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Spark Basics

Chapter 10

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Spark Basics

In this chapter you will learn

- **How to start the Spark Shell**
- **About the SparkContext**
- **Key Concepts of Resilient Distributed Datasets (RDDs)**
  - What are they?
  - How do you create them?
  - What operations can you perform with them?
- **How Spark uses the principles of functional programming**

Chapter Topics

Spark Basics | **Distributed Data Processing with Spark**

- **What is Apache Spark?**
- Using the Spark Shell
- RDDs (Resilient Distributed Datasets)
- Functional Programming in Spark
- Conclusion
- Homework Assignments

What is Apache Spark?

- **Apache Spark is a fast and general engine for large-scale data processing**

- **Written in Scala**
  - Functional programming language that runs in a JVM
- **Spark Shell**
  - Interactive – for learning or data exploration
  - Python or Scala
- **Spark Applications**
  - For large scale data processing
  - Python, Scala, or Java

Chapter Topics

Spark Basics | **Distributed Data Processing with Spark**

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Spark Shell

- **The Spark Shell provides interactive data exploration (REPL)**
- **Writing Spark applications without the shell will be covered later**

Python Shell: **`pyspark`**

```
$ pyspark

Welcome to
      ____              __
     / __/__  ___ _____/ /__
    _\ \/ _ \/ _ `/ __/  '_/
   /__ / .__/\_,_/_/ /_/\_\   version 1.3.0
      /_/

Using Python version 2.7.8 (default, Aug 27
2015 05:23:36)
SparkContext available as sc, HiveContext
available as sqlCtx.
>>>
```

Scala Shell: **`spark-shell`**

```
$ spark-shell

Welcome to
      ____              __
     / __/__  ___ _____/ /__
    _\ \/ _ \/ _ `/ __/  '_/
   /___/ .__/\_,_/_/ /_/\_\   version 1.3.0
      /_/

Using Scala version 2.10.4 (Java HotSpot(TM)
64-Bit Server VM, Java 1.7.0_67)
Created spark context..
Spark context available as sc.
SQL context available as sqlContext.

scala>
```

REPL: Read/Evaluate/Print Loop

Spark Context

- **Every Spark application requires a Spark Context**
  - The main entry point to the Spark API
- **Spark Shell provides a preconfigured Spark Context called `sc`**

Python

```
Using Python version 2.7.8 (default, Aug 27 2015 05:23:36)
SparkContext available as sc, HiveContext available as sqlCtx.

>>> sc.appName
u'PySparkShell'
```

Scala

```
...
Spark context available as sc.
SQL context available as sqlContext.

scala> sc.appName
res0: String = Spark shell
```


Chapter Topics

Spark Basics | **Distributed Data Processing with Spark**

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RDD (Resilient Distributed Dataset)

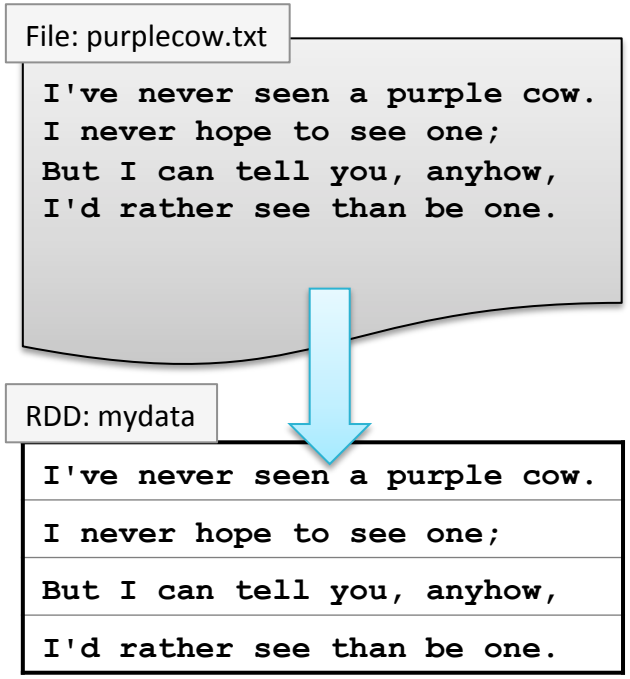
- **RDD (Resilient Distributed Dataset)**
  - Resilient – if data in memory is lost, it can be recreated
  - Distributed – processed across the cluster
  - Dataset – initial data can come from a file or be created programmatically
- **RDDs are the fundamental unit of data in Spark**
- **Most Spark programming consists of performing operations on RDDs**

Creating an RDD

- **Three ways to create an RDD**
  - From a file or set of files
  - From data in memory
  - From another RDD

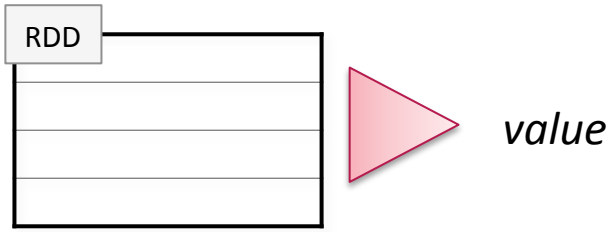
Example: A File-based RDD

```
> val mydata = sc.textFile("purplecow.txt")
…
15/01/29 06:20:37 INFO storage.MemoryStore:
   Block broadcast_0 stored as values to
   memory (estimated size 151.4 KB, free 296.8
   MB)

> mydata.count()

…
15/01/29 06:27:37 INFO spark.SparkContext: Job
   finished: take at <stdin>:1, took
   0.160482078 s
4
```

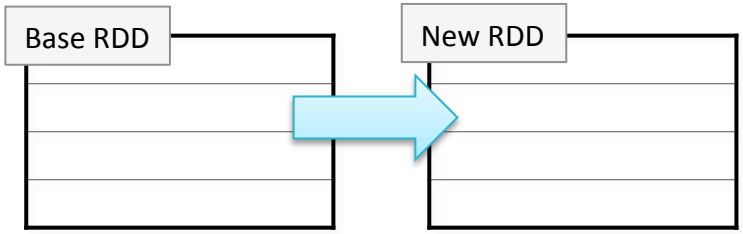


RDD Operations

- **Two types of RDD operations**
  - Actions – return values



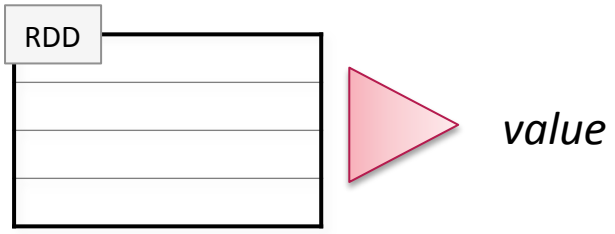
  - Transformations – define a new RDD based on the current one(s)



- **Pop quiz:**
  - Which type of operation is `count()`?

RDD Operations: Actions

- **Some common actions**
  - **`count()`** – return the number of elements
  - **`take(`***`n`***`)`** – return an array of the first *n* elements
  - **`collect()`** – return an array of all elements
  - **`saveAsTextFile(`***`file`***`)`** – save to text file(s)

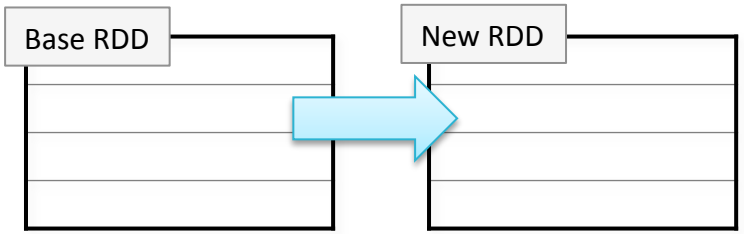



```
> mydata =
  sc.textFile("purplecow.txt")

> mydata.count()
4

> for line in mydata.take(2):
    print line
I've never seen a purple cow.
I never hope to see one;
```

```
> val mydata =
  sc.textFile("purplecow.txt")

> mydata.count()
4

> for (line <- mydata.take(2))
    println(line)
I've never seen a purple cow.
I never hope to see one;
```

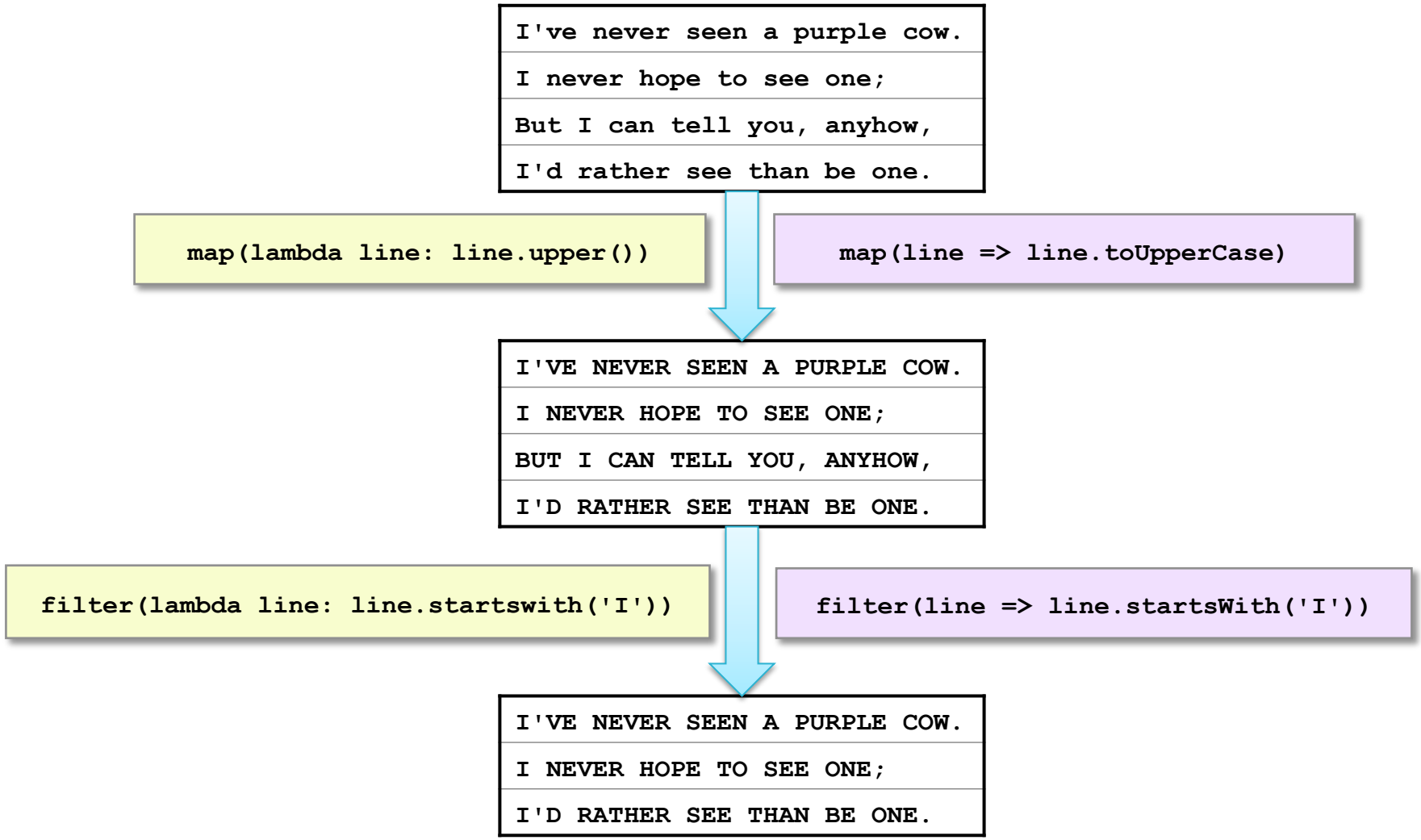
RDD Operations: Transformations

- **Transformations create a new RDD from an existing one**
- **RDDs are immutable**
  - Data in an RDD is never changed
  - Transform in sequence to modify the data as needed



- **Some common transformations**
  - **`map(`***`function`***`)`** – creates a new RDD by performing a function on each record in the base RDD
  - **`filter(`***`function`***`)`** – creates a new RDD by including or excluding each record in the base RDD according to a boolean function

Example: `map` and `filter` Transformations



Lazy Execution (1)

- **Data in RDDs is not processed until an *action* is performed**

File: purplecow.txt

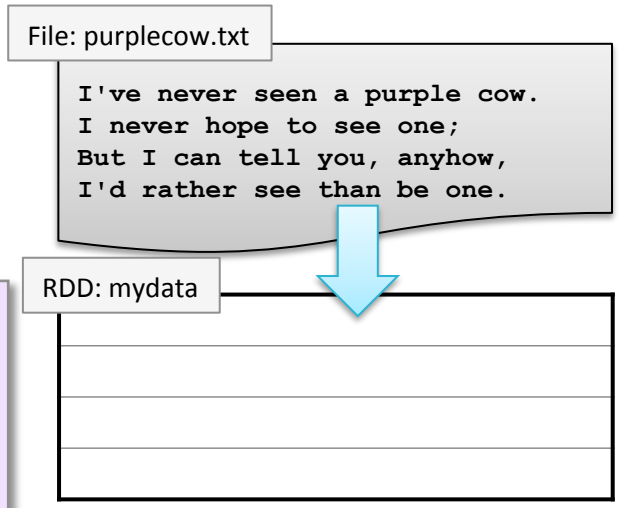
```
I've never seen a purple cow.
I never hope to see one;
But I can tell you, anyhow,
I'd rather see than be one.
```

```
>
```

Lazy Execution (2)

- **Data in RDDs is not processed until an *action* is performed**

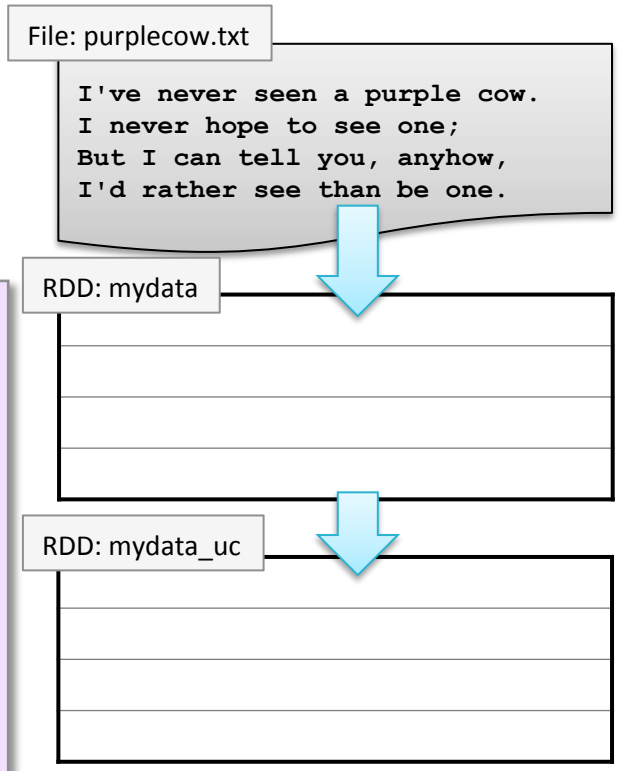
```
> val mydata = sc.textFile("purplecow.txt")
```



Lazy Execution (3)

- **Data in RDDs is not processed until an *action* is performed**

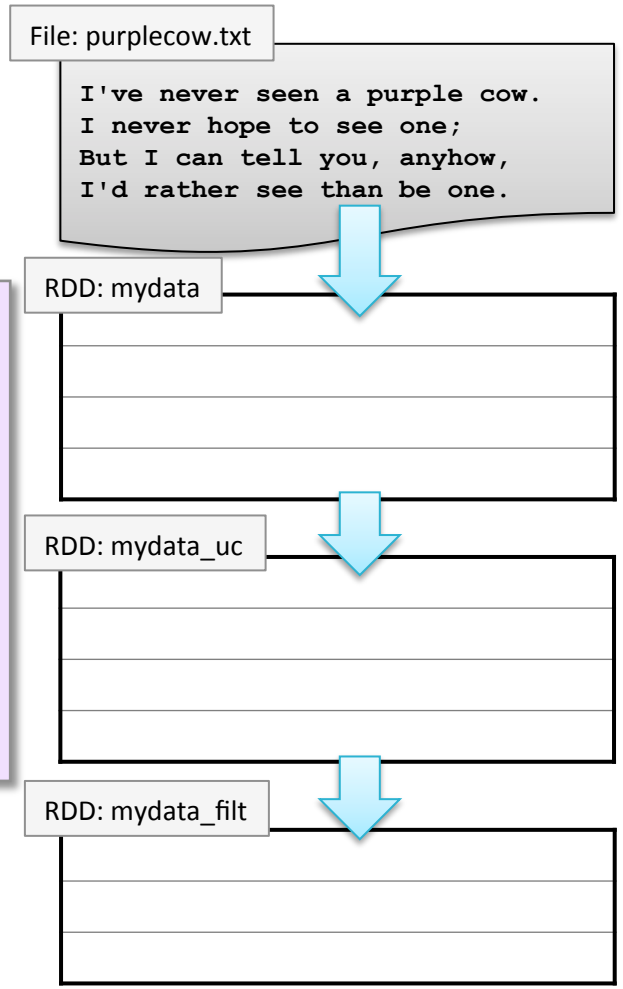
```
> val mydata = sc.textFile("purplecow.txt")
> val mydata_uc = mydata.map(line =>
  line.toUpperCase())
```



Lazy Execution (4)

- **Data in RDDs is not processed until an *action* is performed**

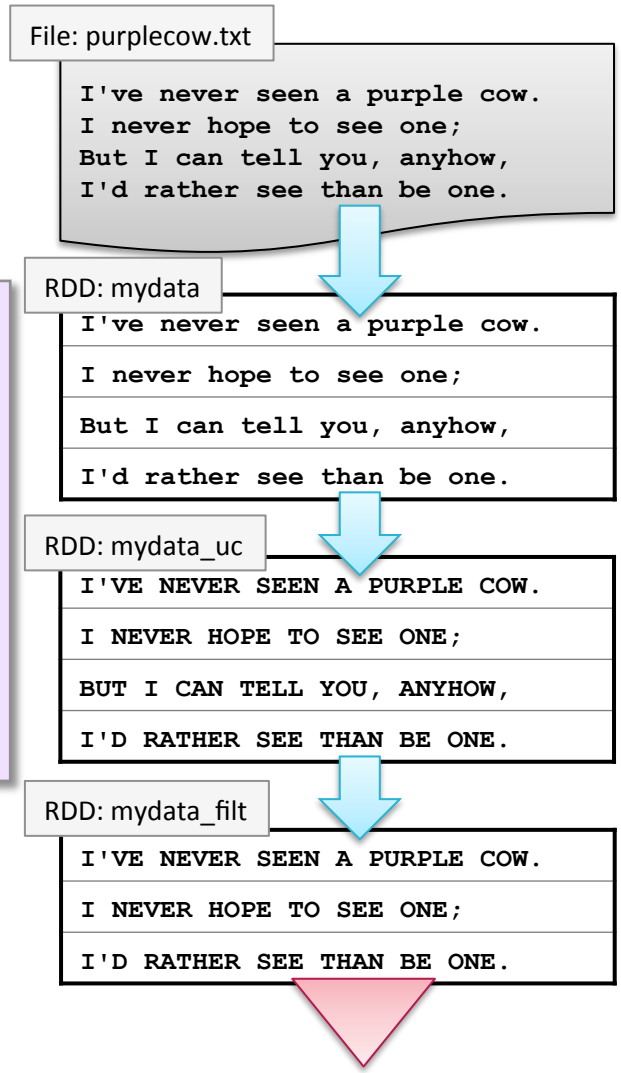
```
> val mydata = sc.textFile("purplecow.txt")
> val mydata_uc = mydata.map(line =>
  line.toUpperCase())
> val mydata_filt = mydata_uc.filter(line
  => line.startsWith("I"))
```



Lazy Execution (5)

- **Data in RDDs is not processed until an *action* is performed**

```
> val mydata = sc.textFile("purplecow.txt")
> val mydata_uc = mydata.map(line =>
  line.toUpperCase())
> val mydata_filt = mydata_uc.filter(line
  => line.startsWith("I"))
> mydata_filt.count()
3
```



Chaining Transformations (Scala)

- **Transformations may be chained together**

```
> val mydata = sc.textFile("purplecow.txt")
> val mydata_uc = mydata.map(line => line.toUpperCase())
> val mydata_filt = mydata_uc.filter(line => line.startsWith("I"))
> mydata_filt.count()
3
```

is exactly equivalent to

```
> sc.textFile("purplecow.txt").map(line => line.toUpperCase()).
   filter(line => line.startsWith("I")).count()
3
```

Chaining Transformations (Python)

- **Same example in Python**

```
> mydata = sc.textFile("purplecow.txt")
> mydata_uc = mydata.map(lambda s: s.upper())
> mydata_filt = mydata_uc.filter(lambda s: s.startswith('I'))
> mydata_filt.count()
3
```

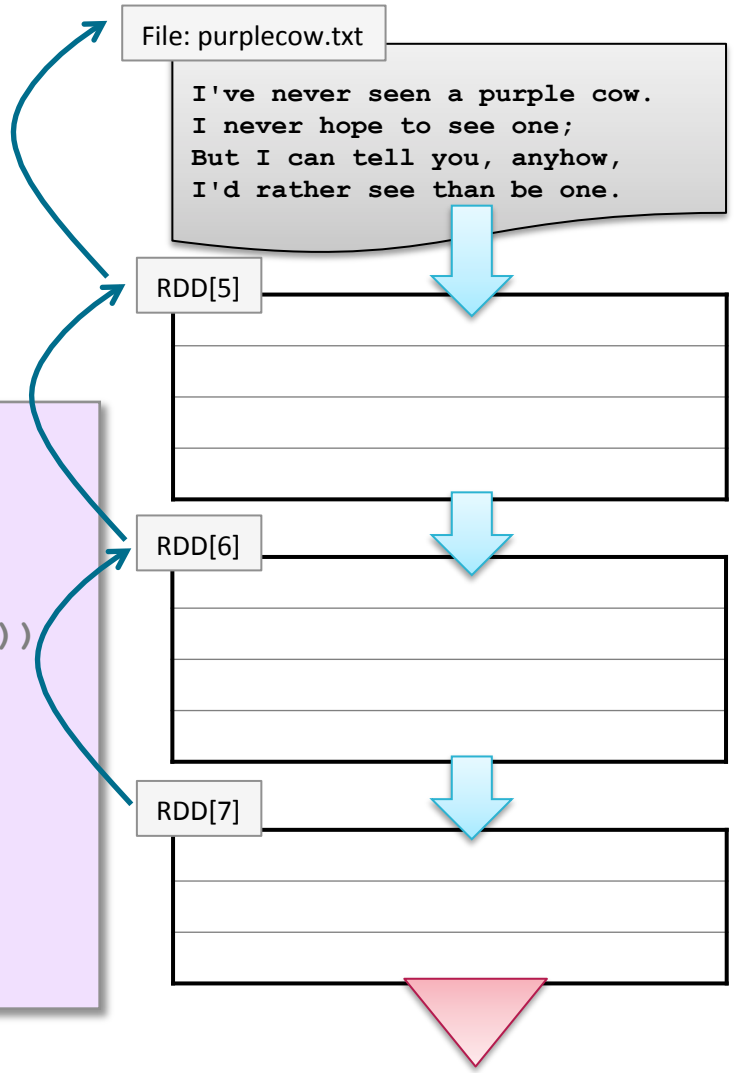
is exactly equivalent to

```
> sc.textFile("purplecow.txt").map(lambda line: line.upper()) \
   .filter(lambda line: line.startswith('I')).count()
3
```

RDD Lineage and `toDebugString` (Scala)

- **Spark maintains each RDD's *lineage* – the previous RDDs on which it depends**
- **Use `toDebugString` to view the lineage of an RDD**

```
> val mydata_filt =
    sc.textFile("purplecow.txt").
    map(line => line.toUpperCase()).
    filter(line => line.startsWith("I"))
> mydata_filt.toDebugString

(2) FilteredRDD[7] at filter …
 |  MappedRDD[6] at map …
 |  purplecow.txt MappedRDD[5] …
 |  purplecow.txt HadoopRDD[4] …
```



RDD Lineage and `toDebugString` (Python)

- **`toDebugString` output is not displayed as nicely in Python**

```
> mydata_filt.toDebugString()
(1) PythonRDD[8] at RDD at …\n |  purplecow.txt MappedRDD[7] at textFile
at …[]\n |  purplecow.txt HadoopRDD[6] at textFile at …[]
```

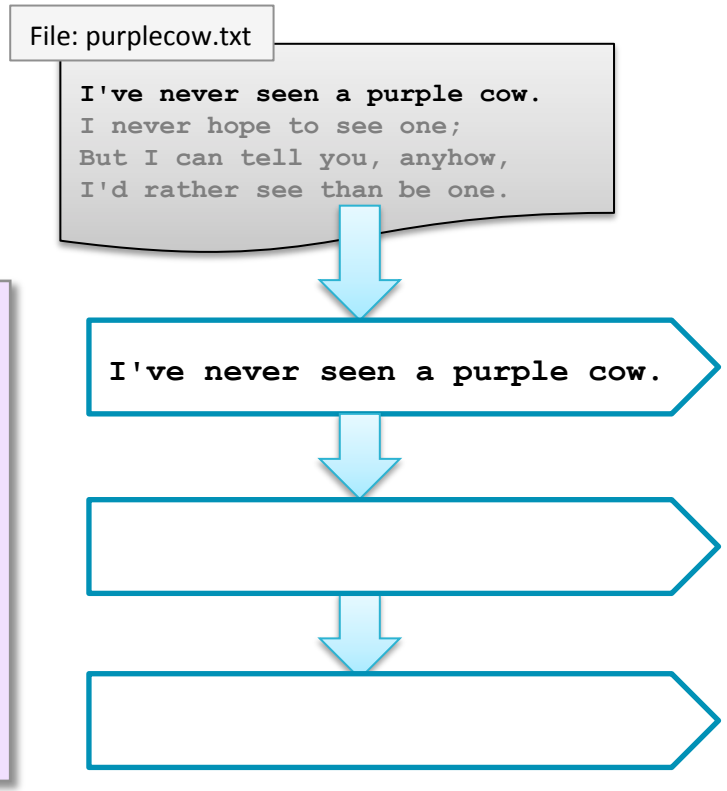
- **Use `print` for prettier output**

```
> print mydata_filt.toDebugString()
(1) PythonRDD[8] at RDD at …
 |  purplecow.txt MappedRDD[7] at textFile at …
 |  purplecow.txt HadoopRDD[6] at textFile at …
```

Pipelining (1)

- **When possible, Spark will perform sequences of transformations by row so no data is stored**

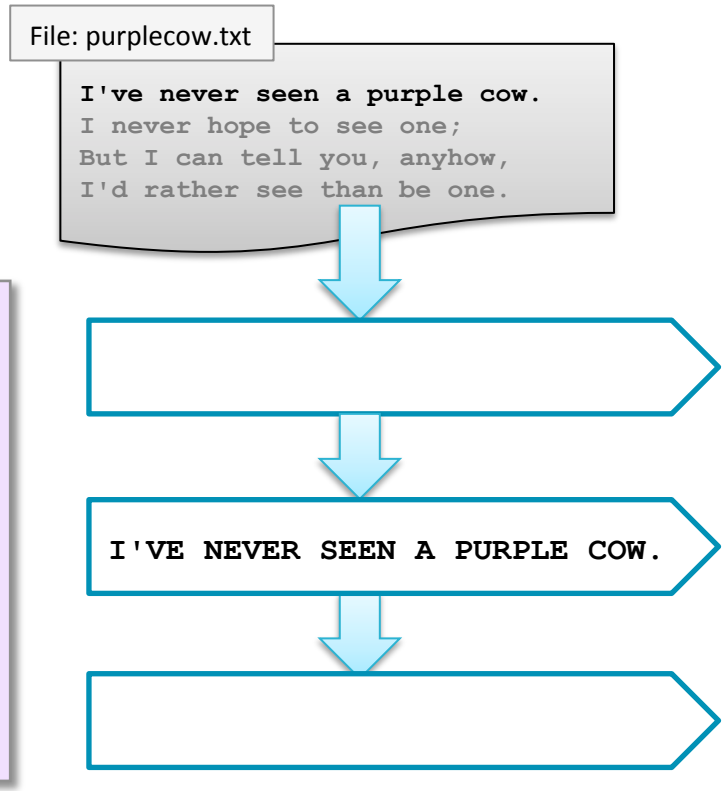
```
> val mydata = sc.textFile("purplecow.txt")
> val mydata_uc = mydata.map(line =>
  line.toUpperCase())
> val mydata_filt = mydata_uc.filter(line
  => line.startsWith("I"))
> mydata_filt.take(2)
```



Pipelining (2)

- **When possible, Spark will perform sequences of transformations by row so no data is stored**

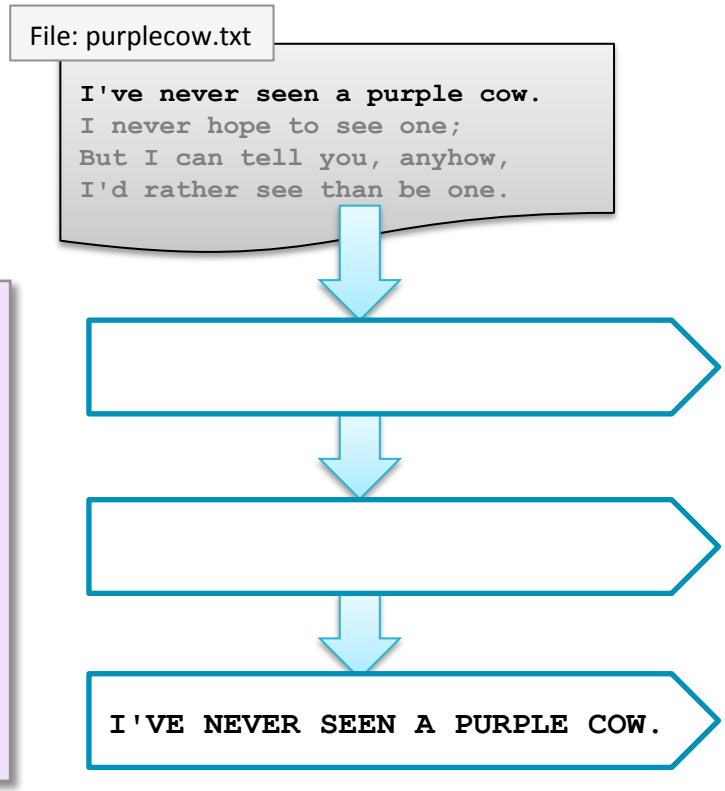
```
> val mydata = sc.textFile("purplecow.txt")
> val mydata_uc = mydata.map(line =>
  line.toUpperCase())
> val mydata_filt = mydata_uc.filter(line
  => line.startsWith("I"))
> mydata_filt.take(2)
```



Pipelining (3)

- **When possible, Spark will perform sequences of transformations by row so no data is stored**

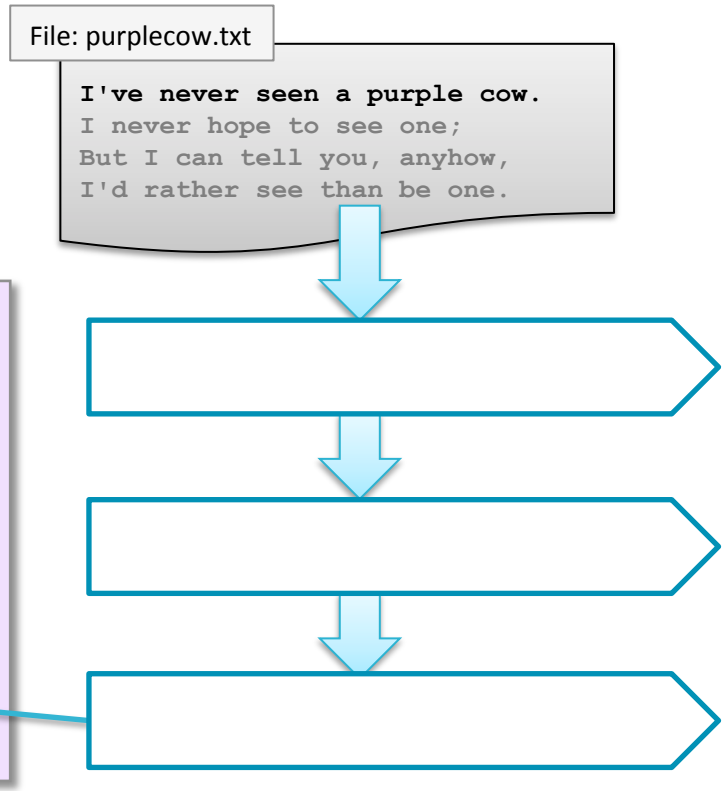
```
> val mydata = sc.textFile("purplecow.txt")
> val mydata_uc = mydata.map(line =>
  line.toUpperCase())
> val mydata_filt = mydata_uc.filter(line
  => line.startsWith("I"))
> mydata_filt.take(2)
```



Pipelining (4)

- **When possible, Spark will perform sequences of transformations by row so no data is stored**

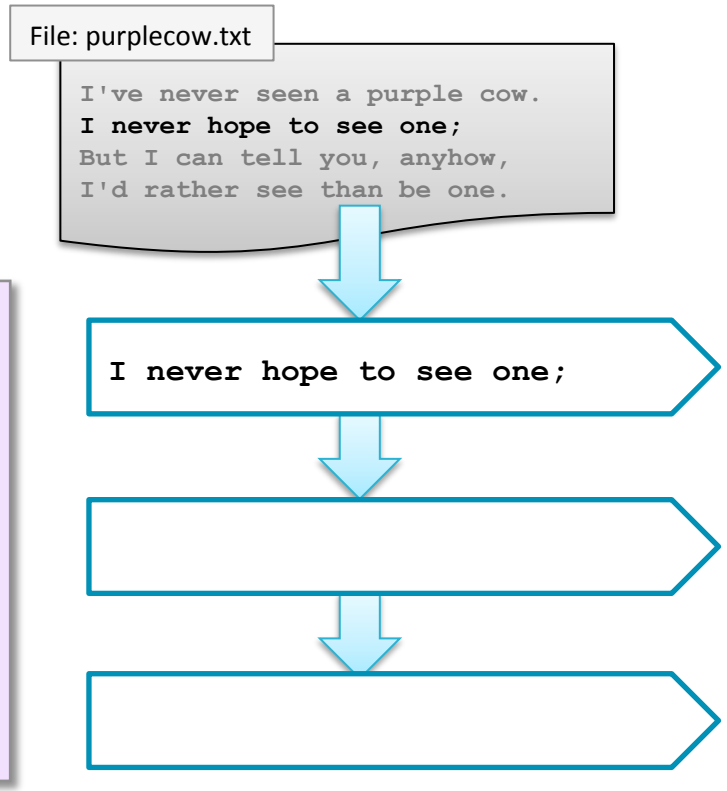
```
> val mydata = sc.textFile("purplecow.txt")
> val mydata_uc = mydata.map(line =>
  line.toUpperCase())
> val mydata_filt = mydata_uc.filter(line
  => line.startsWith("I"))
> mydata_filt.take(2)
I'VE NEVER SEEN A PURPLE COW.
```



Pipelining (5)

- **When possible, Spark will perform sequences of transformations by row so no data is stored**

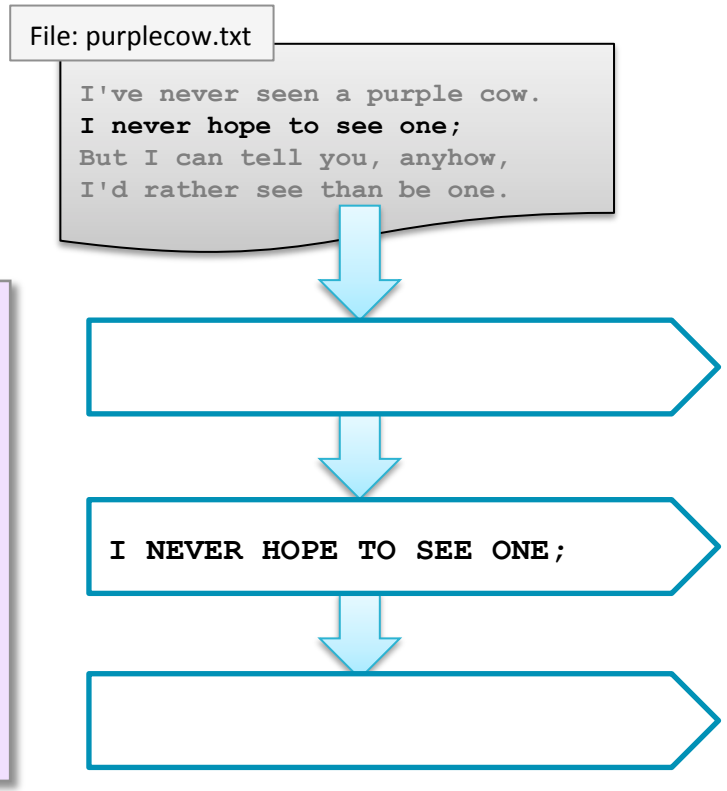
```
> val mydata = sc.textFile("purplecow.txt")
> val mydata_uc = mydata.map(line =>
  line.toUpperCase())
> val mydata_filt = mydata_uc.filter(line
  => line.startsWith("I"))
> mydata_filt.take(2)
I'VE NEVER SEEN A PURPLE COW.
```



Pipelining (6)

- **When possible, Spark will perform sequences of transformations by row so no data is stored**

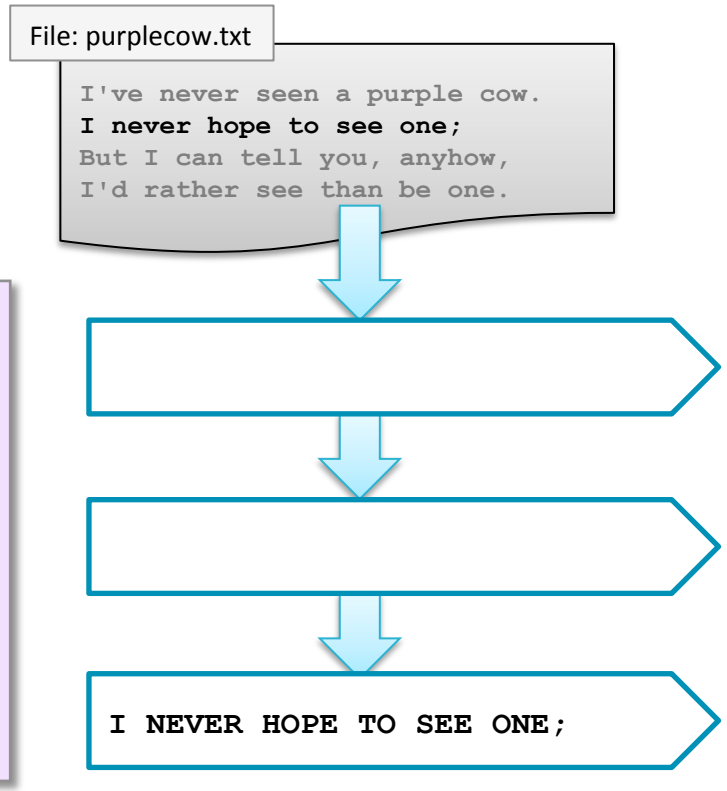
```
> val mydata = sc.textFile("purplecow.txt")
> val mydata_uc = mydata.map(line =>
  line.toUpperCase())
> val mydata_filt = mydata_uc.filter(line
  => line.startsWith("I"))
> mydata_filt.take(2)
I'VE NEVER SEEN A PURPLE COW.
```



Pipelining (7)

- **When possible, Spark will perform sequences of transformations by row so no data is stored**

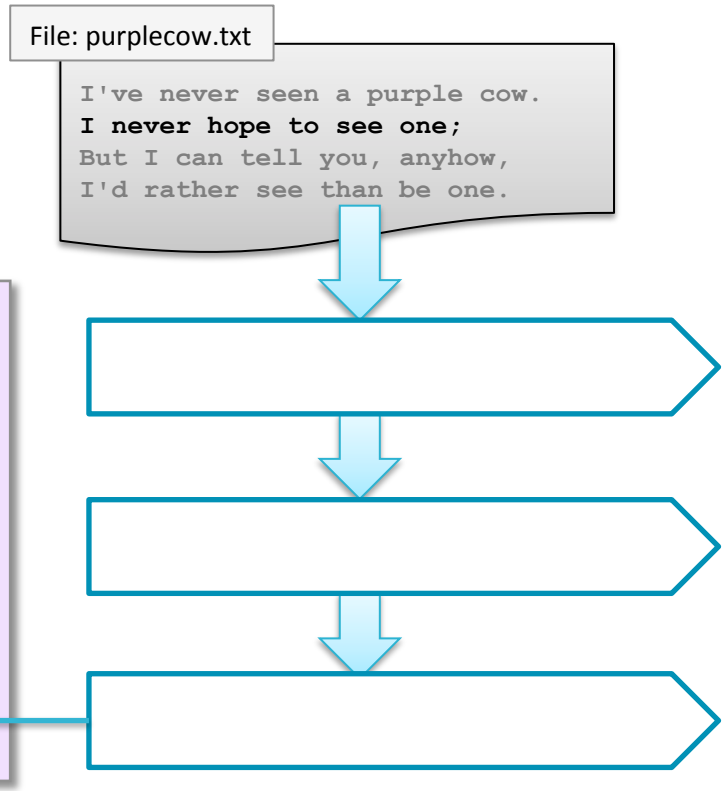
```
> val mydata = sc.textFile("purplecow.txt")
> val mydata_uc = mydata.map(line =>
  line.toUpperCase())
> val mydata_filt = mydata_uc.filter(line
  => line.startsWith("I"))
> mydata_filt.take(2)
I'VE NEVER SEEN A PURPLE COW.
```



Pipelining (8)

- **When possible, Spark will perform sequences of transformations by row so no data is stored**

```
> val mydata = sc.textFile("purplecow.txt")
> val mydata_uc = mydata.map(line =>
  line.toUpperCase())
> val mydata_filt = mydata_uc.filter(line
  => line.startsWith("I"))
> mydata_filt.take(2)
I'VE NEVER SEEN A PURPLE COW.
I NEVER HOPE TO SEE ONE;
```



Chapter Topics

Spark Basics | **Distributed Data Processing with Spark**

- What is Apache Spark?
- Using the Spark Shell
- RDDs (Resilient Distributed Datasets)
- **Functional Programming in Spark**
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Functional Programming in Spark

- **Spark depends heavily on the concepts of *functional programming***
  - Functions are the fundamental unit of programming
  - Functions have input and output only
    - No state or side effects
- **Key concepts**
  - Passing functions as input to other functions
  - Anonymous functions

Passing Functions as Parameters

- **Many RDD operations take functions as parameters**
- **Pseudocode for the RDD map operation**
  - Applies function **`fn`** to each record in the RDD

```
RDD {
    map(fn(x)) {
        foreach record in rdd
        emit fn(record)
    }
}
```

Example: Passing Named Functions

- **Python**

```
> def toUpper(s):
     return s.upper()
> mydata = sc.textFile("purplecow.txt")
> mydata.map(toUpper).take(2)
```

- **Scala**

```
> def toUpper(s: String): String =
    { s.toUpperCase }
> val mydata = sc.textFile("purplecow.txt")
> mydata.map(toUpper).take(2)
```

Anonymous Functions

- **Functions defined in-line without an identifier**
  - Best for short, one-off functions
- **Supported in many programming languages**
  - Python: `lambda x: ...`
  - Scala: `x => ...`
  - Java 8: `x -> ...`

Example: Passing Anonymous Functions

- **Python:**

```
> mydata.map(lambda line: line.upper()).take(2)
```

- **Scala:**

```
> mydata.map(line => line.toUpperCase()).take(2)
```

OR

```
> mydata.map(_.toUpperCase()).take(2)
```

Scala allows anonymous parameters using underscore (_)

Example: Java

Java 7

```
...
  JavaRDD<String> lines = sc.textFile("file");
  JavaRDD<String> lines_uc = lines.map(
    new MapFunction<String, String>() {
      public String call(String line) {
        return line.toUpperCase();
      }
    });
...
```

Java 8

```
...
 JavaRDD<String> lines = sc.textFile("file");
 JavaRDD<String> lines_uc = lines.map(
    line -> line.toUpperCase());
...
```

Chapter Topics

Spark Basics | **Distributed Data Processing with Spark**

- What is Apache Spark?
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- Functional Programming With Spark
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Essential Points

- **Spark can be used interactively via the Spark Shell**
  - Python or Scala
  - Writing non-interactive Spark applications will be covered later
- **RDDs (Resilient Distributed Datasets) are a key concept in Spark**
- **RDD Operations**
  - Transformations create a new RDD based on an existing one
  - Actions return a value from an RDD
- **Lazy Execution**
  - Transformations are not executed until required by an action
- **Spark uses functional programming**
  - Passing functions as parameters
  - Anonymous functions in supported languages (Python and Scala)

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- **Homework Assignments**

Spark Homework: Pick Your Language

- **Your choice: Python or Scala**
  - For the Spark-based homework assignments in this course, you may choose to work with either Python or Scala
- **Conventions:**
  - `.pyspark` – Python shell commands
  - `.scalaspark` – Scala shell commands
  - `.py` – Python Spark applications
  - `.scala` – Scala Spark applications

Spark Homework Assignments

- **There are three homework assignments for this chapter**
  1. *View the Spark Documentation*
     - Familiarize yourself with the Spark documentation; you will refer to this documentation frequently during the course
  2. *Explore RDDs Using the Spark Shell*
     - Follow the instructions for either the Python or Scala shell
  3. *Use RDDs to Transform a Dataset*
     - Explore Loudacre web log files
- **Please refer to the Homework description**