

Algorithms and Applications of Data Mining - Introduction to Spark

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Thanks for source slide and material to: Dr. Heather Miller
<https://www.coursera.org/learn/scala-spark-big-data/home/welcome>

Why Need MapReduce

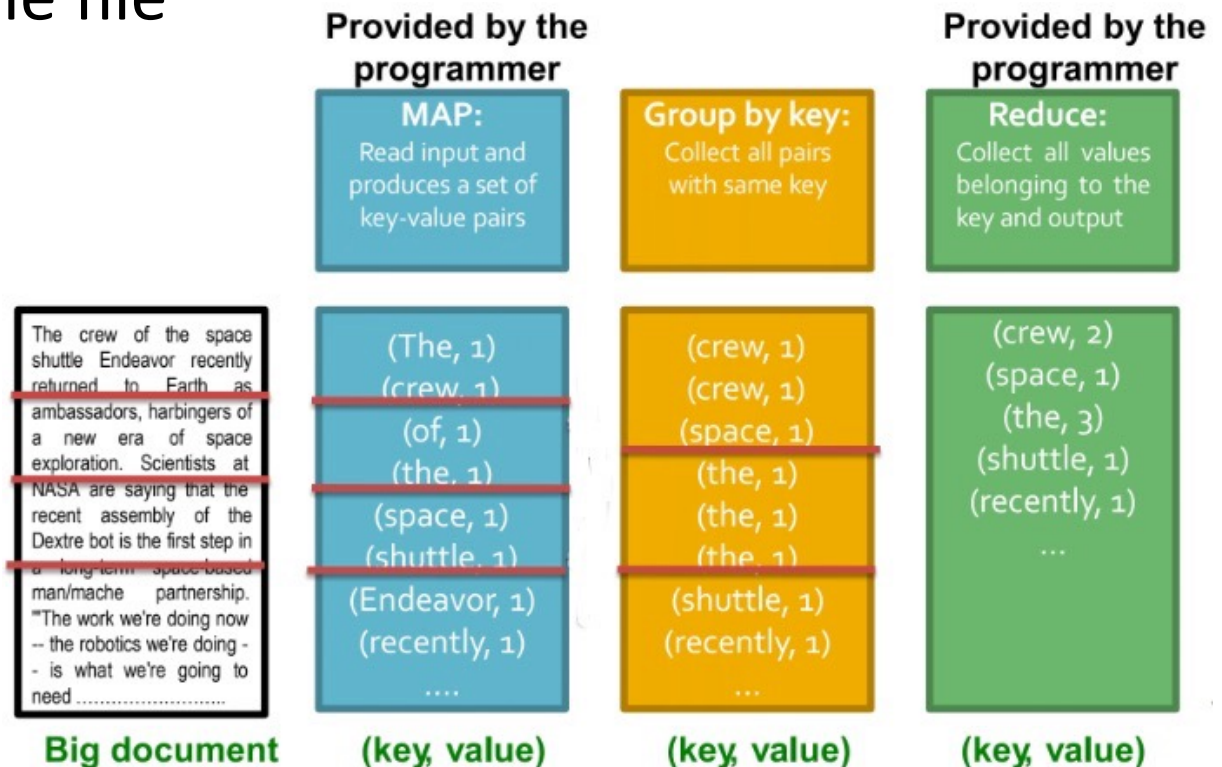
- Challenges in large-scale computing
 - How to distribute computation (moving data around is time-consuming)
 - How to make it easy to write distributed programs
 - How to handle machine failures

What Is MapReduce

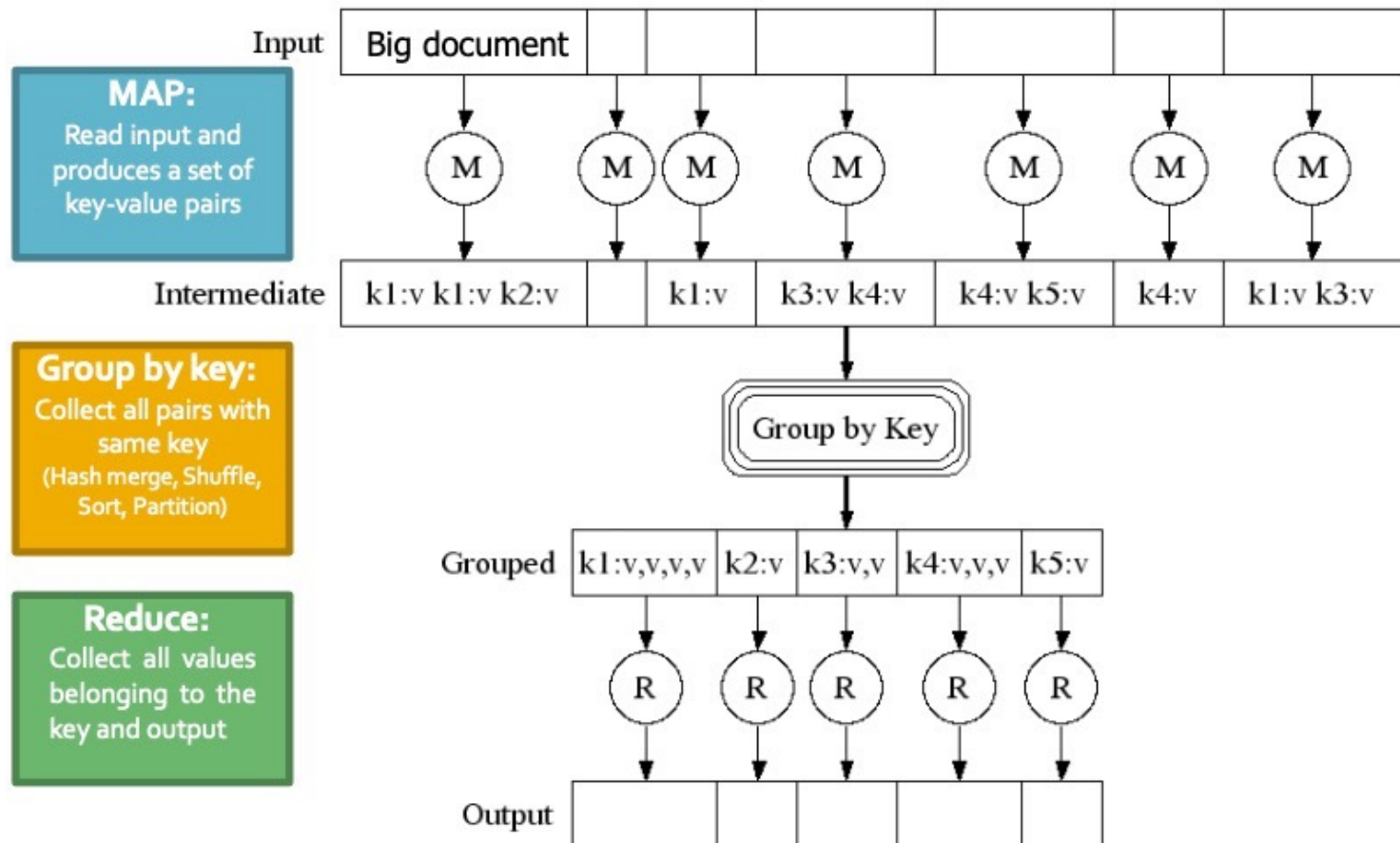
- MapReduce addresses these problems
 - Master Node: Coordinate worker nodes
 - Map worker/node: Extract something you care about, usually data are represented as (key, value) pairs
 - Reduce worker/node: Aggregate, summarize, ...

MapReduce: Word Count

- Task: We have a huge text document, and we want to count the number of times each distinct word appears in the file

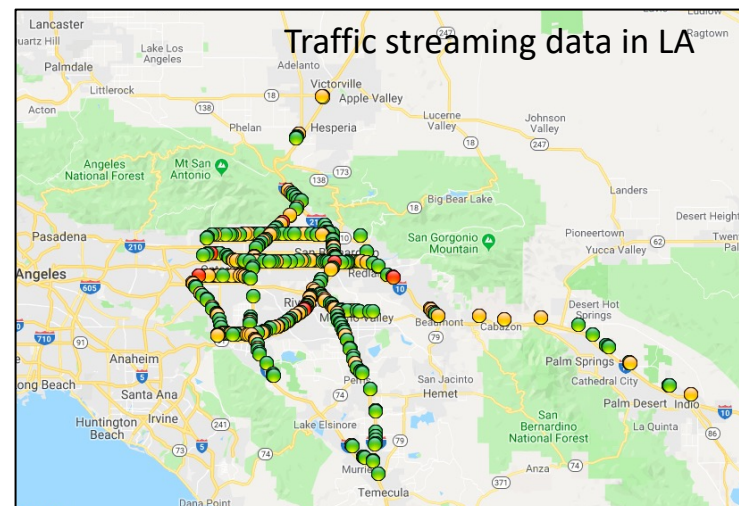
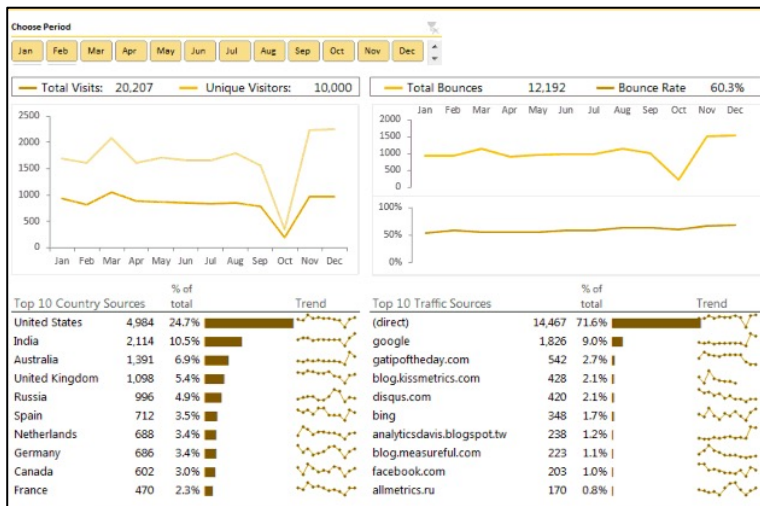


MapReduce: The Diagram



What Is Spark

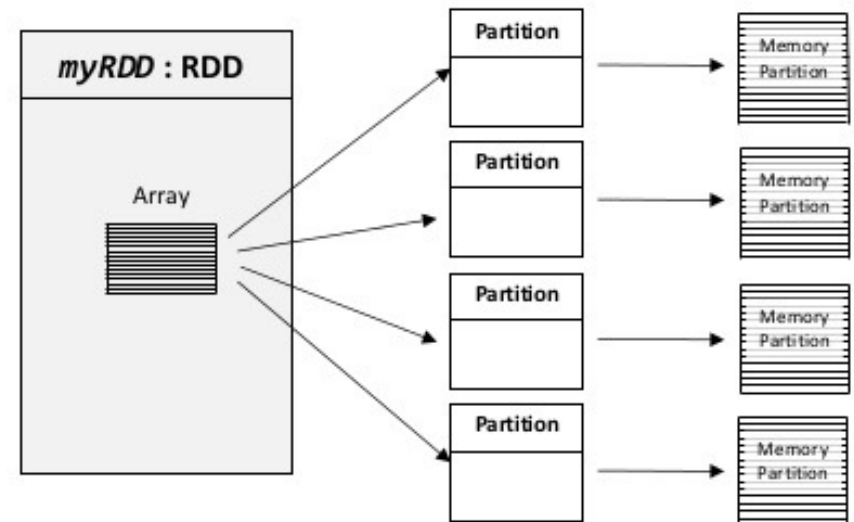
- **Apache Spark** is an open-source cluster-computing framework for large-scale data processing



How Does Spark Work?

- Resilient Distributed Datasets (RDDs)
- An **immutable, in-memory collection** of objects
- Each RDD can be split into multiple partitions, which in turn are computed on different nodes of the cluster

- RDDs are like collections
 - `RDD[T]` and `List[T]`



SparkContext Object

- Create a SparkContext Object to start
 - Can be thought as your handle to the Spark Cluster

```
if __name__ == '__main__':  
  
    sc_conf = pyspark.SparkConf() \  
        .setAppName('task1') \  
        .setMaster('local[*]') \  
        .set('spark.driver.memory', '8g') \  
        .set('spark.executor.memory', '4g')  
  
    sc = pyspark.SparkContext(conf=sc_conf)  
    sc.setLogLevel("OFF")
```


How To Create An RDD

- Create from a SparkContext object
 - **Parallelize:** convert a local collection to an RDD

```
a_list = ['you', 'jump', 'I', 'jump', '']  
a_rdd = sc.parallelize(a_list) # RDD[String]
```

- **TextFile:** read a file from HDFS or local file system

```
input_file = 'work-count-sample-doc.txt'  
text_rdd = sc.textFile(input_file)
```

How To Create An RDD (Cont.)

- Transform from an existing RDD
 - E.g., calling a *map operation* on an existing RDD, it will return a new RDD

```
# call a map operation on an RDD  
length_rdd = word_rdd.map(lambda x: len(x)) # RDD[Int]
```

RDD Operations

- Transformations:
 - E.g., map, filter, ...

```
# call a map operation on an RDD
length_rdd = word_rdd.map(lambda x: len(x)) # RDD[Int]
```

- Actions:
 - E.g., collect, reduce, ...

```
a_coll = a_rdd.collect() # RDD -> collection
print(a_coll) # ['you', 'jump', 'I', 'jump', '']
```

Transformations VS. Actions

- Transformations

- Return new RDDs as results
- They are **lazy**, the result RDD is **not immediately** computed

```
# call a map operation on an RDD
length_rdd = word_rdd.map(lambda x: len(x)) # RDD[Int]
```

- Actions

- Compute a result based on an RDD, and returned
- They are **eager**, the result is **immediately computed**

```
a_coll = a_rdd.collect() # RDD -> collection
print(a_coll) # ['you', 'jump', 'I', 'jump', '']
```

Common Transformations

map **map[T](f: A=>B): RDD[T]**

Apply function to each element in the RDD and return an RDD of the result.

flatMap **flatMap[T](f: A=>B): RDD[T]**

Apply function to each element in the RDD and return an RDD of the result, but output is flattened.

filter **filter[T](pred: A=>Boolean): RDD[T]**

Apply predicate function, pred, to each element in the RDD and return an RDD of elements that passed the condition.

distinct **distinct():RDD[T]**

Return an RDD with duplicates removed



Common Actions

- collect** **collect(): Array[T]**
Return all elements from RDD.
- count** **count(): Long**
Return the number of elements in the RDD.
- take** **take(num: Int): Array[T]**
Return the first <num> elements of the RDD.
- reduce** **reduce(op: (A, A) => A): A**
Combine the elements in the RDD together using op function and return result.
- foreach** **foreach(f: A => Unit): Unit**
Apply function to each element in the RDD and return Unit.

Example

- Consider the following example:

```
a_list = ['you', 'jump', 'I', 'jump', '']  
# create an RDD from a list  
a_rdd = sc.parallelize(a_list) # RDD[String]  
# call a map operation RDD  
a_len_rdd = a_rdd.map(lambda x: len(x)) # RDD[Int]
```

What has happened on the cluster at this point?

Example (Cont.)

- Consider the following example:

```
a_list = ['you', 'jump', 'I', 'jump', '']  
# create an RDD from a list  
a_rdd = sc.parallelize(a_list) # RDD[String]  
# call a map operation RDD  
a_len_rdd = a_rdd.map(lambda x: len(x)) # RDD[Int]
```

What has happened on the cluster at this point?

Nothing. Execution of map (a transformation) is deferred.

Example (Cont.)

- Consider the following example:

```
a_list = ['you', 'jump', 'I', 'jump', '']  
# create an RDD from a list  
a_rdd = sc.parallelize(a_list) # RDD[String]  
# call a map operation RDD  
a_len_rdd = a_rdd.map(lambda x: len(x)) # RDD[Int]
```

How to ensure this computation is done on the cluster?

Example (Cont.)

- Consider the following example:

```
a_list = ['you', 'jump', 'I', 'jump', '']  
# create an RDD from a list  
a_rdd = sc.parallelize(a_list) # RDD[String]  
# call a map operation RDD  
a_len_rdd = a_rdd.map(lambda x: len(x)) # RDD[Int]  
  
total_len = a_len_rdd.reduce(lambda a, b: a + b) # 12
```

add an action, *reduce*

Spark starts the execution when an action is called

Return the total number of characters in the entire RDD of strings

Benefits of Laziness

- Another example:

```
input_path = './work-count-sample-doc.txt'  
data = sc.textFile(input_path)  
first10 = data.map(lambda line: line.split(' ')).take(10)
```

Benefits of Laziness (Cont.)

- Another example:

```
input_path = './work-count-sample-doc.txt'  
data = sc.textFile(input_path)  
first10 = data.map(lambda line: line.split(' ')).take(10)
```

- The execution of filter is deferred until the take happens
- Spark will not compute intermediate RDDs. As soon as 10 elements are picked, first10 is done.

Benefits of Laziness (Cont.)

- Another example:

```
input_path = './work-count-sample-doc.txt'  
data = sc.textFile(input_path)  
first10 = data.map(lambda line: line.split(' ')).take(10)
```

- Spark leverages this by analyzing and optimizing the chain of operations before executing it
- Spark saves time and space to compute elements of the unused result of the filter operation

Word Count Example

- Let's start!

If You Want To Learn More

- Official documentation
 - <http://spark.apache.org/docs/latest/>
- Coursera: Big Data Analysis with Scala and Spark
- Books
 - Learning Spark, O' Reilly
 - Advanced Analytics with Spark: Patterns for Learning from Data at Scale, O' Reilly
 - Machine Learning with Spark, Packt