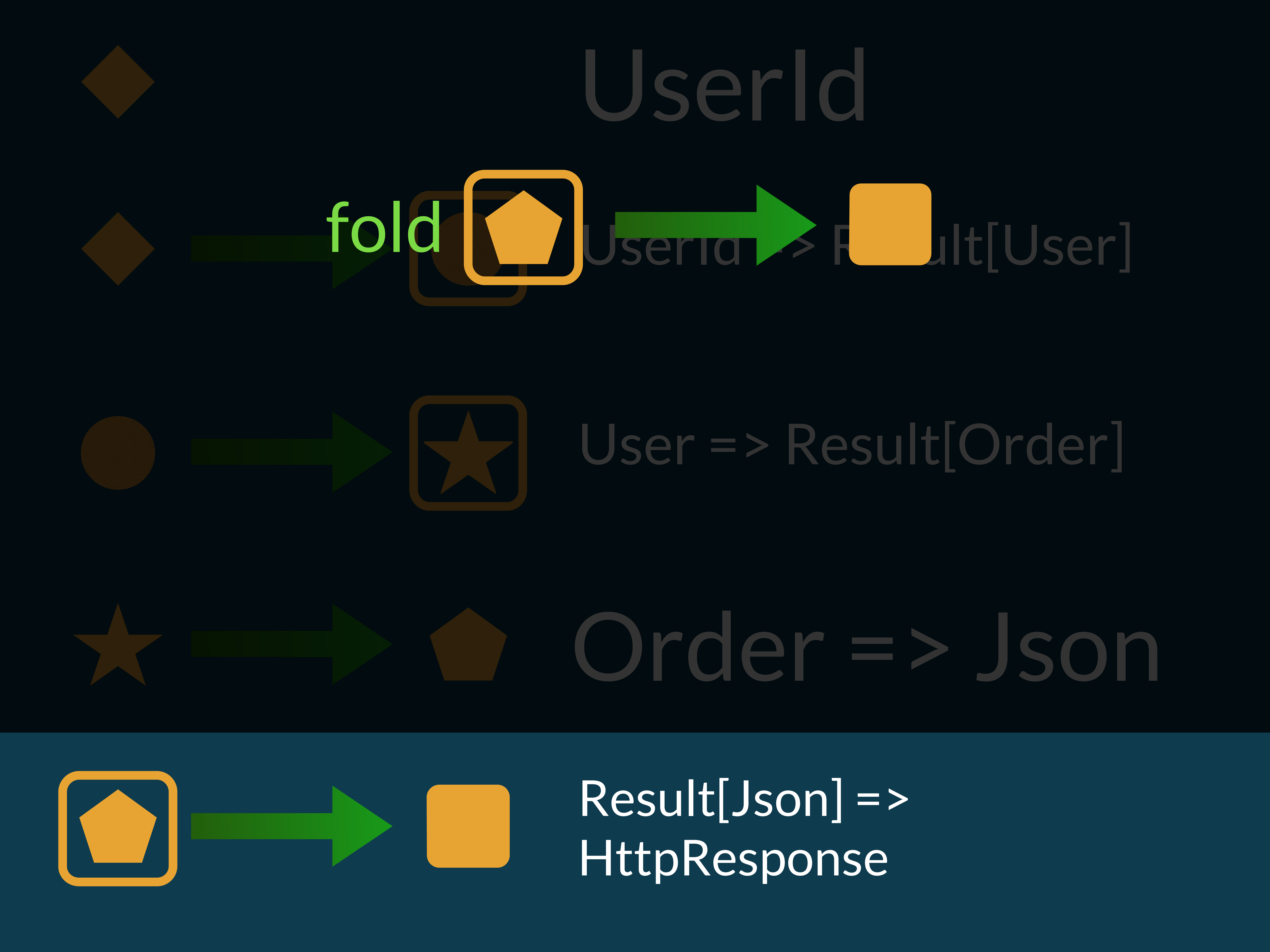


UserId
???
User => Result[Order]
Order => Json
Result[Json] =>
HttpResponse


UserId
map
User => Result[Order]
Order => Json
Result[Json] =>
HttpResponse


UserId
UserId => Result[User]
User => Result[Order]
Order => Json
Result[Json] => HttpResponse


UserId
???
User => Result[Order]
Order => Json
Result[Json] =>
HttpResponse


UserId
fold
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!

# Concerns that cross class hierarchy

E.g. serialize to JSON

# Common behaviour without (useful) common type

# Abstract behaviour to a type class

Can implement type class instances in ad-hoc manner

# Conclusions

# Scala is simple

# 3 patterns are 90% of code

4 patterns are 99% of code

# Program design in Scala is systematic


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

15% off with flatMap

Be like keyboard cat!