Big Data Programming Using Hadoop Workshop

February 2015

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Modifiy from Original Version by Danairat T.
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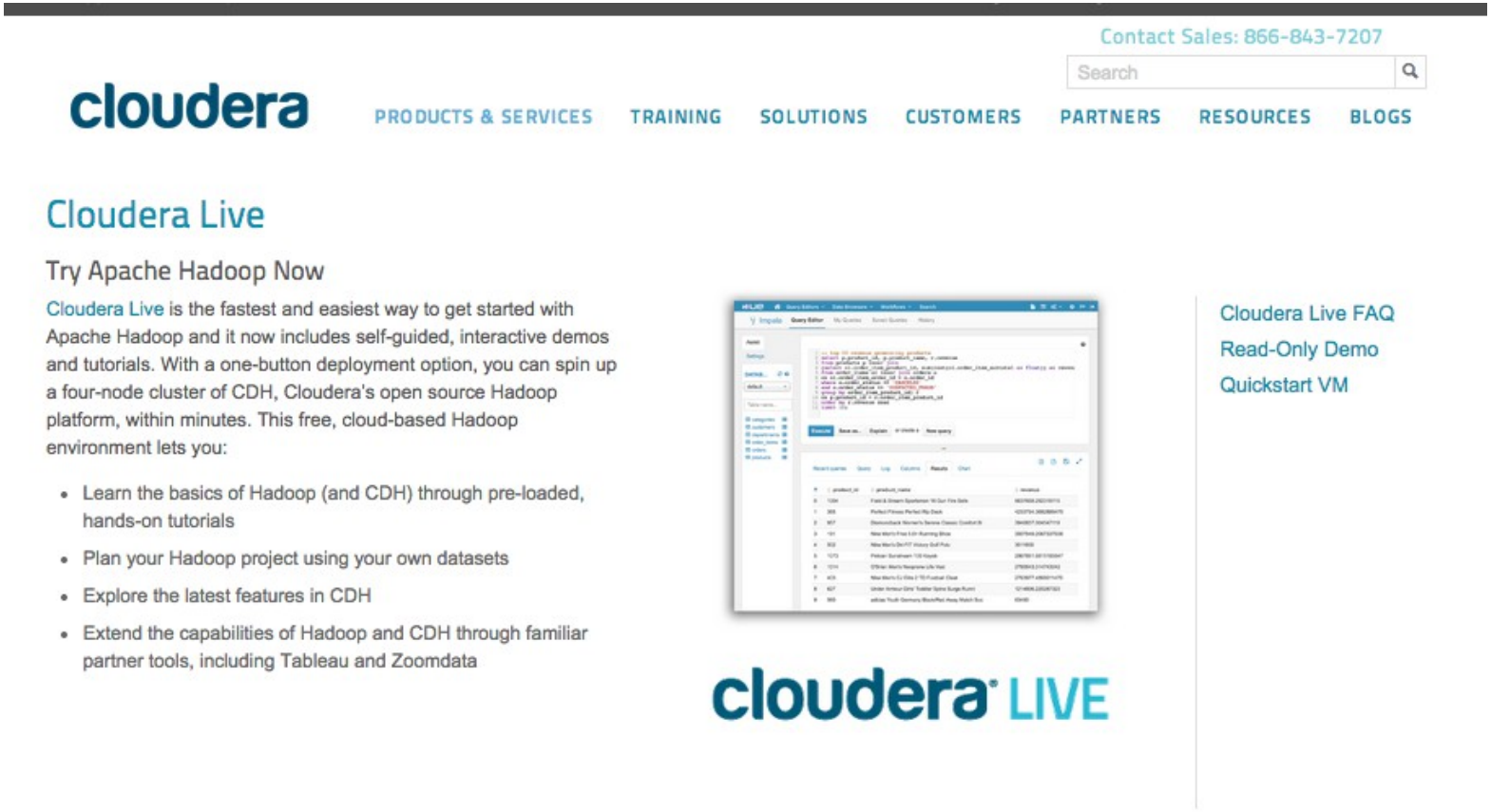
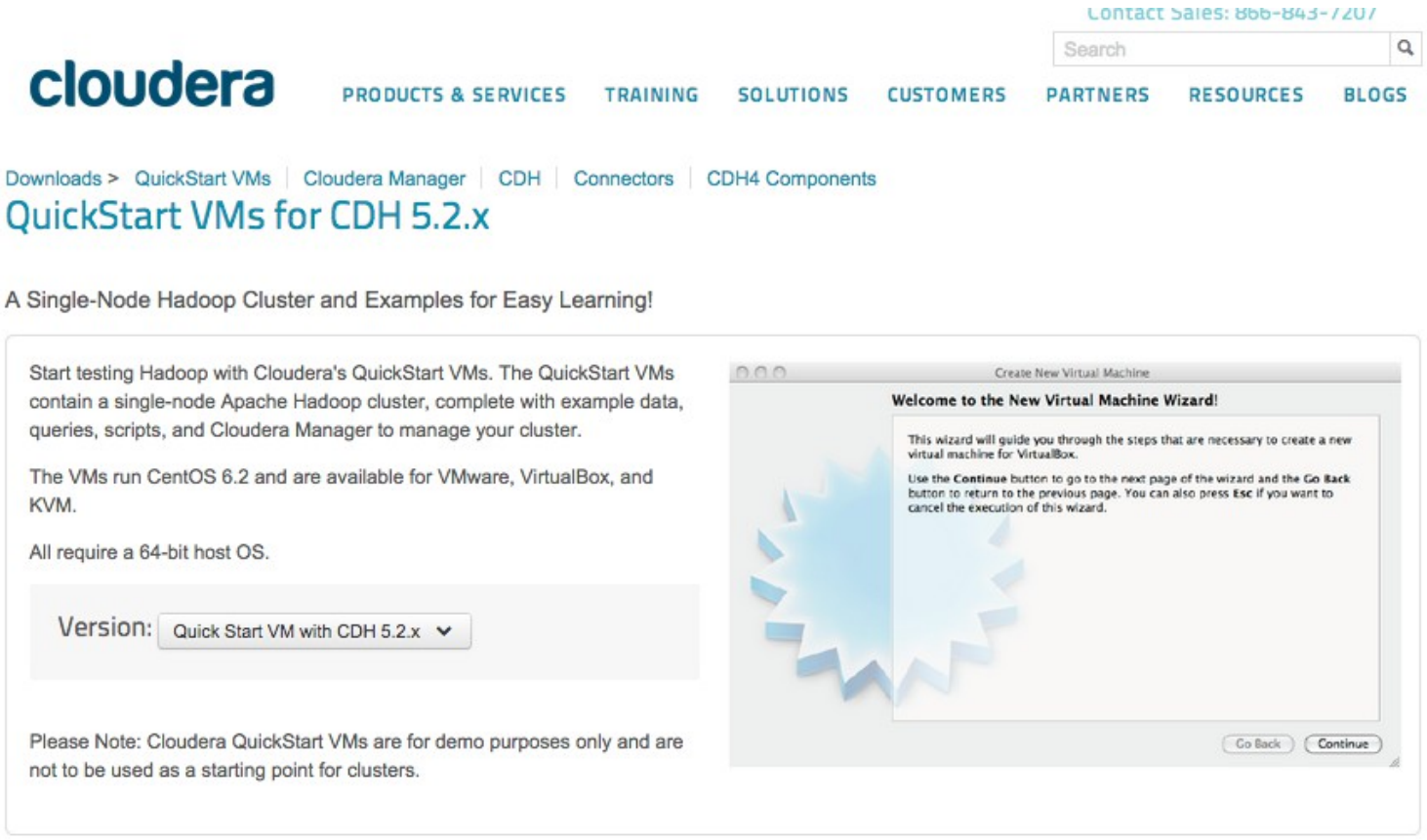
danairat@gmail.com

Hands-On: Running Hadoop

Running this lab using Cloudera Live

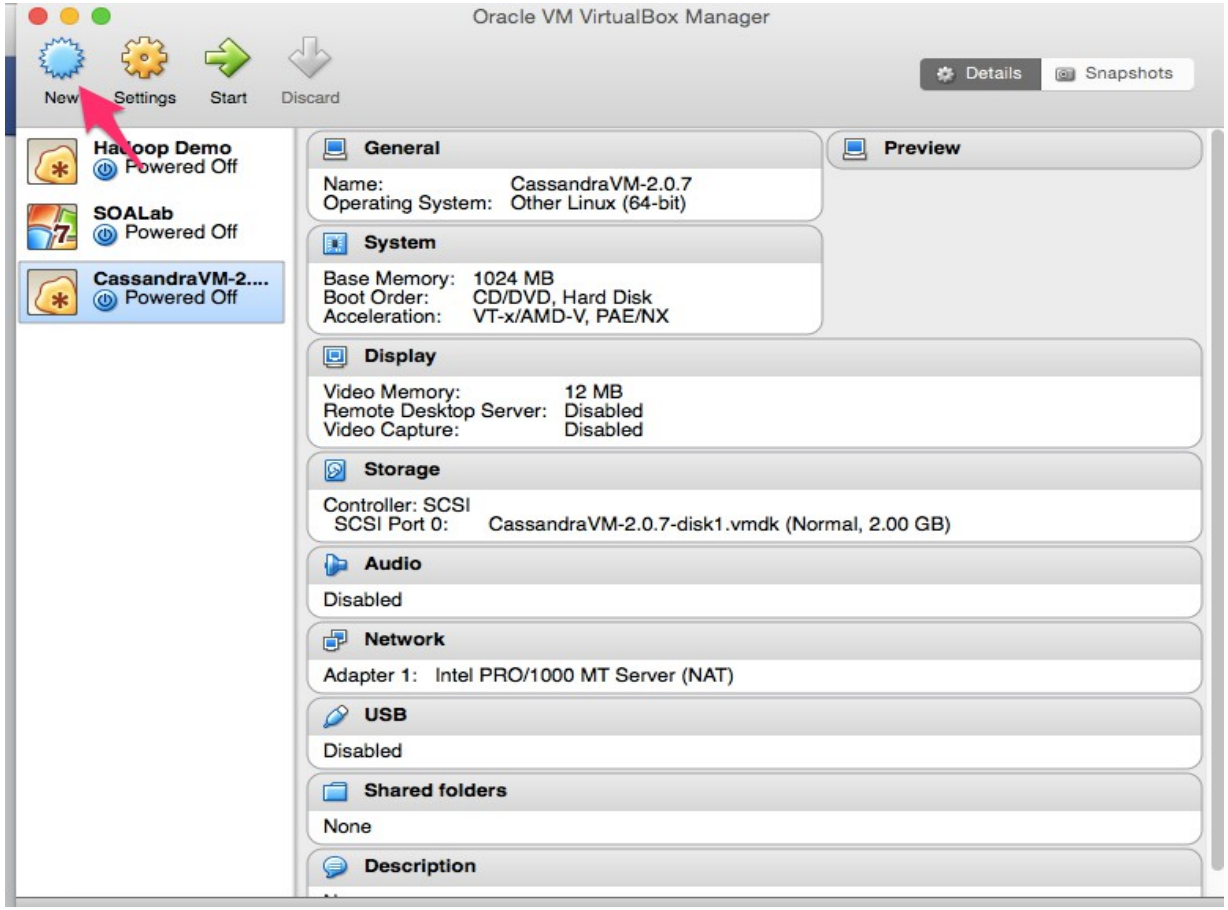


Using Cloudera VM



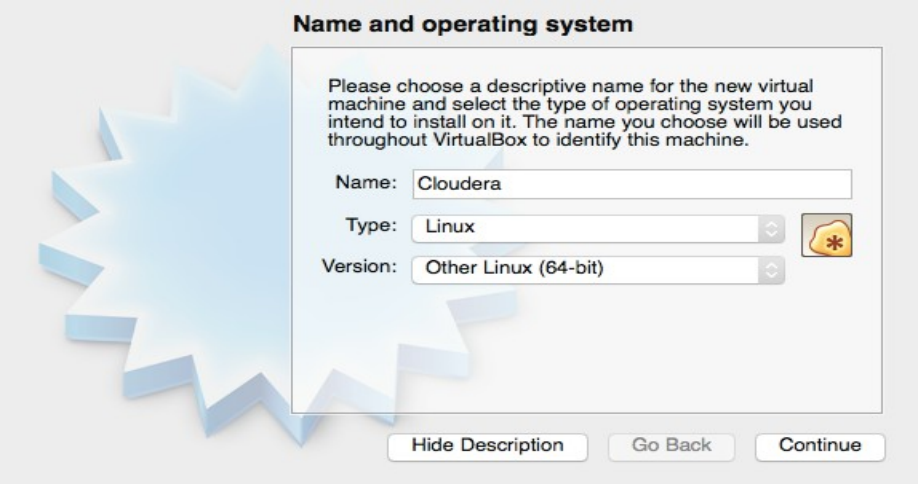
Starting Cloudera VM

Start VirtualBox and Select New

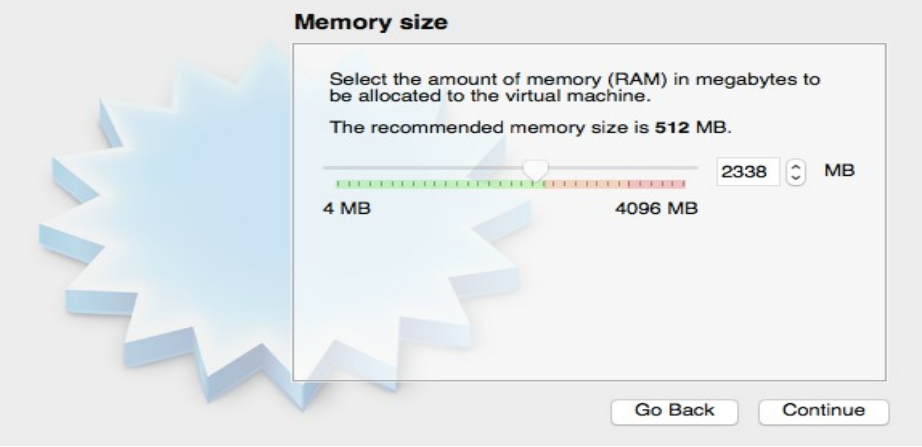


Starting Cloudera VM (cont)

Name the image as Cloudera and select OS as Linux 64 bit



Then select memory size

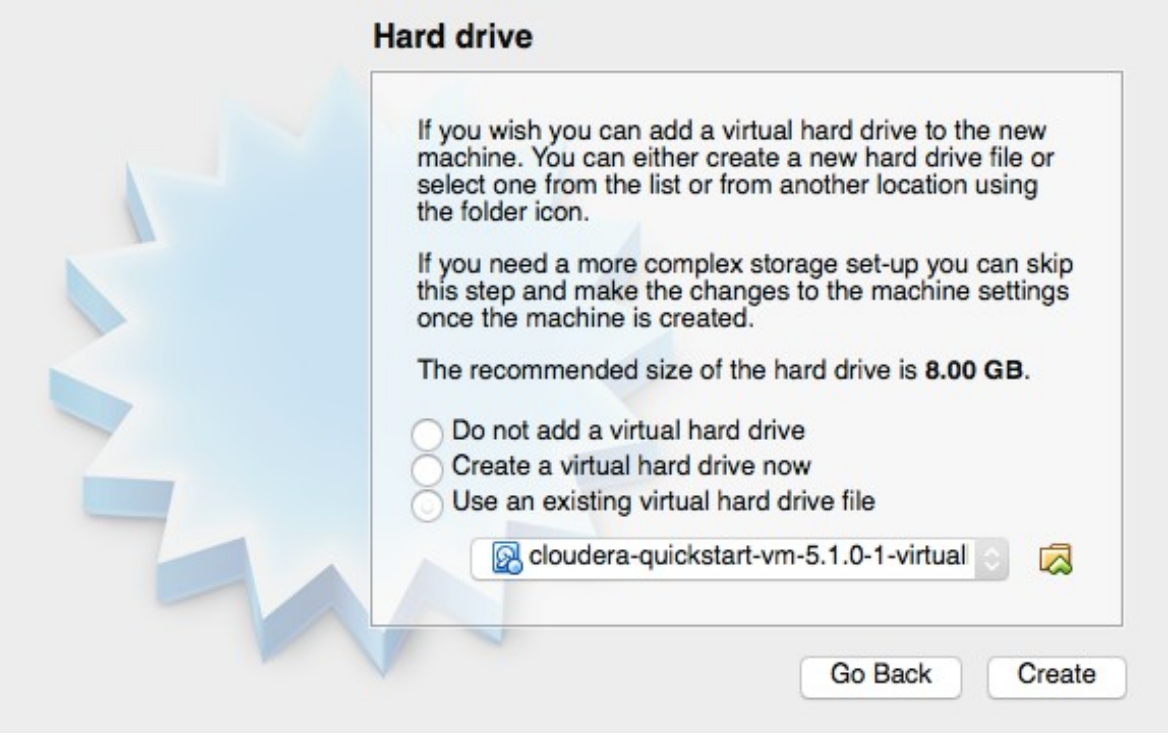


Starting Cloudera VM (cont)

Select >> Use an existing virtual hard drive file

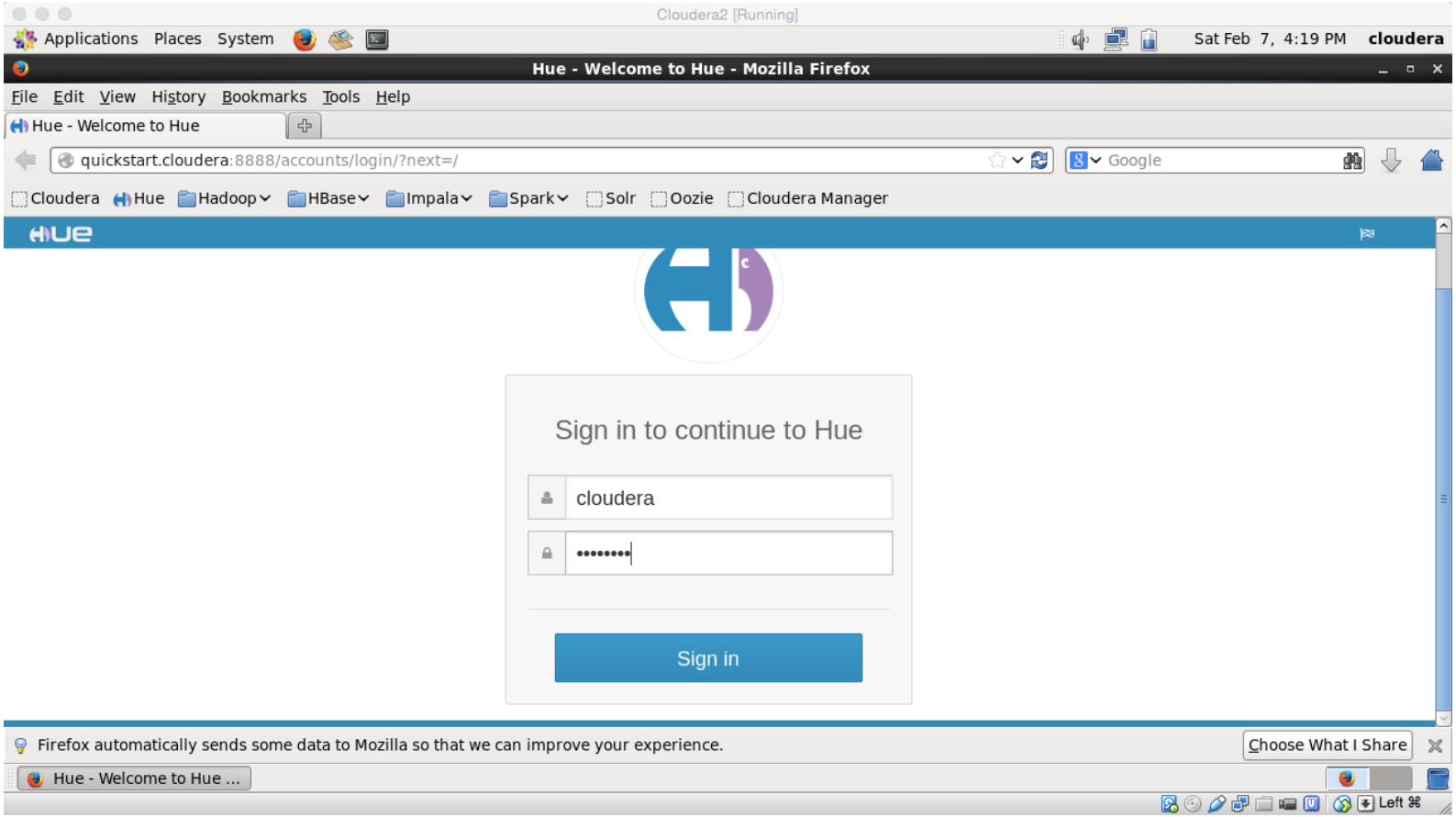
Locate to file cloudera-quickstart-vm-5.1.0-1-virtualbox-disk1.vmdk

Then click Start

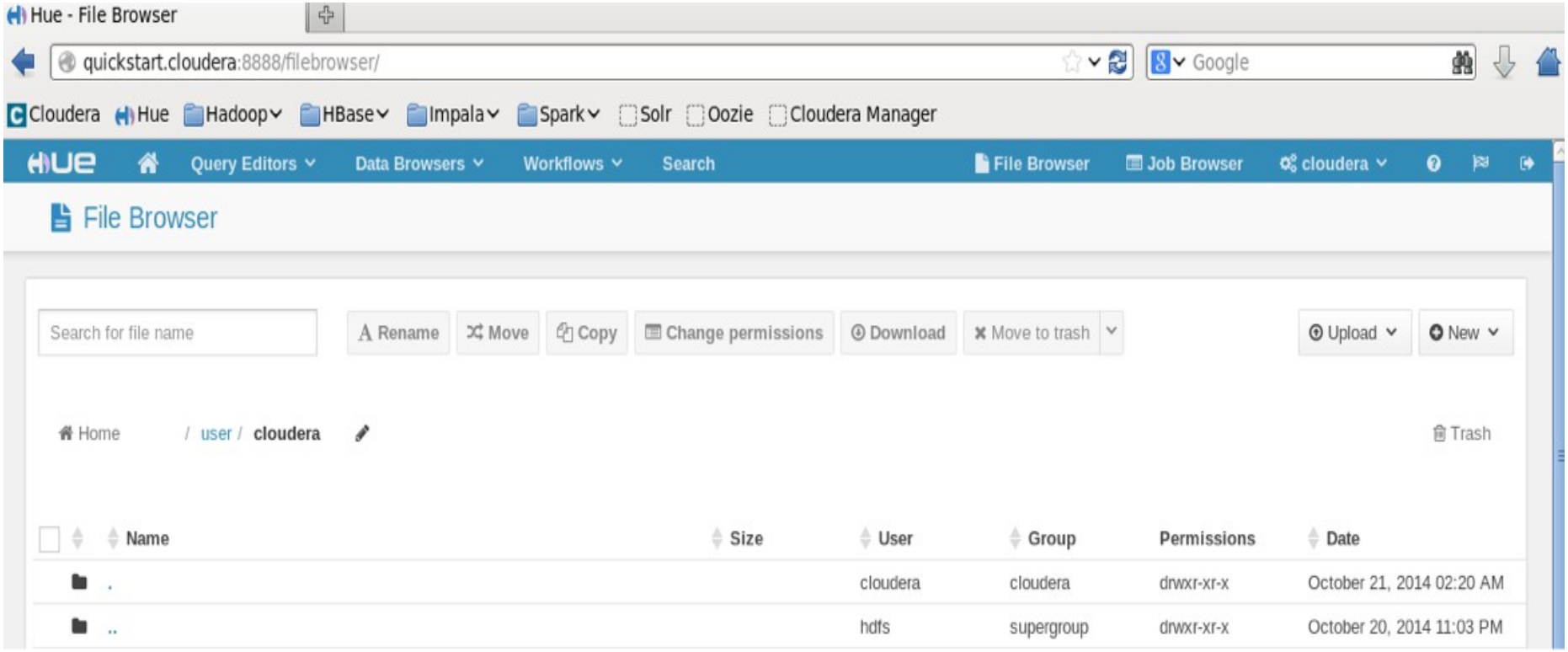


Sign in to Hue

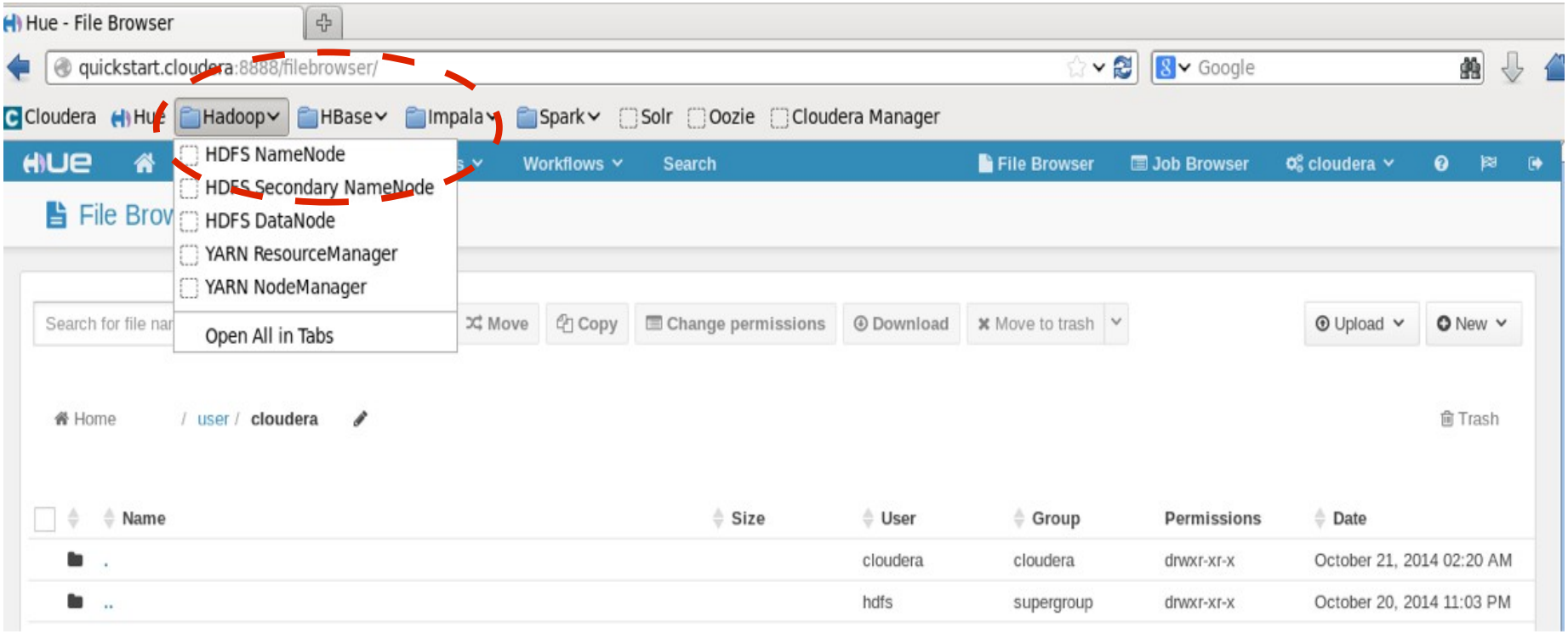
Username: cloudera; Password: cloudera

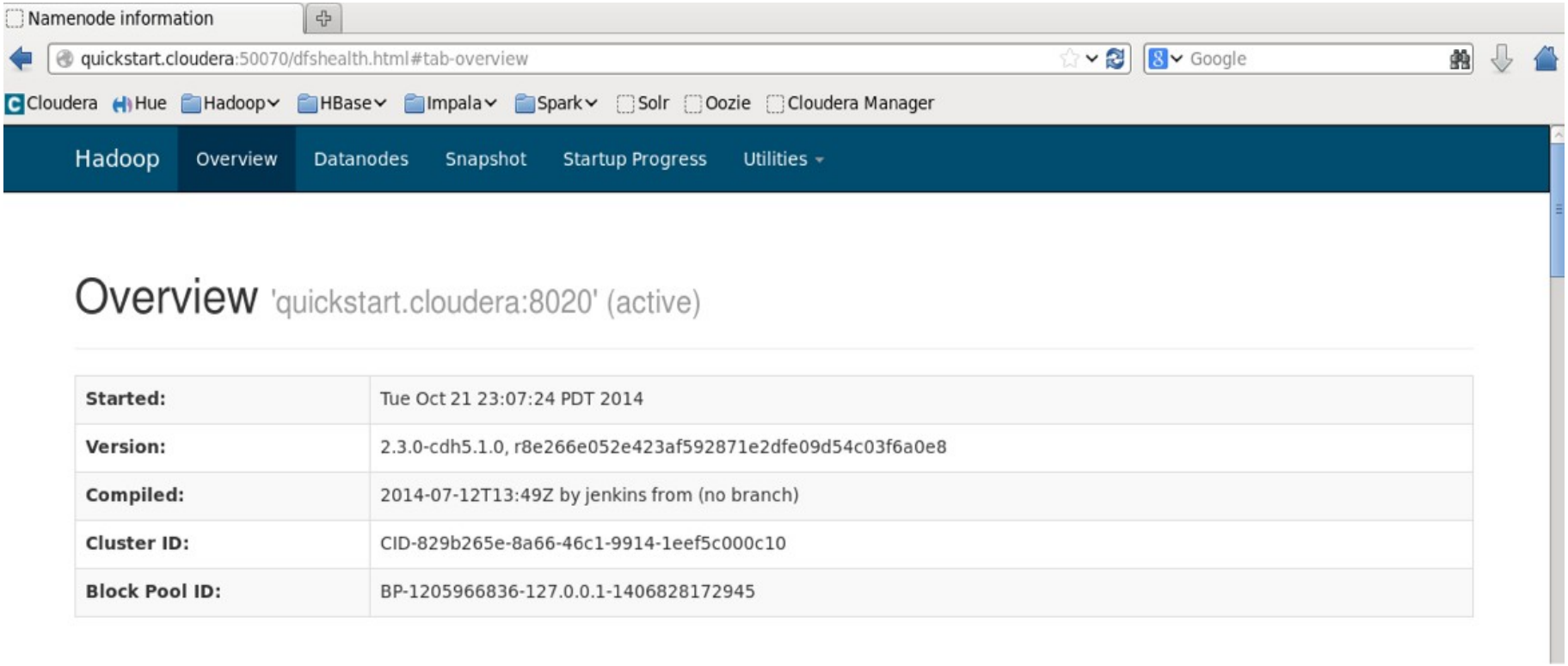


Starting Hue on Cloudera



Viewing HDFS




Namenode information
quickstart.cloudera:50070/dfshealth.html#tab-overview
Google
Cloudera
Hue
Hadoop
HBase
Impala
Spark
Solr
Oozie
Cloudera Manager
Hadoop
Overview
Datanodes
Snapshot
Startup Progress
Utilities
Overview 'quickstart.cloudera:8020' (active)
Started: Tue Oct 21 23:07:24 PDT 2014
Version: 2.3.0-cdh5.1.0, r8e266e052e423af592871e2dfe09d54c03f6a0e8
Compiled: 2014-07-12T13:49Z by jenkins from (no branch)
Cluster ID: CID-829b265e-8a66-46c1-9914-1eef5c000c10
Block Pool ID: BP-1205966836-127.0.0.1-1406828172945

Hands-On: Importing/Exporting Data to HDFS

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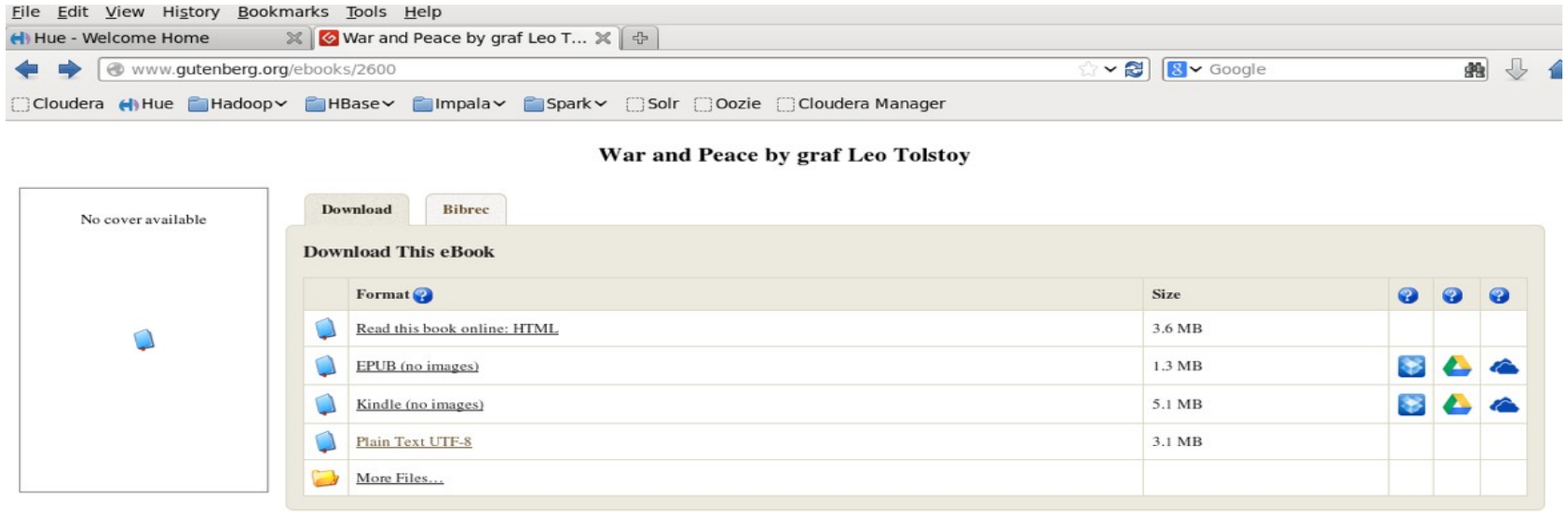
Importing Data to Hadoop

Download War and Peace Full Text

```
www.gutenberg.org/ebooks/2600
```




```
$hadoop fs -mkdir input
$hadoop fs -mkdir output
$hadoop fs -copyFromLocal Downloads/pg2600.txt input
```

Review file in Hadoop HDFS

List HDFS File

```
[cloudera@localhost ~]$ hadoop fs -ls input
Found 1 items
-rw-r--r--   3 cloudera cloudera         15 2014-06-16 19:07 input/input_test.txt
[cloudera@localhost ~]$
```

Read HDFS File

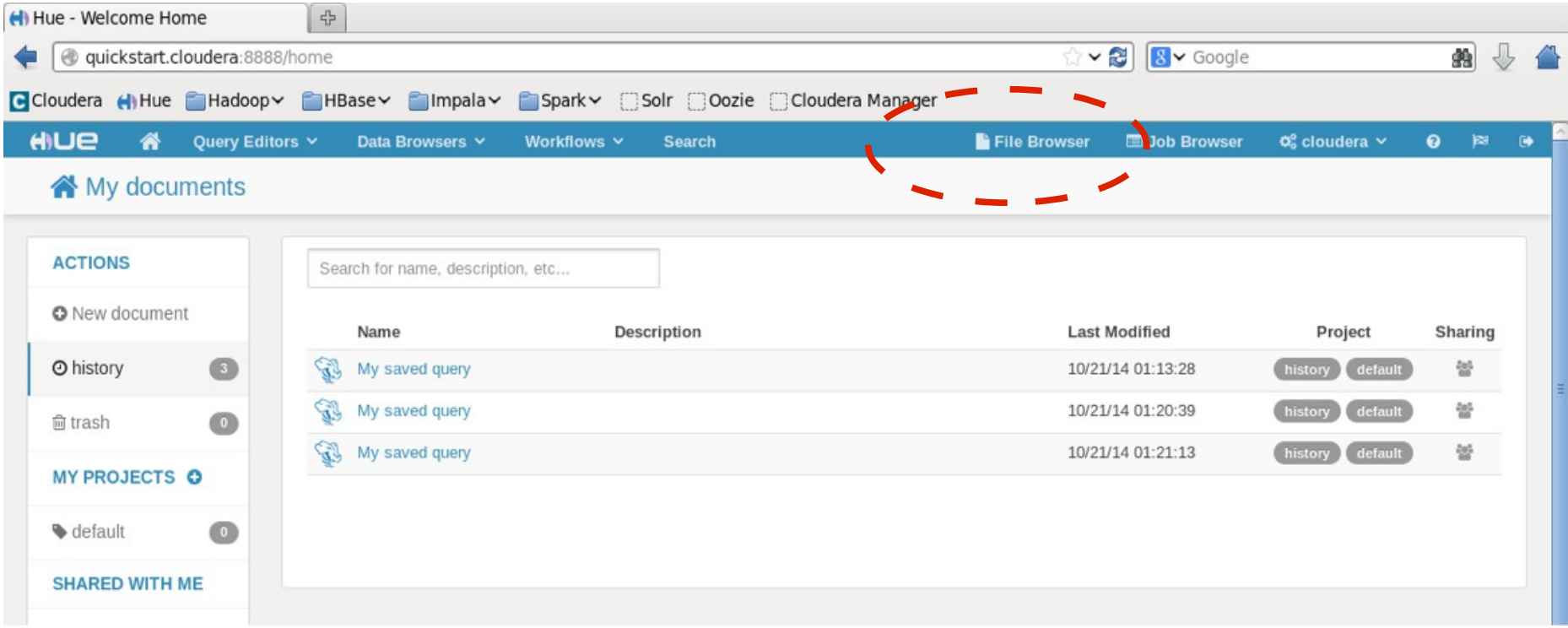
```
[hdadmin@localhost bin]$ hadoop fs -cat input/pg2600.txt
```

Retrieve HDFS File to Local File System

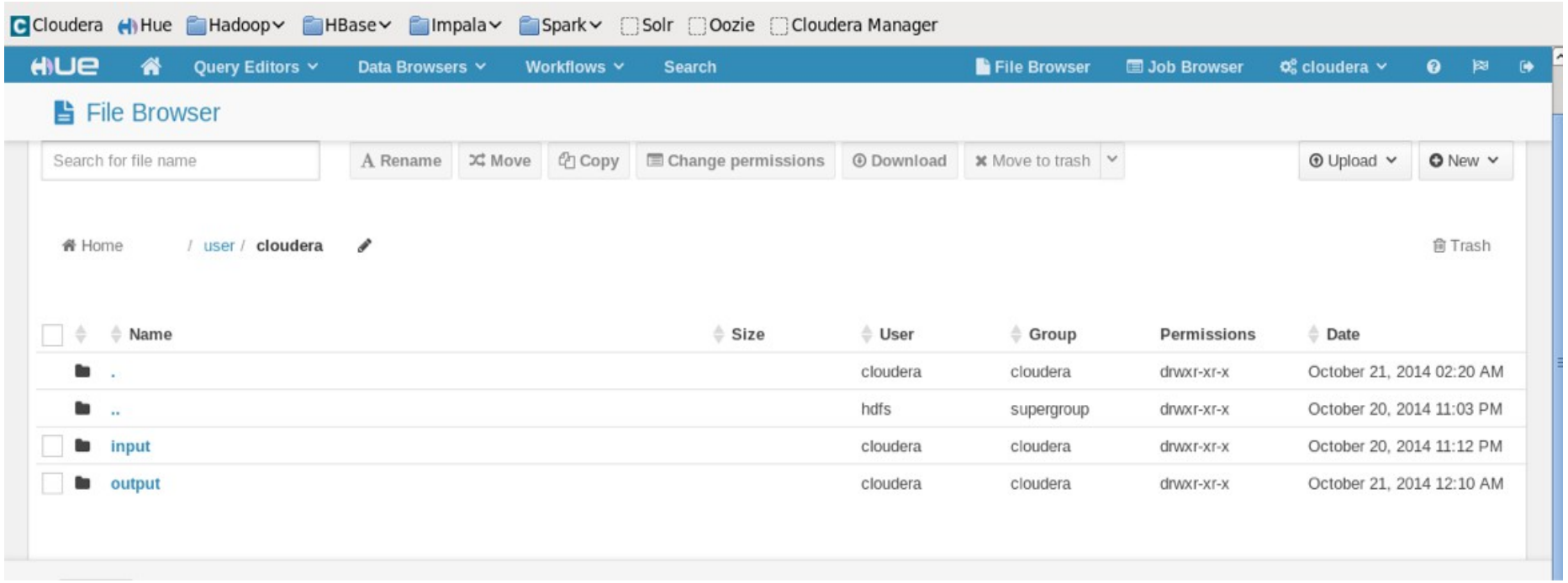
```
[hdadmin@localhost bin]$ hadoop fs -copyToLocal input/pg2600.txt tmp/file.txt
```

Please see also http://hadoop.apache.org/docs/r1.0.4/commands_manual.html

Review file in Hadoop HDFS using File Browse



Review file in Hadoop HDFS using Hue

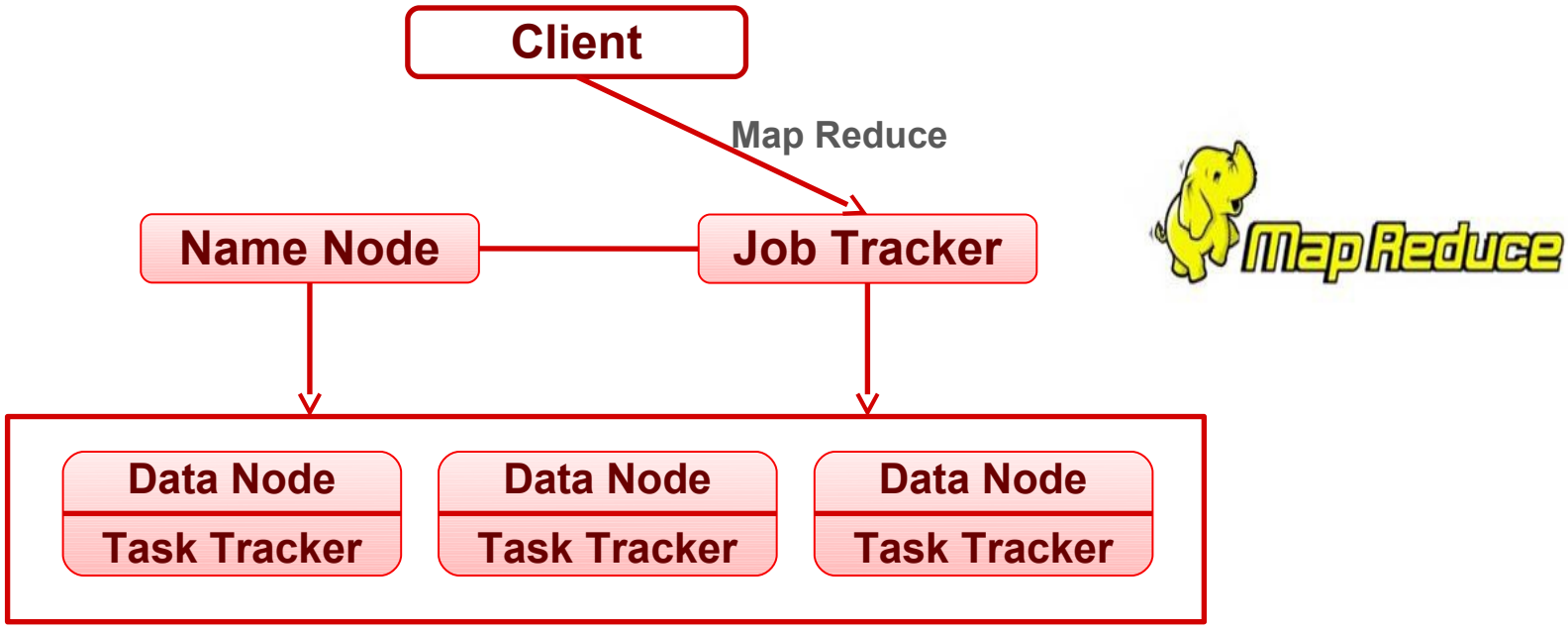


Hadoop Port Numbers

	Daemon	Default Port	Configuration Parameter in conf/*-site.xml
HDFS	Namenode	50070	dfs.http.address
	Datanodes	50075	dfs.datanode.http.address
	Secondarynamenode	50090	dfs.secondary.http.address
MR	JobTracker	50030	mapred.job.tracker.http.address
	Tasktrackers	50060	mapred.task.tracker.http.address

Removing data from HDFS using Shell Command

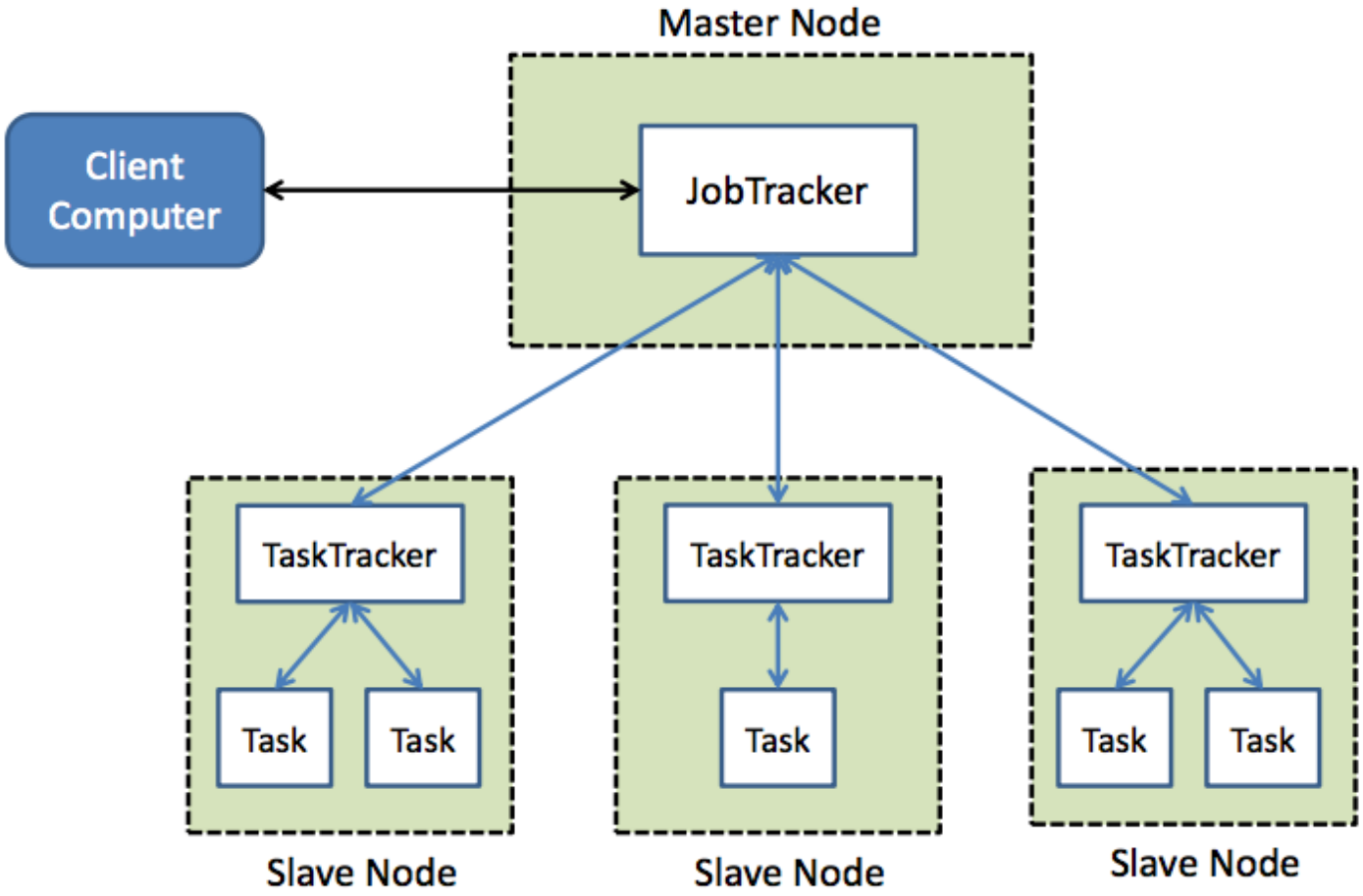
```
hdadmin@localhost detach]$ hadoop fs -rm input/pg2600.txt
Deleted hdfs://localhost:54310/input/pg2600.txt
hdadmin@localhost detach]$
```



Lecture: Understanding Map Reduce Processing

Danairat T., , danairat@gmail.com: Thanachart Numnonda, thanachart@imcinstitute.com Aug 2013

High Level Architecture of MapReduce



Before MapReduce…

- Large scale data processing was difficult!
  - Managing hundreds or thousands of processors
  - Managing parallelization and distribution
  - I/O Scheduling
  - Status and monitoring
  - Fault/crash tolerance
- MapReduce provides all of these, easily!

Source: http://labs.google.com/papers/mapreduce-osdi04-slides/index-auto-0002.html

MapReduce Overview

- What is it?
  - Programming model used by Google
  - A combination of the Map and Reduce models with an associated implementation
  - Used for processing and generating large data sets

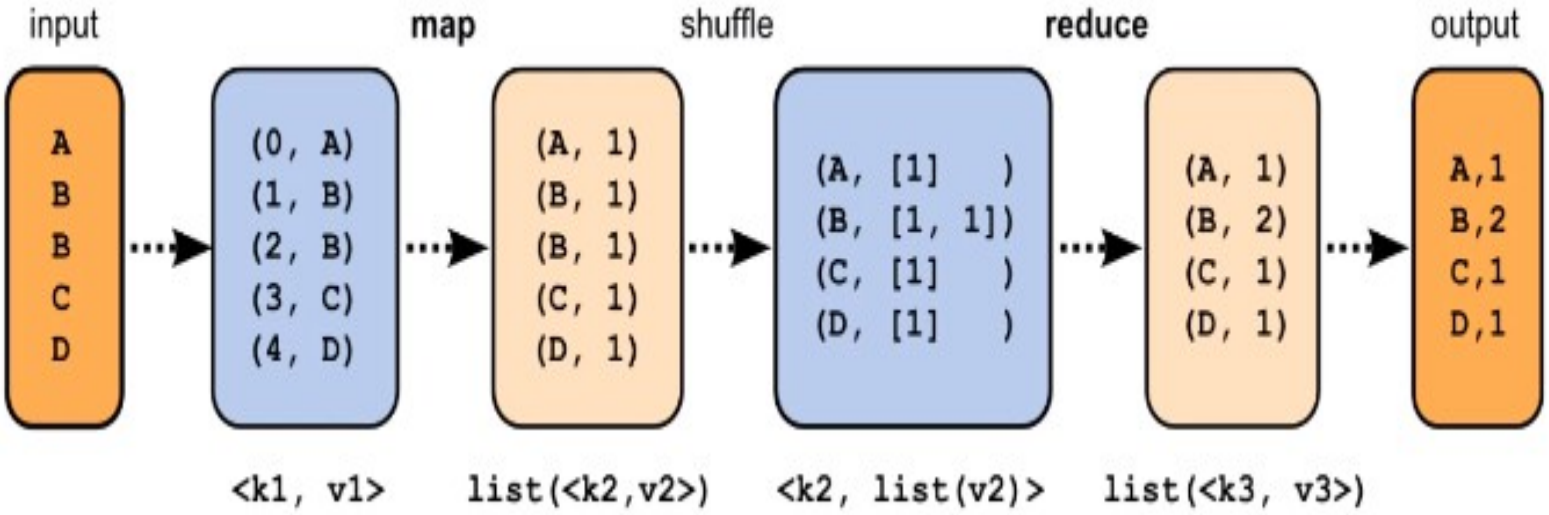
Source: http://labs.google.com/papers/mapreduce-osdi04-slides/index-auto-0002.html

MapReduce Overview

- How does it solve our previously mentioned problems?
  - MapReduce is highly scalable and can be used across many computers.
  - Many small machines can be used to process jobs that normally could not be processed by a large machine.

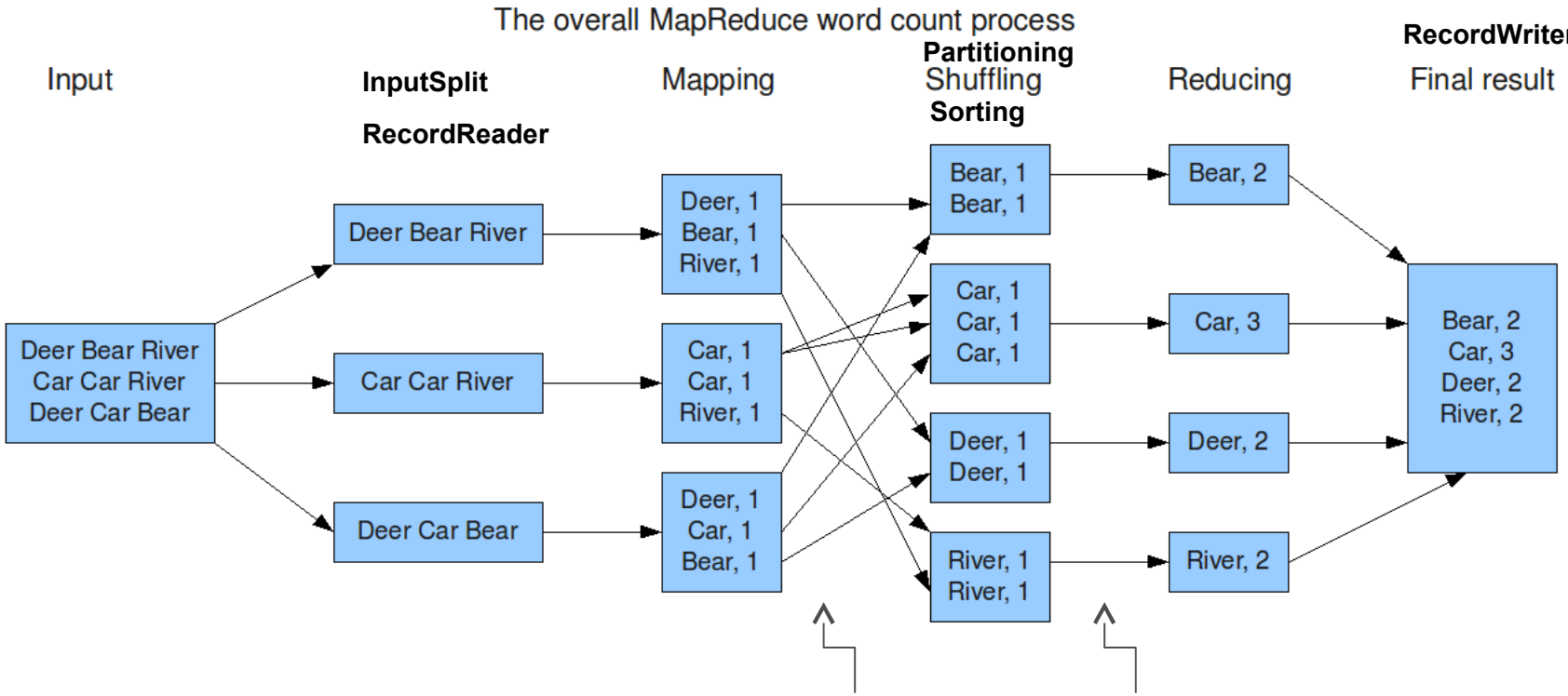
Source: http://labs.google.com/papers/mapreduce-osdi04-slides/index-auto-0002.html

MapReduce Framework



Source: www.bigdatauniversity.com

How does the MapReduce work?



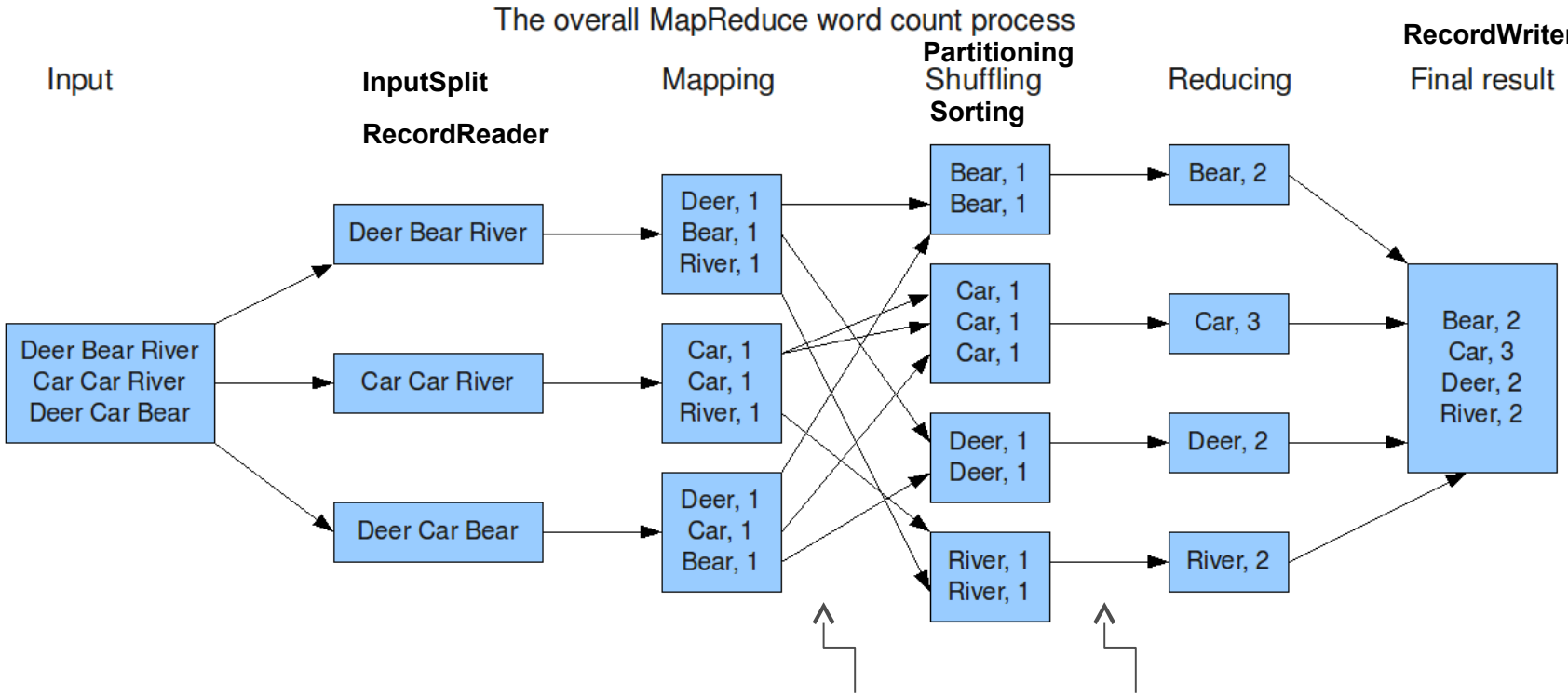
Output in a list of (Key, Value)

in the intermediate file

Output in a list of (Key, List of Values)

in the intermediate file

How does the MapReduce work?



Output in a list of (Key, Value)

in the intermediate file

Output in a list of (Key, List of Values)

in the intermediate file

Map Abstraction

- Inputs a key/value pair
  - Key is a reference to the input value
  - Value is the data set on which to operate
- Evaluation
  - Function defined by user
  - Applies to every value in value input
    - Might need to parse input
- Produces a new list of key/value pairs
  - Can be different type from input pair

Source: http://labs.google.com/papers/mapreduce-osdi04-slides/index-auto-0002.html

Reduce Abstraction

- Starts with intermediate Key / Value pairs
- Ends with finalized Key / Value pairs

- Starting pairs are sorted by key
- Iterator supplies the values for a given key to the Reduce function.

Source: http://labs.google.com/papers/mapreduce-osdi04-slides/index-auto-0002.html

Reduce Abstraction

- Typically a function that:
  - Starts with a large number of key/value pairs
    - One key/value for each word in all files being greped (including multiple entries for the same word)
  - Ends with very few key/value pairs
    - One key/value for each unique word across all the files with the number of instances summed into this entry
- Broken up so a given worker works with input of the same key.

Source: http://labs.google.com/papers/mapreduce-osdi04-slides/index-auto-0002.html

How Map and Reduce Work Together

- Map returns information
- Reduces accepts information
- Reduce applies a user defined function to reduce the amount of data

Other Applications

- Yahoo!
  - Webmap application uses Hadoop to create a database of information on all known webpages
- Facebook
  - Hive data center uses Hadoop to provide business statistics to application developers and advertisers
- Rackspace
  - Analyzes sever log files and usage data using Hadoop

MapReduce Framework

```
map: (K1, V1) -> list(K2, V2))
reduce: (K2, list(V2)) -> list(K3, V3)
```

MapReduce Processing – The Data flow

1. InputFormat, InputSplits, RecordReader
2. Mapper - your focus is here
3. Partition, Shuffle & Sort
4. Reducer - your focus is here
5. OutputFormat, RecordWriter

InputFormat

TextInputFormat	**Default format; reads lines of text files**	**The byte offset of the line**	**The line contents**
KeyValueInputFormat	**Parses lines into key, val pairs**	**Everything up to the first tab character**	**The remainder of the line**
SequenceFileInputFormat	**A Hadoop-specific high-performance binary format**	**user-defined**	**user-defined**

InputSplit

An InputSplit describes a unit of work that comprises a single *map task.*

InputSplit presents a byte-oriented view of the input.

You can control this value by setting the mapred.min.split.size parameter in core-site.xml, or by overriding the parameter in the JobConf object used to submit a particular MapReduce job.

RecordReader

RecordReader reads <key, value> pairs from an InputSplit.

Typically the RecordReader converts the byte-oriented view of the input, provided by the InputSplit, and presents a record-oriented to the Mapper

Mapper

Mapper: The Mapper performs the user-defined logic to the input a key, value and emits (key, value) pair(s) which are forwarded to the Reducers.

Partition, Shuffle & Sort

After the first map tasks have completed, the nodes may still be performing several more map tasks each. But they also begin exchanging the intermediate outputs from the map tasks to where they are required by the reducers.

Partitioner controls the partitioning of map-outputs to assign to reduce task . he total number of partitions is the same as the number of reduce tasks for the job

The set of intermediate keys on a single node is automatically sorted by internal Hadoop before they are presented to the Reducer

This process of moving map outputs to the reducers is known as shuffling.

Reducer

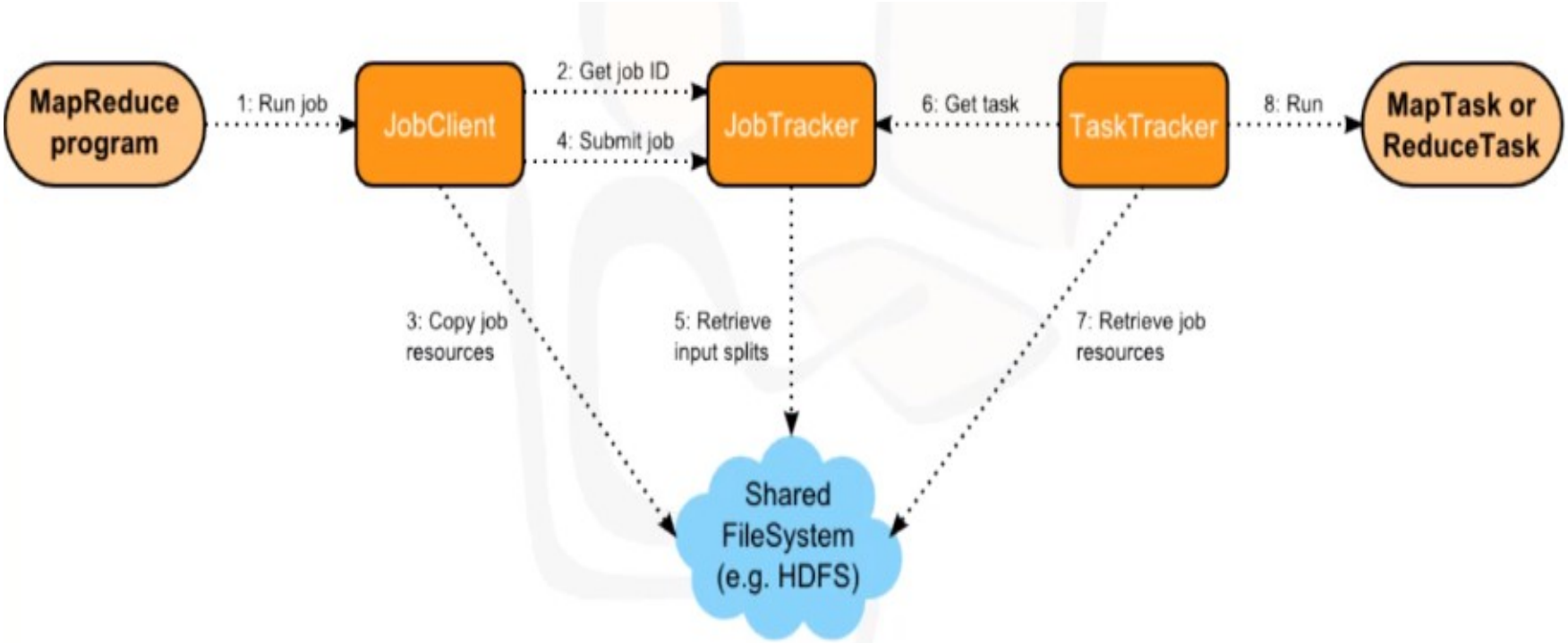
This is an instance of user-provided code that performs read each key, iterator of values in the partition assigned. The *OutputCollector* object in Reducer phase has a method named collect() which will collect a (key, value) output.

OutputFormat, Record Writer

OutputFormat governs the writing format in OutputCollector and RecordWriter writes output into HDFS.

TextOutputFormat	Default; writes lines in "key \t value" form
SequenceFileOutputFormat	Writes binary files suitable for reading into subsequent MapReduce jobs
NullOutputFormat	generates no output files

Submitting a MapReduce job



Source: www.bigdatauniversity.com

Hands-On: Writing you own Map Reduce Program

Wordcount (HelloWord in Hadoop)

```
1.  package org.myorg;
2.
3.  import java.io.IOException;
4.  import java.util.*;
5.
6.  import org.apache.hadoop.fs.Path;
7.  import org.apache.hadoop.conf.*;
8.  import org.apache.hadoop.io.*;
9.  import org.apache.hadoop.mapred.*;
10. import org.apache.hadoop.util.*;
11.
12. public class WordCount {
13.
14.   public static class Map extends MapReduceBase implements Mapper<LongWritable, Text, Text, IntWritable> {
15.     private final static IntWritable one = new IntWritable(1);
16.     private Text word = new Text();
17.
18.     public void map(LongWritable key, Text value, OutputCollector<Text, IntWritable> output, Reporter reporter) throws IOException {
19.       String line = value.toString();
20.       StringTokenizer tokenizer = new StringTokenizer(line);
21.       while (tokenizer.hasMoreTokens()) {
22.         word.set(tokenizer.nextToken());
23.         output.collect(word, one);
24.       }
25.     }
26.   }
```

Wordcount (HelloWord in Hadoop)

```
27.
28.   public static class Reduce extends MapReduceBase implements Reducer<Text, IntWritable, Text, IntWritable> {
29.     public void reduce(Text key, Iterator<IntWritable> values, OutputCollector<Text, IntWritable> output, Reporter reporter) throws IOException {
30.       int sum = 0;
31.       while (values.hasNext()) {
32.         sum += values.next().get();
33.       }
34.       output.collect(key, new IntWritable(sum));
35.     }
36.   }
37.
```

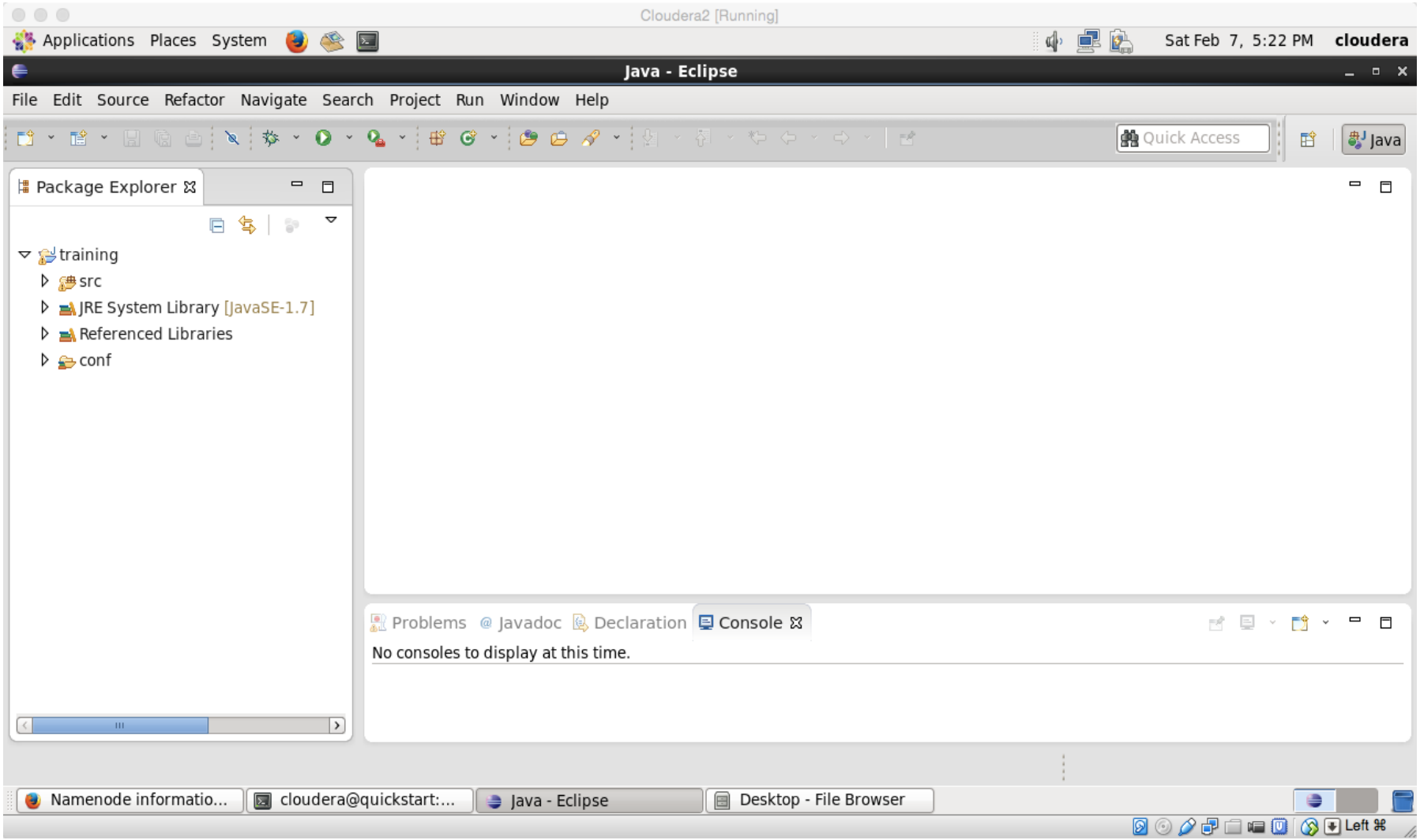
Wordcount (HelloWord in Hadoop)

```
38.     public static void main(String[] args) throws Exception {
39.       JobConf conf = new JobConf(WordCount.class);
40.       conf.setJobName("wordcount");
41.
42.       conf.setOutputKeyClass(Text.class);
43.       conf.setOutputValueClass(IntWritable.class);
44.
45.       conf.setMapperClass(Map.class);
46.
47.       conf.setReducerClass(Reduce.class);
48.
49.       conf.setInputFormat(TextInputFormat.class);
50.       conf.setOutputFormat(TextOutputFormat.class);
51.
52.       FileInputFormat.setInputPaths(conf, new Path(args[1]));
53.       FileOutputFormat.setOutputPath(conf, new Path(args[2]));
54.
55.       JobClient.runJob(conf);
57.     }
58.   }
59.
```

Hands-On: Writing Map/Reduce Program on Eclipse

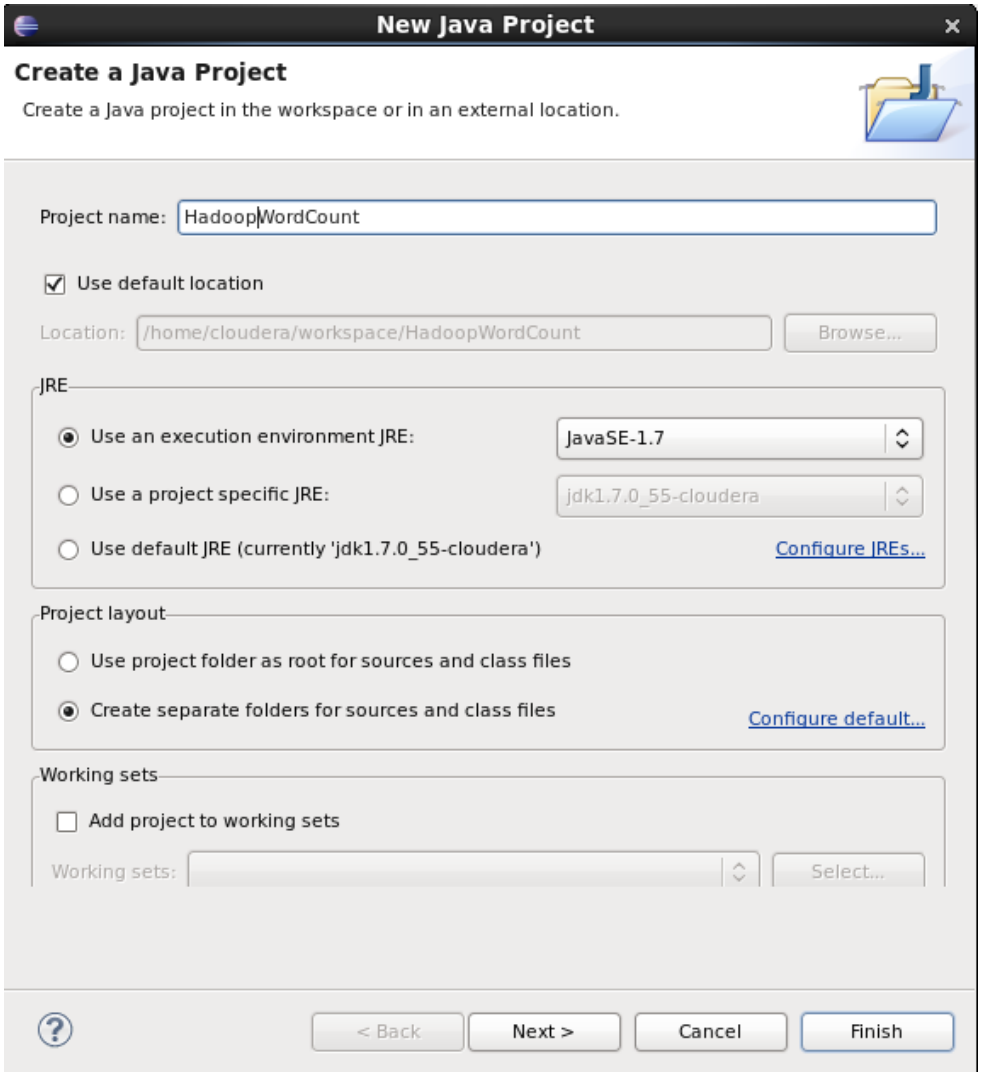
Danairat T., , danairat@gmail.com: Thanachart Numnonda, thanachart@imcinstitute.com

Starting Eclipse in Cloudera VM



Create a Java Project

Let's name it HadoopWordCount

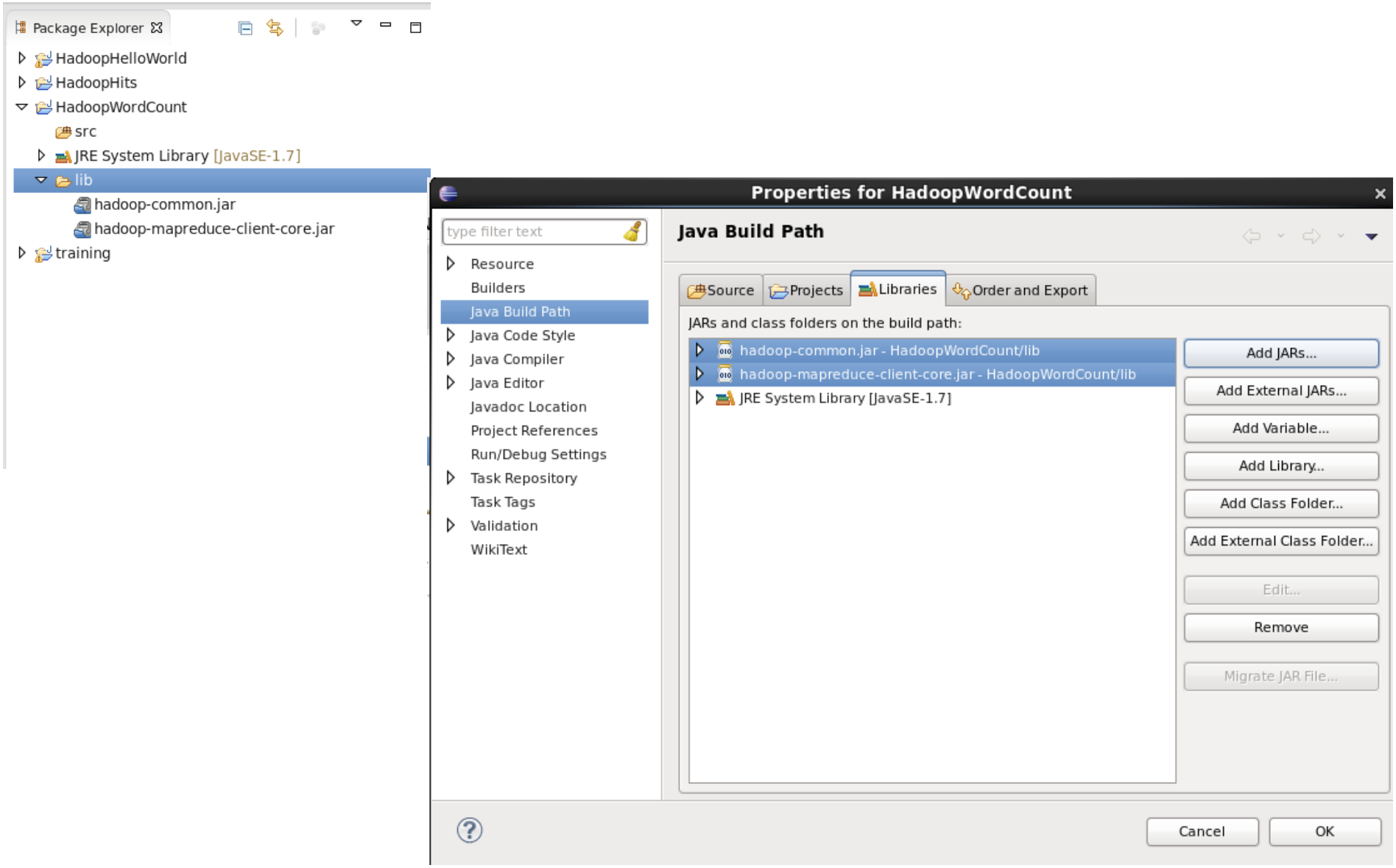


Add dependencies to the project

- Add the following two JARs to your build path
- hadoop-common.jar and hadoop-mapreduce-client-core.jar. Both can be founded at /usr/lib/hadoop/client
- By perform the following steps

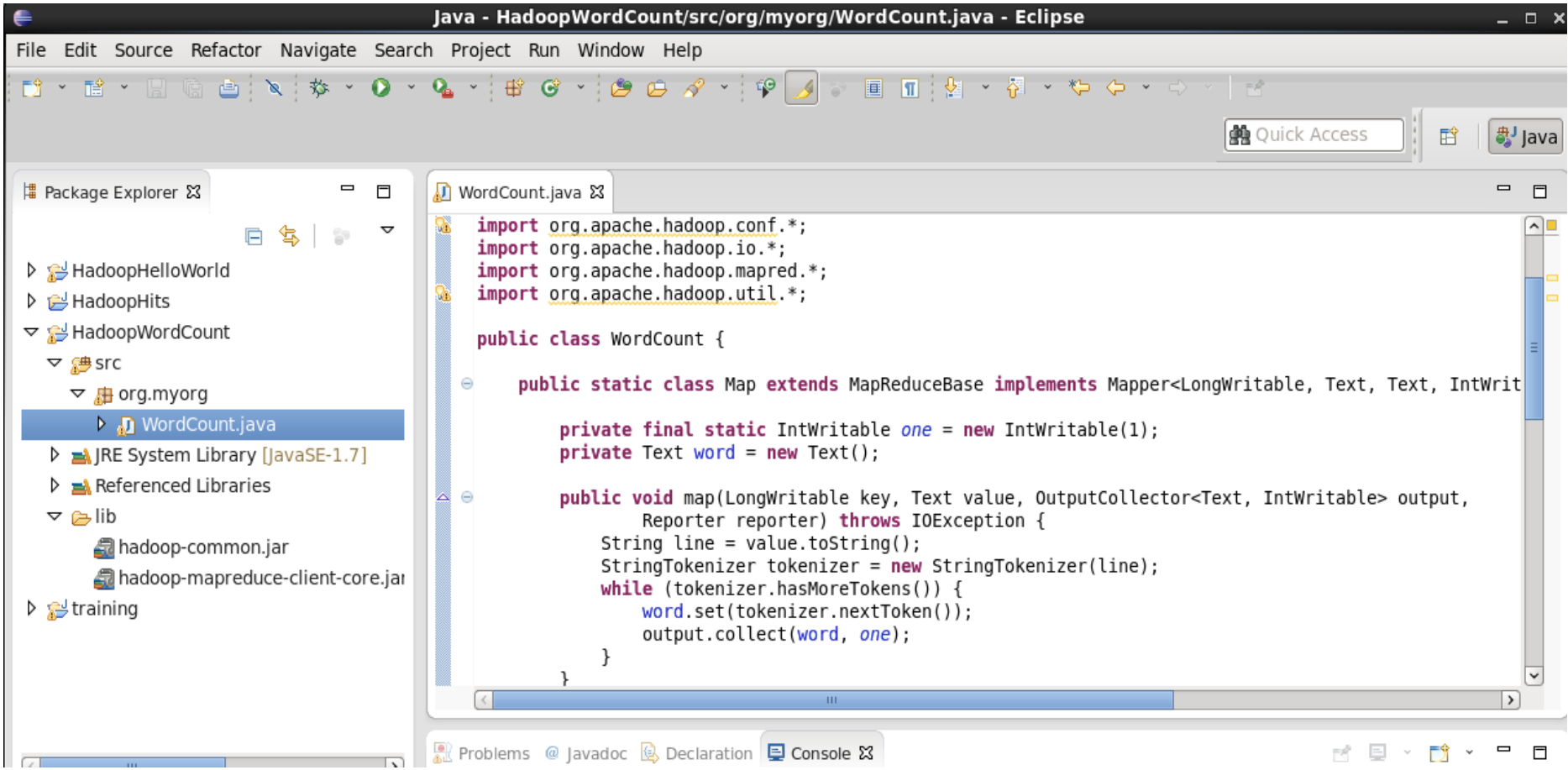
  - Add a folder named lib to the project
  - Copy the mentioned JARs in this folder
  - Right-click on the project name >> select **Build Path** >> then **Configure Build Path**
  - Click on Add Jars, select these two JARs from the lib folder

Add dependencies to the project



Writing a source code

- Right click the project, the select **New** >> **Package**
- Name the package as org.myorg
- Right click at org.myorg, the select **New** >> **Class**
- Name the package as WordCount
- Writing a source code as shown in previoud slides

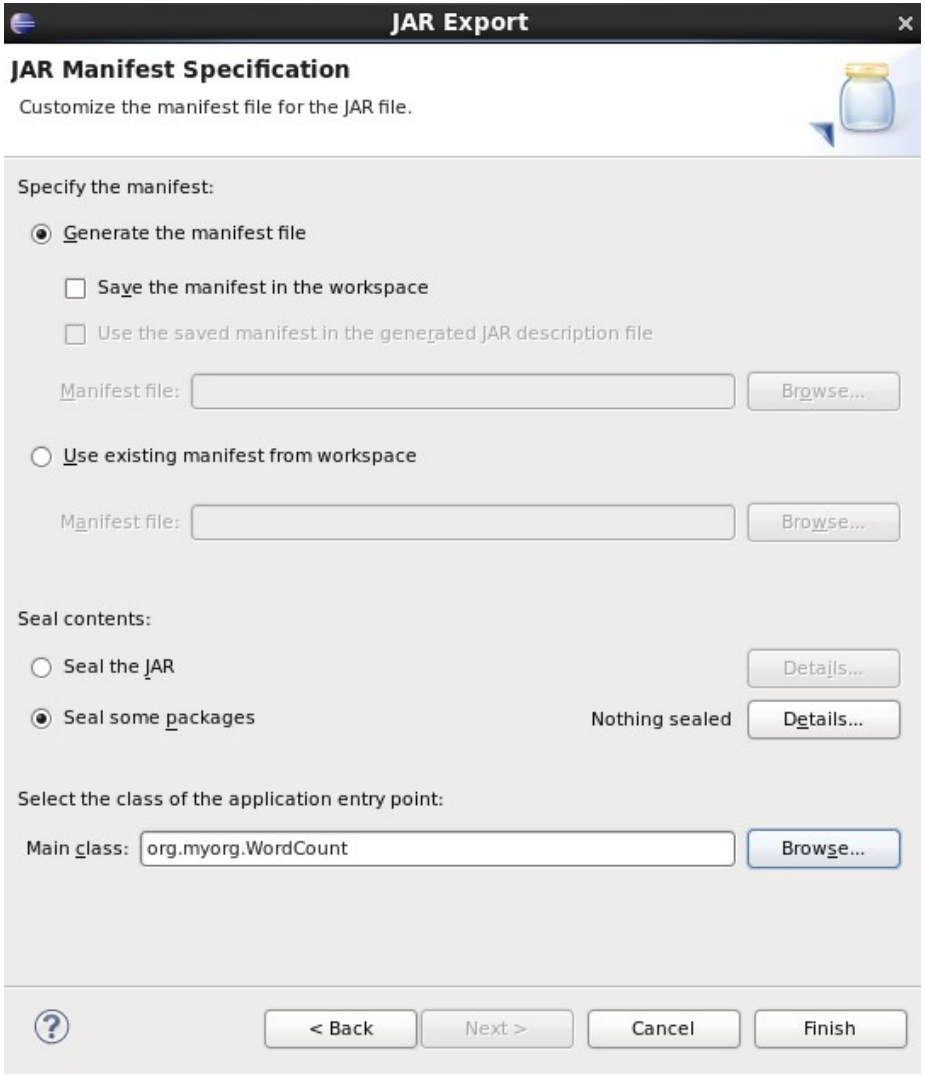

Java - HadoopWordCount/src/org/myorg/WordCount.java - Eclipse
File Edit Source Refactor Navigate Search Project Run Window Help
Quick Access
Java
Package Explorer
HadoopHelloWorld
HadoopHits
HadoopWordCount
src
org.myorg
WordCount.java
JRE System Library [JavaSE-1.7]
Referenced Libraries
lib
hadoop-common.jar
hadoop-mapreduce-client-core.jar
training
WordCount.java
import org.apache.hadoop.conf.*;
import org.apache.hadoop.io.*;
import org.apache.hadoop.mapred.*;
import org.apache.hadoop.util.*;
public class WordCount {
public static class Map extends MapReduceBase implements Mapper<LongWritable, Text, Text, IntWrit
private final static IntWritable one = new IntWritable(1);
private Text word = new Text();
public void map(LongWritable key, Text value, OutputCollector<Text, IntWritable> output,
Reporter reporter) throws IOException {
String line = value.toString();
StringTokenizer tokenizer = new StringTokenizer(line);
while (tokenizer.hasMoreTokens()) {
word.set(tokenizer.nextToken());
output.collect(word, one);
}
}
Problems Javadoc Declaration Console

Building a Jar file

- Right click the project, the select **Export**
- Select **Java** and then **JAR** file
- Provide the JAR name, as wordcount.jar
- Leave the **JAR package options** as default
- In the **JAR Manifest Specification** section, in the botton, specify the **Main** class
- In this case, select WordCount
- Click on **Finish**
- The JAR file will be build and will be located at cloudera/workspace

Note: you may need to re-size the dialog font size by select

Windows >> Preferences >> Appearance >> Colors and Fonts


JAR Export
JAR Manifest Specification
Customize the manifest file for the JAR file.
Specify the manifest:
Generate the manifest file
Save the manifest in the workspace
Use the saved manifest in the generated JAR description file
Manifest file:
Browse...
Use existing manifest from workspace
Manifest file:
Browse...
Seal contents:
Seal the JAR
Details...
Seal some packages
Nothing sealed
Details...
Select the class of the application entry point:
Main class:
org.myorg.WordCount
Browse...
< Back
Next >
Cancel
Finish

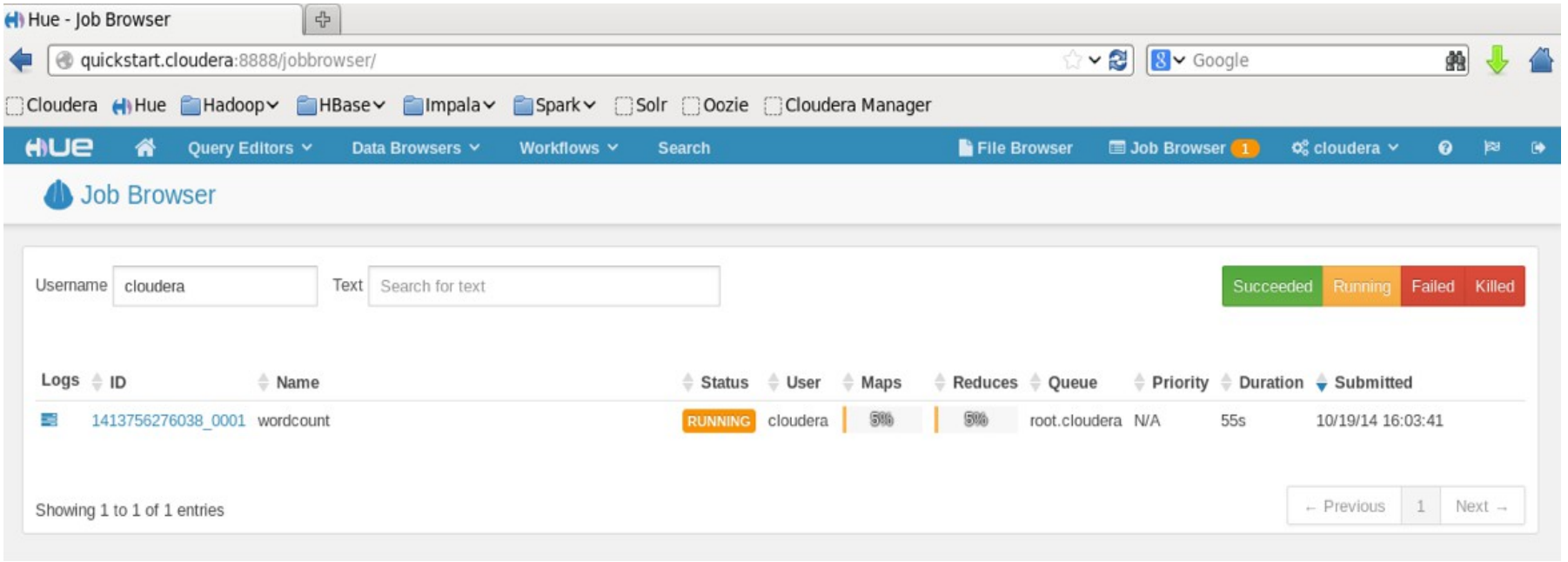
Hands-On: Running Map Reduce and Deploying to Hadoop Runtime Environment

Danairat T., , danairat@gmail.com: Thanachart Numnonda, thanachart@imcinstitute.com Aug 2013

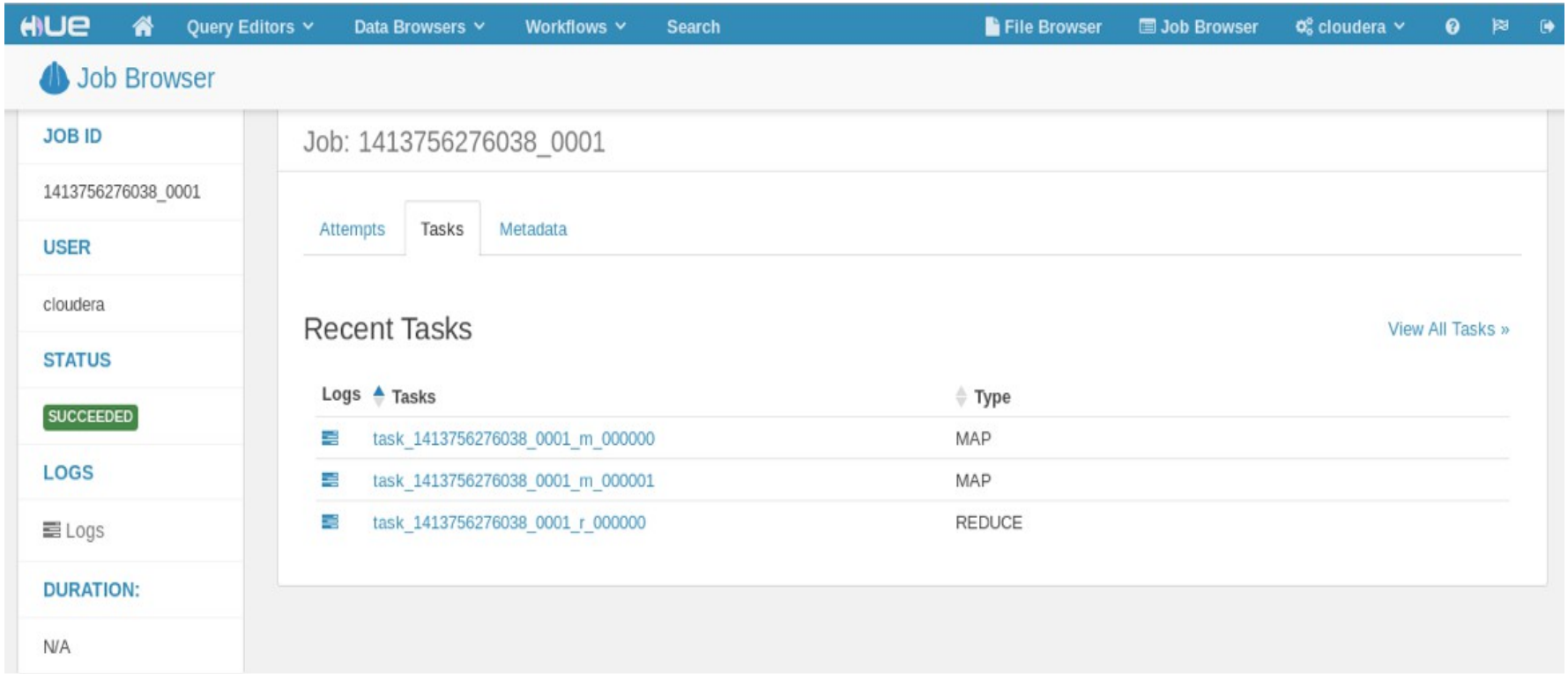
Running Map Reduce Program

```
[cloudera@quickstart ~]$ cd workspace/
[cloudera@quickstart workspace]$ hadoop jar wordcount.jar org.myorg.WordCount input/*  output/wordcount_output
15/02/08 10:30:31 INFO client.RMProxy: Connecting to ResourceManager at /0.0.0.0:8032
15/02/08 10:30:32 INFO client.RMProxy: Connecting to ResourceManager at /0.0.0.0:8032
15/02/08 10:30:33 WARN mapreduce.JobSubmitter: Hadoop command-line option parsing not performed. Implement the Tool i
ation with ToolRunner to remedy this.
15/02/08 10:30:33 INFO mapred.FileInputFormat: Total input paths to process : 1
15/02/08 10:30:34 INFO mapreduce.JobSubmitter: number of splits:2
15/02/08 10:30:34 INFO mapreduce.JobSubmitter: Submitting tokens for job: job_1423408479621_0009
15/02/08 10:30:35 INFO impl.YarnClientImpl: Submitted application application_1423408479621_0009
15/02/08 10:30:35 INFO mapreduce.Job: The url to track the job: http://quickstart.cloudera:8088/proxy/application_142
15/02/08 10:30:35 INFO mapreduce.Job: Running job: job_1423408479621_0009
15/02/08 10:30:52 INFO mapreduce.Job: Job job_1423408479621_0009 running in uber mode : false
15/02/08 10:30:52 INFO mapreduce.Job:  map 0% reduce 0%
15/02/08 10:31:22 INFO mapreduce.Job:  map 58% reduce 0%
15/02/08 10:31:25 INFO mapreduce.Job:  map 100% reduce 0%
15/02/08 10:31:52 INFO mapreduce.Job:  map 100% reduce 100%
15/02/08 10:31:53 INFO mapreduce.Job: Job job_1423408479621_0009 completed successfully
15/02/08 10:31:53 INFO mapreduce.Job: Counters: 49
```

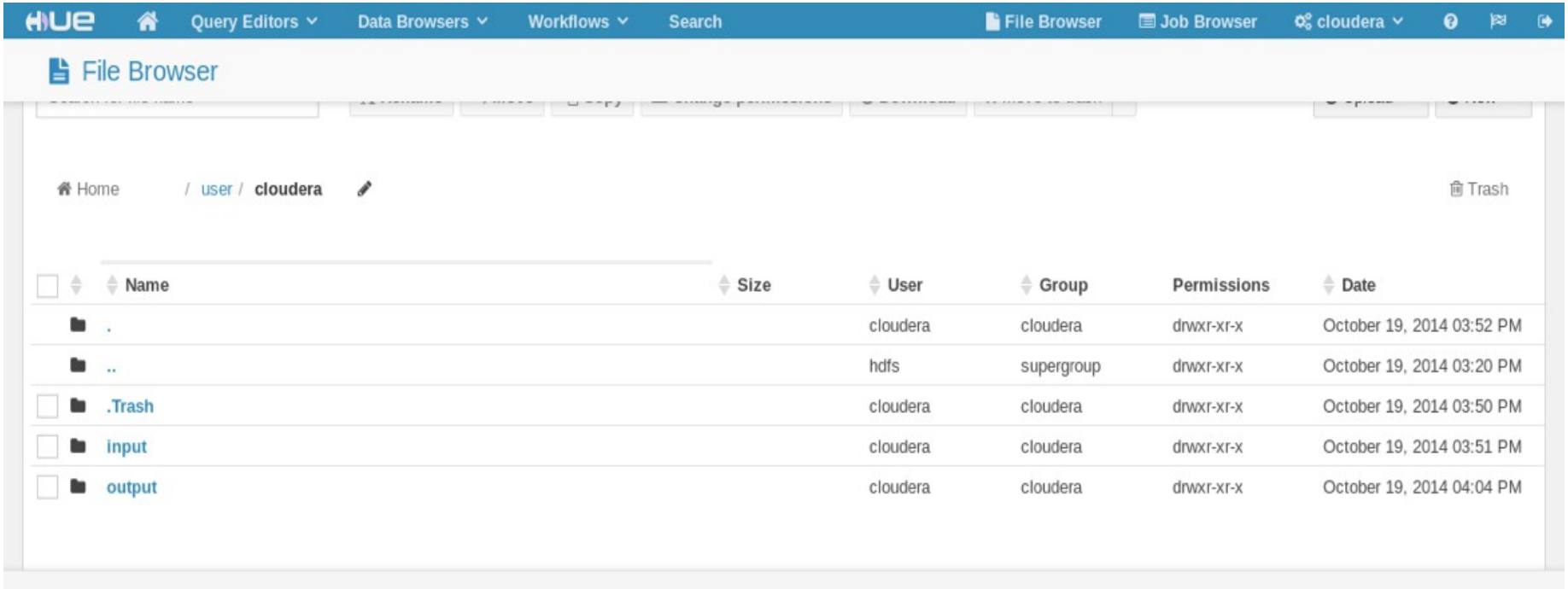
Reviewing MapReduce Job in Hue



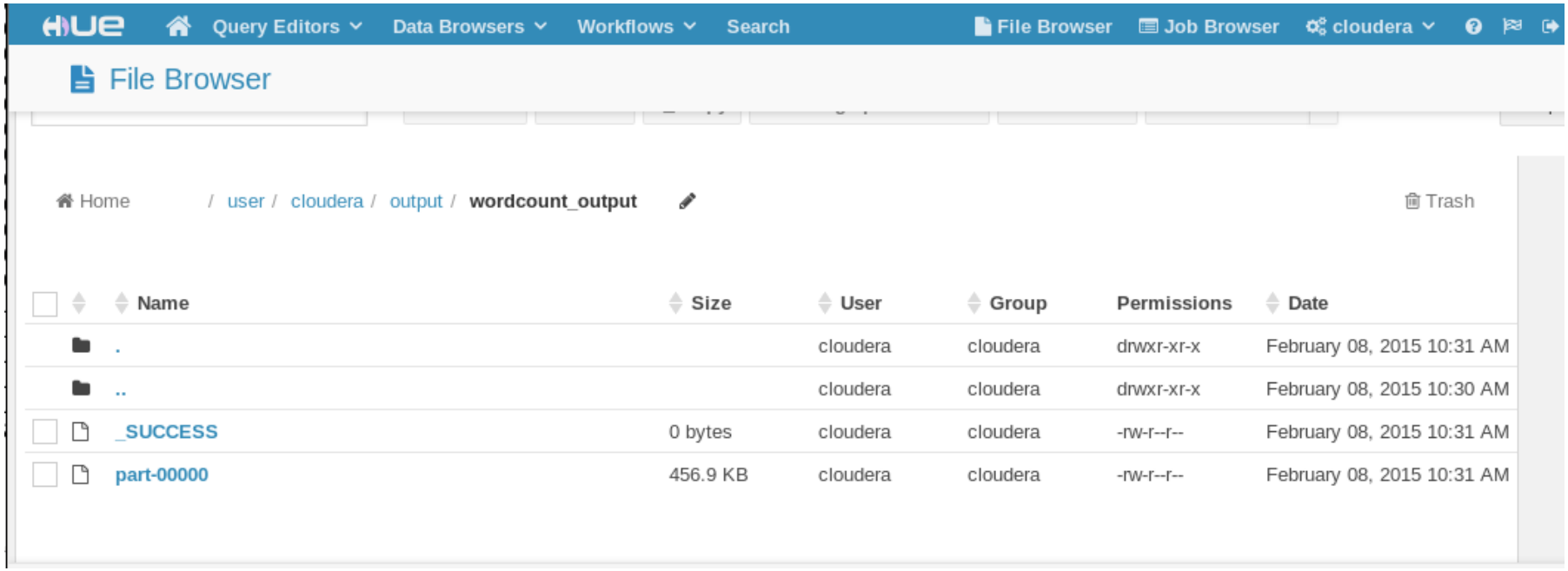
Reviewing MapReduce Job in Hue



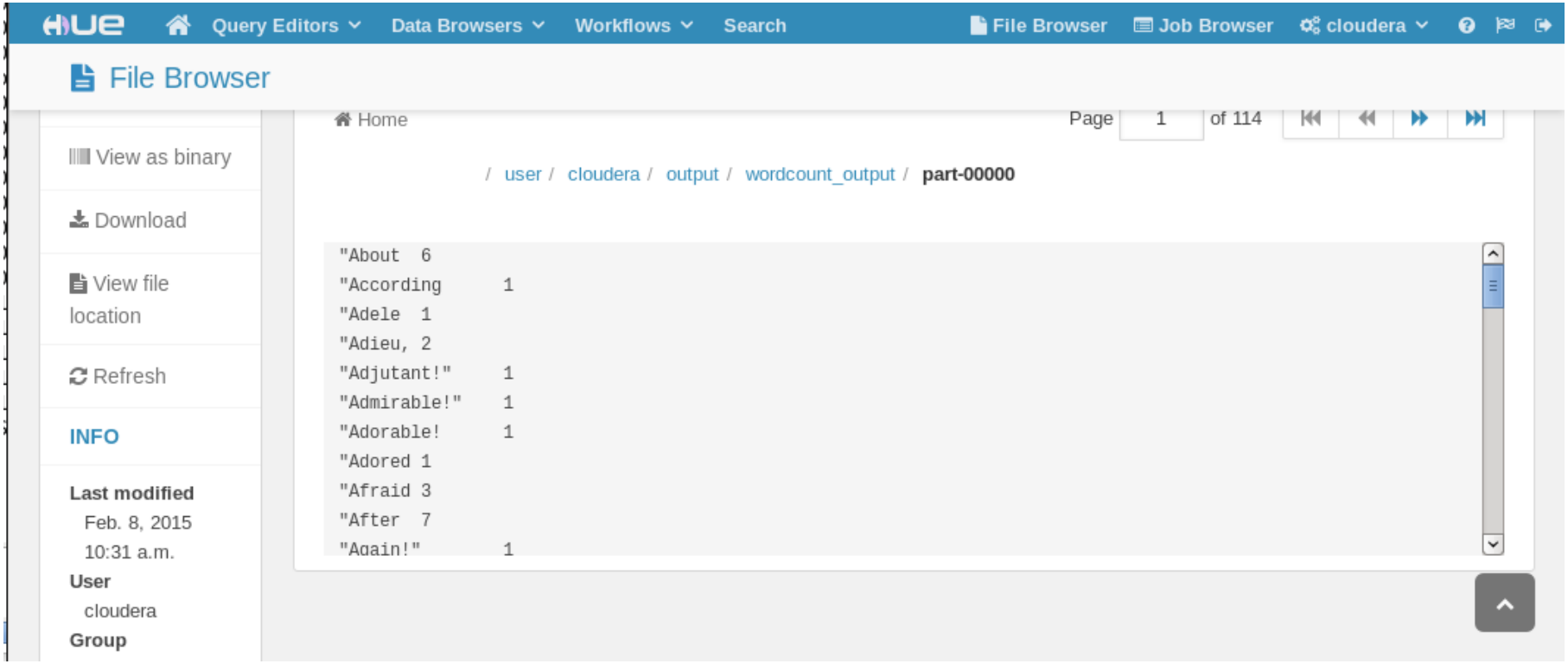
Reviewing MapReduce Output Result



Reviewing MapReduce Output Result



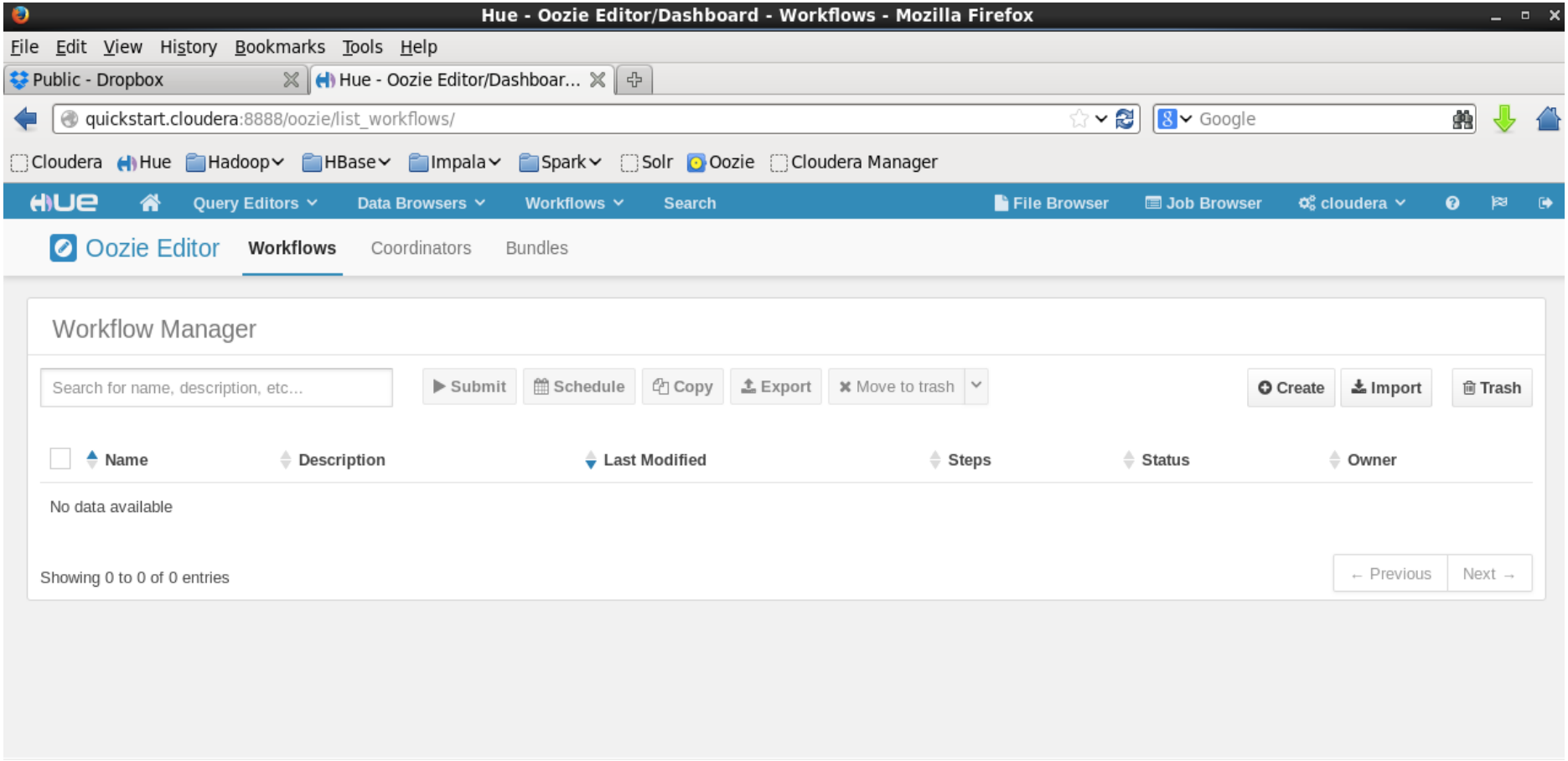
Reviewing MapReduce Output Result



Hands-On: Running Map Reduce using Oozie workflow

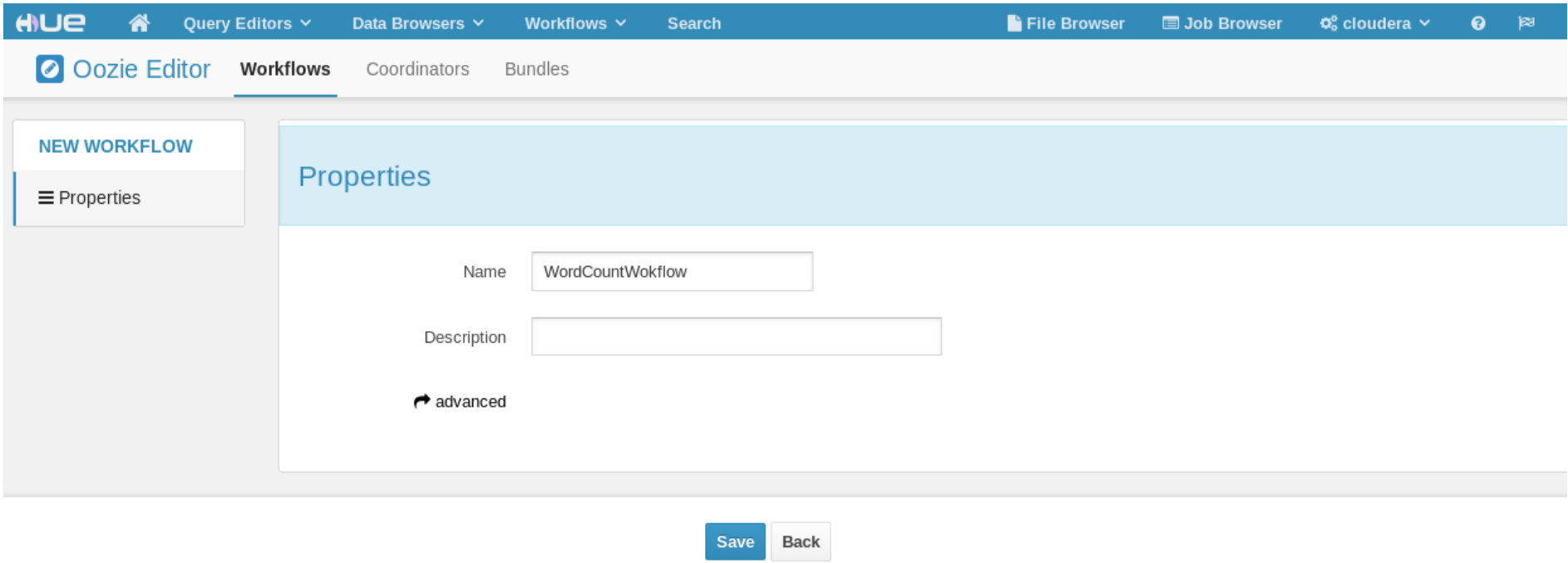
Danairat T., , danairat@gmail.com: Thanachart Numnonda, thanachart@imcinstitute.com Aug 2013

Using Hue: select WorkFlow >> Editor



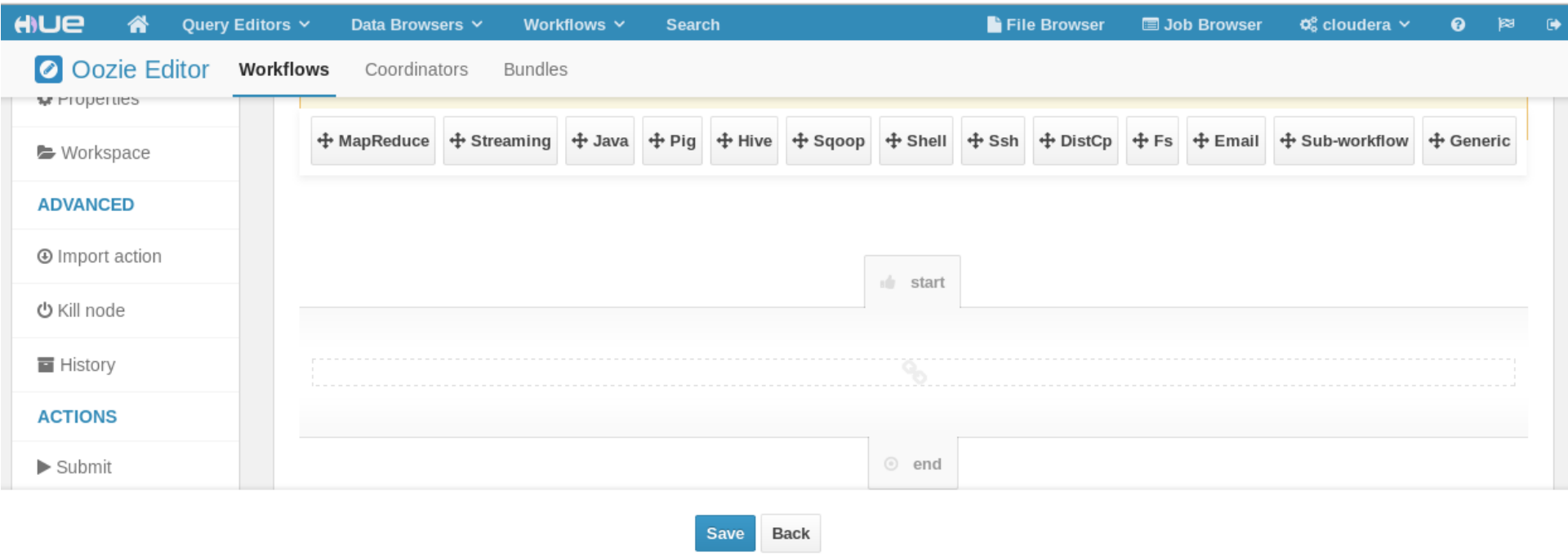
Create a new workflow

- Click Create button; the following screen will be displayed
- Name the workflow as WordCountWorkflow



Select a Java job for the workflow

- From the Oozie editor, drag **Java** and drop between start and end

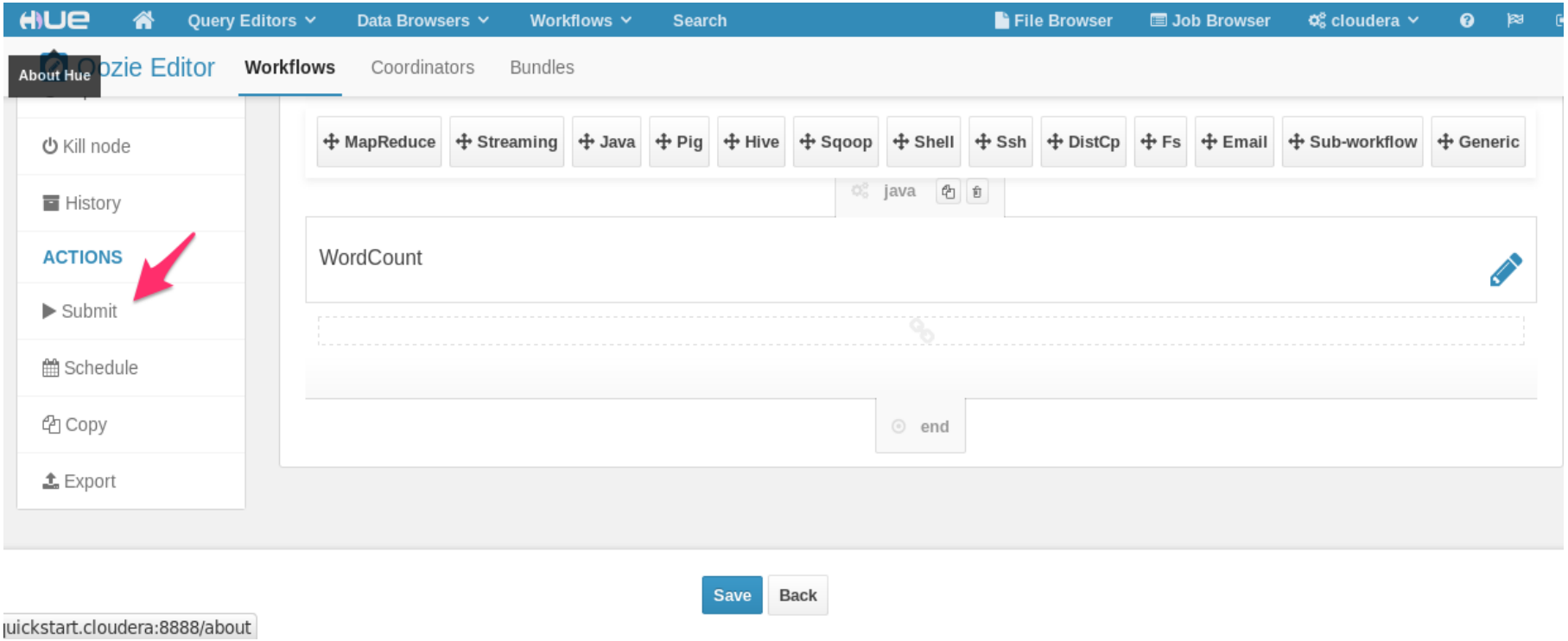


Edit the Java Job

- Assign the following value
  - Name: WordCount
  - Jar name: wordcount.jar (select … choose upload from local machine)
  - Main Class: org.myorg.WordCount
  - Arguments: input/* output/wordcount_output2

Submit the workflow

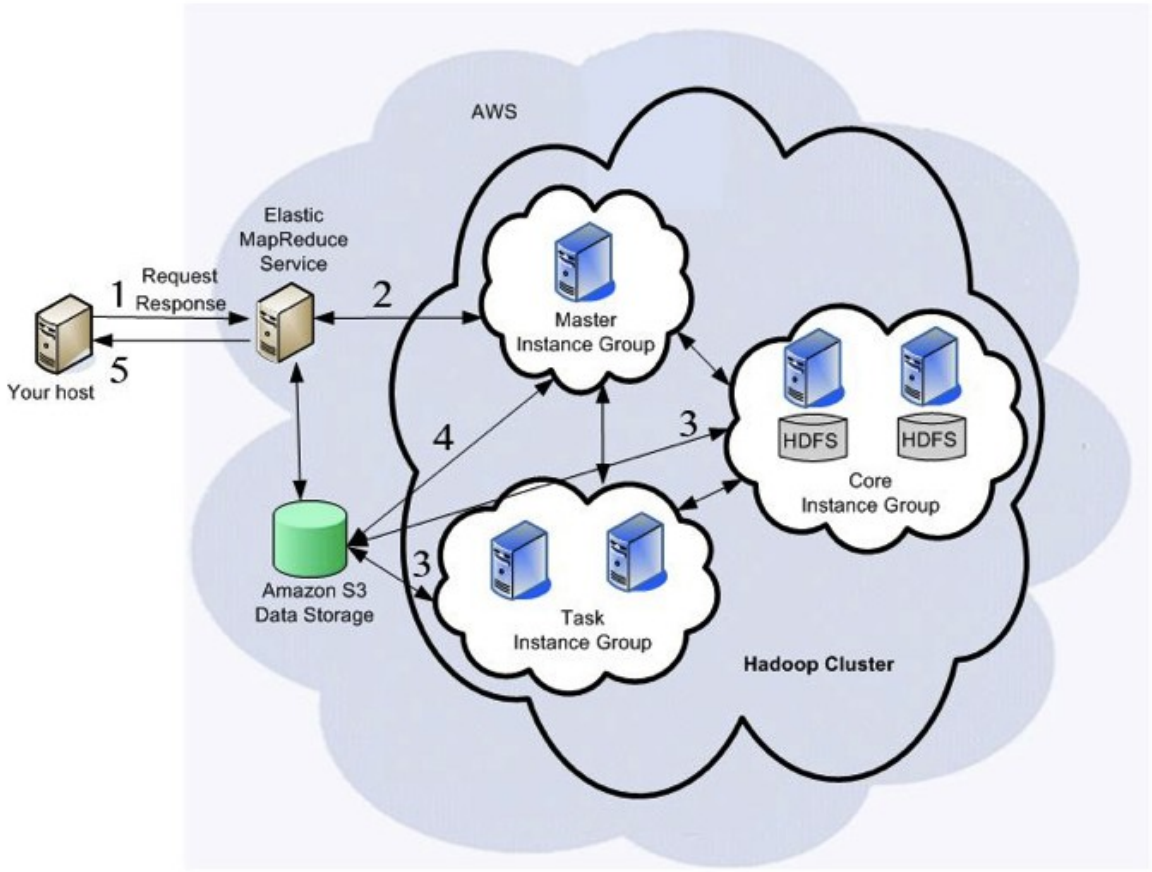
- Click Done, follow by Save
- Then click submit



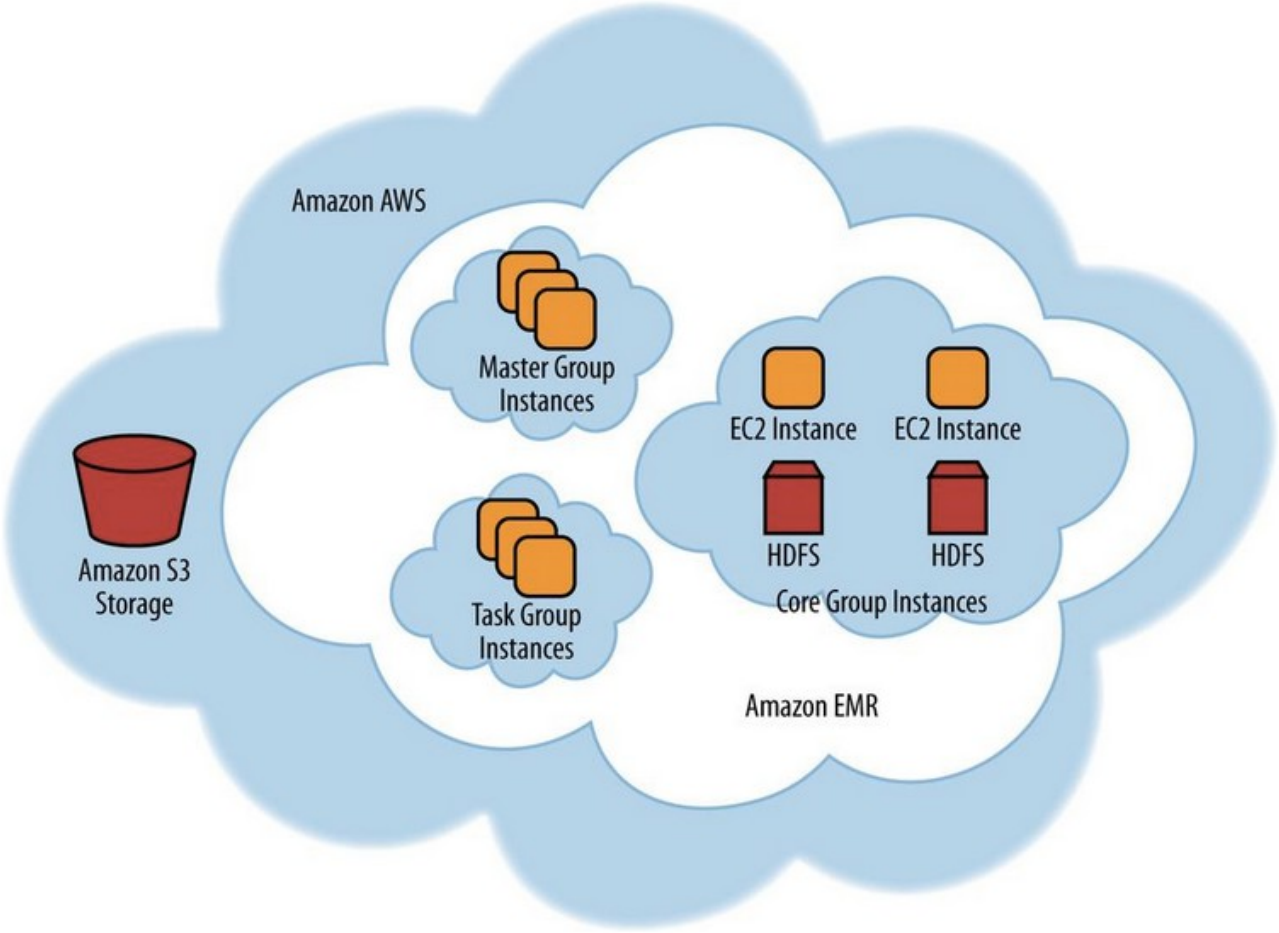
Hands-On: Running WordCount.jar on Amazon EMR

Danairat T., , danairat@gmail.com: Thanachart Numnonda, thanachart@imcinstitute.com Aug 2013

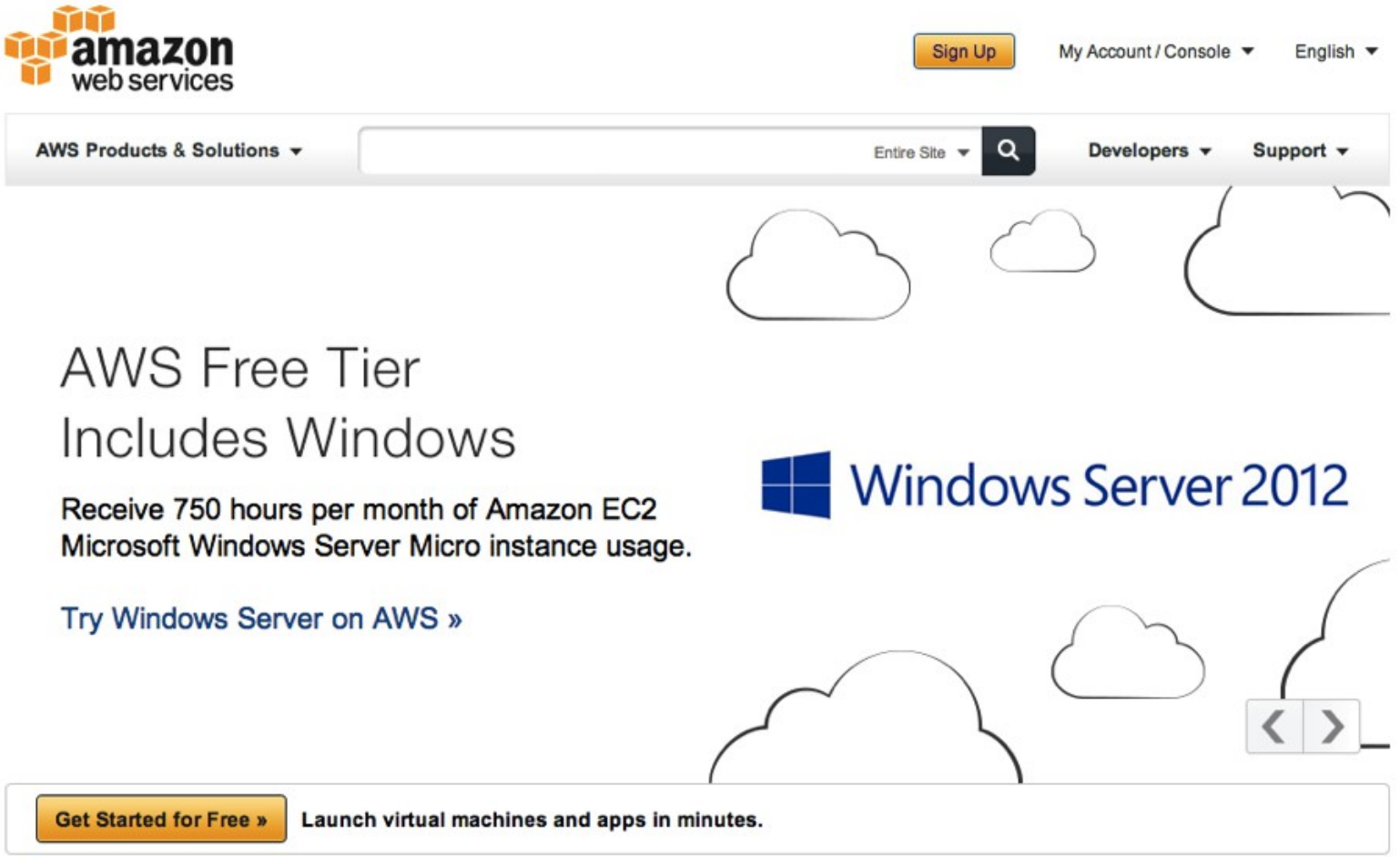
Architecture Overview of Amazon EMR



Amazon EMR Cluster



Creating an AWS account

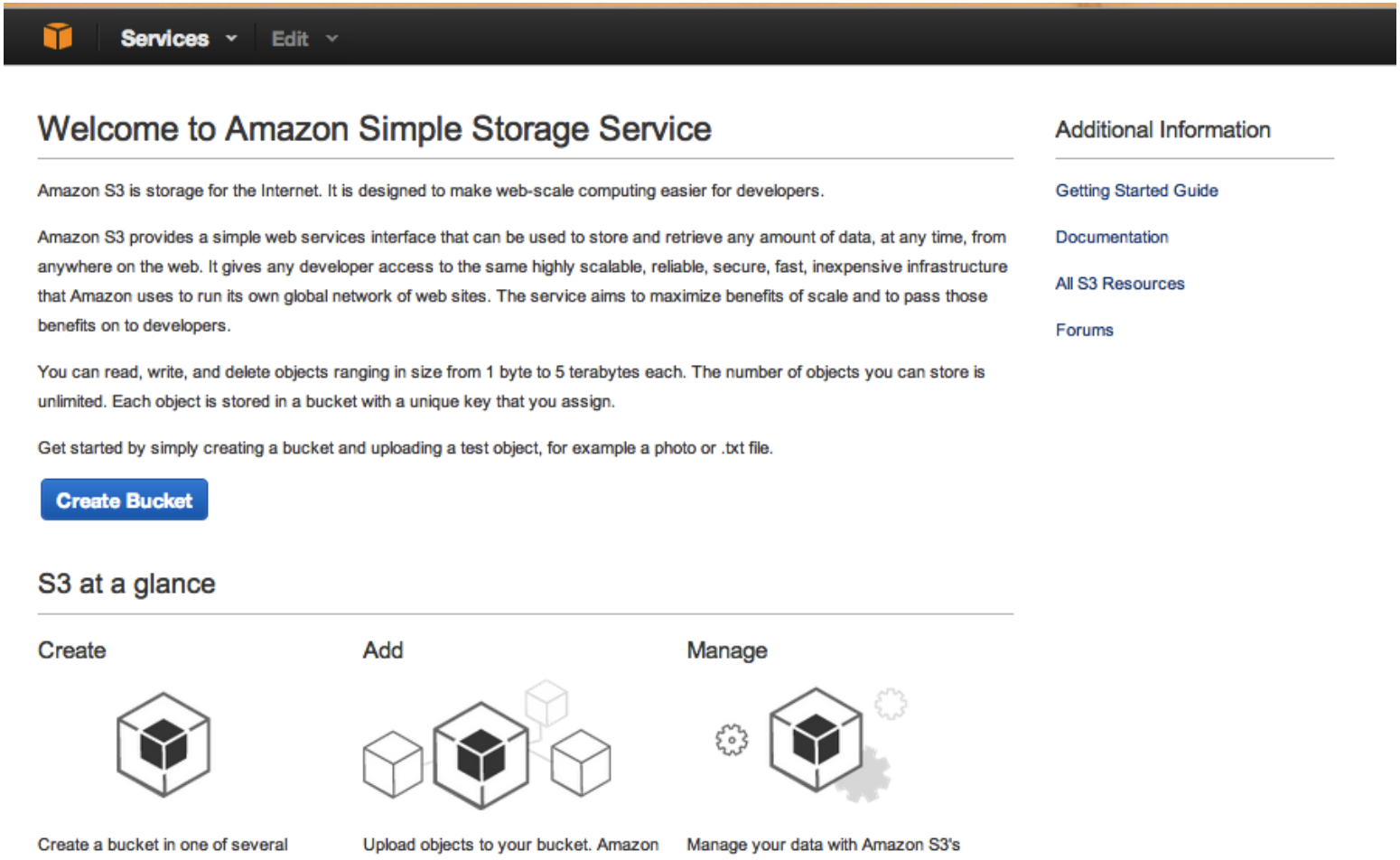


Signing up for the necessary services

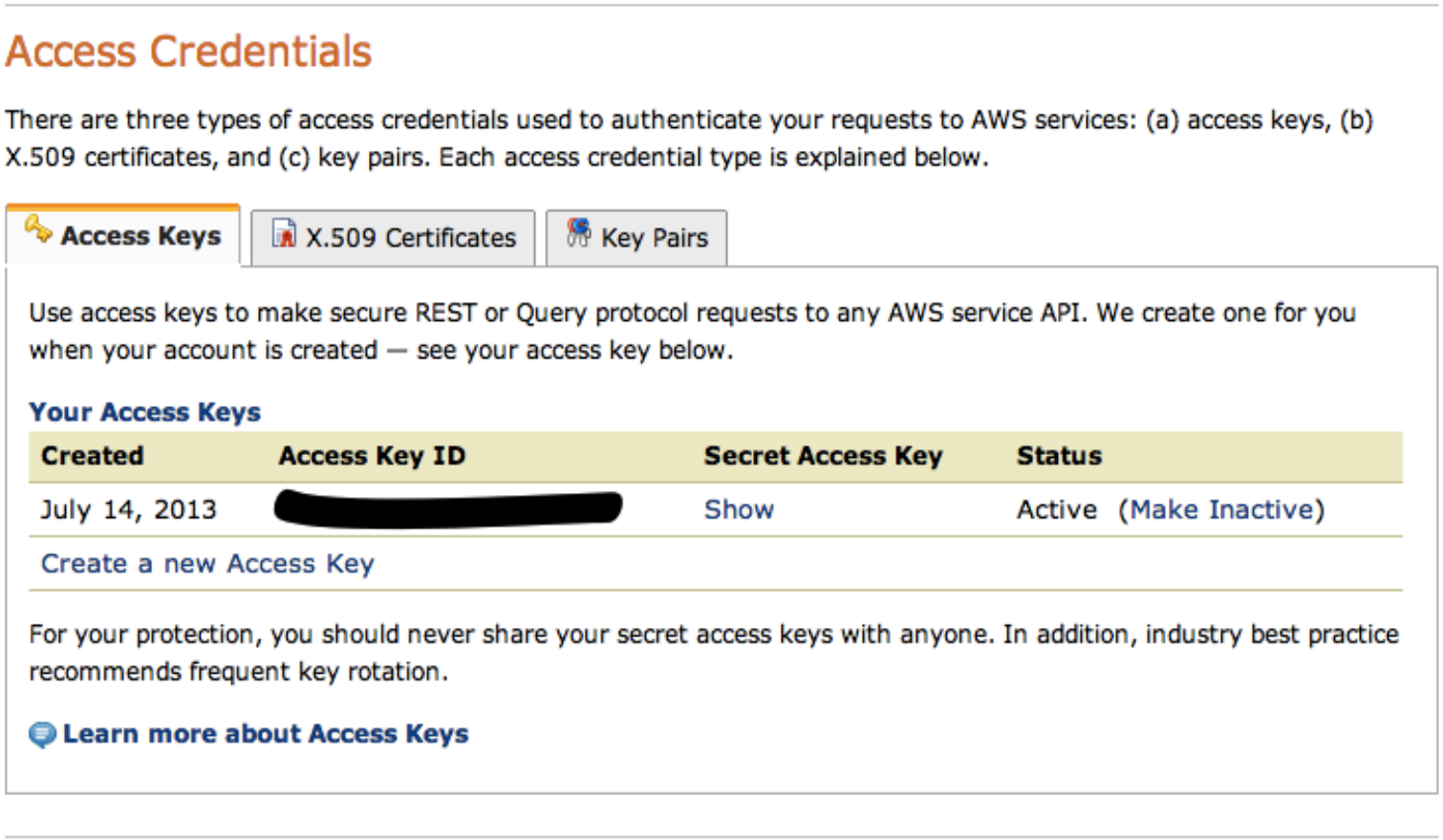
- **Simple Storage Service (S3)**
- **Elastic Compute Cloud (EC2)**
- **Elastic MapReduce (EMR)**

Caution! This costs real money!

Creating Amazon S3 bucket



Create access key using Security Credentials in the AWS Management Console



Access Credentials

There are three types of access credentials used to authenticate your requests to AWS services: (a) access keys, (b) X.509 certificates, and (c) key pairs. Each access credential type is explained below.

Access Keys | X.509 Certificates | Key Pairs

Use access keys to make secure REST or Query protocol requests to any AWS service API. We create one for you when your account is created — see your access key below.

Your Access Keys

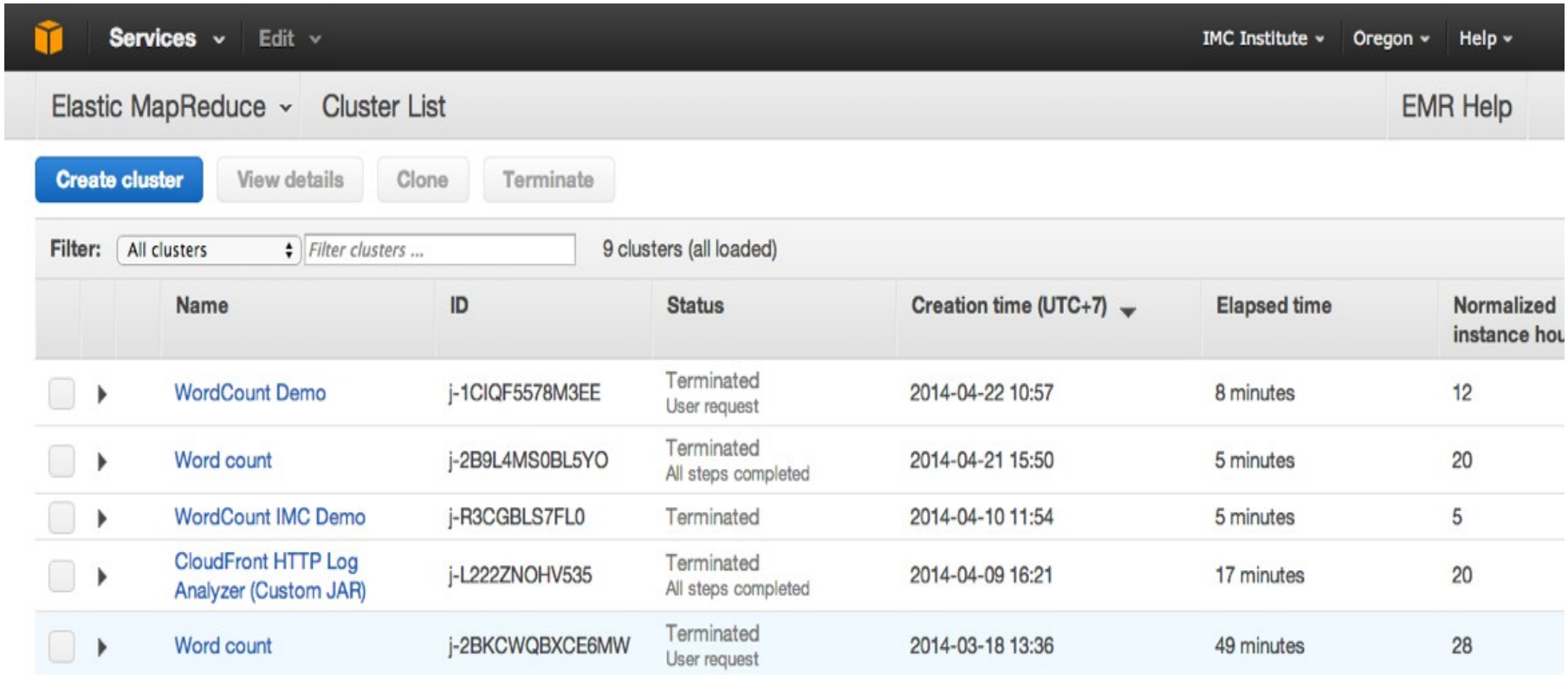
Created	Access Key ID	Secret Access Key	Status
July 14, 2013	[redacted]	Show	Active (Make Inactive)

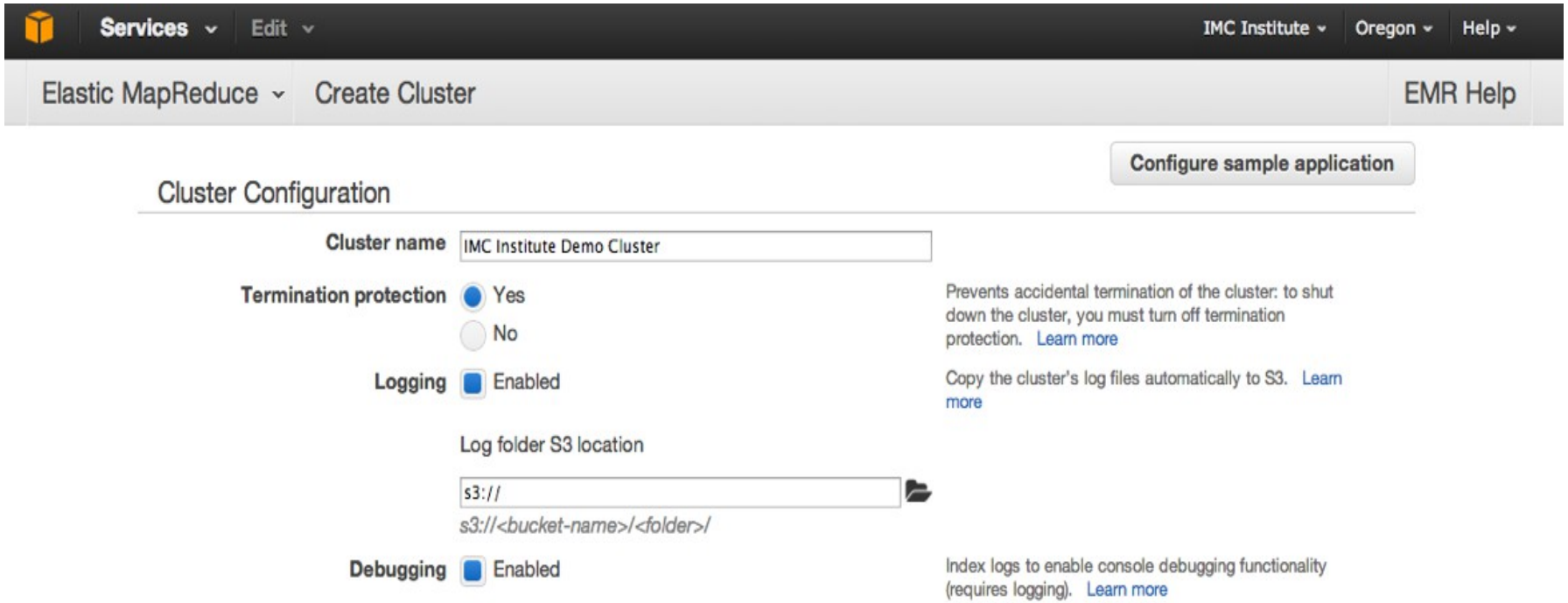
Create a new Access Key

For your protection, you should never share your secret access keys with anyone. In addition, industry best practice recommends frequent key rotation.

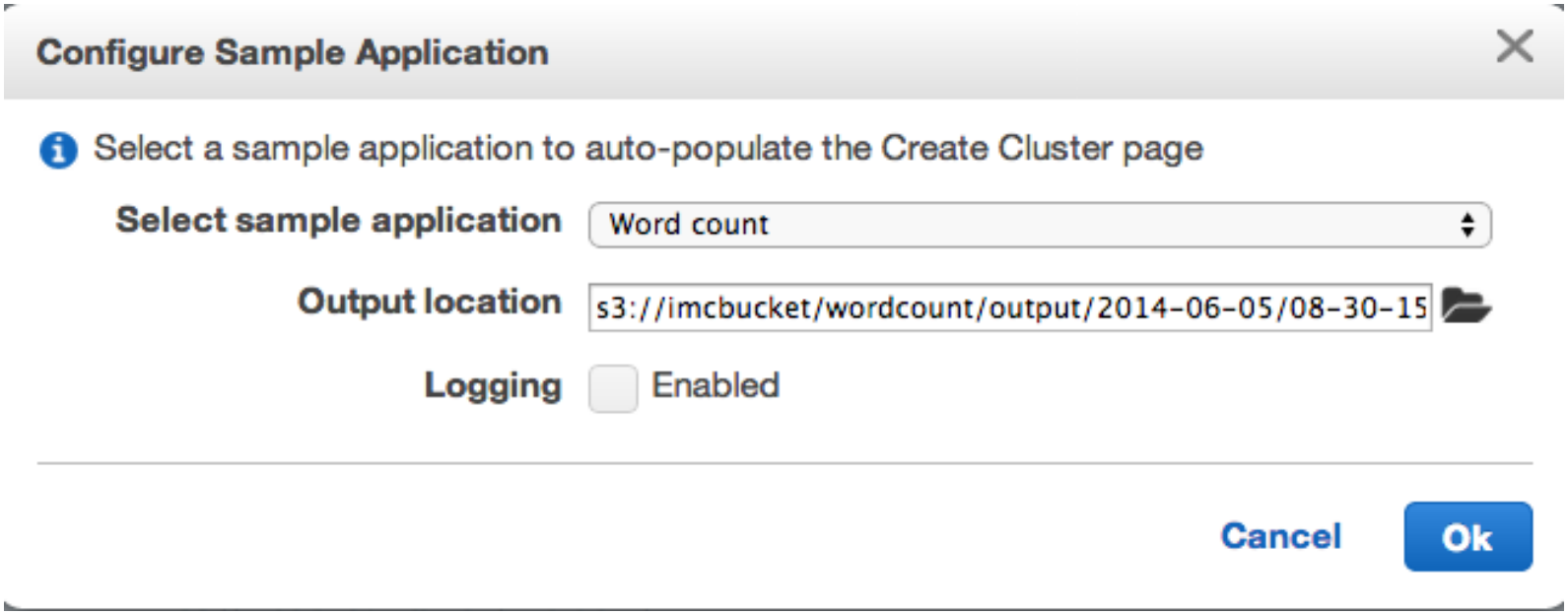
Learn more about Access Keys

Creating a cluster in EMR

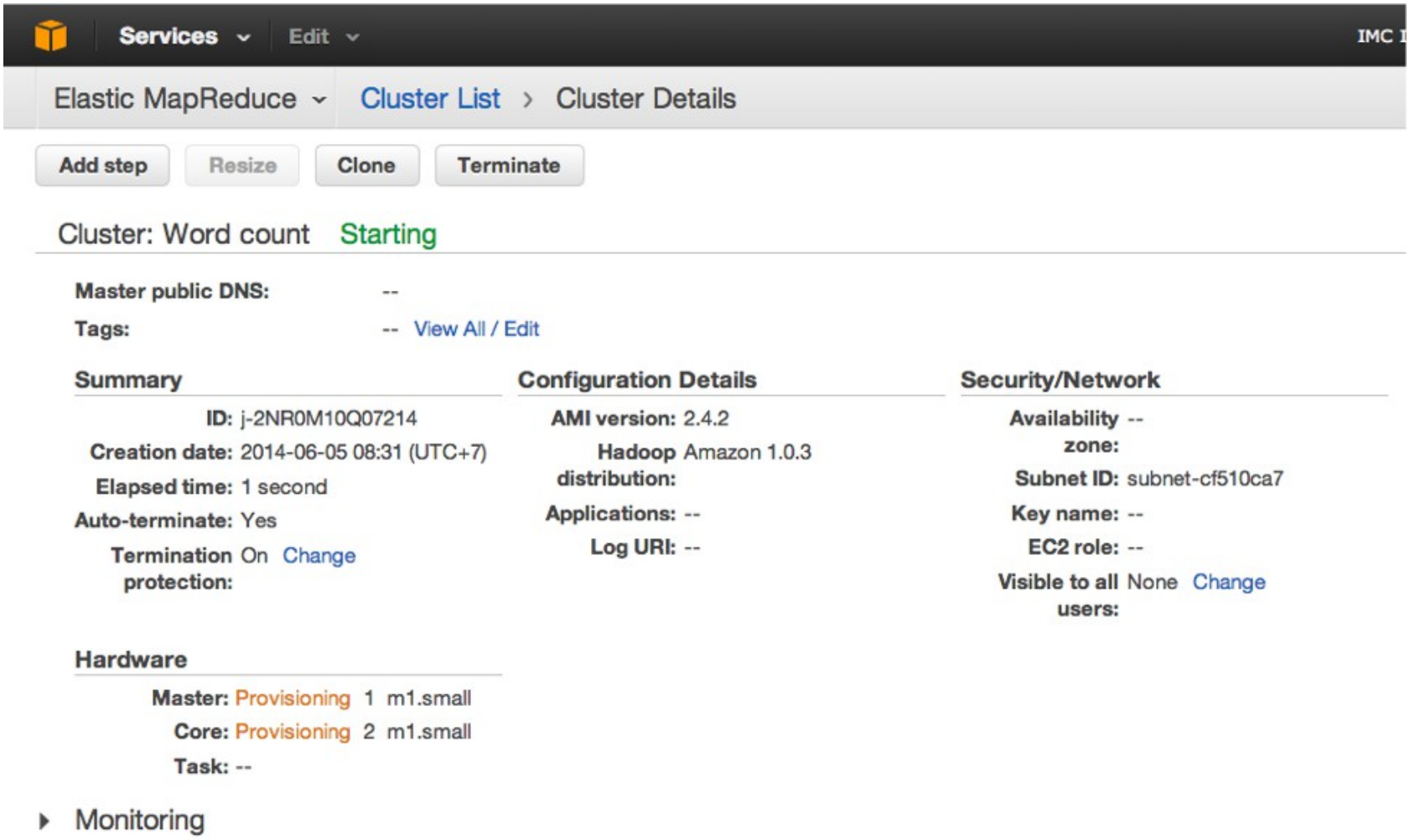


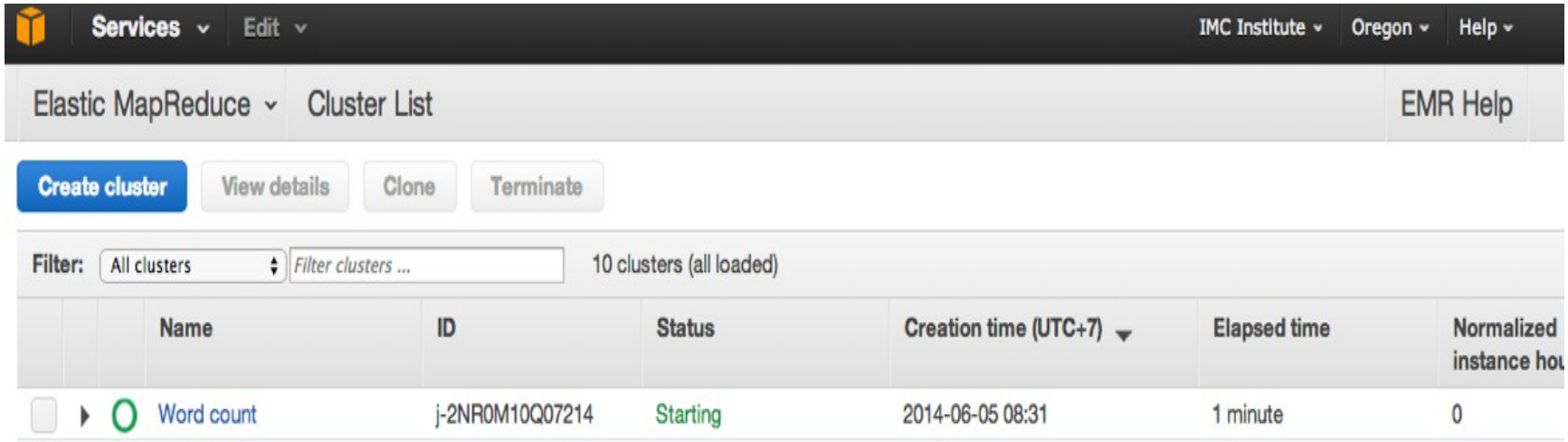

Services
Edit
IMC Institute
Oregon
Help
Elastic MapReduce
Create Cluster
EMR Help
Configure sample application
Cluster Configuration
Cluster name
IMC Institute Demo Cluster
Termination protection
Yes
No
Prevents accidental termination of the cluster: to shut down the cluster, you must turn off termination protection. Learn more
Logging
Enabled
Copy the cluster's log files automatically to S3. Learn more
Log folder S3 location
s3://
s3://<bucket-name>/<folder>/
Debugging
Enabled
Index logs to enable console debugging functionality (requires logging). Learn more

Choose configure sample application



Select create cluster




Services
Edit
IMC Institute
Oregon
Help
Elastic MapReduce
Cluster List
EMR Help
Create cluster
View details
Clone
Terminate
Filter:
All clusters
Filter clusters ...
10 clusters (all loaded)
Name
ID
Status
Creation time (UTC+7)
Elapsed time
Normalized instance hou
Word count
j-2NR0M10Q07214
Starting
2014-06-05 08:31
1 minute
0

View Result from the S3 bucket

Hands-On: Working with a csv data

Danairat T., , danairat@gmail.com: Thanachart Numnonda, thanachart@imcinstitute.com

A sample CSV data

- The input data is access logs with the following form

  Date, Requesting-IP-Address

- We will write a map reduce program to count the number of hits to the website per country.

```
2013-09-01,211.139.190.234
2013-09-01,114.221.140.56
2013-09-01,211.155.113.221
2013-09-01,211.155.113.221
2013-09-01,221.4.143.9
2013-09-01,121.12.149.106
2013-09-01,114.221.140.56
2013-09-01,121.12.149.106
2013-09-01,211.139.190.234
2013-09-01,221.4.143.9
2013-09-01,211.155.113.221
2013-09-01,221.4.143.9
2013-09-01,211.139.190.234
2013-09-01,61.171.134.87
2013-09-01,218.249.47.126
2013-09-01,61.171.134.87
2013-09-01,106.120.176.93
2013-09-01,221.4.143.9
2013-09-01,118.194.193.18
2013-09-01,221.4.143.9
2013-09-01,221.4.143.9
2013-09-01,221.4.143.9
```

HitsByCountryMapper.java

```
package learning.bigdata.mapreduce;

import java.io.IOException;

import org.apache.hadoop.io.IntWritable;
import org.apache.hadoop.io.LongWritable;
import org.apache.hadoop.io.Text;
import org.apache.hadoop.mapreduce.Mapper;

public class HitsByCountryMapper extends Mapper<LongWritable, Text, Text, IntWritable> {

	private final static String[] COUNTRIES = { "India", "UK", "US", "China" };
	private Text outputKey = new Text();
	private IntWritable outputValue = new IntWritable();

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

		super.setup(context);
	}

	@Override
	public void map(LongWritable key, Text value, Context context) throws IOException, InterruptedException {


		try {
			String valueString = value.toString();

			// Split the value string to get Date and ipAddress
			String[] row = valueString.split(",");
```

HitsByCountryMapper.java

```
                // row[0]= Date and row[1]=ipAddress
                String ipAddress = row[1];

                // Get the country name to which the ipAddress belongs
                String countryName = getCountryNameFromIpAddress(ipAddress);
                outputKey.set(countryName);
                outputValue.set(1);
                context.write(outputKey, outputValue);

        } catch (ArrayIndexOutOfBoundsException ex) {
                context.getCounter("Custom counters", "MAPPER_EXCEPTION_COUNTER").increment(1);
                ex.printStackTrace();
        }
    }


    private static String getCountryNameFromIpAddress(String ipAddress) {

        if (ipAddress != null && !ipAddress.isEmpty()) {

                int randomIndex = Math.abs(ipAddress.hashCode()) % COUNTRIES.length;
                return COUNTRIES[randomIndex];
        }

        return null;
    }
}
```

HitsByCountryReducer.java

```
package learning.bigdata.mapreduce;

import java.io.IOException;
import java.util.Iterator;

import org.apache.hadoop.io.IntWritable;
import org.apache.hadoop.io.Text;
import org.apache.hadoop.mapreduce.Reducer;

public class HitsByCountryReducer extends Reducer<Text, IntWritable, Text, IntWritable> {

	private Text outputKey = new Text();
	private IntWritable outputValue = new IntWritable();
	private int count = 0;

	protected void reduce(Text key, Iterable<IntWritable> values, Context context) throws IOException,
			InterruptedException {

		count = 0;
		Iterator<IntWritable> iterator = values.iterator();
		while (iterator.hasNext()) {
			IntWritable value = iterator.next();
			count += value.get();
		}
		outputKey.set(key);
		outputValue.set(count);
		context.write(outputKey, outputValue);
	}
}
```

HitsByCountry.java

```
package learning.bigdata.main;

import learning.bigdata.mapreduce.HitsByCountryMapper;
import learning.bigdata.mapreduce.HitsByCountryReducer;

import org.apache.hadoop.conf.Configuration;
import org.apache.hadoop.conf.Configured;
import org.apache.hadoop.fs.Path;
import org.apache.hadoop.io.IntWritable;
import org.apache.hadoop.io.Text;
import org.apache.hadoop.mapreduce.Job;
import org.apache.hadoop.mapreduce.lib.input.FileInputFormat;
import org.apache.hadoop.mapreduce.lib.input.TextInputFormat;
import org.apache.hadoop.mapreduce.lib.output.FileOutputFormat;
import org.apache.hadoop.mapreduce.lib.output.TextOutputFormat;
import org.apache.hadoop.util.Tool;
import org.apache.hadoop.util.ToolRunner;


public class HitsByCountry extends Configured implements Tool {

        private static final String JOB_NAME = "Calculating hits by country";

        public static void main(String[] args) throws Exception {

                if (args.length < 2) {
                        System.out.println("Usage: HitsByCountry <comma separated input directories> <output dir>");
                        System.exit(-1);
                }
                int result = ToolRunner.run(new HitsByCountry(), args);
                System.exit(result);
        }
```

HitsByCountry.java

```
@Override
public int run(String[] args) throws Exception {

        try {
                Configuration conf = getConf();
                Job job = Job.getInstance(conf);

                job.setJarByClass(HitsByCountry.class);
                job.setJobName(JOB_NAME);

                job.setMapperClass(HitsByCountryMapper.class);
                job.setMapOutputKeyClass(Text.class);
                job.setMapOutputValueClass(IntWritable.class);

                job.setReducerClass(HitsByCountryReducer.class);
                job.setOutputKeyClass(Text.class);
                job.setOutputValueClass(IntWritable.class);

                job.setInputFormatClass(TextInputFormat.class);
                job.setOutputFormatClass(TextOutputFormat.class);

                FileInputFormat.setInputPaths(job, args[0]);
                FileOutputFormat.setOutputPath(job, new Path(args[1]));

                boolean success = job.waitForCompletion(true);
                return success ? 0 : 1;
        } catch (Exception e) {
                e.printStackTrace();
                return 1;
        }
    }
}
```

Exercise: Write a Map Reduce program to count number of vowels in an input file.

Lecture: Developing Complex Hadoop MapReduce Applications

Danairat T., , danairat@gmail.com: Thanachart Numnonda, thanachart@imcinstitute.com Aug 2013

Choosing appropriate Hadoop data types

- Hadoop uses the *Writable* interface based classes as the data types for the MapReduce computations.
- Choosing the appropriate *Writable* data types for your input, intermediate, and output data can have a large effect on the performance and the programmability of your MapReduce programs.
- In order to be used as a *value* data type, a data type must implement the *org.apache.hadoop.io.Writable* interface.
- In order to be used as a *key* data type, a data type must implement the *org.apache.hadoop.io.WritableComparable<T>* interface

Examples

Specify the data types for the input (key: `LongWritable`, value: `Text`) and output (key: `Text`, value: `IntWritable`) key-value pairs of your mapper using the generic-type variables.

```
public class SampleMapper extends Mapper<LongWritable, Text, Text,
IntWritable> {

public void map(LongWritable key, Text value,
    Context context) … {
……  }
}
```

Specify the data types for the input (key: `Text`, value: `IntWritable`) and output (key: `Text`, value: `IntWritable`) key-value pairs of your reducer using the generic-type variables. The reducer's input key-value pair data types should match the mapper's output key-value pairs.

```
public class Reduce extends Reducer<Text, IntWritable, Text,
IntWritable> {

public void reduce(Text key,
    Iterable<IntWritable> values, Context context) {
  ……  }
}
```

Hadoop built-in data types

- *Text*: This stores a UTF8 text
- *BytesWritable*: This stores a sequence of bytes
- *VIntWritable* and *VLongWritable*: These store variable length integer and long values
- *NullWritable*: This is a zero-length Writable type that can be used when you don't want to use a key or value type

Hadoop built-in data types

- The following Hadoop build-in collection data types can only be used as *value* types.
  - *ArrayWritable*: This stores an array of values belonging to a *Writable* type.
  - *TwoDArrayWritable*: This stores a matrix of values belonging to the same *Writable* type.
  - *MapWritable*: This stores a map of key-value pairs. Keys and values should be of the *Writable* data types.
  - *SortedMapWritable*: This stores a sorted map of key-value pairs. Keys should implement the *WritableComparable* interface.

Implementing a custom Hadoop Writable data type

- we can easily write a custom *Writable* data type by implementing the *org.apache.hadoop.io.Writable* interface
- The *Writable* interface-based types can be used as *value* types in Hadoop MapReduce computations.

Examples

Write a new `LogWritable` class implementing the `org.apache.hadoop.io.Writable` interface.

```
public class LogWritable implements Writable{

  private Text userIP, timestamp, request;
  privateIntWritableresponseSize, status;

  public LogWritable() {
    this.userIP = new Text();
    this.timestamp=  new Text();
    this.request = new Text();
    this.responseSize = new IntWritable();
    this.status = new IntWritable();
  }
  public void readFields(DataInput in) throws IOException {
    userIP.readFields(in);
    timestamp.readFields(in);
    request.readFields(in);
```

Examples

```
    responseSize.readFields(in);
    status.readFields(in);
  }

  public void write(DataOutput out) throws IOException {
    userIP.write(out);
    timestamp.write(out);
    request.write(out);
    responseSize.write(out);
    status.write(out);
  }

..... // getters and setters for the fields
}
```

Examples

Use the new `LogWritable` type as a `value` type in your MapReduce computation. In the following example, we use the `LogWritable` type as the Map output value type.

```
public class LogProcessorMap extends Mapper<LongWritable,
Text, Text, LogWritable> {
….
}

public class LogProcessorReduce extends Reducer<Text,
LogWritable, Text, IntWritable> {

public void reduce(Text key,
Iterable<LogWritable> values, Context context) {
     ……  }
}
```

Choosing a suitable Hadoop InputFormat for your input data format

- Hadoop supports processing of many different formats and types of data through *InputFormat*.
- The *InputFormat* of a Hadoop MapReduce computation generates the key-value pair inputs for the mappers by parsing the input data.
- *InputFormat* also performs the splitting of the input data into logical partitions

InputFormat that Hadoop provide

- *TextInputFormat*: This is used for plain text files. *TextInputFormat* generates a key-value record for each line of the input text files.
- *NLineInputFormat*: This is used for plain text files. *NlineInputFormat* splits the input files into logical splits of fixed number of lines.
- *SequenceFileInputFormat*: For Hadoop Sequence file input data
- *DBInputFormat*: This supports reading the input data for MapReduce computation from a SQL table.

Implementing new input data formats

- Hadoop enables us to implement and specify custom *InputFormat* implementations for our MapReduce computations.
- A *InputFormat* implementation should extend the *org.apache.hadoop.mapreduce.InputFormat<K,V>* abstract class
- overriding the *createRecordReader()* and *getSplits()* methods.

Formatting the results of MapReduce computations – using Hadoop OutputFormats

- it is important to store the result of a MapReduce computation in a format that can be consumed efficiently by the target application
- We can use Hadoop *OutputFormat* interface to define the data storage format
- A *OutputFormat* prepares the output location and provides a *RecordWriter* implementation to perform the actual serialization and storage of the data.
- Hadoop uses the *org.apache.hadoop.mapreduce.lib.output.*

  TextOutputFormat<K,V> as the default *OutputFormat*

Hands-On: Analytics Using MapReduce

Danairat T., , danairat@gmail.com: Thanachart Numnonda, thanachart@imcinstitute.com Aug 2013

Three Analytic MapReduce Examples

1. Simple analytics using MapReduce
2. Performing Group-By using MapReduce
3. Calculating frequency distributions and sorting using MapReduce

Preparing Example Data

NASA weblog dataset available from

http://ita.ee.lbl.gov/html/contrib/NASA-HTTP.html

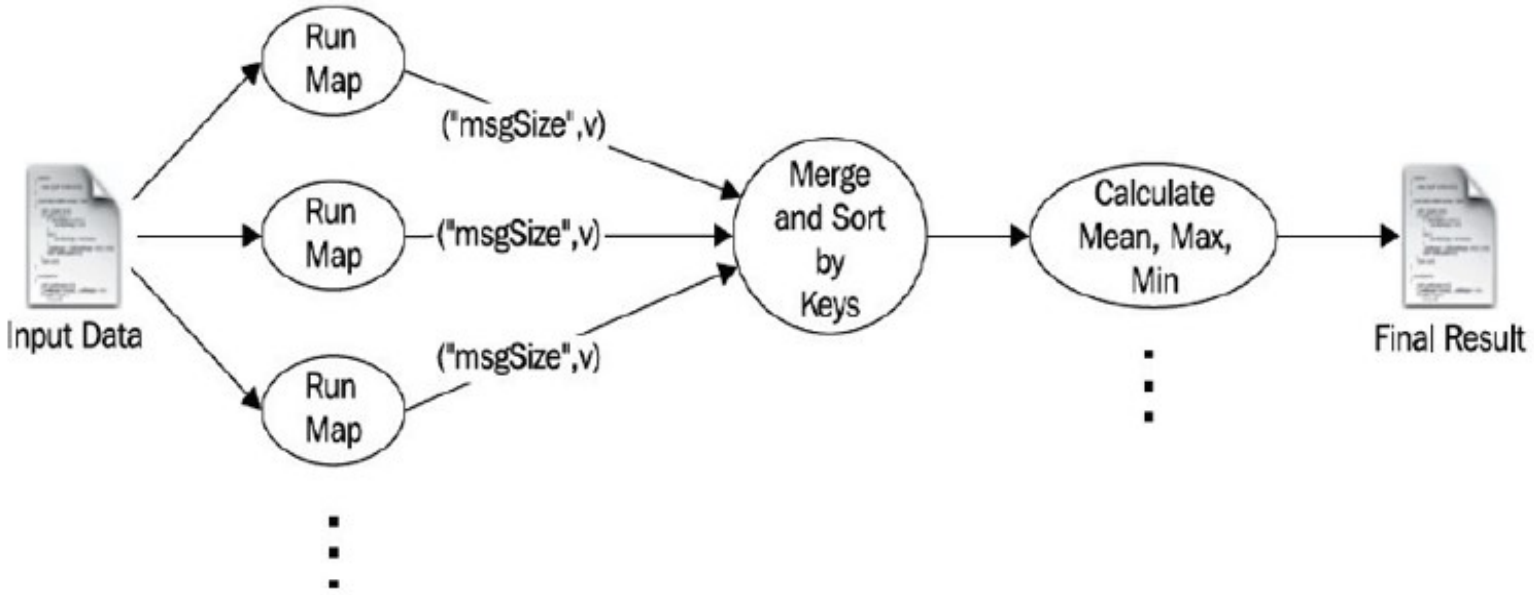
is a real-life dataset collected using the requests received by NASA web servers.

Download the weblog dataset from ftp://ita.ee.lbl.gov/traces/NASA_ access_log_Jul95.gz and unzip it. We call the extracted folder as DATA_DIR.

```
$ hadoopdfs -mkdir /data
$ hadoopdfs -put <DATA_DIR>/NASA_access_log_Jul95 /data/input1
```

Simple analytics using MapReduce

Aggregative values (for example, Mean, Max, Min, standard deviation, and so on) provide the basic analytics about a dataset..



Source: Hadoop MapReduce CookBook

WebLogMessageSizeAggregator.java

```
package analysis;
import java.io.IOException;
import java.util.*;
import java.util.regex.Matcher;
import java.util.regex.Pattern;
import org.apache.hadoop.fs.Path;
import org.apache.hadoop.io.*;
import org.apache.hadoop.mapred.*;
import org.apache.hadoop.util.*;
import org.apache.hadoop.conf.*;

public class WebLogMessageSizeAggregator {
    public static final Pattern httplogPattern = Pattern
            .compile("([^\\s]+) - - \\[(.+)\\] \"([^\\s]+) (/[^\\s]*) HTTP/[^\\s]+\"
[^\\s]+ ([0-9]+)");

    public static class AMapper extends MapReduceBase implements Mapper<LongWritable,
Text, Text, IntWritable> {
```

WebLogMessageSizeAggregator.java

```
        public void map(LongWritable key, Text value, OutputCollector<Text,
IntWritable> output,Reporter reporter) throws IOException {
            Matcher matcher = httplogPattern.matcher(value.toString());
            if (matcher.matches()) {
                int size = Integer.parseInt(matcher.group(5));
                output.collect(new Text("msgSize"), new IntWritable(size));
            }
        }
    }
```

WebLogMessageSizeAggregator.java

```
public static class AReducer extends MapReduceBase implements  Reducer<Text,
IntWritable, Text, IntWritable> {

        public void reduce(Text key, Iterator<IntWritable> values,
OutputCollector<Text, IntWritable> output,Reporter reporter) throws IOException {

            double tot = 0;

            int count = 0;

            int min = Integer.MAX_VALUE;

            int max = 0;


            while (values.hasNext()) {

                int value = values.next().get();

                tot = tot + value;

                count++;

                if (value < min) {

                    min = value;

                }

                if (value > max) {

                    max = value;

                }

            }
```

WebLogMessageSizeAggregator.java

```
            output.collect(new Text("Mean"), new IntWritable((int) tot / count));
            output.collect(new Text("Max"), new IntWritable(max));
            output.collect(new Text("Min"), new IntWritable(min));
        }
    }

public static void main(String[] args) throws Exception {
        JobConf job = new JobConf(WebLogMessageSizeAggregator.class);
        job.setJarByClass(WebLogMessageSizeAggregator.class);
        job.setMapperClass(AMapper.class);
        job.setReducerClass(AReducer.class);
        job.setMapOutputKeyClass(Text.class);
        job.setMapOutputValueClass(IntWritable.class);
        FileInputFormat.setInputPaths(job, new Path(args[0]));
        FileOutputFormat.setOutputPath(job, new Path(args[1]));
        JobClient.runJob(job);
    }
}
```

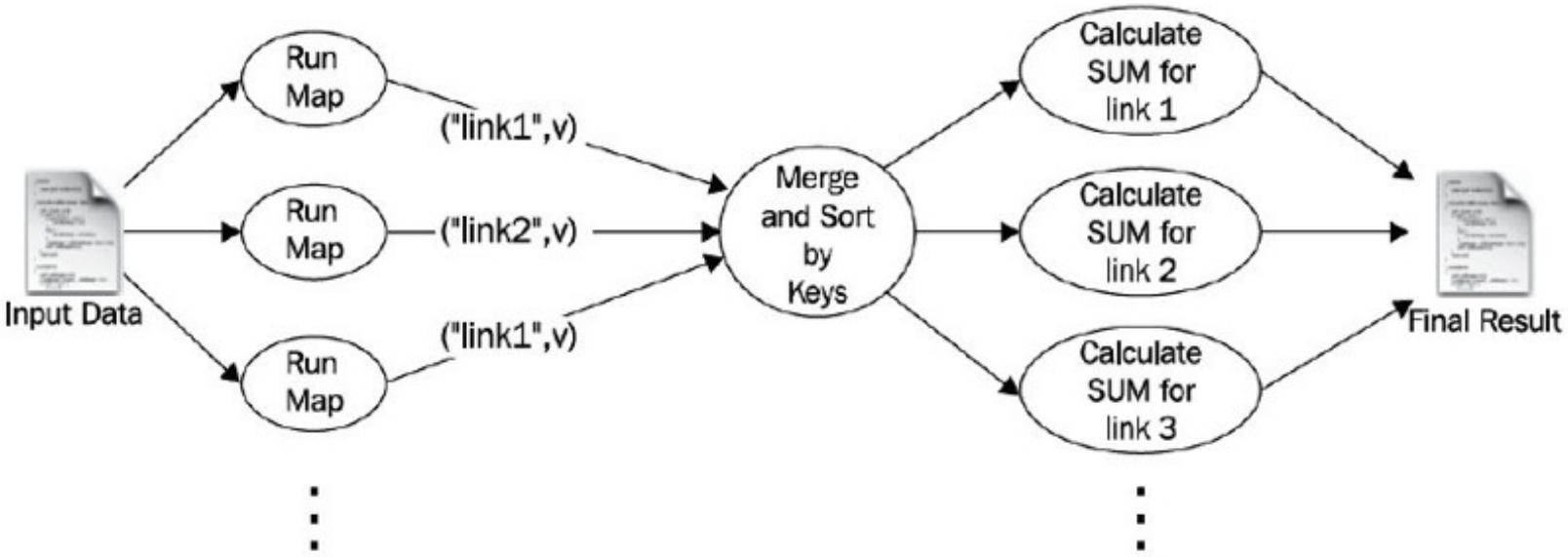
Compile, Build JAR, Submit Job, Review Result

```
$ cd /home/hduser
$ javac -classpath /usr/local/hadoop/hadoop-core-0.20.205.0.jar -d WebLog WebLogMessageSizeAggregator.java
$ jar -cvf ./weblog.jar -C WebLog .
$ hadoop jar ./weblog.jar analysis.WebLogMessageSizeAggregator /data/* /output/result_weblog
Output:
......
$ hadoop dfs -cat /output/result_weblog/part-00000
```

```
Mean    1150
Max     6823936
Min     0
```

Performing Group-By using MapReduce

A MapReduce to group data into simple groups and calculate the analytics for each group.



Source: Hadoop MapReduce CookBook

WeblogHitsByLinkProcessor.java

```
public class WeblogHitsByLinkProcessor {

    public static final Pattern httplogPattern = Pattern
            .compile("([^\\s]+) - - \\[(.+)\\] \"([^\\s]+) (/[^\\s]*) HTTP/[^\\s]+\"
[^\\s]+ ([0-9]+)");


    public static class AMapper extends MapReduceBase implements Mapper<LongWritable,
Text, Text, IntWritable> {


        private final static IntWritable one = new IntWritable(1);

        private Text word = new Text();


        public void map(LongWritable key, Text value, OutputCollector<Text,
IntWritable> output,Reporter reporter) throws IOException {

            Matcher matcher = httplogPattern.matcher(value.toString());

            if (matcher.matches()) {

                String linkUrl = matcher.group(4);

                word.set(linkUrl);

                output.collect(word, one);

            }

        }

    }
```

WeblogHitsByLinkProcessor.java

```
        public static class AReducer extends MapReduceBase implements  Reducer<Text,
IntWritable, Text, IntWritable> {


        private IntWritable result = new IntWritable();


        public void reduce(Text key, Iterator<IntWritable> values,
OutputCollector<Text, IntWritable> output,Reporter reporter) throws IOException {


            int sum = 0;
            while (values.hasNext()) {
                sum += values.next().get();
            }
            result.set(sum);
            output.collect(key, result);
        }
    }
```

Compile, Build JAR, Submit Job, Review Result

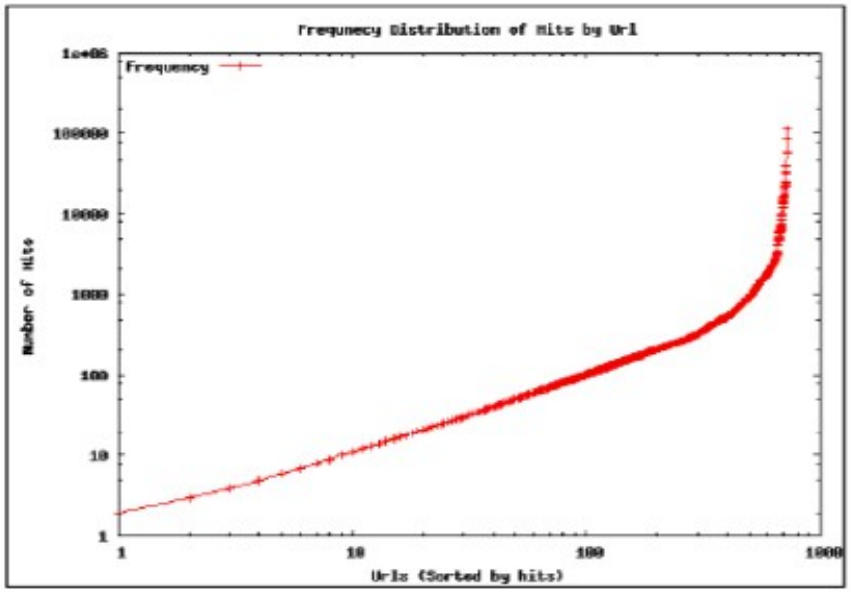
```
$ cd /home/hduser
$ javac -classpath /usr/local/hadoop/hadoop-core-0.20.205.0.jar -d WebLogHit WeblogHitsByLinkProcessor.java
$ jar -cvf ./webloghit.jar -C WebLogHit .
$ hadoop jar ./webloghit.jar analysis.WeblogHitsByLinkProcessor /data/* /output/result_webloghit
Output:
......
$ hadoop dfs -cat /output/result_webloghit/part-00000
```

```
/       32667
/%7Edowns/home.html     2
/%7Edowns/launchup.gif  2
/%7edowns/home.html     3
/./     3
/.ksc.html      6
//      3
//biomed/climate/gif/f16pcfinmed.gif    1
//biomed/gif/   1
//biomed/gif/aerial.gif 1
//elv/bakgro.gif        2
//elv/elvhead2.gif      1
//elv/elvhead3.gif      1
//elv/elvpage.htm       2
//elv/endball.gif       1
//elv/vidpicp.htm       1
//elv/whnew.htm 1
```


Danairat T., , danairat@gmail.com: Thanachart Numnonda, thanachart@imcinstitute.com Aug 2013

Calculating frequency distributions and sorting using MapReduce

Frequency distribution is the number of hits received by each URL sorted in the Ascending order, by the number hits received by a URL. We have already calculated the number of hits inthe previous program.



Source: Hadoop MapReduce CookBook

Lecture
Understanding Hive

Introduction

A Petabyte Scale Data Warehouse Using Hadoop

Hive is developed by Facebook, designed to enable easy data summarization, ad-hoc querying and analysis of large volumes of data. It provides a simple query language called Hive QL, which is based on SQL

What Hive is NOT

Hive is not designed for online transaction processing and does not offer real-time queries and row level updates. It is best used for batch jobs over large sets of immutable data (like web logs, etc.).

Hive Metastore

- Store Hive metadata
- Configurations
  - Embedded: in-process metastore, in-process database
  - Local: in-process metastore, out-of-process database
  - Remote: out-of-process metastore,out-of-process database

Hive Schema-On-Read

- Faster loads into the database (simply copy or move)
- Slower queries
- Flexibility – multiple schemas for the same data

HiveQL

- Hive Query Language
- SQL dialect
- No support for:
  - UPDATE, DELETE
  - Transactions
  - Indexes
  - HAVING clause in SELECT
  - Updateable or materialized views
  - Srored procedure

Hive Tables

- Managed- CREATE TABLE
  - LOAD- File moved into Hive's data warehouse directory
  - DROP- Both data and metadata are deleted.
- External- CREATE EXTERNAL TABLE
  - LOAD- No file moved
  - DROP- Only metadata deleted
  - Use when sharing data between Hive and Hadoop applications or you want to use multiple schema on the same data

Running Hive

Hive Shell

- **Interactive**

  hive

- **Script**

  hive -f myscript

- **Inline**

  *hive -e 'SELECT * FROM mytable'*

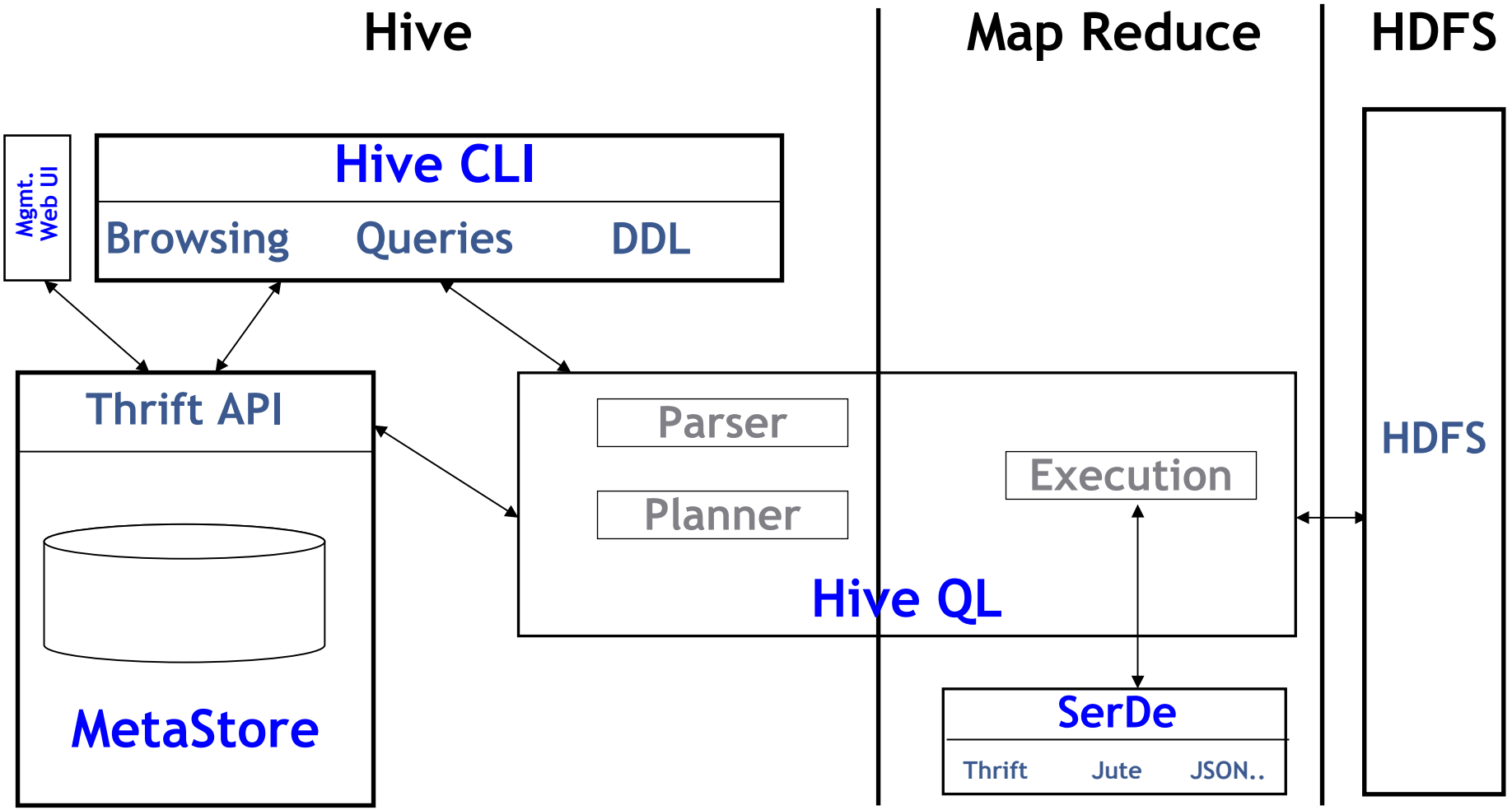
Hive.apache.org

System Architecture and Components

- **Metastore: To store the meta data.**
- **Query compiler and execution engine: To convert SQL queries to a sequence of map/reduce jobs that are then executed on Hadoop.**
- **SerDe and ObjectInspectors: Programmable interfaces and implementations of common data formats and types.**
  A SerDe is a combination of a Serializer and a Deserializer (hence, Ser-De). The Deserializer interface takes a string or binary representation of a record, and translates it into a Java object that Hive can manipulate. The Serializer, however, will take a Java object that Hive has been working with, and turn it into something that Hive can write to HDFS or another supported system.
- **UDF and UDAF: Programmable interfaces and implementations for user defined functions (scalar and aggregate functions).**
- **Clients: Command line client similar to Mysql command line.**

hive.apache.org

Architecture Overview



Hive.apache.org

Sample HiveQL

The Query compiler uses the information stored in the metastore to convert SQL queries into a sequence of map/reduce jobs, e.g. the following query

SELECT * FROM t where t.c = 'xyz'

SELECT t1.c2 FROM t1 JOIN t2 ON (t1.c1 = t2.c1)

SELECT t1.c1, count(1) from t1 group by t1.c1

Hive.apache.org

Hands-On: Creating Table and Retrieving Data using Hive

Danairat T., , danairat@gmail.com: Thanachart Numnonda, thanachart@imcinstitute.com

Running Hive from terminal

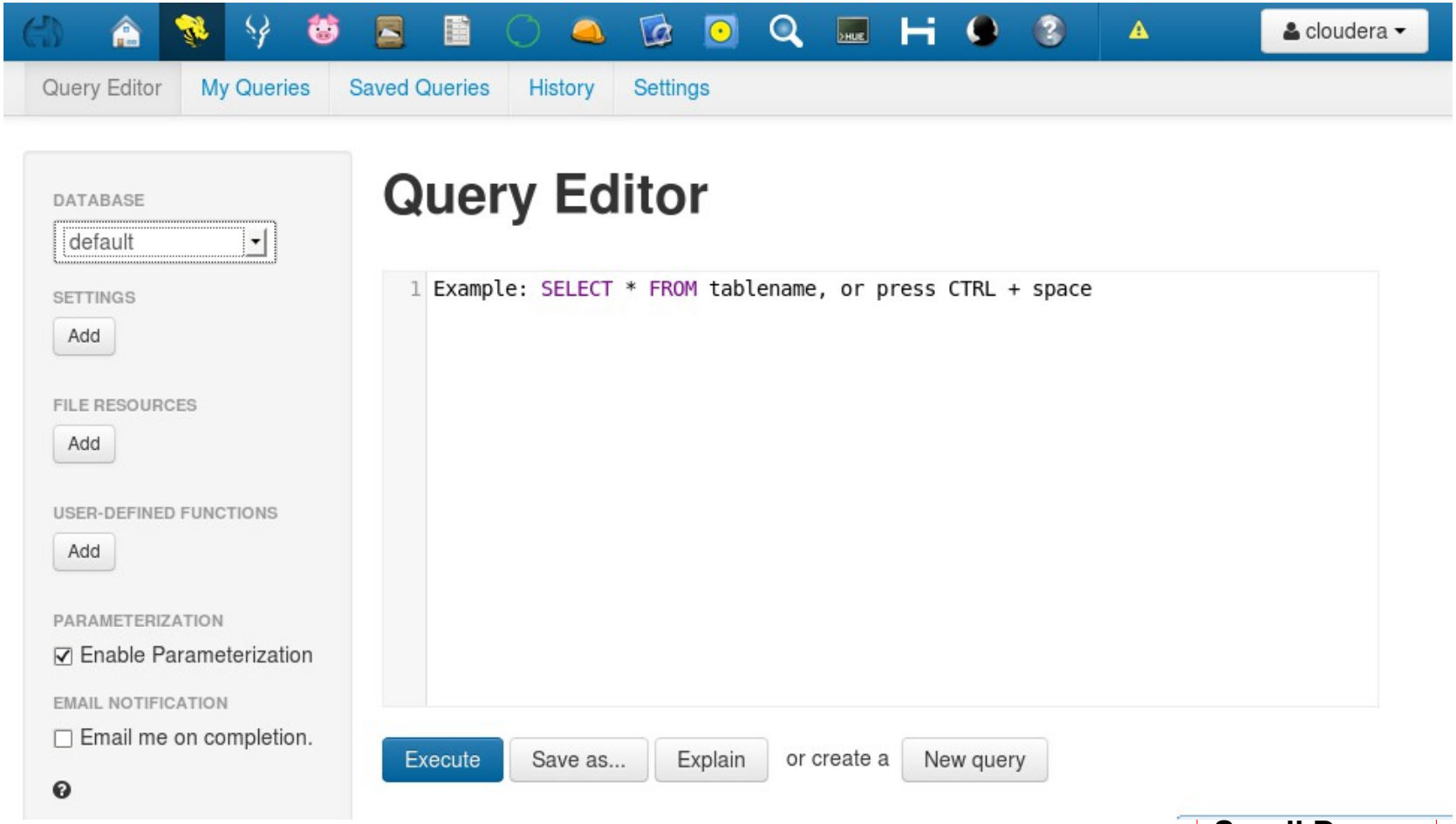
Starting Hive

```
[cloudera@localhost ~]$ hive
Logging initialized using configuration in jar:file:/usr/lib/hive/lib/hive-common-0.10.0-cdh4.4.0.jar!/hive-log4j.properties
Hive history file=/tmp/cloudera/hive_job_log_23b573ac-35ea-432e-93f3-b699630503ec_1889776701.txt
hive>
```

Quit from Hive

```
hive> quit;
```

Starting Hive Editor from Hue



Scroll Down the web page

Creating Hive Table

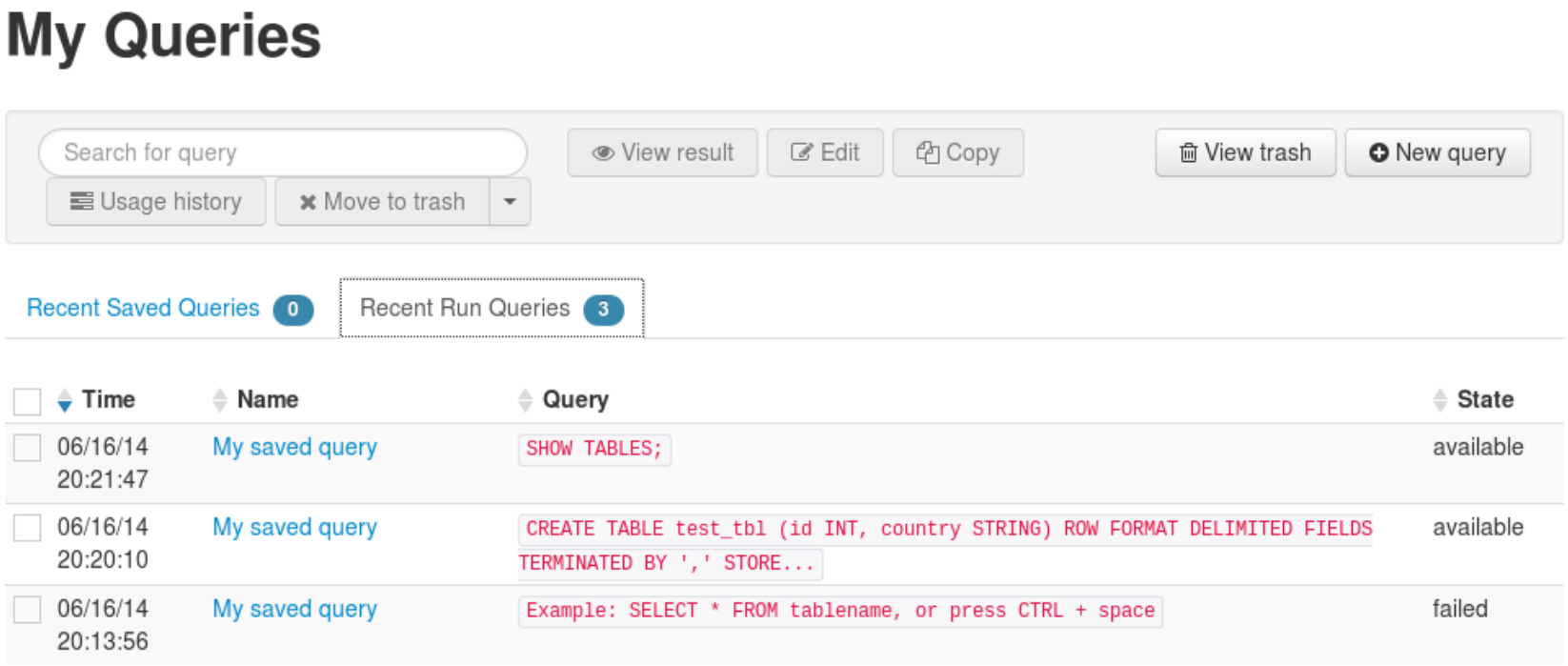
```
hive (default)> CREATE TABLE test_tbl(id INT, country STRING) ROW
FORMAT DELIMITED FIELDS TERMINATED BY ',' STORED AS TEXTFILE;
OK
Time taken: 4.069 seconds
hive (default)> show tables;
OK
test_tbl
Time taken: 0.138 seconds
hive (default)> describe test_tbl;
OK
id   int
country  string
Time taken: 0.147 seconds
hive (default)>
```

See also: https://cwiki.apache.org/Hive/languagemanual-ddl.html

Using Hue Query Editor

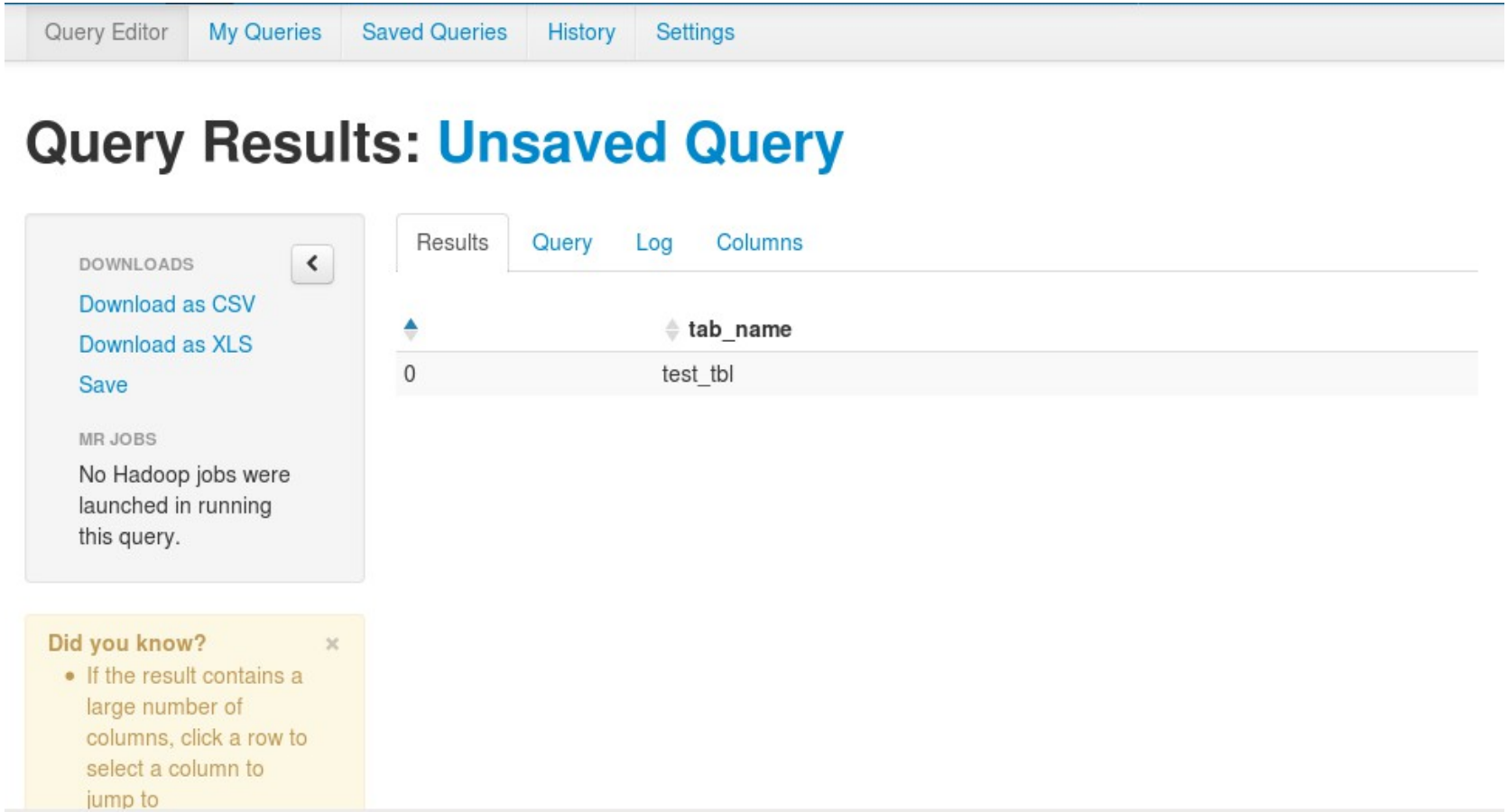
See also: https://cwiki.apache.org/Hive/languagemanual-ddl.html

Using Hue Query Editor



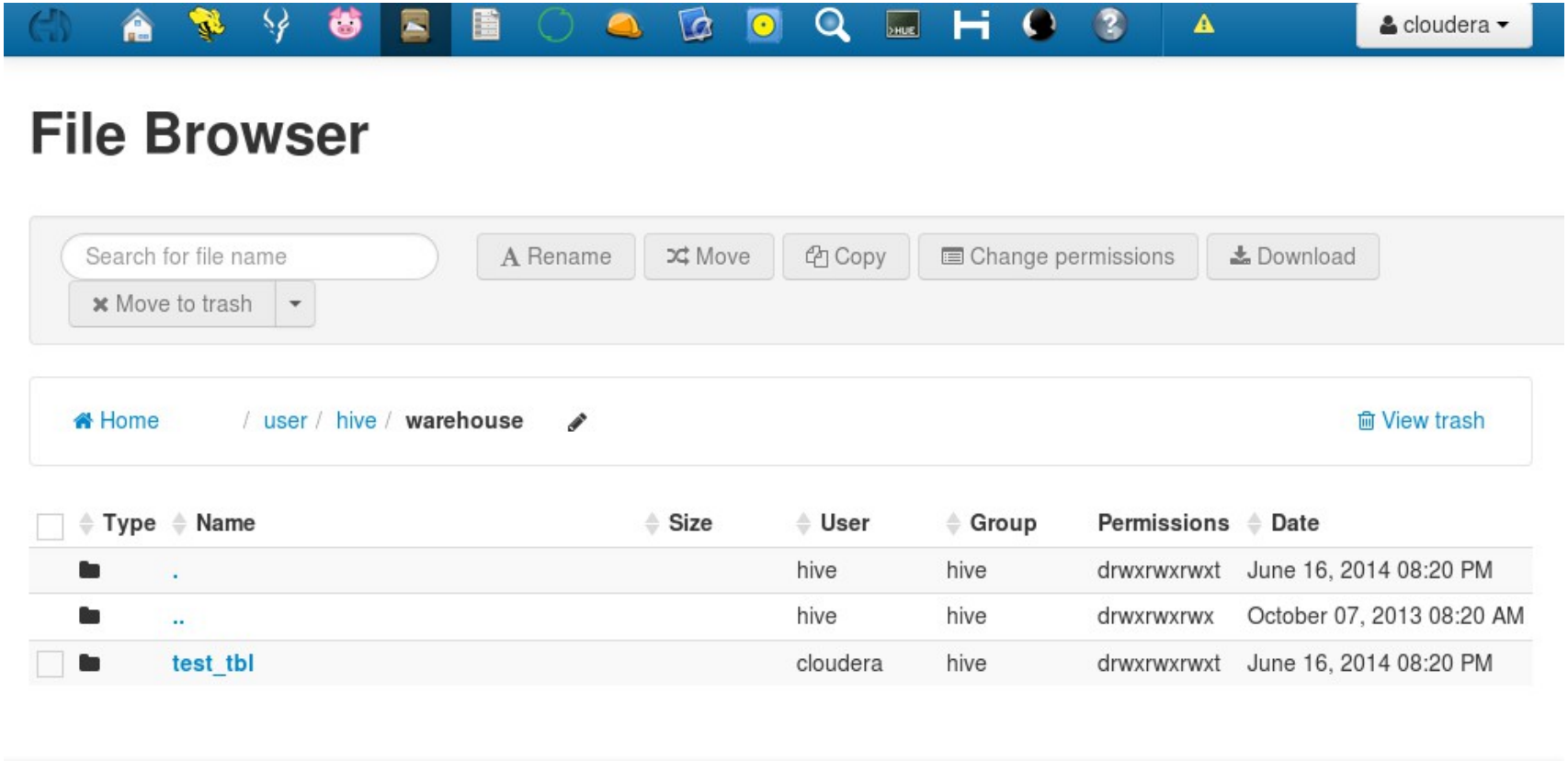
See also: https://cwiki.apache.org/Hive/languagemanual-ddl.html

Using Hue Query Editor



See also: https://cwiki.apache.org/Hive/languagemanual-ddl.html

Reviewing Hive Table in HDFS



Alter and Drop Hive Table

```
hive (default)> alter table test_tbl add columns (remarks STRING);

hive (default)> describe test_tbl;
OK
id   int
country  string
remarks  string
Time taken: 0.077 seconds
hive (default)> drop table test_tbl;
OK
Time taken: 0.9 seconds
```

See also: https://cwiki.apache.org/Hive/adminmanual-metastoreadmin.html

Loading Data to Hive Table

Creating Hive table

```
$ hive

hive (default)> CREATE TABLE test_tbl(id INT, country STRING) ROW
FORMAT DELIMITED FIELDS TERMINATED BY ',' STORED AS TEXTFILE;
```

Loading data to Hive table

```
hive (default)> LOAD DATA LOCAL INPATH '/tmp/country.csv' INTO TABLE test_tbl;

Copying data from file:/tmp/test_tbl_data.csv

Copying file: file:/tmp/test_tbl_data.csv

Loading data to table default.test_tbl

OK

Time taken: 0.241 seconds

hive (default)>
```

Querying Data from Hive Table

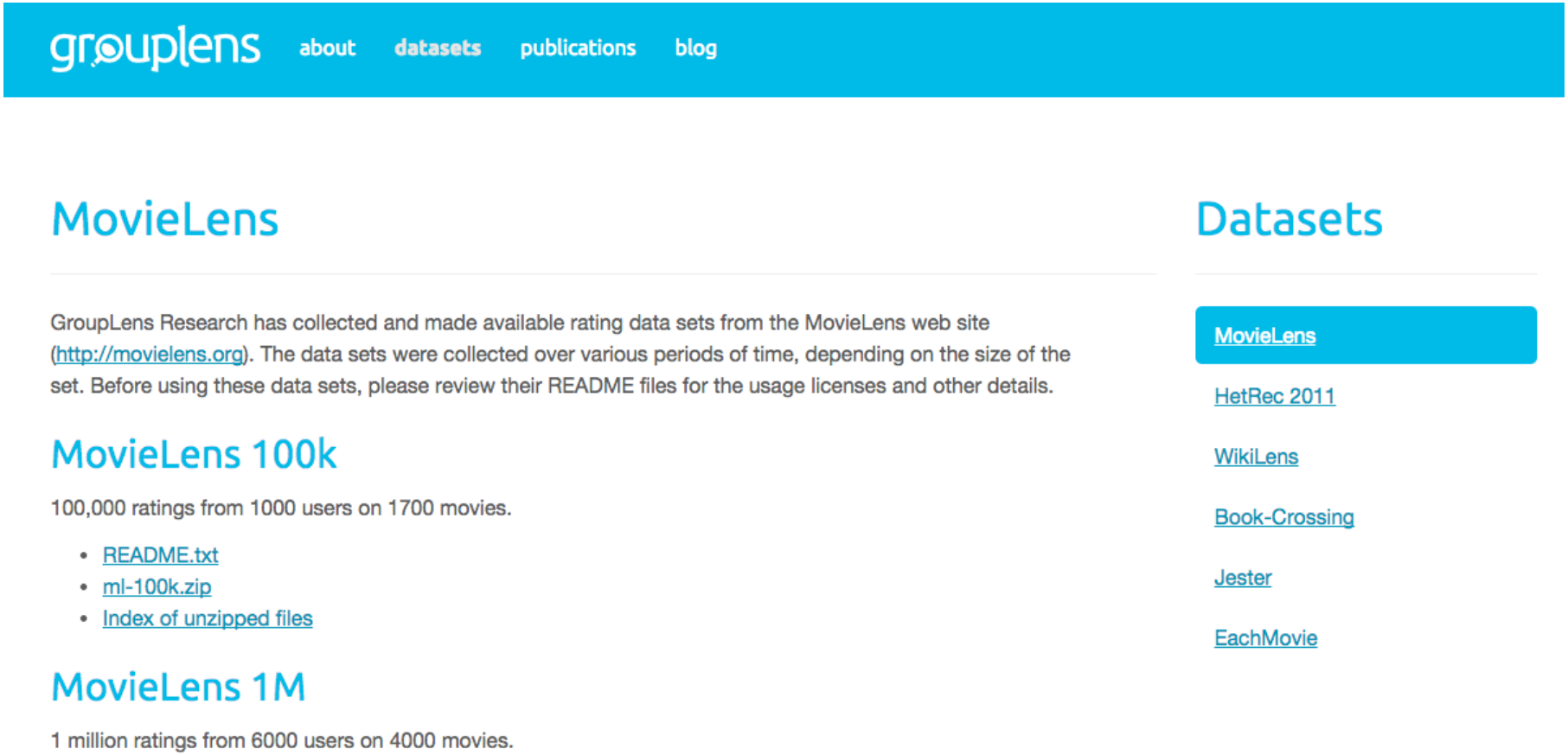
```
hive (default)> select * from test_tbl;
OK
1   USA
62  Indonesia
63  Philippines
65  Singapore
66  Thailand
Time taken: 0.287 seconds
hive (default)>
```

Insert Overwriting the Hive Table

```
hive (default)>  LOAD DATA LOCAL INPATH
'/home/cloudera/Downloads/test_tbl_data_updated.csv' overwrite INTO
TABLE test_tbl;

Copying data from file:/tmp/test_tbl_data_updated.csv

Copying file: file:/tmp/test_tbl_data_updated.csv

Loading data to table default.test_tbl

Deleted hdfs://localhost:54310/user/hive/warehouse/test_tbl

OK

Time taken: 0.204 seconds

hive (default)>
```

MovieLens

http://grouplens.org/datasets/movielens/



Create the Hive Table for movielen

```
hive (default)>  CREATE TABLE u_data (
  userid INT,
  movieid INT,
  rating INT,
  unixtime STRING)
ROW FORMAT DELIMITED
FIELDS TERMINATED BY '\t'
STORED AS TEXTFILE;
hive (default)> LOAD DATA LOCAL INPATH
'/home/cloudera/Downloads/u.data' overwrite INTO TABLE u_data;
```

Create the Hive Table for Apache LOf

```
hive (default)>  CREATE TABLE apachelog (
  host STRING,
  identity STRING,
  user STRING,
  time STRING,
  request STRING,
  status STRING,
  size STRING,
  referer STRING,
  agent STRING)
ROW FORMAT SERDE 'org.apache.hadoop.hive.serde2.RegexSerDe'
WITH SERDEPROPERTIES (
  "input.regex" = "([^]*) ([^]*) ([^]*) (-|\\[^\\]*\\])
([^ \"]*|\"[^\"]*\") (-|[0-9]*) (-|[0-9]*)(?: ([^ \"]*|\".*\")
([^ \"]*|\".*\"))?"
)
STORED AS TEXTFILE;
```

Lecture
Understanding Pig

Danairat T., , danairat@gmail.com: Thanachart Numnonda, thanachart@imcinstitute.com Aug 2013

Introduction

A high-level platform for creating MapReduce programs Using Hadoop

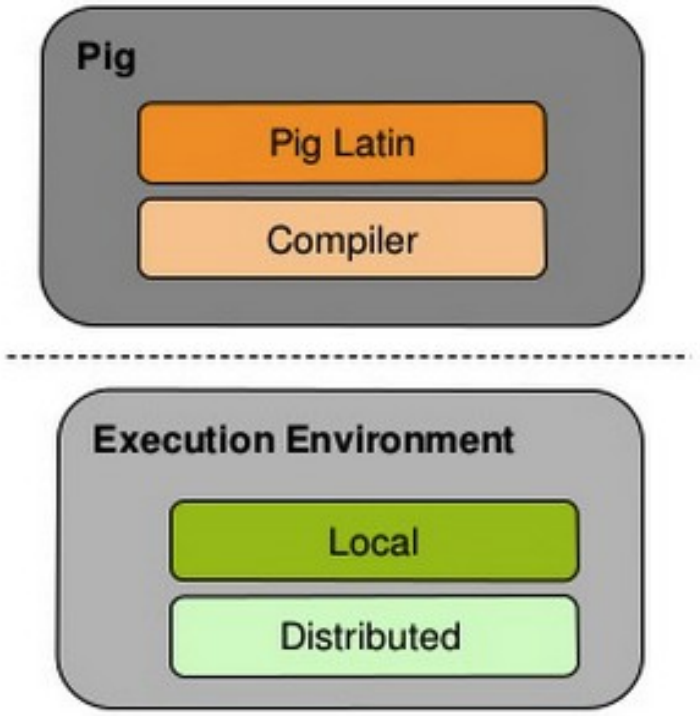
Pig is a platform for analyzing large data sets that consists of a high-level language for expressing data analysis programs, coupled with infrastructure for evaluating these programs. The salient property of Pig programs is that their structure is amenable to substantial parallelization, which in turns enables them to handle very large data sets.

Pig Components

- **Two Compnents**
  - Language (Pig Latin)
  - Compiler
- **Two Execution Environments**
  - **Local**

    pig -x local
  - **Distributed**

    pig -x mapreduce



Hive.apache.org

Running Pig

- **Script**

  pig myscript
- **Command line (Grunt)**

  pig
- **Embedded**

  Writing a java program

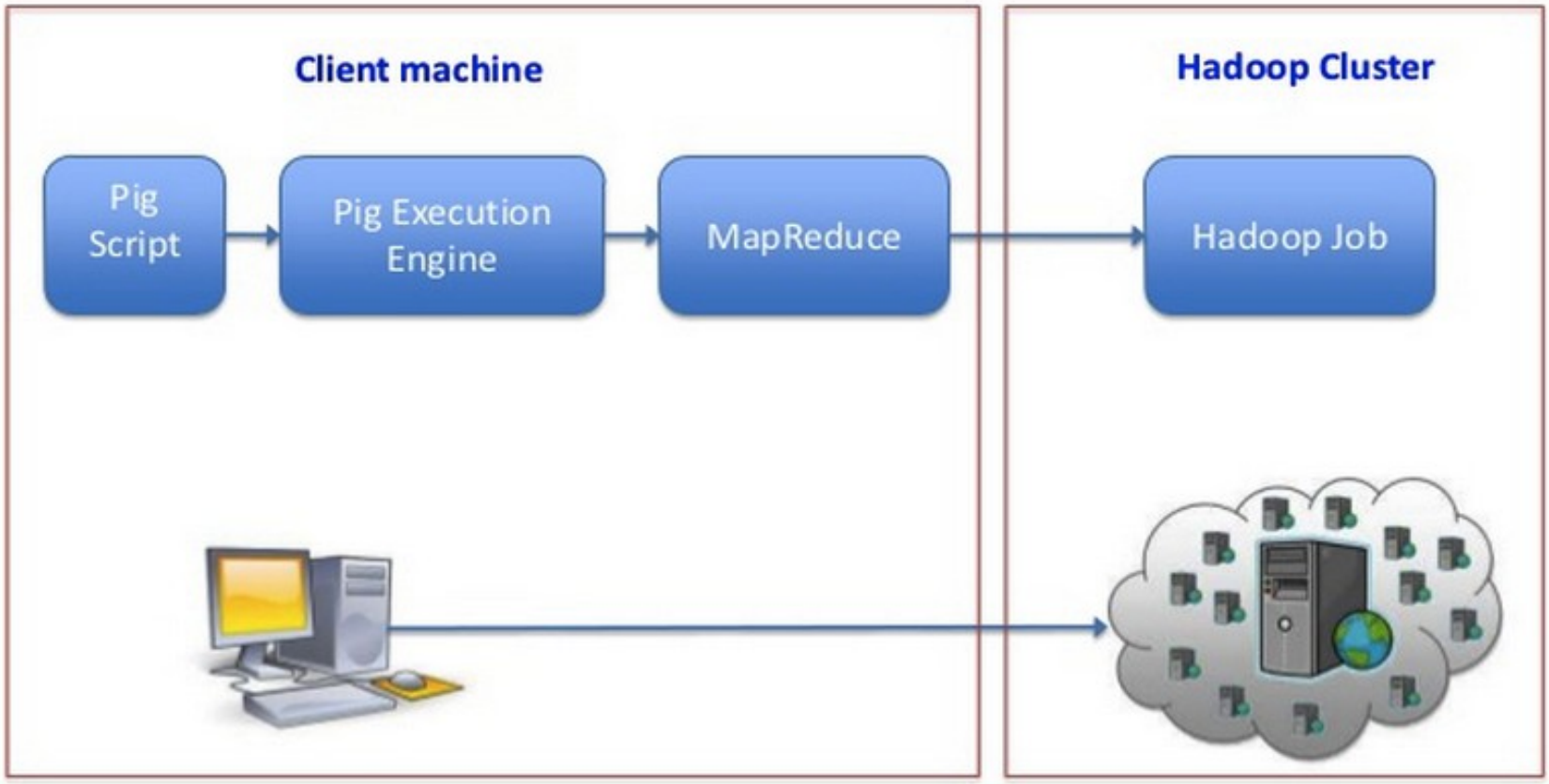
Hive.apache.org

Pig Latin

```
Users = load'users'as (name, age);
Fltrd = filter Users by
        age >= 18 and age <= 25;
Pages = load 'pages' as (user, url);
Jnd = joinFltrdby name, Pages by user;
Grpd = groupJndbyurl;
Smmd = foreachGrpdgenerate group,
COUNT(Jnd) as clicks;
Srtd = orderSmmdby clicks desc;
Top5 = limitSrtd 5;
store Top5 into'top5sites';
```

Hive.apache.org

Pig Execution Stages



Source Introduction to Apache Hadoop-Pig: PrashantKommireddi

Hive.apache.org

Why Pig?

- **Makes writing Hadoop jobs easier**
  - 5% of the code, 5% of the time
  - You don't need to be a programmer to write Pig scripts
- **Provide major functionality required for DatawareHouse and Analytics**
  - *Load, Filter, Join, Group By, Order, Transform*
- **User can write custom UDFs (User Defined Function)**

Source Introduction to Apache Hadoop-Pig: PrashantKommireddi

Hive.apache.org

Running MapReduce Job Using Oozie : Select Java

Characteristic	Pig	Hive
Developed by	Yahoo!	Facebook
Language name	Pig Latin	HiveQL
Type of language	Data flow	Declarative (SQL dialect)
Data structures it operates on	Complex, nested	
Schema optional?	Yes	No, but data can have many schemas
Relational complete?	Yes	Yes
Turing complete?	Yes when extended with Java UDFs	Yes when extended with Java UDFs

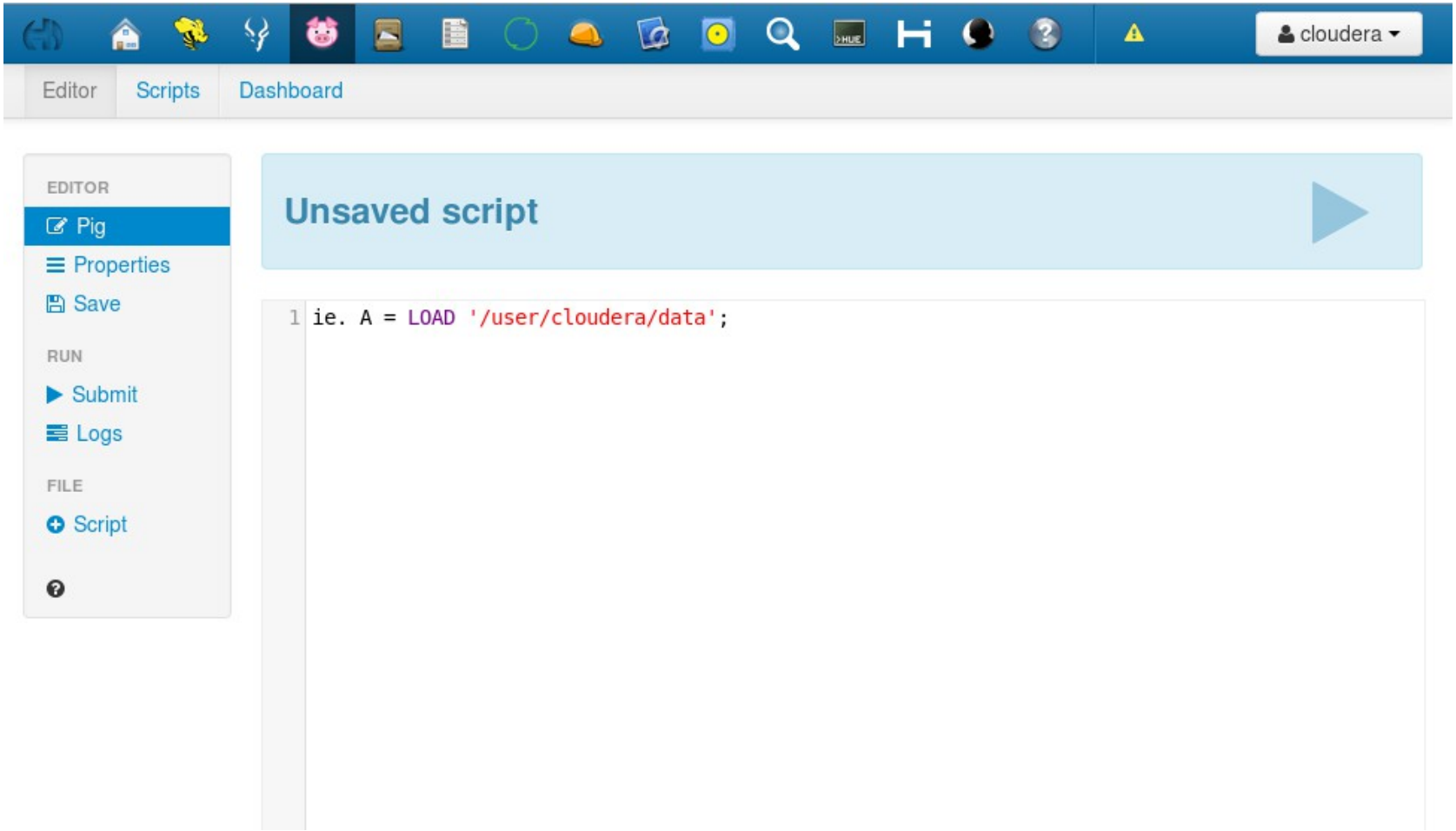
Hive.apache.org

Hands-On: Running a Pig script

Starting Pig Command Line

```
[hdadmin@localhost ~]$  pig -x local

2013-08-01 10:29:00,027 [main] INFO  org.apache.pig.Main - Apache Pig
version 0.11.1 (r1459641) compiled Mar 22 2013, 02:13:53

2013-08-01 10:29:00,027 [main] INFO  org.apache.pig.Main - Logging error
messages to: /home/hdadmin/pig_1375327740024.log

2013-08-01 10:29:00,066 [main] INFO  org.apache.pig.impl.util.Utils -
Default bootup file /home/hdadmin/.pigbootup not found

2013-08-01 10:29:00,212 [main] INFO
org.apache.pig.backend.hadoop.executionengine.HExecutionEngine - Connecting
to hadoop file system at: file:///

grunt>
```

Starting Pig from Hue



Writing a Pig Script

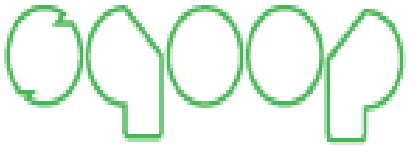
```
#Preparing Data
Download hdi-data.csv

#Edit Your Script
[hdadmin@localhost ~]$ cd Downloads/
[hdadmin@localhost ~]$ vi countryFilter.pig
```

countryFilter.pig

```
A = load 'hdi-data.csv' using PigStorage(',')  AS (id:int, country:chararray, hdi:float,
lifeex:int, mysch:i
nt, eysch:int, gni:int);
B = FILTER A BY gni > 2000;
C = ORDER B BY gni;
dump C;
```

Running a Pig Script

```
[hdadmin@localhost ~]$ cd Downloads
[hdadmin@localhost ~]$ pig -x local
grunt > run countryFilter.pig

....

(150,Cameroon,0.482,51,5,10,2031)
(126,Kyrgyzstan,0.615,67,9,12,2036)
(156,Nigeria,0.459,51,5,8,2069)
(154,Yemen,0.462,65,2,8,2213)
(138,Lao People's Democratic Republic,0.524,67,4,9,2242)
(153,Papua New Guinea,0.466,62,4,5,2271)
(165,Djibouti,0.43,57,3,5,2335)
(129,Nicaragua,0.589,74,5,10,2430)
(145,Pakistan,0.504,65,4,6,2550)
```



Lecture: Understanding Sqoop

Danairat T., , danairat@gmail.com: Thanachart Numnonda, thanachart@imcinstitute.com Aug 2013

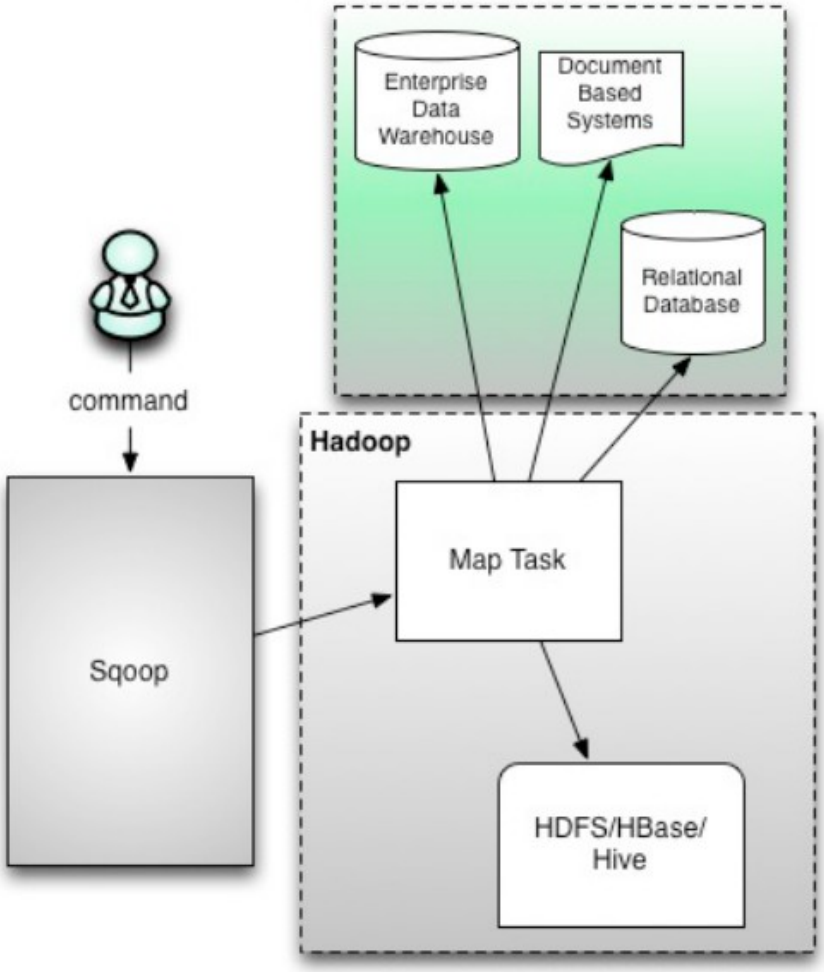
Introduction

Sqoop ("SQL-to-Hadoop") is a straightforward command-line tool with the following capabilities:

- **Imports individual tables or entire databases to files in HDFS**
- **Generates Java classes to allow you to interact with your imported data**
- **Provides the ability to import from SQL databases straight into your Hive data warehouse**

See also: http://sqoop.apache.org/docs/1.4.2/SqoopUserGuide.html

Architecture Overview



Hive.apache.org

Hands-On: Loading Data from DBMS to Hadoop HDFS

Danairat T., , danairat@gmail.com: Thanachart Numnonda, thanachart@imcinstitute.com Aug 2013

Loading Data into MySQL DB

```
[root@localhost ~]# service mysqld start
Starting mysqld:                                           [  OK  ]
[root@localhost ~]# mysql -u root -p
Password: cloudera

mysql> create database countrydb;
Query OK, 1 row affected (0.00 sec)

mysql> use countrydb;
Database changed

mysql> create table country_tbl(id INT, country VARCHAR(100));
Query OK, 0 rows affected (0.02 sec)

mysql> LOAD DATA LOCAL INFILE '/home/cloudera/Downloads/country.csv' INTO
TABLE country_tbl FIELDS terminated by ',' LINES TERMINATED BY '\n';
Query OK, 237 rows affected, 4 warnings (0.00 sec)
Records: 237  Deleted: 0  Skipped: 0  Warnings: 0
```

Loading Data into MySQL DB

Testing data query from MySQL DB

```
mysql> select * from country_tbl;
+------+------------------------------+
| id   | country                      |
+------+------------------------------+
|   93 | Afghanistan                  |
|  355 | Albania                      |
|  213 | Algeria                      |
| 1684 | AmericanSamoa                |
|  376 | Andorra                      |
...
+------+------------------------------+
237 rows in set (0.00 sec)

mysql>
```


Danairat T., , danairat@gmail.com: Thanachart Numnonda, thanachart@imcinstitute.com Aug 2013

Importing data from MySQL to Hive Table

```
[hdadmin@localhost ~]$ sqoop import --connect
jdbc:mysql://localhost/countrydb --username root -P --table
country_tbl --hive-import --hive-table country_tbl -m 1

Warning: /usr/lib/hbase does not exist! HBase imports will fail.

Please set $HBASE_HOME to the root of your HBase installation.

Warning: $HADOOP_HOME is deprecated.


Enter password: <enter here>
```

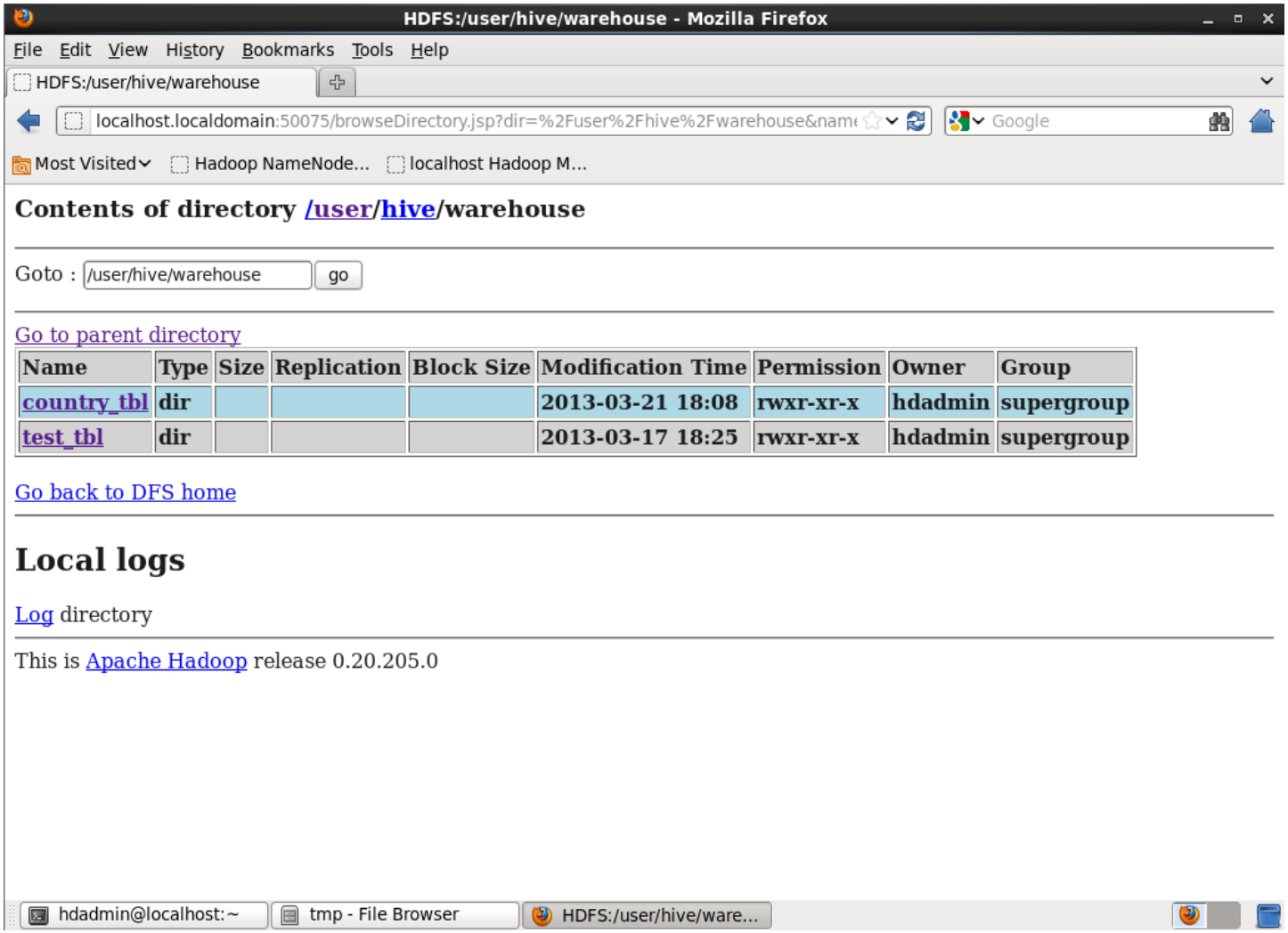
```
13/03/21 18:07:43 INFO tool.BaseSqoopTool: Using Hive-specific delimiters for output. You can override

13/03/21 18:07:43 INFO tool.BaseSqoopTool: delimiters with --fields-terminated-by, etc.

13/03/21 18:07:43 INFO manager.MySQLManager: Preparing to use a MySQL streaming resultset.

13/03/21 18:07:43 INFO tool.CodeGenTool: Beginning code generation

13/03/21 18:07:44 INFO manager.SqlManager: Executing SQL statement: SELECT t.* FROM `country_tbl` AS t LIMIT 1

13/03/21 18:07:44 INFO manager.SqlManager: Executing SQL statement: SELECT t.* FROM `country_tbl` AS t LIMIT 1

13/03/21 18:07:44 INFO com.CompilationManager: HADOOP_HOME is /usr/local/hadoop/libexec/..

Note: /tmp/sqoop-hdadmin/compile/0b65b003bf2936e1303f5edf93338215/country_tbl.java uses or overrides a deprecated API.

Note: Recompile with -Xlint:deprecation for details.

13/03/21 18:07:44 INFO com.CompilationManager: Writing jar file: /tmp/sqoop-hdadmin/compile/0b65b003bf2936e1303f5edf93338215/country_tbl.jar

13/03/21 18:07:44 WARN manager.MySQLManager: It looks like you are importing from mysql.

13/03/21 18:07:44 WARN manager.MySQLManager: This transfer can be faster! Use the --direct

13/03/21 18:07:44 WARN manager.MySQLManager: option to exercise a MySQL-specific fast path.

13/03/21 18:07:44 INFO manager.MySQLManager: Setting zero DATETIME behavior to convertToNull (mysql)

13/03/21 18:07:44 INFO mapreduce.ImportJobBase: Beginning import of country_tbl

13/03/21 18:07:45 INFO mapred.JobClient: Running job: job_201303211744_0001

13/03/21 18:07:46 INFO mapred.JobClient:  map 0% reduce 0%

13/03/21 18:08:02 INFO mapred.JobClient:  map 100% reduce 0%

13/03/21 18:08:07 INFO mapred.JobClient: Job complete: job_201303211744_0001

13/03/21 18:08:07 INFO mapred.JobClient: Counters: 18

13/03/21 18:08:07 INFO mapred.JobClient:   Job Counters

13/03/21 18:08:07 INFO mapred.JobClient:     SLOTS_MILLIS_MAPS=12154

13/03/21 18:08:07 INFO mapred.JobClient:     Total time spent by all reduces waiting after reserving slots (ms)=0

13/03/21 18:08:07 INFO mapred.JobClient:     Total time spent by all maps waiting after reserving slots (ms)=0
```

Reviewing data from Hive Table

```
[hdadmin@localhost ~]$ hive

Logging initialized using configuration in file:/usr/local/hive-0.9.0-
bin/conf/hive-log4j.properties

Hive history
file=/tmp/hdadmin/hive_job_log_hdadmin_201303211810_964909984.txt

hive (default)> show tables;

OK

country_tbl

test_tbl

Time taken: 2.566 seconds

hive (default)> select * from country_tbl;

OK

93   Afghanistan

355  Albania

.....

Time taken: 0.587 seconds

hive (default)> quit;

[hdadmin@localhost ~]$
```

Reviewing HDFS Database Table files

Start Web Browser to http://localhost:50070/ then navigate to /user/hive/warehouse



Lecture
Understanding HBase

Danairat T., , danairat@gmail.com: Thanachart Numnonda, thanachart@imcinstitute.com Aug 2013

Introduction

An open source, non-relational, distributed database

HBase is an open source, non-relational, distributed database modeled after Google's BigTable and is written in Java. It is developed as part of Apache Software Foundation's Apache Hadoop project and runs on top of HDFS (, providing BigTable-like capabilities for Hadoop. That is, it provides a fault-tolerant way of storing large quantities of sparse data.

HBase Features

- Hadoop database modelled after Google's Bigtab;e
- Column oriented data store, known as Hadoop Database
- Support random realtime CRUD operations (unlike HDFS)
- No SQL Database
- Opensource, written in Java
- Run on a cluster of commodity hardware

Hive.apache.org

When to use Hbase?

- When you need high volume data to be stored
- Un-structured data
- Sparse data
- Column-oriented data
- Versioned data (same data template, captured at various time, time-elapse data)
- When you need high scalability

Hive.apache.org

Which one to use?

- HDFS
  - Only append dataset (no random write)
  - Read the whole dataset (no random read)
- HBase
  - Need random write and/or read
  - Has thousands of operation per second on TB+ of data
- RDBMS
  - Data fits on one big node
  - Need full transaction support
  - Need real-time query capabilities

Hive.apache.org

HBase vs. RDBMS

	HBase	RDBMS
Hardware architecture	Similar to Hadoop. Clustered commodity hardware. Very affordable.	Typically large scalable multiprocessor systems. Very expensive.
Fault Tolerance	Built into the architecture. Lots of nodes means each is relatively insignificant. No need to worry about individual node downtime.	Requires configuration of the HW and the RDBMS with the appropriate high availability options.
Typical Database Size	Terabytes to Petabytes - hundred of millions to billions of rows.	Gigabytes to Terabytes – hundred of thousands to millions of rows.
Data Layout	A sparse, distributed, persistent, multidimensional sorted map.	Rows or column oriented.
Data Types	Bytes only.	Rich data type support.
Transactions	ACID support on a single row only	Full ACID compliance across rows and tables
Query Language	API primitive commands only, unless combined with Hive or other technology	SQL
Indexes	Row-Key only unless combined with other technologies such as Hive or IBM's BigSQL	Yes
Throughput	Millions of queries per second	Thousands of queries per second

- Given this RDBMS:

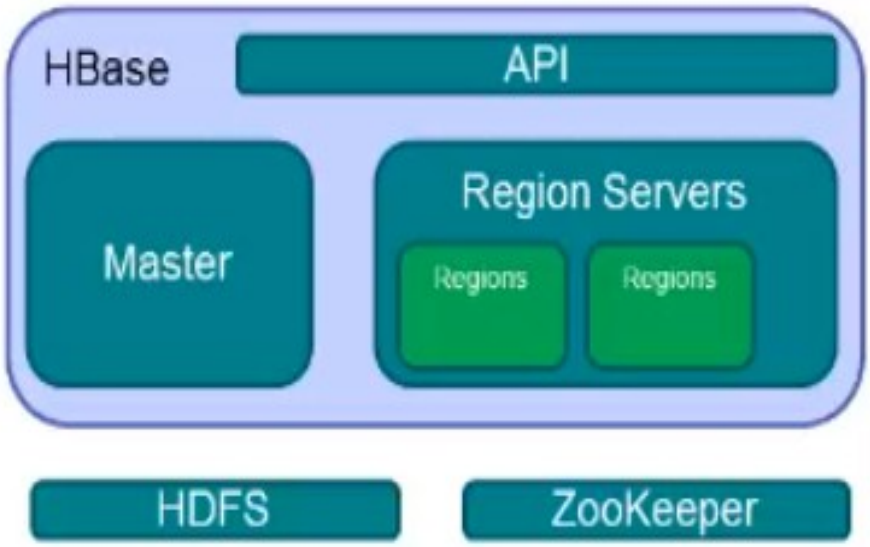
ID (Primary key)	Last name	First name	Password	Timestamp
1234	Smith	John	Hello, world!	20130710
5678	Cooper	Joyce	wysiwyg	20120825
5678	Cooper	Joyce	wisiwig	20130916

- Logical view in HBase:

Row-Key	Value (CF, Qualifier, Version)
1234	info {'lastName': 'Smith', 'firstName': 'John'} pwd {'password': 'Hello, world!'}
5678	info {'lastName': 'Cooper', 'firstName': 'Joyce'} pwd {'password': 'wysiwyg'@ts 20130916, 'password': 'wisiwig'@ts 20120825}

HBase Components

- Region
  - Row of table are stores
- Region Server
  - Hosts the tables
- Master
  - Coordinating the Region Servers
- ZooKeeper
- HDFS
- API
  - The Java Client API



Hive.apache.org

HBase Shell Commands

- See the list of the tables

```
list
```

- Create a table:

```
create 'testTable', 'cf'
```

- Insert data into a table:

  Insert at rowA, column "cf:columnName" with a value of "val1"

```
put 'testTable', 'rowA', 'cf:columnName', 'val1'
```

- Retrieve data from a table:

  Retrive "rowA" from the table "testTable"

```
get 'testTable', 'rowA'
```

- Iterate through a table:

```
– scan 'testTable'
```

- Delete a table:

```
disable 'testTable'
drop 'testTable'
```

Hive.apache.org

Hands-On: Running HBase

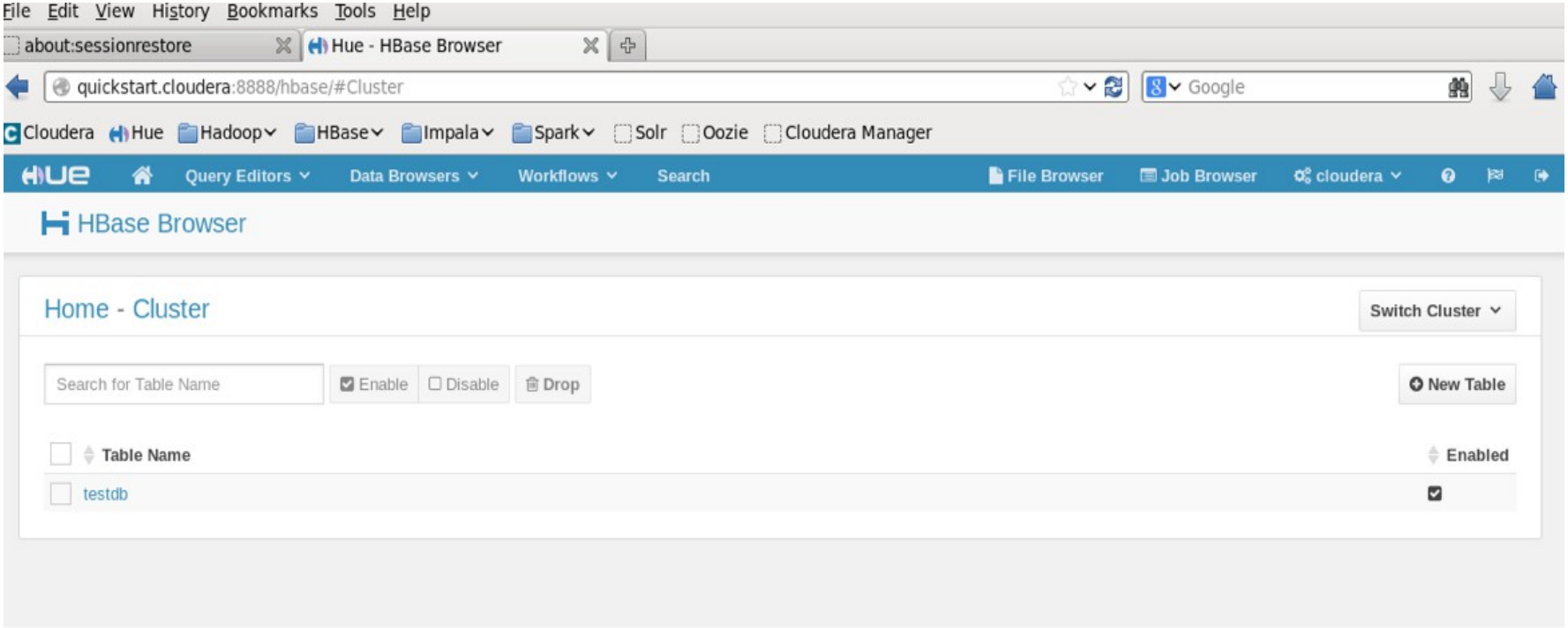
Starting HBase shell

```
[hdadmin@localhost ~]$ start-hbase.sh
starting master, logging to /usr/local/hbase-0.94.10/logs/hbase-hdadmin-master-localhost.localdomain.out
[hdadmin@localhost ~]$ jps
3064 TaskTracker
2836 SecondaryNameNode
2588 NameNode
3513 Jps
3327 HMaster
2938 JobTracker
2707 DataNode
[hdadmin@localhost ~]$ hbase shell
HBase Shell; enter 'help<RETURN>' for list of supported commands.
Type "exit<RETURN>" to leave the HBase Shell
Version 0.94.10, r1504995, Fri Jul 19 20:24:16 UTC 2013

hbase(main):001:0>
```

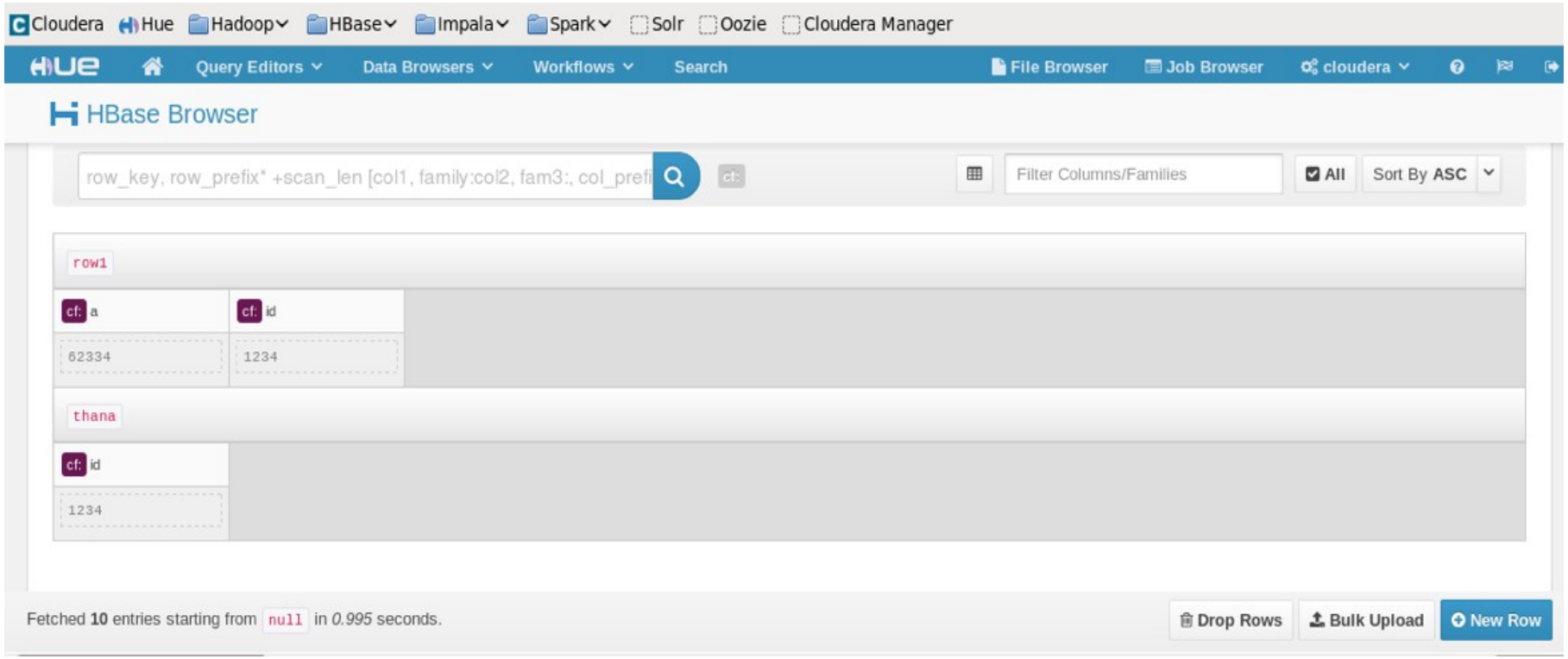
Create a table and insert data in HBase

```
hbase(main):009:0> create 'test', 'cf'
0 row(s) in 1.0830 seconds
hbase(main):010:0> put 'test', 'row1', 'cf:a', 'val1'
0 row(s) in 0.0750 seconds
hbase(main):011:0> scan 'test'
ROW                           COLUMN+CELL
 row1                         column=cf:a, timestamp=1375363287644,
value=val1
1 row(s) in 0.0640 seconds

hbase(main):002:0> get 'test', 'row1'
COLUMN                        CELL
 cf:a                         timestamp=1375363287644, value=val1
1 row(s) in 0.0370 seconds
```

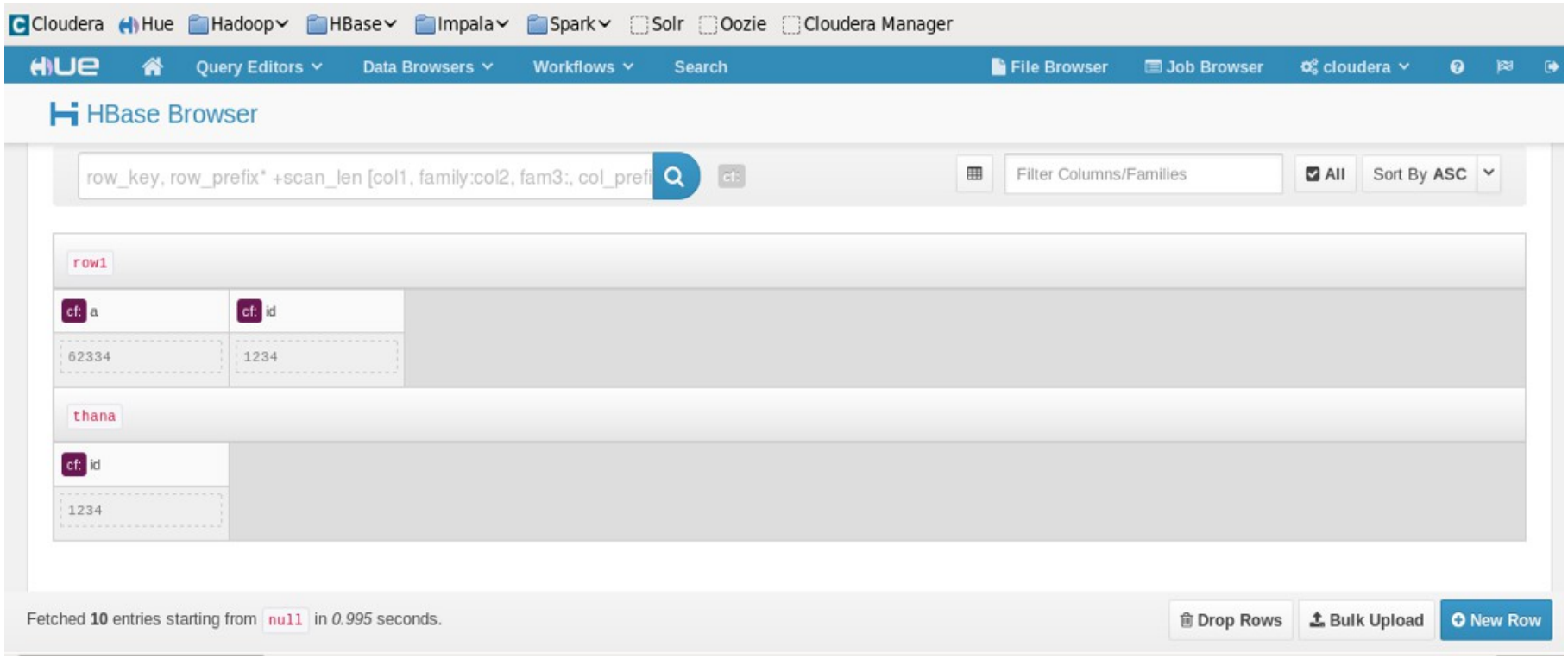
Using Data Browsers in Hue for HBase



Using Data Browsers in Hue for HBase



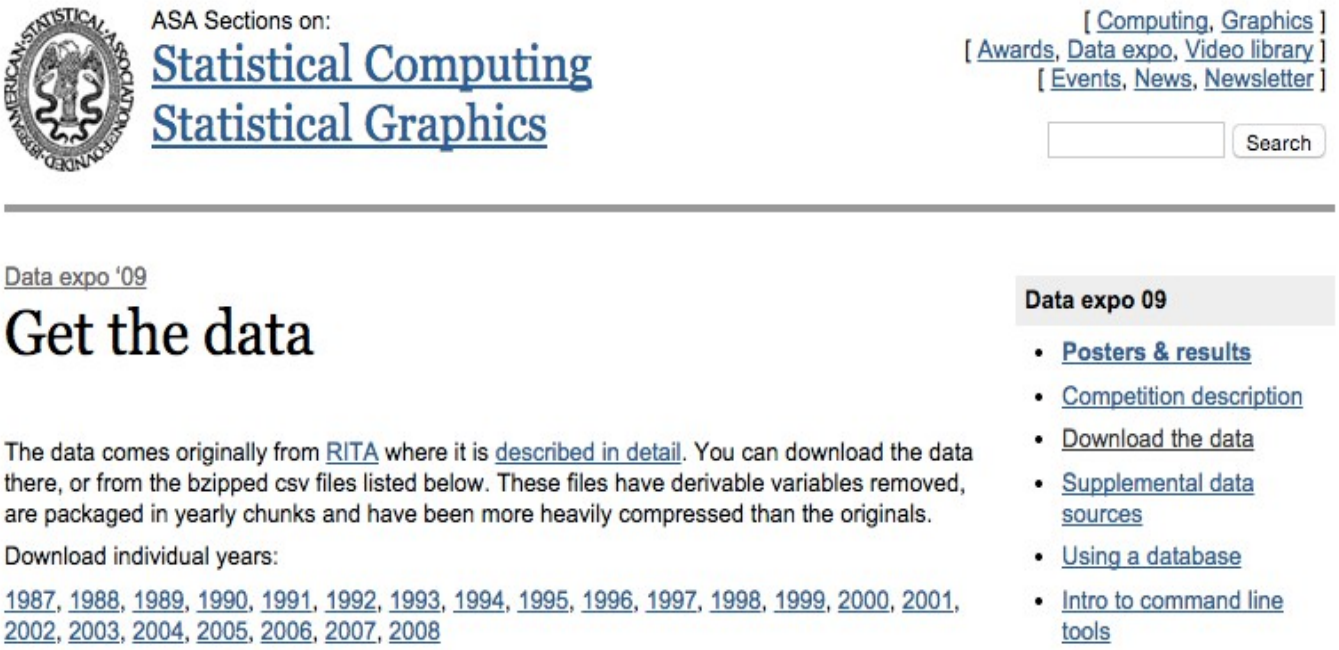
Using Data Browsers in Hue for HBase



Project: Flight

Flight Details Data

http://stat-computing.org/dataexpo/2009/the-data.html



ASA Sections on:
Statistical Computing
Statistical Graphics

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[Awards, Data expo, Video library]
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Data expo '09

Get the data

The data comes originally from RITA where it is described in detail. You can download the data there, or from the bzipped csv files listed below. These files have derivable variables removed, are packaged in yearly chunks and have been more heavily compressed than the originals.

Download individual years:

1987, 1988, 1989, 1990, 1991, 1992, 1993, 1994, 1995, 1996, 1997, 1998, 1999, 2000, 2001, 2002, 2003, 2004, 2005, 2006, 2007, 2008

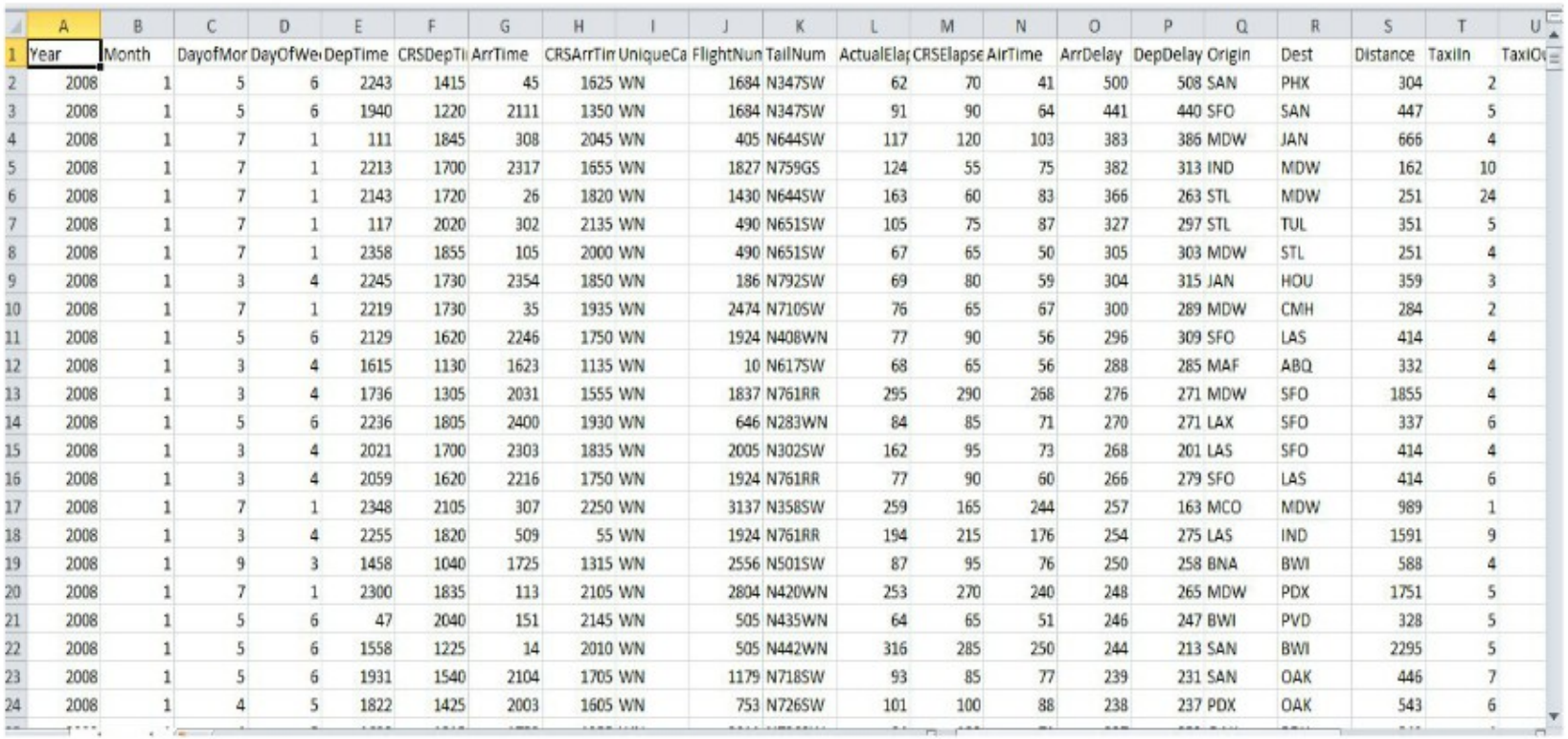
Data expo 09

- Posters & results
- Competition description
- Download the data
- Supplemental data sources
- Using a database
- Intro to command line tools

Data Description

	Name	Description
1	Year	1987-2008
2	Month	1-12
3	DayofMonth	1-31
4	DayOfWeek	1 (Monday) - 7 (Sunday)
5	DepTime	actual departure time (local, hhmm)
6	CRSDepTime	scheduled departure time (local, hhmm)
7	ArrTime	actual arrival time (local, hhmm)
8	CRSArrTime	scheduled arrival time (local, hhmm)
9	UniqueCarrier	unique carrier code
10	FlightNum	flight number
11	TailNum	plane tail number
12	ActualElapsedTime	in minutes
13	CRSElapsedTime	in minutes
14	AirTime	in minutes
15	ArrDelay	arrival delay, in minutes
16	DepDelay	departure delay, in minutes
17	Origin	origin IATA airport code
18	Dest	destination IATA airport code
19	Distance	in miles
20	TaxiIn	taxi in time, in minutes
21	TaxiOut	taxi out time in minutes
22	Cancelled	was the flight cancelled?
23	CancellationCode	reason for cancellation (A = carrier, B = weather, C = NAS, D = security)
24	Diverted	1 = yes, 0 = no
25	CarrierDelay	in minutes
26	WeatherDelay	in minutes
27	NASDelay	in minutes
28	SecurityDelay	in minutes
29	LateAircraftDelay	in minutes

Snapshot of Dataset



	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U
1	Year	Month	DayofMor	DayOfWe	DepTime	CRSDepTi	ArrTime	CRSArrTir	UniqueCa	FlightNun	TailNum	ActualEla	CRSElapse	AirTime	ArrDelay	DepDelay	Origin	Dest	Distance	TaxiIn	TaxiO
2	2008	1	5	6	2243	1415	45	1625	WN	1684	N347SW	62	70	41	500	508	SAN	PHX	304	2	
3	2008	1	5	6	1940	1220	2111	1350	WN	1684	N347SW	91	90	64	441	440	SFO	SAN	447	5	
4	2008	1	7	1	111	1845	308	2045	WN	405	N644SW	117	120	103	383	386	MDW	JAN	666	4	
5	2008	1	7	1	2213	1700	2317	1655	WN	1827	N759GS	124	55	75	382	313	IND	MDW	162	10	
6	2008	1	7	1	2143	1720	26	1820	WN	1430	N644SW	163	60	83	366	263	STL	MDW	251	24	
7	2008	1	7	1	117	2020	302	2135	WN	490	N651SW	105	75	87	327	297	STL	TUL	351	5	
8	2008	1	7	1	2358	1855	105	2000	WN	490	N651SW	67	65	50	305	303	MDW	STL	251	4	
9	2008	1	3	4	2245	1730	2354	1850	WN	186	N792SW	69	80	59	304	315	JAN	HOU	359	3	
10	2008	1	7	1	2219	1730	35	1935	WN	2474	N710SW	76	65	67	300	289	MDW	CMH	284	2	
11	2008	1	5	6	2129	1620	2246	1750	WN	1924	N408WN	77	90	56	296	309	SFO	LAS	414	4	
12	2008	1	3	4	1615	1130	1623	1135	WN	10	N617SW	68	65	56	288	285	MAF	ABQ	332	4	
13	2008	1	3	4	1736	1305	2031	1555	WN	1837	N761RR	295	290	268	276	271	MDW	SFO	1855	4	
14	2008	1	5	6	2236	1805	2400	1930	WN	646	N283WN	84	85	71	270	271	LAX	SFO	337	6	
15	2008	1	3	4	2021	1700	2303	1835	WN	2005	N302SW	162	95	73	268	201	LAS	SFO	414	4	
16	2008	1	3	4	2059	1620	2216	1750	WN	1924	N761RR	77	90	60	266	279	SFO	LAS	414	6	
17	2008	1	7	1	2348	2105	307	2250	WN	3137	N358SW	259	165	244	257	163	MCO	MDW	989	1	
18	2008	1	3	4	2255	1820	509	55	WN	1924	N761RR	194	215	176	254	275	LAS	IND	1591	9	
19	2008	1	9	3	1458	1040	1725	1315	WN	2556	N501SW	87	95	76	250	258	BNA	BWI	588	4	
20	2008	1	7	1	2300	1835	113	2105	WN	2804	N420WN	253	270	240	248	265	MDW	PDX	1751	5	
21	2008	1	5	6	47	2040	151	2145	WN	505	N435WN	64	65	51	246	247	BWI	PVD	328	5	
22	2008	1	5	6	1558	1225	14	2010	WN	505	N442WN	316	285	250	244	213	SAN	BWI	2295	5	
23	2008	1	5	6	1931	1540	2104	1705	WN	1179	N718SW	93	85	77	239	231	SAN	OAK	446	7	
24	2008	1	4	5	1822	1425	2003	1605	WN	753	N726SW	101	100	88	238	237	PDX	OAK	543	6	

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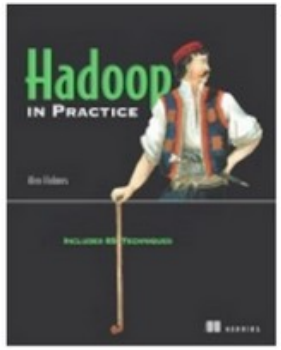
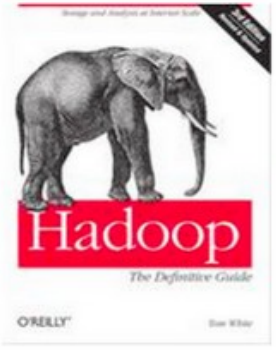
Problem

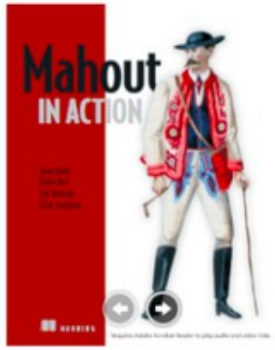
- **Write a map reduce to count the frequency of arrival delay in each airport by classify in to three groups:**
  - *Very late : delay > 30*
  - Late : 5 <delay <= 30
  - Ontime: delay <= 5
- **Export the result to excel and plot the histogram**

Hive.apache.org

Recommendation to Further Study



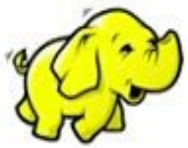




Big Data Certification Course

120 Hrs: Start 12 March 2015

IMC Institute



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