datacrunchers

Big Data
Too Big To Ignore

datacrunchers

Geert

- Big Data Consultant and Manager
- Currently finishing a 3rd Big Data project
- IBM & Cloudera Certified
- IBM & Microsoft Big Data Partner

Agenda

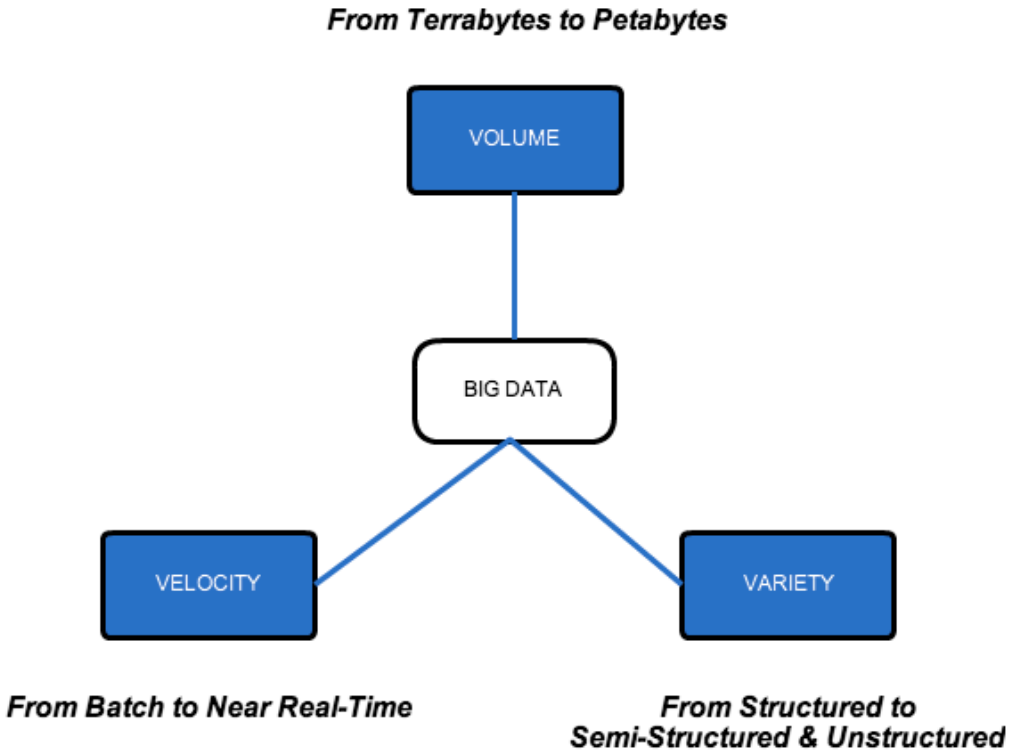
- Defining Big Data
- Introduction to Hadoop


Volume

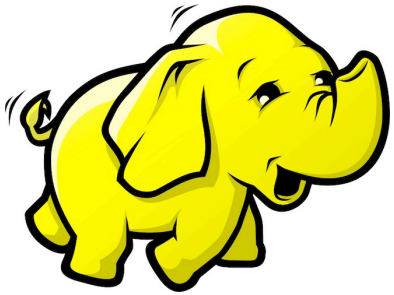

Big Data
Velocity


Variety

Big Data Technical Drivers

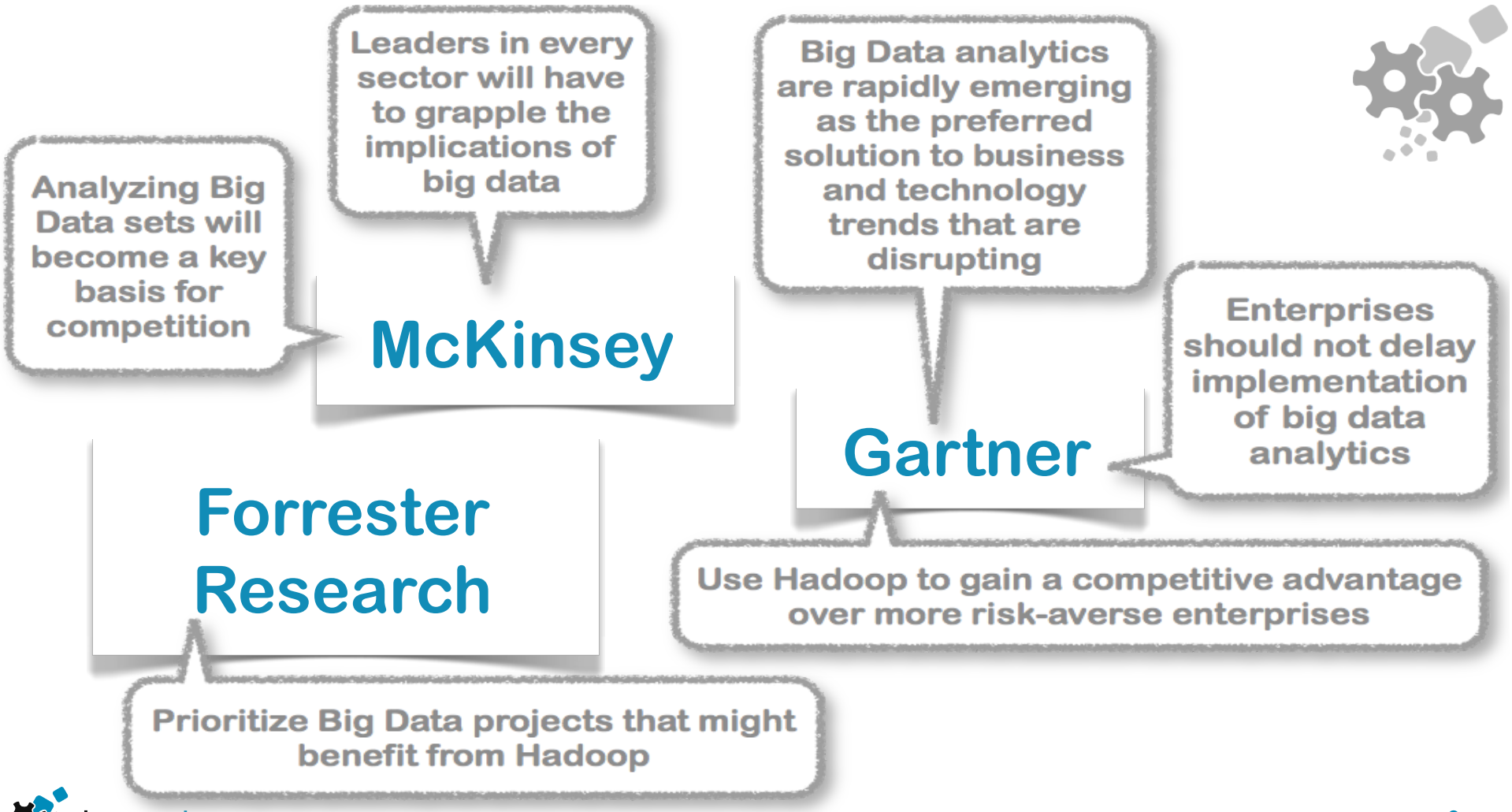


Big Data Business Drivers



Do More **ANALYTICS**

with Less **COSTS**


Leaders in every sector will have to grapple the implications of big data
Analyzing Big Data sets will become a key basis for competition
McKinsey
Big Data analytics are rapidly emerging as the preferred solution to business and technology trends that are disrupting
Enterprises should not delay implementation of big data analytics
Gartner
Use Hadoop to gain a competitive advantage over more risk-averse enterprises
Forrester Research
Prioritize Big Data projects that might benefit from Hadoop

Transformation of Online Marketing

THEN...

Leads

Company	First	Last	Oppty	Created
Acme	Fred	Langan	$250K	6/08/12
BigCo	Tom	Jones	$100K	6/17/12
DealCo	Jan	Sedor	$50K	7/01/12
Stor Works	Liza	Grear	$750K	7/14/12
RF Group	Carl	Tomer	$47K	7/18/12

NOW...

Marketing and Sales Recommendations

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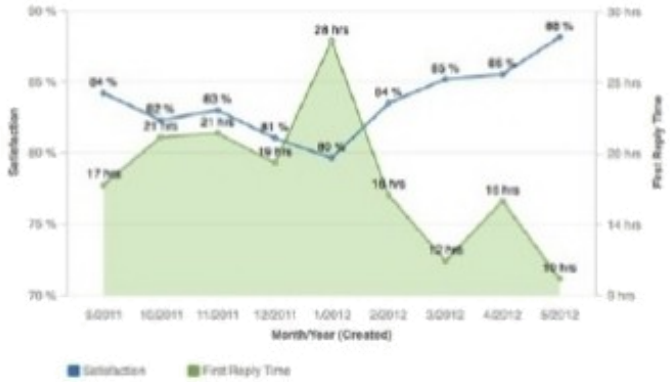
Transformation of Customer Service

THEN...

Unhappy customers

NOW...

Customer insight



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Big Data Definition

Big Data Technologies allow you to implement Use Cases which Legacy Technologies can’t.

Implementing Big Data

Our Vision on Data

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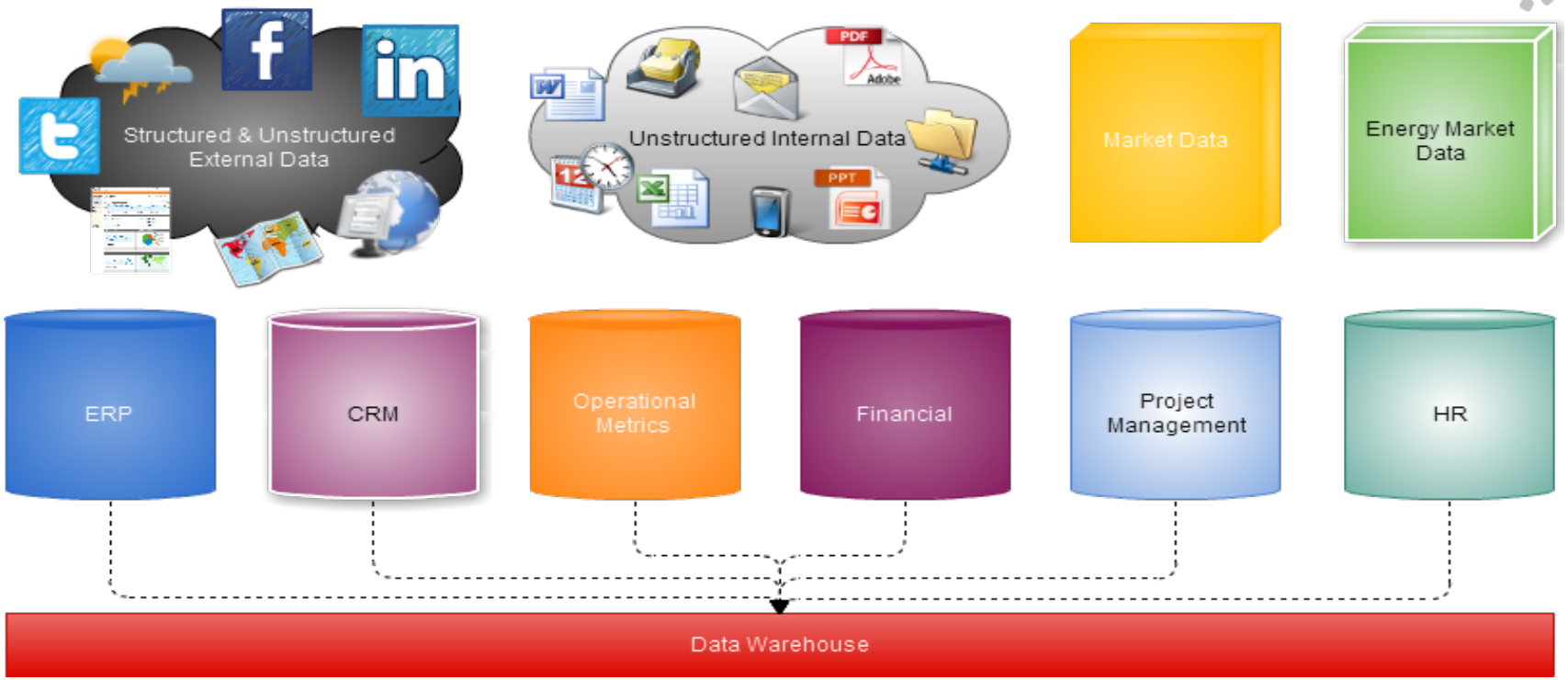
Current Situation



Our Vision #1

Focus on Data not on Derived Data

Our Vision #2

Data is immutable

Our Vision #3

Query = function (all data)

Concept


Structured & Unstructured External Data
Unstructured Internal Data
Market Data
Energy Market Data
ERP
CRM
Operational Metrics
Financial
Project Management
HR
Data Warehouse

Introducing
The Hadoop Ecosystem

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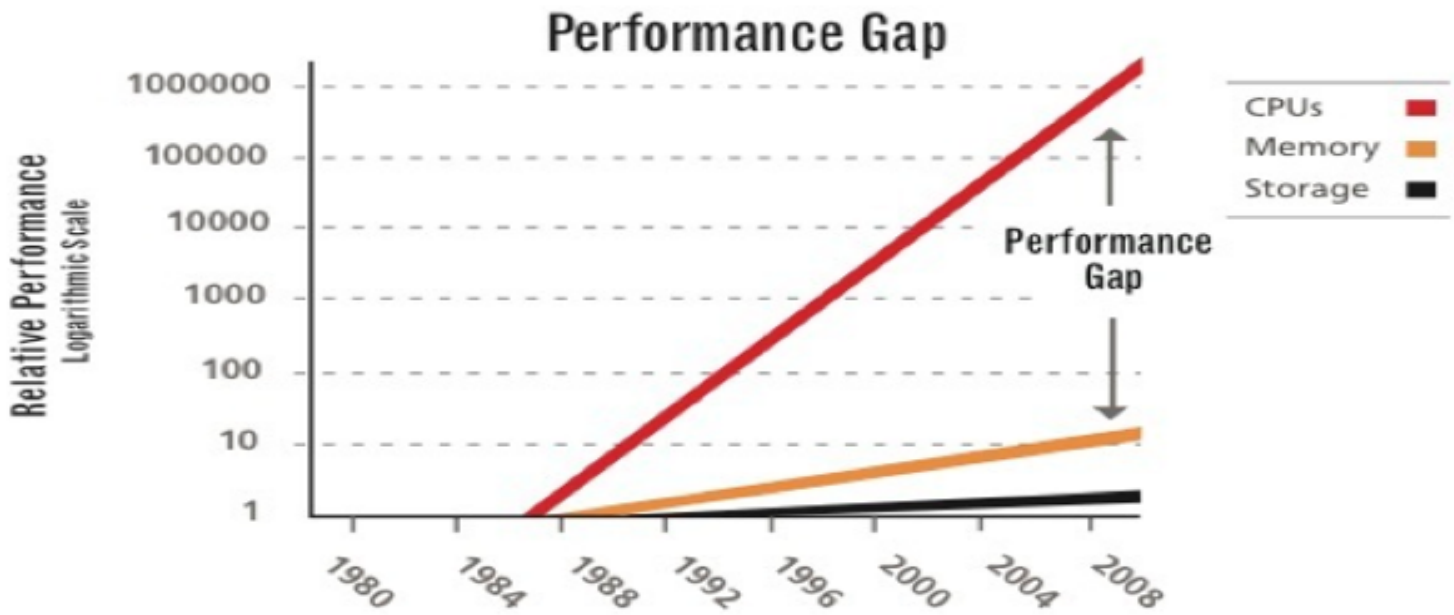
Context: Performance Gap Trend



Context: Exponential for Decades

- Abundance of
  - computing & storage
  - generated data (estimated 8ZB in ’15)
  - things
- More data provides greater value
- Traditional data doesn’t scale well
- It’s time for a new approach!

New Hardware Approach

Traditional

- Exotic HW
  - big central servers
  - SAN
  - RAID
- Hardware reliability
- Limited scalability
- Expensive

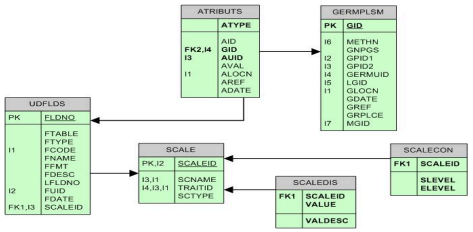
Big Data

- Commodity HW
  - racks of pizza boxes
  - Ethernet
  - JBOD
- Unreliable HW
- Scales further
- Cost effective

New Software Approach

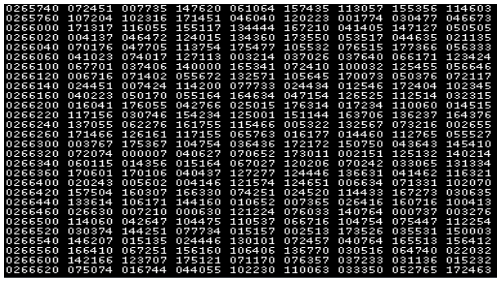
Traditional

- Monolotic
  - Centralized
  - RDBMS
- Schema first
- Proprietary



Big Data

- Distributed
  - storage & compute nodes
- Raw data
- Open source



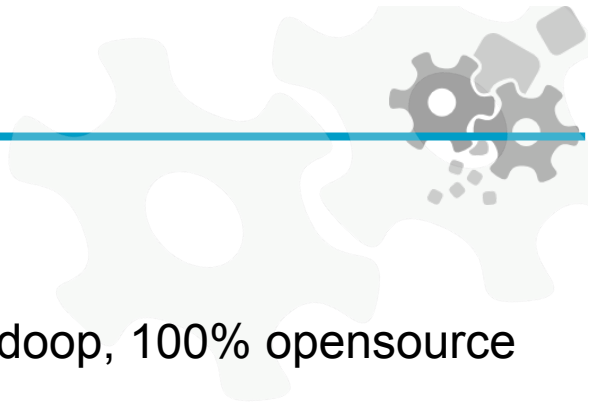
Hadoop

- De facto big data industry standard (batch)
- Vendor adoption
  - IBM, Microsoft, Oracle, EMC, ...
- A collection of projects at Apache
  - HDFS, MapReduce, Hive, Pig, Hbase, Flume, Oozie, ...
- Main components
  - HDFS
  - MapReduce
- Cluster
  - Set of machines running HDFS and MapReduce

Distributions

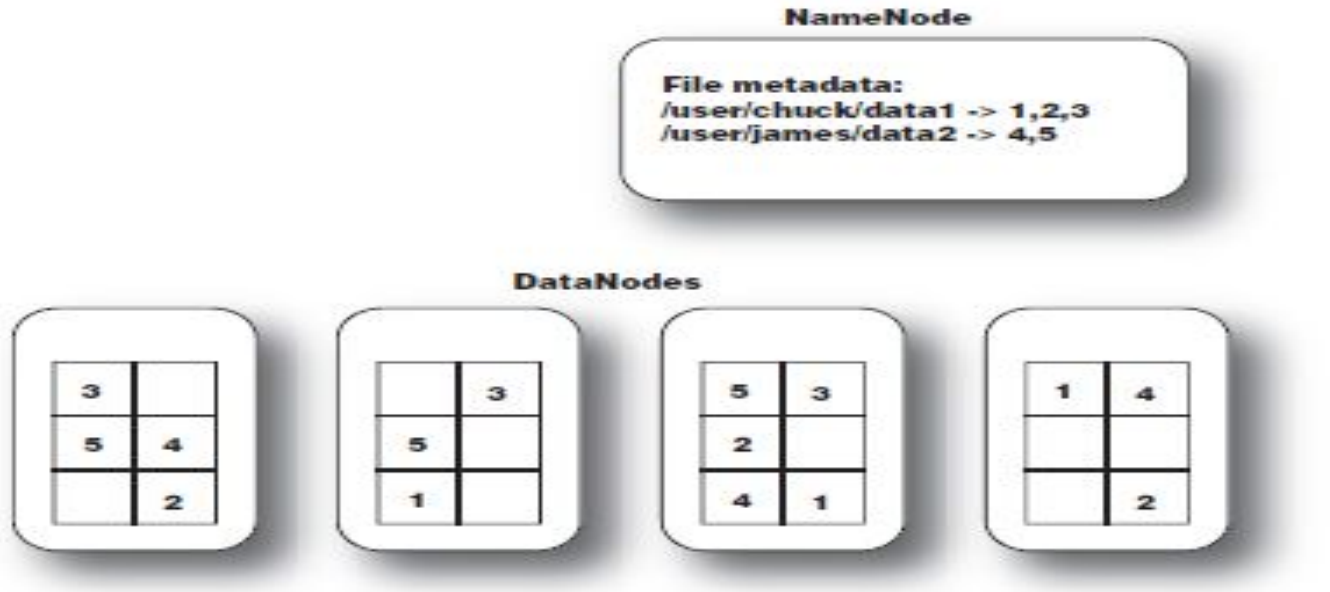
- Cloudera
  - www.cloudera.com
  - Cloudera Enterprise subscription
  - Currently CDH3
    - Linux package
    - Virtual machine
    - Cloud
  - Stack
    - hadoop, hbase, hive, pig, mahout, flume, ...
  - Cloudera SCM
  - Connectors for Teradata, Netezza, Microstrategy and Quest

Distributions



- Hortonworks
  - www.hortonworks.com
  - Hortonworks Data Platform Powered by Apache Hadoop, 100% opensource solution
- IBM
  - Offers a derivative version of Apache Hadoop that IBM supports on IBM JVMs on a number of platforms
- Microsoft
  - Hadoop on Azure & Hadoop on Premise
- Apache Hadoop
  - Distribution for individual components only

HDFS


NameNode
File metadata:
/user/chuck/data1 -> 1,2,3
/user/james/data2 -> 4,5
DataNodes
3
5
4
2
3
5
1
5
3
2
4
1
1
4
2

Access to HDFS

- The HDFS java client api's can be used
- Typically files are moved from local filesystem into HDFS
- Using hadoop fs commands
- Through Hue (Cloudera SCM)
- Fuse
- HDFS DAV

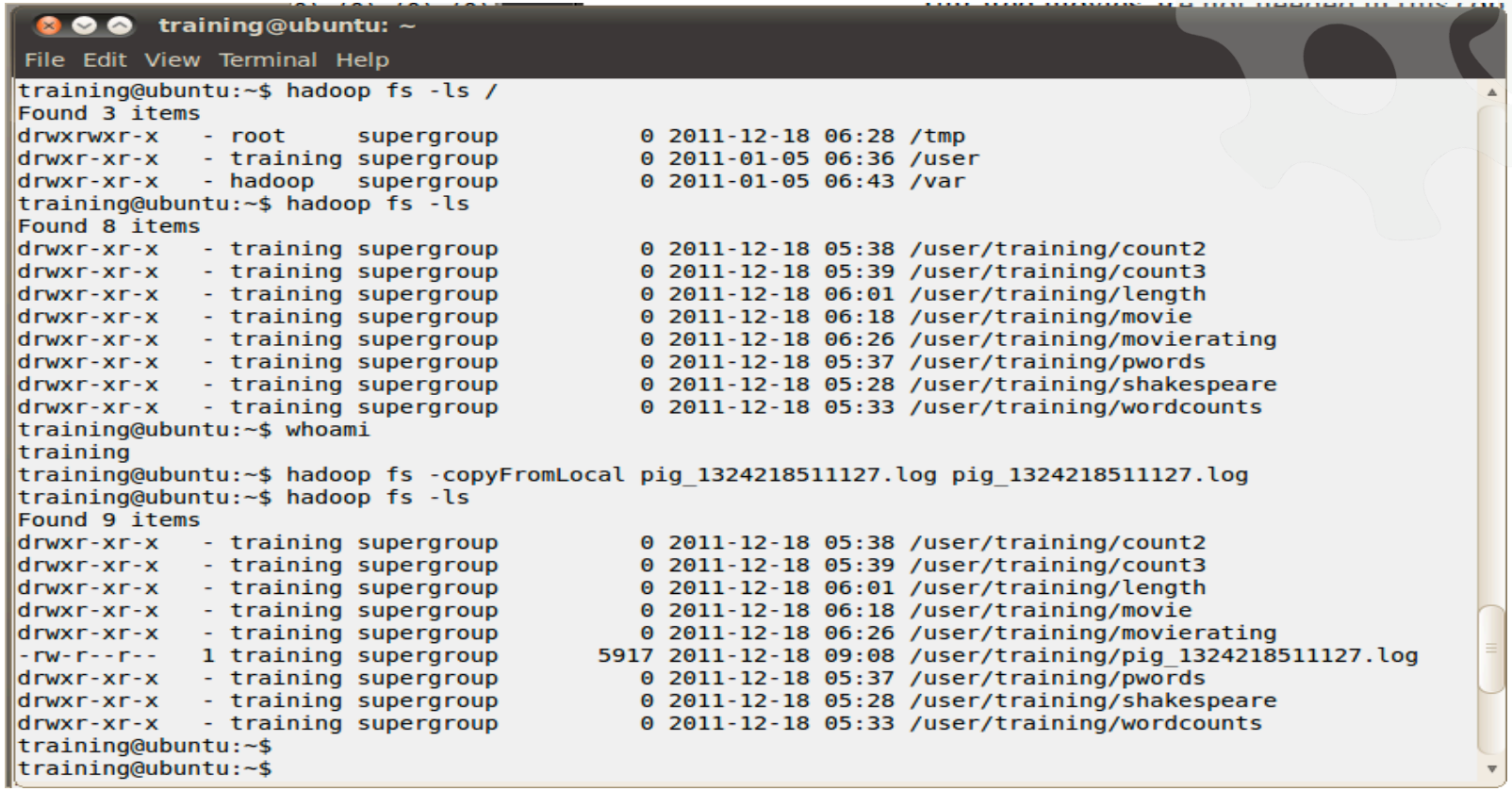
hadoop fs examples

- Get directory listing of user home directory in hdfs
  - hadoop fs -ls
- Get directory listing of root directory
  - hadoop fs -ls /
- Copy a local file to hdfs (user home directory)
  - hadoop fs -copyFromLocal foo.txt foo.txt
- Move a file from hdfs to local disk
  - hadoop fs -copyToLocal /user/geert/foo.txt foo.txt
- Display the contents of a file
  - hadoop fs -cat /data/as400/customers.txt
- Make a new directory (user home directory)
  - hadoop fs -mkdir output

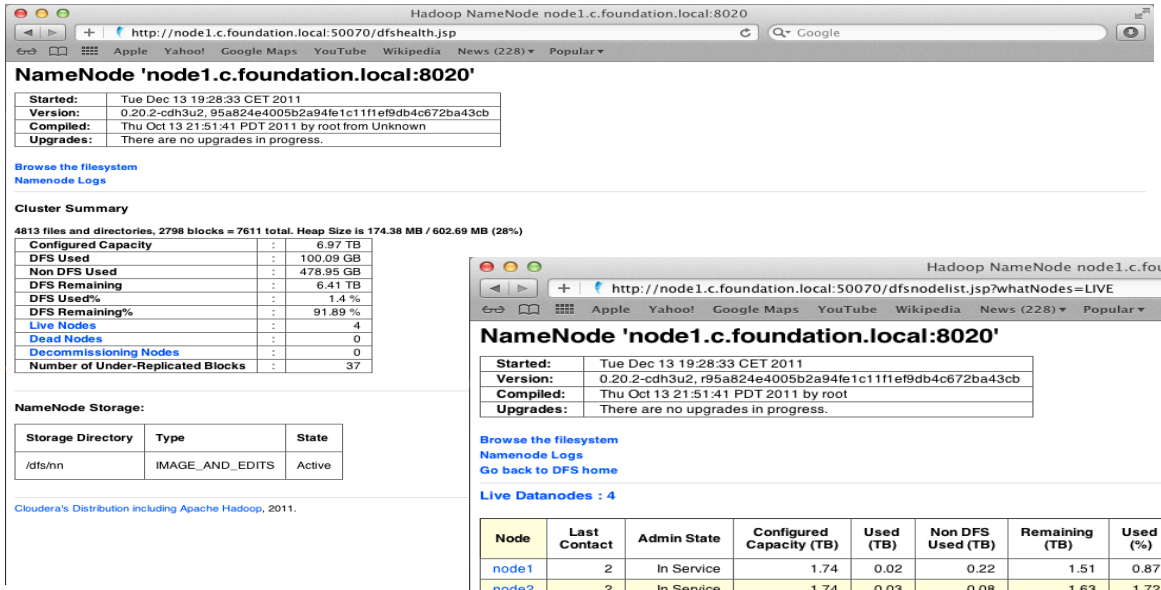
hadoop fs examples

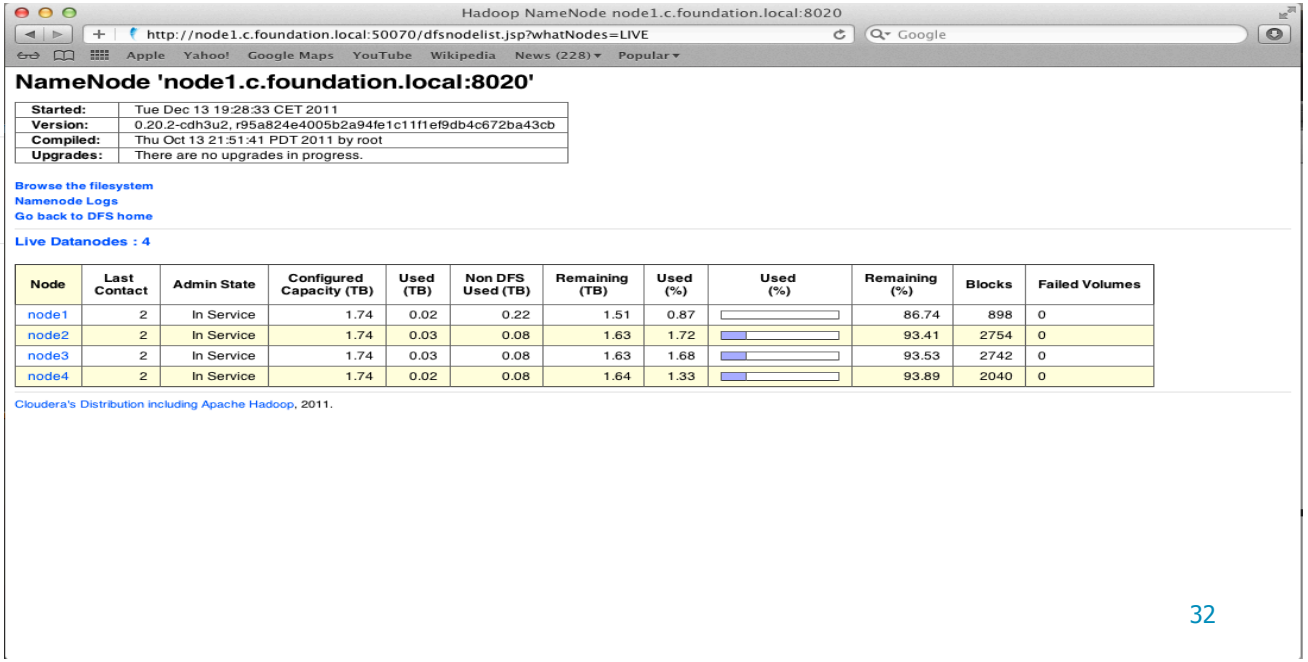
- Remove a directory
  - hadoop fs -rm /business/data
- Remove a directory and all its content (recursive)
  - hadoop fs -rmr /business/data
- More information about hadoop fs command options
  - http://hadoop.apache.org/common/docs/r0.20.2/hdfs_shell.html

hadoop fs examples



Hadoop Namenode webpage





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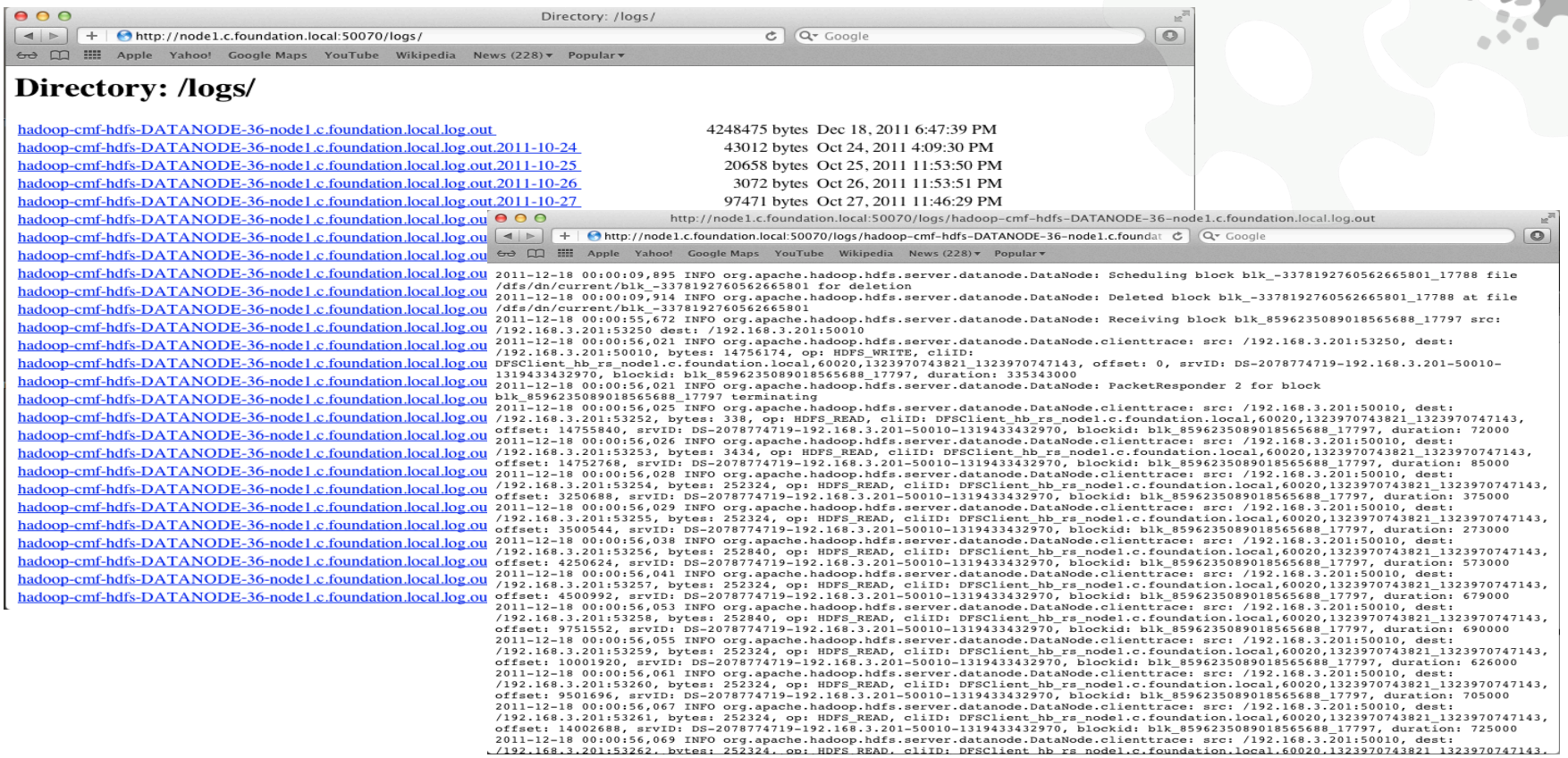
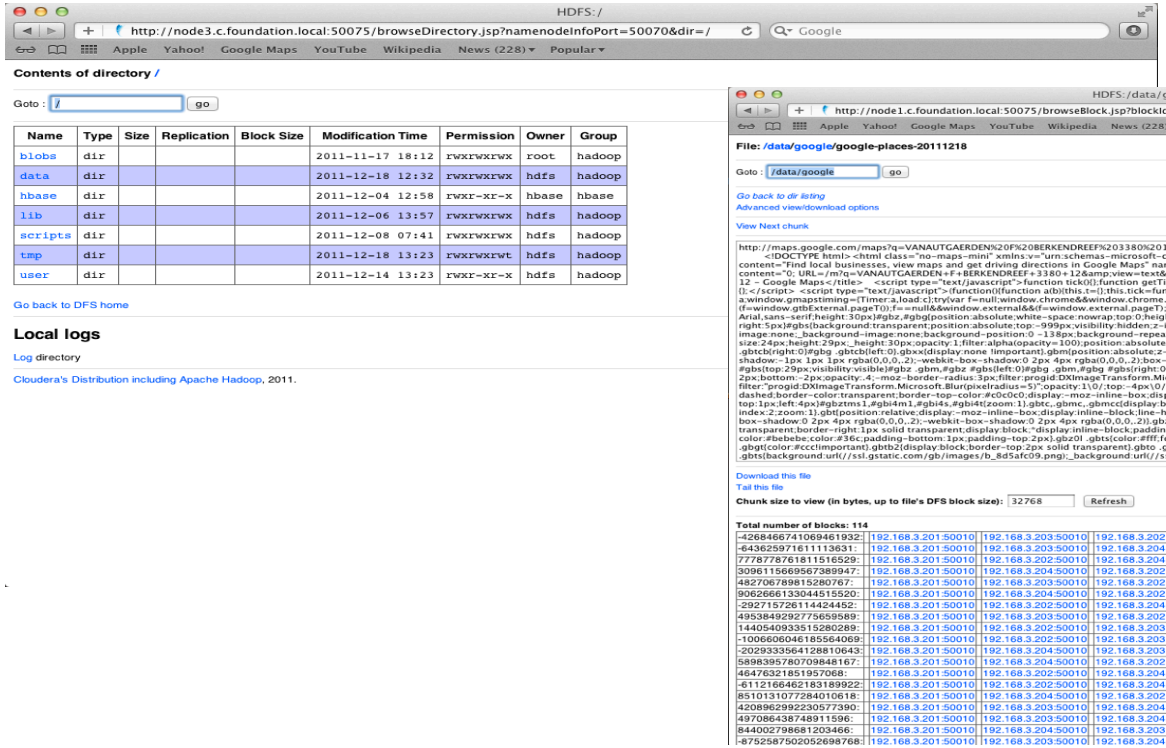
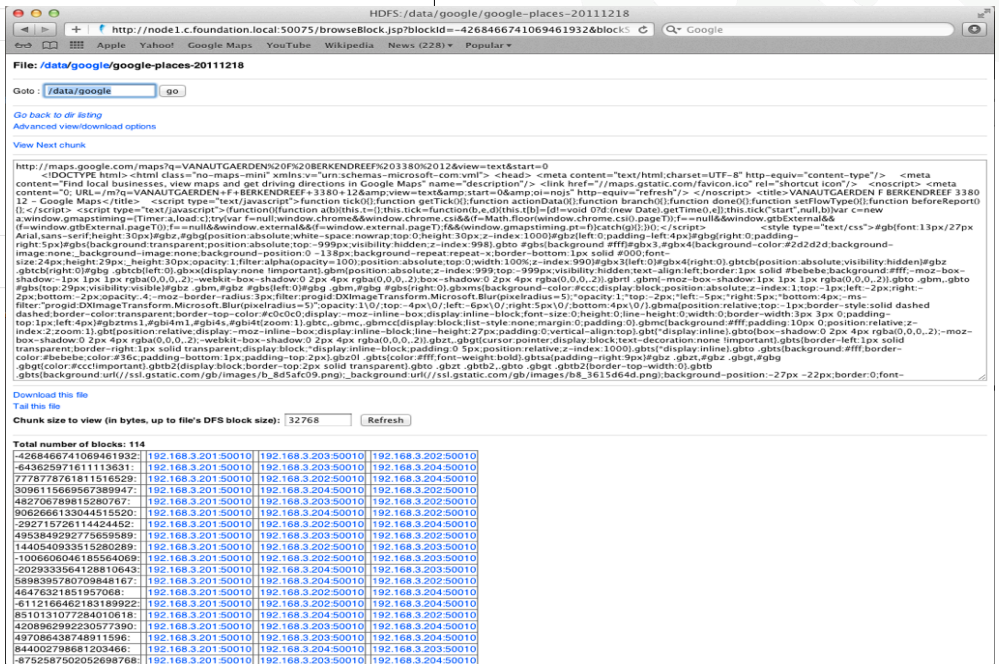
Hadoop Namenode webpage



Hadoop Namenode webpage





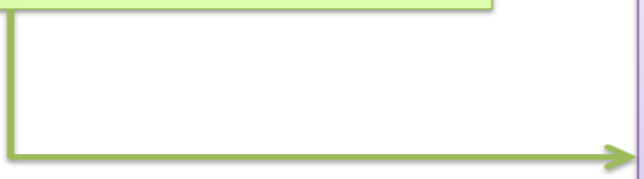
MapReduce

- MapReduce is the system used to process data in the Hadoop cluster
- Consists of two phases
  - Map & Reduce
  - Between the two is a stage known as the shuffle and sort
- Data Locality
  - Each Map task operates on a discrete portion of the overall dataset
  - Typically one HDFS block of data
- After all Maps are complete, the MapReduce system distributes the intermediate data to nodes which perform the Reduce phase

MapReduce

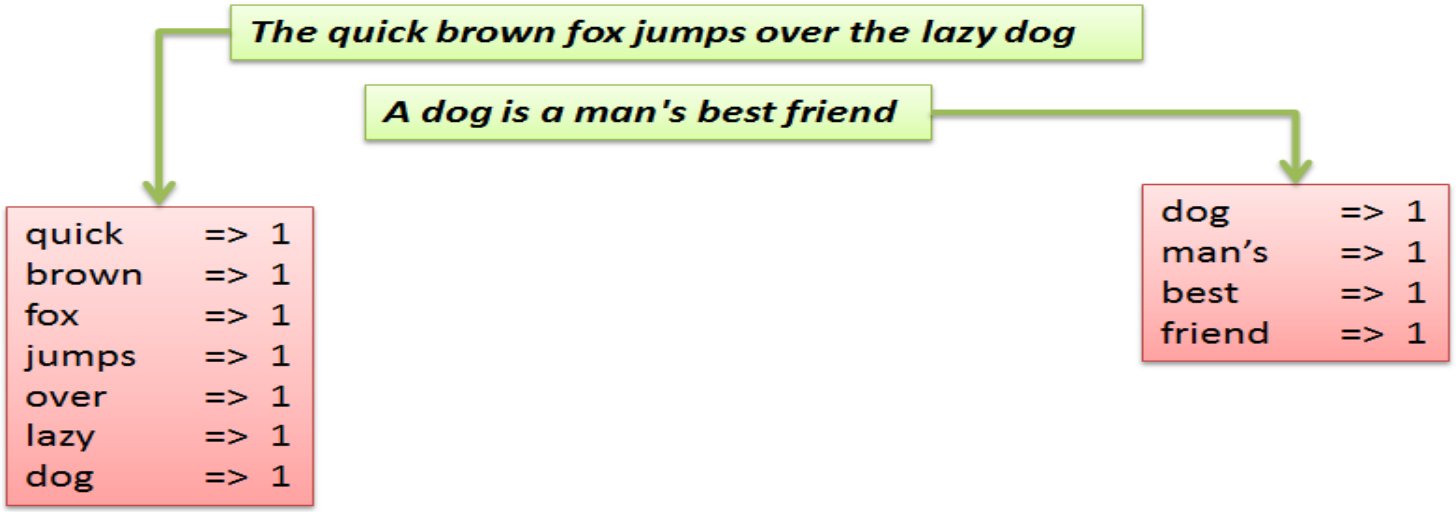
Count the number of words in the following paragraph.
Make sure you do not count “Stop Words” (the, a, is)

The quick brown fox jumps over the lazy dog
A dog is a man's best friend

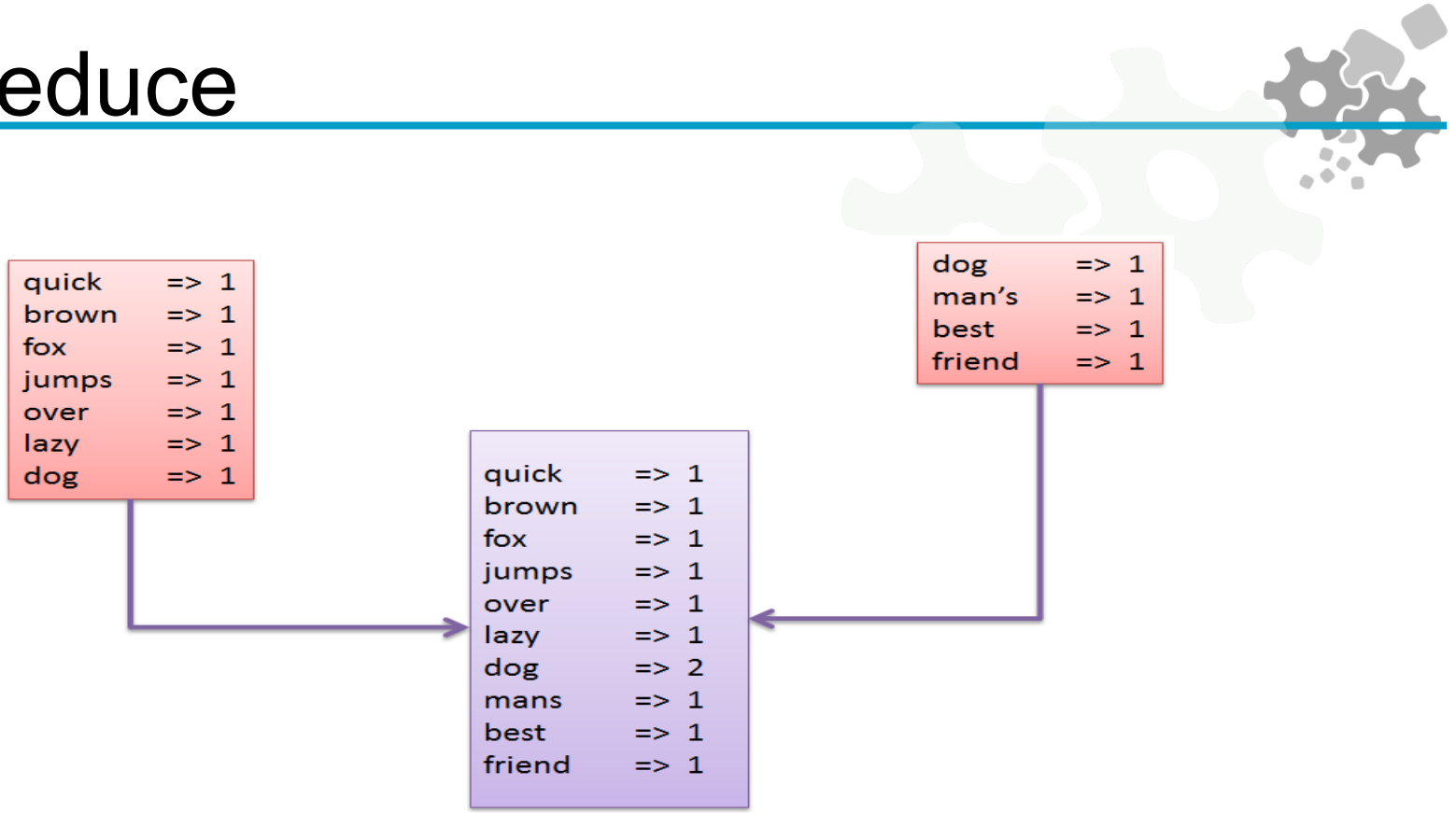


```
quick    => 1
brown    => 1
fox      => 1
jumps    => 1
over     => 1
lazy     => 1
dog      => 2
mans     => 1
best     => 1
friend   => 1
```

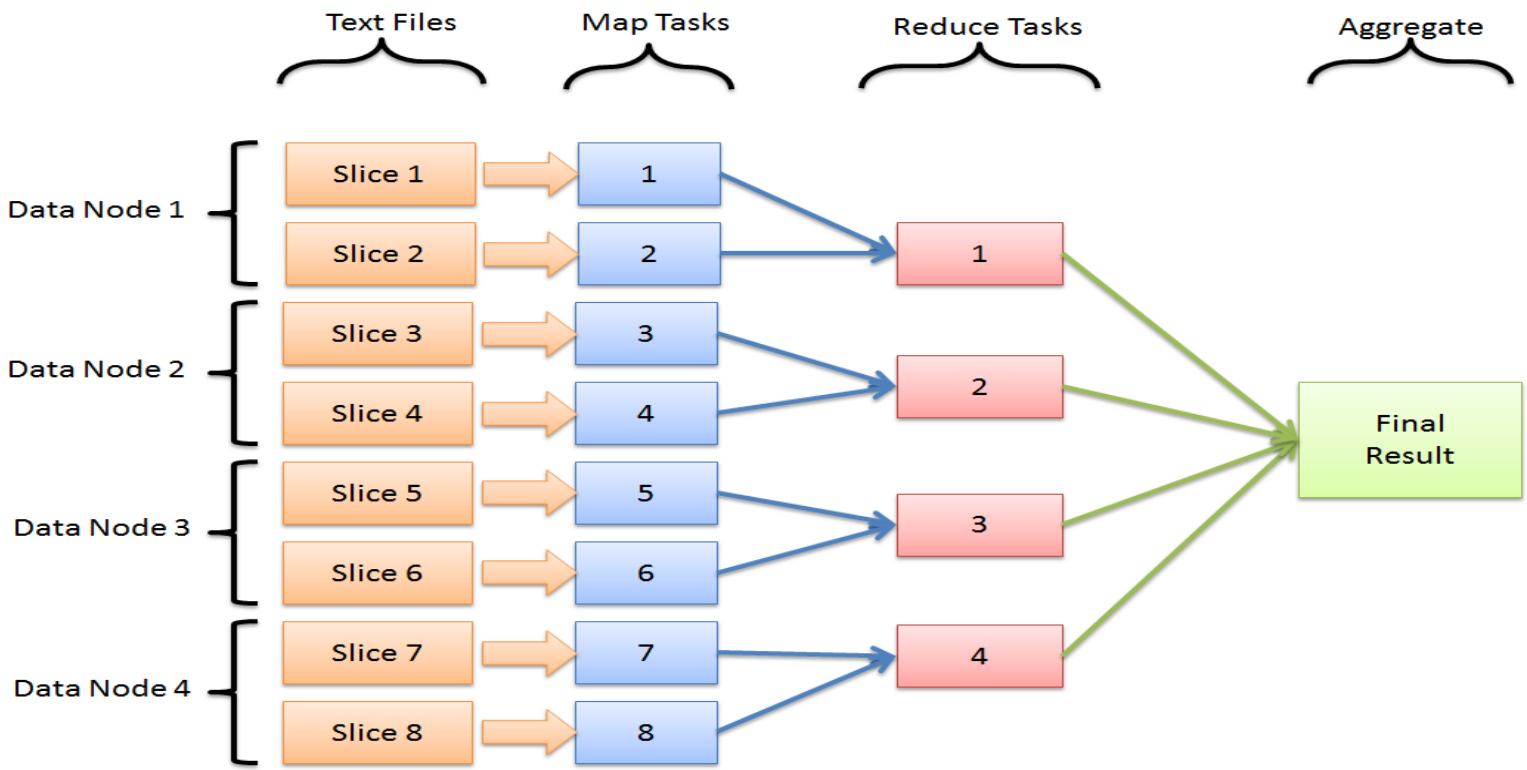
MapReduce


The quick brown fox jumps over the lazy dog
A dog is a man's best friend
quick => 1
brown => 1
fox => 1
jumps => 1
over => 1
lazy => 1
dog => 1
dog => 1
man's => 1
best => 1
friend => 1

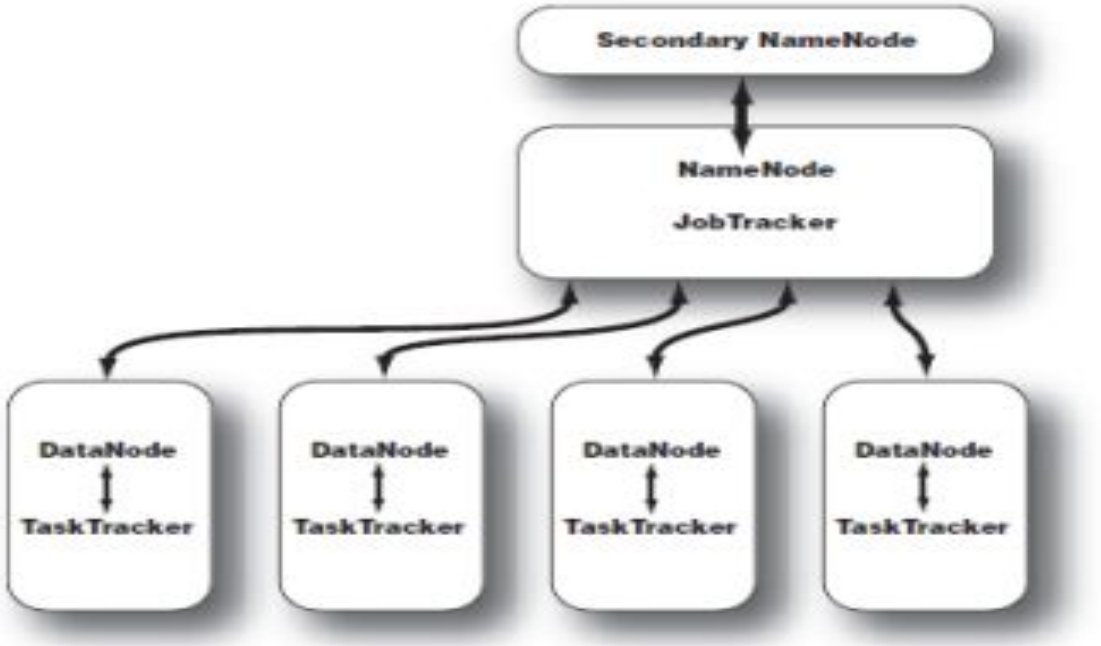
MapReduce


quick => 1
brown => 1
fox => 1
jumps => 1
over => 1
lazy => 1
dog => 1
dog => 1
man's => 1
best => 1
friend => 1
quick => 1
brown => 1
fox => 1
jumps => 1
over => 1
lazy => 1
dog => 2
mans => 1
best => 1
friend => 1

MapReduce


Text Files
Map Tasks
Reduce Tasks
Aggregate
Data Node 1
Data Node 2
Data Node 3
Data Node 4
Slice 1
Slice 2
Slice 3
Slice 4
Slice 5
Slice 6
Slice 7
Slice 8
1
2
3
4
5
6
7
8
1
2
3
4
Final Result

Hadoop Architecture



MapReduce In Action

- Calculate average word length per first letter of word
  - AverageWordLength.java: launches job
  - LetterMapper.java: mapper per first letter
  - AverageReducer.java: calculates average length

AverageWordLength

```java
import org.apache.hadoop.fs.Path;
import org.apache.hadoop.io.FloatWritable;
import org.apache.hadoop.io.IntWritable;
import org.apache.hadoop.io.Text;
import org.apache.hadoop.mapred.FileInputFormat;
import org.apache.hadoop.mapred.FileOutputFormat;
import org.apache.hadoop.mapred.JobClient;
import org.apache.hadoop.mapred.JobConf;

import org.apache.hadoop.conf.Configured;
import org.apache.hadoop.util.Tool;
import org.apache.hadoop.util.ToolRunner;

public class AverageWordLength extends Configured implements Tool {

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

                if (args.length != 2) {
                        System.out.printf("Usage: %s [generic options] <indir> <outdir>\n",
                                        getClass().getSimpleName());
                        ToolRunner.printGenericCommandUsage(System.out);
                        System.exit(-1);
                }

                JobConf conf = new JobConf(getConf(), AverageWordLength.class);
                conf.setJobName("AverageWordLength");

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

                conf.setMapperClass(LetterMapper.class);
                conf.setReducerClass(AverageReducer.class);

                conf.setMapOutputKeyClass(Text.class);
                conf.setMapOutputValueClass(IntWritable.class);

                conf.setOutputKeyClass(Text.class);
                conf.setOutputValueClass(FloatWritable.class);

                JobClient.runJob(conf);
                return 0;
        }

        public static void main(String[] args) throws Exception {
                int exitCode = ToolRunner.run(new AverageWordLength(), args);
                System.exit(exitCode);
        }
}
```

LetterMapper

```
import java.io.IOException;
import java.util.StringTokenizer;

import org.apache.hadoop.io.IntWritable;
import org.apache.hadoop.io.Text;
import org.apache.hadoop.mapred.Mapper;
import org.apache.hadoop.mapred.MapReduceBase;
import org.apache.hadoop.mapred.OutputCollector;
import org.apache.hadoop.mapred.Reporter;

public class LetterMapper extends MapReduceBase
                implements Mapper<Object, Text, Text, IntWritable> {

        private Text letter = new Text();
        private IntWritable wordLength = new IntWritable(1);

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

                // Break line into words for processing
                StringTokenizer wordList =
                        new StringTokenizer(value.toString());

                while (wordList.hasMoreTokens()) {
                        String word = wordList.nextToken();
                        letter.set(word.substring(0, 1));
                        wordLength.set(word.length());
                        output.collect(letter, wordLength);
                }
        }
}
```

AverageReducer

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

import org.apache.hadoop.io.FloatWritable;
import org.apache.hadoop.io.IntWritable;
import org.apache.hadoop.io.Text;
import org.apache.hadoop.mapred.OutputCollector;
import org.apache.hadoop.mapred.MapReduceBase;
import org.apache.hadoop.mapred.Reducer;
import org.apache.hadoop.mapred.Reporter;

public class AverageReducer extends MapReduceBase
                implements Reducer<Text, IntWritable, Text, FloatWritable> {

        private FloatWritable avg = new FloatWritable();

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

                int wordCount = 0;
                int letterCount = 0;
                while (values.hasNext()) {
                        wordCount++;
                        letterCount += values.next().get();
                }

                avg.set((float) letterCount / wordCount);
                output.collect(key, avg);
        }
}
```

MapReduce In Action

```
training@ubuntu:~/git/exercises/averagewordlength/java$ ls
AverageReducer.class  AverageReducer.java  AverageWordLength.class  AverageWordLength.java  LetterMapper.class  LetterMapper.java  wl.jar
training@ubuntu:~/git/exercises/averagewordlength/java$ hadoop jar wl.jar AverageWordLength shakespeare report
11/12/18 13:26:54 INFO mapred.FileInputFormat: Total input paths to process : 4
11/12/18 13:26:54 INFO mapred.JobClient: Running job: job_201112180521_0013
11/12/18 13:26:55 INFO mapred.JobClient:  map 0% reduce 0%
11/12/18 13:27:05 INFO mapred.JobClient:  map 50% reduce 0%
11/12/18 13:27:08 INFO mapred.JobClient:  map 100% reduce 0%
11/12/18 13:27:17 INFO mapred.JobClient:  map 100% reduce 100%
11/12/18 13:27:19 INFO mapred.JobClient: Job complete: job_201112180521_0013
11/12/18 13:27:19 INFO mapred.JobClient: Counters: 18
11/12/18 13:27:19 INFO mapred.JobClient:   Job Counters
11/12/18 13:27:19 INFO mapred.JobClient:     Launched reduce tasks=1
11/12/18 13:27:19 INFO mapred.JobClient:     Launched map tasks=4
11/12/18 13:27:19 INFO mapred.JobClient:     Data-local map tasks=4
11/12/18 13:27:19 INFO mapred.JobClient:   FileSystemCounters
11/12/18 13:27:19 INFO mapred.JobClient:     FILE_BYTES_READ=12543198
11/12/18 13:27:19 INFO mapred.JobClient:     HDFS_BYTES_READ=5284231
11/12/18 13:27:19 INFO mapred.JobClient:     FILE_BYTES_WRITTEN=20057238
11/12/18 13:27:19 INFO mapred.JobClient:     HDFS_BYTES_WRITTEN=728
11/12/18 13:27:19 INFO mapred.JobClient:   Map-Reduce Framework
11/12/18 13:27:19 INFO mapred.JobClient:     Reduce input groups=69
11/12/18 13:27:19 INFO mapred.JobClient:     Combine output records=0
11/12/18 13:27:19 INFO mapred.JobClient:     Map input records=173126
11/12/18 13:27:19 INFO mapred.JobClient:     Reduce shuffle bytes=7513912
11/12/18 13:27:19 INFO mapred.JobClient:     Reduce output records=69
11/12/18 13:27:19 INFO mapred.JobClient:     Spilled Records=2507132
11/12/18 13:27:19 INFO mapred.JobClient:     Map output bytes=5635416
11/12/18 13:27:19 INFO mapred.JobClient:     Map input bytes=5284231
11/12/18 13:27:19 INFO mapred.JobClient:     Combine input records=0
11/12/18 13:27:19 INFO mapred.JobClient:     Map output records=939236
11/12/18 13:27:19 INFO mapred.JobClient:     Reduce input records=939236
training@ubuntu:~/git/exercises/averagewordlength/java$ hadoop fs -cat report/part-00000 | head -5
&       3.0422535
'       4.9115677
(       8.342302
-       8.333333
.       1.0
training@ubuntu:~/git/exercises/averagewordlength/java$
```

JobTracker page

localhost Hadoop Map/Reduce Administration

Quick Links

State: RUNNING
Started: Sun Dec 18 05:21:40 PST 2011
Version: 0.20.2+320, r9b72d268a0b590b4fd7d13aca17c1c453f8bc957
Compiled: Mon Jun 28 23:17:49 UTC 2010 by root
Identifier: 201112180521

Cluster Summary (Heap Size is 15.19 MB/966.69 MB)

Maps	Reduces	Total Submissions	Nodes	Map Task Capacity	Reduce Task Capacity	Avg. Tasks/Node	Blacklisted Nodes
0	0	12	1	2	2	4.00	0

Scheduling Information

Queue Name	Scheduling Information
default	N/A

Filter (Jobid, Priority, User, Name)
Example: 'user:smith 3200' will filter by 'smith' only in the user field and '3200' in all fields

Running Jobs

none

Completed Jobs

Jobid	Priority	User	Name	Map % Complete	Map Total	Maps Completed	Reduce % Complete	Reduce Total	Reduces Completed	Job Scheduling Information
job_201112180521_0001	NORMAL	training	WordCount	100.00%	4	4	100.00%	1	1	NA
job_201112180521_0002	NORMAL	training	WordCount	100.00%	2	2	100.00%	1	1	NA
job_201112180521_0003	NORMAL	training	WordCount	100.00%	2	2	100.00%	1	1	NA
job_201112180521_0004	NORMAL	training	WordCount	100.00%	2	2	100.00%	1	1	NA
job_201112180521_0005	NORMAL	training	AverageWordLength	100.00%	4	4	100.00%	1	1	NA
job_201112180521_0006	NORMAL	training	movie.jar	100.00%	5	5	100.00%	0	0	NA

JobTracker page

Hadoop job_201112180521_0001 on localhost

User: training
Job Name: WordCount
Job File: hdfs://localhost/var/lib/hadoop-0.20/cache/hadoop/mapred/system/job_201112180521_0001/job.xml
Job Setup: Successful
Status: Succeeded
Started at: Sun Dec 18 05:33:22 PST 2011
Finished at: Sun Dec 18 05:33:48 PST 2011
Finished in: 26sec
Job Cleanup: Successful

Kind	% Complete	Num Tasks	Pending	Running	Complete	Killed	Failed/Killed Task Attempts
map	100.00%	4	0	0	4	0	0 / 0
reduce	100.00%	1	0	0	1	0	0 / 0

	Counter	Map	Reduce	Total
Job Counters	Launched reduce tasks	0	0	1
	Launched map tasks	0	0	4
	Data-local map tasks	0	0	4
FileSystemCounters	FILE_BYTES_READ	7,200,180	10,768,592	17,968,772
	HDFS_BYTES_READ	5,284,231	0	5,284,231
	FILE_BYTES_WRITTEN	17,968,918	10,768,592	28,737,510
	HDFS_BYTES_WRITTEN	0	753,527	753,527
Map-Reduce Framework	Reduce input groups	0	70,139	70,139
	Combine output records	0	0	0
	Map input records	173,126	0	173,126
	Reduce shuffle bytes	0	10,768,610	10,768,610
	Reduce output records	0	70,139	70,139
	Spilled Records	1,567,896	939,236	2,507,132
	Map output bytes	8,890,114	0	8,890,114
	Map input bytes	5,284,231	0	5,284,231
	Map output records	939,236	0	939,236
	Combine input records	0	0	0
	Reduce input records	0	939,236	939,236

Hadoop map task list for job_201112180521_0001 on localhost

All Tasks

Task	Complete	Status	Start Time	Finish Time	Errors	Counters
task_201112180521_0001_m_000000	100.00%	hdfs://localhost/user/training/shakespeare/comedies:0+1784616	18-Dec-2011 05:33:27	18-Dec-2011 05:33:33 (6sec)		10
task_201112180521_0001_m_000001	100.00%	hdfs://localhost/user/training/shakespeare/tragedies:0+1752440	18-Dec-2011 05:33:27	18-Dec-2011 05:33:33 (6sec)		10
task_201112180521_0001_m_000002	100.00%	hdfs://localhost/user/training/shakespeare/histories:0+1479035	18-Dec-2011 05:33:33	18-Dec-2011 05:33:36 (3sec)		9
task_201112180521_0001_m_000003	100.00%	hdfs://localhost/user/training/shakespeare/poems:0+268140	18-Dec-2011 05:33:33	18-Dec-2011 05:33:36 (3sec)		9

Go back to JobTracker

Cloudera's Distribution for Hadoop, 2011.

datacrunchers

MapReduce

- Abstract Processing Model
  - Distributed sort merge engine
- Implementation
  - Programming
    - Java
    - Python
  - High-level tool using MapReduce Jobs
    - Hive
    - Pig
    - ...

Hive

- Framework for data warehousing on top of Hadoop
- Developed at Facebook for managing and learning from the huge volumes of data Facebook was generating
- Makes it possible for analysts with strong SQL skills to run queries
- Used by many organizations
- SQL is lingua franca in business intelligence tools
- SQL is limited so Hive is not fit for building complex machine learning algorithms
- Generates MR jobs when executing queries

Hive

```
CREATE EXTERNAL TABLE movie (id INT, name STRING, year INT) ROW FORMAT DELIMITED FIELDS TERMINATED BY '\t' LOCATION '/user/
    root/movie'

CREATE EXTERNAL TABLE movierating (userid INT, movieid INT, rating INT)
 ROW FORMAT DELIMITED FIELDS TERMINATED BY '\t'
 LOCATION '/user/cloudera/movierating'

SELECT * FROM movie

--Select oldest movie
SELECT *
FROM movie
WHERE year != 0
SORT BY year
LIMIT 1

--Select movies without rating
SELECT name, year
FROM movie LEFT OUTER JOIN movierating
ON movie.id = movierating.movieid
WHERE movieid IS NULL

--Update movies with numratings, avgrating
DROP TABLE newmovie
```

Hive

```
root@master ~ # hive
Hive history file=/tmp/root/hive_job_log_root_201108031010_1952745660.txt
hive> select * from movie limit 10;
OK
1       Toy Story       1995
2       Jumanji 1995
3       Grumpier Old Men        1995
4       Waiting to Exhale       1995
5       Father of the Bride Part II     1995
6       Heat    1995
7       Sabrina 1995
8       Tom and Huck    1995
9       Sudden Death    1995
10      GoldenEye       1995
Time taken: 0.067 seconds
hive>
```

Pig

- Abstraction layer for processing large data sets
- 2 Components
  - Pig Latin: the language used to express data flows
  - Grunt: the execution environment
- Pig Program
  - Composed of series of operations, or transformations
  - The operations describe a dataflow that is translated into one or more MapReduce jobs

Pig

```
-- max_temp.pig: Finds the maximum temperature by year
records =
        LOAD 'input/ncdc/micro-tab/sample.txt'
        AS (year:chararray, temperature:int, quality:int);

filtered_records =
        FILTER records
        BY temperature != 9999
        AND ( quality == 0 OR
              quality == 1 OR
              quality == 4 OR
              quality == 5 OR
              quality == 9);

grouped_records =
        GROUP filtered_records
        BY year;

max_temp =
        FOREACH grouped_records
        GENERATE group, MAX(filtered_records.temperature);
DUMP max_temp;
```