Hi! 👋
My name is @folone

https://github.com/folone/london-scala

Type level programming in Scala [1]

[1] with lies

```
sealed trait Bool {
  type &&[B <: Bool] <: Bool
  type ||[B <: Bool] <: Bool
  type IfElse[T, F] <: Any
}
trait True extends Bool {
  type &&[B <: Bool] = B
  type ||[B <: Bool] = True
  type IfElse[T, F] = T
}
trait False extends Bool {
  type &&[B <: Bool] = False
  type ||[B <: Bool] = B
  type IfElse[T, F] = F
}
```

```
// false || true == true
// false.||(true) == true
implicitly[False # `||` [True] =:= True]

// if(true) String else Int
// true.ifElse(string, int) == string
implicitly[True # IfElse[String, Int] =:= String]

/* if(true) {
 *   if(false) Long else String
 * } else Int
 *
 * true.ifElse(false.ifElse(long, string), string) == string
 */
implicitly[True # IfElse[False # IfElse[Long, String], Int] =:= String]
```


https://github.com/folone/type-level-birds

There's a Smalltalk in your Scala

– Stefan Zeiger - Type level Computations in Scala - ScalaIO - 2015


Peano numbers!

```
trait Nat
trait Z extends Nat
trait Succ[A <: Nat] extends Nat

type _1 = Succ[Z]
type _2 = Succ[_1]
type _3 = Succ[_2]
```

```scala
trait MinusOne[A <: Nat] {
  type Res <: Nat
}

object MinusOne {
  implicit val baseCase: MinusOne[Z] { type Res = Z } =
    new MinusOne[Z] {
      type Res = Z
    }
  implicit def inductiveCase[A <: Nat]: MinusOne[Succ[A]] { type Res =  A } =
    new MinusOne[Succ[A]] {
      type Res = A
    }
}
```

```scala
trait MinusOne[A <: Nat] {
  type Res <: Nat
}

object MinusOne {

  type Aux[A <: Nat, Res1 <: Nat] = MinusOne[A] { type Res = Res1 }

  implicit val baseCase: Aux[Z, Z] = new MinusOne[Z] {
    type Res = Z
  }
  implicit def inductiveCase[A <: Nat]: Aux[Succ[A], A] = new MinusOne[Succ[A]] {
    type Res = A
  }
}
```

```
trait Plus[A <: Nat, B <: Nat] {
  type Res <: Nat
}
object Plus {
  implicit def baseCase[A <: Nat]: Plus[A, Z] { type Res = A } =
    new Plus[A, Z] {
      type Res = A
    }
  implicit def inductiveCase[A <: Nat, B <: Nat, C <: Nat, D <: Nat]
    (implicit ev0: MinusOne[B] { type Res = C },
              ev1: Plus[Succ[A], C] { type Res = D }): Plus[A, B] { type Res = D } =
    new Plus[A, B] {
      type Res = D
    }
}
```

```
implicit def inductiveCase[A <: Nat,
                           B <: Nat,
                           C <: Nat,
                           D <: Nat]
  (implicit ev0: MinusOne[B] { type Res = C },
            ev1: Plus[Succ[A], C] { type Res = D }): Plus[A, B] { type Res = D } =
  new Plus[A, B] {
    type Res = D
  }
```

```
trait Plus[A <: Nat, B <: Nat] {
  type Res <: Nat
}
object Plus {
  type Aux[A <: Nat, B <: Nat, Res1 <: Nat] = Plus[A, B] { type Res = Res1 }

  implicit def baseCase[A <: Nat]: Aux[A, Z, A] = new Plus[A, Z] {
    type Res = A
  }
  implicit def inductiveCase[A <: Nat, B <: Nat, C <: Nat, D <: Nat]
    (implicit ev0: MinusOne.Aux[B, C],
              ev1: Plus.Aux[Succ[A], C, D]): Aux[A, B, D] =
    new Plus[A, B] {
      type Res = D
    }
}
```

```
type _1 = Succ[Z]
type _2 = Succ[_1]
type _3 = Succ[_2]

@ implicitly[Plus[_1, _2]]
res0: Plus[_1, _2] { type Res = _3 } = Plus$$anon$2@f79a760
```

```
@ implicitly[Plus[_1, _2]]
res0: Plus[_1, _2] = Plus$$anon$2@13c3c1e1

@ implicitly[Plus[_1, _2]#Res =:= _3]
res1: =:=[Plus[_1, _2]#Res ,_3] = <function1>
```

```
@ implicitly[Plus.Aux[_1, _2, _3]]
res0: Plus.Aux[_1, _2, _3] = Plus.Aux$$anon$2@3d08f3f5

@ implicitly[Plus.Aux[_1, _2, Z]]
<console>:15: error: could not find implicit value for parameter e: Plus.Aux[_1, _2, Z]
       implicitly[Plus.Aux[_1, _2, Z]]
                  ^
```

HLists!

```
trait Nat
trait Z extends Nat
trait Succ[A <: Nat] extends Nat

trait HList
trait HNil extends HList
trait HCons[A, T <: HList] extends HList
```

```
trait Length[L <: HList] {
  type Res <: Nat
}

object Length {
  implicit val baseCase: Length[HNil.type] { type Res = Z } =
    new Length[HNil.type] {
      type Res = Z
    }
  implicit def inductiveCase[H,
                             T <: HList,
                             N <: Nat]
    (implicit ev0: Length[T] { type Res = N }) =
      new Length[HCons[H, T]] {
        type Res = Succ[N]
      }
}
```

```
trait Length[L <: HList] {
  type Res <: Nat
}

object Length {
  type Aux[L <: HList, Res1 <: Nat] = Length[L] { type Res = Res1 }
  implicit val baseCase: Aux[HNil.type, Z] = new Length[HNil.type] {
    type Res = Z
  }
  implicit def inductiveCase[H, T <: HList, N <: Nat]
    (implicit ev0: Length.Aux[T, N]) =
    new Length[HCons[H, T]] {
      type Res = Succ[N]
    }
}
```


Shapeless!
https://github.com/milessabin/shapeless

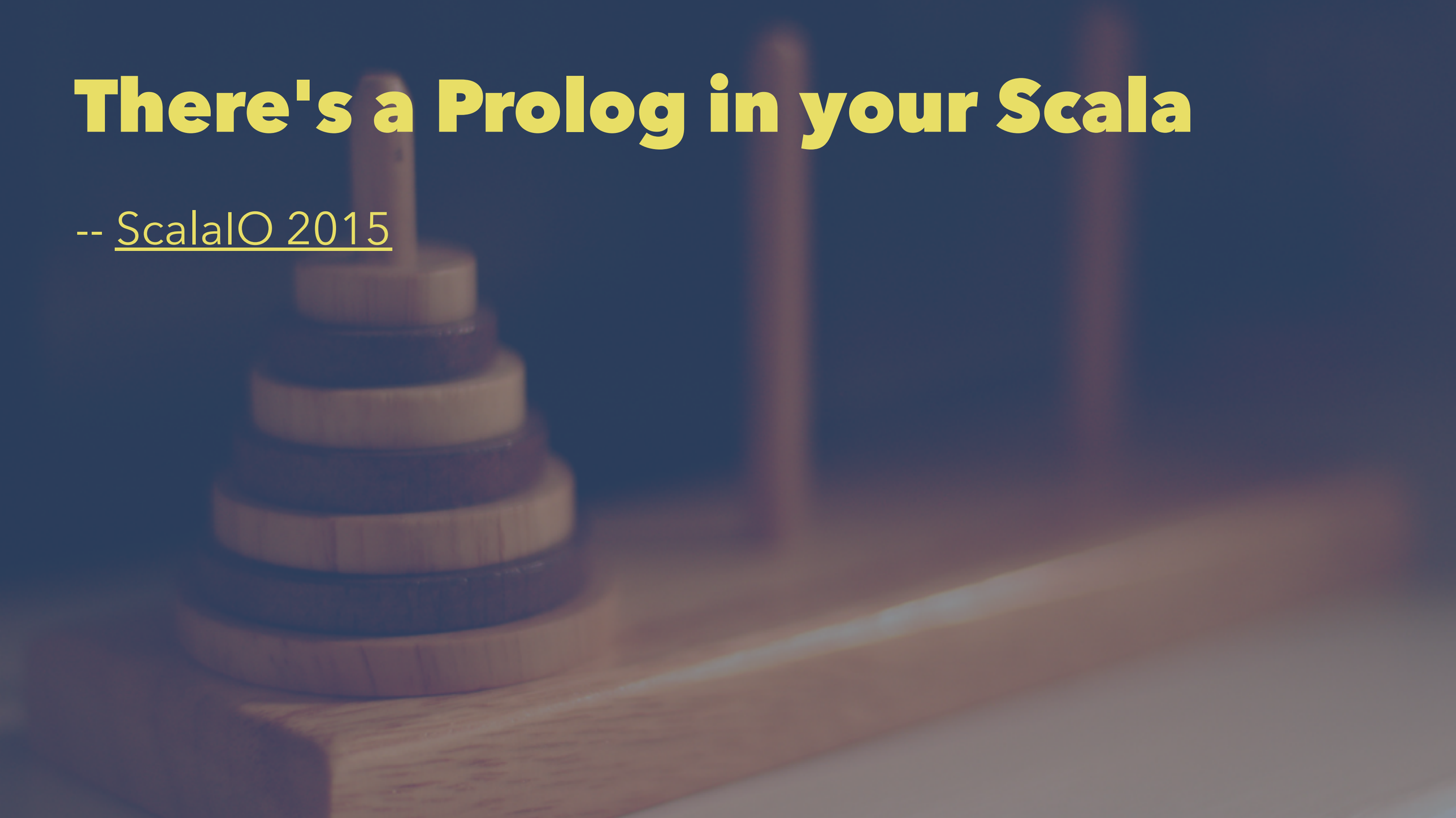
```
@ import shapeless._
import shapeless._

@ val hlist = 1l :: "hello" :: HNil
hlist: Long :: String :: HNil = 1 :: hello :: HNil
```

```
@ hlist(0)
res7: Long = 1

@ hlist(1)
res8: String = hello

@ hlist(2)
<console>:16: error:
Implicit not found: Scary[Type].Please#Ignore
You requested to access an element at the position
TypelevelEncodingFor[2.type]
but the HList Long :: String :: HNil is too short.
       hlist(2)
             ^
Compilation failed.
```



There's a Prolog in your Scala

-- ScalaIO 2015

Json serialization

```
def json(o: Any): String
```

```
def json(o: Any): JsonAst
```

def json[A : Writes](o: A): JsonAst

```
trait Writes[A] {
  def write(o: A): JsonAst
}
```

```
@ import play.api.libs.json.{Json => PJson}
import play.api.libs.json.{Json => PJson}

@ case class Thing(id: Long, payload: String)
defined class Thing

@ PJson.writes[Thing]
res0: Writes[Thing] = Writes$$anon$2@f79a760
```

```
@ case class Omg(_1: Int, _2: Int, _3: Int, _4: Int, _5: Int,
_6: Int, _7: Int, _8: Int, _9: Int, _10: Int, _11: Int, _12: Int,
_13: Int, _14: Int, _15: Int, _16: Int, _17: Int, _18: Int,
_19: Int, _20: Int, _21: Int, _22: Int, _23: Int)
defined class Omg
@ PJson.writes[Omg]
cmd9.sc:1: No unapply or unapplySeq function found for class Omg.
val res9 = PJson.writes[Omg]
                       ^
Compilation Failed
```

😱 >700LOC of macro 😱

😱

```
Thing(id: Long, payload: String)
```

```
(Long, String)
```

```
Long :: String :: HNil
```

1. Case classes are essentially tuples (or `HLists`) with names. Can we transform one to another?
2. Define `Writes` for an `HList`:
    1. How do we serialize an `HNil`?
    2. How do we serialize an `HCons`?
3. 🌈

Two (mandatory) building blocks

- `HLists`
- `Generic`[2]

[2] lie: what we actually need is a `LabelledGeneric`

HList

```
@ import shapeless._
import shapeless._

@ val hlist = 1l :: "hello" :: HNil
hlist: Long :: String :: HNil = 1 :: hello :: HNil
```

```
@ hlist(0)
res7: Long = 1

@ hlist(1)
res8: String = hello

@ hlist(2)
<console>:16: error:
Implicit not found: Scary[Type].Please#Ignore
You requested to access an element at the position
TypelevelEncodingFor[2.type]
but the HList Long :: String :: HNil is too short.
       hlist(2)
             ^
Compilation failed.
```

Generic

```
@ case class Thing(id: Long, payload: String)
defined class Thing

@ val generic = Generic[Thing]
generic: shapeless.Generic[Thing]{type Repr = Long :: String :: HNil} =
  anon$macro$3$1@7f8f5e52
```

```
@ val representation = generic.to(Thing(1, "hello"))
representation: res0.Repr = 1 :: hello :: HNil

@ representation(0)
res10: Long = 1

@ representation(1)
res11: String = hello

@ representation(2)
<console>:19: error:
Implicit not found: Scary[Type].Please#Ignore
You requested to access an element at the position
TypelevelEncodingFor[2.type]
but the HList Long :: String :: HNil is too short.
       representation(2)
                      ^
```

```
@ generic.from(hlist)
res7: Thing = Thing(1L, "hello")
```

Putting this together

1. Let shapeless transform our case classes into some unified form (`HLists`)
2. Write down instances of the `Writes` typeclass for those forms in a generic way (`HNil`, `HCons`)
3. Let the magic flow 🌈

```scala
object writes extends LabelledProductTypeClassCompanion[Writes] with DefaultWrites {
    object typeClass extends LabelledProductTypeClass[Writes] {
      override def emptyProduct: Writes[HNil] =
        Writes(_ => PlayJson.obj())

      override def product[H, T <: HList](name: String, headEv: Writes[H], tailEv: Writes[T]) =
        Writes[H :: T] {
          case head :: tail =>
            val h = headEv.writes(head)
            val t = tailEv.writes(tail)
            PlayJson.obj(name -> h) ++ t
        }

      override def project[F, G](instance: => Writes[G], to: F => G, from: G => F) =
        Writes[F](f => instance.writes(to(f)))
    }
}
```

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        Writes[H :: T] {
          case head :: tail =>
            val h = headEv.writes(head)
            val t = tailEv.writes(tail)
            PlayJson.obj(name -> h) ++ t
        }

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}
```

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      Writes[H :: T] {
        case head :: tail =>
          val h = headEv.writes(head)
          val t = tailEv.writes(tail)
          PlayJson.obj(name -> h) ++ t
      }

    override def project[F, G](instance: => Writes[G], to: F => G, from: G => F) =
      Writes[F](f => instance.writes(to(f)))
  }
}
```

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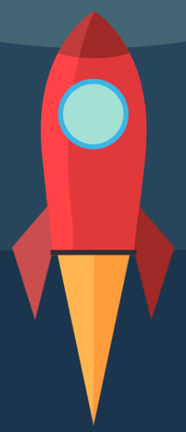
        Writes[H :: T] {
          case head :: tail =>
            val h = headEv.writes(head)
            val t = tailEv.writes(tail)
            PlayJson.obj(name -> h) ++ t
        }

      override def project[F, G](instance: => Writes[G], to: F => G, from: G => F) =
        Writes[F](f => instance.writes(to(f)))
    }
}
```



The Type Astronaut's Guide to Shapeless

Dave Gurnell
foreword by Miles Sabin

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https://github.com/folone/london-scala

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