MIE-PDB.16: **Advanced Database Systems**

http://www.ksi.mff.cuni.cz/~svoboda/courses/191-MIE-PDB/

Practical Class 4

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
- $(key, value) \rightarrow$ list of $(key, value)$

Reduce function

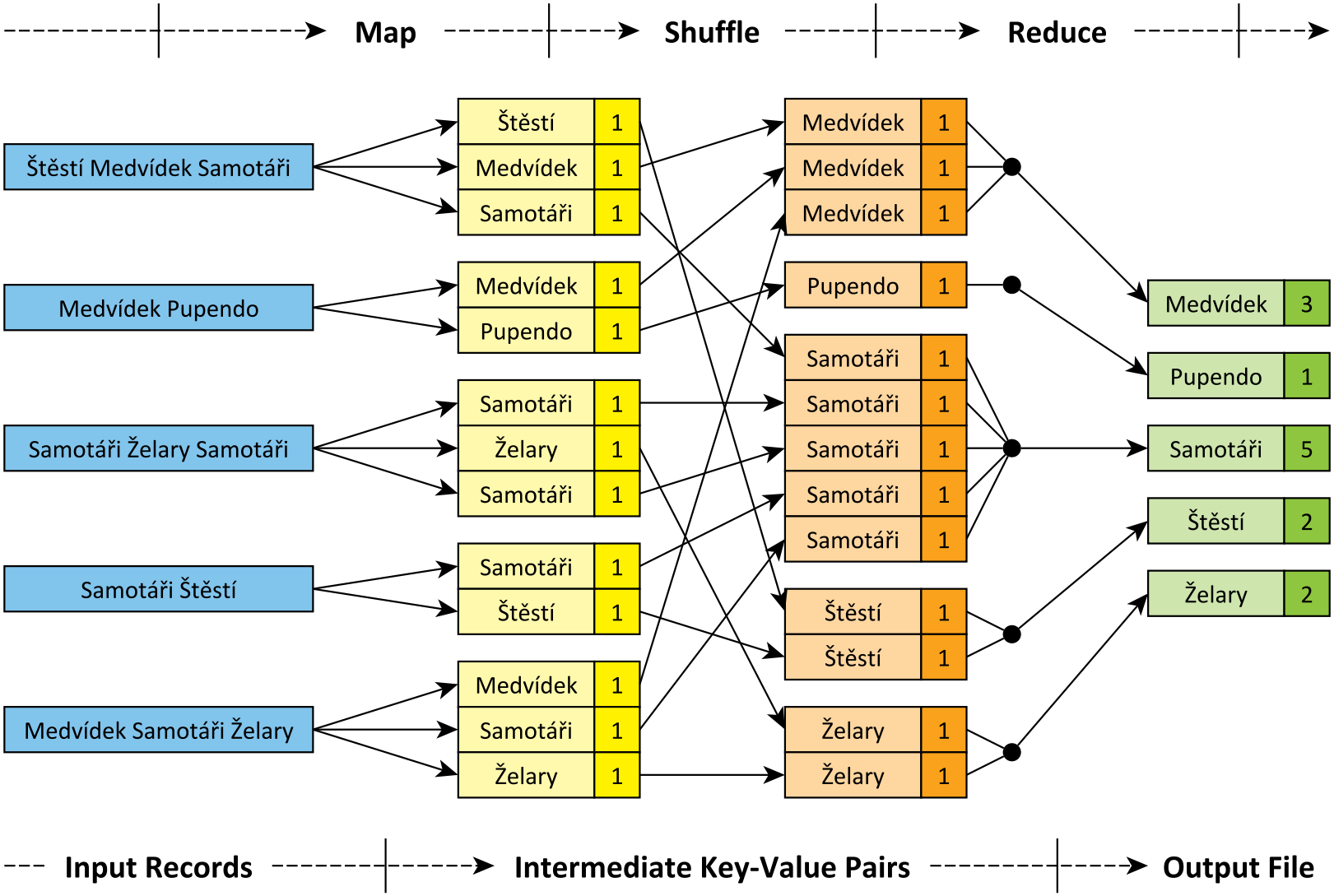
- *Input*: **an intermediate key + a set of (all) values** for this key
- *Output*: **a possibly smaller set of values** for this key
  - From the same domain
- $(key,$ list of $values) \rightarrow (key,$ list of $values)$

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);
}
```

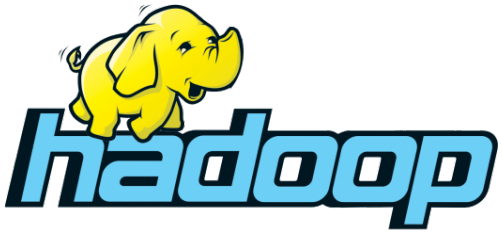
```
/**
 * Reduce function
 * @param key    Particular word
 * @param values List of count values generated for this word
 */
reduce(String key, Iterator values) {
  int result = 0;
  foreach v in values: result += v;
  emit(key, result);
}
```

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.ms.mff.cuni.cz:42222**
- Login and password sent by e-mail

Change your initial password (if not yet changed)

- `passwd`

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-3.1.1.jar:/home/PDB/mapreduce/hadoop-mapreduce-client-core-3.1.1.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

Useful Commands

Additional MapReduce commands that might be helpful

- `mapred job -list all`
  - Lists identifiers of all the MapReduce jobs
- `mapred job -status job-id`
  - Prints status counters for a given MapReduce job
- `mapred job -kill job-id`
  - Kills a particular MapReduce job

MapReduce Project

Download the following Hadoop libraries

- `/home/PDB/mapreduce/`
  `hadoop-common-3.1.1.jar`
- `/home/PDB/mapreduce/`
  `hadoop-mapreduce-client-core-3.1.1.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/r3.1.1/hadoop-project-dist/hadoop-common/FileSystemShell.html

MapReduce: tutorial

- https://hadoop.apache.org/docs/r3.1.1/hadoop-mapreduce-client/hadoop-mapreduce-client-core/MapReduceTutorial.html

MapReduce: shell commands

- https://hadoop.apache.org/docs/r3.1.1/hadoop-mapreduce-client/hadoop-mapreduce-client-core/MapredCommands.html

MapReduce: JavaDoc

- https://hadoop.apache.org/docs/r3.1.1/api/