Adventures in Meta-Programming

Macros vs Shapeless

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underscore

meta-programming

[**mee**-t<u>uh</u>-**proh**-gram-ing]

noun

1. the practice of writing code that writes code;

domain specific languages

scrapping boilerplate

meta-programming

[**mee**-tuh-**proh**-gram-ing]

noun

1. the practice of writing code that writes code;
2. a pretty big time sink;
3. sometimes an uphill struggle.

when do they work well?

when do they work less well?

macros

shapeless

simple applications of each technique

tips to make things easier

constructing values

```scala
case class IceCream(
  name: String,
  numCherries: Int,
  inCone: Boolean)


create[IceCream]
// IceCream("", 0, false)
```

macros

```
create[IceCream]
```

```
IceCream("", 0, false)
```

```
def create[A]: A =
  macro Macros.createMacro[A]
```

```scala
def createMacro[A: WeakTypeTag]: Tree = {
  val targetType  = weakTypeOf[A]

  val applyMethod = findApplyMethod(targetType)

  val applyParams = applyMethod
    .paramLists.map { paramList =>
      paramList.map { param =>
        createApplyParam(param.typeSignature)
      }
    }

  q"$applyMethod(...$applyParams)"
}
```

```scala
def createApplyParam(paramType: Type): Tree =
  if(paramType <:< typeOf[String]) {
    q""" "" """
  } else if(paramType <:< typeOf[Int]) {
    q"0"
  } else if(paramType <:< typeOf[Boolean]) {
    q"false"
  } else {
    c.abort(c.enclosingPosition, "FAIL!")
  }
```

```
create[IceCream]
```

```
IceCream("", 0, false)
```

analysis

lots of drawbacks

only handles three parameter types

not customisable by the user

macros v2

```scala
trait Pure[A] {
  def value: A
}

implicit val stringPure: Pure[String] =
  new Pure[String] { def value = "" }

implicit val intPure: Pure[Int] =
  new Pure[Int] { def value = 0 }

implicit val booleanPure: Pure[Boolean] =
  new Pure[Boolean] { def value = false }
```

```scala
def createApplyParam(paramType: Type): Tree =
  q"""
  _root_.scala.Predef
    .implicitly[_root_.Pure[$paramType]]
    .value
  """
```

```scala
def createApplyParam(paramType: Type): Tree =
  q"""
  _root_.scala.Predef
    .implicitly[_root_.Pure[$paramType]]
    .value
  """

// implicitly[Pure[Foo]].value
```

```
create[IceCream]
```

```
create[IceCream](IceCream(
  implicitly[Pure[String]].value,
  implicitly[Pure[Int]].value,
  implicitly[Pure[Boolean]].value
))
```

analysis

user-customisable and extendable

handles any parameter type

macro only works with specific types

shapeless

```scala
trait Pure[A] {
  def value: A
}

implicit val stringPure: Pure[String] =
  new Pure[A] { def value = "" }

implicit val intPure: Pure[Int] =
  new Pure[A] { def value = 0 }

implicit val booleanPure: Pure[Boolean] =
  new Pure[A] { def value = false }
```

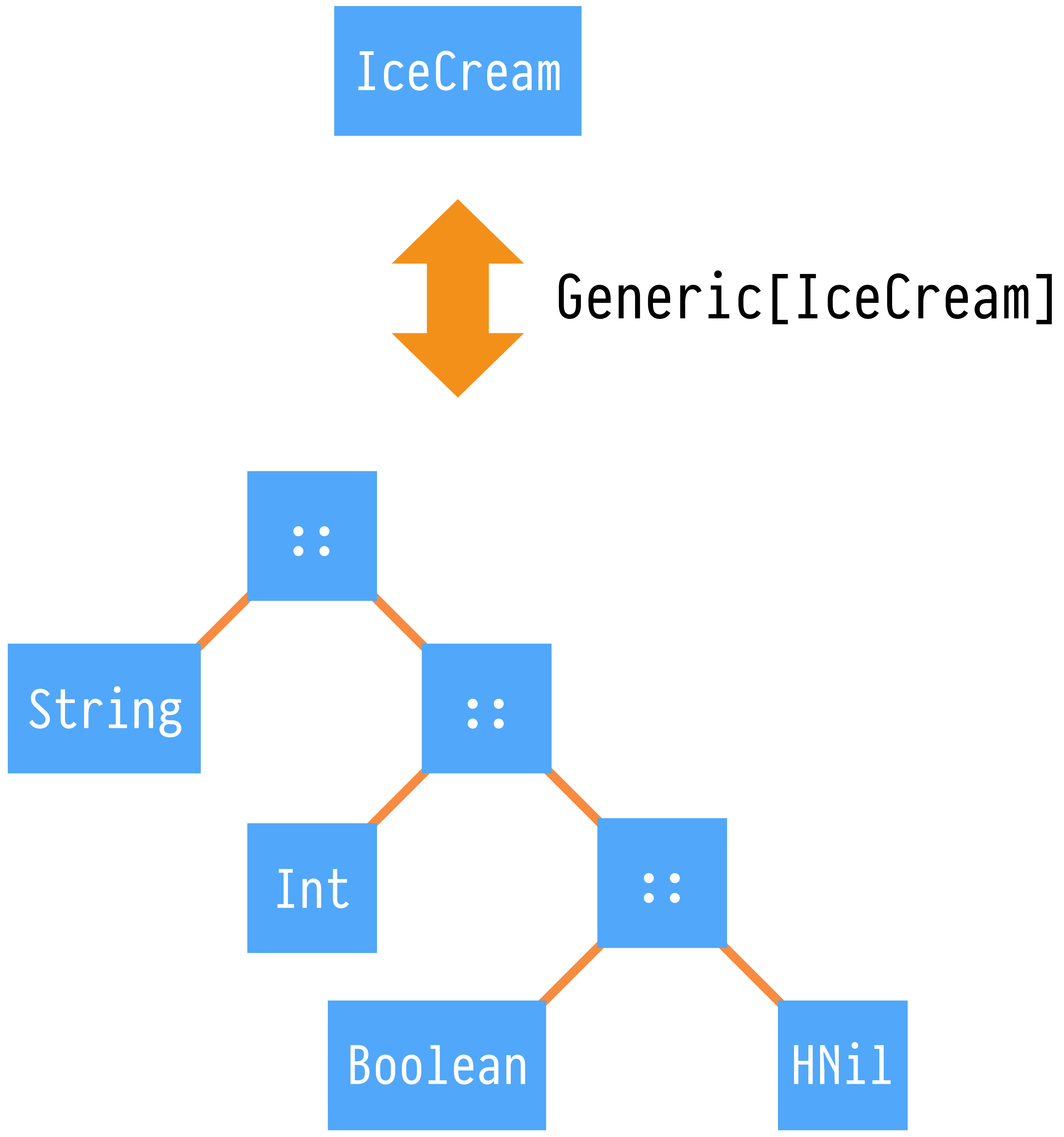
```
trait Pure[A] {
  def value: A
}

implicit val stringPure: Pure[String] =
  new Pure[A] { def value = "" }

implicit val intPure: Pure[Int] =
  new Pure[A] { def value = 0 }

implicit val booleanPure: Pure[Boolean] =
  new Pure[A] { def value = false }

implicit def genericPure[A]: Pure[A] =
  ???
```


IceCream
Generic[IceCream]
::
String
::
Int
::
Boolean
HNil

```scala
implicit val hnilPure: Pure[HNil] =
  instance(HNil)

implicit def hconsPure[H, T <: HList](
  implicit
  hPure: Lazy[Pure[H]],
  tPure: Pure[T]
): Pure[H :: T] =
  instance(hPure.value.value :: tPure.value)

implicit def genericPure[A, R](
  implicit
  gen: Generic.Aux[A, R],
  pure: Lazy[Pure[R]]
): Pure[A] =
  instance(gen.from(pure.value.value))
```

analysis

completely
user-customisable

lots of similarities
between macros and shapeless

macros are syntactic,
shapeless is structural

what wins?

in this case,
IMO shapeless

shapeless' `Generic` isolates
the meta-programming

50% of the code,
no deprecated APIs

data validation

https://github.com/davegurnell/checklist

```
case class IceCream(
  name: String,
  cherries: Int,
  cone: Boolean)
```

```scala
case class IceCream(
  name: String,
  cherries: Int,
  cone: Boolean)

val rule = Rule[IceCream]
  .field(_.name)(nonEmpty)
  .field(_.cherries)(gte(0))
```

```scala
case class IceCream(
  name: String,
  cherries: Int,
  cone: Boolean)

val rule = Rule[IceCream]
  .field(_.name)(nonEmpty)
  .field(_.cherries)(gte(0))

rule(IceCream("", -1, false))
// List(
//   Error("Must be non-empty", List("name")),
//   Error("Must be >= 0",      List("cherries"))
// ))
```

```scala
case class IceCream(
  name: String,
  cherries: Int,
  cone: Boolean)

val rule = Rule[IceCream]
  .field(_.name)(nonEmpty)
  .field(_.cherries)(gte(0))

rule(IceCream("", -1, false))
// List(
//   Error("Must be non-empty", List("name")),
//   Error("Must be >= 0",      List("cherries"))
// ))
```

macros

```scala
val rule = Rule[IceCream]
  .field(_.name)(nonEmpty)
  .field(_.cherries)(gte(0))
```

```
"cherries"    _.cherries
```

```scala
val rule = Rule[IceCream]
  .field(_.name)(nonEmpty)
  .field(_.cherries)(gte(0))
```

```
"cherries"    _.cherries
```

```
val rule = gte(0)

rule.apply(-1)
// List(Error("Must be >= 0", Nil))
```

```scala
val rule = gte(0)
  .prefixed("cherries")

rule.apply(-1)
// List(Error("Must be >= 0", List("cherries")))
```

```scala
val rule = gte(0)
  .prefixed("cherries")
  .contramap[IceCream](_.cherries)

rule.apply(IceCream("Sundae", -1, false))
// List(Error("Must be >= 0", List("cherries")))
```

```scala
val rule = Rule[IceCream]
  .field(_.name)(nonEmpty)
  .field(_.cherries)(gte(0))
```

```scala
val rule = Rule[IceCream]
  .and(nonEmpty
    .prefixed("name")
    .contramap[IceCream](_.name))
  .and(gte(0)
    .prefixed("cherries")
    .contramap[IceCream](_.cherries))
```

```
trait Rule[A] {
  def apply(value: A): List[Error]

  def field(func: A => B)(rule: Rule[B]): Rule[A] =
    macro Macros.fieldMacro(func)(rule)
}
```

```scala
def fieldMacro(func: Tree)(rule: Tree): Tree = {
  val name = func match {
    case q"($param) => $obj.$name" =>
      q"${name.toString}"
    case other =>
      c.abort(c.enclosingPosition, "FAIL!")
  }

  q"""
  ${c.prefix}.and(
    $rule
      .prefixed($name)
      .contramap($func)
  )
  """
}
```

```
Rule[IceCream]
  .field(_.cherries)(gte(0))
```

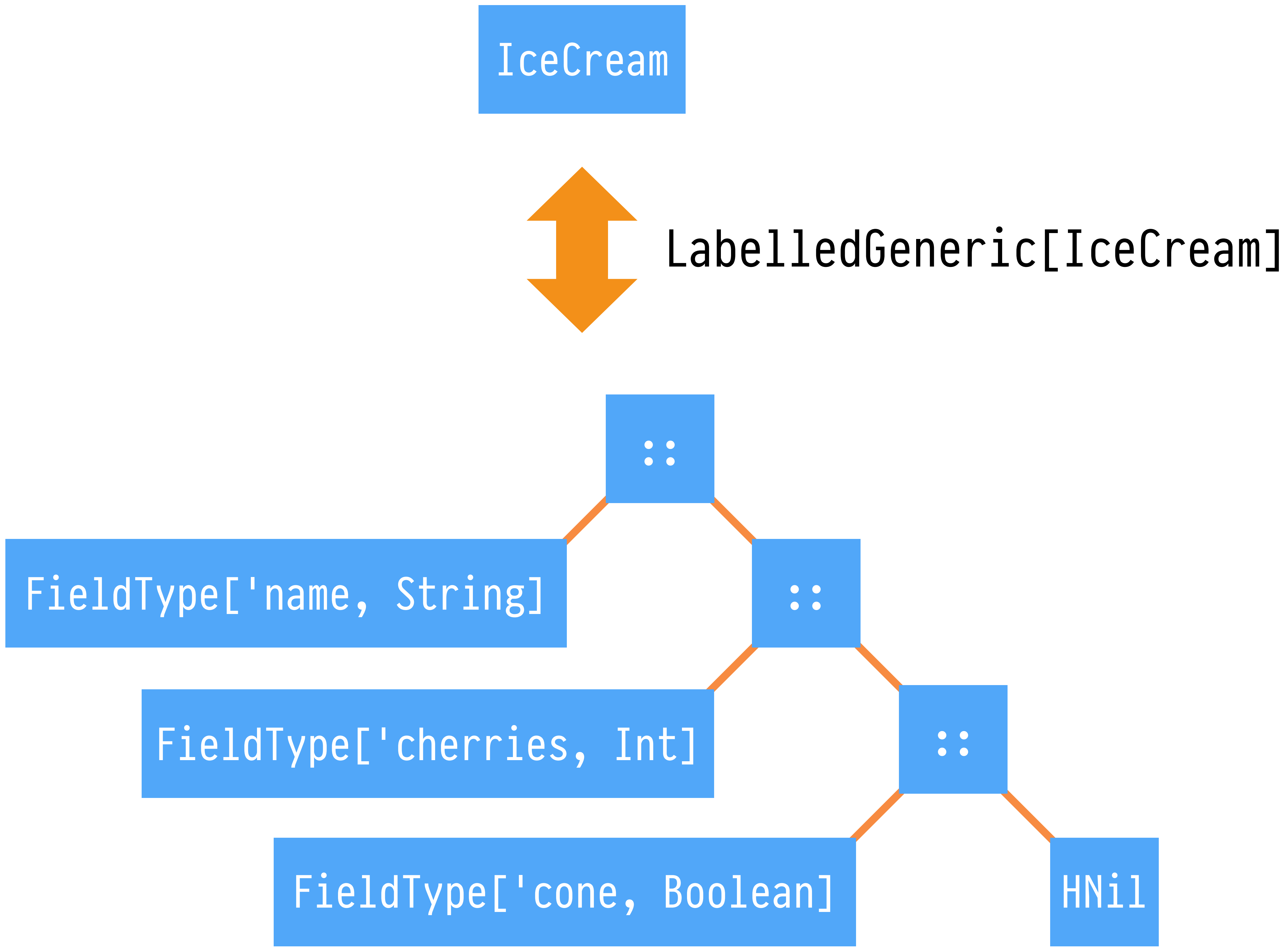
```
Rule[IceCream].and(
  get(0)
    .prefixed("cherries")
    .contramap[IceCream](_.cherries)
)
```

analysis

syntactic solution
to a syntactic problem

code is short and simple
(easy to maintain/replace)

shapeless


IceCream
LabelledGeneric[IceCream]
::
FieldType['name, String]
::
FieldType['cherries, Int]
::
FieldType['cone, Boolean]
HNil

```scala
val rule = Rule[IceCream]
  .field('name)(nonEmpty)
  .field('cherries)(gte(0))
```

```scala
trait Rule[A] {
  def apply(value: A): List[Error]

  def field[B]
      (field: Witness)
      (rule: Rule[B])
      (implicit wrap: HasField[A, field.T, B]): Rule[A] =
    this.and(wrap(rule))
}
```

```scala
/**
 * Proof that an object of type A
 * has a field of type B named K.
 */
trait HasField[A, K, B] {
  def name: String
  def zoom(value: A): B

  def apply(rule: Rule[B]): Rule[A] =
    rule.prefixed(name).contramap(zoom)
}
```

```scala
implicit def hlistHasField[L <: HList, K, F](
  implicit
  ev: K <:< Symbol,
  witness: Witness.Aux[K],
  selector: Selector.Aux[L, K, F]
): HasField[L, K, F] =
  new HasField[L, K, F] {
    val name = witness.value.name
    def zoom(value: L): F = selector(value)
  }

implicit def genericHasField[A, L, K, F](
  implicit
  ev: K <:< Symbol,
  gen: LabelledGeneric.Aux[A, L],
  hf: HasField[L, K, F]
): HasField[A, K, F] =
  new HasField[A, K, F] {
    val name = hf.name
    def zoom(value: A): F = hf.zoom(gen.to(value))
  }
```

what wins?

in this case, IMO macros

short code,
easy to maintain/replace

syntactic problem,
syntactic solution

summary

macros are good
for syntaxy stuff

/

shapeless is good
for typey stuff

meta-programming
is a convenience,
not a solution

both of our solutions
were 90% regular scala
and 10% meta-programming

we can do most stuff
with ADTs and type classes

using these patterns
makes meta-programming easier

macros

Dave Gurnell - Macros for the Rest of Us
https://www.youtube.com/watch?v=ZVYdiAudr-I

Tomer Wix - Leveraging Scala Macros for Better Validation
https://www.youtube.com/watch?v=Li19Cif7uS8

Chris Birchall - Meta-Program and/or Shapeless all the Things!
https://skillsmatter.com/skillscasts/9294

shapeless

Dave Gurnell - The Type Astronaut’s Guide to Shapeless
http://underscore.io/books/shapeless-guide

Dave Gurnell - Establishing Orbit with Shapeless
https://skillsmatter.com/skillscasts/9136

Sam Halliday - Shapeless for Mortals
https://skillsmatter.com/skillscasts/6875

functional design

Noel Welsh - Six Core Principles for Learning Scala
https://www.youtube.com/watch?v=J8wUy1XxL5o

Dave Gurnell - Functional Data Validation (Part 1)
https://skillsmatter.com/skillscasts/5837

Dave Gurnell - Functional Data Validation (Part 2)
https://www.youtube.com/watch?v=0DPGpyt6joE

bonus macro!

unindent

https://github.com/davegurnell/unindent

```scala
val lorem =
  s"""
  |Lorem ipsum
  |dolor sit amet
  |consectetur
  """.trim.stripMargin

println(lorem)
// "Lorem ipsum\ndolor sit\nconsectetur"
```

```scala
import unindent._

val lorem =
  i"""
  Lorem ipsum
  dolor sit amet
  consectetur
  """

println(lorem)
// "Lorem ipsum\ndolor sit\nconsectetur"
```

thank you

https://github.com/davegurnell/macros-vs-shapeless

underscore