

Scala for Apache Spark

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Jan 2019

- Slides: <https://github.com/medale/scala-spark/blob/master/presentation/ScalaSpark.pdf>
- Scala Spark Code Examples: <https://github.com/medale/scala-spark>

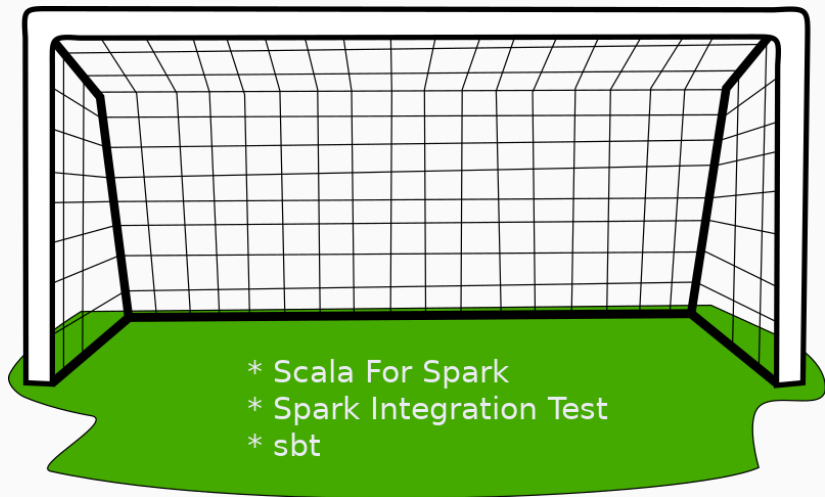
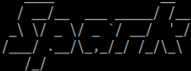


Figure 1: Intro to Scala for Spark

Why Scala for Spark?

```
Spark session available as 'spark'.  
Welcome to  
 version 2.4.0  
  
Using Scala version 2.11.12 (Java HotSpot(TM) 64-Bit  
Type in expressions to have them evaluated.  
Type :help for more information.  
  
scala> █
```

- full interoperability with Java
 - strong type system
 - elegant multi-paradigm (functional & OO)
 - less boilerplate/less code
- JVM

```
package com.uebercomputing.scalaspark.common;

public class JavaMain {
    private int answer = 0;
    public JavaMain(int answer) {
        this.answer = answer;
    }
    public int getAnswer() {
        return answer;
    }
    public static void main(String[] args) {
        System.out.println("Starting a Java program...");
        JavaMain jaMain = new JavaMain(42);
        int answer = jaMain.getAnswer();
        System.out.println("The answer was " + answer);
    }
}
```

Scala Main One

```
package com.uebercomputing.scalaspark.common
```

```
class ScalaMainOne(val answer: Int)
```

```
object ScalaMainOne {
```

```
  def main(args: Array[String]): Unit = {  
    println("Starting a Scala program...")
```

```
    val scMain = new ScalaMainOne(42)
```

```
    val answer = scMain.answer
```

```
    println(s"The answer was ${answer}")
```

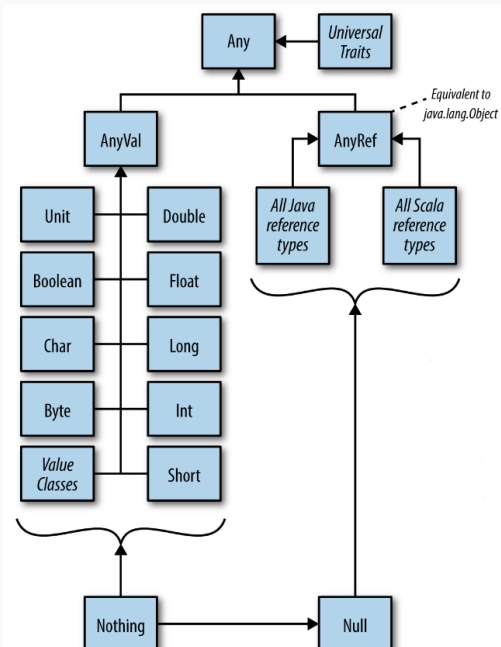
```
  }
```

```
}
```

HelloSparkWorld - expression-oriented

```
object HelloWorld {  
  ...  
  def main(args: Array[String]): Unit = {  
  
    val lines = if (!args.isEmpty) {  
      val inputFile = args(0)  
      readLinesFromFile(inputFile)  
    } else {  
      readLinesFromString(GhandiQuote)  
    }  
  
    wordCountLocal(lines)  
    ...  
  }  
}
```

Scala Type Hierarchy




```
val GhandiQuote =  
  """Live as if you were to die tomorrow  
    |Learn as if you were to live forever""".stripMargin  
  
def readLinesFromString(input: String): Seq[String] = {  
  val lines = input.split("\n")  
  lines  
}  
...  
readLinesFromString(GhandiQuote)
```

String[]	split(String regex, int limit) Splits this string around matches of the given regular expression .
boolean	startsWith(String prefix) Tests if this string starts with the specified prefix.
boolean	startsWith(String prefix, int toffset) Tests if the substring of this string beginning at the specified offset starts with the specified prefix.
CharSequence	subSequence(int beginIndex, int endIndex) Returns a character sequence that is a subsequence of this string.
String	substring(int beginIndex) Returns a string that is a substring of this string.
String	substring(int beginIndex, int endIndex) Returns a string that is a substring of this string.

Figure 3: Java String API

Scala Predef API - implicit conversions

tests an expression, throwing an `ASSERTIONError` if false.

```
implicit def augmentString(x: String): StringOps
```

```
implicit def boolean2Boolean(x: Boolean): java.lang.Boolean
```

```
implicit def booleanArrayOps(xs: Array[Boolean]): ArrayOps[Boolean]
```

```
implicit def booleanWrapper(x: Boolean): RichBoolean
```

```
implicit def byte2Byte(x: Byte): java.lang.Byte
```

```
implicit def byteArrayOps(xs: Array[Byte]): ArrayOps[Byte]
```

```
implicit def byteWrapper(x: Byte): RichByte
```

We prefer the java.lang.* boxed types to these wrappers in any potential conflict.

```
implicit def char2Character(x: Char): Character
```

```
implicit def charArrayOps(xs: Array[Char]): ArrayOps[Char]
```

```
implicit def charWrapper(c: Char): RichChar
```

Figure 4: Scala Predef API

Scala StringOps API - stripMargin

Defines the prefix of this object's toString representation.

▶	def stripLineEnd : String Strip trailing line end character from this string if it has one.
▶	def stripMargin : String For every line in this string:
▶	def stripMargin (marginChar: Char): String For every line in this string:
▶	def stripPrefix (prefix: String): String Returns this string with the given prefix stripped.
▶	def stripSuffix (suffix: String): String Returns this string with the given suffix stripped.
▶	def subSequence (arg0: Int , arg1: Int): CharSequence

Figure 5: Scala StringOps API

HelloSparkWorld - accessing Java API/libraries

```
import java.nio.file.Files
import java.nio.file.Paths
import java.util.{List => JavaList}

import scala.collection.JavaConverters._

def readLinesFromFile(inputFile: String): Seq[String] = {
  val inputPath = Paths.get(inputFile)
  val linesJava: JavaList[String] =
    Files.readAllLines(inputPath)
  val lines = linesJava.asScala //mutable.Buffer
  lines
}
```

wordCountLocal: map higher-order function w/named function

```
def wordCountLocal(lines: Seq[String]): Unit = {  
  
  def toLower(s: String): String = {  
    s.toLowerCase  
  }  
  
  val lowerLines = lines.map(toLower)  
  ...  
}
```

```
//function literal - anonymous function explicit type:
```

```
lines.map((l: String) => l.toLowerCase)
```

```
//function literal - anonymous with inferred type:
```

```
lines.map(l => l.toLowerCase)
```

```
//function literal with placeholder syntax
```

```
lines.map(_.toLowerCase)
```

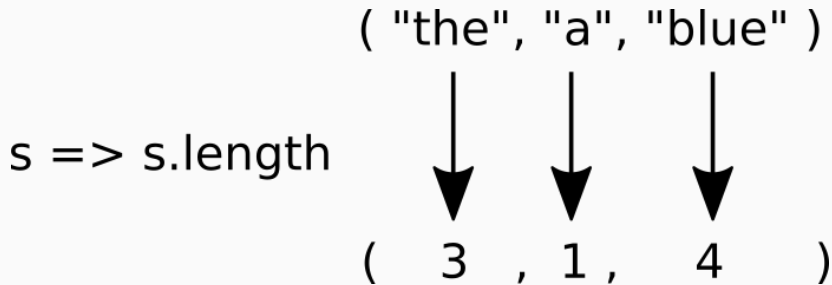


Figure 6: Map

flatMap function: `s => s.split("\\s+")`

Original: `("the quick", "brown fox")`

After map: `(Array("the", "quick"), Array("brown", "fox"))`

After flatten: `("the", "quick", "brown", "fox")`

Figure 7: flatMap

```
val words = lowerLines.flatMap { line =>  
    line.split("""\s+""")  
}
```

```
val noStopWords = words.filter(!StopWords.contains(_))
```

The equals method for arbitrary sequences.

```
def exists(p: (A) => Boolean): Boolean
```

Tests whether a predicate holds for at least one element of this iterable collection.

```
def filter(p: (A) => Boolean): Seq[A]
```

Selects all elements of this traversable collection which satisfy a predicate.

```
def filterNot(p: (A) => Boolean): Seq[A]
```

Selects all elements of this traversable collection which do not satisfy a predicate.

```
def find(p: (A) => Boolean): Option[A]
```

Finds the first element of the iterable collection satisfying a predicate, if any.

```
def flatMap[B](f: (A) => GenTraversableOnce[B]): Seq[B]
```

[use case] Builds a new collection by applying a function to all elements of this sequence and u

```
def flatten[R]: Seq[R]
```

Figure 8: Scala Seq

```
val emptyMapWithZeroDefault =  
  Map[String, Int]().withDefaultValue(0)  
  
//foldLeft(z: B)((B,A) => B): B  
val wordCountsMap: Map[String, Int] =  
  noStopWords.foldLeft(emptyMapWithZeroDefault)(  
    (wcMap, word) => {  
      val newCount = wcMap(word) + 1  
      wcMap + (word -> newCount)  
    })
```

```
val countsString = wordCountsMap.mkString("\n", "\n", "\n")  
println(s"The word counts were: ${countsString}")
```

The word counts were:

learn -> 1

if -> 2

as -> 2

you -> 2

die -> 1

...

```
import org.apache.spark.sql.SparkSession
...
def main(args: Array[String]): Unit = {
    val lines = ...

    val spark = SparkSession.builder.
        appName("HelloSparkWorld").
        master("local[2]").
        getOrCreate()

    wordCountRdd(spark, lines)

    spark.close()
}
```

SparkSession Scala API

sparksession

#ABCDEFGHIJKLMNOPQRSTUVWXYZ – deprecated

display packages only

org.apache.spark.sql

hide focus

SparkSession

SparkSessionExtensions

org.apache.spark.sql

SparkSession

class **SparkSession** extends Serializable with Closeable with [Logging](#)

The entry point to programming Spark with the Dataset and DataFrame API.
In environments that this has been created upfront (e.g. REPL, notebooks), use the builder to get an existing session:

```
SparkSession.builder().getOrCreate()
```


The builder can also be used to create a new session:

```
SparkSession.builder  
  .master("local")  
  .appName("Word Count")  
  .config("spark.some.config.option", "some-value")  
  .getOrCreate()
```

Self Type: [SparkSession](#)
Annotations: [@Stable\(\)](#)
Source: [SparkSession.scala](#)

► Linear Supertypes

Q

Ordering: [Alphabetic](#) [By Inheritance](#)

Inherited: [SparkSession](#) [Logging](#) [Closeable](#) [AutoCloseable](#) [Serializable](#) [Serializable](#) [AnyRef](#) [Any](#)

Hide All [Show All](#)

Visibility: [Public](#) [All](#)

Value Members

►

def [baseRelationToDataFrame](#)(baseRelation: [BaseRelation](#)): [DataFrame](#)
Convert a BaseRelation created for external data sources into a DataFrame.

►

lazy val [catalog](#): [Catalog](#)
Interface through which the user may create, drop, alter or query underlying databases, tables,

►

def [close](#)(): Unit
Synonym for stop().

►

lazy val [conf](#): [RuntimeConfig](#)
Runtime configuration interface for Spark.

def [createDataFrame](#)(data: List[Row], baseClass: Class[Row], DataFormat: DataFormat): DataFrame

Figure 9: SparkSession class

HelloSparkWorld - RDD map, flatMap, filter

```
//val mixedLinesRdd = spark.read.textFile(inputPath).rdd
val sc = spark.sparkContext

val mixedLinesRdd: RDD[String] =
    sc.parallelize(seq = lines, numSlices = 2)

val lowerLinesRdd = mixedLinesRdd.map(_.toLowerCase)

val wordsRdd = lowerLinesRdd.flatMap(_.split("""\s+"""))

val noStopWordsRdd = wordsRdd.filter(!StopWords.contains(_))
```



```
val wordCountTuplesRdd = noStopWordsRdd.map { (_, 1) }  
  
//No groupBy - expensive to shuffle words!  
val wordCountsRdd = wordCountTuplesRdd.reduceByKey(_ + _)  
  
//and Action!  
val localWordCounts = wordCountsRdd.collect()
```

RDD object API

object RDD extends Serializable

Defines implicit functions that provide extra functionalities on RDDs of specific types.

For example, [RDD.rddToPairRDDFunctions](#) converts an RDD into a [PairRDDFunctions](#) for key-value-pair RDDs, and enabling extra functionalities such as [Pair](#)

Source [RDD.scala](#)

► Linear Supertypes

Q

Ordering ☒ Alphabetic ☐ By Inheritance

Inherited ☒ RDD ☒ Serializable ☒ Serializable ☐ AnyRef ☐ Any

☐ Hide All ☒ Show All

Visibility ☒ Public ☐ All

Value Members

implicit def [doubleRDDToDoubleRDDFunctions](#)(rdd: [RDD](#)[Double]): [DoubleRDDFunctions](#)

implicit def [numericRDDToDoubleRDDFunctions](#)[T](rdd: [RDD](#)[T])(implicit num: Numeric[T]): [DoubleRDDFunctions](#)

implicit def [rddToAsyncRDDActions](#)[T](rdd: [RDD](#)[T])(implicit arg0: ClassTag[T]): [AsyncRDDActions](#)[T]

implicit def [rddToOrderedRDDFunctions](#)[K, V](rdd: [RDD](#)[(K, V)])(implicit arg0: Ordering[K], arg1: ClassTag[K]):

implicit def [rddToPairRDDFunctions](#)[K, V](rdd: [RDD](#)[(K, V)])(implicit kt: ClassTag[K], vt: ClassTag[V], ord:

implicit def [rddToSequenceFileRDDFunctions](#)[K, V](rdd: [RDD](#)[(K, V)])(implicit kt: ClassTag[K], vt: ClassTag[V],
valueWritableFactory: WritableFactory[V]): [SequenceFileRDDFunctions](#)[K, V]

Figure 10: RDD object API

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

HelloSparkDatasetWorld - javap Person.class

```
public class Person implements Product,Serializable {
    public static Option<Tuple3<String,String,Object>>
        ⇨ unapply(Person);
    public static Person apply(String, String, int);
    ...
    public String firstName();
    public String lastName();
    public int age();
    ...
    public Person copy(String, String, int);
    ...
    public String productPrefix();
    public int productArity();
    public Object productElement(int);
    public Iterator<Object> productIterator();
    ...
    public int hashCode();
```

```
//Person.apply("John...  
val persons = List(Person("John","Doe",42),  
                    Person("Jane","Doe",43))  
  
//createDataset[T : Encoder](data: Seq[T]): Dataset[T]  
import spark.implicit._  
val people: Dataset[Person] =  
    ↪ spark.createDataset(persons)  
  
//people.where(people("age").>(olderCutoff))  
val youngers: Dataset[Row] = people.  
    where($"age" < ageCutoff).  
    select("firstName")  
  
youngers.count
```

▶	<code>def from_utc_timestamp(ts: Column, tz: String): Column</code> Given a timestamp like '2017-07-14 02:40:00.0', interprets it as a time i
▶	<code>def hour(e: Column): Column</code> Extracts the hours as an integer from a given date/timestamp/string.
▶	<code>def last_day(e: Column): Column</code> Returns the last day of the month which the given date belongs to.
▶	<code>def minute(e: Column): Column</code> Extracts the minutes as an integer from a given date/timestamp/string.
▶	<code>def month(e: Column): Column</code> Extracts the month as an integer from a given date/timestamp/string.
▶	<code>def months_between(end: Column, start: Column, roundOff: Boolean): Column</code> Returns number of months between dates end and start.
▶	<code>def months_between(end: Column, start: Column): Column</code> Returns number of months between dates start and end.
▶	<code>def next_day(date: Column, dayOfWeek: String): Column</code> Returns the first date which is later than the value of the date column
▶	<code>def quarter(e: Column): Column</code>

Figure 11: Spark SQL functions

```
//load initial dataset (file, directory...)
def createPersonDataset(spark: SparkSession,
                        persons: Seq[Person]): Dataset[Person]

def countAgeLessThanCutoff(spark: SparkSession,
                           people: Dataset[Person],
                           ageCutoff: Int = 42): Long
```

Integration Testing - ScalaTest with Spark Testing Base

```
class HelloSparkDatasetWorldIntegrationTest extends
  FunSpec with Matchers with DatasetSuiteBase {
  ...
  describe("countAgeLessThanCutoff") {
    def assertExpectedCountForCutoff(ageCutoff: Int,
                                     expectedCount: Int): Assertion...
    it("should return count = all for high cutoff") {
      val ageCutoff = 99
      val expectedCount = MyPersons.size
      assertExpectedCountForCutoff(ageCutoff, expectedCount)
    }
    it("should return count = 0 for low cutoff")...
    it("should return count = 2 for cutoff of 43")...
```



```
def assertExpectedCountForCutoff(ageCutoff: Int,  
    expectedCount: Int): Assertion = {  
    val people = HelloSparkDatasetWorld.  
        createPersonDataset(spark, MyPersons)  
  
    val actualCount = HelloSparkDatasetWorld.  
        countAgeLessThanCutoff(spark, people, ageCutoff)  
  
    actualCount should equal (expectedCount)  
}
```

sbt - “build tool for Scala, Java and more”

- build.sbt
- version.sbt
- project/
 - build.properties
 - plugins.sbt
 - Dependencies.scala
- common
 - src
 - it/resources
 - it/scala
 - main
 - test
 - target
 - scala-2.11/analytics-0.9.0-SNAPSHOT-fat.jar
 - scala-2.11/classes

```
import sbt._

object Dependencies {
  //match Spark's pom for dependencies!
  val sparkVersion = "2.4.0"

  lazy val commonDependencies = Seq(
    ("commons-io" % "commons-io" % "2.4")
  )

  lazy val sparkDependencies = Seq(
    ("org.apache.spark" %% "spark-core" % sparkVersion)
    ...
  )
}
```

```
ThisBuild / scalaVersion := "2.11.8"
...
lazy val analytics = project
  .dependsOn(common)
  .configs(IntegrationTest)
  .settings(Defaults.itSettings: _*)
  .settings(
    name := s"${namePrefix}-analytics",
    libraryDependencies :=
      commonDependencies ++
        sparkDependencies ++
        testDependencies ++
        sparkTestDependencies
  )
lazy val root = (project in file("."))
  .aggregate(common, analytics)
...
```

sbt

sbt:root> compile

sbt:root> test

sbt:root> analytics/it:test

sbt:root> common/console

sbt:root> common/run

sbt:root> assembly

sbt:root> publish

And now for something completely different: Colon Cancer



- Screening saves lives!
 - Colonoscopy - talk to your doc
 - Dave Barry: A journey into my colon — and yours
- Colorectal Cancer Alliance

- Dean Wampler, Alex Payne, “Programming Scala, 2nd Edition”, O’Reilly, 2014
- Jacek Laskowski, Mastering Spark SQL, Gitbook
- ScalaTest
- Holden Karau Spark Testing Base
- sbt reference manual

Questions?



- medale@asymmetrik.com
- Infrequent blog/past presentations <http://uebercomputing.com/>
- Scala Spark repo: <https://github.com/medale/scala-spark>