Distributed File Systems, MapReduce

Seminar 1 of *NoSQL Databases* (PA195)

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Agenda

- MetaCentrum Hadoop Cluster
  - Login, basic tools, monitoring
- Hadoop Distributed File System
  - Basics, working with files, monitoring, advanced settings
- Hadoop MapReduce
  - Writing own MapReduce program: WordCount
  - Running on small data, monitoring
  - Running on large data
  - Advanced MapReduce task: Average Max Temperature
- Simple example in Spark

Basic Information

- We will be using Hadoop version 3.0.0
  - Hadoop main page: http://hadoop.apache.org/
  - documentation (v3.0.0): http://hadoop.apache.org/docs/r3.0.0/

- MetaCentrum Hadoop cluster
  - MetaCentrum account: http://metavo.metacentrum.cz/en/application/index.html
  - Hadoop cluster access: https://www.metacentrum.cz/en/hadoop/
  - MetaCentrum Hadoop cluster documentation: https://wiki.metacentrum.cz/wiki/Hadoop_documentation

MetaCentrum Hadoop Access

localhost

nymfe

- edit file on your local machine `~/.ssh/config`
  - or for OpenSSH on Windows `C:\Users\<login>\.ssh`

```
## MetaCentrum ##########
Host hador
   HostName hador.ics.muni.cz
   User <login_in_MetaCentrum>
   Port 22
```

- log in to Hadoop Cluster frontend

```
$ ssh hador
```

MetaCentrum Hadoop Access

nymfe

- Web interface:
  - Firstly, gain Kerberos ticket on your local machine:

```
scp login@hador.ics.muni.cz:/etc/krb5.conf .
export KRB5_CONFIG=krb5.conf
kinit <login>@META
```

  - Chrome on the local machine (in the same terminal):

```
$ /opt/google/chrome/chrome --auth-server-whitelist="hador*.ics.muni.cz" &
```

    - open https://hador-c1.ics.muni.cz:9871/

  - or use Firefox and configure it using this manual:

https://wiki.metacentrum.cz/wiki/Hadoop_documentation#Web_accessibility

HDFS DFS (1)

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- HDFS system monitoring & basic commands

```
$ hdfs dfs -help
```

- Documentation of HDFS DFS file system commands

- get some data (complete Shakespeare's plays)

```
$ wget https://goo.gl/KyDfc7 -O shake.txt
$ hdfs dfs -put shake.txt
```

- or, alternatively

```
$ hdfs dfs -put shake.txt /user/<user>/shake.txt

$ hdfs dfs -ls
```

HDFS DFS (2)

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```
$ hdfs dfs -ls

$ hdfs dfs -setrep -w 2 shake.txt

$ hdfs dfs -rm shake.txt
$ hdfs dfs -D dfs.block.size=1048576 -put shake.txt
$ hdfs fsck /user/<user>/shake.txt -files -locations -
blocks
$ hdfs dfs -mkdir input
```

Check HDFS files in browser nymfe

https://hador-c1.ics.muni.cz:9871/explorer.html#/user/<user>/

nymfe

Java Development

- Download the project from IS seminar 1

  https://is.muni.cz/auth/el/fi/podzim2021/PA195/um/seminar-1/

  - `$ unzip pa195-hadoop-scafolding.zip`
- Development with InteliJ IDEA

```
$ module add jdk-1.8.0
$ module add idea-loc
$ idea.sh &
```

- Project is in Maven with dependencies:

```
org.apache.hadoop.hadoop-common
org.apache.hadoop.hadoop-mapreduce-client-core
```

- Compilation by Maven

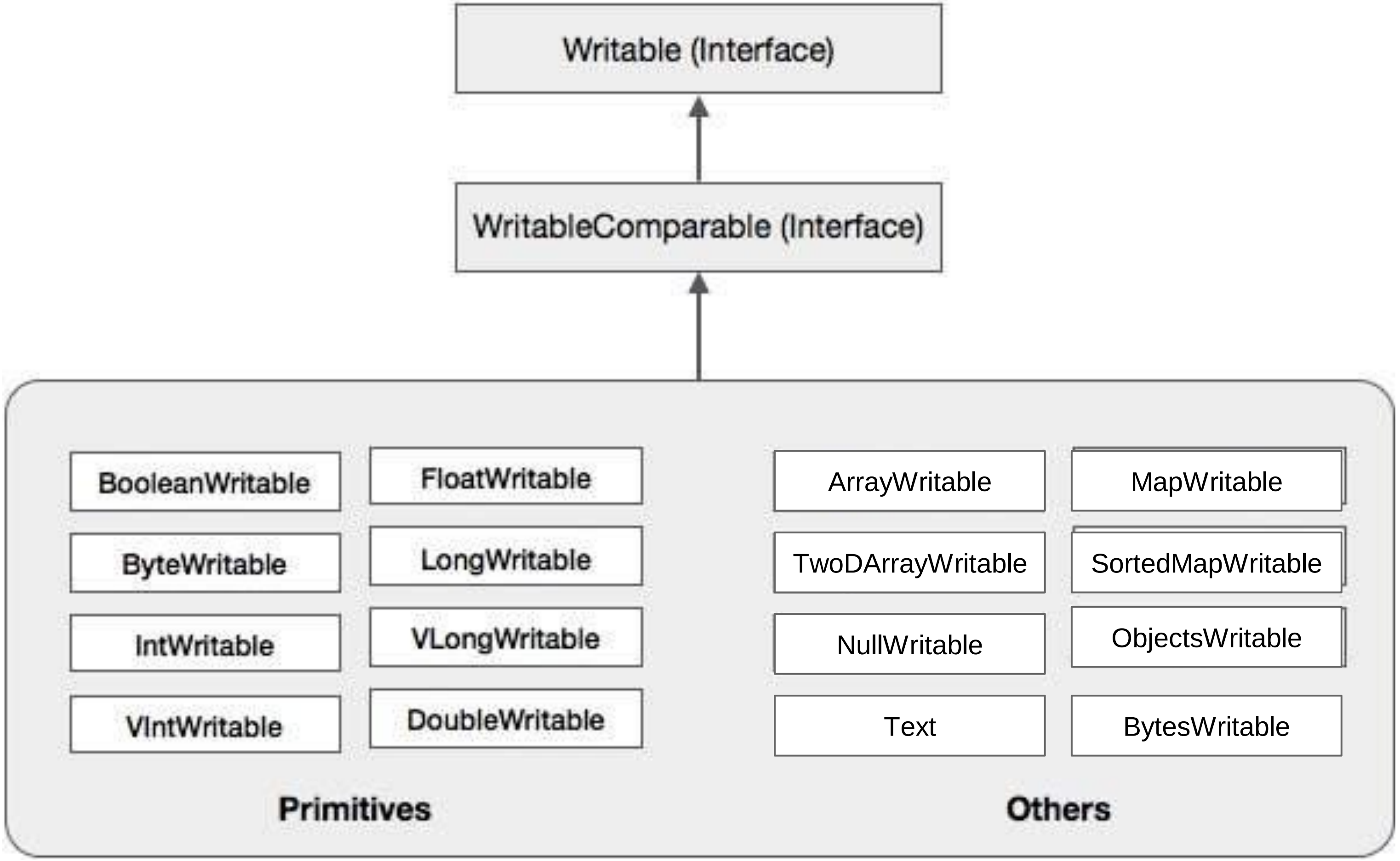
```
$ mvn install
```

MapReduce: WordCount (1)

Task 1: Calculate word frequency in a document.

Sub-task 1.1: Use the Hadoop Java interface to implement the WordCount as introduced in the lecture.

Hadoop Writable Classes



MapReduce: WordCount (2)

localhost

```
local$ module add maven
local$ mvn install
local$ scp target/pa195-hadoop-1.0.jar hador:
```

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```
hador$ hdfs dfs -mkdir input
$ hdfs dfs -mv shake.txt input
$ hadoop jar pa195-hadoop-1.0.jar
pa195.hadoop.WordCount input/ output/


$ hdfs dfs -get output .
$ sort -k 2 -g -r part-r-00000 > sorted.txt
```

https://hador-c2.ics.muni.cz:19890

MapReduce: WordCount (3)

- **Sub-task 1.2:**
    - try it with a Combiner and observe the difference in MapReduce log (output of the hadoop process)

- **Sub-task 1.3:**
    - clean the input: remove characters ,.();:!?- and numbers

MapReduce: WordCount (3)

- **Sub-task 1.4:** do not lowercase the characters but ignore case when counting the words
- **Sub-task 1.5:** sort the results by the word frequency (descending)
    - use a second MapReduce job to do this

MapReduce: Large-scale Test

- **Task 2:** Run the WordCount (count & sort) on a multi-GB collection of documents
  - observe the performance
    - the actual output is not important
  - downloaded Wikipedia in

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```
$ DIR=/storage/brno2/home/dohnal/pa195/wikipedia
$ hdfs dfs -mkdir wiki-input
$ for F in $DIR/*.xml; do hdfs dfs -put $F wiki-input; done
```

  - increase # of reduce jobs

MapReduce: Weather Data

- **Task 3:** Find out the average maximum temperature for each month.

Data: historic temperatures in Milano (CSV format)

```
date,day-min,day-max
01012000,-4.0,5.0
02012000,-5.0,5.1
03012000,-5.0,7.7
04012000,-3.0,9.7
…
```

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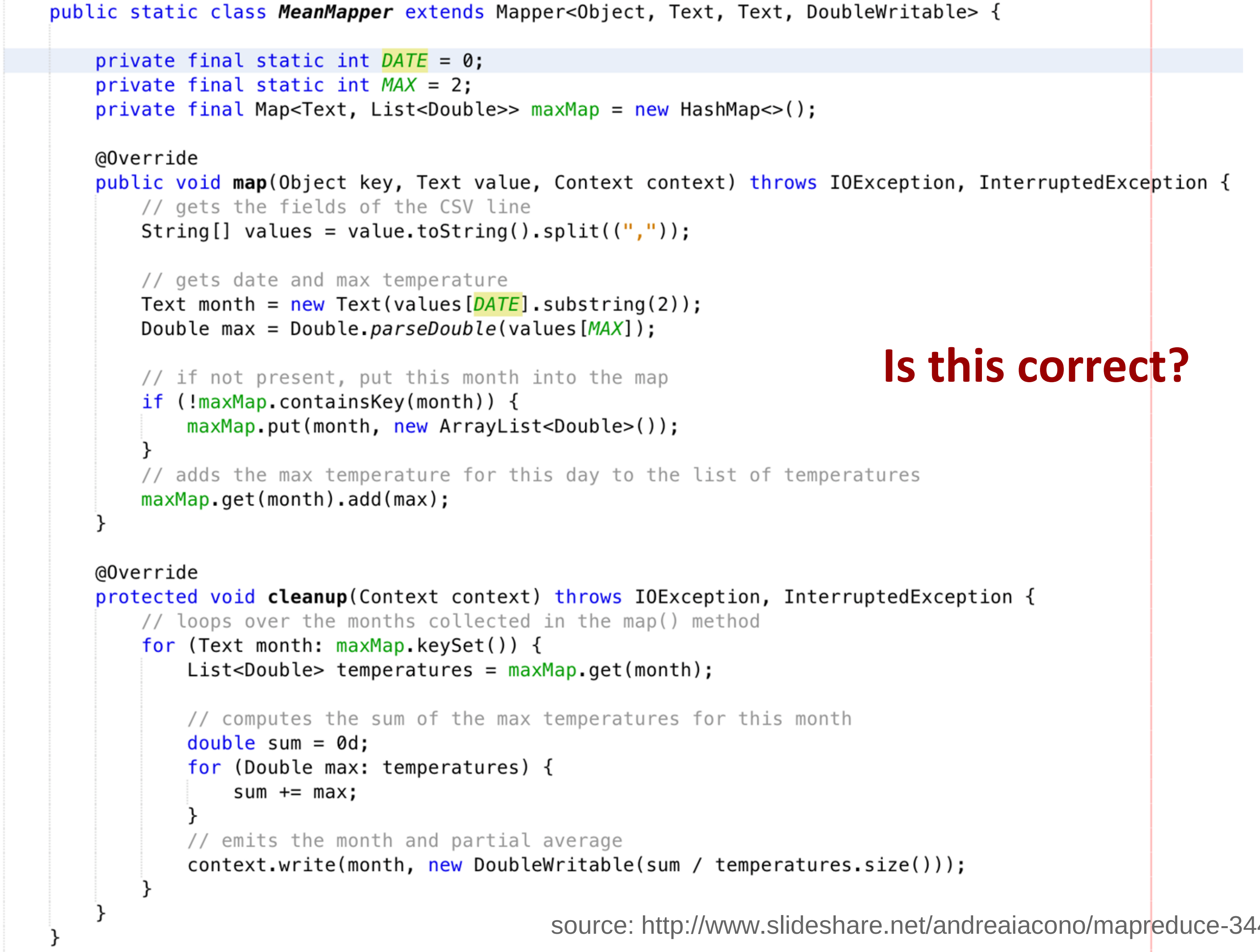
```
$ /storage/brno2/home/dohnal/pa195/weather.csv
```



```java
public static class MeanMapper extends Mapper<Object, Text, Text, DoubleWritable> {

    private final static int DATE = 0;
    private final static int MAX = 2;
    private final Map<Text, List<Double>> maxMap = new HashMap<>();

    @Override
    public void map(Object key, Text value, Context context) throws IOException, InterruptedException {
        // gets the fields of the CSV line
        String[] values = value.toString().split((","));

        // gets date and max temperature
        Text month = new Text(values[DATE].substring(2));
        Double max = Double.parseDouble(values[MAX]);

        // if not present, put this month into the map
        if (!maxMap.containsKey(month)) {
            maxMap.put(month, new ArrayList<Double>());
        }
        // adds the max temperature for this day to the list of temperatures
        maxMap.get(month).add(max);
    }

    @Override
    protected void cleanup(Context context) throws IOException, InterruptedException {
        // loops over the months collected in the map() method
        for (Text month: maxMap.keySet()) {
            List<Double> temperatures = maxMap.get(month);

            // computes the sum of the max temperatures for this month
            double sum = 0d;
            for (Double max: temperatures) {
                sum += max;
            }
            // emits the month and partial average
            context.write(month, new DoubleWritable(sum / temperatures.size()));
        }
    }
}
```

Is this correct?

Weather: Partial Avg Example

source data:

```
01012000, -4.0, 10.0
02012000, -5.0, 20.0
03012000, -5.0, 2.0
04012000, -3.0, 4.0
05012000, -3.0, 3.0
```

Mapper #1: lines 1,2

Mapper #2: lines 3,4,5

Mapper #1 avg: (10 + 20) / 2 = 15

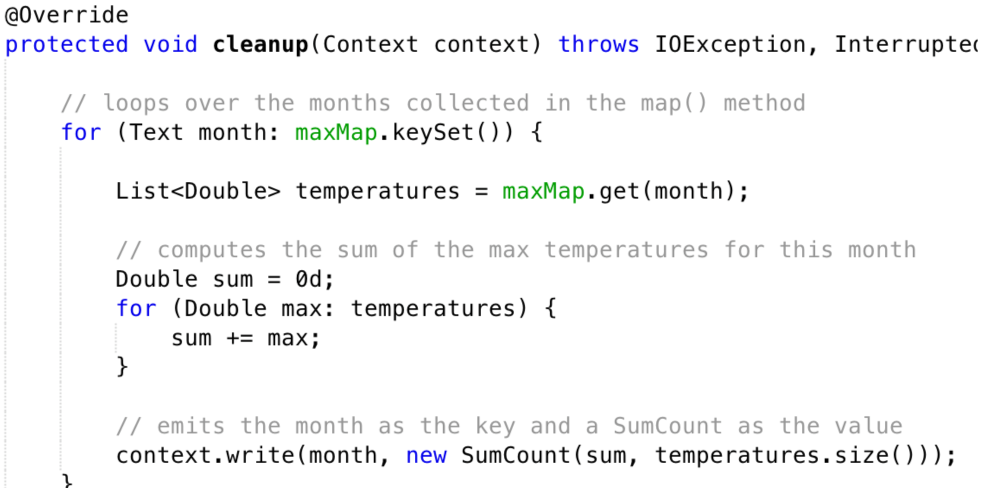
Mapper #2 avg: (2 + 4 + 3) / 3 = 3

Reducer avg: (15 + 3) / 2 = 9

Not correct!

Correct avg: (10+20+2+4+3)/5 = 7.8

This is correct



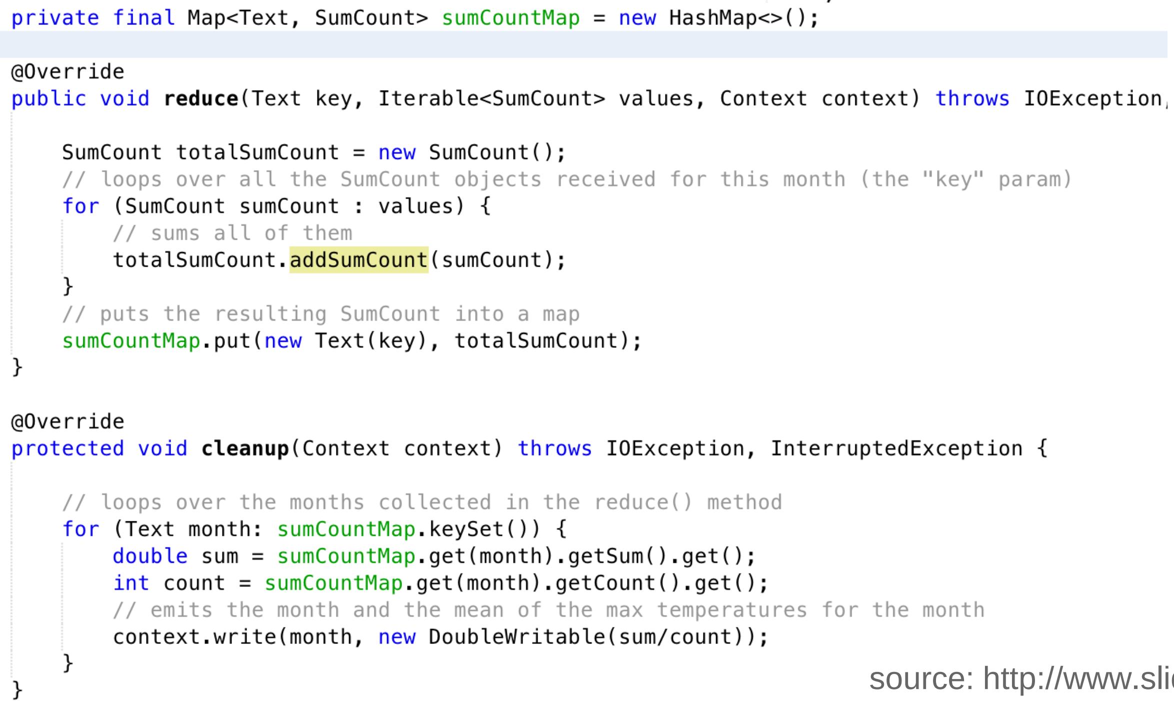
```java
@Override
protected void cleanup(Context context) throws IOException, Interrupte

    // loops over the months collected in the map() method
    for (Text month: maxMap.keySet()) {

        List<Double> temperatures = maxMap.get(month);

        // computes the sum of the max temperatures for this month
        Double sum = 0d;
        for (Double max: temperatures) {
            sum += max;
        }

        // emits the month as the key and a SumCount as the value
        context.write(month, new SumCount(sum, temperatures.size()));
    }
```



```java
private final Map<Text, SumCount> sumCountMap = new HashMap<>();

@Override
public void reduce(Text key, Iterable<SumCount> values, Context context) throws IOException,

    SumCount totalSumCount = new SumCount();
    // loops over all the SumCount objects received for this month (the "key" param)
    for (SumCount sumCount : values) {
        // sums all of them
        totalSumCount.addSumCount(sumCount);
    }
    // puts the resulting SumCount into a map
    sumCountMap.put(new Text(key), totalSumCount);
}

@Override
protected void cleanup(Context context) throws IOException, InterruptedException {

    // loops over the months collected in the reduce() method
    for (Text month: sumCountMap.keySet()) {
        double sum = sumCountMap.get(month).getSum().get();
        int count = sumCountMap.get(month).getCount().get();
        // emits the month and the mean of the max temperatures for the month
        context.write(month, new DoubleWritable(sum/count));
    }
}
```

source: http://www.slideshare.net/andreaiacono/mapreduce-34478449

Spark: Simple Example

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- The MetaCentrum cluster has Spark installed: doc
- A simple example to count words in Shakespeare:

```
$ spark-shell --master yarn


scala> :help
scala> val file = sc.textFile("hdfs://hador-
cluster/user/<login>/shake.txt")
scala> val counts = file.flatMap(line => line.split("
")).map(word => (word, 1)).reduceByKey(_ + _)
scala> counts.saveAsTextFile("spark-output")
scala> :quit
$ hdfs dfs -get spark-output/
```

Lessons Learned & Cleanup

What lessons did we take from the following?

- Basic work with the HDFS distributed file system
- Hadoop MapReduce in Java
    - simple word count and it's modifications
    - large-scale distributed job
    - distributed average

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- Clean the large files from both HDFS and the your home dir on the Hadoop Cluster, please

```
$ hdfs dfs -rm -R wiki-input/
$ hdfs dfs -rm -R output
```