

Scala

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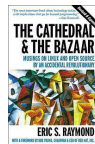


- ▶ **Scala**: scalable language
- ▶ A blend of object-oriented and functional programming.
- ▶ Runs on the Java Virtual Machine.
- ▶ Designed by Martin Odersky at EPFL.



Cathedral vs. Bazaar

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



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.



Functional Programming (FP)

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- ▶ In a **wider** sense: focusing on the functions.



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

FP Languages (1/2)

- ▶ In a **restricted** sense: a language that does **not** have **mutable variables**, **assignments**, or **imperative control** structures.
- ▶ In a **wider** sense: it enables the construction of programs that **focus on functions**.

FP Languages (1/2)

- ▶ In a **restricted** sense: a language that does **not** have **mutable variables**, **assignments**, or **imperative control** structures.
- ▶ In a **wider** sense: it enables the construction of programs that **focus on functions**.
- ▶ **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

```
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
```



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

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Scala Variables

- ▶ **Values:** immutable
- ▶ **Variables:** mutable

```
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)

```
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

```
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

```
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.

```
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

```
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)
```

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

- ▶ 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**

```
// 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

```
// 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.

```
// 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**

```
// 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**

```
// 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)

```
// the value of an Option[type] variable is either Some or None.
scala> var s = Some("abc")
scala> var t: Option[String] = None
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

```
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

```
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.

```
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

```
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
```

- ▶ 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

```
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> 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.

- ▶ 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 := "2.10.3"
```

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" % "0.9.0-incubating",  
  "org.apache.spark" %% "spark-streaming" % "0.9.0-incubating"  
)
```

- ▶ sbt uses the standard Maven2 repository by default, but you can add more `resolvers`.

```
resolvers += "Akka Repository" at "http://repo.akka.io/releases/"
```

Questions?