Big data: architectures and data analytics

Clustering algorithms

Clustering algorithms

- Spark MLlib provides a (limited) set of clustering algorithms
  - K-means
  - Gaussian mixture
  - …

3

Clustering

- Each clustering algorithm has its own parameters
- However, all the provided algorithms identify a set of groups of objects/clusters and assign each input object to one single cluster
- All the clustering algorithms available in Spark work only with numerical data
  - Categorical values must be mapped to integer values (i.e, numerical values)

4

K-means clustering algorithm

K-means clustering algorithm

- K-means is one of the most popular clustering algorithms
- It is characterized by one important parameter
  - The number of clusters K
    - The choice of K is a complex operation
- It is able to identify only spherical shaped clusters

6

K-means clustering algorithm

- The following slides show how to
  - Cluster the input data by means of the **K-means algorithm**
- The input dataset is a structured dataset with a fixed number of attributes
  - All the attributes are numerical attributes
  - Data must be normalized before applying the clustering algorithm in order to give the same importance to all attributes

7

K-means clustering algorithm

- Example of input file

  0.5,0.9,1.0

  0.6,0.6,0.7
- In the following example code we suppose that the input data are already normalized
  - E.g., All values are already in the range [0-1]

8

K-means clustering algorithm: 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.sql.types.Metadata;
import org.apache.spark.sql.types.StructField;
import org.apache.spark.sql.types.StructType;
import org.apache.spark.mllib.linalg.VectorUDT;
import org.apache.spark.ml.Pipeline;
import org.apache.spark.ml.PipelineModel;
import org.apache.spark.ml.PipelineStage;
import org.apache.spark.ml.clustering.KMeans;

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

K-means clustering algorithm: example

```
public class SparkDriver {

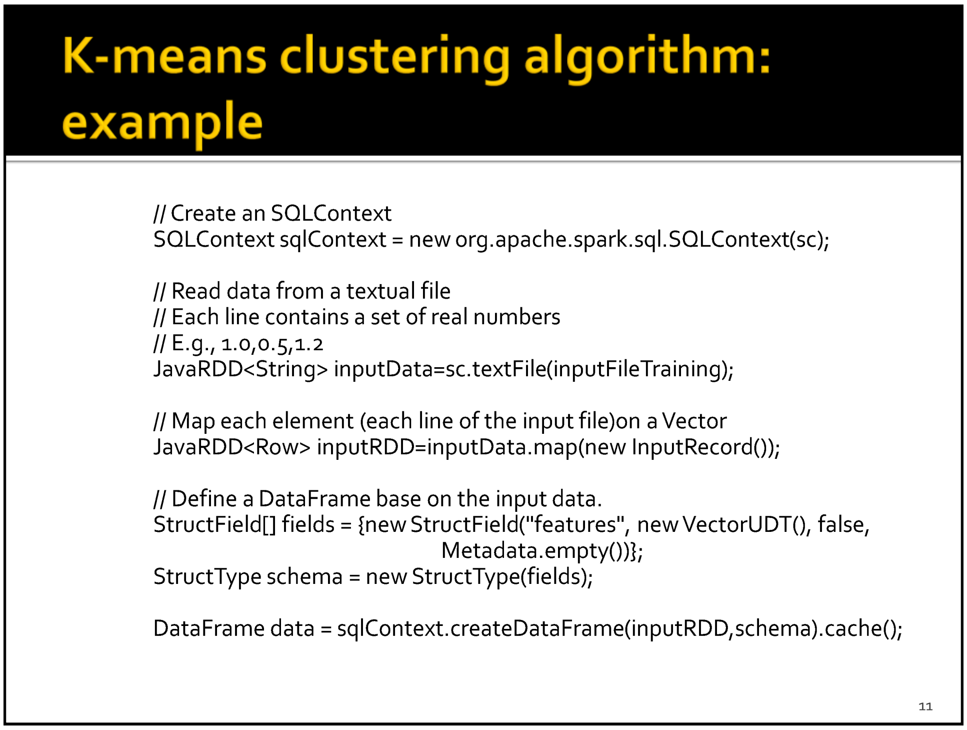
    public static void main(String[] args) {

        String inputFileTraining;
        String outputPath;

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

        // Create a configuration object and set the name of the application
        SparkConf conf=new SparkConf().setAppName("MLlib - k-means");

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



K-means clustering algorithm: example

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

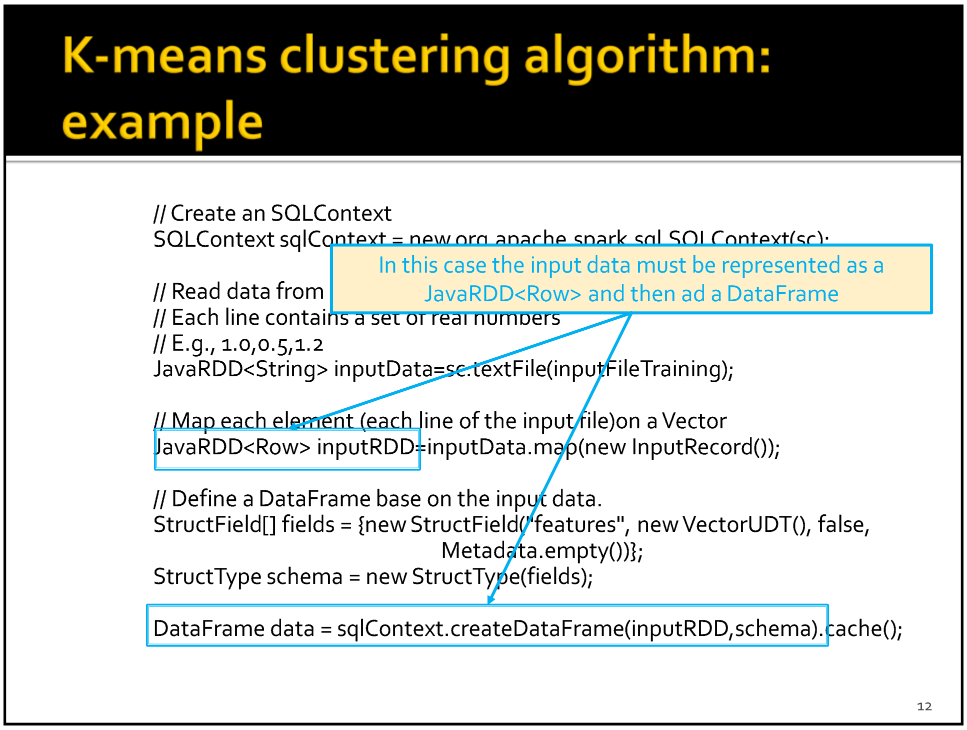
// Read data from a textual file
// Each line contains a set of real numbers
// E.g., 1.0,0.5,1.2
JavaRDD<String> inputData=sc.textFile(inputFileTraining);

// Map each element (each line of the input file)on a Vector
JavaRDD<Row> inputRDD=inputData.map(new InputRecord());

// Define a DataFrame base on the input data.
StructField[] fields = {new StructField("features", new VectorUDT(), false,
                              Metadata.empty())};
StructType schema = new StructType(fields);

DataFrame data = sqlContext.createDataFrame(inputRDD,schema).cache();
```

11



K-means clustering algorithm: example

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In this case the input data must be represented as a JavaRDD<Row> and then ad a DataFrame

12

K-means clustering algorithm: example

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```

We must specify what is the schema of the Row objects and assign a name to the list of features

13

K-means clustering algorithm: example

```
// Create a k-means object.
// k-means is an Estimator that is used to
// create a k-means algorithm
KMeans km = new KMeans();

// Set the value of k ( = number of clusters)
km.setK(2);

// Define the pipeline that is used to cluster
// the input data
// In this case the pipeline contains one single stage/step (the model
// generation step).
Pipeline pipeline = new Pipeline()
                            .setStages(new PipelineStage[] {km});
```

14

K-means clustering algorithm: example

```
            // Execute the pipeline on the data to build the
            // clustering model
            PipelineModel model = pipeline.fit(data);

            // Now the clustering model can be applied on the data
            // to assign them to a cluster (i.e., assign a cluster id)
            // The returned DataFrame has the following schema (attributes)
            // - features: vector (values of the attributes)
            // - prediction: double (the predicted cluster id)
            DataFrame clusteredData = model.transform(data);

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

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

15

K-means clustering algorithm: example

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

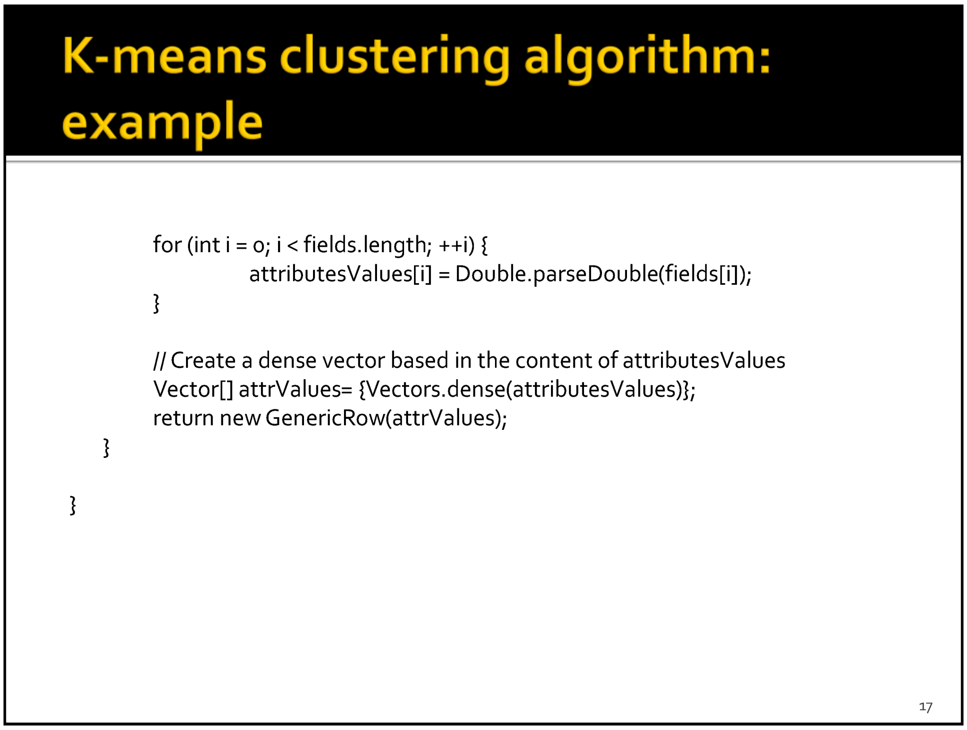
import org.apache.spark.api.java.function.Function;
import org.apache.spark.mllib.linalg.Vectors;
import org.apache.spark.sql.Row;
import org.apache.spark.mllib.linalg.Vector;
import org.apache.spark.sql.catalyst.expressions.GenericRow;

@SuppressWarnings("serial")
public class InputRecord implements Function<String, Row> {

      public Row call(String record) {
            String[] fields = record.split(",");

            // Create a vector of double. One value for each attribute
            double[] attributesValues = new double[fields.length];
```

16



K-means clustering algorithm: example

```
                for (int i = 0; i < fields.length; ++i) {
                                attributesValues[i] = Double.parseDouble(fields[i]);
                }

                // Create a dense vector based in the content of attributesValues
                Vector[] attrValues= {Vectors.dense(attributesValues)};
                return new GenericRow(attrValues);
        }

}
```

17