732A54/TDDE31 Big Data Analytics

Exercise Session

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Agenda

- Aims of this exercise session
- Review
  - ✓ Map-Reduce: Working with key-value pairs
  - ✓ Lambda functions
- How to design and write PySpark code
- Lab introduction and exercises
  - ✓ Conceptual design
  - ✓ Write PySpark code
- *How to work on heffa

Aims

- Give you an overview of the labs
- Help you to understand how to design and write code using Spark in python
- Exercises: start to solve the assignments in the labs

Map-Reduce: Working with key-value pairs

- Data elements: key-value pairs
- Python's tuple structure fit this key-value pair: (key, value)
  - ✓ (1,2), (1,3), (1,4), (1,5), (2,2), (2,3)
- A tuple is a sequence of immutable Python objects

  ('a', 3), (1, (3, 4)), ((1,1), 2)
- Accessing elements done with [index]

  x = (3, ('c', [1])), y = ((3, 'a'), ('c', [1]))

  x[0] = 3, x[1] = x[-1] = ('c', [1]), x[1][1] = [1]

  y[0] = (3, 'a'), y[0][0] = 3, y[1][1] = [1]
- 'Shuffle' operations by a key work on RDDs containing built-in Python tuples
  - ✓ 'repartition' operations
  - ✓ 'byKey' operations
  - ✓ 'join' operations

Lambda functions– a way to pass function to a RDD operation

- General form

  lambda arguments: expression

- Examples:

  *lambda a: 2 * a* –double the argument *a*

  lambda a, b: a + b –produce the sum of arguments *a* and *b*

  lambda input_list : (input_list[0], input_list[1])

  lambda input_list : max(input_list)

RDD - Operations

Transformations	$map(f : \mathrm{T} \Rightarrow \mathrm{U})$	:	$\mathrm{RDD[T]} \Rightarrow \mathrm{RDD[U]}$
	$filter(f : \mathrm{T} \Rightarrow \mathrm{Bool})$	:	$\mathrm{RDD[T]} \Rightarrow \mathrm{RDD[T]}$
	$flatMap(f : \mathrm{T} \Rightarrow \mathrm{Seq[U]})$	:	$\mathrm{RDD[T]} \Rightarrow \mathrm{RDD[U]}$
	$sample(fraction : \mathrm{Float})$	:	$\mathrm{RDD[T]} \Rightarrow \mathrm{RDD[T]}$ (Deterministic sampling)
	$groupByKey()$	:	$\mathrm{RDD[(K, V)]} \Rightarrow \mathrm{RDD[(K, Seq[V])]}$
	$reduceByKey(f : (\mathrm{V}, \mathrm{V}) \Rightarrow \mathrm{V})$	:	$\mathrm{RDD[(K, V)]} \Rightarrow \mathrm{RDD[(K, V)]}$
	$union()$	:	$(\mathrm{RDD[T]}, \mathrm{RDD[T]}) \Rightarrow \mathrm{RDD[T]}$
	$join()$	:	$(\mathrm{RDD[(K, V)]}, \mathrm{RDD[(K, W)]}) \Rightarrow \mathrm{RDD[(K, (V, W))]}$
	$cogroup()$	:	$(\mathrm{RDD[(K, V)]}, \mathrm{RDD[(K, W)]}) \Rightarrow \mathrm{RDD[(K, (Seq[V], Seq[W]))]}$
	$crossProduct()$	:	$(\mathrm{RDD[T]}, \mathrm{RDD[U]}) \Rightarrow \mathrm{RDD[(T, U)]}$
	$mapValues(f : \mathrm{V} \Rightarrow \mathrm{W})$	:	$\mathrm{RDD[(K, V)]} \Rightarrow \mathrm{RDD[(K, W)]}$ (Preserves partitioning)
	$sort(c : \mathrm{Comparator[K]})$	:	$\mathrm{RDD[(K, V)]} \Rightarrow \mathrm{RDD[(K, V)]}$
	$partitionBy(p : \mathrm{Partitioner[K]})$	:	$\mathrm{RDD[(K, V)]} \Rightarrow \mathrm{RDD[(K, V)]}$
Actions	$count()$	:	$\mathrm{RDD[T]} \Rightarrow \mathrm{Long}$
	$collect()$	:	$\mathrm{RDD[T]} \Rightarrow \mathrm{Seq[T]}$
	$reduce(f : (\mathrm{T}, \mathrm{T}) \Rightarrow \mathrm{T})$	:	$\mathrm{RDD[T]} \Rightarrow \mathrm{T}$
	$lookup(k : \mathrm{K})$	:	$\mathrm{RDD[(K, V)]} \Rightarrow \mathrm{Seq[V]}$ (On hash/range partitioned RDDs)
	$save(path : \mathrm{String})$	:	Outputs RDD to a storage system, *e.g.*, HDFS

Table 2: Transformations and actions available on RDDs in Spark. Seq[T] denotes a sequence of elements of type T.

- You need more than the above to solve all assignments in the lab.
  - ✓ PySpark library: https://spark.apache.org/docs/1.6.1/api/python/pyspark.html
  - ✓ Spark 1.6 programming guide: https://spark.apache.org/docs/1.6.0/programming-guide.html

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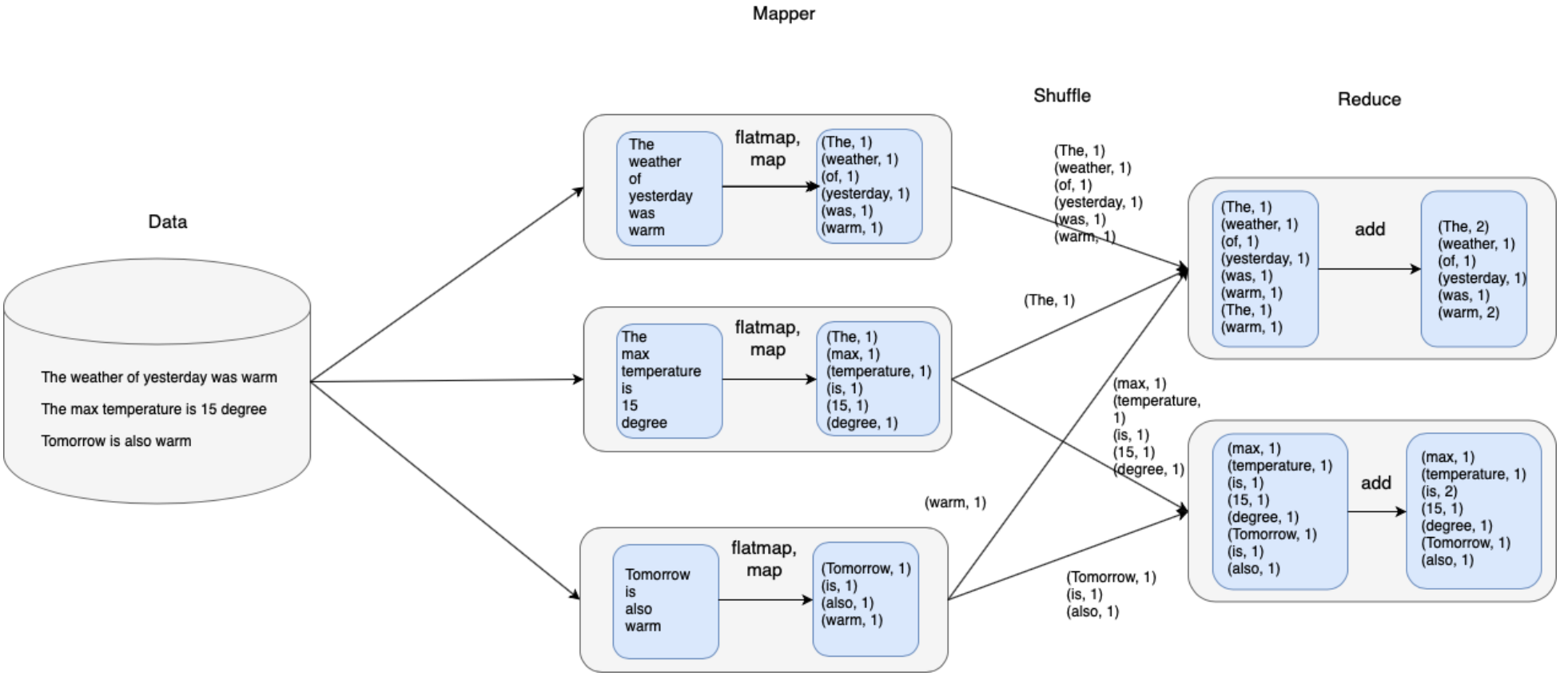
Word Count – Conceptual Design

- In terms of map-reduce programming model, how to form key, value pair and what kind of transforms are needed.
- During reduce process, what functions are needed on the values.



How to write PySpark code

- Step 1. To create a SparkContext object which tells Spark how to access a cluster.
- Step 2. To create distributed datasets (RDD)
  - ✓ Use external datasets by local file system or HDFS
- Step 3. RDD operating: transformation, action

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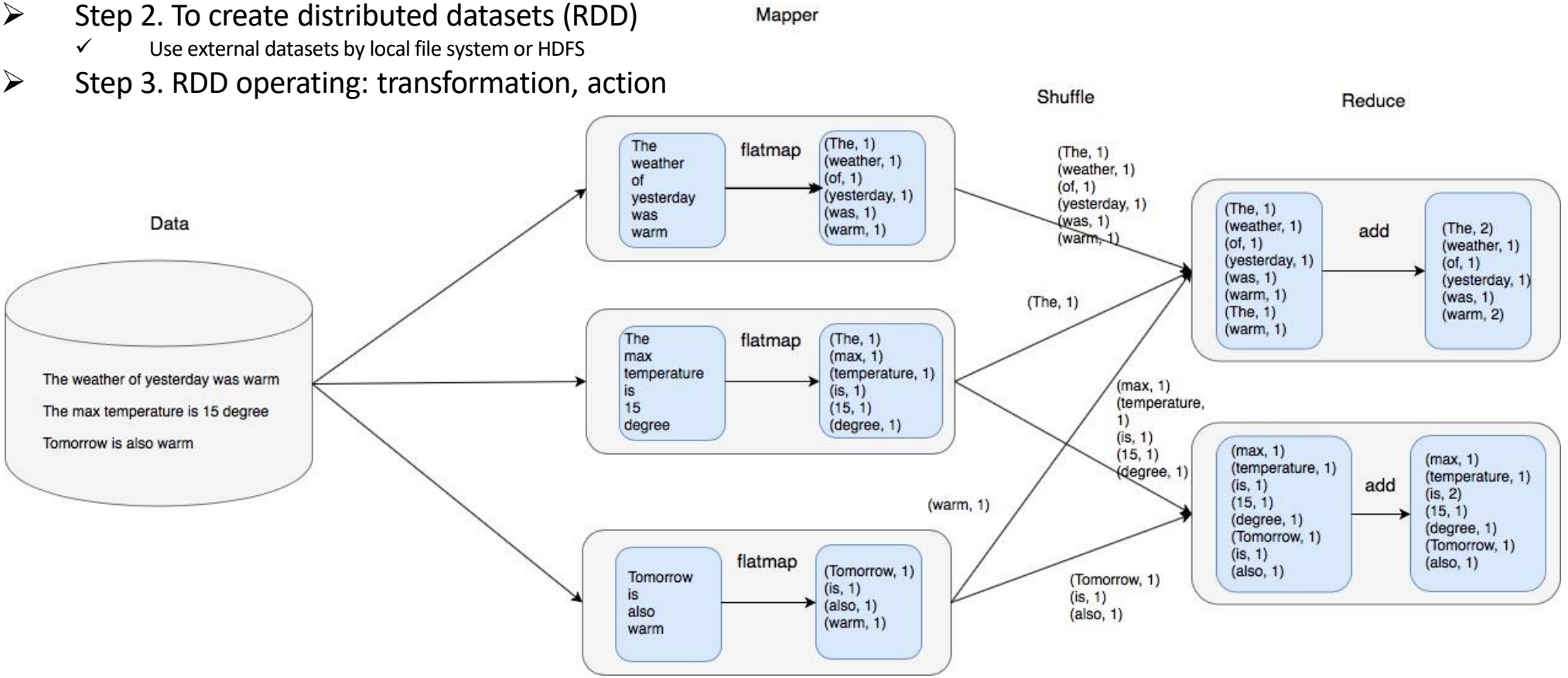


```
1 from pyspark import SparkContext
2 sc = SparkContext(appName = "exercise test")
3 news_file = sc.textFile("/user/x_huali/data/news.txt")
4 words = news_file.flatMap(lambda line: line.split(" "))
5 word_count = words.map(lambda word: (word, 1))
6 counts = word_count.reduceByKey(lambda v1, v2: v1+v2)
7 counts.saveAsTextFile("word_count_result")
```

step 1

step 2

step 3: RDD transformation(s)

step 3: RDD action

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Lab Introduction

- Working with the historical meteorological data from Swedish Meteorological Hydrological Institute (SMHI)
  - ✓ The data includes air temperature and precipitation readings from 812 stations in Sweden.
- Three labs
  - ✓ BDA1 – Spark: 5 assignments
    - In general, you need to do filtering, grouping, aggregating … over the data.
    - Map-reduce programming model, PySpark,
    - working with key-value pairs
  - ✓ BDA2 – Spark SQL: Redo the 5 assignments in BDA1 with Spark SQL
  - ✓ BDA3 – Machine Learning with Spark:
- Example: Find highest temperature for a certain period
  - ✓ temperature-readings.csv

Headers for *temperature-readings.csv*

Station number	Date	Time	Air temperature (in °C)	Quality[3]

```
102170;2013-11-01;06:00:00;6.8;G
102170;2013-11-01;18:00:00;3.8;G
102170;2014-11-02;06:00:00;5.8;G
102170;2014-11-02;18:00:00;-1.1;G
102170;2015-11-03;06:00:00;-0.2;G
102170;2015-11-03;18:00:00;5.6;G
102170;2015-11-04;06:00:00;6.5;G
……..
```

Find the highest temperature in 2014 and 2015.

Show the year and highest temperature in the result

- Conceptual design
  - ✓ Understand the question and data
  - ✓ How to form key, value pair and what RDD operations are needed
  - ✓ What operations are needed during mapping and reducing?
- Write pyspark code

Headers for *temperature-readings.csv*

Station number	Date	Time	Air temperature (in °C)	Quality[3]

102170;2013-11-01;06:00:00;6.8;G
102170;2013-11-01;18:00:00;3.8;G
102170;2014-11-02;06:00:00;5.8;G
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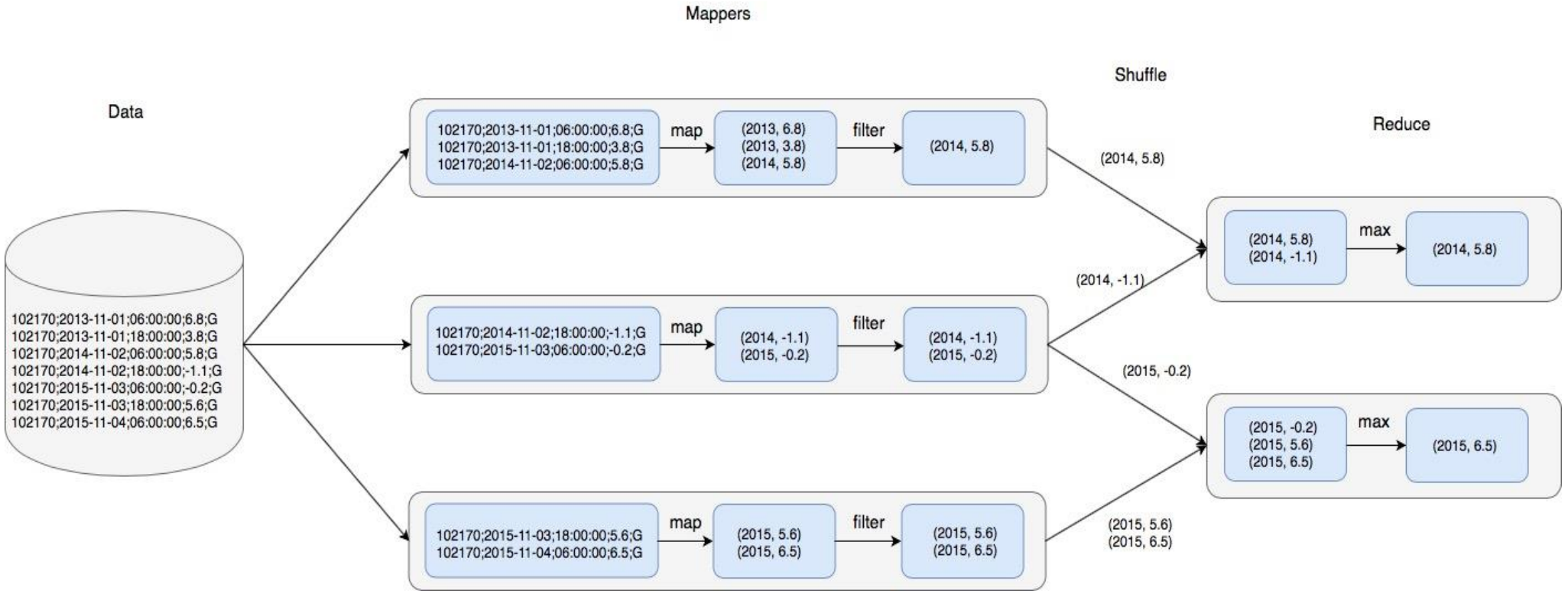
102170;2015-11-03;06:00:00;-0.2;G
102170;2015-11-03;18:00:00;5.6;G
102170;2015-11-04;06:00:00;6.5;G
…….

Solution – Conceptual design

- Extract year as key and temperature as value
- Filter data (2014 and 2015)
- Reduce by key and then compare each two values to get the higher temperature.



- Step 1. To create a SparkContext object which tells Spark how to access a cluster.
- Step 2. To create distributed datasets (RDD) from HDFS.
- Step 3. RDD operating: transformation, action

Solution

- Question : Find the highest temperature in 2014 and 2015.

```
1  from pyspark import SparkContext
2  def max_temperature(a,b):
3      if a>=b:
4          return a
5      else:
6          return b
7  sc = SparkContext(appName = "exercise test")
8  temperature_file = sc.textFile("/user/x_huali/data/temperature-readings.csv")
9  lines = temperature_file.map(lambda line: line.split(";"))
10 year_temperature = lines.map(lambda x: (x[1][0:4], float(x[3])))
11 year_temperature = year_temperature.filter(lambda x: int(x[0])==2014 or int(x[0])==2015)
12 #max_temperatures = year_temperature.reduceByKey(lambda a,b: a if a>=b else b)
13 #max_temperatures = year_temperature.reduceByKey(max)
14 max_temperatures = year_temperature.reduceByKey(max_temperature)
15 max_temperatures.saveAsTextFile("max_temperature_2014_2015")
```

- line 7: create SparkContext object
- line 8: get the file on hdfs, absolute path needed! '/user/USERNAME/…' or 'hdfs:namenode:8020/user/USERNAME/…'
- line 9: transform the data by splitting each line
- line 10: transform the data by extracting year and temperature as tuple
- line 11: filter data by year
- line 14: reducer, to get the max temperature,
  - line 12, line 13, line 14 show the different ways of passing functions to Spark
- line 15: save result in a directory

For the first assignment in BDA1

- 1) What are the highest temperatures measured each year for the period 1950-2014. Provide the listed sorted in the descending order with respect to the maximum temperature
- Exercise (30 mins)
  - ✓ Conceptual design (how to form key, value pairs and what RDD operations are needed)
  - ✓ Write pyspark code (Pseudocode)

Headers for *temperature-readings.csv*

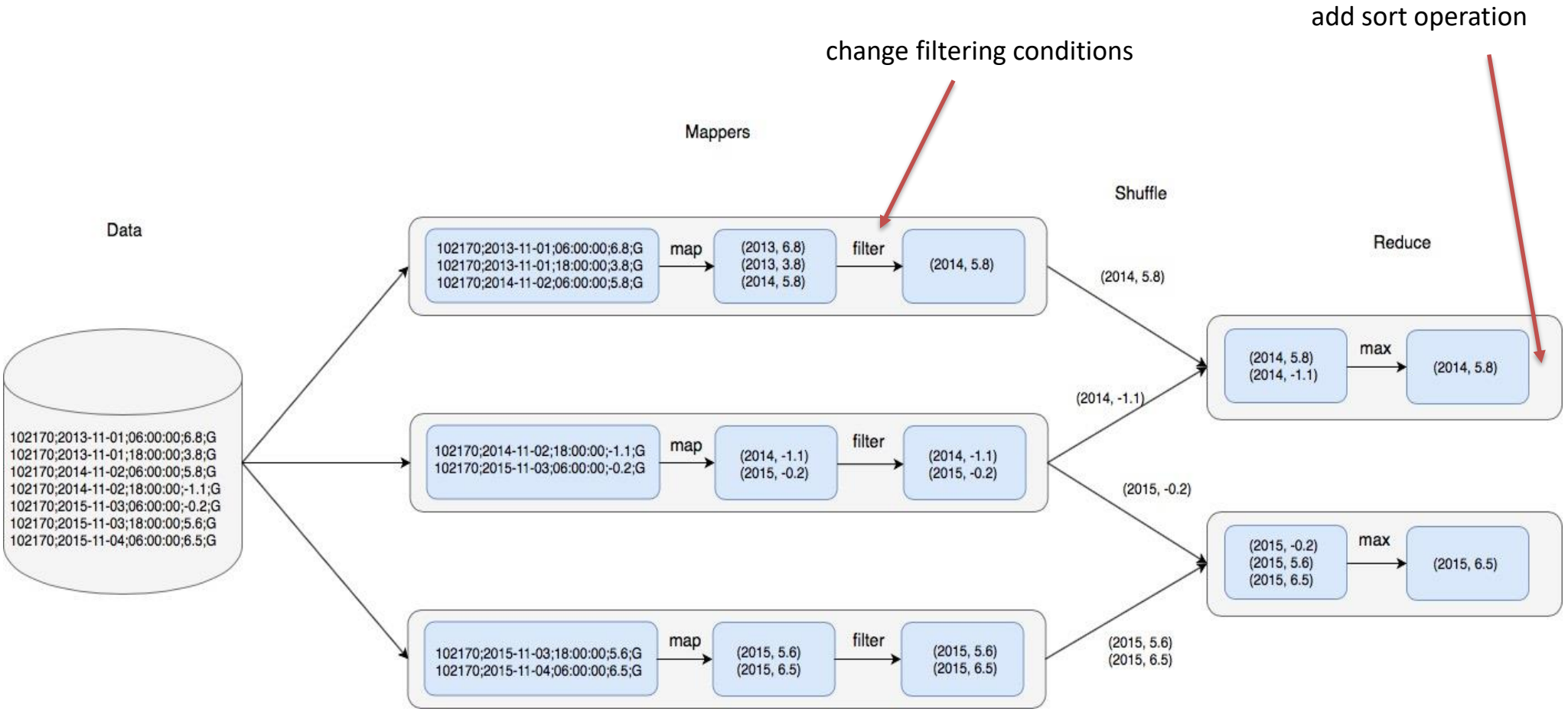
Station number	Date	Time	Air temperature (in °C)	Quality[3]

102170;2013-11-01;06:00:00;6.8;G
102170;2013-11-01;18:00:00;3.8;G
102170;2014-11-02;06:00:00;5.8;G
102170;2014-11-02;18:00:00;-1.1;G
102170;2015-11-03;06:00:00;-0.2;G
102170;2015-11-03;18:00:00;5.6;G
102170;2015-11-04;06:00:00;6.5;G
…….

How to write PySpark code
Step 1: To create a SparkContext object
Step 2: To create distributed datasets (RDD)
Step 3: RDD operating

Solution – Conceptual design

- Extract year and temperature
- Filter data ~~(2014 and 2015)~~ 1950-2014
- Reduce by key to get maximum
- Sort



The previous design for finding max temperatures in 2014 and 2015

Solution

- Pre steps: Distribute your data
- Step 1. To create a SparkContext object which tells Spark how to access a cluster.
- Step 2. To create distributed datasets (RDD) from HDFS.
- Step 3. RDD operating: transformation, action

```
1  from pyspark import SparkContext
2  def max_temperature(a,b):
3      if a>=b:
4          return a
5      else:
6          return b
7  sc = SparkContext(appName = "exercise test")
8  temperature_file = sc.textFile("/user/x_huali/data/temperature-readings.csv")
9  lines = temperature_file.map(lambda line: line.split(";"))
10 year_temperature = lines.map(lambda x: (x[1][0:4], float(x[3])))
11 year_temperature = year_temperature.filter(lambda x: int(x[0])>=1950 and int(x[0])<=2014)
12 #max_temperatures = year_temperature.reduceByKey(lambda a,b: a if a>=b else b)
13 #max_temperatures = year_temperature.reduceByKey(max)
14 max_temperatures = year_temperature.reduceByKey(max_temperature)
15 max_temperaturesSorted = max_temperatures.sortBy(ascending = False, keyfunc=lambda k: k[1])
16 max_temperaturesSorted.saveAsTextFile("max_temperature")
```

- line 7: create SparkContext object
- line 8: get the file on hdfs, absolute path needed! '/user/USERNAME/…' or 'hdfs:namenode:8020/user/USERNAME/…'
- line 9: transform the data by splitting each line
- line 10: transform the data by extracting year and temperature as tuple
- line 11: filter data by a time period
- line 14: reducer, to get the max temperature,
  - line 12, line 13, line 14 show the different ways of passing functions to Spark
- line 15: sort result by temperature
- line 16: save result in a directory

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Data paths

- Heffa locally: /nfshome/hadoop_examples/shared_data
  temperature-readings.csv,
  precipitation-readings.csv
  temperatures-big.csv
- Heffa hdfs: /user/common/732A54
  temperatures-big.csv
- *https://www.ida.liu.se/~732A54/lab/station_data.zip*
  stations.csv
  stations-Ostergotland.csv

*How to work on heffa

Commands

- ssh -X
- scp file.txt username@heffa.nsc.liu.se:Desktop
- hdfs dfs -ls /user/username/
- hdfs dfs -mkdir data
- cd /nfshome/hadoop_examples/shared_data
- hdfs dfs -copyFromLocal ./temperature-readings.csv /user/username/data
- …..

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