

NIE-PDB: Advanced Database Systems

<http://www.ksi.mff.cuni.cz/~svoboda/courses/NIE-PDB/>

Practical Class 3

MapReduce

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MapReduce Model

Map function

- **Input: an input key-value pair** (input *record*)
- **Output: a set of intermediate key-value pairs**
 - Usually from a different domain
 - Keys do not have to be unique
- $(key, value) \rightarrow \text{list of } (key, value)$

Reduce function

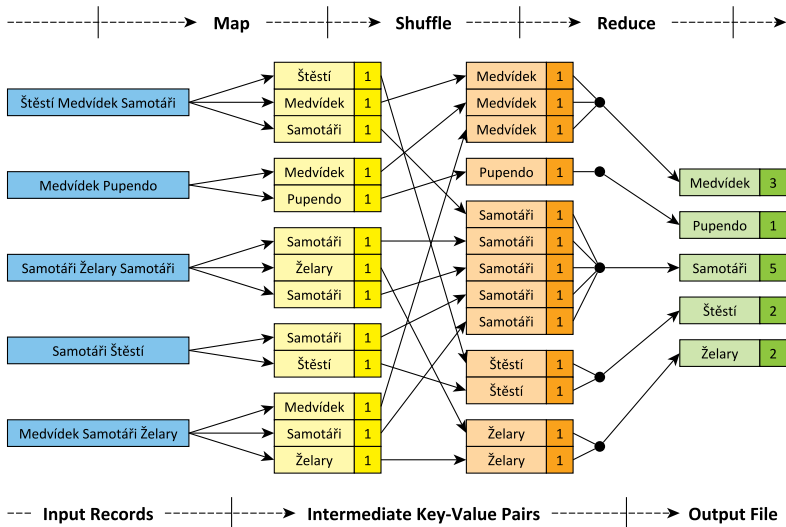
- **Input: an intermediate key + a set of (all) values** for this key
- **Output: a possibly smaller set of values** for this key
 - From the same domain
- $(key, \text{list of } values) \rightarrow (key, \text{list of } values)$

Example: Word Frequency

```
/**
 * Map function
 * @param key    Document identifier
 * @param value  Document contents
 */
map(String key, String value) {
    foreach word w in value: emit(w, 1);
}
```

```
/**
 * Reduce function
 * @param key    Particular word
 * @param values  List of count values generated for this word
 */
reduce(String key, Iterator values) {
    int result = 0;
    foreach v in values: result += v;
    emit(key, result);
}
```

Example: Word Frequency



Apache Hadoop

Open-source framework



- Hadoop Common
- Hadoop **Distributed File System** (HDFS)
- Hadoop Yet Another Resource Negotiator (YARN)
- Hadoop **MapReduce**

Server Access

Connect to our NoSQL server

- ssh and sftp on Linux
- **PuTTY** and **WinSCP** on Windows
- **nosql.kti.in.fit.cvut.cz:42222**
- Login and password sent by e-mail

First Steps

Get familiar with basic Hadoop commands

- `hadoop`
 - Basic help for Hadoop commands
- `hadoop fs`
 - Distributed file system commands
- `hadoop jar`
 - Execution of MapReduce jobs

Browse the HDFS namespace

- `hadoop fs -ls /`
- `hadoop fs -ls /user/`
- `hadoop fs -ls /user/login/`

Word Count Job

Create your working directory

- `cd ~`
- `mkdir -p mapreduce/WordCount`
- `cd mapreduce/WordCount`

Make a copy of the sample java source file

- `cp /home/PDB/mapreduce/WordCount.java .`

Word Count Job

Compile our Word Count implementation

- `mkdir classes`
- `javac -classpath \`
`/home/PDB/mapreduce/hadoop-common-3.3.4.jar:\`
`/home/PDB/mapreduce/\`
`hadoop-mapreduce-client-core-3.3.4.jar \`
`-d classes/ WordCount.java`
- `jar -cvf WordCount.jar -C classes/ .`

Word Count Job

Create your HDFS working directories

- `hadoop fs -mkdir /user/login/WordCount`
- `hadoop fs -mkdir /user/login/WordCount/input1`

Prepare the sample input data

- `hadoop fs -copyFromLocal \`
 `/home/PDB/mapreduce/input1/movies.txt \`
 `/user/login/WordCount/input1`

Word Count Job

Run the prepared MapReduce job

- `hadoop jar WordCount.jar WordCount \`
 `/user/login/WordCount/input1 \`
 `/user/login/WordCount/output1`

Word Count Job

Retrieve and explore the job result

- `hadoop fs -copyToLocal \`
`/user/login/WordCount/output1/part-r-00000 \`
`result.txt`
- `cat result.txt`

Clean the output HDFS directory

- `hadoop fs -rm -r /user/login/WordCount/output1/`

Bigger Word Count Job

Run our MapReduce job on a bigger input file

- Create your input2 HDFS directory
- Deploy a copy of the following input file
`/home/PDB/mapreduce/input2/RomeoAndJuliet.txt`
- Run the MapReduce job
- Retrieve and browse the result
- Clean the output HDFS directory

MapReduce Project

Download the following Hadoop libraries

- `/home/PDB/mapreduce/
hadoop-common-3.3.4.jar`
- `/home/PDB/mapreduce/
hadoop-mapreduce-client-core-3.3.4.jar`

Choose your preferred Java IDE

- NetBeans
- IntelliJ IDEA

NetBeans Project

Launch NetBeans IDE and create a new project

- Select *Java application* as a project type
 - Let the main class to be created automatically
 - Do not use explicit packages
- Add both the Hadoop libraries into the project
 - Use *Add JAR/Folder* in the project context menu
- Replace the contents of the main class with our pattern
 - `/home/PDB/mapreduce/WordCount.java`
 - Change the name of the class appropriately

Build the project to create a *jar* distribution

IntelliJ IDEA Project

Launch IntelliJ IDEA and create a new project

- Select *Java* as a project type
 - Do not include any additional libraries or frameworks
- Add both the Hadoop libraries into the project
 - Open *Project Structure* in the *File* menu
 - Select *Modules* at the left panel and then *Dependencies* tab
 - Click *+* on the right and select *JARs or directories*
- Add a new Java class into the project
 - Replace its contents with the sample pattern
 - `/home/PDB/mapreduce/WordCount.java`
 - Change the name of the class appropriately

Build the project to create a *jar* distribution

Java Interface

Mapper class

- Implementation of the **map function**
- Template parameters
 - KEYIN, VALUEIN – types of input key-value pairs
 - KEYOUT, VALUEOUT – types of intermediate key-value pairs
- Intermediate pairs are emitted via `context.write(k, v)`

```
class MyMapper extends Mapper<KEYIN, VALUEIN, KEYOUT, VALUEOUT> {  
    @Override  
    public void map(KEYIN key, VALUEIN value, Context context)  
        throws IOException, InterruptedException  
    {  
        // Implementation  
    }  
}
```

Java Interface

Reducer class

- Implementation of the **reduce function**
- Template parameters
 - KEYIN, VALUEIN – types of intermediate key-value pairs
 - KEYOUT, VALUEOUT – types of output key-value pairs
- Output pairs are emitted via `context.write(k, v)`

```
class MyReducer extends Reducer<KEYIN, VALUEIN, KEYOUT, VALUEOUT> {  
    @Override  
    public void reduce(KEYIN key, Iterable<VALUEIN> values, Context context)  
        throws IOException, InterruptedException  
    {  
        // Implementation  
    }  
}
```

Inverted Index

Implement an *inverted index* using MapReduce

- Use input files in `/home/PDB/mapreduce/input3/`
- Produce a list of *file:occurrences* pairs for each word
 - E.g.: Samotari file1:1 file3:2 file4:1 file5:1
- Use `((FileSplit)context.getInputSplit()).getPath().getName();` to access input file names
- Use `Map<String, Integer> map = new HashMap<>();` to process intermediate key-value pairs
- Use `map.entrySet()` to iterate over map entries

Compile, deploy and run the job...

References

HDFS: File System Shell commands

- <https://hadoop.apache.org/docs/r3.3.4/hadoop-project-dist/hadoop-common/FileSystemShell.html>

MapReduce: tutorial

- <https://hadoop.apache.org/docs/r3.3.4/hadoop-mapreduce-client/hadoop-mapreduce-client-core/MapReduceTutorial.html>

MapReduce: shell commands

- <https://hadoop.apache.org/docs/r3.3.4/hadoop-mapreduce-client/hadoop-mapreduce-client-core/MapredCommands.html>

MapReduce: JavaDoc

- <https://hadoop.apache.org/docs/r3.3.4/api/>