A Crash Course in Scala

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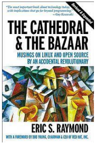
Scala

- Scala: scalable language
- A blend of object-oriented and functional programming.
- Runs on the Java Virtual Machine.
- Designed by Martin Odersky at EPFL.

Cathedral vs. Bazaar

- Two metaphors for software development (Eric S. Raymond)



"The most important book about technology today, with implications that go far beyond programming." —Guy Kawasaki

Revised & Expanded

THE CATHEDRAL & THE BAZAAR

MUSINGS ON LINUX AND OPEN SOURCE BY AN ACCIDENTAL REVOLUTIONARY

ERIC S. RAYMOND

WITH A FOREWORD BY BOB YOUNG, CHAIRMAN & CEO OF RED HAT, INC.

Cathedral vs. Bazaar

- The cathedral
  - A near-perfect building that takes a long time to build.
  - Once built, it stays unchanged for a long time.
- The bazaar
  - Adapted and extended each day by the people working in it.
  - Open-source software development.

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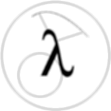
Scala is much more like a bazaar than a cathedral!

Functional Programming (FP)

- In a restricted sense: programming without mutable variables, assignments, loops, and other imperative control structures.
- In a wider sense: focusing on the functions.



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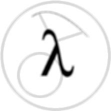

- Functions can be values that are produced, consumed, and composed.

FP Languages (1/2)

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- In a restricted sense: a language that does not have mutable variables, assignments, or imperative control structures.

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- Functions are first-class citizens:
  - Defined anywhere (including inside other functions).
  - Passed as parameters to functions and returned as results.
  - Operators to compose functions.

FP Languages (2/2)

- In the restricted sense:
  - Pure Lisp, XSLT, XPath, XQuery, Erlang
- In the wider sense:
  - Lisp, Scheme, Racket, Clojure, SML, Ocaml, Haskell (full language), Scala, Smalltalk, Ruby

HELLO
WORLD!

The “Hello, world!” Program

```scala
object HelloWorld {
  def main(args: Array[String]) {
    println("Hello, world!")
  }
}
```

Run It Interactively!

```
> scala
This is a Scala shell.
Type in expressions to have them evaluated.
Type :help for more information.

scala> object HelloWorld {
    |   def main(args: Array[String]) {
    |     println("Hello, world!")
    |   }
    | }
defined module HelloWorld

scala> HelloWorld.main(null)
Hello, world!

scala>:q
>
```

Compile and Execute It!

```
// Compile it!
> scalac HelloWorld.scala
> scalac -d classes HelloWorld.scala

// Execute it!
> scala HelloWorld
> scala -cp classes HelloWorld
```

Script It!

```
# script.sh
#!/bin/bash
exec scala $0 $@
!#

object HelloWorld {
  def main(args: Array[String]) {
    println("Hello, world!")
  }
}

HelloWorld.main(null)

# Execute it!
> ./script.sh
```

Outline

- Scala basics
- Functions
- Collections
- Classes and objects
- SBT

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Scala Variables

- Values: immutable
- Variables: mutable

```scala
var myVar: Int = 0
val myVal: Int = 1

// Scala figures out the type of variables based on the assigned values
var myVar = 0
val myVal = 1

// If the initial values are not assigned, it cannot figure out the type
var myVar: Int
val myVal: Int
```

Scala Data Types

- Boolean: true or false
- Byte: 8 bit signed value
- Short: 16 bit signed value
- Char: 16 bit unsigned Unicode character
- Int: 32 bit signed value
- Long: 64 bit signed value
- Float: 32 bit IEEE 754 single-precision float
- Double: 64 bit IEEE 754 double-precision float
- String: A sequence of characters

```
var myInt: Int
var myString: String
```

If ... Else

```
var x = 30;

if (x == 10) {
  println("Value of X is 10");
} else if (x == 20) {
  println("Value of X is 20");
} else {
  println("This is else statement");
}
```

Loops (1/3)

```scala
var a = 10

// do-while
do {
  println("Value of a: " + a)
  a = a + 1
} while(a < 20)

// while loop execution
while(a < 20) {
  println("Value of a: " + a)
  a = a + 1
}
```

Loops (2/3)

```
var a = 0
var b = 0

for (a <- 1 to 3; b <- 1 until 3) {
  println("Value of a: " + a + ", b: " + b )
}

Value of a: 1, b: 1
Value of a: 1, b: 2
Value of a: 2, b: 1
Value of a: 2, b: 2
Value of a: 3, b: 1
Value of a: 3, b: 2
```

Loops (3/3)

```
// loop with collections
val numList = List(1, 2, 3, 4, 5, 6)
for (a <- numList) {
  println("Value of a: " + a)
}

// for loop with multiple filters
for (a <- numList if a != 3; if a < 5) {
  println("Value of a: " + a)
}

// for loop with a yield
// store return values from a for loop in a variable
var retVal = for(a <- numList if a != 3; if a < 6) yield a
println(retVal)
```

Exception Handling

```scala
import java.io.FileReader
import java.io.FileNotFoundException
import java.io.IOException

object Test {
  def main(args: Array[String]) {
    try {
      val f = new FileReader("input.txt")
    } catch {
      case ex: FileNotFoundException => { println("Missing file exception") }
      case ex: IOException => { println("IO Exception") }
    } finally {
      println("Exiting finally...")
    }
  }
}
```

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Functions - Definition

```scala
def functionName([list of parameters]): [return type] = {
  function body
  return [expr]
}

def addInt(a: Int, b: Int): Int = {
  var sum: Int = 0
  sum = a + b
  sum
}

println("Returned Value: " + addInt(5, 7))
```

Functions - Default Parameter Values

```
def addInt(a: Int = 5, b: Int = 7): Int = {
  var sum: Int = 0
  sum = a + b
  return sum
}

println("Returned Value :" + addInt())
```

Functions - Variable Arguments

```
def printStrings(args: String*) = {
  var i : Int = 0;
  for (arg <- args) {
    println("Arg value[" + i + "] = " + arg )
    i = i + 1;
  }
}

printStrings("SICS", "Scala", "BigData")
```

Functions - Nested Functions

```
def factorial(i: Int): Int = {
  def fact(i: Int, accumulator: Int): Int = {
    if (i <= 1)
      accumulator
    else
      fact(i - 1, i * accumulator)
  }

  fact(i, 1)
}

println(factorial(5))
```

Functions - Anonymous Functions

- Lightweight syntax for defining anonymous functions.

```scala
var inc = (x: Int) => x + 1
var x = inc(7) - 1

var mul = (x: Int, y: Int) => x * y
println(mul(3, 4))

var userDir = () => { System.getProperty("user.dir") }
println(userDir())
```

Functions - Higher-Order Functions

```scala
def apply(f: Int => String, v: Int) = f(v)

def layout[A](x: A) = "[" + x.toString() + "]"

println(apply(layout, 10))
```

Functions - Call-by-Value

- Call-by-Value: the value of the parameter is determined before it is passed to the function.

```
def time() = {
  println("Getting time in nano seconds")
  System.nanoTime
}

def delayed(t: Long) {
  println("In delayed method")
  println("Param: " + t)
}

delayed(time())

Getting time in nano seconds
In delayed method
Param: 2532847321861830
```

Functions - Call-by-Name

- Call-by-Name: the value of the parameter is not determined until it is called within the function.

```
def time() = {
  println("Getting time in nano seconds")
  System.nanoTime
}

def delayed2(t: => Long) {
  println("In delayed method")
  println("Param: " + t)
}

delayed2(time())

In delayed method
Getting time in nano seconds
Param: 2532875587194574
```

Functions - Partial Applied

- If you do not pass in arguments for all of the parameters.

```
def adder(m: Int, n: Int, p: Int) = m + n + p

val add2 = adder(2, _: Int, _: Int)

add2(3, 5)
```

Functions - Currying (1/2)

- Transforms a function with multiple arguments into a chain of functions, each accepting a single argument and returning another function.

- For example transforms `f(x, y, z) // (int,int,int) -> int` to `g(x)(y)(z) // int -> (int -> (int -> int))`, in which `g(x)` returns another function, `h(y)` that takes an argument and returns `k(z)`.

- Used to partially apply a function to some value while leaving other values undecided,

Functions - Currying (2/2)

```
def adder(m: Int)(n: Int)(p: Int) = m + n + p
adder: (m: Int)(n: Int)(p: Int)Int

// The above definition does not return a curried function yet
// (adder: (m: Int)(n: Int)(p: Int)Int)
// To obtain a curried version we still need to transform the method.
// into a function value.

val currAdder = adder _
currAdder: Int => Int => Int => Int = <function1>

val add2 = currAdder(2)

val add5 = add2(3)

add5(5)
```

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Collections

- Scala collections can be mutable and immutable collections.

- Mutable collections can be updated or extended in place.

- Immutable collections never change: additions, removals, or updates operators return a new collection and leave the old collection unchanged.

Collections

- Arrays
- Lists
- Sets
- Maps
- Tuples
- Option

Collections - Arrays

- A fixed-size sequential collection of elements of the same type
- Mutable

```scala
// Array definition
val t: Array[String] = new Array[String](3)
val t = new Array[String](3)


// Assign values or get access to individual elements
t(0) = "zero"; t(1) = "one"; t(2) = "two"


// There is one more way of defining an array
val t = Array("zero", "one", "two")
```

Collections - Lists

- A sequential collection of elements of the same type
- Immutable
- Lists represent a linked list

```scala
// List definition
val l1 = List(1, 2, 3)
val l1 = 1 :: 2 :: 3 :: Nil

// Adding an element to the head of a list
val l2 = 0 :: l1

// Adding an element to the tail of a list
val l3 = l1 :+ 4

// Concatenating lists
val t3 = List(4, 5)
val t4 = l1 ::: t3
```

Collections - Sets

- A sequential collection of elements of the same type
- Immutable and mutable
- No duplicates.

```scala
// Set definition
val s = Set(1, 2, 3)

// Add a new element to the set
val s2 = s + 0

// Remove an element from the set
val s3 = s2 - 2

// Test the membership
s.contains(2)
```

Collections - Maps

- A collection of key/value pairs
- Immutable and mutable

```scala
// Map definition
var m1: Map[Char, Int] = Map()
val m2 = Map(1 -> "Carbon", 2 -> "Hydrogen")

// Finding the element associated to a key in a map
m2(1)

// Adding an association in a map
val m3 = m2 + (3 -> "Oxygen")

// Returns an iterable containing each key (or values) in the map
m2.keys
m2.values
```

Collections - Tuples

- A fixed number of items of different types together

- Immutable

```scala
// Tuple definition
val t = (1, "hello", Console)
val t = new Tuple3(1, "hello", 20)

// Tuple getters
t._1
t._2
t._3
```

Collections - Option (1/2)

- Sometimes you might or might not have a value.

- Java typically returns the value null to indicate nothing found.
  - You may get a NullPointerException, if you don't check it.

- Scala has a null value in order to communicate with Java.
  - You should use it only for this purpose.

- Everyplace else, you should use Option.

Collections - Option (2/2)

```
scala> val numbers = Map(1 -> "one", 2 -> "two")
numbers: scala.collection.immutable.Map[Int, String] = Map((1, one), (2, two))

scala> numbers.get(2)
res0: Option[String] = Some(two)

scala> numbers.get(3)
res1: Option[String] = None

// Check if an Option value is defined (isDefined and isEmpty).
scala> val result = numbers.get(3).isDefined
result: Boolean = false

// Extract the value of an Option.
scala> val result = numbers.get(3).getOrElse("zero")
result: String = zero
```

Functional Combinators

- map
- foreach
- filter
- zip
- partition
- find
- drop and dropWhile
- foldRight and foldLeft
- flatten
- flatMap

Functional Combinators - map

- Evaluates a function over each element in the list, returning a list with the same number of elements

```
scala> val numbers = List(1, 2, 3, 4)
numbers: List[Int] = List(1, 2, 3, 4)


scala> numbers.map((i: Int) => i * 2)
res0: List[Int] = List(2, 4, 6, 8)


scala> def timesTwo(i: Int): Int = i * 2
timesTwo: (i: Int)Int


scala> numbers.map(timesTwo _)
or
scala> numbers.map(timesTwo)
res1: List[Int] = List(2, 4, 6, 8)
```

Functional Combinators - foreach

- It is like map but returns nothing

```
scala> val numbers = List(1, 2, 3, 4)
numbers: List[Int] = List(1, 2, 3, 4)


scala> val doubled = numbers.foreach((i: Int) => i * 2)
doubled: Unit = ()


scala> numbers.foreach(print)
1234
```

Functional Combinators - filter

- Removes any elements where the function you pass in evaluates to false

```
scala> val numbers = List(1, 2, 3, 4)
numbers: List[Int] = List(1, 2, 3, 4)


scala> numbers.filter((i: Int) => i % 2 == 0)
res0: List[Int] = List(2, 4)


scala> def isEven(i: Int): Boolean = i % 2 == 0
isEven: (i: Int)Boolean


scala> numbers.filter(isEven)
res2: List[Int] = List(2, 4)
```

Functional Combinators - zip

- Aggregates the contents of two lists into a single list of pairs

```
scala> val numbers = List(1, 2, 3, 4)
numbers: List[Int] = List(1, 2, 3, 4)

scala> val chars = List("a", "b", "c")
chars: List[String] = List(a, b, c)

scala> numbers.zip(chars)
res0: List[(Int, String)] = List((1, a), (2, b), (3, c))
```

Functional Combinators - partition

- Splits a list based on where it falls with respect to a predicate function

```
scala> val numbers = List(1, 2, 3, 4, 5, 6, 7, 8, 9, 10)
numbers: List[Int] = List(1, 2, 3, 4, 5, 6, 7, 8, 9, 10)

scala> numbers.partition(_ % 2 == 0)
res0: (List[Int], List[Int]) = (List(2, 4, 6, 8, 10), List(1, 3, 5, 7, 9))
```

Functional Combinators - find

- Returns the first element of a collection that matches a predicate function

```
scala> val numbers = List(1, 2, 3, 4, 5, 6, 7, 8, 9, 10)
numbers: List[Int] = List(1, 2, 3, 4, 5, 6, 7, 8, 9, 10)

scala> numbers.find(i => i > 5)
res0: Option[Int] = Some(6)
```

Functional Combinators - drop and dropWhile

- drop drops the first i elements
- dropWhile removes the first elements that match a predicate function

```
scala> val numbers = List(1, 2, 3, 4, 5, 6, 7, 8, 9, 10)
numbers: List[Int] = List(1, 2, 3, 4, 5, 6, 7, 8, 9, 10)

scala> numbers.drop(5)
res0: List[Int] = List(6, 7, 8, 9, 10)

scala> numbers.dropWhile(_ % 3 != 0)
res1: List[Int] = List(3, 4, 5, 6, 7, 8, 9, 10)
```

Functional Combinators - foldLeft

- It goes through the whole List, from head to tail, and passes each value to f.
- For the first list item, that first parameter, z, is used as the first parameter to f.
- For the second list item, the result of the first call to f is used as the B type parameter.

```
def foldLeft[B](z: B)(f: (B, A) => B): B

scala> val numbers = List(1, 2, 3, 4, 5)
scala> numbers.foldLeft(0) { (m, n) => println("m: " + m + " n: " + n);
m + n }
m: 0 n: 1
m: 1 n: 2
m: 3 n: 3
m: 6 n: 4
m: 10 n: 5
res0: Int = 15
```

Functional Combinators - foldRight

- It is the same as foldLeft except it runs in the opposite direction

```
def foldRight[B](z: B)(f: (A, B) => B): B

scala> val numbers = List(1, 2, 3, 4, 5)
scala> numbers.foldRight(0) { (m, n) => println("m: " + m + " n: " + n);
m + n }
m: 5 n: 0
m: 4 n: 5
m: 3 n: 9
m: 2 n: 12
m: 1 n: 14
res52: Int = 15
```

Functional Combinators - flatten

- It collapses one level of nested structure

```
scala> List(List(1, 2), List(3, 4)).flatten
res0: List[Int] = List(1, 2, 3, 4)
```

Functional Combinators - flatMap

- It takes a function that works on the nested lists and then concatenates the results back together

```
scala> val nestedNumbers = List(List(1, 2), List(3, 4))
nestedNumbers: List[List[Int]] = List(List(1, 2), List(3, 4))

scala> nestedNumbers.flatMap(x => x.map(_ * 2))
res0: List[Int] = List(2, 4, 6, 8)

// Think of it as short-hand for mapping and then flattening:
scala> nestedNumbers.map((x: List[Int]) => x.map(_ * 2)).flatten
res1: List[Int] = List(2, 4, 6, 8)
```

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Everything is an Object

- Scala is a pure object-oriented language.

- Everything is an object, including numbers.

```
1 + 2 * 3 / x
(1).+(((2).*(3))./(x))
```

- Functions are also objects, so it is possible to pass functions as arguments, to store them in variables, and to return them from other functions.

Classes and Objects

```scala
class Calculator {
  val brand: String = "HP"
  def add(m: Int, n: Int): Int = m + n
}

val calc = new Calculator
calc.add(1, 2)
println(calc.brand)
```

Constructors

```scala
class Calculator(brand: String) {
  // A constructor.
  val color: String = if (brand == "TI") {
    "blue"
  } else if (brand == "HP") {
    "black"
  } else {
    "white"
  }

  // An instance method.
  def add(m: Int, n: Int): Int = m + n
}

val calc = new Calculator("HP")
println(calc.color)
```

Inheritance and Overloading Methods

- Scala allows the inheritance from just one class only.

```scala
class SciCalculator(brand: String) extends Calculator(brand) {
  def log(m: Double, base: Double) = math.log(m) / math.log(base)
}

class MoreSciCalculator(brand: String) extends SciCalculator(brand) {
  def log(m: Int): Double = log(m, math.exp(1))
}
```

Singleton Objects

- A singleton is a class that can have only one instance.

```
class Point(val xc: Int, val yc: Int) {
  var x: Int = xc
  var y: Int = yc
}

object Test {
  def main(args: Array[String]) {
    val point = new Point(10, 20)
    printPoint

    def printPoint {
      println ("Point x location : " + point.x);
      println ("Point y location : " + point.y);
    }
  }
}

Test.main(null)
```

Abstract Classes

```scala
abstract class Shape {
  // subclass should define this
  def getArea(): Int
}

class Circle(r: Int) extends Shape {
  def getArea(): Int = { r * r * 3 }
}

val s = new Shape // error: class Shape is abstract
val c = new Circle(2)
c.getArea
```

Traits

- A class can mix in any number of traits.

```
trait Car {
  val brand: String
}

trait Shiny {
  val shineRefraction: Int
}

class BMW extends Car with Shiny {
  val brand = "BMW"
  val shineRefraction = 12
}
```

Generic Types

```scala
trait Cache[K, V] {
  def get(key: K): V
  def put(key: K, value: V)
  def delete(key: K)
}

def remove[K](key: K)
```

Case Classes and Pattern Matching

- Case classes are used to store and match on the contents of a class.
- They are designed to be used with pattern matching.
- You can construct them without using new.

```scala
scala> case class Calculator(brand: String, model: String)
scala> val hp20b = Calculator("hp", "20B")

def calcType(calc: Calculator) = calc match {
  case Calculator("hp", "20B") => "financial"
  case Calculator("hp", "48G") => "scientific"
  case Calculator("hp", "30B") => "business"
  case _ => "Calculator of unknown type"
}

scala> calcType(hp20b)
```

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Simple Build Tool (SBT)

- An open source build tool for Scala and Java projects.
- Similar to Java's Maven or Ant.
- It is written in Scala.

SBT - Hello World!

```
$ mkdir hello
$ cd hello
$ cp <path>/HelloWorld.scala .
$ sbt
...
> run
```

Running SBT

- Interactive mode

```
$ sbt
> compile
> run
```

- Batch mode

```
$ sbt clean run
```

- Continuous build and test: automatically recompile or run tests whenever you save a source file.

```
$ sbt
> ~ compile
```

Common Commands

- `clean`: deletes all generated files (in target).
- `compile`: compiles the main sources (in src/main/scala).
- `test`: compiles and runs all tests.
- `console`: starts the Scala interpreter.
- `run <argument>*`: run the main class.
- `package`: creates a jar file containing the files in src/main/resources and the classes compiled from src/main/scala.
- `help <command>`: displays detailed help for the specified command.
- `reload`: reloads the build definition (build.sbt, project/*.scala, project/*.sbt files).

Create a Simple Project

- Create `project` directory.
- Create `src/main/scala` directory.
- Create `build.sbt` in the project root.

build.sbt

- A list of Scala expressions, separated by blank lines.
- Located in the project's base directory.

```
$ cat build.sbt
name := "hello"

version := "1.0"

scalaVersion := "2.11.5"
```

Add Dependencies

- Add in `build.sbt`.

- Module ID format:
  `"groupID" %% "artifact" % "version" % "configuration"`

```
libraryDependencies += "org.apache.spark" %% "spark-core" % "0.9.0-incubating"

// multiple dependencies
libraryDependencies ++= Seq(
    "org.apache.spark" %% "spark-core" % "1.6.2-incubating",
    "org.apache.spark" %% "spark-streaming" % "1.6.2-incubating"
)
```

Questions?