The Seductions of Scala

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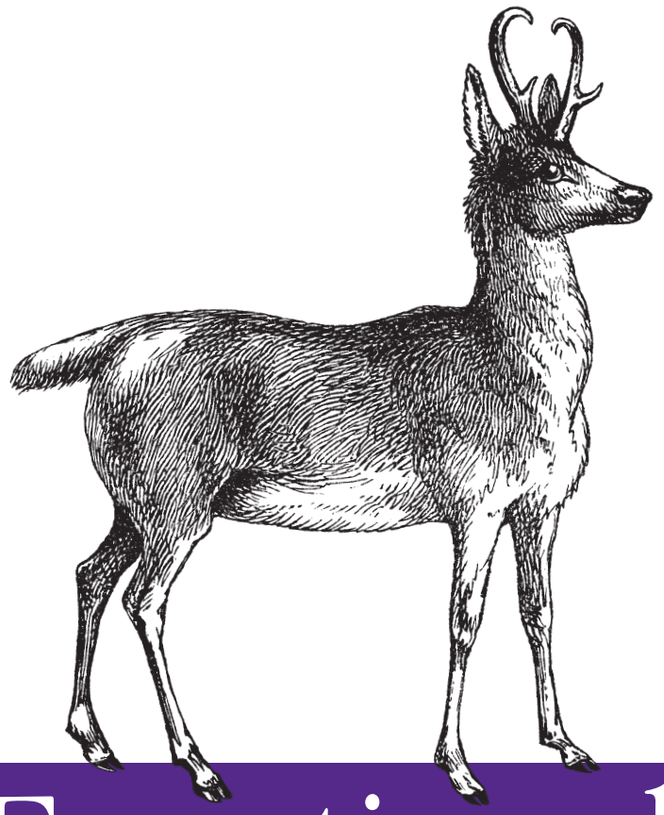
April 17, 2012

Sunday, January 20, 13

The online version contains more material. You can also find this talk and the code used for many of the examples at github.com/deanwampler/Presentations/tree/master/SeductionsOfScala.



Functional Programming

for Java Developers

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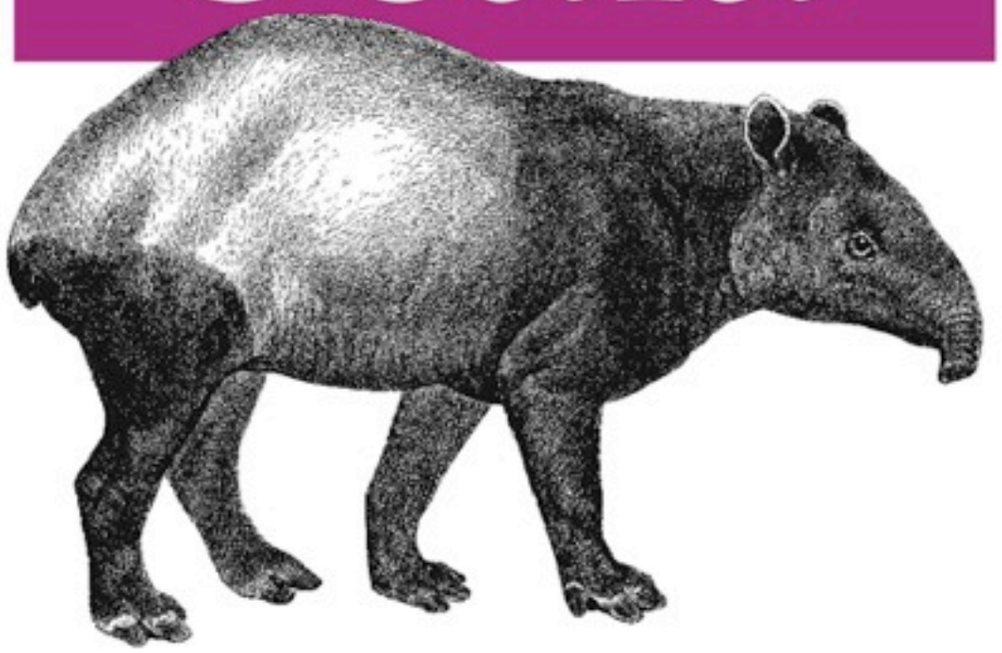
Scalability = Functional Programming + Objects

Programming

Scala



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Dean Wampler & Alex Payne

polyglotprogramming.com/fpjava

programmingscala.com

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Why do we *need* a *new* language?

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I picked Scala to learn in 2007 because I wanted to learn a functional language. Scala appealed because it runs on the JVM and interoperates with Java. In the end, I was seduced by its power and flexibility.

#1

We need

Functional

Programming

• • •

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First reason, we need the benefits of FP.

... for *concurrency*.

... for *concise* code.

... for *correctness*.

#2

We need a better

Object Model

• • •

... for *composability*.

... for *scalable designs*.

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Java's object model (and to a lesser extent, C#'s) has significant limitations.

Scala's *Thesis:* Functional Prog. *Complements* Object-Oriented Prog.

Despite surface contradictions...

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We think of objects as mutable and methods as state-modifying, while FP emphasizes immutability, which reduces bugs and often simplifies code. Objects don't have to be mutable!

But we want to
keep our *investment*
in *Java*.

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We rarely have the luxury of starting from scratch...

Scala is...

- A *JVM* language.
- *Functional* and *object oriented*.
- *Statically* typed.
- An *improved* Java.

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There has also been work on a .NET version of Scala, but it seems to be moving slowly.

Martin Odersky

- Helped design java *generics*.
- Co-wrote *GJ* that became *javac* (v1.3+).

- Understands Computer Science theory *and* industry's needs.

Odersky is the creator of Scala. He's a prof. at EPFL in Switzerland. Many others have contributed to it, mostly his grad. students.
GJ had generics, but they were disabled in javac until v1.5.

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Not all objects are functions, but they can be...

Objects as *Functions*

```
class Logger(val level:Level) {

 def apply(message: String) = {
  // pass to Log4J...
  Log4J.log(level, message)
 }
}
```


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A simple wrapper around your favorite logging library (e.g., Log4J).

makes "level" a field

```
class Logger(val level:Level) {

  def apply(message: String) = {
   // pass to Log4J...
   Log4J.log(level, message)
  }
}
```

method

class body is the "primary" constructor

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Note how variables are declared, "name: Type".

```
class Logger(val level:Level) {

 def apply(message: String) = {
  // pass to Log4J...
  Log4J.log(level, message)
 }
}
```

```
val error = new Logger(ERROR)

…
error("Network error.")
```


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After creating an instance of Logger, in this case for Error logging, we can “pretend” the object is a function!

```
class Logger(val level:Level) {

  def apply(message: String) = {
    // pass to Log4J...
    Log4J.log(level, message)
  }
}
```

apply is called

"function object"

```
...
error("Network error.")
```


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Adding a parameterized arg. list after an object causes the compiler to invoke the object's "apply" method.

When you put an *argument list* after any *object*, *apply* is called.

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This is how any object can be a function, if it has an apply method. Note that the signature of the argument list must match the arguments specified. Remember, this is a statically-typed language!

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While an object can be a function, every “bare” function is actually an object, both because this is part of the “theme” of scala’s unification of OOP and FP, but practically, because the JVM requires everything to be an object!

Int, Double, etc.
are true *objects*.

But they are compiled to primitives.

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This is how any object can be a function, if it has an apply method. Note that the signature of the argument list must match the arguments specified. Remember, this is a statically-typed language!

Lists

List.apply()

```
val list = List(1, 2, 3, 4, 5)
```

The same as this "list literal" syntax:

```
val list =
  1 :: 2 :: 3 :: 4 :: 5 :: Nil
```

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We build up a literal list with the "::" cons operator to prepend elements, starting with an empty list, the Nil "object".

Baked into the Grammar?

```
val list =
  1 :: 2 :: 3 :: 4 :: 5 :: Nil
```

No, just method calls!

```
val list = Nil.::(5).::(4).::(
 3).::(2).::(1)
```


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But this isn't something backed into the grammar; we're just making method calls on the List type!

```
val list =
  1 :: 2 :: 3 :: 4 :: 5 :: Nil

val list = Nil.::(5).::(4).::(
 3).::(2).::(1)
```

Method names can contain almost any character.

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There are some restrictions, like square brackets [and], which are reserved for other uses.

```
val list =
   1 :: 2 :: 3 :: 4 :: 5 :: Nil

val list = Nil.::(5).::(4).::(
 3).::(2).::(1)
```

Any method ending in ":" binds to the right!

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"::" binds to the right, so the second form shown is equivalent to the first.

```
val list =
   1 :: 2 :: 3 :: 4 :: 5 :: Nil

val list = Nil.::(5).::(4).::(
 3).::(2).::(1)
```

If a method takes one argument, you can drop the "." and the parentheses, "(" and ")".

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Infix operator notation.

Infix Operator Notation

```
"hello" + "world"
```

is actually just

```
"hello".+("world")
```


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Note the “infix operator notation”; x.m(y) ==> x m y. It’s not just a special case backed into the language grammar (like Java’s special case for string addition). Rather, it’s a general feature of the language you can use for your classes.

Oh, and Maps

```
val map = Map(
   "name" -> "Dean",
   "age"  -> 39)
```


Maps also have a literal syntax, which should look familiar to you Ruby programmers ;) Is this a special case in the language grammar?

Oh, and Maps

```
val map = Map(
  "name" -> "Dean",
  "age"  -> 39)
```

"baked" into the language grammar?

No, just method calls...

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Scala provides mechanisms to define convenient "operators" as methods, without special exceptions baked into the grammer (e.g., strings and "+" in Java).

Oh, and Maps

```
val map = Map(
   "name" -> "Dean",
   "age"  -> 39)
```

What we like to write:

```
val map = Map(
   Tuple2("name", "Dean"),
   Tuple2("age",  39))
```

What Map.apply() actually wants:

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We won't discuss implicit conversions here, due to time....

Oh, and Maps

```
val map = Map(
  "name" -> "Dean",
  "age"  -> 39)
```

What we like to write:

```
val map = Map(
  ("name", "Dean"),
  ("age",  39))
```

What Map.apply() actually wants:

More succinct syntax for Tuples

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We won't discuss implicit conversions here, due to time....

We need to get from this,

```
"name" -> "Dean"
```

to this,

```
Tuple2("name", "Dean")
```

There is no String.-> method!

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We won't discuss implicit conversions here, due to time....

Implicit Conversions

```
class ArrowAssoc[T1](t:T1) {
  def -> [T2](t2:T2) =
    new Tuple2(t1, t2)
}
```

```
implicit def
 toArrowAssoc[T](t:T) =
   new ArrowAssoc(t)
```


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String doesn't have ->, but ArrowAssoc does! Also, it's -> returns a Tuple2. So we need to somehow convert our strings used as keys, i.e., on the left-hand side of the ->, to ArrowAssoc object, then call -> with the value on the right-hand side of the -> in the Map literals, and then we'll get the Tuple2 objects we need for the Map factory method.

The trick is to declare a method (or in some contexts, a value) with the keyword "implicit". The compiler will look for those in scope and then call them to convert the object without the desired method (a string and -> in our case) to an object with the method (ArrowAssoc).

Back to Maps

```
val map = Map(
 "name" -> "Dean",
 "age"  -> 39)
```

toArrowAssoc called for each pair, then ArrowAssoc.-> called

```
val map = Map(
 Tuple2("name", "Dean"),
 Tuple2("age",  39))
```


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We won't discuss implicit conversions here, due to time....

Similar mini-DSLs have been defined for other types.

Also in many third-party libraries.

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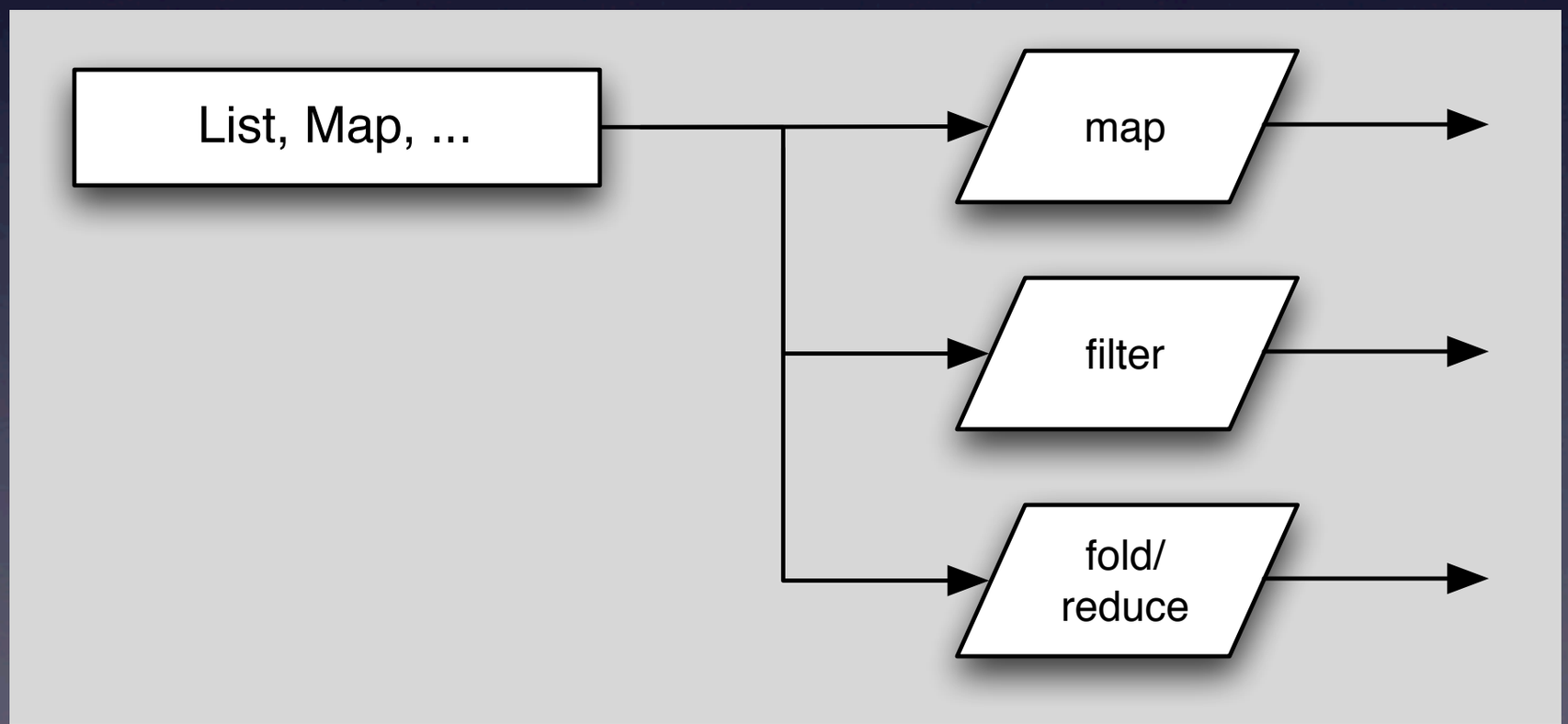
Examples include the built-in Map type hierarchy.

Functions

as

Objects

Classic *Operations* on *"Container"* Types



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Collections like List and Map are containers. So are specialized containers like Option (Scala) or Maybe (Haskell) and other "monads".

```
val list = "a" :: "b" :: Nil

list map {
  s => s.toUpperCase
}

// => "A" :: "B" :: Nil
```


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Let’s map a list of strings with lower-case letters to a corresponding list of uppercase strings.

map called on list (dropping the ".")

argument to map (using "{" vs. "(")

```
list map {
  s => s.toUpperCase
}
```

"function literal"

function argument list

function body

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Note that the function literal is just the "s => s.toUpperCase". The {…} are used like parentheses around the argument to map, so we get a block-like syntax.

```
list map {
   s => s.toUpperCase
}
```

inferred type

```
list map {
   (s:String) => s.toUpperCase
}
```

Explicit type

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We've used type inference, but here's how we could be more explicit about the argument list to the function literal.

So far,
we have used
type inference
a lot...

How the Sausage Is Made

Parameterized type

```
class List[A] {
  …
  def map[B](f: A => B): List[B]
  …
}
```

Declaration of map

The function argument

map's return type

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Here's the declaration of List's map method (lots of details omitted…). Scala uses [...] for parameterized types, so you can use "<" and ">" for method names!
Note that explicitly show the return type from map (List[B]). In our previous examples, we inferred the return type. However, Scala requires types to be specified on all method arguments!

How the Sausage Is Made

like an "abstract" class

"contravariant", "covariant" typing

```
trait Function1[-A,+R] {

  def apply(a:A): R

  ...
}
```

No method body: => abstract

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We look at the actual implementation of Function1 (or any FunctionN). Note that the scaladocs have links to the actual source listings.
(We're omitting some details…) The trait declares an abstract method "apply" (i.e., it doesn't also *define* the method.)
Traits are a special kind of abstract class/interface definition, that promote "mixin composition". (We won't have time to discuss…)

What the Compiler Does

```
(s:String) => s.toUpperCase
```

What you write.

```
new Function1[String,String] {
 def apply(s:String) = {
  s.toUpperCase
 }
}
```

No "return" needed

What the compiler generates

An anonymous class

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You use the function literal syntax and the compiler instantiates an anonymous class using the corresponding FunctionN trait, with a concrete definition of apply provided by your function literal.

Functions as Objects

```
val list = "a" :: "b" :: Nil

list map {
  s => s.toUpperCase
}
```

{…} ok, instead of (…)

Function "object"

```
// => "A" :: "B" :: Nil
```


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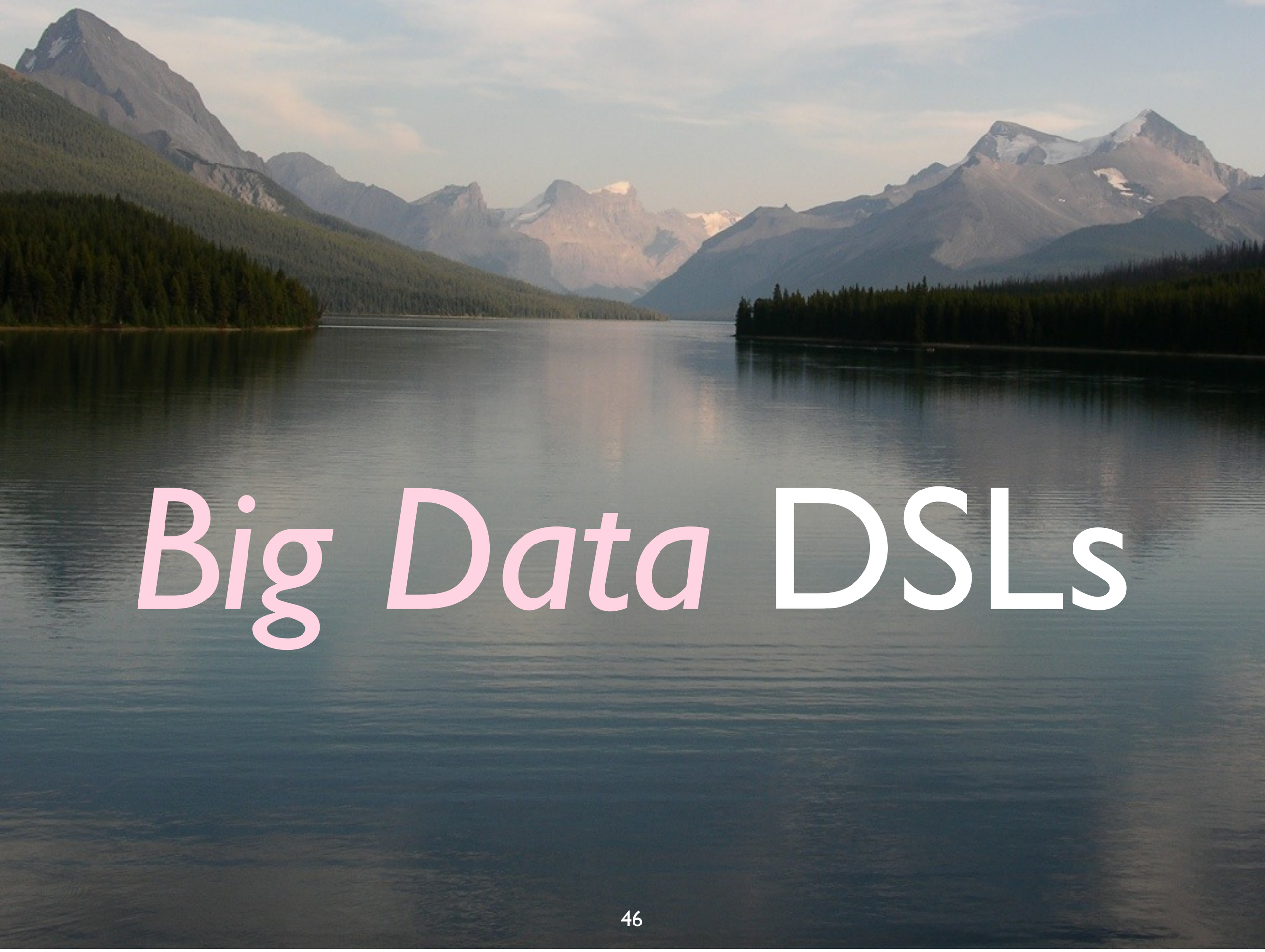
Back to where we started. Note again that we can use "{…}" instead of "(…)" for the argument list (i.e., the single function) to map. Why, to get a nice block-like syntax.



FP is going mainstream because it is the best way to write robust concurrent software. Here's an example...

Scalding: Scala DSL for *Cascading*

- *FP idioms* are a better fit for data than *objects*.
- https://github.com/twitter/scalding
- http://blog.echen.me/2012/02/09/movie-recommendations-and-more-via-mapreduce-and-scalding/

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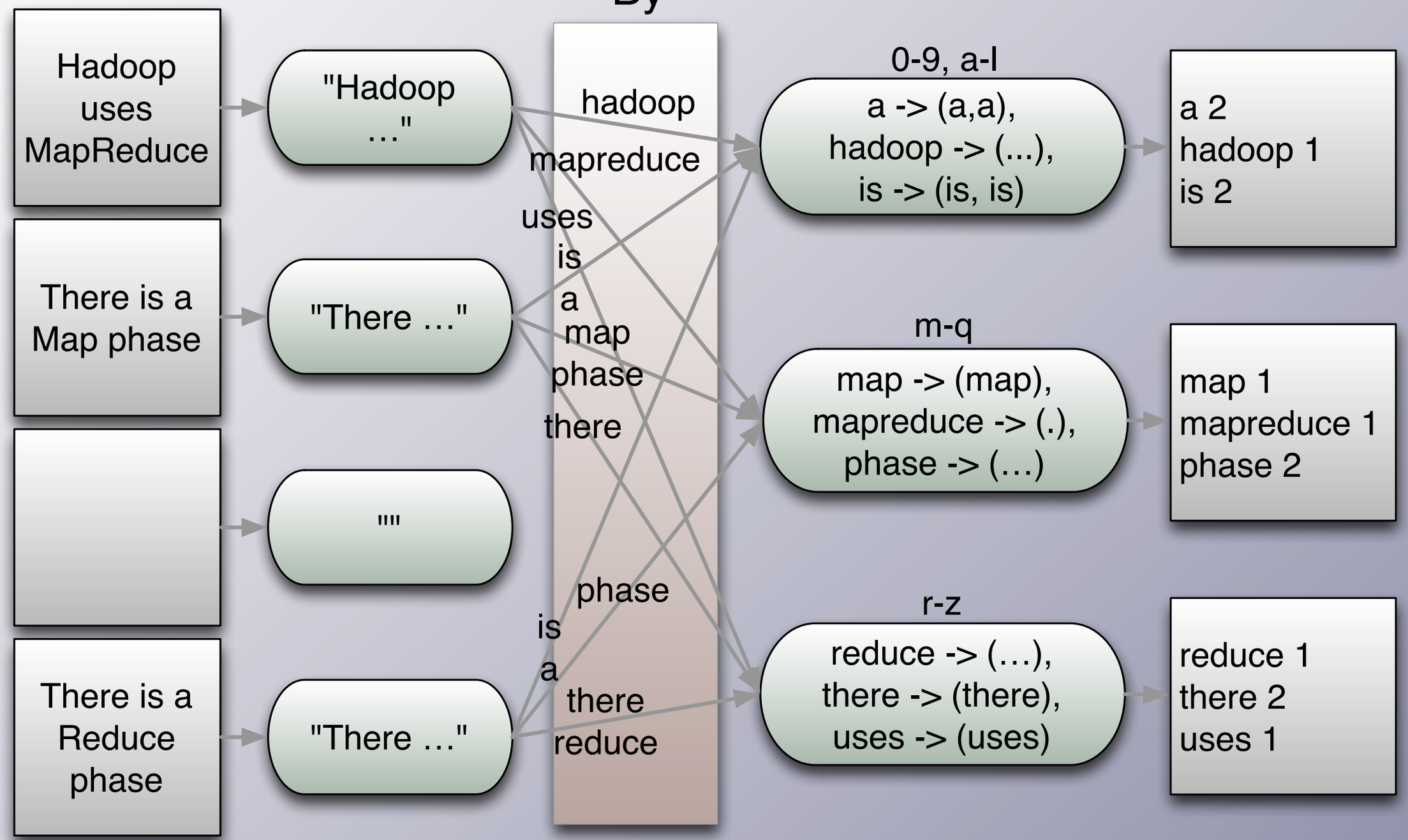
Cascading is a Java toolkit for Hadoop that provides higher-level abstractions like pipes and filters composed into workflows. Using Scala makes it much easier to write concise, focused code.
Scalding is one of many Scala options. See also Scrunch, a Scala DSL for the Java Crunch library, and Spark, a different framework that can work with the Hadoop Distributed File System (HDFS).

Let's look at
the classic
Word Count
algorithm.



Schematic of the Word Count algorithm. Starting with 4 input docs (one of which is empty), tokenize it into words and emit every word found, then group by the words, finally counting them to output the word count to one or more files.

```
class WordCount(args : Args)
 extends Job(args) {
  TextLine(args("input"))
    .read
    .flatMap('line -> 'word) {
     line: String =>
     line.toLowerCase.split("\\s")
    }.groupBy('word) {
     group => group.size
    }.write(Tsv(args("output")))
}
```

```
class WordCount(args : Args)
 extends Job(args) {
   TextLine(args("input"))
     .read
     .flatMap('line -> 'word) {
      line: String =>
      line.toLowerCase.split("\\s")
     }.groupBy('word) {
      group => group.size
     }.write(Tsv(args("output")))
}
```

A workflow "job".

```
class WordCount(args : Args)
 extends Job(args) {
  TextLine(args("input"))
   .read
   .flatMap('line -> 'word) {
    line: String =>
    line.toLowerCase
   }.groupBy('word) {
     group => group.size
   }.write(Tsv(args("output")))
}
```

Read the text file given by the "--input ..." argument.

```
class WordCount(args : Args)
 extends Job(args) {
  TextLine(args("input"))
    .read
    .flatMap('line -> 'word) {
     line: String =>
     line.toLowerCase.split("\\s")
    }.groupBy('word) {
     group => group.s
    }.write(Tsv(args(  output )))
}
```

Tokenize lines into lower-case words.

```
class WordCount(args : Args)
 extends Job(args) {
  TextLine(args("input"))
    .read
    .flatMap('line -> 'word) {
     line: String =>
     line.toLowerCase.split("\\s")
    }.groupBy('word) {
     group => group.size
    }.write(Tsv(args("output")))
}
```

Group by word and count each group size.

```
class WordCount(args : Args)
 extends Job(args) {
  TextLine(args("input"))
    .read
    .flatMap('line -> 'word) {
     line: String =>
     line.toLowerCase.split("\\s")
    }.groupBy('word) {
     group => group.size
    }.write(Tsv(args("output")))
}
```

Write to tab-delim. output.

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FP is going mainstream because it is the best way to write robust concurrent software. Here’s an example...

Avoiding Nulls

```
sealed abstract class Option[+T]
{…}

case class Some[+T](value: T)
  extends Option[T] {…}

case object None
  extends Option[Nothing] {…}
```

An Algebraic Data Type

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I am omitting MANY details. You can't instantiate Option, which is an abstraction for a container/collection with 0 or 1 item. If you have one, it is in a Some, which must be a class, since it has an instance field, the item. However, None, used when there are 0 items, can be a singleton object, because it has no state! Note that type parameter for the parent Option. In the type system, Nothing is a subclass of all other types, so it substitutes for instances of all other types. This combined with a property called covariant subtyping means that you could write "val x: Option[String] = None" and it would type correctly, as None (and Option[Nothing]) is a subtype of Option[String]. Note that Options[+T] is only covariant in T because of the "+" in front of the T.

Also, Option is an algebraic data type, and now you know the scala idiom for defining one.

```
// Java style (schematic)
class Map[K, V] {
 def get(key: K): V = {
  return value || null;
 }}

// Scala style
class Map[K, V] {
 def get(key: K): Option[V] = {
  return Some(value) || None;
 }}
```

Which is the better API?

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Returning Option tells the user that “there may not be a value” and forces proper handling, thereby drastically reducing sloppy code leading to NullPointerExceptions.

In Use:

Literal syntax for map creation

```
val m =
  Map("one" -> 1, "two" -> 2)
…
val n = m.get("four") match {
 case Some(i) => i
 case None    => 0 // default
}
```

Use pattern matching to extract the value (or not)

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Here's idiomatic scala for how to use Options. Our map if of type Map[String,Int]. We match on the Option[V] returned by map.get. If Some(i), we use the integer value I. If there is no value for the key, we use 0 as the default. Note: Option has a short-hand method for this idiom: m.getOrElse("four", 0).

Option Details: sealed

```
sealed abstract class Option[+T]
{…}
```

All children must be defined in the same file

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I am omitting MANY details. You can't instantiate Option, which is an abstraction for a container/collection with 0 or 1 item. If you have one, it is in a Some, which must be a class, since it has an instance field, the item. However, None, used when there are 0 items, can be a singleton object, because it has no state! Note that type parameter for the parent Option. In the type system, Nothing is a subclass of all other types, so it substitutes for instances of all other types. This combined with a proper called covariant subtyping means that you could write "val x: Option[String = None" it would type correctly, as None (and Option[Nothing]) is a subtype of Option[String].

Case Classes

```
case class Some[+T](value: T)
```

- *Provides factory method, pattern matching, equals, toString, etc.*
- *Makes "value" a field without* ***val*** *keyword.*

Object

```
case object None
  extends Option[Nothing] {…}
```

A "singleton". Only one instance will exist.

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The scala runtime controls (lazy) instantiation of the single instance. Since the user can't instantiate the instance, objects can't have constructor argument lists, but they are allowed to define fields inside the class body (i.e., primary - and only - constructor body).

Nothing

```
case object None
  extends Option[Nothing] {…}
```

Special child type of all other types. Used for this special case where no actual instances required.

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None is used when there are 0 items, can be a singleton object, because it has no state! Note that type parameter for the parent Option. In the type system, Nothing is a subclass of all other types, so it substitutes for instances of all other types. This combined with a proper called covariant subtyping means that you could write “val x: Option[String = None” it would type correctly, as None (and Option[Nothing]) is a subtype of Option[String].

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We've seen a lot of syntax. Let's recap a few of the ways Scala keeps your code succinct.

Infix Operator Notation

```
"hello" + "world"
```

same as

```
"hello".+("world")
```


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Syntactic sugar: obj.operation(arg) == obj operation arg

Type *Inference*

```
// Java
HashMap<String,Person> persons =
  new HashMap<String,Person>();
```

vs.

```
// Scala
val persons
  = new HashMap[String,Person]
```


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Java (and to a lesser extent C#) require explicit type “annotations” on all references, method arguments, etc., leading to redundancy and noise.
Note that Scala use [] rather than <>, so you can use “<“ and “>” as method names!

Type *Inference*

```
// Java
HashMap<String,Person> persons =
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```

vs.

```
// Scala
val persons
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```


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Java (and to a lesser extent C#) require explicit type “annotations” on all references, method arguments, etc., leading to redundancy and noise.
Note that Scala use [] rather than <>, so you can use “<“ and “>” as method names!

```scala
// Scala
val persons
 = new HashMap[String,Person]
```

no () needed.
Semicolons inferred.

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Other things aren't needed...

User-defined *Factory* Methods

```
val words =
  List("Scala", "is", "fun!")
```

no new needed.
Can return a subtype!

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Factory methods on the cheap...

```
class Person {
  private String firstName;
  private String lastName;
  private int    age;

  public Person(String firstName, String lastName, int age){
    this.firstName = firstName;
    this.lastName  = lastName;
    this.age       = age;
  }

  public void String getFirstName() {return this.firstName;}
  public void setFirstName(String firstName) {
    this.firstName = firstName;
  }

  public void String getLastName() {return this.lastName;}
  public void setLastName(String lastName) {
    this.lastName = lastName;
  }

  public void int getAge() {return this.age;}
  public void setAge(int age) {
    this.age = age;
  }
}
```

Typical Java

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Typical Java boilerplate for a simple “struct-like” class.
Deliberately too small to read...

```
class Person(
  var firstName: String,
  var lastName: String,
  var age: Int)
```

Typical Scala!

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Scala is much more succinct. It eliminates a lot of boilerplate.

Class body is the "primary" constructor

Parameter list for c'tor

```
class Person(
  var firstName: String,
  var lastName: String,
  var age: Int)
```

Makes the arg a field with accessors

No class body {…}. nothing else needed!

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Scala is much more succinct. It eliminates a lot of boilerplate.

Even Better...

```
case class Person(
    firstName: String,
    lastName: String,
    age: Int)
```

Constructor args are automatically ***vals****, plus other goodies.*

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Case classes also get equals, hashCode, toString, and the “factory” method we’ve mentioned (e.g., for List and Map) that, by default, creates an instance of the type without the “new”. We’ll see more about case classes later.

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Fixes limitations of Java's object model.

We would like to compose *objects* from *mixins*.

Java: What to Do?

```
class Server
 extends Logger { … }
```

"Server is a Logger"?

```
class Server
 implements Logger { … }
```

Logger isn't an interface!

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Made-up example Java type. The "is a" relationship makes no sense, but the Logger we implemented earlier isn't an interface either.

Java's object model

- *Good*
  - Promotes abstractions.
- *Bad*
  - No *composition* through reusable *mixins*.

Chances are, the “logging” and “filtering” behaviors are reusable, yet Java provides no built-in way to “mix-in” reusable implementations. Ad hoc mechanisms must be used.

Traits

Like interfaces with implementations,

One way to compare traits to what you know...

Traits

… or like

abstract classes +

multiple inheritance

(if you prefer).

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… and another way.

Logger as a Mixin:

```
trait Logger {
 val level: Level // abstract

 def log(message: String) = {
  Log4J.log(level, message)
 }
}
```

Traits don't have constructors, but you can still define fields.

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I changed some details compared to our original Logger example. Traits don't have constructor argument lists (for various technical reasons), but we can define fields for them, as shown. Here, I make the field abstract, which means that any class that mixes in the trait will have to define "level".

Logger as a Mixin:

```
trait Logger {
 val level: Level // abstract
  …
}

val server =
  new Server(…) with Logger {
    val level = ERROR
  }
server.log("Internet down!!")
```

mixed in Logging

abstract member defined

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Note that could have declared a type, say “class ServerWithLogger(…) extends Server(...) with Logger {…}, but if you only need one instance, we can just do it “on the fly!” Note that the level is defined as a body for this object, much the same way you define an anonymous inner class and define its abstract members.

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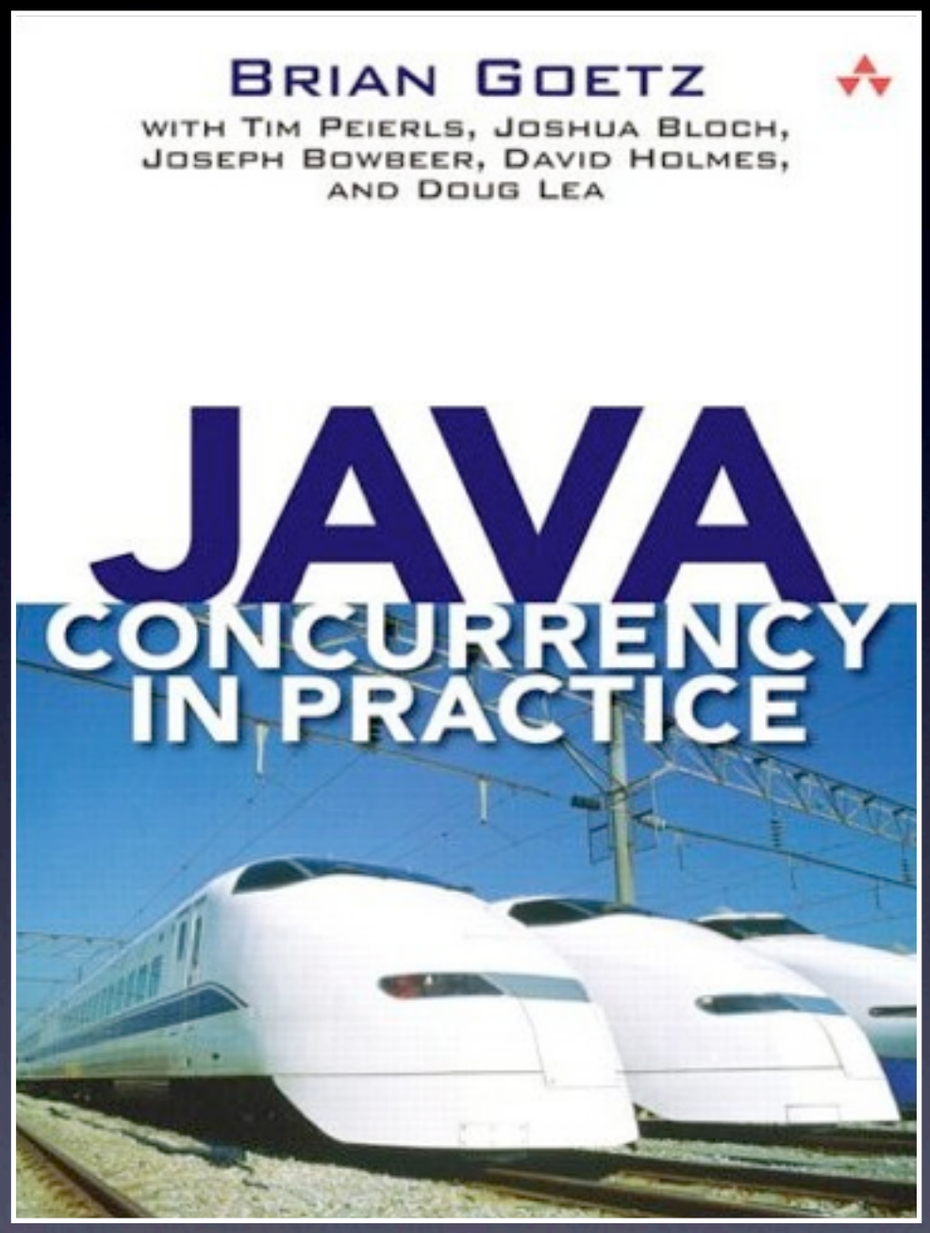
FP is going mainstream because it is the best way to write robust concurrent software. Here's an example…

NOTE: The full source for this example is at https://github.com/deanwampler/Presentations/tree/master/SeductionsOfScala/code-examples/actor.

When you share mutable state...

Hic sunt dracones
(Here be dragons)



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It's very hard to do multithreaded programming robustly. We need higher levels of abstraction, like Actors.

Actor Model

- *Message* passing between autonomous *actors*.
- No *shared* (mutable) *state*.

Actor Model

- First developed in the 70's by Hewitt, Agha, Hoare, *etc.*
- Made "famous" by *Erlang*.
  - Scala's Actors patterned after Erlang's.

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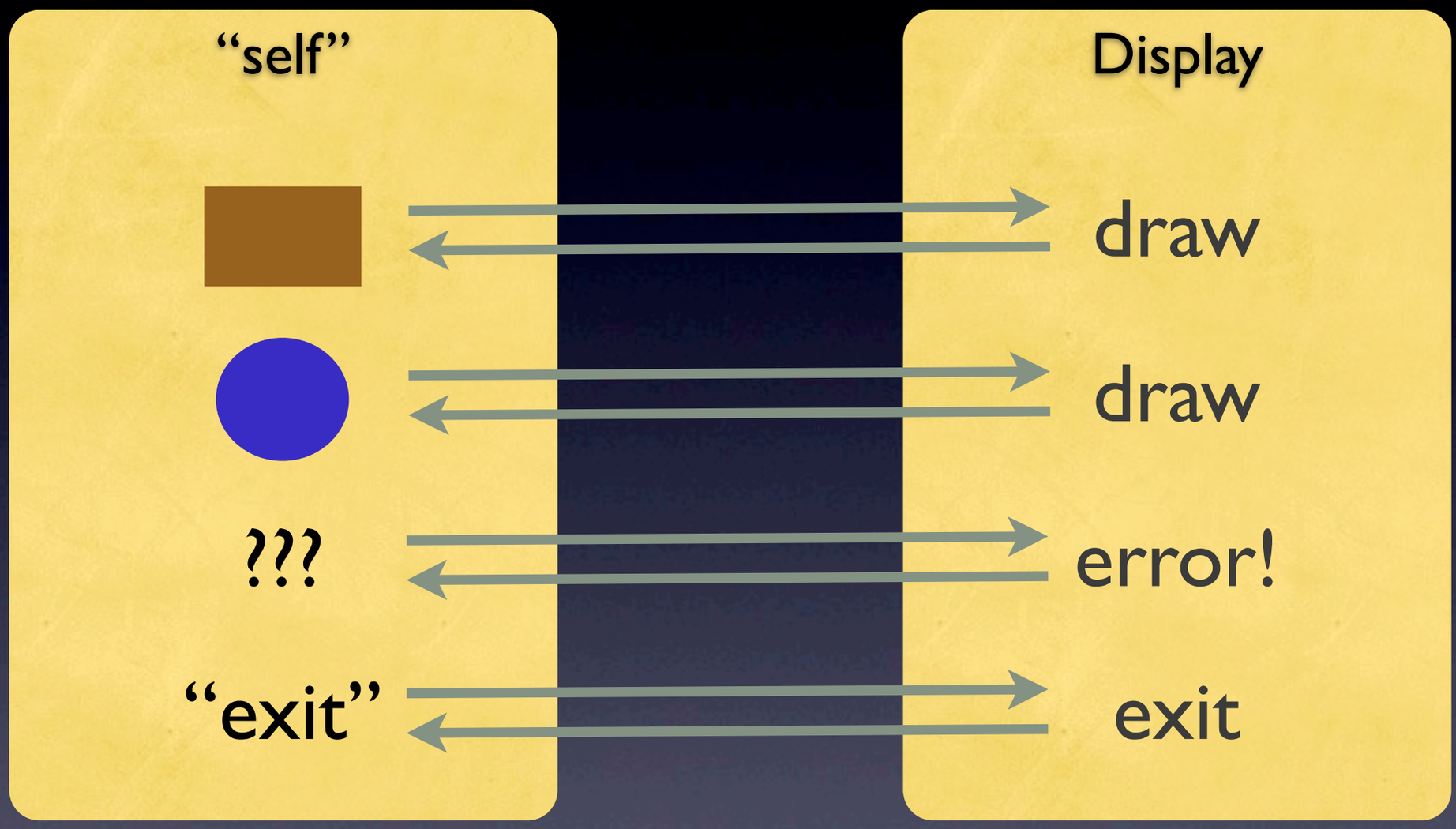
The actor model is not new!!

2 Actors:



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Our example. An actor for drawing geometric shapes and another actor that drives it.

```
package shapes

case class Point(
 x: Double, y: Double)

abstract class Shape {
  def draw()
}
```

abstract "draw" method

Hierarchy of geometric shapes

"Case" classes for 2-dim. points and a hierarchy of shapes. Note the abstract draw method in Shape. The "case" keyword makes the arguments "vals" by default, adds factory, equals, etc. methods. Great for "structural" objects.
(Case classes automatically get generated equals, hashCode, toString, so-called "apply" factory methods - so you don't need "new" - and so-called "unapply" methods used for pattern matching.)

NOTE: The full source for this example is at https://github.com/deanwampler/Presentations/tree/master/SeductionsOfScala/code-examples/actor.

```
case class Circle(
  center:Point, radius:Double)
      extends Shape {
  def draw() = …
}

case class Rectangle(
    ll:Point, h:Double, w:Double)
      extends Shape {
  def draw() = …
}
```

concrete "draw" methods

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Case classes for 2-dim. points and a hierarchy of shapes. Note the abstract draw method in Shape.
For our example, the draw methods will just do "println("drawing: "+this.toString)".

```
package shapes
import akka.actor._

class ShapeDrawingActor
      extends Actor {
  def receive = {
    ...
  }
}
```

Use the "Akka" Actor library

Actor

receive and handle each message

Actor for drawing shapes

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An actor that waits for messages containing shapes to draw. Imagine this is the window manager on your computer. It loops indefinitely, blocking until a new message is received...

Note: This example uses the Akka Frameworks Actor library (see http://akka.io), which I prefer over Scala's native actors.

Receive method

```
receive = {
 case s:Shape =>
    print("-> "); s.draw()
    self.reply("Shape drawn.")
 case "exit" =>
    println("-> exiting...")
    self.reply("good bye!")
 case x =>                    // default
    println("-> Error: " + x)
    self.reply("Unknown: " + x)
}
```

Actor for drawing shapes

“Receive” blocks until a message is received. Then it does a pattern match on the message. In this case, looking for a Shape object, the “exit” message, or an unexpected object, handled with the last case, the default.

```
receive = {
 case s:Shape =>
    print("-> "); s.draw()
    self.reply("Shape draw
 case "exit" =>
    println("-> exiting...")
    self.reply("good bye!")
 case x =>                    // default
    println("-> Error: " + x)
    self.reply("Unknown: " + x)
}
```

pattern matching

Actor for drawing shapes

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Each pattern is tested and the first match “wins”. The messages we expect are a Shape object, the “exit” string or anything else. Hence, the last “case” is a “default” that catches anything, we we treat as an unexpected error.

```
receive = {
  case s:Shape =>
    print("-> "); s.draw()
    self.reply("Shape drawn.")
  case "exit" =>
    println("-> exiting...")
    self.reply("good bye!")
  case x =>                    // default
    println("-> Error: " + x)
    self.reply("Unknown: " + x)
}
```

draw shape & send reply

done

unrecognized message

After handling each message, a reply is sent to the sender, using “self” to get the handle to our actor “nature”.

```
package shapes
import akka.actor._
class ShapeDrawingActor extends Actor {
 receive = {
  case s:Shape =>
    print("-> "); s.draw()
    self.reply("Shape drawn.")
  case "exit" =>
    println("-> exiting...")
    self.reply("good bye!")
  case x =>                  // default
    println("-> Error: " + x)
    self.reply("Unknown: " + x)
 }
}
```

Altogether

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Even compressed on a presentation slide, there isn't a lot of code!

```
import shapes._
import akka.actor._
import akka.actor.Actor

object Driver {
  def main(args:Array[String])={
    val driver = actorOf[Driver]
    driver.start
    driver ! "go!"
  }
}

class Driver …
```

a "singleton" type to hold main

! is the message send "operator"

driver to try it out

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Here's the driver actor. It is declared as an "object" not a class, making it a singleton.
When we start, we send the "go!" message to the Driver actor that is defined on the next slide. This starts the asynchronous message passing.
The "!" is the message send method (stolen from Erlang).

Its "companion" object Driver was on the previous slide.

```
...
class Driver extends Actor {
  val drawer =
    actorOf[ShapeDrawingActor]
  drawer.start
  def receive = {
    ...
  }
}
```

driver to try it out

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Here's the driver actor "companion class" for the object on the previous slide that held main.
Normally, you would not do such synchronous call and response coding, if avoidable, as it defeats the purpose of using actors for concurrency.

```
def receive = {
   case "go!" =>
      drawer ! Circle(Point(…),…)
      drawer ! Rectangle(…)
      drawer ! 3.14159
      drawer ! "exit"
   case "good bye!" =>
      println("<- cleaning up…")
      drawer.stop; self.stop
   case other =>
      println("<- " + other)
}
```

sent by main

sent by drawer

driver to try it out

Sunday, January 20, 13

Here's the driver actor, a scala script (precompilation not required) to drive the drawing actor.
Normally, you would not do such synchronous call and response coding, if avoidable, as it defeats the purpose of using actors for concurrency.

```
case "go!" =>
  drawer ! Circle(Point(…),…)
  drawer ! Rectangle(…)
  drawer ! 3.14159
  drawer ! "exit"

// run Driver.main (see github README.md)
-> drawing: Circle(Point(0.0,0.0),1.0)
-> drawing: Rectangle(Point(0.0,0.0),
2.0,5.0)
-> Error: 3.14159
-> exiting...
<- Shape drawn.
<- Shape drawn.
<- Unknown: 3.14159
<- cleaning up...
```

"<-" and "->" messages may be interleaved!!

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NOTE: The full source for this example is at https://github.com/deanwampler/Presentations/tree/master/SeductionsOfScala/code-examples/actor. See the README.md for instructions.

Note that the -> messages will always be in the same order and the <- will always be in the same order, but the two groups may be interleaved!!

```
…
// ShapeDrawingActor
receive = {
  case s:Shape =>
    s.draw()
    self.reply("…")

  case …

  case …
}
```

Functional-style pattern matching

Object-oriented-style polymorphism

"Switch" statements are not evil!

Sunday, January 20, 13

The power of combining the best features of FP (pattern matching and "destructuring") and OOP (polymorphic behavior).


Recap

Scala is...

a *better* Java,

object-oriented

and

functional,

succinct,

elegant,

and

powerful.

Questions?

Dean Wampler
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polyglotprogramming.com/talks

April 16, 2012

Sunday, January 20, 13

The online version contains more material. You can also find this talk and the code used for many of the examples at github.com/deanwampler/Presentations/tree/master/SeductionsOfScala.


Extra Slides


Modifying
Existing
Behavior
with Traits

Example

```
trait Queue[T] {
  def get(): T
  def put(t: T)
}
```

A pure abstraction (in this case...)

Sunday, January 20, 13

A very simple abstraction for a Queue.

Log put

```
trait QueueLogging[T]
 extends Queue[T] {
  abstract override def put(
    t: T) = {
   println("put("+t+")")
   super.put(t)
  }
}
```


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(We're ignoring "get"…) "Super" is not yet bound, because the "super.put(t)" so far could only call the abstract method in Logging, which is not allowed. Therefore, "super" will be bound "later", as we'll so. So, this method is STILL abstract and it's going to override a concrete "put" "real soon now".

Log put

```
trait QueueLogging[T]
  extends Queue[T] {
  abstract override def put(
      t: T) = {
    println("put("+t+")")
    super.put(t)
  }
}
```

What is "super" bound to??

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(We're ignoring "get"…) "Super" is not yet bound, because the "super.put(t)" so far could only call the abstract method in Logging, which is not allowed. Therefore, "super" will be bound "later", as we'll so. So, this method is STILL abstract and it's going to override a concrete "put" "real soon now".

```
class StandardQueue[T]
          extends Queue[T] {
  import ...ArrayBuffer
  private val ab =
        new ArrayBuffer[T]
  def put(t: T) = ab += t
  def get() = ab.remove(0)
  ...
}
```

Concrete (boring) implementation

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Our concrete class. We import scala.collection.mutable.ArrayBuffer wherever we want, in this case, right were it's used. This is boring; it's just a vehicle for the cool traits stuff...

```
val sq = new StandardQueue[Int]
       with QueueLogging[Int]

sq.put(10)              // #1
println(sq.get())       // #2
// => put(10)           (on #1)
// => 10                (on #2)
```

Example use

Sunday, January 20, 13

We instantiate StandardQueue AND mixin the trait. We could also declare a class that mixes in the trait.
The “put(10)” output comes from QueueLogging.put. So “super” is StandardQueue.

Mixin composition; no class required

```
val sq = new StandardQueue[Int]
         with QueueLogging[Int]

sq.put(10)              // #1
println(sq.get())       // #2

// => put(10)           (on #1)
// => 10                (on #2)
```

Example use

Sunday, January 20, 13

We instantiate StandardQueue AND mixin the trait. We could also declare a class that mixes in the trait.
The “put(10)” output comes from QueueLogging.put. So “super” is StandardQueue.

Like Aspect-Oriented Programming?

Traits give us *advice*, but not a *join point* *“query” language.*

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If you know AspectJ or Spring AOP, traits make it easy to implement “advice”, but there is no join point language for querying over the set of all possible join points, like a real AOP framework provides.

Traits are a powerful *composition* mechanism!

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Not shown, nesting of traits...


Functional
Programming

What is *Functional Programming*?

Don't we already write "functions"?

$$y = \sin(x)$$

Based on *Mathematics*

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"Functional Programming" is based on the behavior of mathematical functions and variables.

$$y = \sin(x)$$

Setting *x* fixes *y*

∴ *variables* are *immutable*

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"Functional Programming" is based on the behavior of mathematical functions.
"Variables" are actually immutable values.

20 += 1 ??

We never *modify*

the 20 "object"

Concurrency

No *mutable state*

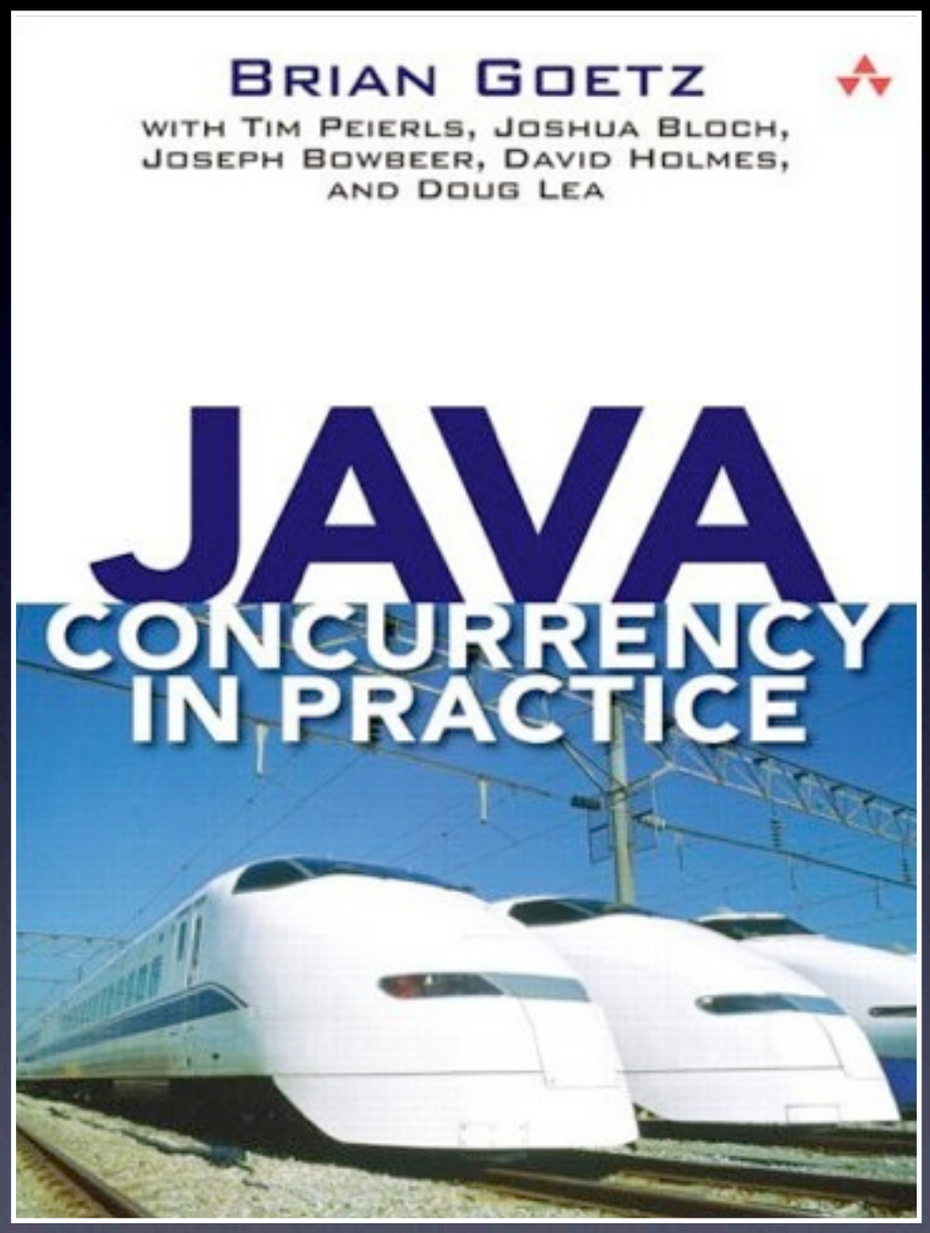
∴ *nothing* to *synchronize*

Sunday, January 20, 13

FP is breaking out of the academic world, because it offers a better way to approach concurrency, which is becoming ubiquitous.

When you share mutable state...

Hic sunt dracones
(Here be dragons)



$y = \sin(x)$

Functions don't

change state

$\therefore$ *side-effect* free

Sunday, January 20, 13

A math function doesn't change any "object" or global state. All the work it does is returned by the function. This property is called "referential transparency".

Side-effect free functions

- Easy to *reason* about *behavior*.
- Easy to invoke *concurrently*.
- Easy to invoke *anywhere*.
- Encourage *immutable* objects.

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side-effect free functions are far less likely to introduce subtle integration bugs, especially in concurrent systems. By encouraging immutable objects (e.g., when methods return new objects, rather than modify existing ones), that improves concurrency robustness.

$$\tan(\Theta) = \sin(\Theta)/\cos(\Theta)$$

Compose functions of other functions

$\therefore$ *first-class citizens*

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Function are “first-class citizens”; you can assign them to variables and pass them to other (higher-order) functions, giving you composable behavior.


Even More
Functional
Hotness

For "Comprehensions"

```
val l = List(
 Some("a"), None, Some("b"),
 None, Some("c"))

for (Some(s) <- l) yield s
// List(a, b, c)
```

No "if" statement

Pattern match; only take elements of "l" that are Somes.

Sunday, January 20, 13

We're using the type system and pattern matching built into case classes to discriminate elements in the list. No conditional statements required.
This is just the tip of the iceberg of what "for comprehensions" can do and not only with Options, but other containers, too.