The Scala programming ecosystem

Leveraging functional, OO, libraries and frameworks

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Scala - The Good

The Scala Programming Language

- Martin Odersky, EPFL, Switzerland
  - Worked on javac (1.3)
  - Java Generics
- Lightbend (formerly Typesafe)
- Multi-paradigm language
  - Functional and Object-Oriented
- Statically typed
- Scalable language - script to large program
- Stretch your mind - functions and immutability

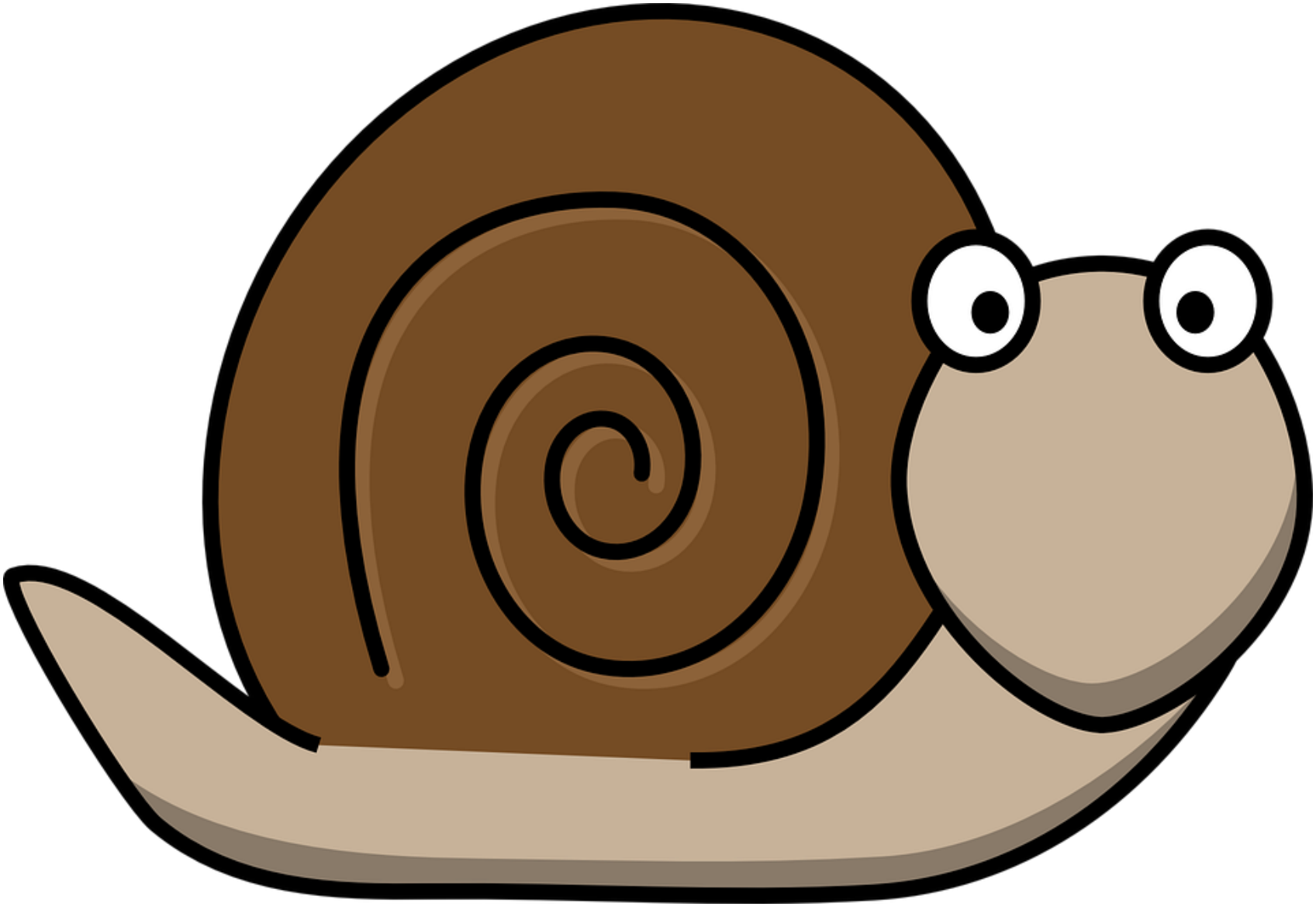
Sca(lable) la(nguage)

- Apache Kafka (LinkedIn)
- Apache Spark (Databricks)
- Finagle (Twitter)
- Akka (Lightbend)
- Lucid Software - scala.js presentation
- Play Web Framework
  - Lichess Online Chess
- Lightbend customers: Walmart, Verizon, Twitter, LinkedIn, Coursera, The Guardian, Airbnb...

Scala to Java bytecode

- Leverage Java Virtual Machine (JVM)
  - Over 20 years of optimizations
  - Java Interpreter and Just-in-time (JIT) compilers
  - Portability and Security
  - Ever-evolving garbage collectors
- Full interoperability with Java and Java libraries

Exploration - Scala Shell and Worksheet



Scala Tour

- Conciseness
- Mixed Paradigms
  - Object Oriented
  - Functional
- Options, Collections
- Functional Pattern Matching
- Implicits
- Spark

Vals and vars but no semicolons

```
val helloWorld = "Hello, Scala World!"

//vals are immutable
//helloWorld2 = "this is a different string"

val names = List("Markus", "Joe", "Jane")

//vars are mutable
var allHellos = ""

names.foreach(name =>
    allHellos += s"Hello, ${name}! ")

println(allHellos)
> Hello, Markus! Hello, Joe! Hello, Jane!
```

Defining a function, higher-order functions

```
def hasAtLeastThreeLetters(input: String): Boolean = {
    if ((input != null) && (!input.isEmpty)) {
        val letters = input.filter(c => c.isLetter)
        letters.size >= 3
    } else {
      false
    }
}
```

Calling a function - syntactic sugar

```
val testInputs = List(null, "", "lower", "Upper")

testInputs.map((input: String) =>
    hasAtLeastThreeLetters(input))

testInputs.map((input) =>
        hasAtLeastThreeLetters(input))

testInputs.map(input => hasAtLeastThreeLetters(input))

testInputs.map(hasAtLeastThreeLetters(_))

testInputs.map(hasAtLeastThreeLetters)
> res0: List[Boolean] = List(false, false, true, true)
```

Assigning functions/function literals to variables

```
val vowels = List('a','e','i','o','u')

val threeLs: String => Boolean = hasAtLeastThreeLetters

threeLs("abcd")
> res1: Boolean = true

val removeVowels: (String) => String = { (str) =>
    str.filter(c => !vowels.contains(c))
}

val removeNonLetters: String => String = { str =>
    str.filter(c => c.isLetter)
}

removeVowels("wabbit")
> res2: String = wbbt
```

Everything's an object, more syntactic sugar, == equality

```
3 * 10

3.*(10)

1 to 10
1.to(10)
> res2: scala.collection.immutable.Range.Inclusive =
 Range(1, 2, 3, 4, 5, 6, 7, 8, 9, 10)

val foo = "foo"
val bar = new String("foo")

foo == bar
```

Built-in tuples

```
val tuple = ("hello", 42)

val tuple2: (String, Int) = ("hello", 42)

val tuple3: Tuple2[String, Int] = ("hello", 42)

val triple = ("123-22-2111", "Joe", "443.998.8899")

tuple._1
tuple._2

val (word, count) = tuple
> word: String = hello
> count: Int = 5
```

Options - no more NullPointerExceptions!

```
val portOpt: Option[Int] = Some(5123)
val port2Opt: Option[Int] = None
portOpt.get
> res0: Int = 5123

port2Opt.get -
> java.util.NoSuchElementException: None.get

port2Opt.getOrElse(3306)
> res1: Int = 3306

portOpt.foreach(port => println(s"opening port ${port}"))
> res2: Unit = ()

Option(null)
> res3: Option[Null] = None
```

Collections - Arrays (with syntactic sugar)

```
val a : Array[Int] = Array(1,3,7,9)
//val b = Array.apply(1,3,7,9)

a(0)
//b.apply(0)

a(0) = 5
//b.update(0, 5)

a.mkString(",")
> res1: String = 5,3,7,9
```

Collections - Lists

```
val ws = List("When", "shall", "we", "three")

val ws2 = "When" :: "shall" :: Nil

val longWords = ws.filter(s => s.length > 4)

val lowers = ws.map(_.toLowerCase)

lowers.flatMap(_.permutations)
> res3: List[String] = List(when, whne, wehn...

//how many letters in our list?
val lengths = ws.map(_.length)
lengths.reduce(_ + _)
lengths.sum
```

Collections - Maps 1

```
var transMap = Map("when" -> "wann",
    "shall" -> "sollen", "we" -> "wir")

val entryTuple1 = ("three" -> "drei")
val entryTuple2 = ("meet", "treffen")

transMap = transMap + entryTuple1
transMap = transMap + entryTuple2

transMap("when")
//transMap("who") //java.util.NoSuchElementException

transMap.get("when")
> res10: Option[String] = Some(wann)

transMap.get("who")
res11: Option[String] = None
```

Collections - Maps 1

```
val whenGerman = if (transMap.contains("when")) {
    transMap("when")
} else {
    "unbekannt"
}

val whenGerman2 = transMap.getOrElse("when", "unbekannt")

val transMap2 = transMap.withDefaultValue("unbekannt")

transMap2("when")
> res12: String = wann

transMap2("who")
> res13: String = unbekannt
```

Collections - higher-order functions

```
val wordLengthTuples = ws.map(s => (s, s.length))

val lengthMap =
   wordLengthTuples.groupBy { case (word, length) =>
      length }
> lengthMap: immutable.Map[Int,List[(String, Int)]]

lengthMap(5)
>res14: List[(String, Int)] = List((shall,5), (three,5))
```

For Comprehensions, yield, guards

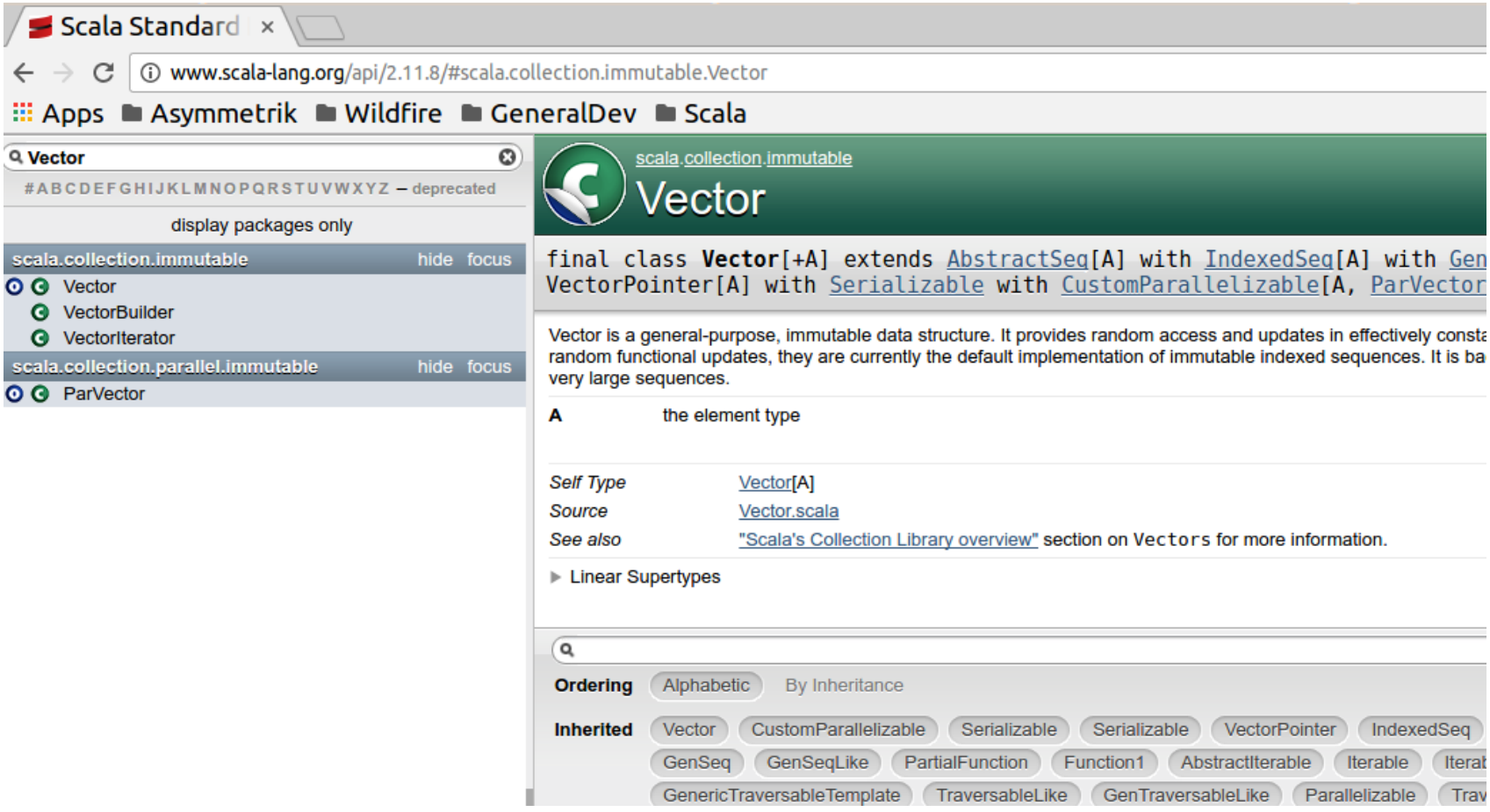
```
val input = "afed-123-ghi-45-67"

//if we did not have RichChar.isDigit...
def isDigit(c : Char): Boolean = {
    ('0' to '9').contains(c)
}

var digits = ""
for (c <- input) {
    if (isDigit(c)) digits += c
}
digits
> res1: String = 1234567

val digits2 = for(c <- input if isDigit(c)) yield c
> digits2: String = 1234567
```

Scala Docs


Scala Standard
www.scala-lang.org/api/2.11.8/#scala.collection.immutable.Vector
Apps
Asymmetrik
Wildfire
GeneralDev
Scala
Vector
#ABCDEFGHIJKLMNOPQRSTUVWXYZ – deprecated
display packages only
scala.collection.immutable hide focus
Vector
VectorBuilder
VectorIterator
scala.collection.parallel.immutable hide focus
ParVector
scala.collection.immutable
Vector
final class Vector[+A] extends AbstractSeq[A] with IndexedSeq[A] with Gen
VectorPointer[A] with Serializable with CustomParallelizable[A, ParVector
Vector is a general-purpose, immutable data structure. It provides random access and updates in effectively consta
random functional updates, they are currently the default implementation of immutable indexed sequences. It is ba
very large sequences.
A the element type
Self Type Vector[A]
Source Vector.scala
See also "Scala's Collection Library overview" section on Vectors for more information.
Linear Supertypes
Ordering Alphabetic By Inheritance
Inherited Vector CustomParallelizable Serializable Serializable VectorPointer IndexedSeq
GenSeq GenSeqLike PartialFunction Function1 AbstractIterable Iterable
GenericTraversableTemplate TraversableLike GenTraversableLike Parallelizable

Multiline strings and interpolations

```
val multi = """It was the best of times,
            |it was the worst of times""".stripMargin

val d = 100
val s = f"${d}%05d"
> s: String = 00100
```

Functional Pattern Matching - constant, type & variable

```
val result: Long = myObj match {
    case 1234 => {
        println("Constant pattern 1234")
        1234
    }
    case i: Int => {
        println(s"Typed pattern int: ${i}")
        i
    }
    case d: Double => {
        println(s"Typed pattern Double: ${d}")
        math.round(d)
    }
    case default => //or wildcard _ (can't reference)
        println(s"Variable pattern: ${default.getClass}")
        0
}
```

Functional Pattern Matching - sequence patterns

```
l match {
    case List(1, x, y) => {
        println(s"1, then ${x}, ${y}")
    }
    case List(1, x, _*) => {
        println(s"second element ${x}")
    }
    case 1 :: x :: xs => {
        println(s"head 1, ${x} and tail ${xs}")
    }
    case x :: xs => {
        println(s"Head ${x}, tail ${xs}")
    }
    case Nil => println("List was empty")
}
```

Regex Pattern

```
val HostPortRegex =
    """http://([\w.]+):(\d+)""".r

val url = "http://es.host.com:9200"
val HostPortRegex(host,port) = url

val hostPortOpt = url match {
    case HostPortRegex(host, port) =>
        Some((host, port.toInt))
    case _ => None
}
```

Classes

```
class Person(var name: String) {
    if (name.isEmpty) throw new
            IllegalArgumentException("Empty name")
}

val p1 = new Person("John Doe")

p1.name
> res1: String = John Doe

p1.name = "Joe Doe"
```

Class inheritance

```
class Employee(name: String,
               val id: String = "009")
    extends Person(name)

val e1 = new Employee("Jennifer Huston")

e1.name
e1.id
```

Traits

```
trait Audit {
    var auditLevel = "low"
    def audit(action: String): Unit = {
        val user = getUser()
        val message = getLogMessage(user, action)
        writeAudit(message)
    }

    def writeAudit(message: String): Unit

    def getUser(): String = {
        "alice"
    }
    def getLogMessage(user: String,
                      action: String): String = {
        s"${user} - ${action}"
    }
}
```

LogAudit Trait

```
trait LogAudit extends Audit {

    var logFile = "/var/log/audit"

    override def writeAudit(message: String): Unit = {
        //use log4j or Files to append to logFile
        println(message)
    }

    override def getLogMessage(user: String,
                               action: String): String = {
        val basicMessage =
           super.getLogMessage(action, user)
        s"${basicMessage} to ${logFile}"
    }
}
```

CloudAudit Trait

```
trait CloudAudit extends Audit {
    var remoteHost = "host1:2121"

    override def writeAudit(message: String): Unit = {
        //write to remote host
        println(message)
    }

    override def getLogMessage(action: String,
                               user: String): String = {
        val basicMessage =
           super.getLogMessage(action, user)
        s"${basicMessage} to ${remoteHost}"
    }
}
```

Audited Service class

```
abstract class MyService extends Audit {
    def execute(): Unit = {
        audit("MyService.execute")
        //execute...
    }
}
```

Mixins

```
val myService0 = new MyService with LogAudit
myService0.execute()
> MyService.execute - alice to /var/log/audit

val myService1 =
   new MyService with LogAudit with CloudAudit
myService1.execute()
> MyService.execute - alice to /var/log/audit to host1

val myService2 =
   new MyService with CloudAudit with LogAudit
myService2.execute()
> MyService.execute - alice to host1 to /var/log/audit
```

Case Classes

```
case class Person(name: String, age: Int)

val p1 = Person("John Doe", 42)

p1.name //val
p1.age

val p2 = Person("Jane Doe", 39)
val p3 = Person("Jane Doe", 39)

val areTheyEqual = p2 == p3
> areTheyEqual: Boolean = true
```

Constructor pattern with pattern guard

```
val people: List[Person] =
    List(p1,p2,p3)

val (youngerPeople, youngPeople) =
    people.partition { person =>
    person match {
        case Person(_, age) if age < 40 => true
        case _ => false
    }
}

val Person(name, age) = p3
```

Scala in the small - scripting

```
import scala.sys.process._
import scala.sys.env
import scala.sys.props
import scala.language.postfixOps

val externalCommand = "tokenGenerator"

//run command and get its status code
s"chmod +x ${externalCommand}"!

//run command and get its output
val myToken = s"./${externalCommand}"!!

env("PATH")
> res2: String = /usr/local/bin:/usr/sbin:...
props("user.name")
> res3: String = medale
```

Import Aliasing, Java Interoperability

```
import scala.collection._
import scala.collection.JavaConverters._
import java.util.ArrayList
import java.util.{List => JavaList}

val myJavaList = new ArrayList[String]()
myJavaList.add("hello")
myJavaList.add("world")

val buffer: mutable.Buffer[String] = myJavaList.asScala
val myScalaList: List[String] = buffer.toList

val capStrings = myScalaList.map { str =>
    str.capitalize
}

val javaCapStrings: JavaList[String] = capStrings.asJava
> javaCapStrings: java.util.List[String] = [Hello, World]
```

Implicits - Predef - StringOps

```
"abcdef".diff("abef")
> res0: String = cd

"abc".permutations.toList
> res1: List[String] = List(abc, acb, bac, bca, cab, cba)

"bi-grams".sliding(2).toList
> res2: List[String] = List(bi, i-, -g, gr, ra, am, ms)

"No earth without art".slice(4,7)
> res3: String = art

From: Predef
implicit def augmentString(x: String): StringOps
   = new StringOps(x)
```

Writing your own Implicit - Map with getOpt

```
import java.util.{Map => JavaMap}
import java.util.HashMap
import scala.language.implicitConversions

val map = new HashMap[String,String]()
map.put("foo","bar")

map.get("baz")
> res5: String = null
```

Implicit: Augmenting Map with getOpt

```
class JavaMapOps[K,V](map: JavaMap[K,V]) {
    def getOpt(key: K): Option[V] = {
        if (map.containsKey(key)) {
            Some(map.get(key))
        } else {
            None
        }
    }
}
implicit def augmentJavaMap[K,V](map: JavaMap[K,V]):
  JavaMapOps[K,V] = {
    new JavaMapOps(map)
}
map.getOpt("foo")
> res5: Option[String] = Some(bar)
fooMap.getOpt("baz")
> res6: Option[String] = None
```

Scala in action - Spark big data processing

```
val spark = SparkSession.builder()
    .master("local")
    .appName("combined-age")
    .getOrCreate()
import spark.implicits._
val peopleDs = spark.createDataset(people)
val youngerDs = peopleDs.filter(p => p.age < 40)

val resultRows = peopleDs.
  groupBy($"name").
  avg("age").collect()

resultRows.foreach { row =>
  println(s"Name: ${row.get(0)} Avg. age: ${row.get(1)}")
}
> Name: John Avg. age: 30.0
> Name: Jane Avg. age: 25.0
```

Learn by doing - Scala exercises

- See scalatour_exercises and scalatour_solutions

Resources

- Coursera/EPFL Functional Programming in Scala Specialization
- Horstmann, Scala for the Impatient Video
- Odersky et al., Programming in Scala, 3rd Edition
- Payne, Wampler, Programming Scala, 2nd Edition
- Alexander, Scala Cookbook
- Chiusano, Bjarnason, Functional Programming in Scala
- Twitter Scala School