

A Crash Course on Scala

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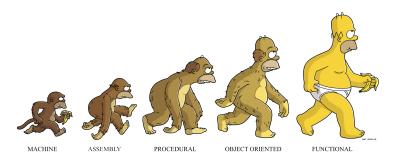
- ► Scala: scalable language
- ▶ A blend of object-oriented and functional programming.
- ▶ Runs on the Java Virtual Machine.
- ▶ Designed by Martin Odersky at EPFL.





Functional Programming Languages

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



[https://medium.com/@cscalfani/so-you-want-to-be-a-functional-programmer-part-1-1f15e387e536]





The "Hello, world!" Program

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

Compile and Execute It!

```
// Compile it!
> scalac HelloWorld.scala

// Execute it!
> scala HelloWorld
```

Compile and Execute It!

```
// Compile it!
> scalac HelloWorld.scala

// Execute it!
> scala HelloWorld
```

▶ It is always better to separate sources and build products.

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

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

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
```



Run in Jupyter-Notebook

► Apache toree



Outline

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

Outline

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

- ▶ Values: immutable
- ► Variables: mutable
- ► Always use immutable values by default, unless you know for certain they need to be 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

```
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");
}
```

```
var a = 10

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

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

```
var a = 0
var b = 0
for (a <- 1 to 3; b <- 1 until 3) {
 println(s"Value of a: $a, b: $b")
/* output
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(s"Value of a: $a")
}</pre>
```

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

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

```
// loop with collections
val numList = List(1, 2, 3, 4, 5, 6)
for (a <- numList) {</pre>
  println(s"Value of a: $a")
// for loop with multiple filters
for (a <- numList if a != 3; if a < 5) {</pre>
  println(s"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</pre>
println(retVal)
```

```
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...")
```



- ► Scala basics
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```
// def [function name]([list of parameters]): [return type] = [expr]
// the expression may be a {}-block
```

```
// def [function name]([list of parameters]): [return type] = [expr]
// the expression may be a {}-block
```

```
def addInt(a: Int, b: Int): Int = a + b
println("Returned Value: " + addInt(5, 7))
// Returned Value: 12
```

```
// def [function name]([list of parameters]): [return type] = [expr]
// the expression may be a {}-block
```

```
def addInt(a: Int, b: Int): Int = a + b
println("Returned Value: " + addInt(5, 7))
// Returned Value: 12
```

► You can also specify default values for all or some parameters.

```
def addInt(a: Int = 5, b: Int = 7): Int = a + b

// and then invoke with named parameters
println("Returned Value: " + addInt(a = 10))
// Returned Value: 17
```

Functions - Variable Arguments

```
def printStrings(args: String*) = {
  var i : Int = 0;
  for (arg <- args) {
     println(s"Arg value[$i] = $arg")
     i = i + 1;
  }
}
printStrings("SICS", "Scala", "BigData")</pre>
```

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)
}</pre>
```



Functions - Anonymous Functions

▶ Lightweight syntax for defining anonymous functions.

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



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))
```

Functions - Higher-Order Functions

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

def layout[A](x: A) = s"[$x]"

println(apply(layout, 10))
// [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(s"Param: $t")
delayed(time())
/* output
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(s"Param: $t")
delayed2(time())
/* output
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)
// 10
```

Outline

- ► 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.

- ► Arrays
- ► Lists
- ► Sets
- Maps

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)
```

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"
```

- ► 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")
```



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

```
// List definition
val 11 = List(1, 2, 3)
val 11 = 1 :: 2 :: 3 :: Nil
```



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

```
// List definition

val 11 = List(1, 2, 3)

val 11 = 1 :: 2 :: 3 :: Nil

// Adding an element to the head of a list

val 12 = 0 :: 11
```



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

```
// List definition

val 11 = List(1, 2, 3)

val 11 = 1 :: 2 :: 3 :: Nil

// Adding an element to the head of a list

val 12 = 0 :: 11

// Adding an element to the tail of a list

val 13 = 11 :+ 4
```



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

```
// List definition
val 11 = List(1, 2, 3)
val 11 = 1 :: 2 :: 3 :: Nil

// Adding an element to the head of a list
val 12 = 0 :: 11

// Adding an element to the tail of a list
val 13 = 11 :+ 4

// Concatenating lists
val t3 = List(4, 5)
val t4 = 11 ::: 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)
```



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
```

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
```

- ► 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)
```



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

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



- ► 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)
```



- ► 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")
```

- ► 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
```



Common Other Types

- ► Tuples
- ► Option
- ► Either



Common Data Types - Tuples

- ► A fixed number of items of different types together
- ► Immutable

```
// Tuple definition
val t2 = (1 -> "hello") // special pair constructor
val t3 = (1, "hello", Console)
val t3 = new Tuple3(1, "hello", 20)

// Tuple getters
t3._1
t3._2
t3._3
```



- ► 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.

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

```
val numbers = Map(1 -> "one", 2 -> "two")
// numbers: scala.collection.immutable.Map[Int, String] = Map((1, one), (2, two))
numbers.get(2)
// res0: Option[String] = Some(two)
```

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

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

numbers.get(3)
// res1: Option[String] = None
```

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

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

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

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

```
val numbers = Map(1 -> "one", 2 -> "two")
// numbers: scala.collection.immutable.Map[Int, String] = Map((1, one), (2, two))
numbers.get(2)
// res0: Option[String] = Some(two)
numbers.get(3)
// res1: Option[String] = None
// Check if an Option value is defined (isDefined and isEmpty).
val result = numbers.get(3).isDefined
// result: Boolean = false
// Extract the value of an Option.
val result = numbers.get(3).getOrElse("zero")
// result: String = zero
```



Common Data Types - Either

- ► Sometimes you might definitely have a value, but it can be one of two different types.
- ► Scala provides the Either type for these cases.

```
def getNum(s: String): Either[Int, String] = try {
   Left(s.toInt)
} catch {
   case _ => Right(s)
}
getNum("5")
// Left(5)
```



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.

```
val numbers = List(1, 2, 3, 4)
// numbers: List[Int] = List(1, 2, 3, 4)
numbers.map((i: Int) => i * 2)
// res0: List[Int] = List(2, 4, 6, 8)
```



Functional Combinators - map

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

```
val numbers = List(1, 2, 3, 4)
// numbers: List[Int] = List(1, 2, 3, 4)
numbers.map((i: Int) => i * 2)
// res0: List[Int] = List(2, 4, 6, 8)

def timesTwo(i: Int): Int = i * 2
// timesTwo: (i: Int)Int
numbers.map(timesTwo_)
// or
numbers.map(timesTwo)
// res1: List[Int] = List(2, 4, 6, 8)
```



Functional Combinators - foreach

▶ It is like map, but returns nothing.

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

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

numbers.foreach(print)
// 1234
```



Functional Combinators - filter

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

```
val numbers = List(1, 2, 3, 4)
// numbers: List[Int] = List(1, 2, 3, 4)
numbers.filter((i: Int) => i % 2 == 0)
// res0: List[Int] = List(2, 4)
```



Functional Combinators - filter

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

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

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

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

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

▶ Aggregates the contents of two lists into a single list of pairs.

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

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

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.

```
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)
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.

```
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)
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.

```
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)
numbers.drop(5)
// res0: List[Int] = List(6, 7, 8, 9, 10)
numbers.dropWhile(_ % 3 != 0)
// res1: List[Int] = List(3, 4, 5, 6, 7, 8, 9, 10)
```



Functional Combinators - foldLeft

- ► Takes an associative binary operator function and uses it to collapse elements from the collection.
- ▶ It goes through the whole List, from head (left) to tail (right).

```
val numbers = List(1, 2, 3, 4, 5)
numbers.foldLeft(0) { (acc, i) =>
    println("i: " + i + " acc: " + acc)
    i + acc
}

/* output
i: 1 acc: 0
i: 2 acc: 1
i: 3 acc: 3
i: 4 acc: 6
i: 5 acc: 10
15 */
```



Functional Combinators - foldRight

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

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

numbers.foldRight(0) { (i, acc) =>
    println("i: " + i + " acc: " + acc)
    i + acc
}

/* output
i: 5 acc: 0
i: 4 acc: 5
i: 3 acc: 9
i: 2 acc: 12
i: 1 acc: 14
15 */
```



Functional Combinators - flatten

▶ It collapses one level of nested structure.

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

List(Some(1), None, Some(3)).flatten
// res0: List[Int] = List(1, 3)
```



Functional Combinators - flatMap

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

```
val nestedNumbers = List(List(1, 2), List(3, 4))
// nestedNumbers: List[List[Int]] = List(List(1, 2), List(3, 4))
nestedNumbers.flatMap(x => x.map(_ * 2))
// res0: 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.

```
// constructor parameters can be declared as fields and can have default values
class Calculator(val brand = "HP") {
    // an instance method
    def add(m: Int, n: Int): Int = m + n
}

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



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))
}
```

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

```
class Point(val x: Int, val y: Int) {
  def printPoint {
    println(s"Point x location: $x");
    println(s"Point y location: $y");
  }
}

object SpecialPoint extends Point(10, 20)

SpecialPoint.printPoint
/* output
Point x location: 10
Point y location: 20
*/
```

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

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

val s = new Shape // error: class Shape is abstract
val c = new Circle(2)
c.getArea
// 12
```

▶ 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
}
```

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

// a generic function
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.

```
$ 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 := "2.12.8"
```

- ▶ Add in build.sbt.
- ► Module ID format:

```
"groupID" %% "artifact" % "version" % "configuration"
```

```
libraryDependencies += "org.apache.spark" %% "spark-core" % "2.4.3"

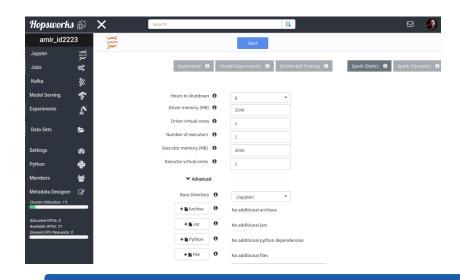
// multiple dependencies
libraryDependencies ++= Seq(
   "org.apache.spark" %% "spark-core" % "2.4.3",
   "org.apache.spark" % "spark-streaming_2.12" % "2.4.3",
   "org.apache.spark" % "spark-streaming-kafka-0-10_2.12" % "2.4.3"
)
```



Cluster Development Environments

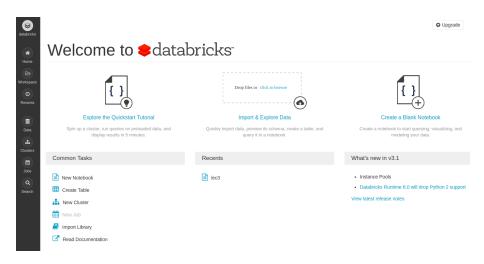


LogicalClocks Hopsworks





Databricks





Summary

Summary

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



▶ M. Odersky, Scala by example, 2011.



Questions?