MapReduce - Exercises

Exercise #1

- Word count problem
  - Input: (unstructured) textual file
  - Output: number of occurrences of each word appearing at least one time in the input file

Exercise #1 - Example

- Input file

```
Toy example
file for Hadoop.
Hadoop running
example.
```

- Output pairs

```
(toy, 1)
(example, 2)
(file, 1)
(for, 1)
(hadoop, 2)
(running, 1)
```

Exercise #2

- Word count problem
  - Input: a HDFS folder containing textual files
  - Output: number of occurrences of each word appearing in at least one file of the collection (i.e., files of the input directory)
- The only difference with respect to exercise #1 is given by the input
  - Now the input is a collection of textual files

Exercise #2 - Example

- Input files

Toy example
file for Hadoop.
Hadoop running
example.

Another file for
Hadoop.

- Output pairs

(another, 1)
(example, 2)
(file, 2)
(for, 2)
(hadoop, 3)
(running, 1)
(toy, 1)

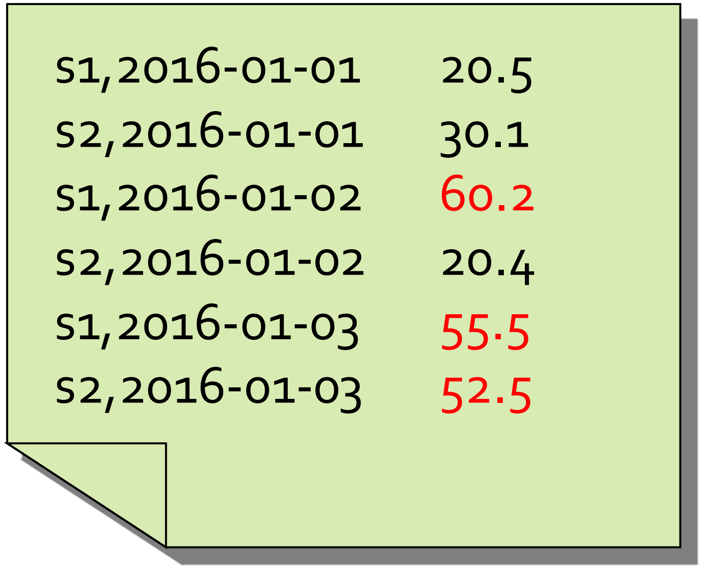
Exercise #3

- PM10 pollution analysis
  - Input: a (structured) textual file containing the daily value of PM10 for a set of sensors
    - Each line of the file has the following format

      sensorId**,**date**\t**PM10 value (µg/m^3)**\n**
  - Output: report for each sensor the number of days with PM10 above a specific threshold
    - Suppose to set threshold = 50 µg/m^3
    - Select only the sensors that are associated at least one time with a PM10 above the threshold

Exercise #3 - 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 pairs

(s1, 2)
(s2, 1)

Exercise #4

- PM10 pollution analysis per city zone
- Input: a (structured) textual file containing the daily value of PM10 for a set of city zones
  - Each line of the file has the following format

    zoneId**,**date**\t**PM10 value (µg/m^3)**\n**
- Output: report for each zone the list of dates associated with a PM10 value above a specific threshold
  - Suppose to set threshold = 50 µg/m^3
  - Report only the zones with at least one date with PM10 above the threshold

Exercise #4 - Example

- Input file

```
zone1,2016-01-01          20.5
zone2,2016-01-01          30.1
zone1,2016-01-02          60.2
zone2,2016-01-02          20.4
zone1,2016-01-03          55.5
zone2,2016-01-03          52.5
```

- Output pairs

(zone1, [2016-01-03, 2016-01-02])
(zone2, [2016-01-01])

Exercise #5

- Average
  - 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/m^3)**\n**
  - Output: report for each sensor the average value of PM10

Exercise #5 - 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 pairs

```
(s1, 45.4)
(s2, 34.3)
```

Exercise #6

- Max and Min
  - 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/m^3)**\n**
  - Output: report for each sensor the maximum and the minimum value of PM10

Exercise #6 - 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 pairs (s1, max=60.2_min=20.5)
  (s2, max=52.5_min=20.4)

Exercise #7

- Inverted index
  - Input: a textual file containing a set of sentences
    - Each line of the file has the following format

      sentenceId**\t**sentence**\n**
  - Output: report for each word **w** the list of sentenceIds of the sentences containing **w**
    - Do not consider the words “and”, “or”, “not”

Exercise #7 - Example

- Input file

Sentence#1	Hadoop or Spark
Sentence#2	Hadoop or Spark and Java
Sentence#3	Hadoop and Big Data

- Output pairs

(hadoop, [Sentence#1, Sentence#2, Sentence#3])
(spark, [Sentence#1, Sentence#2])
(java, [Sentence#2])
(big, [Sentence#3])
(data, [Sentence#3])

Exercise #8

- Total income for each month of the year and Average monthly income per year
  - Input: a (structured) textual csv files containing the daily income of a company
    - Each line of the files has the following format

      date**\t**daily income**\n**
  - Output:
    - Total income for each month of the year
    - Average monthly income for each year considering only the months with a total income greater than 0

Exercise #8 - Example

- Input file

```
2015-11-01      1000
2015-11-02      1305
2015-12-01      500
2015-12-02      750
2016-01-01      345
2016-01-02      1145
2016-02-03      200
2016-02-04      500
```

- Output

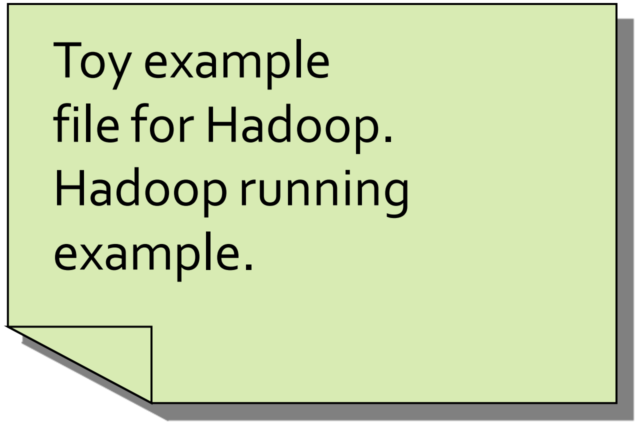
```
(2015-11,2305)        (2015, 1777.5)
(2015-12, 1250)
(2016-01, 1490)       (2016,1095.0)
(2016-02, 700)
```

Exercise #9

- Word count problem
  - Input: (unstructured) textual file
  - Output: number of occurrences of each word appearing in the input file
- Solve the problem by using in-mapper combiners

Exercise #9 - Example

- Input file



Toy example
file for Hadoop.
Hadoop running
example.

- Output pairs

(toy, 1)
(example, 2)
(file, 1)
(for, 1)
(hadoop, 2)
(running, 1)

Exercise #10

- Total count
  - 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/m^3)**\n**
  - Output:
    - Print on the standard output the total number of records

Exercise #10 - Example

- Input file

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

- Output: 6

Exercise #11

- Average
  - 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/m^3)**\n**
  - Output: report for each sensor the average value of PM10
  - Suppose the number of sensors is equal to 2 and their ids are s1 and s2

Exercise #11 - Example

- Input file

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

- Output

```
s1, 45.4
s2, 34.3
```

Exercise #12

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

      sensorId**,**date**\t**PM10 value (μg/m^3)**\n**
  - Output: the records with a PM10 value below a user provided threshold (the threshold is an argument of the program)

Exercise #12 - Example

- Input file

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

  - Threshold: 21
- Output

```
s1,2016-01-01    20.5
s2,2016-01-02    20.4
```

Exercise #13

- Top 1 most profitable date
  - Input: a (structured) textual csv files containing the daily income of a company
    - Each line of the files has the following format

      date**\t**daily income**\n**
  - Output:
    - Select the date and income of the top 1 most profitable date
      - In case of tie, select the first date

Exercise #13 - Example

- Input file

```
2015-11-01      1000
2015-11-02      1305
2015-12-01      500
2015-12-02      750
2016-01-01      345
2016-01-02      1145
2016-02-03      200
2016-02-04      500
```

- Output

```
2015-11-02      1305
```

Exercise #13 Bis

- Top 2 most profitable dates
  - Input: a (structured) textual csv files containing the daily income of a company
    - Each line of the files has the following format

      date**\t**daily income**\n**
  - Output:
    - Select the date and income of the top 2 most profitable dates
      - In case of tie, select the first 2 dates among the ones associated with the highest income

Exercise #13 Bis - Example

- Input file

```
2015-11-01        1000
2015-11-02        1305
2015-12-01        500
2015-12-02        750
2016-01-01        345
2016-01-02        1145
2016-02-03        200
2016-02-04        500
```

- Output

```
2015-11-02        1305
2016-01-02        1145
```

Exercise #14

- Dictionary
  - Input: a collection of news (textual files)
  - Output:
    - List of distinct words occurring in the collection

Exercise #14 - Example

- Input file

```
Toy example
file for Hadoop.
Hadoop running
example.
```

- Output

```
example
file
for
hadoop
running
toy
```

Exercise #15

- Dictionary – Mapping word - integer
  - Input: a collection of news (textual files)
  - Output:
    - List of distinct words occurring in the collection associated with a set of unique integers
      - Each word is associated with a unique integer (and viceversa)

Exercise #15 - Example

- Input file

Toy example
file for Hadoop.
Hadoop running
example.

- Output

(example, 1)
(file , 2)
(for , 3)
(hadoop , 4)
(running , 5)
(toy , 6)

Exercise #17

- Select maximum temperature for each date
  - Input: two structured textual files containing the temperatures gathered by a set of sensors
    - Each line of the first file has the following format

      sensorID,date,hour,temperature**\n**
    - Each line of the second file has the following format

      date,hour,temperature,sensorID**\n**
  - Output: the maximum temperature for each date (considering the data of both input files)

Exercise #17 - Example

- Input files

```
s1,2016-01-01,14:00,20.5
s2,2016-01-01,14:00,30.2
s1,2016-01-02,14:10,11.5
s2,2016-01-02,14:10,30.2
```

```
2016-01-01,14:00,20.1,s3
2016-01-01,14:00,10.2,s4
2016-01-02,14:15,31.5,s3
2016-01-02,14:15,20.2,s4
```

- Output

```
2016-01-01        30.2
2016-01-02        31.5
```

Exercise #18

- Filter the readings of a set of sensors based on the value of the measurement
  - Input: a set of textual files containing the temperatures gathered by a set of sensors
    - Each line of the files has the following format

      sensorID,date,hour,temperature**\n**
  - Output:
    - The lines of the input files associated with a temperature value greater than 30.0

Exercise #18 - Example

- Input file

```
s1,2016-01-01,14:00,20.5
s2,2016-01-01,14:00,30.2
s1,2016-01-02,14:10,11.5
s2,2016-01-02,14:10,30.2
```

- Output file

```
s2,2016-01-01,14:00,30.2
s2,2016-01-02,14:10,30.2
```

Exercise #19

- Filter the readings of a set of sensors based on the value of the measurement
  - Input: a set of textual files containing the temperatures gathered by a set of sensors
    - Each line of the files has the following format

      sensorID,date,hour,temperature**\n**
  - Output:
    - The lines of the input files associated with a temperature value less than or equal to 30.0

Exercise #19 - Example

- Input file

```
s1,2016-01-01,14:00,20.5
s2,2016-01-01,14:00,30.2
s1,2016-01-02,14:10,11.5
s2,2016-01-02,14:10,30.2
```

- Output file

```
s1,2016-01-01,14:00,20.5
s1,2016-01-02,14:10,11.5
```

Exercise #20

- Split the readings of a set of sensors based on the value of the measurement
  - Input: a set of textual files containing the temperatures gathered by a set of sensors
    - Each line of the files has the following format

      sensorID,date,hour,temperature**\n**
  - Output:
    - a set of files with the prefix "high-temp-" containing the lines of the input files with a temperature value greater than 30.0
    - a set of files with the prefix "normal-temp-" containing the lines of the input files with a temperature value less than or equal to 30.0

Exercise #20 - Example

- Input file

```
s1,2016-01-01,14:00,20.5
s2,2016-01-01,14:00,30.2
s1,2016-01-02,14:10,11.5
s2,2016-01-02,14:10,30.2
```

- Output files

high-temp-m-00001

```
s2,2016-01-01,14:00,30.2
s2,2016-01-02,14:10,30.2
```

normal-temp-m-00001

```
s1,2016-01-01,14:00,20.5
s1,2016-01-02,14:10,11.5
```

Exercise #20 Bis

- Split the readings of a set of sensors based on the value of the measurement
  - Input: a set of textual files containing the temperatures gathered by a set of sensors
    - Each line of the files has the following format

      sensorID,date,hour,temperature**\n**
  - Output:
    - a set of files with the prefix "high-temp-" containing the temperatures associated with the lines of the input files with temperature values greater than 30.0
    - a set of files with the prefix "normal-temp-" containing the lines of the input files with a temperature value less than or equal to 30.0

Exercise #20 Bis - Example

- Input file

```
s1,2016-01-01,14:00,20.5
s2,2016-01-01,14:00,30.2
s1,2016-01-02,14:10,11.5
s2,2016-01-02,14:10,41.5
```

- Output files

high-temp-m-00001

```
30.2
41.5
```

normal-temp-m-00001

```
s1,2016-01-01,14:00,20.5
s1,2016-01-02,14:10,11.5
```

Exercise #21

- Stopword elimination problem
  - Input:
    - A large textual file containing one sentence per line
    - A small file containing a set of stopwords
      - One stopword per line
  - Output:
    - A textual file containing the same sentences of the large input file without the words appearing in the small file
    - The order of the sentences in the output file can be different from the order of the sentences in the input file

Exercise #21 - Example

- Input files
  - Large file

```
This is the first sentence and it contains some stopwords
Second sentence with a stopword here and another here
Third sentence of the stopword example
```

  - Stopword file

```
a
an
and
the
```

Exercise #21 - Example

- Output file

```
This is  first sentence it contains some stopwords
Second sentence with stopword here another here
Third sentence of stopword example
```

Exercise #22

- Friends of a specific user
  - Input:
    - A textual file containing pairs of users (one pair per line)
      - Each line has the format
        - Username1,Username2
      - Each pair represents the fact that Username1 is friend of Username2 (and vice versa)
    - One username specified as parameter by means of the command line
  - Output:
    - The friends of the specified username stored in a textual file
      - One single line with the list of friends

Exercise #22 - Example

- Input file

```
User1,User2
User1,User3
User1,User4
User2,User5
```

- Username parameter: User2
- Output file

```
User1 User5
```

Exercise #23

- Potential friends of a specific user
  - Input:
    - A textual file containing pairs of users (one pair per line)
      - Each line has the format
        - Username1,Username2
      - Each pair represents the fact that Username1 is friend of Username2 (and vice versa)
    - One username specified as parameter by means of the command line
  - Output:
    - The potential friends of the specified username stored in a textual file
      - One single line with the list of potential friends
    - User1 is a potential friend of User2 if they have at least one friend in common

Exercise #23 - Example

- Input file

```
User1,User2
User1,User3
User1,User4
User2,User3
User2,User4
User2,User5
User5,User6
```

- Username parameter: User2
- Output file

```
User1 User3 User4 User6
```

Exercise #23 Bis

- Potential friends of a specific user
    - Solve problem #23 by removing the friends of the specified user from the list of its potential friends

Exercise #23 Bis - Example

- Input file

```
User1,User2
User1,User3
User1,User4
User2,User3
User2,User4
User2,User5
User5,User6
```

- Username parameter: User2
- Output file

```
User6
```

Exercise #24

- Compute the list of friends for each user
  - Input:
    - A textual file containing pairs of users (one pair per line)
      - Each line has the format
        - Username1,Username2
      - Each pair represents the fact that Username1 is friend of Username2 (and vice versa)
  - Output:
    - A textual file containing one line for each user. Each line contains a user and the list of its friends

Exercise #24 - Example

- Input file

```
User1,User2
User1,User3
User1,User4
User2,User5
```

- Output file

```
User1: User2 User 3 User 4
User2: User1 User5
User3: User1
User4: User1
User5: User2
```

Exercise #25

- Compute the list of potential friends for each user
  - Input:
    - A textual file containing pairs of users (one pair per line)
      - Each line has the format
        - Username1,Username2
      - Each pair represents the fact that Username1 is friend of Username2 (and vice versa)
  - Output:
    - A textual file containing one line for each user with at least one potential friend. Each line contains a user and the list of its potential friends
    - User1 is a potential friend of User2 if they have at least one friend in common

Exercise #25 - Example

- Input file

```
User1,User2
User1,User3
User1,User4
User2,User3
User2,User4
User2,User5
User5,User6
```

- Output file

```
User1: User2 User3 User4 User5
User2: User1 User3 User4 User6
User3: User1 User2 User4 User5
User4: User1 User2 User3 User5
User5: User1 User3 User4
User6: User2
```

Exercise #26

- Word (string) to integer conversion
  - Input:
    - A large textual file containing a list of words per line
    - The small file dictionary.txt containing the mapping of each possible word appearing in the first file with an integer. Each line contain the mapping of a word with an integer and it has the following format
      - Word**\t**Integer**\n**
  - Output:
    - A textual file containing the content of the large file where the appearing words are substituted by the corresponding integers

Exercise #26 - Example

- Input files
  - Large textual file

```
TEST CONVERTION WORD TO INTEGER
SECOND LINE TEST WORD TO INTEGER
```

  - Small dictionary file

```
1        CONVERTION
2        INTEGER
3        LINE
4        SECOND
5        TEST
6        TO
7        WORD
```

Exercise #26 - Example

- Output file

```
5 1 7 6 2
4 3 5 7 6 2
```

Exercise #27

- Categorization rules
  - Input:
    - A large textual file containing a set of records
      - Each line contains the information about one single user
      - Each line has the format
        - UserId,Name,Surname,Gender,YearOfBirth,City,Education
    - A small file with a set of business rules that are used to assign each user to a category
      - Each line contains a business rule with the format
        - Gender=<value> and YearOfBirth=<value> -> Category
      - Rules are mutually exclusive

Exercise #27

- Output:
  - One record for each user with the following format
    - The original information about the user plus the category assigned to the user by means of the business rules
    - Since the rules are mutually exclusive, there is only one rule applicable for each user
    - If no rules is applicable/satisfied by a user, assign the user to the "Unknown" category

Exercise #27 - Example

- Users

```
User#1,John,Smith,M,1934,New York,Bachelor
User#2,Paul,Jones,M,1956,Dallas,College
User#3,Jenny,Smith,F,1934,Philadelphia,Bachelor
User#4,Laura,White,F,1926,New York,Doctorate
```

- Business rules

```
Gender=M and YearOfBirth=1934 -> Category#1
Gender=M and YearOfBirth=1956 -> Category#3
Gender=F and YearOfBirth=1934 -> Category#2
Gender=F and YearOfBirth=1956 -> Category#3
```

Exercise #27 - Example

- Output

```
User#1,John,Smith,M,1934,New York,Bachelor,Category#1
User#2,Paul,Jones,M,1956,Dallas,College,Category#3
User#3,Jenny,Smith,F,1934,Los Angleses,Bachelor,Category#2
User#4,Laura,White,F,1926,New York,Doctorate,Unknown
```

Exercise #28

- 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

Exercise #28

- Output:
  - One line for each pair (question,answer) with the following format
    - QuestionId,TextOfTheQuestion, AnswerId,TextOfTheAnswer

Exercise #28 - 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 #28 - Example

- Output

```
Q1,What is ..?,A1,It is ..
Q1,What is ..?,A3,I think it is ..
Q2,Who invented ..,A2,John Smith
```

Exercise #29

- User selection
  - Input:
    - A large textual file containing a set of records
      - Each line contains the information about one single user
      - Each line has the format
        - UserId,Name,Surname,Gender,YearOfBirth,City,Education
    - A large textual file with pairs (Userid, MovieGenre)
      - Each line contains pair Userid, MovieGenre with the format
        - Userid,MovieGenre
        - It means that UserId likes movies of genre MovieGenre

Exercise #29

- Output:
  - One record for each user that likes both Comedy and Adventure movies
  - Each output record contains only Gender and YearOfBirth of a selected user
    - Gender,YearOfBirth
  - Duplicate pairs must not be removed

Exercise #29 - Example

- Users

```
User#1,John,Smith,M,1934,New York,Bachelor
User#2,Paul,Jones,M,1956,Dallas,College
User#3,Jenny,Smith,F,1934,Philadelphia,Bachelor
```

- Likes

```
User#1,Comedy
User#1,Adventure
User#1,Drama
User#2,Comedy
User#2,Crime
User#3, Comedy
User#3,Horror
User#3,Adventure
```

Exercise #29 - Example

- Output

```
M,1934
F,1934
```