Big data: architectures and data analytics

Spark MLlib

Textual data classification

Textual data classification

- The following slides show how to
  - Create a classification model based on the logistic regression algorithm for **textual documents**
  - Apply the model to new textutal documents
- The input training dataset represents a textual document collection
  - Each line contains one document and its class
    - The class label
    - A list of words (the text of the document)

Textual data classification

- Consider the following example file

  1,The Spark system is based on scala
  1,Spark is a new distributed system
  0,Turin is a beautiful city
  0,Turin is in the north of Italy
- It contains four textual documents
- Each line contains two attributes
  - The class label (first attribute)
  - The text of the document (second attribute)

Textual data classification

- DataFrame associated with the input data before pre-processing

Label	Text
1	The Spark system is based on scala
1	Spark is a new distributed system
0	Turin is a beautiful city
0	Turin is in the north of Italy

Textual data classification

- A set of preprocessing steps must be applied on the textual attribute before generating a classification model

Textual data classification

1. Since Spark ML algorithms work only on "Table", the textual part of the input data must be translated in a set of attributes in order to represent the data as a table
   - Usually a table with an attribute for each word is generated

Textual data classification

2. Many words are useless (e.g., conjunctions)
   - Stopwords are usually removed

Textual data classification

- The words appearing in almost all documents are not characterizing the data
  - Hence, they are not very important for the classification problem
- The words appearing in few documents allow distinguish the content of those documents (and hence the class label) with respect to the others
  - Hence, they are very important for the classification problem

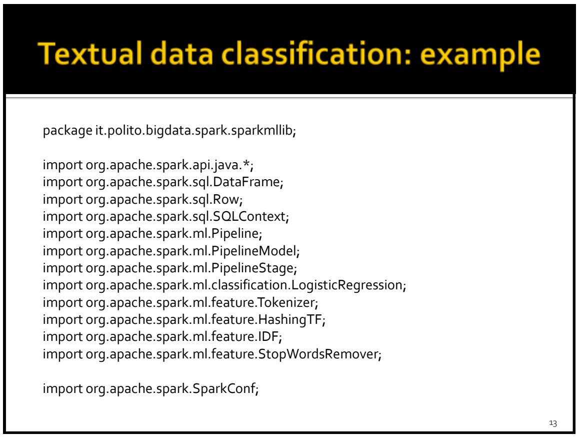
Textual data classification

3. Traditionally a weight, based on the TF-IDF measure, is used to assign a difference importance to the words based on their frequency in the collection

Textual data classification

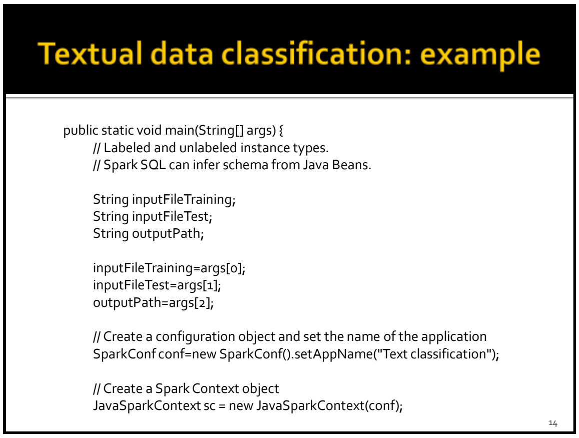
- DataFrame associated with the input data after the transformations (tokenization, stopword removal, TF-IDF computation)

Label	Spark	system	scala	…..
1	0.5	0.3	0.75	..
1	0.5	0.3	0	…
0	0	0	0	…
0	0	0	0	…



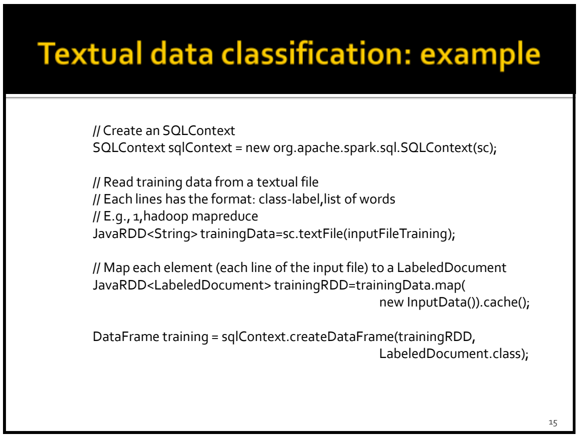
Textual data classification: example

```
package it.polito.bigdata.spark.sparkmllib;

import org.apache.spark.api.java.*;
import org.apache.spark.sql.DataFrame;
import org.apache.spark.sql.Row;
import org.apache.spark.sql.SQLContext;
import org.apache.spark.ml.Pipeline;
import org.apache.spark.ml.PipelineModel;
import org.apache.spark.ml.PipelineStage;
import org.apache.spark.ml.classification.LogisticRegression;
import org.apache.spark.ml.feature.Tokenizer;
import org.apache.spark.ml.feature.HashingTF;
import org.apache.spark.ml.feature.IDF;
import org.apache.spark.ml.feature.StopWordsRemover;

import org.apache.spark.SparkConf;
```



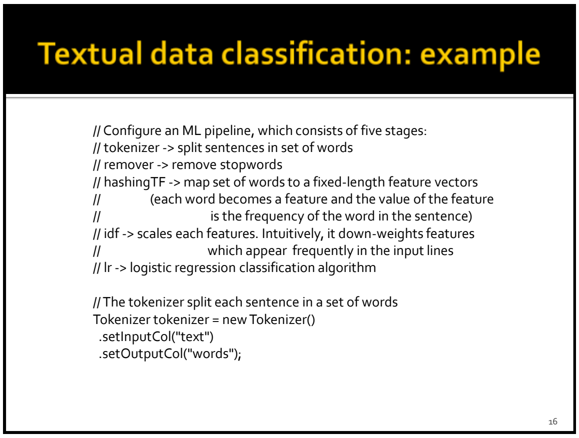
Textual data classification: example

```
public static void main(String[] args) {
    // Labeled and unlabeled instance types.
    // Spark SQL can infer schema from Java Beans.

    String inputFileTraining;
    String inputFileTest;
    String outputPath;

    inputFileTraining=args[0];
    inputFileTest=args[1];
    outputPath=args[2];

    // Create a configuration object and set the name of the application
    SparkConf conf=new SparkConf().setAppName("Text classification");

    // Create a Spark Context object
    JavaSparkContext sc = new JavaSparkContext(conf);
```



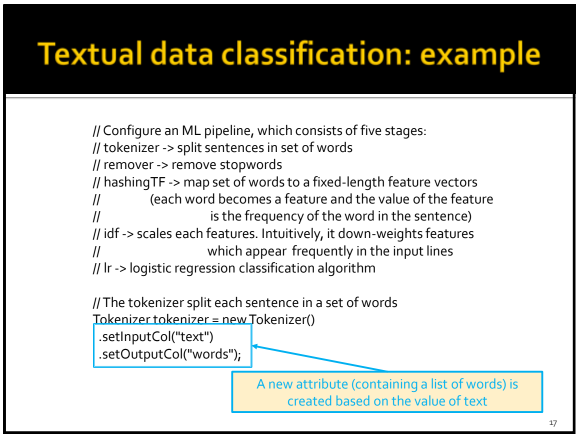
Textual data classification: example

```
// Create an SQLContext
SQLContext sqlContext = new org.apache.spark.sql.SQLContext(sc);

// Read training data from a textual file
// Each lines has the format: class-label,list of words
// E.g., 1,hadoop mapreduce
JavaRDD<String> trainingData=sc.textFile(inputFileTraining);

// Map each element (each line of the input file) to a LabeledDocument
JavaRDD<LabeledDocument> trainingRDD=trainingData.map(
                                    new InputData()).cache();

DataFrame training = sqlContext.createDataFrame(trainingRDD,
                                    LabeledDocument.class);
```



Textual data classification: example

```
// Configure an ML pipeline, which consists of five stages:
// tokenizer -> split sentences in set of words
// remover -> remove stopwords
// hashingTF -> map set of words to a fixed-length feature vectors
//          (each word becomes a feature and the value of the feature
//                   is the frequency of the word in the sentence)
// idf -> scales each features. Intuitively, it down-weights features
//                   which appear  frequently in the input lines
// lr -> logistic regression classification algorithm

// The tokenizer split each sentence in a set of words
Tokenizer tokenizer = new Tokenizer()
  .setInputCol("text")
  .setOutputCol("words");
```



Textual data classification: example

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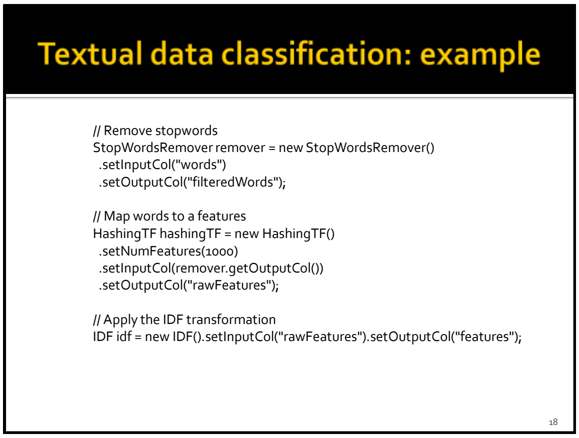
// The tokenizer split each sentence in a set of words
Tokenizer tokenizer = new Tokenizer()
  .setInputCol("text")
  .setOutputCol("words");
```

A new attribute (containing a list of words) is created based on the value of text

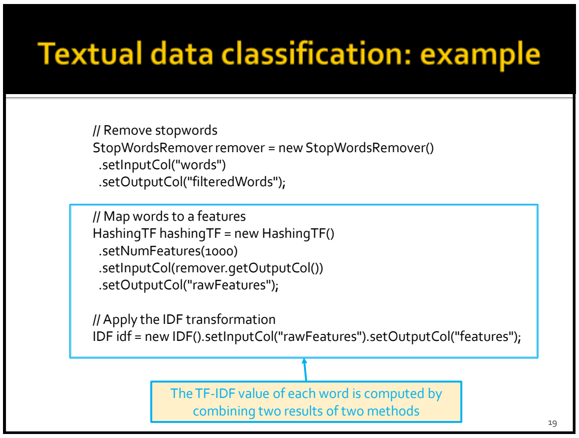


Textual data classification: example

```
// Remove stopwords
StopWordsRemover remover = new StopWordsRemover()
  .setInputCol("words")
  .setOutputCol("filteredWords");

// Map words to a features
HashingTF hashingTF = new HashingTF()
  .setNumFeatures(1000)
  .setInputCol(remover.getOutputCol())
  .setOutputCol("rawFeatures");

// Apply the IDF transformation
IDF idf = new IDF().setInputCol("rawFeatures").setOutputCol("features");
```



Textual data classification: example

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IDF idf = new IDF().setInputCol("rawFeatures").setOutputCol("features");
```
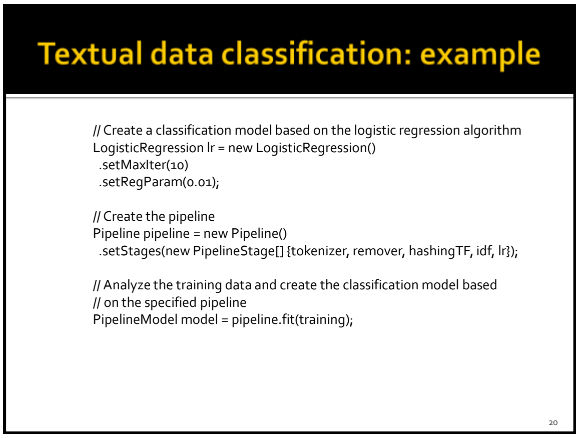
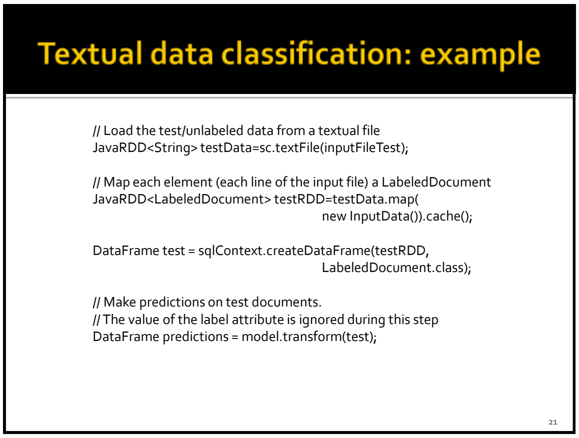

The TF-IDF value of each word is computed by combining two results of two methods



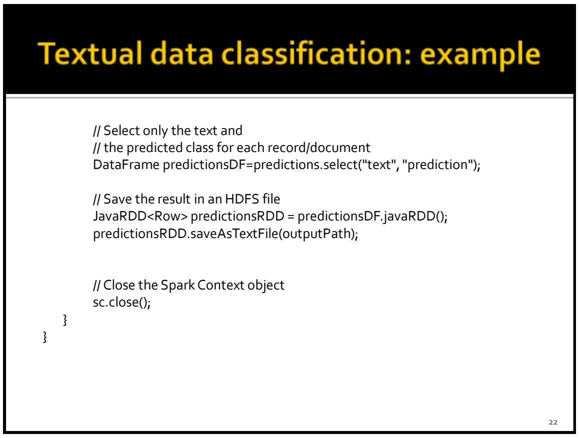
Textual data classification: example

```
// Create a classification model based on the logistic regression algorithm
LogisticRegression lr = new LogisticRegression()
  .setMaxIter(10)
  .setRegParam(0.01);

// Create the pipeline
Pipeline pipeline = new Pipeline()
  .setStages(new PipelineStage[] {tokenizer, remover, hashingTF, idf, lr});

// Analyze the training data and create the classification model based
// on the specified pipeline
PipelineModel model = pipeline.fit(training);
```



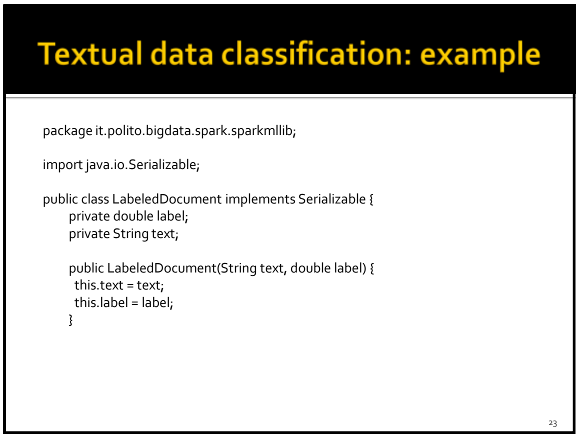
Textual data classification: example

```
// Load the test/unlabeled data from a textual file
JavaRDD<String> testData=sc.textFile(inputFileTest);

// Map each element (each line of the input file) a LabeledDocument
JavaRDD<LabeledDocument> testRDD=testData.map(
                                        new InputData()).cache();

DataFrame test = sqlContext.createDataFrame(testRDD,
                                        LabeledDocument.class);

// Make predictions on test documents.
// The value of the label attribute is ignored during this step
DataFrame predictions = model.transform(test);
```



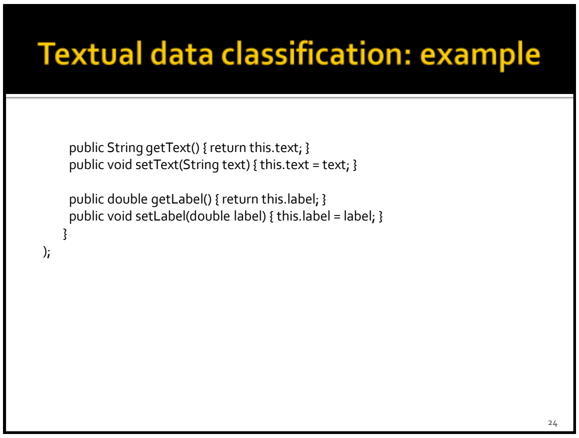
Textual data classification: example

```
        // Select only the text and
        // the predicted class for each record/document
        DataFrame predictionsDF=predictions.select("text", "prediction");

        // Save the result in an HDFS file
        JavaRDD<Row> predictionsRDD = predictionsDF.javaRDD();
        predictionsRDD.saveAsTextFile(outputPath);


        // Close the Spark Context object
        sc.close();
    }
}
```



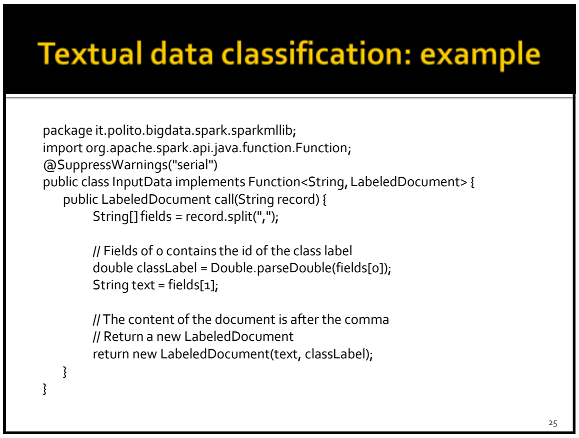
Textual data classification: example

```
package it.polito.bigdata.spark.sparkmllib;

import java.io.Serializable;

public class LabeledDocument implements Serializable {
    private double label;
    private String text;

    public LabeledDocument(String text, double label) {
      this.text = text;
      this.label = label;
    }
```



Textual data classification: example

```
        public String getText() { return this.text; }
        public void setText(String text) { this.text = text; }

        public double getLabel() { return this.label; }
        public void setLabel(double label) { this.label = label; }
    }
);
```



Textual data classification: example

```
package it.polito.bigdata.spark.sparkmllib;
import org.apache.spark.api.java.function.Function;
@SuppressWarnings("serial")
public class InputData implements Function<String, LabeledDocument> {
    public LabeledDocument call(String record) {
          String[] fields = record.split(",");

          // Fields of 0 contains the id of the class label
          double classLabel = Double.parseDouble(fields[0]);
          String text = fields[1];

          // The content of the document is after the comma
          // Return a new LabeledDocument
          return new LabeledDocument(text, classLabel);
    }
}
```