Big data: architectures and data analytics

Spark - Exercises

Exercise #30

- Log filtering
  - Input: a simplified log of a web server (i.e., a textual file)
    - Each line of the file is associated with a URL request
  - Output: the lines containing the word "google"
    - Store the output in an HDFS folder

Exercise #30 - Example

- Input file

```
66.249.69.97 - - [24/Sep/2014:22:25:44 +0000] "GET http://www.google.com/bot.html"
66.249.69.97 - - [24/Sep/2014:22:26:44 +0000] "GET http://www.google.com/how.html"
66.249.69.97 - - [24/Sep/2014:22:28:44 +0000] "GET http://dbdmg.polito.it/course.html"
71.19.157.179 - - [24/Sep/2014:22:30:12 +0000] "GET http://www.google.com/faq.html"
66.249.69.97 - - [24/Sep/2014:31:28:44 +0000] "GET http://dbdmg.polito.it/thesis.html"
```

- Output

```
66.249.69.97 - - [24/Sep/2014:22:25:44 +0000] "GET http://www.google.com/bot.html"
66.249.69.97 - - [24/Sep/2014:22:26:44 +0000] "GET http://www.google.com/how.html"
71.19.157.179 - - [24/Sep/2014:22:30:12 +0000] "GET http://www.google.com/faq.html"
```


Exercise #31

- Log analysis
  - Input: log of a web server (i.e., a textual file)
    - Each line of the file is associated with a URL request
  - Output: the list of distinct IP addresses associated with the connections to a google page (i.e., connections to URLs containing the term "www.google.com")
    - Store the output in an HDFS folder

Exercise #31 - Example

- Input file

```
66.249.69.97 - - [24/Sep/2014:22:25:44 +0000] "GET http://www.google.com/bot.html"
66.249.69.97 - - [24/Sep/2014:22:26:44 +0000] "GET http://www.google.com/how.html"
66.249.69.97 - - [24/Sep/2014:22:28:44 +0000] "GET http://dbdmg.polito.it/course.html"
71.19.157.179 - - [24/Sep/2014:22:30:12 +0000] "GET http://www.google.com/faq.html"
66.249.69.95 - - [24/Sep/2014:31:28:44 +0000] "GET http://dbdmg.polito.it/thesis.html"
66.249.69.97 - - [24/Sep/2014:56:26:44 +0000] "GET http://www.google.com/how.html"
56.249.69.97 - - [24/Sep/2014:56:26:44 +0000] "GET http://www.google.com/how.html"
```

- Output

```
66.249.69.97
71.19.157.179
56.249.69.97
```

Exercise #32

- Maximum value
  - Input: a collection of (structured) textual csv files containing the daily value of PM10 for a set of sensors
    - Each line of the files has the following format

      sensorId,date,PM10 value (μg/m³)\n
  - Output: report the maximum value of PM10
    - Print the result on the standard output

Exercise #32 - Example

- Input file

```
s1,2016-01-01,20.5
s2,2016-01-01,30.1
s1,2016-01-02,60.2
s2,2016-01-02,20.4
s1,2016-01-03,55.5
s2,2016-01-03,52.5
```

- Output

```
60.2
```


Exercise #33

- Top-k maximum values
  - Input: a collection of (structured) textual csv files containing the daily value of PM10 for a set of sensors
    - Each line of the files has the following format

      sensorId,date,PM10 value (μg/m³)\n
  - Output: report the top-3 maximum values of PM10
    - Print the result on the standard output

Exercise #33 - Example

- Input file

```
s1,2016-01-01,20.5
s2,2016-01-01,30.1
s1,2016-01-02,60.2
s2,2016-01-02,20.4
s1,2016-01-03,55.5
s2,2016-01-03,52.5
```

- Output

```
60.2
55.5
52.5
```


Exercise #34

- Readings associated with the maximum value
  - Input: a collection of (structured) textual csv files containing the daily value of PM10 for a set of sensors
    - Each line of the files has the following format

      sensorId,date,PM10 value (μg/m³)\n
  - Output: the line(s) associated with the maximum value of PM10
    - Store the result in an HDFS folder

Exercise #34 - Example

- Input file

```
s1,2016-01-01,20.5
s2,2016-01-01,30.1
s1,2016-01-02,60.2
s2,2016-01-02,20.4
s1,2016-01-03,60.2
s2,2016-01-03,52.5
```

- Output

```
s1,2016-01-02,60.2
s1,2016-01-03,60.2
```

Exercise #35

- Dates associated with the maximum value
  - Input: a collection of (structured) textual csv files containing the daily value of PM10 for a set of sensors
    - Each line of the files has the following format
      sensorId,date,PM10 value (μg/m3)\n
  - Output: the date(s) associated with the maximum value of PM10
    - Store the result in an HDFS folder

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Exercise #35 - Example

- Input file

```
s1,2016-01-01,20.5
s2,2016-01-01,30.1
s1,2016-01-02,60.2
s2,2016-01-02,20.4
s1,2016-01-03,60.2
s2,2016-01-03,52.5
```

- Output

```
2016-01-02
2016-01-03
```

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Exercise #36

- Average value
  - Input: a collection of (structured) textual csv files containing the daily value of PM10 for a set of sensors
    - Each line of the files has the following format
      sensorId,date,PM10 value (μg/m3)\n
  - Output: compute the average PM10 value
    - Print the result on the standard output

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Exercise #36 - Example

- Input file

```
s1,2016-01-01,20.5
s2,2016-01-01,30.1
s1,2016-01-02,60.2
s2,2016-01-02,20.4
s1,2016-01-03,55.5
s2,2016-01-03,52.5
```

- Output

```
39.86
```

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Exercise #31

- Log analysis
  - Input: log of a web server (i.e., a textual file)
    - Each line of the file is associated with a URL request
  - Output: the list of distinct IP addresses associated with the connections to a google page (i.e., connections to URLs containing the term "www.google.com")
    - Store the output in an HDFS folder

Exercise #31 - Example

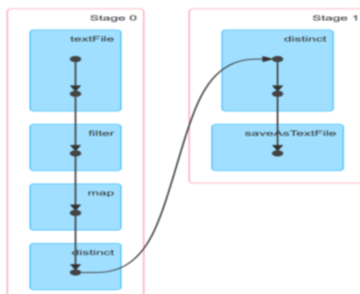
- Input file

```
66.249.69.97 - - [24/Sep/2014:22:25:44 +0000] "GET http://www.google.com/bot.html"
66.249.69.97 - - [24/Sep/2014:22:26:44 +0000] "GET http://www.google.com/how.html"
66.249.69.97 - - [24/Sep/2014:22:28:44 +0000] "GET http://dbdmg.polito.it/course.html"
71.19.157.179 - - [24/Sep/2014:22:30:12 +0000] "GET http://www.google.com/faq.html"
66.249.69.95 - - [24/Sep/2014:31:28:44 +0000] "GET http://dbdmg.polito.it/thesis.html"
66.249.69.97 - - [24/Sep/2014:56:26:44 +0000] "GET http://www.google.com/how.html"
56.249.69.97 - - [24/Sep/2014:56:26:44 +0000] "GET http://www.google.com/how.html"
```

- Output

```
66.249.69.97
71.19.157.179
56.249.69.97
```


Exercise #31 - DAG



Exercise #31 - Simulation

- Suppose that Sparks splits the RDD associated with the input file in two partitions
- Part. #1

```
66.249.69.97 - - [24/Sep/2014:22:25:44 +0000] "GET http://www.google.com/bot.html"
66.249.69.97 - - [24/Sep/2014:22:26:44 +0000] "GET http://www.google.com/how.html"
66.249.69.97 - - [24/Sep/2014:22:28:44 +0000] "GET http://dbdmg.polito.it/course.html"
```

- Part. #2

```
71.19.157.179 - - [24/Sep/2014:22:30:12 +0000] "GET http://www.google.com/faq.html"
66.249.69.95 - - [24/Sep/2014:31:28:44 +0000] "GET http://dbdmg.polito.it/thesis.html"
66.249.69.97 - - [24/Sep/2014:56:26:44 +0000] "GET http://www.google.com/how.html"
56.249.69.97 - - [24/Sep/2014:56:26:44 +0000] "GET http://www.google.com/how.html"
```


Exercise #31 - Simulation

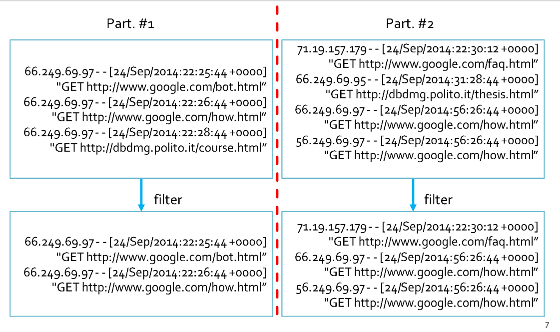
Part. #1

```
66.249.69.97 - - [24/Sep/2014:22:25:44 +0000]
"GET http://www.google.com/bot.html"
66.249.69.97 - - [24/Sep/2014:22:26:44 +0000]
"GET http://www.google.com/how.html"
66.249.69.97 - - [24/Sep/2014:22:28:44 +0000]
"GET http://dbdmg.polito.it/course.html"
```

Part. #2

```
71.19.157.179 - - [24/Sep/2014:22:30:12 +0000]
"GET http://www.google.com/faq.html"
66.249.69.95 - - [24/Sep/2014:31:28:44 +0000]
"GET http://dbdmg.polito.it/thesis.html"
66.249.69.97 - - [24/Sep/2014:56:26:44 +0000]
"GET http://www.google.com/how.html"
56.249.69.97 - - [24/Sep/2014:56:26:44 +0000]
"GET http://www.google.com/how.html"
```

Exercise #31 - Simulation



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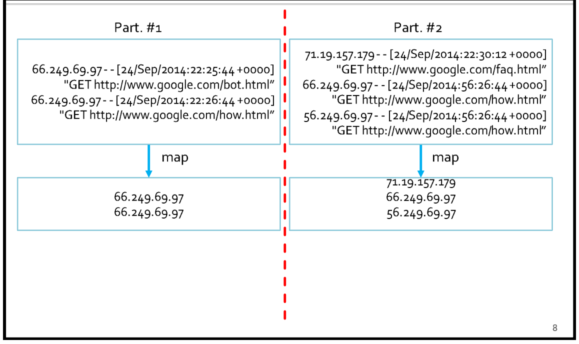
Exercise #31 - Simulation



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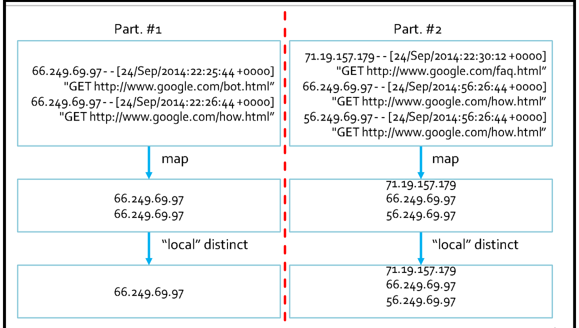
Exercise #31 - Simulation



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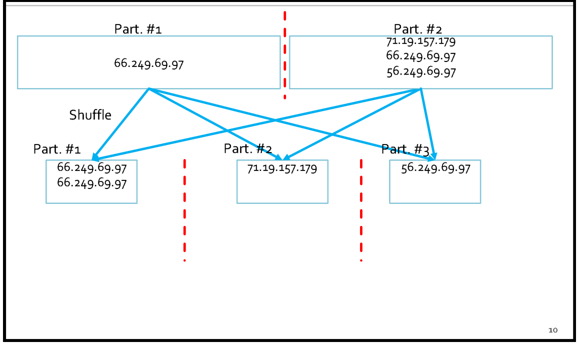
Exercise #31 - Simulation



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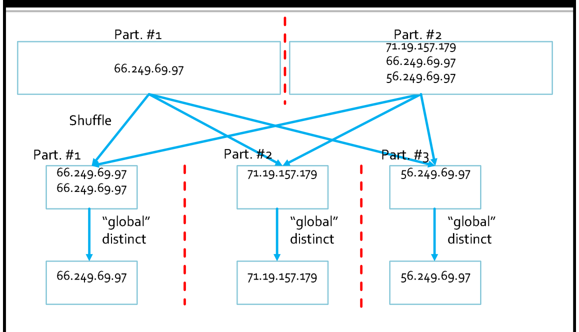
Exercise #31 - Simulation



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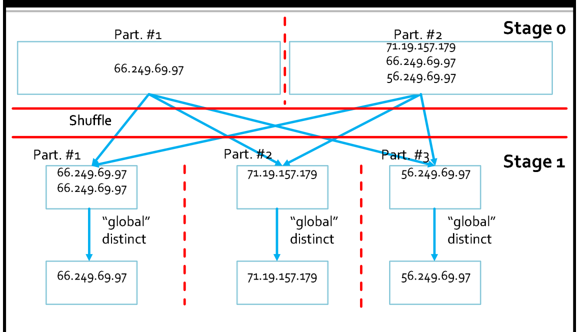
Exercise #31 - Simulation



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Big data: architectures and data analytics

Spark - Exercises

Exercise #37

- Maximum values
  - Input: a textual csv file containing the daily value of PM10 for a set of sensors
    - Each line of the files has the following format
      sensorId,date,PM10 value (μg/m³)\n
  - Output: the maximum value of PM10 for each sensor
    - Store the result in an HDFS file

Exercise #37 - Example

- Input file

```
s1,2016-01-01,20.5
s2,2016-01-01,30.1
s1,2016-01-02,60.2
s2,2016-01-02,20.4
s1,2016-01-03,55.5
s2,2016-01-03,52.5
```

- Output

```
(s1,60.2)
(s2,52.5)
```


Exercise #38

- Pollution analysis
  - Input: a textual csv file containing the daily value of PM10 for a set of sensors
    - Each line of the files has the following format
      sensorId,date,PM10 value (μg/m³)\n
  - Output: the sensors with at least 2 readings with a PM10 value greater than the critical threshold 50
    - Store in an HDFS file the sensorIds of the selected sensors and also the number of times each of those sensors is associated with a PM10 value greater than 50

Exercise #38 - Example

- Input file

```
s1,2016-01-01,20.5
s2,2016-01-01,30.1
s1,2016-01-02,60.2
s2,2016-01-02,20.4
s1,2016-01-03,55.5
s2,2016-01-03,52.5
```

- Output

```
(s1,2)
```

Exercise #39

- Critical dates analysis
  - Input: a textual csv file containing the daily value of PM10 for a set of sensors
    - Each line of the files has the following format
      sensorId,date,PM10 value (μg/m^3)\n
  - Output: an HDFS file containing one line for each sensor
    - Each line contains a sensorId and the list of dates with a PM10 values greater than 50 for that sensor

Exercise #39 - Example

- Input file

```
s1,2016-01-01,20.5
s2,2016-01-01,30.1
s1,2016-01-02,60.2
s2,2016-01-02,20.4
s1,2016-01-03,55.5
s2,2016-01-03,52.5
```

- Output

```
(s1,[2016-01-02, 2016-01-03])
(s2,[2016-01-03])
```

Big data: architectures and data analytics

Spark - Exercises

Exercise #40

- Order sensors by number of critical days
  - Input: a textual csv file containing the daily value of PM10 for a set of sensors
    - Each line of the files has the following format

      sensorId,date,PM10 value (μg/m3)\n
  - Output: an HDFS file containing the sensors ordered by the number of critical days
    - Each line of the output file contains the number of days with a PM10 values greater than 50 for a sensor s and the sensorId of sensor s

Exercise #40 - Example

- Input file

```
s1,2016-01-01,20.5
s2,2016-01-01,30.1
s1,2016-01-02,60.2
s2,2016-01-02,20.4
s1,2016-01-03,55.5
s2,2016-01-03,52.5
```

- Output

```
2, s1
1, s2
```


Exercise #41

- Top-k most critical sensors
  - Input:
    - A textual csv file containing the daily value of PM10 for a set of sensors
      - Each line of the files has the following format

        sensorId,date,PM10 value (μg/m3)\n
    - The value of k
      - It is an argument of the application

Exercise #41

- Top-k most critical sensors
  - Output:
    - An HDFS file containing the top-k critical sensors
      - The "criticality" of a sensor is given by the number of days with a PM10 values greater than 50
      - Each line contains the number of critical days and the sensorId

Exercise #41 - Example

- Input file

```
s1,2016-01-01,20.5
s2,2016-01-01,30.1
s1,2016-01-02,60.2
s2,2016-01-02,20.4
s1,2016-01-03,55.5
s2,2016-01-03,52.5
```

  - k = 1
- Output

```
2, s1
```

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Exercise #42

- Mapping Question-Answer(s)
  - Input:
    - A large textual file containing a set of questions
      - Each line contains one question
      - Each line has the format
        - QuestionId,Timestamp,TextOfTheQuestion
    - A large textual file containing a set of answers
      - Each line contains one answer
      - Each line has the format
        - AnswerId,QuestionId,Timestamp,TextOfTheAnswer

8

Exercise #42

- Output:
  - A file containing one line for each question
  - Each line contains a question and the list of answers to that question
    - QuestionId, TextOfTheQuestion, list of Answers

9

Exercise #42- Example

- Questions

```
Q1,2015-01-01,What is ..?
Q2,2015-01-03,Who invented ..
```

- Answers

```
A1,Q1,2015-01-02,It is ..
A2,Q2,2015-01-03,John Smith
A3,Q1,2015-01-05,I think it is ..
```

Exercise #42 - Example

- Output

```
(Q1,([What is ..?],[It is .., I think it is ..]))
(Q2,([Who invented ..],[John Smith]))
```

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Spark - Exercises

Exercise #43 – 1

- Critical bike sharing station analysis
- Input:
  - A textual csv file containing the occupancy of the stations of a bike sharing system
    - The sampling rate is 5 minutes
    - Each line of the files contains one sensor reading/sample has the following format
      stationId,date,hour,minute,num_of_bikes,num_of_free_slots
    - Some readings are missing due to temporarily malfunctions of the stations
      - Hence, the number of samplings is not exactly the same for all stations
  - The number of distinct stations is 100

Exercise #43 – 2

- Input:
  - A second textual csv file containing the list of neighbors of each station
    - Each line of the files has the following format
      stationId_x, list of neighbors of stationId_x
    - E.g.,
      s1,s2 s3
      means that s2 and s3 are neighbors of s1

Exercise #43 – 3

- Outputs:
  - Compute the percentage of critical situations for each station
    - A station is in a critical situation if the number of free slots is below a user provided threshold (e.g., 3 slots)
    - The percentage of critical situations for a station Si is defined as (number of critical readings associated with Si)/(total number of readings associated with Si)

Exercise #43 – 4

- Store in an HDFS file the stations with a percentage of critical situations higher than 80% (i.e., stations that are almost always in a critical situation and need to be extended)
  - Each line of the output file is associated with one of the selected stations and contains the percentage of critical situations and the stationId
  - Sort the stored stations by percentage of critical situations

Exercise #43 – 5

- Compute the percentage of critical situations for each pair (timeslot, station)
  - Timeslot can assume the following 6 values
    - [0-3]
    - [4-7]
    - [8-11]
    - [12-15]
    - [16-19]
    - [20-23]

Exercise #43 – 6

- Store in an HDFS file the pairs (timeslot, station) with a percentage of critical situations higher than 80% (i.e., stations that need rebalancing operations in specific timeslots)
  - Each line of the output file is associated with one of the selected pairs (timeslot, station) and contains the percentage of critical situations and the pair (timeslot, stationId)
  - Sort the result by percentage of critical situations

Exercise #43 – 7

- Select a reading (i.e., a line) of the first input file if and only if the following constraints are true
  - The line is associated with a full station situation
    - i.e., the station Si associated with the current line has a number of free slots equal to 0
  - All the neighbor stations of the station Si are full in the time stamp associated with the current line
    - i.e., bikers cannot leave the bike at Station Si and also all the neighbor stations are full in the same time stamp
- Store the selected readings/lines in an HDFS file and print on the standard output the total number of such lines

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Spark - Exercises

Exercise #44

- Misleading profile selection
- Input:
  - A textual file containing the list of movies watched by the users of a video on demand service
    - Each line of the file contains the information about one visualization
      userid,movieid,start-timestamp,end-timestamp
    - The user with id *userid* watched the movie with id *movieid* from *start-timestamp* to *end-timestamp*

Exercise #44

- Input:
  - A second textual file containing the list of preferences for each user
    - Each line of the file contains the information about one preference
      userid,movie-genre
    - The user with id *userid* liked the movie of type *movie-genre*

Exercise #44

- Input:
  - A third textual file containing the list of movies with the associated information
    - Each line of the file contains the information about one movie
      movieid,title,movie-genre
    - There is only one line for each movie
      - i.e., each movie has one single genre

Exercise #44

- Output:
  - Select the userids of the list of users with a misleading profile
    - A user has a misleading profile if more than **threshold%** of the movies he/she watched are not associated with a movie genre he/she likes
    - **threshold** is an argument/parameter of the application and it is specified by the user
  - Store the result in an HDFS file

Exercise #45

- Profile update
- Input:
  - A textual file containing the list of movies watched by the users of a video on demand service
    - Each line of the file contains the information about one visualization
      userid,movieid,start-timestamp,end-timestamp
    - The user with id *userid* watched the movie with id *movieid* from *start-timestamp* to *end-timestamp*

Exercise #45

- Input:
  - A second textual file containing the list of preferences for each user
    - Each line of the file contains the information about one preference
      userid,movie-genre
    - The user with id *userid* liked the movie of type *movie-genre*

Exercise #45

- Input:
  - A third textual file containing the list of movies with the associated information
    - Each line of the file contains the information about one movie
      movieid,title,movie-genre
    - There is only one line for each movie
      - i.e., each movie has one single genre

Exercise #45

- Output:
  - Select for each user with a misleading profile (according to the same definition of Exercise #44) the list of movie genres that are not in his/her preferred genres and are associated with at least 5 movies watched by the user
  - Store the result in an HDFS file
    - Each line of the output file is associated with one pair (user, selected misleading genre) associated with him/her
    - The format is
      userid, selected (misleading) genre
    - Users associated with a list of selected genres are associated with multiple lines of the output file

Exercise #46

- Time series analysis
- Input:
  - A textual file containing a set of temperature readings
  - Each line of the file contains one timestamp and the associated temperature reading
    timestamp, temperature
    - The format of the timestamp is the Unix timestamp that is defined as the number of seconds that have elapsed since 00:00:00 Coordinated Universal Time (UTC), Thursday, 1 January 1970
  - The sample rate is 1 minute
    - i.e., the difference between the timestamps of the two consecutive readings is 60

Exercise #46

- Output:
  - Consider all the windows containing 3 consecutive temperature readings and
    - Select the windows characterized by an increasing trend
      - A window is characterized by an increasing trend if for all the temperature readings in it
        temperature(t)>temperature(t-60seconds)
    - Store the result into an HDFS file

Exercise #46 - Example

- Input file

```
1451606400,12.1
1451606460,12.2
1451606520,13.5
1451606580,14.0
1451606640,14.0
1451606700,15.5
1451606760,15.0
```

- Output file

```
1451606400,12.1,1451606460,12.2,1451606520,13.5
1451606460,12.2,1451606520,13.5,1451606580,14.0
```

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