PARLab Parallel Boot Camp

Cloud Computing with MapReduce and Hadoop

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What is Cloud Computing?

- “Cloud” refers to large Internet services like Google, Yahoo, etc that run on 10,000’s of machines
- More recently, “cloud computing” refers to services by these companies that let external customers rent computing cycles on their clusters
  - Amazon EC2: virtual machines at 10¢/hour, billed hourly
  - Amazon S3: storage at 15¢/GB/month
- Attractive features:
  - Scale: up to 100’s of nodes
  - Fine-grained billing: pay only for what you use
  - Ease of use: sign up with credit card, get root access

What is MapReduce?

- Simple data-parallel programming model designed for scalability and fault-tolerance

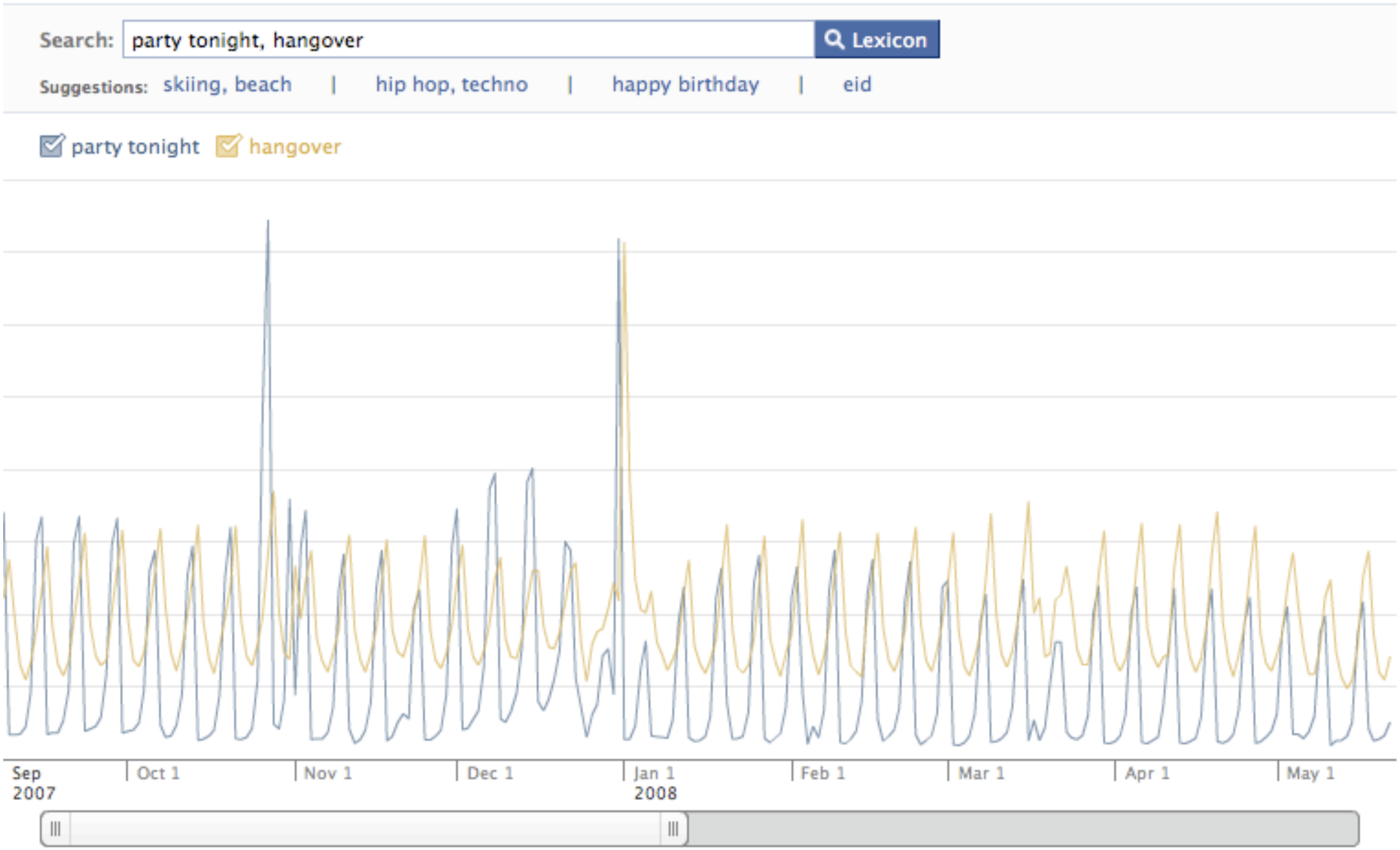
- Pioneered by Google
  - Processes 20 petabytes of data per day

- Popularized by open-source Hadoop project
  - Used at Yahoo!, Facebook, Amazon, …

What is MapReduce used for?

- At Google:
  - Index construction for Google Search
  - Article clustering for Google News
  - Statistical machine translation
- At Yahoo!:
  - “Web map” powering Yahoo! Search
  - Spam detection for Yahoo! Mail
- At Facebook:
  - Data mining
  - Ad optimization
  - Spam detection

Example: Facebook Lexicon

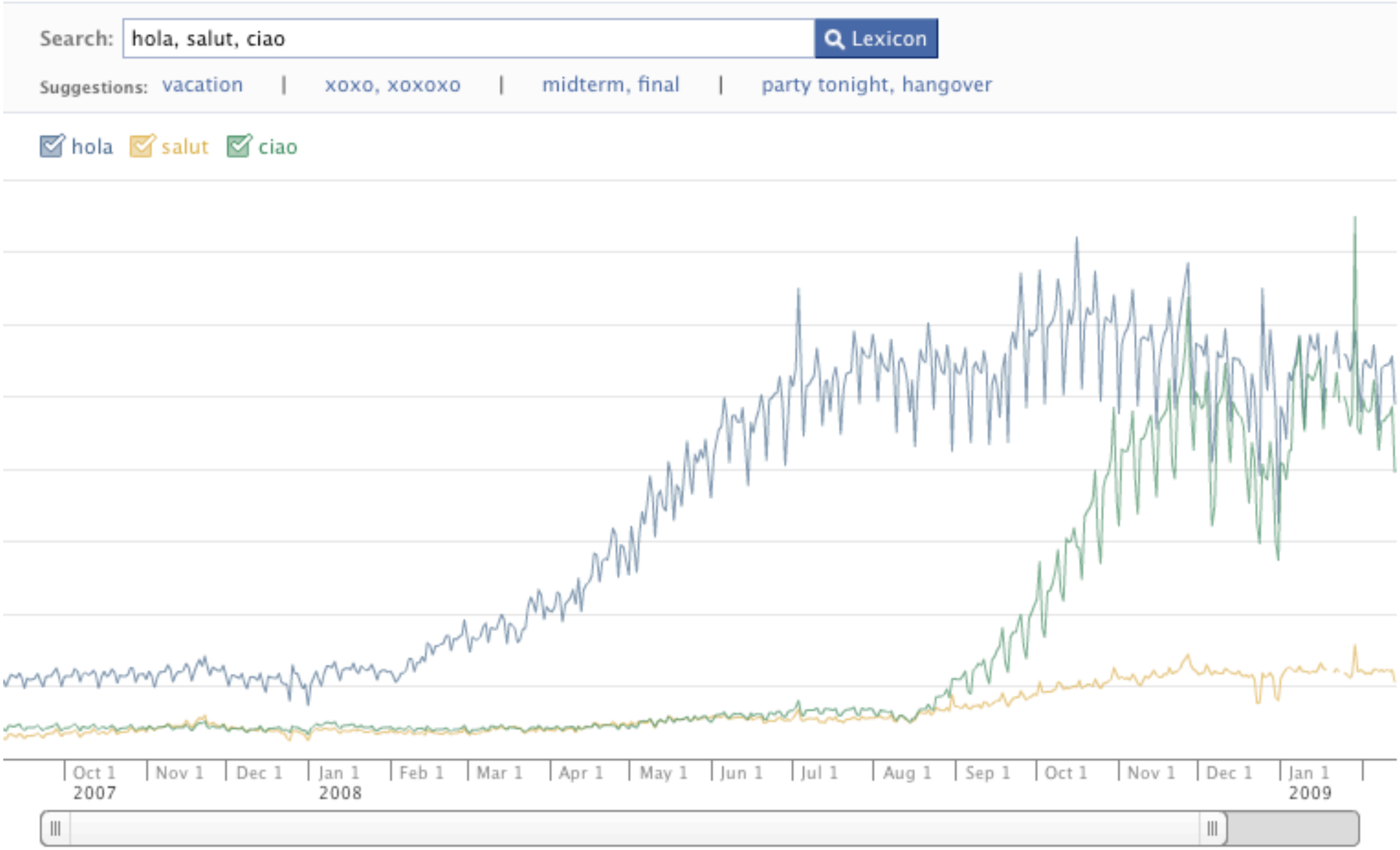


Search: party tonight, hangover

Lexicon
Suggestions: skiing, beach | hip hop, techno | happy birthday | eid
☑ party tonight ☑ hangover
Sep 2007
Oct 1
Nov 1
Dec 1
Jan 1 2008
Feb 1
Mar 1
Apr 1
May 1

www.facebook.com/lexicon

Example: Facebook Lexicon



Search: hola, salut, ciao

Suggestions: vacation | xoxo, xoxoxo | midterm, final | party tonight, hangover

www.facebook.com/lexicon

What is MapReduce used for?

- In research:
  - Astronomical image analysis (Washington)
  - Bioinformatics (Maryland)
  - Analyzing Wikipedia conflicts (PARC)
  - Natural language processing (CMU)
  - Particle physics (Nebraska)
  - Ocean climate simulation (Washington)
  - <Your application here>

Outline

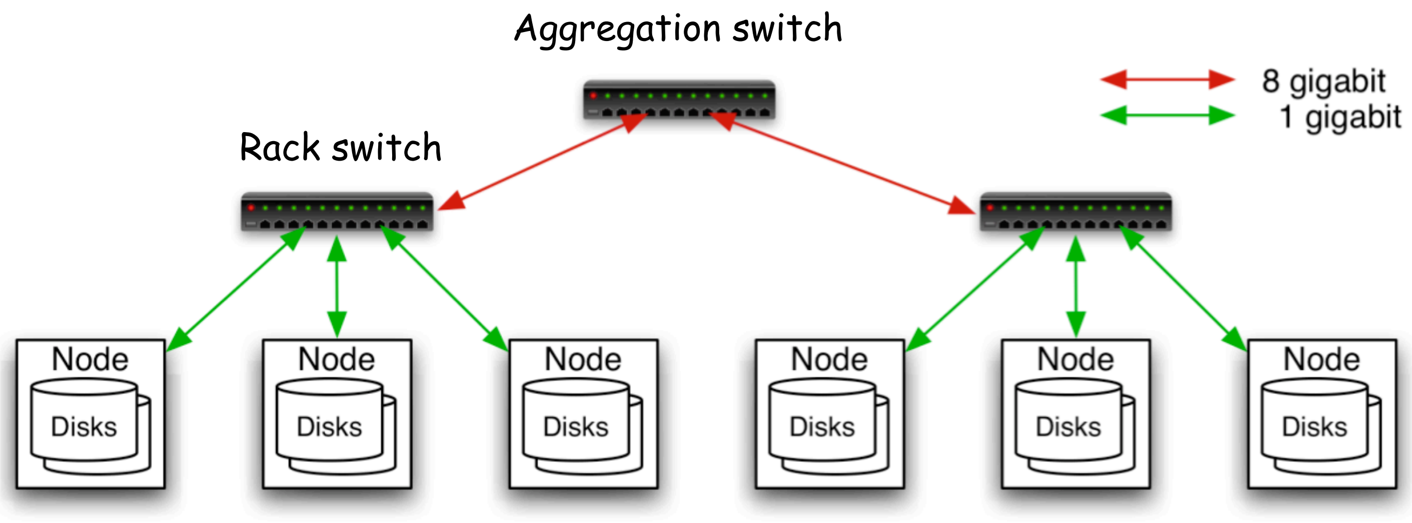
- MapReduce architecture
- Example applications
- Getting started with Hadoop
- Higher-level languages over Hadoop: Pig and Hive
- Amazon Elastic MapReduce

MapReduce Design Goals

1. **Scalability to large data volumes:**
   - 1000's of machines, 10,000's of disks

2. **Cost-efficiency:**
   - Commodity machines (cheap, but unreliable)
   - Commodity network
   - Automatic fault-tolerance (fewer administrators)
   - Easy to use (fewer programmers)

Typical Hadoop Cluster



- 40 nodes/rack, 1000-4000 nodes in cluster
- 1 Gbps bandwidth within rack, 8 Gbps out of rack
- Node specs (Yahoo terasort):
  8 x 2GHz cores, 8 GB RAM, 4 disks (= 4 TB?)

Image from http://wiki.apache.org/hadoop-data/attachments/HadoopPresentations/attachments/YahooHadoopIntro-apachecon-us-2008.pdf

Typical Hadoop Cluster

Image from http://wiki.apache.org/hadoop-data/attachments/HadoopPresentations/attachments/aw-apachecon-eu-2009.pdf

Challenges

1. **Cheap nodes fail, especially if you have many**
   - Mean time between failures for 1 node = 3 years
   - Mean time between failures for 1000 nodes = 1 day
   - <u>Solution:</u> Build fault-tolerance into system

2. **Commodity network = low bandwidth**
   - <u>Solution:</u> Push computation to the data

3. **Programming distributed systems is hard**
   - <u>Solution:</u> Data-parallel programming model: users write "map" & "reduce" functions, system distributes work and handles faults

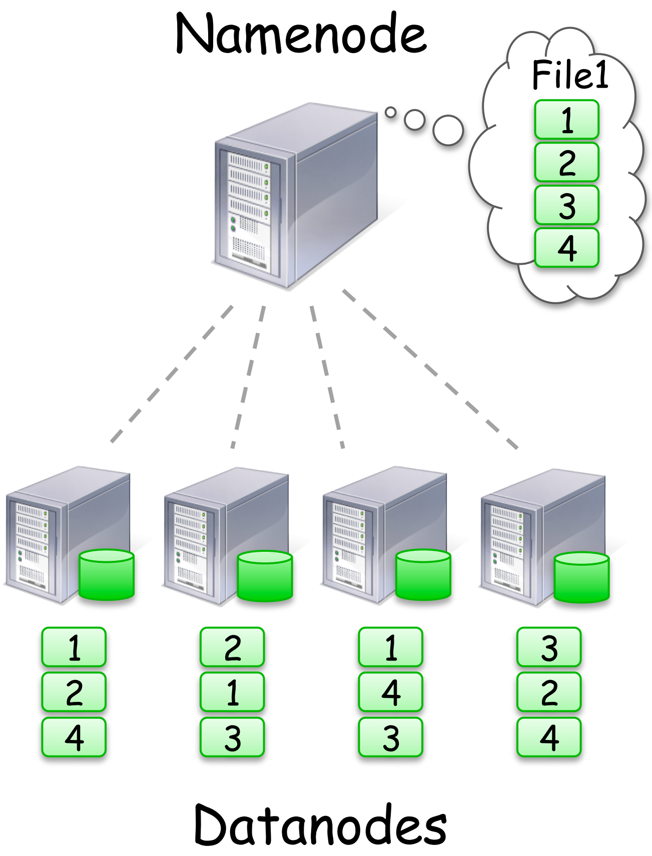
Hadoop Components

- **Distributed file system (HDFS)**
  - Single namespace for entire cluster
  - Replicates data 3x for fault-tolerance

- **MapReduce framework**
  - Executes user jobs specified as “map” and “reduce” functions
  - Manages work distribution & fault-tolerance

Hadoop Distributed File System

- Files split into 128MB *blocks*
- Blocks replicated across several *datanodes* (usually 3)
- Single *namenode* stores metadata (file names, block locations, etc)
- Optimized for large files, sequential reads
- Files are append-only



MapReduce Programming Model

- Data type: key-value *records*

- Map function:

$$(K_{in}, V_{in}) \rightarrow \text{list}(K_{inter}, V_{inter})$$

- Reduce function:

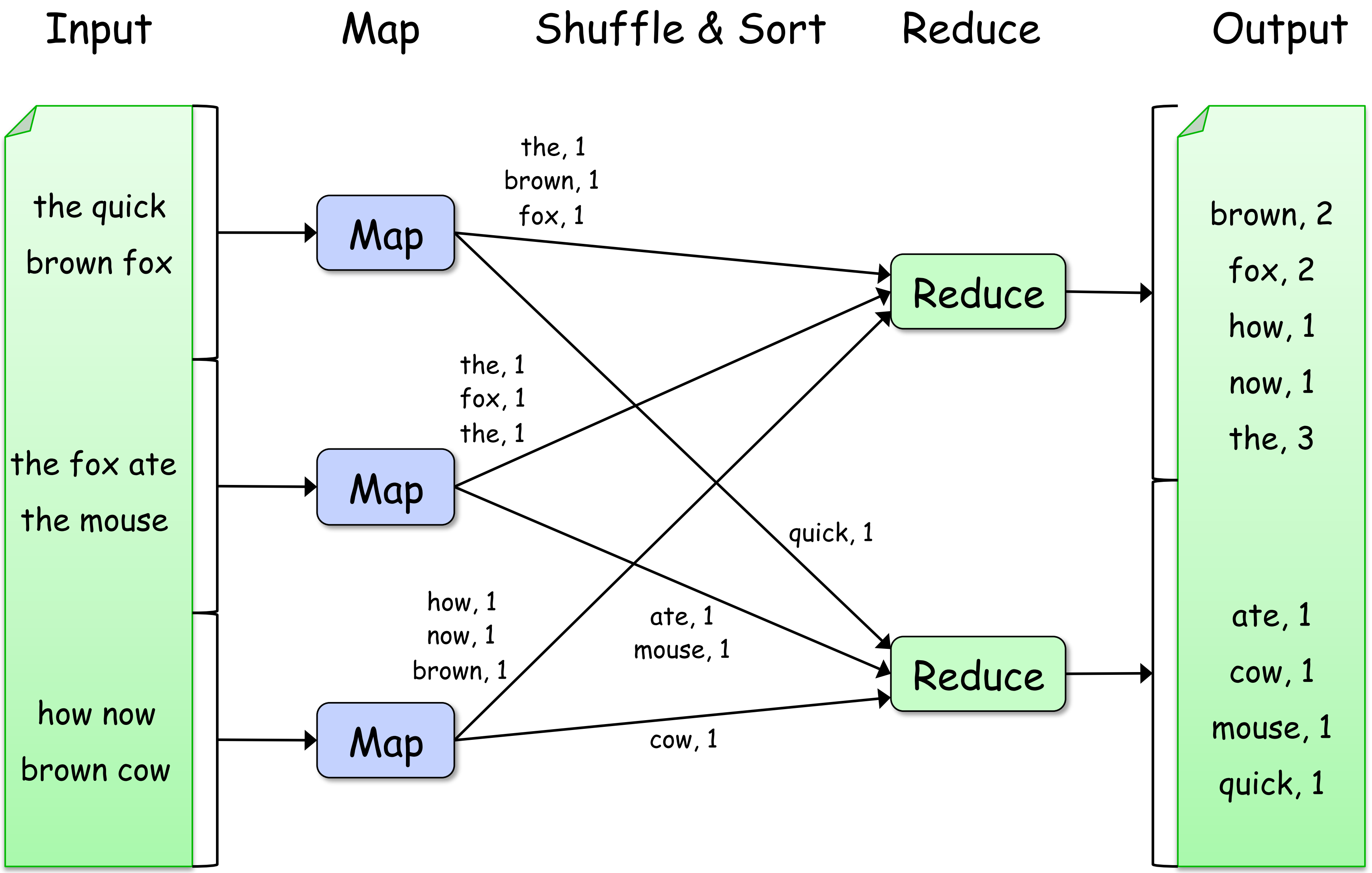
$$(K_{inter}, \text{list}(V_{inter})) \rightarrow \text{list}(K_{out}, V_{out})$$

Example: Word Count

```
def mapper(line):
    foreach word in line.split():
        output(word, 1)

def reducer(key, values):
    output(key, sum(values))
```

Word Count Execution



MapReduce Execution Details

- Single *master* controls job execution on multiple *slaves*

- Mappers preferentially placed on same node or same rack as their input block
  - Minimizes network usage

- Mappers save outputs to local disk before serving them to reducers
  - Allows recovery if a reducer crashes
  - Allows having more reducers than nodes

An Optimization: The Combiner

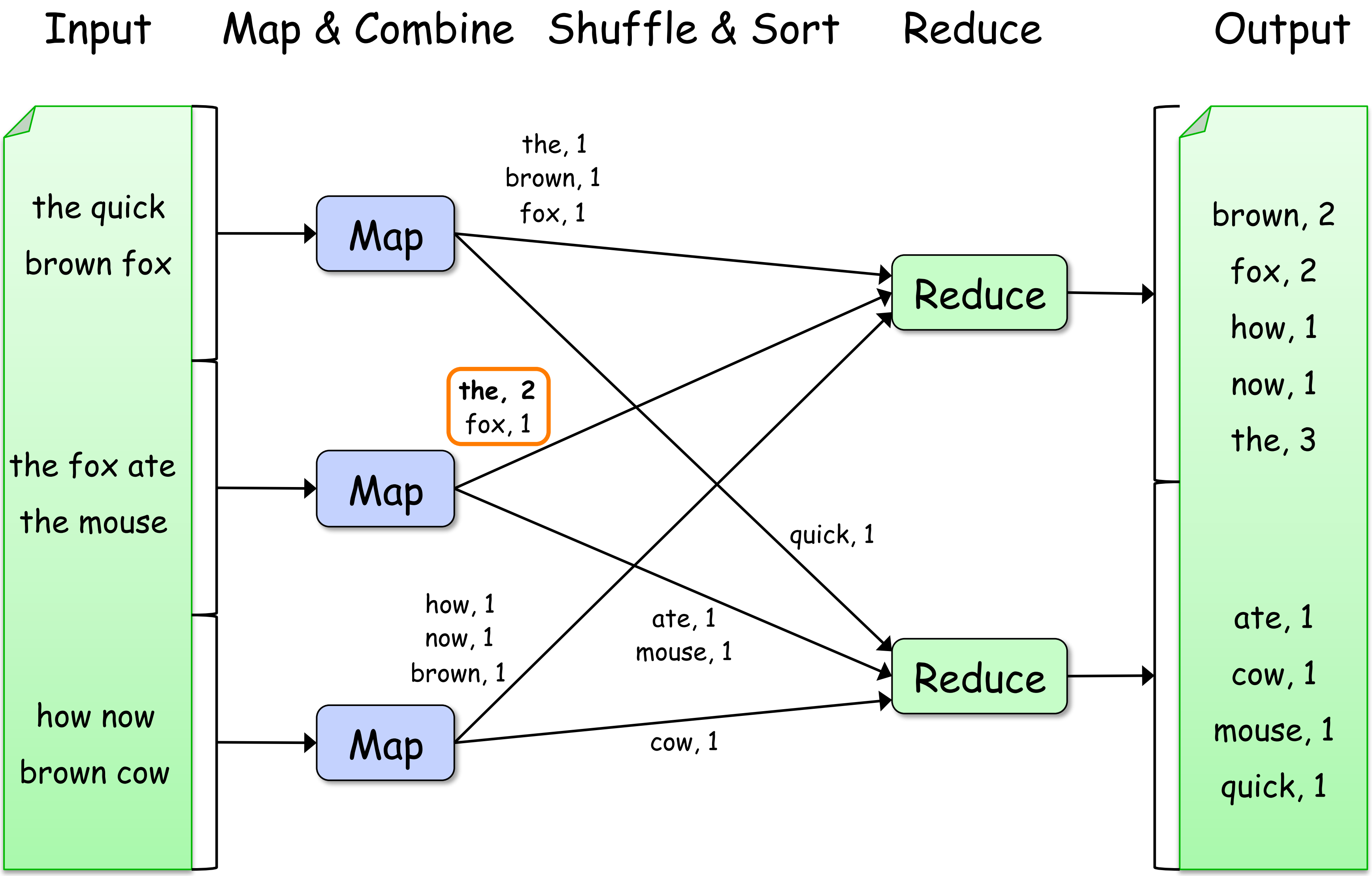
- A combiner is a local aggregation function for repeated keys produced by same map
- Works for associative functions like sum, count, max

- Decreases size of intermediate data

- Example: map-side aggregation for Word Count:

```
def combiner(key, values):
    output(key, sum(values))
```

Word Count with Combiner



Input

Map & Combine

Shuffle & Sort

Reduce

Output

the quick brown fox

the fox ate the mouse

how now brown cow

Map

Map

Map

the, 1
brown, 1
fox, 1

the, 2
fox, 1

how, 1
now, 1
brown, 1

quick, 1

ate, 1
mouse, 1

cow, 1

Reduce

Reduce

brown, 2
fox, 2
how, 1
now, 1
the, 3

ate, 1
cow, 1
mouse, 1
quick, 1

Fault Tolerance in MapReduce

1. If a task crashes:
   - Retry on another node
     - » OK for a map because it has no dependencies
     - » OK for reduce because map outputs are on disk
   - If the same task fails repeatedly, fail the job or ignore that input block (user-controlled)

- ➢ Note: For these fault tolerance features to work, *your map and reduce tasks must be side-effect-free*

Fault Tolerance in MapReduce

2. If a node crashes:
   - Re-launch its current tasks on other nodes
   - Re-run any maps the node previously ran
     - » Necessary because their output files were lost along with the crashed node

Fault Tolerance in MapReduce

3. If a task is going slowly (straggler):
   - Launch second copy of task on another node ("speculative execution")
   - Take the output of whichever copy finishes first, and kill the other

- ➢ Surprisingly important in large clusters
  - Stragglers occur frequently due to failing hardware, software bugs, misconfiguration, etc
  - Single straggler may noticeably slow down a job

Takeaways

- By providing a data-parallel programming model, MapReduce can control job execution in useful ways:
  - Automatic division of job into tasks
  - Automatic placement of computation near data
  - Automatic load balancing
  - Recovery from failures & stragglers
- User focuses on application, not on complexities of distributed computing

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1. Search

- **Input:** (lineNumber, line) records
- **Output:** lines matching a given pattern

- **Map:**

```
if(line matches pattern):
    output(line)
```

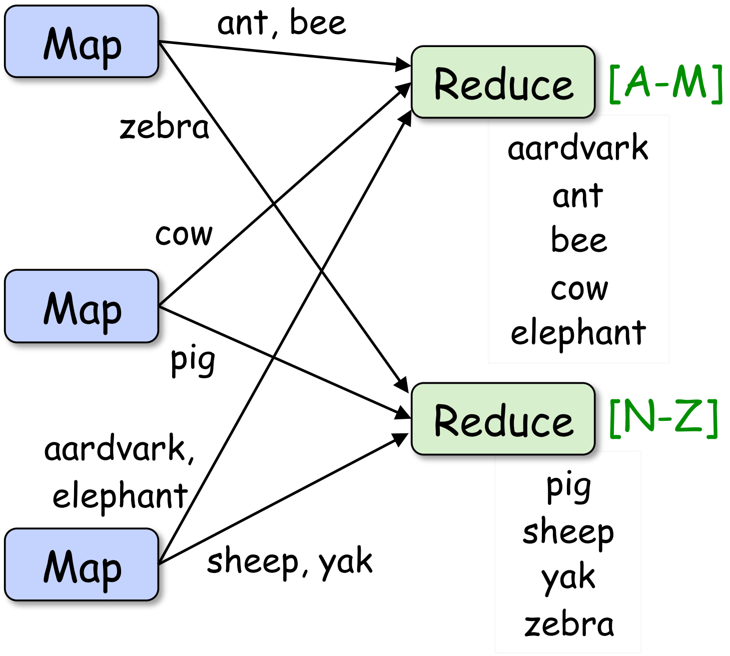
- **Reduce:** identify function
  - Alternative: no reducer (map-only job)

2. Sort

- **Input:** (key, value) records
- **Output:** same records, sorted by key

- **Map:** identity function
- **Reduce:** identify function

- **Trick:** Pick partitioning function h such that $k_1 < k_2 \Rightarrow h(k_1) < h(k_2)$



3. Inverted Index

- **Input:** (filename, text) records
- **Output:** list of files containing each word

- **Map:**

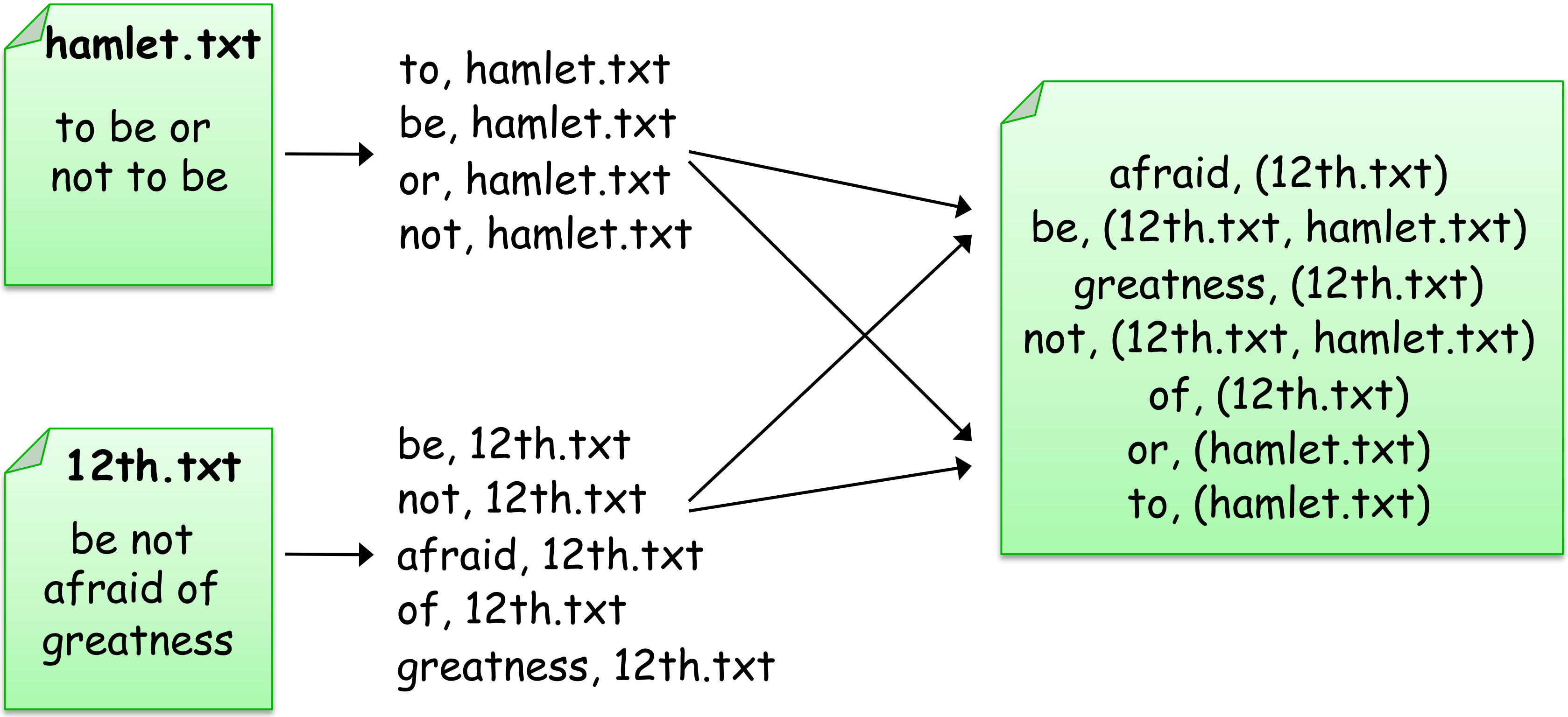
```
foreach word in text.split():
    output(word, filename)
```

- **Combine:** uniquify filenames for each word

- **Reduce:**

```
def reduce(word, filenames):
    output(word, sort(filenames))
```

Inverted Index Example



hamlet.txt

to be or
not to be

to, hamlet.txt
be, hamlet.txt
or, hamlet.txt
not, hamlet.txt

12th.txt

be not
afraid of
greatness

be, 12th.txt
not, 12th.txt
afraid, 12th.txt
of, 12th.txt
greatness, 12th.txt

afraid, (12th.txt)
be, (12th.txt, hamlet.txt)
greatness, (12th.txt)
not, (12th.txt, hamlet.txt)
of, (12th.txt)
or, (hamlet.txt)
to, (hamlet.txt)

4. Most Popular Words

- **Input:** (filename, text) records
- **Output:** top 100 words occurring in the most files

- Two-stage solution:
  - **Job 1:**
    - » Create inverted index, giving (word, list(file)) records
  - **Job 2:**
    - » Map each (word, list(file)) to (count, word)
    - » Sort these records by count as in sort job

- Optimizations:
  - Map to (word, 1) instead of (word, file) in Job 1
  - Count files in job 1's reducer rather than job 2's mapper
  - Estimate count distribution in advance and drop rare words

5. Numerical Integration

- **Input:** (start, end) records for sub-ranges to integrate
  - Easy using custom InputFormat
- **Output:** integral of f(x) dx over entire range

- **Map:**

```
def map(start, end):
    sum = 0
    for(x = start; x < end; x += step):
        sum += f(x) * step
    output(“”, sum)
```

- **Reduce:**

```
def reduce(key, values):
    output(key, sum(values))
```

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Getting Started with Hadoop

- Download from hadoop.apache.org
- To install locally, unzip and set JAVA_HOME
- Details: hadoop.apache.org/core/docs/current/quickstart.html

- Three ways to write jobs:
  - Java API
  - Hadoop Streaming (for Python, Perl, etc)
  - Pipes API (C++)

Word Count in Java

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

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

   public void map(LongWritable key, Text value,
                   OutputCollector<Text, IntWritable> out,
                   Reporter reporter) throws IOException {
     String line = value.toString();
     StringTokenizer itr = new StringTokenizer(line);
     while (itr.hasMoreTokens()) {
       out.collect(new text(itr.nextToken()), ONE);
     }
   }
 }
```

Word Count in Java

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

   public void reduce(Text key, Iterator<IntWritable> values,
                      OutputCollector<Text, IntWritable> out,
                      Reporter reporter) throws IOException {
     int sum = 0;
     while (values.hasNext()) {
       sum += values.next().get();
     }
     out.collect(key, new IntWritable(sum));
   }
 }
```

Word Count in Java

```
public static void main(String[] args) throws Exception {
   JobConf conf = new JobConf(WordCount.class);
   conf.setJobName("wordcount");

   conf.setMapperClass(MapClass.class);
   conf.setCombinerClass(ReduceClass.class);
   conf.setReducerClass(ReduceClass.class);

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

   conf.setOutputKeyClass(Text.class); // out keys are words (strings)
   conf.setOutputValueClass(IntWritable.class); // values are counts

   JobClient.runJob(conf);
 }
```

Word Count in Python with Hadoop Streaming

Mapper.py:

```
import sys
for line in sys.stdin:
  for word in line.split():
    print(word.lower() + "\t" + 1)
```

Reducer.py:

```
import sys
counts = {}
for line in sys.stdin:
  word, count = line.split("\t”)
  dict[word] = dict.get(word, 0) + int(count)
for word, count in counts:
  print(word.lower() + "\t" + 1)
```

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Motivation

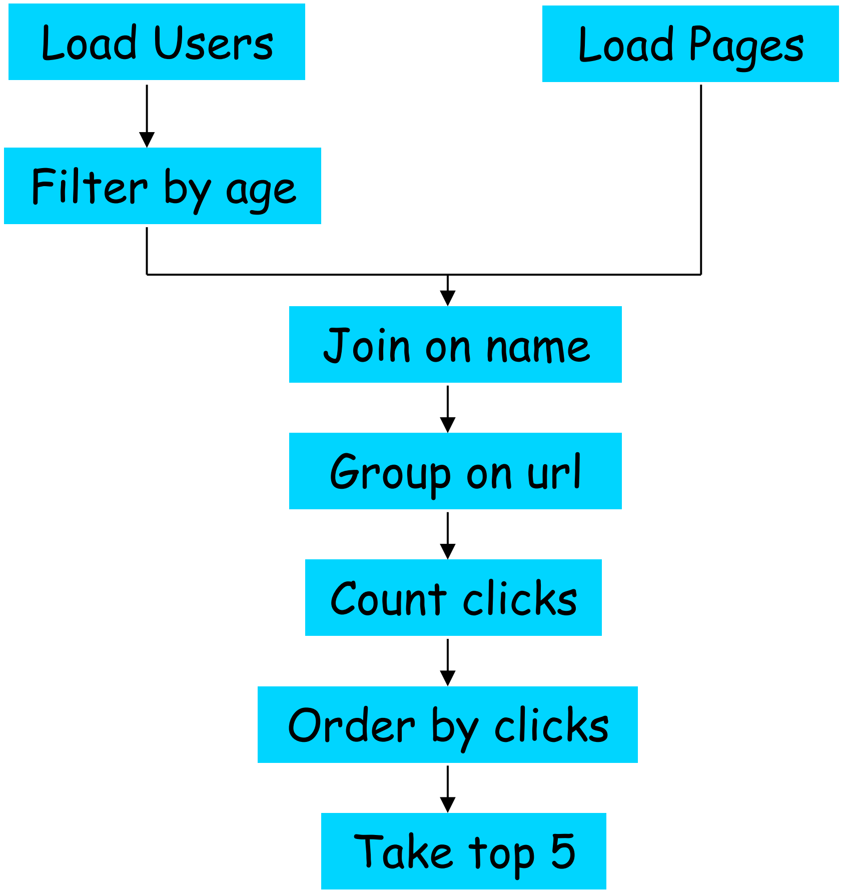
- Many parallel algorithms can be expressed by a series of MapReduce jobs
- But MapReduce is fairly low-level: must think about keys, values, partitioning, etc
- Can we capture common “job building blocks”?

Pig

- Started at Yahoo! Research
- Runs about 30% of Yahoo!'s jobs
- Features:
  - Expresses sequences of MapReduce jobs
  - Data model: nested "bags" of items
  - Provides relational (SQL) operators (JOIN, GROUP BY, etc)
  - Easy to plug in Java functions
  - Pig Pen development environment for Eclipse

An Example Problem

Suppose you have user data in one file, page view data in another, and you need to find the top 5 most visited pages by users aged 18 - 25.



Load Users

Load Pages

Filter by age

Join on name

Group on url

Count clicks

Order by clicks

Take top 5

Example from http://wiki.apache.org/pig-data/attachments/PigTalksPapers/attachments/ApacheConEurope09.ppt

In MapReduce

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

import org.apache.hadoop.fs.Path;
import org.apache.hadoop.io.LongWritable;
import org.apache.hadoop.io.Text;
import org.apache.hadoop.io.Writable;
import org.apache.hadoop.io.WritableComparable;
import org.apache.hadoop.mapred.FileInputFormat;
import org.apache.hadoop.mapred.FileOutputFormat;
import org.apache.hadoop.mapred.JobConf;
import org.apache.hadoop.mapred.KeyValueTextInputFormat;
import org.apache.hadoop.mapred.Mapper;
import org.apache.hadoop.mapred.MapReduceBase;
import org.apache.hadoop.mapred.OutputCollector;
import org.apache.hadoop.mapred.RecordReader;
import org.apache.hadoop.mapred.Reducer;
import org.apache.hadoop.mapred.Reporter;
import org.apache.hadoop.mapred.SequenceFileInputFormat;
import org.apache.hadoop.mapred.SequenceFileOutputFormat;
import org.apache.hadoop.mapred.TextInputFormat;
import org.apache.hadoop.mapred.jobcontrol.Job;
import org.apache.hadoop.mapred.jobcontrol.JobControl;
import org.apache.hadoop.mapred.lib.IdentityMapper;

public class MRExample {
    public static class LoadPages extends MapReduceBase
        implements Mapper<LongWritable, Text, Text, Text> {

        public void map(LongWritable k, Text val,
                OutputCollector<Text, Text> oc,
                Reporter reporter) throws IOException {
            // Pull the key out
            String line = val.toString();
            int firstComma = line.indexOf(',');
            String key = line.substring(0, firstComma);
            String value = line.substring(firstComma + 1);
            Text outKey = new Text(key);
            // Prepend an index to the value so we know which file
            // it came from.
            Text outVal = new Text("1" + value);
            oc.collect(outKey, outVal);
        }
    }
    public static class LoadAndFilterUsers extends MapReduceBase
        implements Mapper<LongWritable, Text, Text, Text> {

        public void map(LongWritable k, Text val,
                OutputCollector<Text, Text> oc,
                Reporter reporter) throws IOException {
            // Pull the key out
            String line = val.toString();
            int firstComma = line.indexOf(',');
            String value = line.substring( firstComma + 1);
            int age = Integer.parseInt(value);
            if (age < 18 || age > 25) return;
            String key = line.substring(0, firstComma);
            Text outKey = new Text(key);
            // Prepend an index to the value so we know which file
            // it came from.
            Text outVal = new Text("2" + value);
            oc.collect(outKey, outVal);
        }
    }
    public static class Join extends MapReduceBase
        implements Reducer<Text, Text, Text, Text> {

        public void reduce(Text key,
                Iterator<Text> iter,
                OutputCollector<Text, Text> oc,
                Reporter reporter) throws IOException {
            // For each value, figure out which file it's from and
store it
            // accordingly.
            List<String> first = new ArrayList<String>();
            List<String> second = new ArrayList<String>();

            while (iter.hasNext()) {
                Text t = iter.next();
                String value = t.toString();
                if (value.charAt(0) == '1')
first.add(value.substring(1));
                else second.add(value.substring(1));
                reporter.setStatus("OK");
            }

            // Do the cross product and collect the values
            for (String s1 : first) {
                for (String s2 : second) {
                    String outval = key + "," + s1 + "," + s2;
                    oc.collect(null, new Text(outval));
                    reporter.setStatus("OK");
                }
            }
        }
    }
    public static class LoadJoined extends MapReduceBase
        implements Mapper<Text, Text, Text, LongWritable> {

        public void map(
                Text k,
                Text val,
                OutputCollector<Text, LongWritable> oc,
                Reporter reporter) throws IOException {
            // Find the url
            String line = val.toString();
            int firstComma = line.indexOf(',');
            int secondComma = line.indexOf(',', firstComma);
            String key = line.substring(firstComma, secondComma);
            // drop the rest of the record, I don't need it anymore,
            // just pass a 1 for the combiner/reducer to sum instead.
            Text outKey = new Text(key);
            oc.collect(outKey, new LongWritable(1L));
        }
    }
    public static class ReduceUrls extends MapReduceBase
        implements Reducer<Text, LongWritable, WritableComparable,
Writable> {

        public void reduce(
                Text key,
                Iterator<LongWritable> iter,
                OutputCollector<WritableComparable, Writable> oc,
                Reporter reporter) throws IOException {
            // Add up all the values we see

            long sum = 0;
            while (iter.hasNext()) {
                sum += iter.next().get();
                reporter.setStatus("OK");
            }

            oc.collect(key, new LongWritable(sum));
        }
    }
    public static class LoadClicks extends MapReduceBase
        implements Mapper<WritableComparable, Writable, LongWritable,
Text> {

        public void map(
                WritableComparable key,
                Writable val,
                OutputCollector<LongWritable, Text> oc,
                Reporter reporter)  throws IOException {
            oc.collect((LongWritable)val, (Text)key);
        }
    }
    public static class LimitClicks extends MapReduceBase
        implements Reducer<LongWritable, Text, LongWritable, Text> {

        int count = 0;
        public void reduce(
            LongWritable key,
            Iterator<Text> iter,
            OutputCollector<LongWritable, Text> oc,
            Reporter reporter) throws IOException {

            // Only output the first 100 records
            while (count < 100 && iter.hasNext()) {
                oc.collect(key, iter.next());
                count++;
            }
        }
    }
    public static void main(String[] args) throws IOException {
        JobConf lp = new JobConf(MRExample.class);
        lp.setJobName("Load Pages");
        lp.setInputFormat(TextInputFormat.class);
        lp.setOutputKeyClass(Text.class);
        lp.setOutputValueClass(Text.class);
        lp.setMapperClass(LoadPages.class);
        FileInputFormat.addInputPath(lp, new
Path("/user/gates/pages"));
        FileOutputFormat.setOutputPath(lp,
            new Path("/user/gates/tmp/indexed_pages"));
        lp.setNumReduceTasks(0);
        Job loadPages = new Job(lp);

        JobConf lfu = new JobConf(MRExample.class);
        lfu.setJobName("Load and Filter Users");
        lfu.setInputFormat(TextInputFormat.class);
        lfu.setOutputKeyClass(Text.class);
        lfu.setOutputValueClass(Text.class);
        lfu.setMapperClass(LoadAndFilterUsers.class);
        FileInputFormat.addInputPath(lfu, new
Path("/user/gates/users"));
        FileOutputFormat.setOutputPath(lfu,
            new Path("/user/gates/tmp/filtered_users"));
        lfu.setNumReduceTasks(0);
        Job loadUsers = new Job(lfu);

        JobConf join = new JobConf( MRExample.class);
        join.setJobName("Join Users and Pages");
        join.setInputFormat(KeyValueTextInputFormat.class);
        join.setOutputKeyClass(Text.class);
        join.setOutputValueClass(Text.class);
        join.setMapperClass(IdentityMapper.class);
        join.setReducerClass(Join.class);
        FileInputFormat.addInputPath(join, new
Path("/user/gates/tmp/indexed_pages"));
        FileInputFormat.addInputPath(join, new
Path("/user/gates/tmp/filtered_users"));
        FileOutputFormat.setOutputPath(join, new
Path("/user/gates/tmp/joined"));
        join.setNumReduceTasks(50);
        Job joinJob = new Job(join);
        joinJob.addDependingJob(loadPages);
        joinJob.addDependingJob(loadUsers);

        JobConf group = new JobConf(MRExample.class);
        group.setJobName("Group URLs");
        group.setInputFormat(KeyValueTextInputFormat.class);
        group.setOutputKeyClass(Text.class);
        group.setOutputValueClass(LongWritable.class);
        group.setOutputFormat(SequenceFileOutputFormat.class);
        group.setMapperClass(LoadJoined.class);
        group.setCombinerClass(ReduceUrls.class);
        group.setReducerClass(ReduceUrls.class);
        FileInputFormat.addInputPath(group, new
Path("/user/gates/tmp/joined"));
        FileOutputFormat.setOutputPath(group, new
Path("/user/gates/tmp/grouped"));
        group.setNumReduceTasks(50);
        Job groupJob = new Job(group);
        groupJob.addDependingJob(joinJob);

        JobConf top100 = new JobConf(MRExample.class);
        top100.setJobName("Top 100 sites");
        top100.setInputFormat(SequenceFileInputFormat.class);
        top100.setOutputKeyClass(LongWritable.class);
        top100.setOutputValueClass(Text.class);
        top100.setOutputFormat(SequenceFileOutputFormat.class);
        top100.setMapperClass(LoadClicks.class);
        top100.setCombinerClass(LimitClicks.class);
        top100.setReducerClass(LimitClicks.class);
        FileInputFormat.addInputPath(top100, new
Path("/user/gates/tmp/grouped"));
        FileOutputFormat.setOutputPath(top100, new
Path("/user/gates/top100sitesforusers18to25"));
        top100.setNumReduceTasks(1);
        Job limit = new Job(top100);
        limit.addDependingJob(groupJob);

        JobControl jc = new JobControl("Find top  100 sites for users
18 to 25");
        jc.addJob(loadPages);
        jc.addJob(loadUsers);
        jc.addJob(joinJob);
        jc.addJob(groupJob);
        jc.addJob(limit);
        jc.run();
    }
}
```

Example from http://wiki.apache.org/pig-data/attachments/PigTalksPapers/attachments/ApacheConEurope09.ppt

In Pig Latin

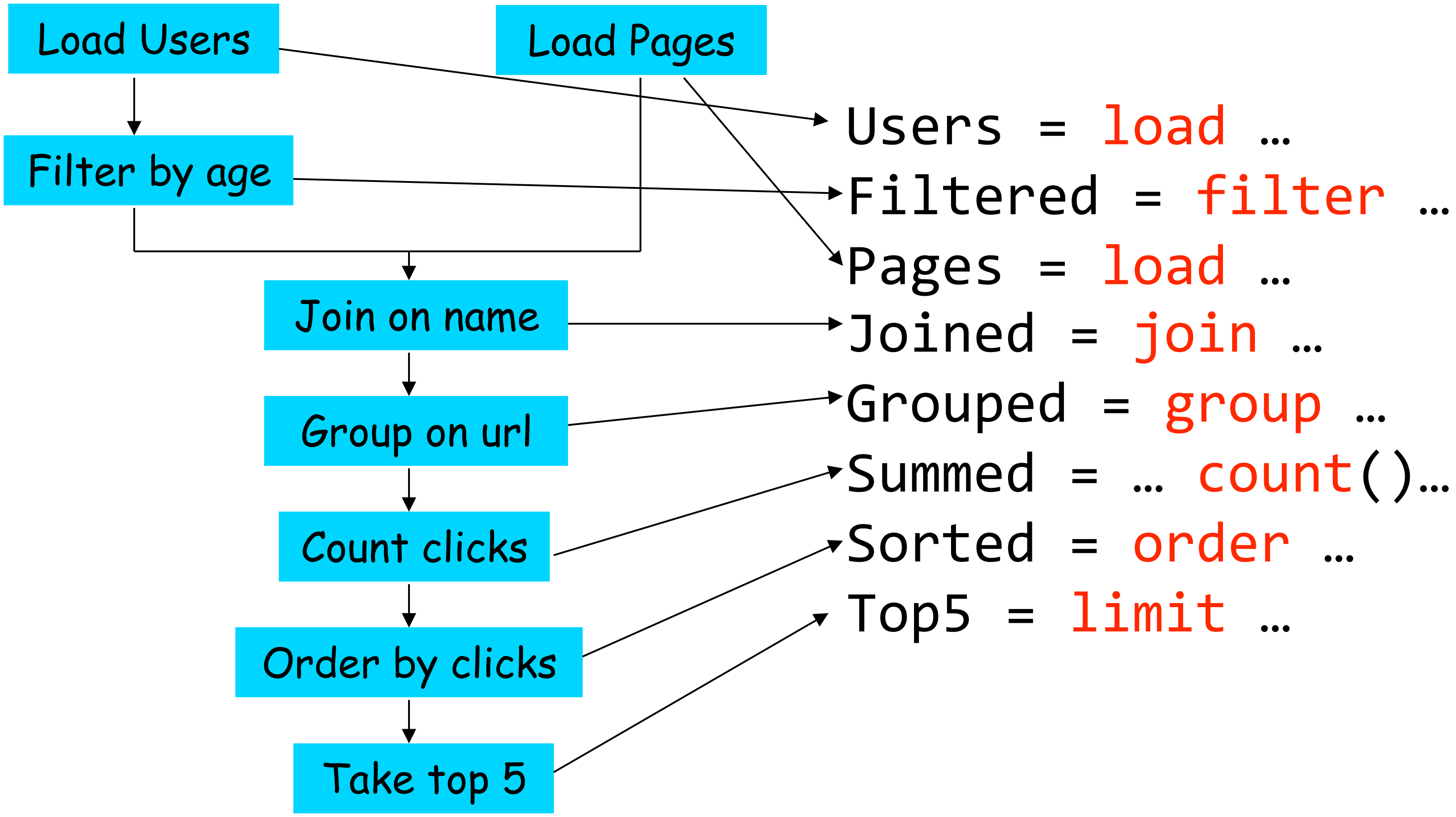
```
Users    = load ‘users’ as (name, age);
Filtered = filter Users by
                  age >= 18 and age <= 25;
Pages    = load ‘pages’ as (user, url);
Joined   = join Filtered by name, Pages by user;
Grouped  = group Joined by url;
Summed   = foreach Grouped generate group,
                   count(Joined) as clicks;
Sorted   = order Summed by clicks desc;
Top5     = limit Sorted 5;

store Top5 into ‘top5sites’;
```

Example from http://wiki.apache.org/pig-data/attachments/PigTalksPapers/attachments/ApacheConEurope09.ppt

Ease of Translation

Notice how naturally the components of the job translate into Pig Latin.



Load Users

Load Pages

Filter by age

Join on name

Group on url

Count clicks

Order by clicks

Take top 5

```
Users = load …
Filtered = filter …
Pages = load …
Joined = join …
Grouped = group …
Summed = … count()…
Sorted = order …
Top5 = limit …
```

Example from http://wiki.apache.org/pig-data/attachments/PigTalksPapers/attachments/ApacheConEurope09.ppt

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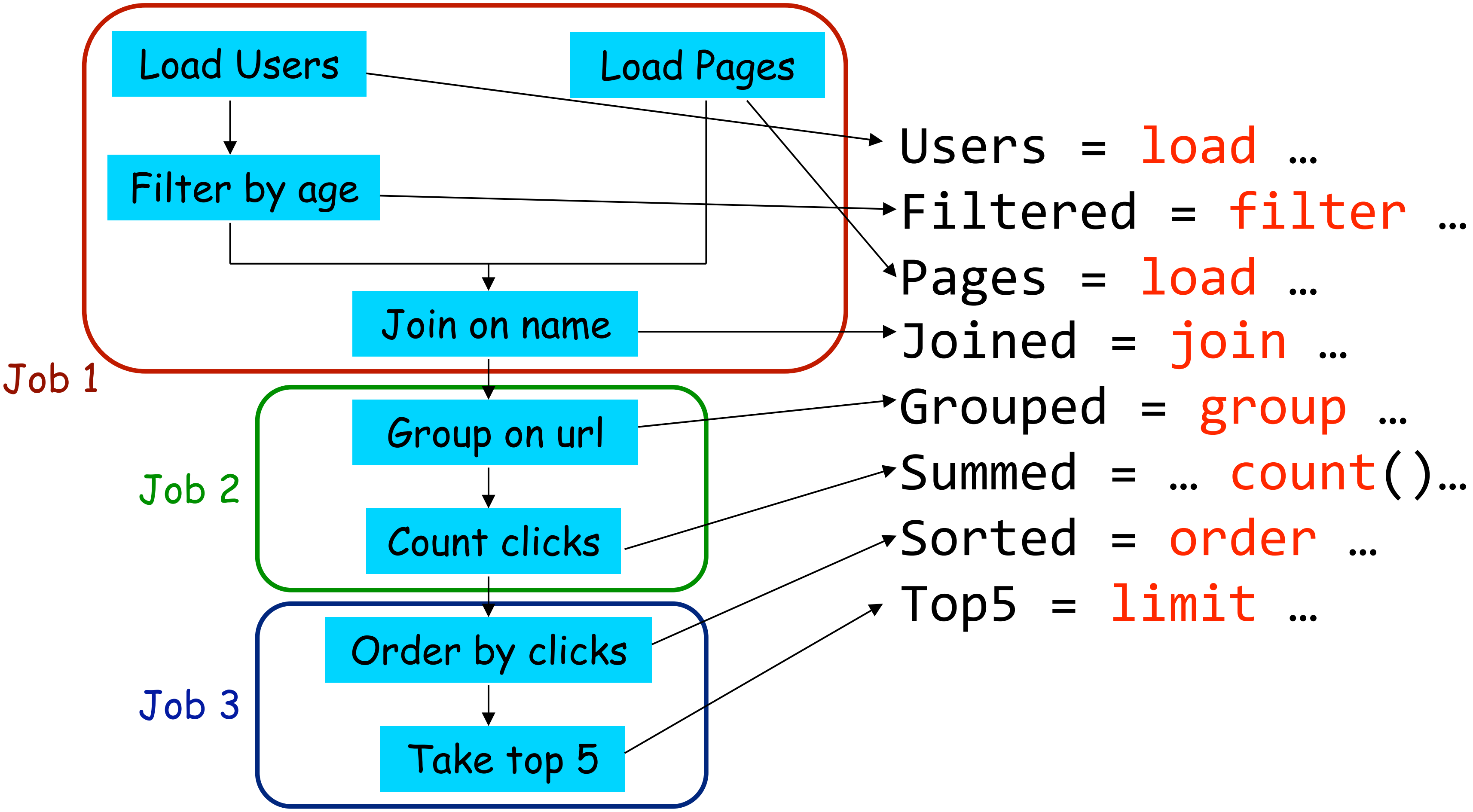

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Hive

- Developed at Facebook
- Used for majority of Facebook jobs
- "Relational database" built on Hadoop
  - Maintains list of table schemas
  - SQL-like query language (HQL)
  - Can call Hadoop Streaming scripts from HQL
  - Supports table partitioning, clustering, complex data types, some optimizations

Sample Hive Queries

- Find top 5 pages visited by users aged 18-25:

```
SELECT p.url, COUNT(1) as clicks
FROM users u JOIN page_views p ON (u.name = p.user)
WHERE u.age >= 18 AND u.age <= 25
GROUP BY p.url
ORDER BY clicks
LIMIT 5;
```

- Filter page views through Python script:

```
SELECT TRANSFORM(p.user, p.date)
USING 'map_script.py'
AS dt, uid CLUSTER BY dt
FROM page_views p;
```

Outline

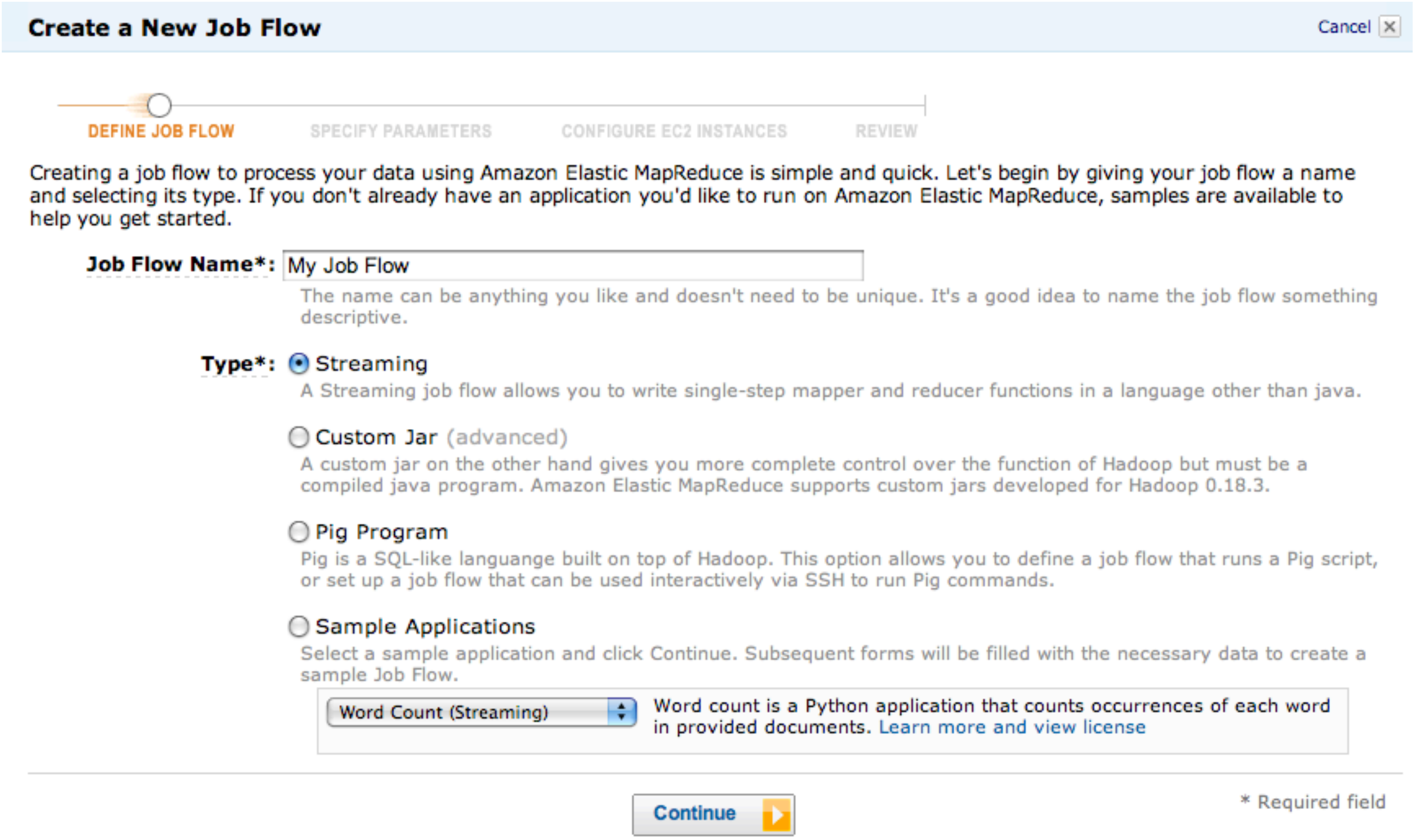
- MapReduce architecture
- Example applications
- Getting started with Hadoop
- Higher-level languages over Hadoop: Pig and Hive
- Amazon Elastic MapReduce

Amazon Elastic MapReduce

- Provides a web-based interface and command-line tools for running Hadoop jobs on Amazon EC2
- Data stored in Amazon S3
- Monitors job and shuts down machines after use
- Small extra charge on top of EC2 pricing

- If you want more control over how you Hadoop runs, you can launch a Hadoop cluster on EC2 manually using the scripts in `src/contrib/ec2`

Elastic MapReduce Workflow



Create a New Job Flow

Creating a job flow to process your data using Amazon Elastic MapReduce is simple and quick. Let's begin by giving your job flow a name and selecting its type. If you don't already have an application you'd like to run on Amazon Elastic MapReduce, samples are available to help you get started.

Job Flow Name*: My Job Flow

The name can be anything you like and doesn't need to be unique. It's a good idea to name the job flow something descriptive.

Type*: ● Streaming

A Streaming job flow allows you to write single-step mapper and reducer functions in a language other than java.

○ Custom Jar (advanced)

A custom jar on the other hand gives you more complete control over the function of Hadoop but must be a compiled java program. Amazon Elastic MapReduce supports custom jars developed for Hadoop 0.18.3.

○ Pig Program

Pig is a SQL-like languange built on top of Hadoop. This option allows you to define a job flow that runs a Pig script, or set up a job flow that can be used interactively via SSH to run Pig commands.

○ Sample Applications

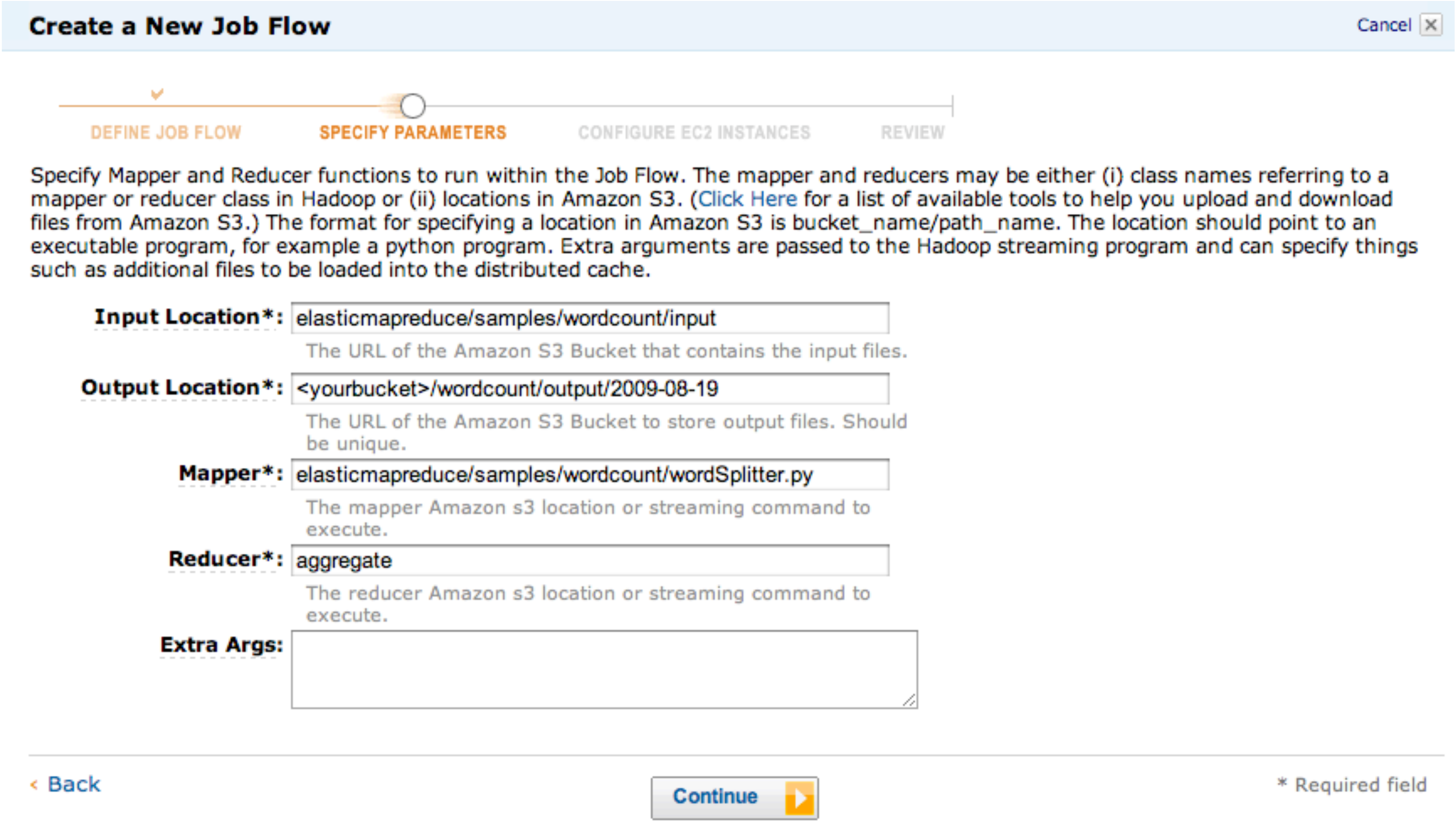
Select a sample application and click Continue. Subsequent forms will be filled with the necessary data to create a sample Job Flow.

Word Count (Streaming)

Word count is a Python application that counts occurrences of each word in provided documents. Learn more and view license

* Required field

Elastic MapReduce Workflow



Create a New Job Flow

Specify Mapper and Reducer functions to run within the Job Flow. The mapper and reducers may be either (i) class names referring to a mapper or reducer class in Hadoop or (ii) locations in Amazon S3. (Click Here for a list of available tools to help you upload and download files from Amazon S3.) The format for specifying a location in Amazon S3 is bucket_name/path_name. The location should point to an executable program, for example a python program. Extra arguments are passed to the Hadoop streaming program and can specify things such as additional files to be loaded into the distributed cache.

Input Location*: elasticmapreduce/samples/wordcount/input
The URL of the Amazon S3 Bucket that contains the input files.

Output Location*: <yourbucket>/wordcount/output/2009-08-19
The URL of the Amazon S3 Bucket to store output files. Should be unique.

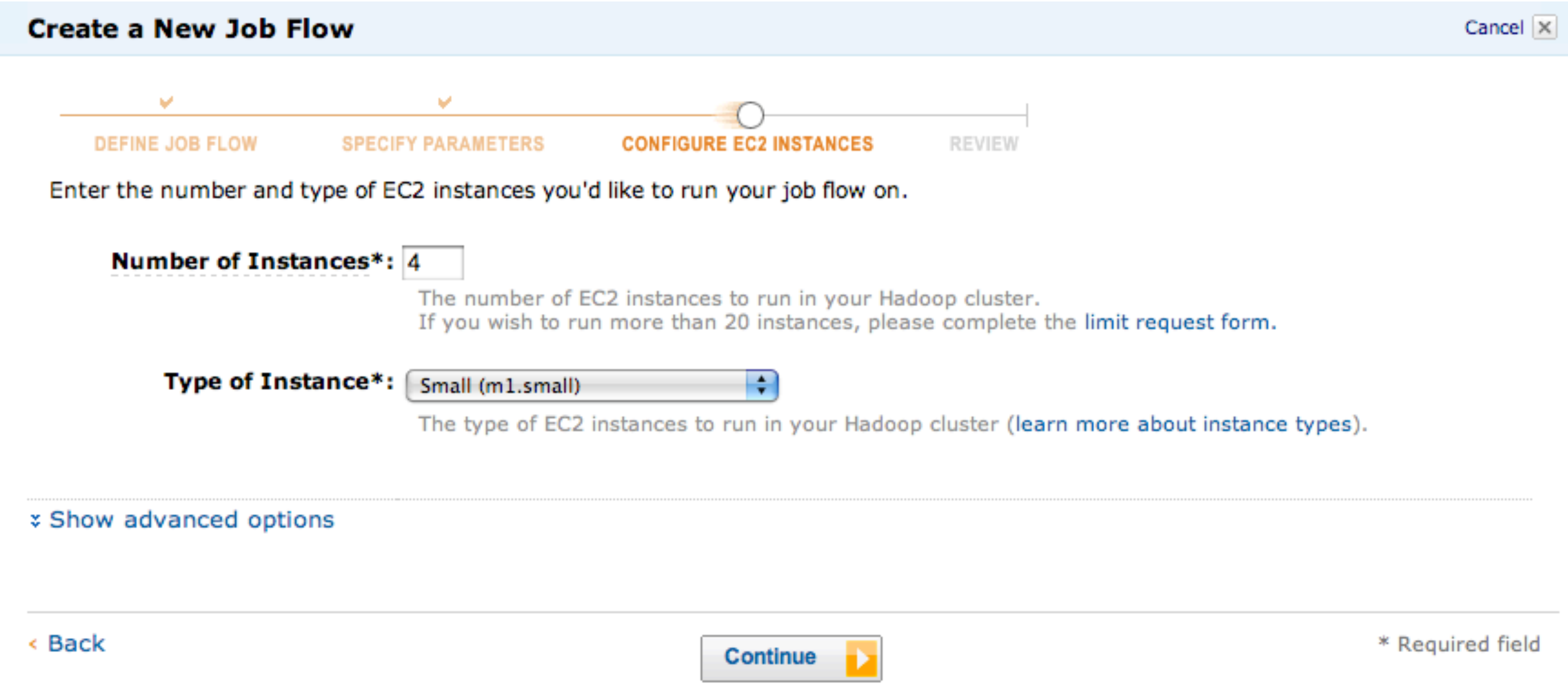
Mapper*: elasticmapreduce/samples/wordcount/wordSplitter.py
The mapper Amazon s3 location or streaming command to execute.

Reducer*: aggregate
The reducer Amazon s3 location or streaming command to execute.

Extra Args:

* Required field

Elastic MapReduce Workflow



Create a New Job Flow

Enter the number and type of EC2 instances you'd like to run your job flow on.

Number of Instances*: 4

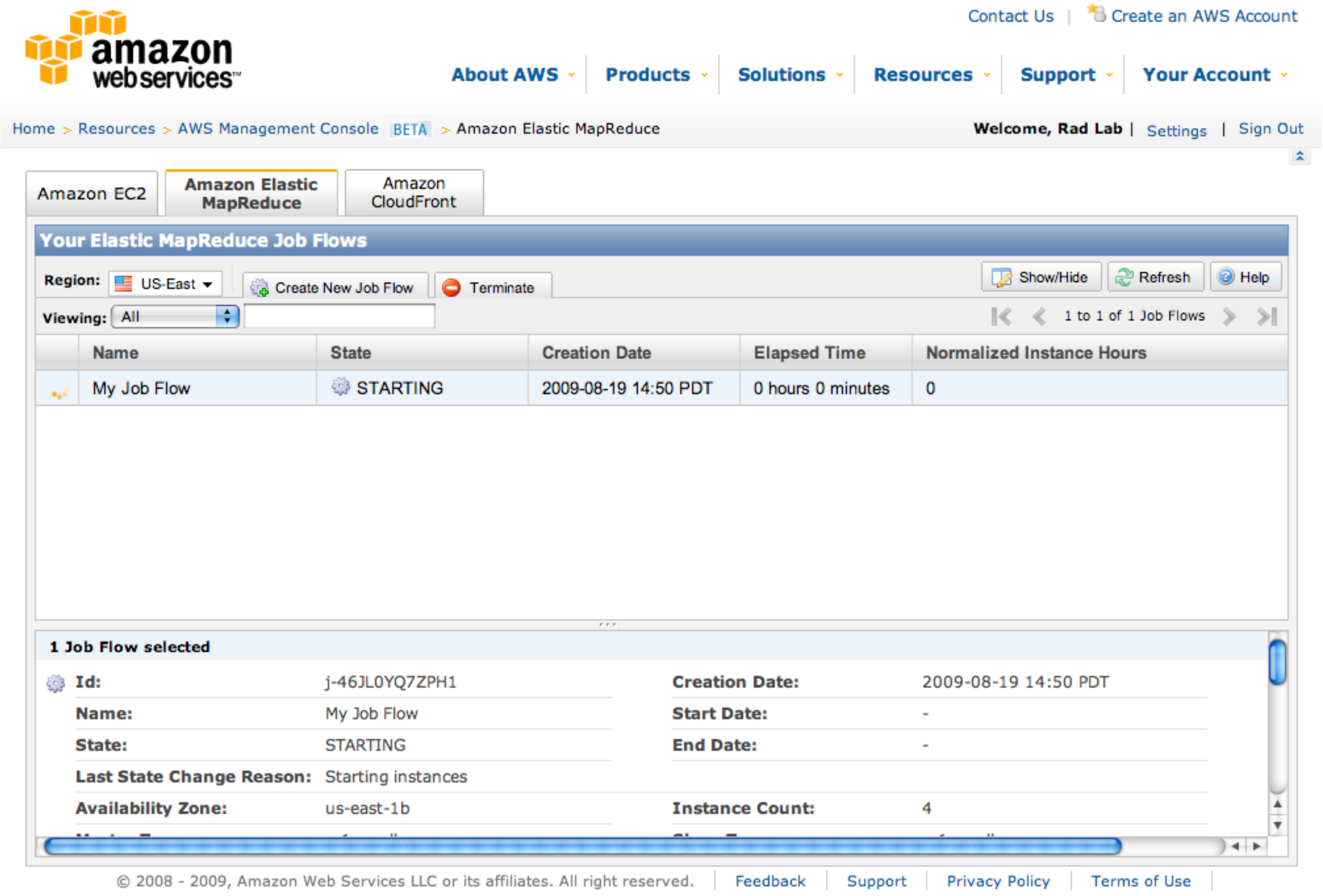
The number of EC2 instances to run in your Hadoop cluster.
If you wish to run more than 20 instances, please complete the limit request form.

Type of Instance*: Small (m1.small)

The type of EC2 instances to run in your Hadoop cluster (learn more about instance types).

* Required field

Elastic MapReduce Workflow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Resources
Support
Your Account
Home > Resources > AWS Management Console BETA > Amazon Elastic MapReduce
Welcome, Rad Lab | Settings | Sign Out
Amazon EC2
Amazon Elastic MapReduce
Amazon CloudFront
Your Elastic MapReduce Job Flows
Region: US-East
Create New Job Flow
Terminate
Show/Hide
Refresh
Help
Viewing: All
1 to 1 of 1 Job Flows

Name	State	Creation Date	Elapsed Time	Normalized Instance Hours
My Job Flow	STARTING	2009-08-19 14:50 PDT	0 hours 0 minutes	0

1 Job Flow selected

Id:	j-46JL0YQ7ZPH1	**Creation Date:**	2009-08-19 14:50 PDT
Name:	My Job Flow	**Start Date:**	-
State:	STARTING	**End Date:**	-
Last State Change Reason:	Starting instances		
Availability Zone:	us-east-1b	**Instance Count:**	4

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Conclusions

- MapReduce programming model hides the complexity of work distribution and fault tolerance

- Principal design philosophies:
  - *Make it scalable*, so you can throw hardware at problems
  - *Make it cheap*, lowering hardware, programming and admin costs

- MapReduce is not suitable for all problems, but when it works, it may save you quite a bit of time

- Cloud computing makes it straightforward to start using Hadoop (or other parallel software) at scale

Resources

- Hadoop: http://hadoop.apache.org/core/
- Pig: http://hadoop.apache.org/pig
- Hive: http://hadoop.apache.org/hive
- Video tutorials: http://www.cloudera.com/hadoop-training

- Amazon Web Services: http://aws.amazon.com/
- Amazon Elastic MapReduce guide: http://docs.amazonwebservices.com/ElasticMapReduce/latest/GettingStartedGuide/

- My email: matei@berkeley.edu