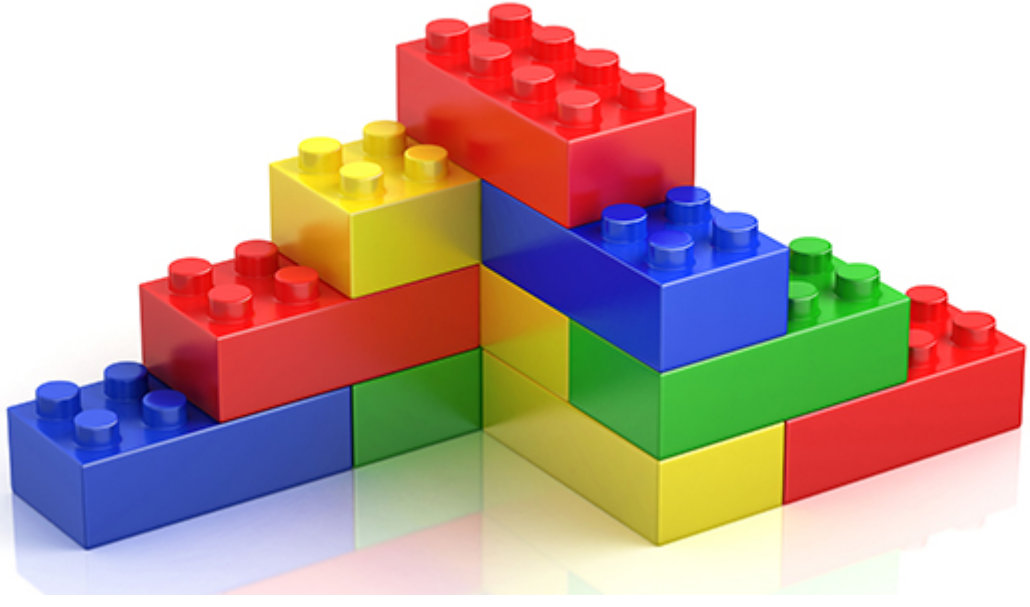
PRACTICAL TYPE SAFETY



Jacob Wang

HELLO

- Scala Developer at 

- @jatcwang

THIS TALK

- **Type Safety** - What and why?
- Principles
- Practical techniques for Scala

STATIC TYPES & TYPE SAFETY

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- Static types
  - Prevent incorrect behaviour, without running the program

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- Static types
  - Prevent incorrect behaviour, without running the program
- Type Safety is “how much” we take this approach

THE GOAL

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  - Tooling: Autocomplete, code browsing, refactoring
  - Understanding the code
  - Design & Prototyping

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- Consider the trade-offs

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PRINCIPLES & TECHNIQUES

I. GUARD AGAINST CHANGE

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- Code is written once, and changed many times
  - Change in requirement
  - Change in code architecture (refactoring)
- **Want**: Compile errors where our previous assumptions no longer holds
  - Prompt us to reconsider the logic
- “If I change a basic assumption I’m making here, will the compiler tell me?”

I. GUARD AGAINST CHANGE

Avoid catch-alls in pattern matching

```
sealed trait User {
  def name: String
}
final case class Guest(name: String) extends User
final case class Member(name: String) extends User
final case class Admin(name: String, level: Int) extends User

def canEdit(role: User): Boolean = {
  role match {
    case _: Guest => false
    case _      => true
  }
}
```

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def canEdit(role: User): Boolean = {
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  }
}
```

Bug if we add another role that isn’t allowed to edit!

I. GUARD AGAINST CHANGE

Avoid catch-alls in pattern matching

```
def canEditV2(role: User): Boolean = {
  role match {
    case _: Guest => false
    case u @ (_: Member | _: Admin) => {
      // u is a User
      // useful if you want to access fields on User class
      true
    }
  }
}
```

I. GUARD AGAINST CHANGE

Avoid default parameters

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```scala
// Version 1
final case class User(name: String, age: Int)

// Version 2
final case class User(name: String, age: Int, isAdmin: Boolean = false)
```

I. GUARD AGAINST CHANGE

Avoid default parameters

```
// Version 1
final case class User(name: String, age: Int)

// Version 2
final case class User(name: String, age: Int, isAdmin: Boolean = false)
```

```
def createFromLegacyUser(legacyUser: LegacyUser): User = {
  User(legacyUser.name, legacyUser.age)
}
```

I. GUARD AGAINST CHANGE

Avoid default parameters

Use explicitly named values/functions

```
final case class User(name: String, age: Int, isAdmin: Boolean)

object User {
  val defaultUser: User = ...
  // or
  def notAdmin(name: String, age: Int, isAdmin: Boolean = true): User
}
```

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```
final case class Vacancy(job: String, since: Instant)

// Usage
Url(s"company.com/create_vacancy/${vacancy.job}").post.send()
// POST https://company.com/create_vacancy/engineer
```

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// Usage
Url(s"company.com/create_vacancy/${vacancy.job}").post.send()
// POST https://company.com/create_vacancy/engineer
```

```
final case class Job(name: String, category: JobCategory)
final case class Vacancy(job: Job, since: Instant)

// Oops
// POST https://company.com/create_vacancy/Job(engineer, 2019-01-01T00:00:00Z)
```

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- Don’t use toString unless you’re forced to (e.g. Int)

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Solution 1:

- Use a custom interpolator that only allows `String` parameters,
- Explicit conversion to String
- Don’t use toString unless you’re forced to (e.g. Int)

```
// Compile error! vacancy.job is not a String!
Url(str"company.com/create_vacancy/${vacancy.job}").post.send()

// Compiles, all interpolated values are type String!
Url(str"company.com/create_vacancy/${vacancy.job.name}").post.send()
```

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- Scala allow custom string interpolators (For example see `cats.Show`)

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Solution 2: Custom typeclass

- Write custom typeclass e.g. `UrlShow`
- Provide typeclasses instances for types that are safe to be printed
- Scala allow custom string interpolators (For example see `cats.Show`)

```
Url(url"company.com/jobs/${vacancy.job.value}?page=${someNumber}").get.send()
```

II. MAKE IT EASY TO DO THE RIGHT THING

…and hard to make mistakes

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- Use types & language features as guard rails

II. MAKE IT EASY TO DO THE RIGHT THING

Newtypes

Wrap existing types in a new class

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Newtypes

Wrap existing types in a new class

- Readability - Domain concepts!
- Avoid mistakes
- Improves refactoring
- Enforce additional constraints

II. MAKE IT EASY TO DO THE RIGHT THING

Newtypes

Which is easier to use and understand?

```
final case class Directory(
  id: UUID,
  ownerId: UUID,
  parentId: Option[UUID],
  name: String
)
```

```
final case class Directory(
  id: DirectoryId,
  ownerId: UserId,
  parentId: Option[DirectoryId],
  name: DirectoryName
)
```

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```scala
final case class DirectoryId(uuid: UUID) extends AnyVal

// Use it like any other case class
DirectoryId(someUuid)
```

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How?

- Scala 2: **Case class + AnyVal**, or newtype library
- Scala 3: **Opaque Type**

```scala
final case class DirectoryId(uuid: UUID) extends AnyVal

// Use it like any other case class
DirectoryId(someUuid)
```

- **AnyVal** will avoid allocating the wrapper class*
  - Reduce allocations (GC) and indirection
  - *Allocations are still incurred in some cases
- **newtype** library does not suffer from this issue

II. MAKE IT EASY TO DO THE RIGHT THING

Newtypes with constraints

Enforce constraints using wrapper classes

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  - No direct construction (`new`, `apply`) nor `copy`
  - `unapply`, `hashCode` and `equals`

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Newtypes with constraints

Enforce constraints using wrapper classes

- We want:
  - No direct construction (`new`, `apply`) nor `copy`
  - `unapply`, `hashCode` and `equals`

```
final class private DirectoryName // Need to implement equals manually :(
final case class DirectoryName private (str: String) // .copy still accessible :(
```

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Introducing `sealed abstract case class`!!

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Introducing `sealed abstract case class`!!

- No `copy`, `new` nor `apply`
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Recommendation:

- A validated construction function
  - Returns **Either / Validated (cats)**
- An unsafe construction (explicitly marked unsafe)
  - Throws exception if an invalid input is provided

II. MAKE IT EASY TO DO THE RIGHT THING

Newtypes with constraints

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Newtypes with constraints

```scala
sealed abstract case class DirectoryName(strValue: String)

object DirectoryName {
  def fromString(str: String): Either[DirectoryNameError, DirectoryName] = {
    if (str.isEmpty)
      Left(DirectoryNameError.StringIsEmpty)
    else
      // Use anonymous subclass (allowed only in this file) to create an instance
      Right(new DirectoryName(str) {}) // ###
  }

  import cats.syntax.either._ // Provides .valueOr extension method
  // For tests or parsing from trusted/validated sources (e.g. Database)
  def fromStringUnsafe(str: String): DirectoryName = {
    fromString(str).valueOr(e  => throw e)
  }
}
```

II. MAKE IT EASY TO DO THE RIGHT THING

Named Parameters

Named parameters improves readability and help spot mistakes

```
def calculateTotal(
  items: List[Item],
  addTax: Boolean,
  addServiceCharge: Boolean
)
```

II. MAKE IT EASY TO DO THE RIGHT THING

Named Parameters

```
def printReceipt(items: List[Item], options: PrintOption)
calculateTotal(
  items,
  options.addServiceCharge, // bug
  options.addTax,
)
```

```
def printReceipt(items: List[Item], options: PrintOption)
calculateTotal(
  items,
  addServiceCharge = options.addTax, // Aha!
  addTax = options.addServiceCharge,
)
```

III. BUILD ABSTRACTIONS WITH TYPES

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  - Allows aggresive refactoring

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```
def f[T](list: List[T]): List[T]

f(List(1,2,3))
// List(1)

f(List(1.0, 2.0, 3.0))
// List(1.0)

f(List("1", "2", "3"))
// Nil ??!!!
```

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// List(1)

f(List(1.0, 2.0, 3.0))
// List(1.0)

f(List("1", "2", "3"))
// Nil ??!!!
```

```
// Don't do this!
list match {
  case (s: String) :: rest => Nil
  case s :: rest => List(s)
  // ...
}
```

III. BUILD ABSTRACTIONS WITH TYPES

Parametricity

Solution: Use typeclasses! (or subtype constraints)

```
def f[T](list: List[T])(implicit monoid: Monoid[T]): T = {
  // Might use "empty" and "combine" from the Monoid typeclass instance of T
}
```

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```
// Refactoring this will change the behaviour :(
for {
  _ <- Future { println("hi") }
  _ <- Future { println("hi") }
} yield ()
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```
// Usine ZIO
def task1: IO[Int] = IO { /* Side effect here */ }
def tasks: List[IO[Int]] = List(task1, task2, task3)

ZIO.sequence(tasks)    // Sequential execution
ZIO.sequencePar(tasks) // Parallel execution
task1.race(task2)      // First success is returned, other is cancelled
```

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- Avoid default parameters
- Avoid catch-alls in pattern matching
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- Newtypes
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- Parametricity
- Use IO

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- Learn, but verify - “Does it really solve a problem for me?”
- The principles applies to other languages too!
- Always keep the trade-offs in mind

REFERENCES

- Constraints Liberate, Liberties Constrain by Rúnar Bjarnason
- Cats Effect: The IO Monad for Scala by Gabriel Volpe
- Scaluzzi - Linting rules with Scalafix

THANK YOU!