cloudera

Running Hadoop in the Cloud

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About me

- Apache Hadoop Committer, PMC Member, Apache Member
- Employed by Cloudera
- Writing a book on Hadoop for O’Reilly
  - http://hadoopbook.com

Agenda

- Cloud Computing and Hadoop
- Hadoop on Amazon EC2
  - Storage options
  - Deployment options
- Demo
- Case Study

Cloud Computing

- Definitions from Armbrust et al, “Above the Clouds: A Berkeley View of Cloud Computing”, February 2009
- “Cloud” = data center hardware and software
  - Public cloud – service sold to the public
  - Private cloud – internal to an organization
- Three new aspects (of public clouds)

1. The illusion of infinite computing resources available on demand
2. The elimination of an up-front commitment by Cloud users
3. The ability to pay for use of computing resources on a short-term basis as needed

Why run Hadoop in the “public” cloud?

- “Infinite” resources
  - Hadoop scales linearly
- No upfront commitment
  - Try before you buy
  - Will Hadoop solve my problem?
- Pay as you go
  - Elasticity
  - Run a large cluster for a short time
  - Grow or shrink a cluster on demand
- **Lower administration costs and total cost of ownership**

Requirements for Hadoop

- Hardware
  - Hadoop needs lots of memory and disks
- Storage
  - Hadoop works best when storage is integrated with compute nodes
- Networking topology
  - Prefer control over placement of machines
  - Hadoop needs visibility into topology
- Bandwidth control
  - Dedicated switches are best

Hadoop on Amazon EC2

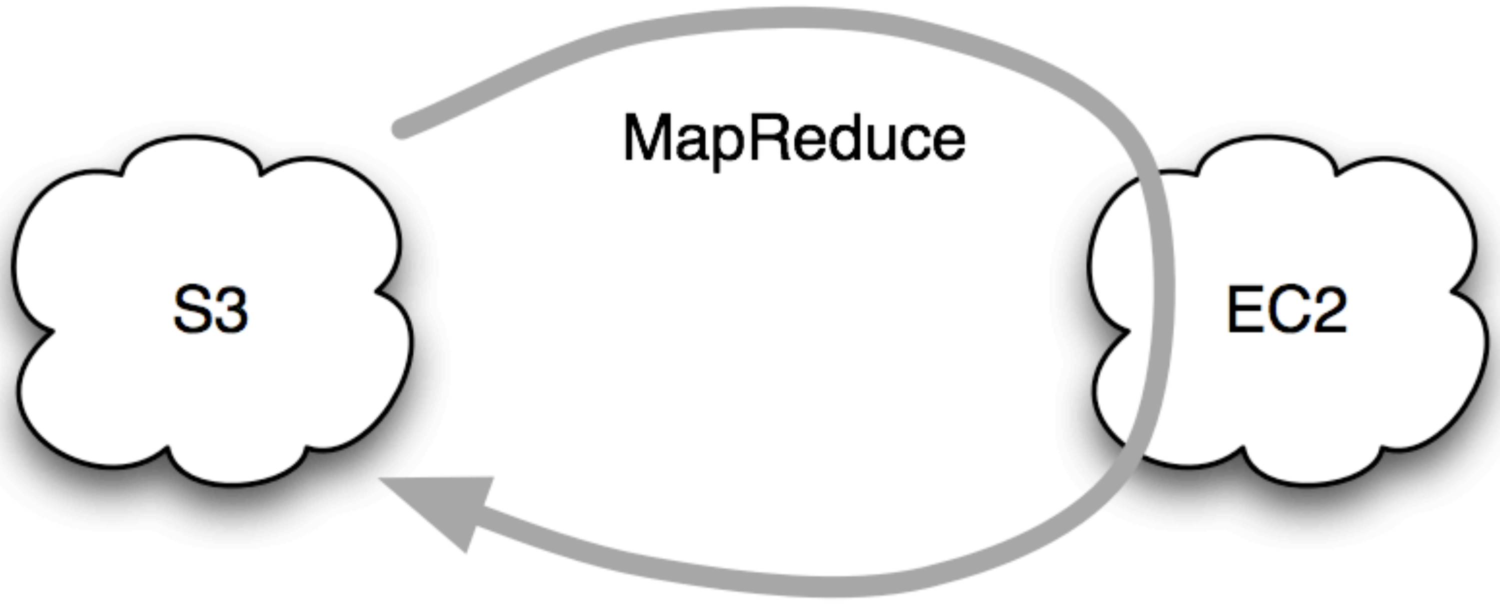
Hadoop on Amazon EC2

- Hardware
  - E.g. High-CPU XLarge:
    - 8 cores, 7GB memory, 1690 GB storage
- Storage
  - Choice of local disks, S3, EBS
- Networking topology
  - Finest granularity is “availability zone”
- Bandwidth control
  - Large instances have “high” I/O performance (no guarantees)

Storage options

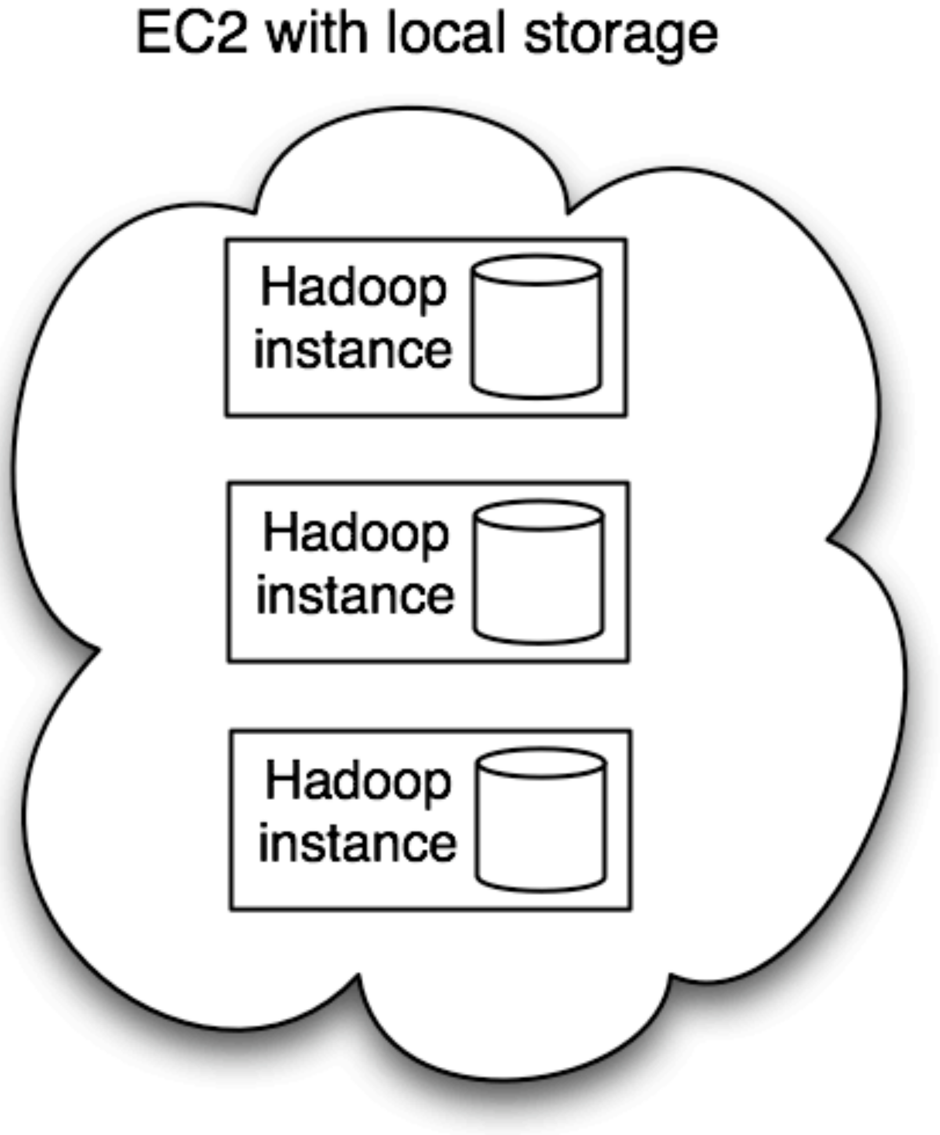
Hadoop on EC2 with S3 storage

- Pros
  - Elastic
  - Use existing S3 data
  - Cheap
- Cons
  - No locality
  - Poor transfer speed



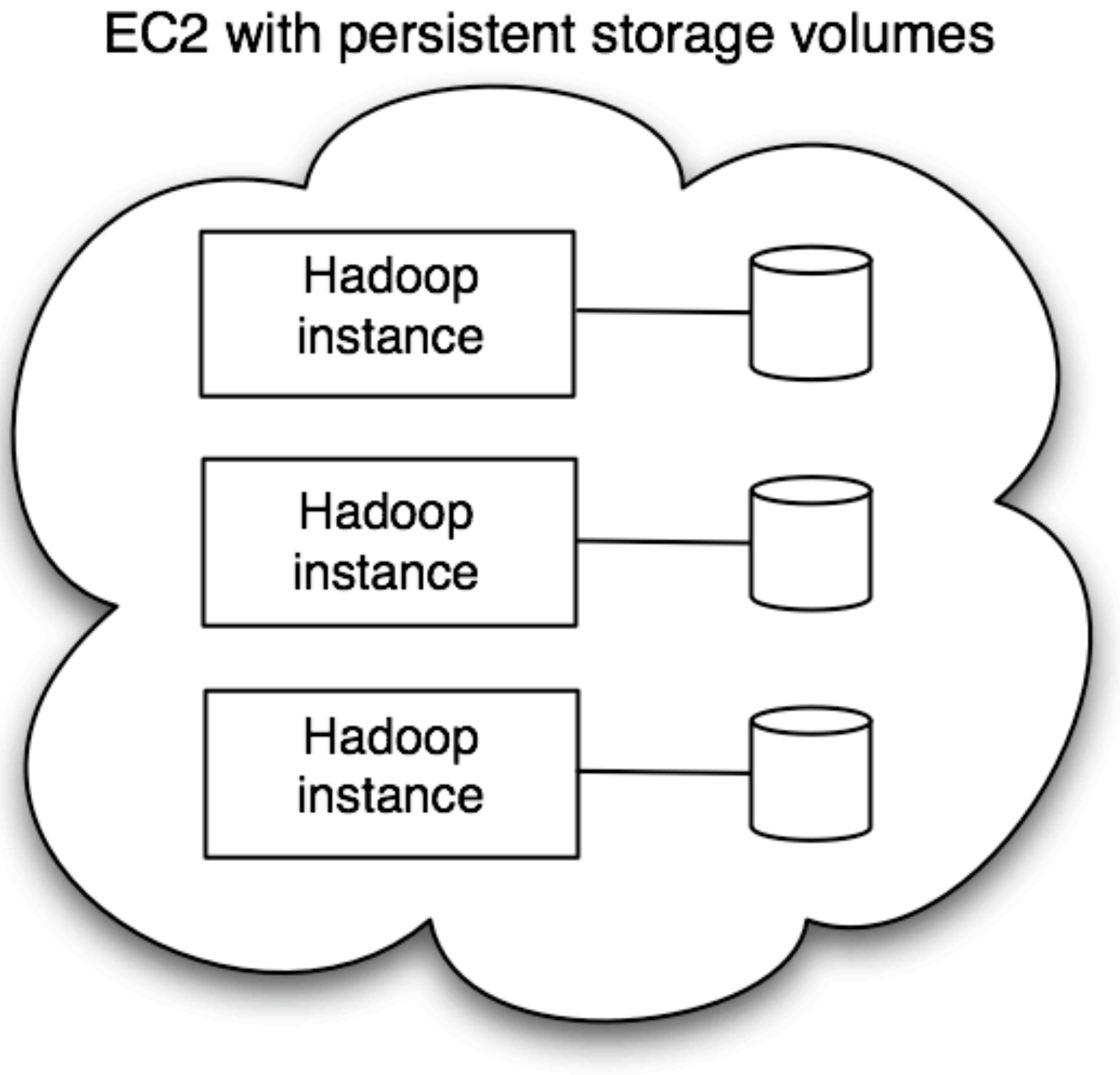
Hadoop on EC2 with local storage

- Pros
  - Data locality
- Cons
  - No rack locality
  - Cluster is always on



Hadoop on EC2 with EBS storage

- Pros
  - Data locality
  - Elastic
- Cons
  - No rack locality
  - No pre-existing AMIs



Economics

Storage	Price (per GB month)	Transfer cost (within AWS)
EBS	$0.10	$0.10 per million I/O requests
S3	$0.15	$0.01 per thousand HTTP requests
EC2 local storage (reserved instance for one year)	$0.32	$0.00

- EBS is a good fit for clusters with low–medium utilization

Deployment options

S3 Filesystems

- Hadoop Filesystem abstraction
  - HDFS (hdfs://), KFS (kfs://), local (file://)
- S3 Native Filesystem (s3n://)
  - 5GB file size
  - Use with existing S3 data and tools
- S3 Block Filesystem (s3://)
  - Unlimited file size
  - Can’t use with existing S3 data or tools

Hadoop S3 Examples

- Copy from HDFS to S3

  -
    ```
    hadoop fs -cp hdfs://namenode/path s3n://bucket/path
    ```
- Parallel copy from HDFS to S3

  -
    ```
    hadoop distcp hdfs://namenode/path s3://bucket/path
    ```
- Run MapReduce on S3 data

  -
    ```
    hadoop jar hadoop-*-examples.jar grep \
    s3n://bucket/input s3n://bucket/output pattern
    ```

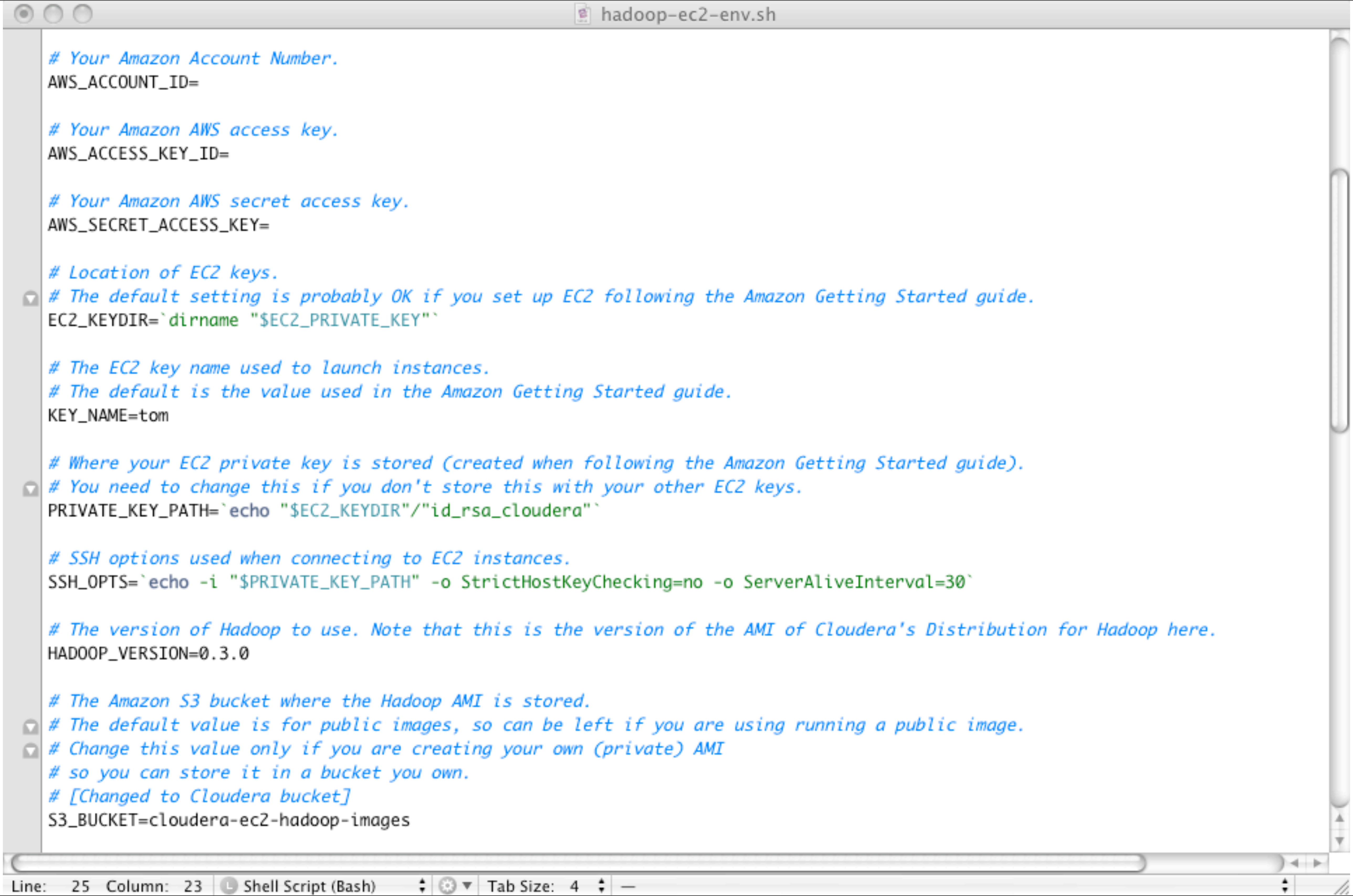
Hadoop EC2 AMIs

- Public AMIs provided by Apache and Cloudera
  - Use the same launch scripts
    - http://wiki.apache.org/hadoop/AmazonEC2
    - http://www.cloudera.com/hadoop-ec2
  - Launch scripts do cluster coordination and configuration
- AMIs are easy to customize
  - Patches
  - Extra software

Apache Hadoop and Cloudera’s Distribution

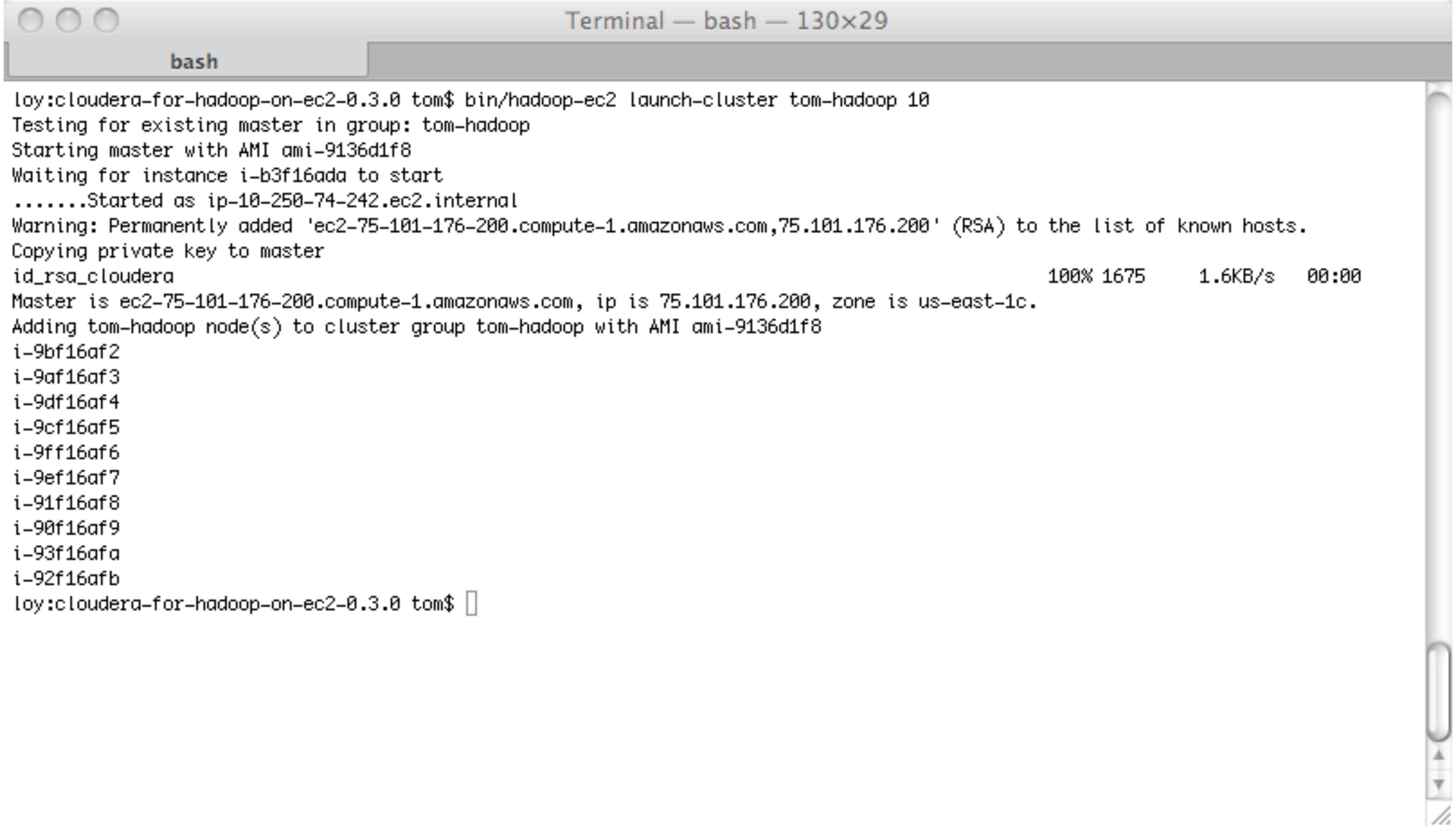
- Apache hosts Hadoop development
  - Nightly builds
  - Releases
- Cloudera’s Distribution for Hadoop
  - Based on most recent stable version
  - Uses RPMs for deployment (other packages coming soon)
    - Linux Filesystem Hierarchy Standard
    - Standard Linux service management
    - Dependency management

Demo

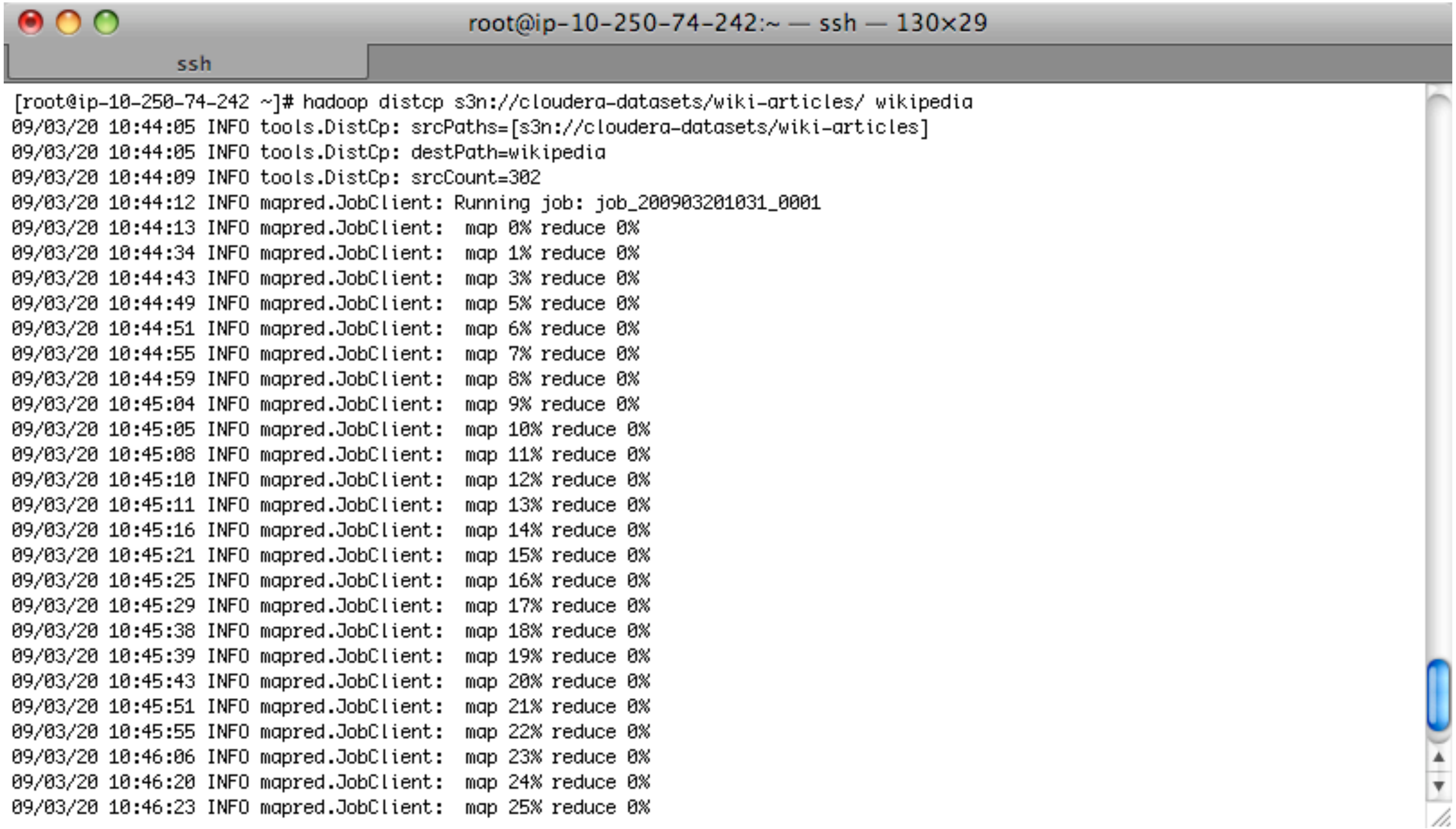


```
# Your Amazon Account Number.
AWS_ACCOUNT_ID=

# Your Amazon AWS access key.
AWS_ACCESS_KEY_ID=

# Your Amazon AWS secret access key.
AWS_SECRET_ACCESS_KEY=

# Location of EC2 keys.
# The default setting is probably OK if you set up EC2 following the Amazon Getting Started guide.
EC2_KEYDIR=`dirname "$EC2_PRIVATE_KEY"`

# The EC2 key name used to launch instances.
# The default is the value used in the Amazon Getting Started guide.
KEY_NAME=tom

# Where your EC2 private key is stored (created when following the Amazon Getting Started guide).
# You need to change this if you don't store this with your other EC2 keys.
PRIVATE_KEY_PATH=`echo "$EC2_KEYDIR"/"id_rsa_cloudera"`

# SSH options used when connecting to EC2 instances.
SSH_OPTS=`echo -i "$PRIVATE_KEY_PATH" -o StrictHostKeyChecking=no -o ServerAliveInterval=30`

# The version of Hadoop to use. Note that this is the version of the AMI of Cloudera's Distribution for Hadoop here.
HADOOP_VERSION=0.3.0

# The Amazon S3 bucket where the Hadoop AMI is stored.
# The default value is for public images, so can be left if you are using running a public image.
# Change this value only if you are creating your own (private) AMI
# so you can store it in a bucket you own.
# [Changed to Cloudera bucket]
S3_BUCKET=cloudera-ec2-hadoop-images
```

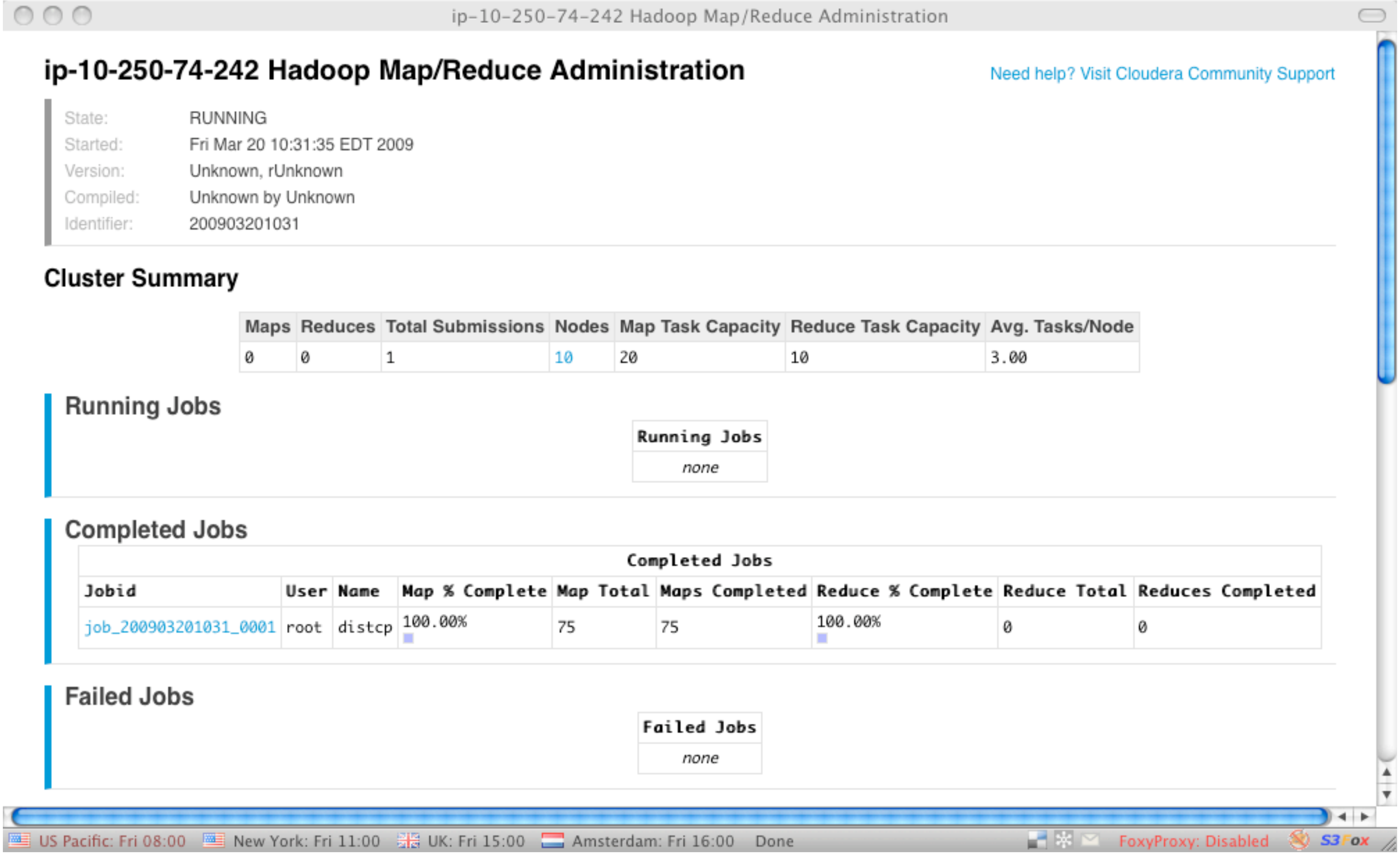
Line: 25 Column: 23 Shell Script (Bash) Tab Size: 4



```
loy:cloudera-for-hadoop-on-ec2-0.3.0 tom$ bin/hadoop-ec2 launch-cluster tom-hadoop 10
Testing for existing master in group: tom-hadoop
Starting master with AMI ami-9136d1f8
Waiting for instance i-b3f16ada to start
.......Started as ip-10-250-74-242.ec2.internal
Warning: Permanently added 'ec2-75-101-176-200.compute-1.amazonaws.com,75.101.176.200' (RSA) to the list of known hosts.
Copying private key to master
id_rsa_cloudera                                                                     100% 1675     1.6KB/s   00:00
Master is ec2-75-101-176-200.compute-1.amazonaws.com, ip is 75.101.176.200, zone is us-east-1c.
Adding tom-hadoop node(s) to cluster group tom-hadoop with AMI ami-9136d1f8
i-9bf16af2
i-9af16af3
i-9df16af4
i-9cf16af5
i-9ff16af6
i-9ef16af7
i-91f16af8
i-90f16af9
i-93f16afa
i-92f16afb
loy:cloudera-for-hadoop-on-ec2-0.3.0 tom$ 
```



```
[root@ip-10-250-74-242 ~]# hadoop distcp s3n://cloudera-datasets/wiki-articles/ wikipedia
09/03/20 10:44:05 INFO tools.DistCp: srcPaths=[s3n://cloudera-datasets/wiki-articles]
09/03/20 10:44:05 INFO tools.DistCp: destPath=wikipedia
09/03/20 10:44:09 INFO tools.DistCp: srcCount=302
09/03/20 10:44:12 INFO mapred.JobClient: Running job: job_200903201031_0001
09/03/20 10:44:13 INFO mapred.JobClient:  map 0% reduce 0%
09/03/20 10:44:34 INFO mapred.JobClient:  map 1% reduce 0%
09/03/20 10:44:43 INFO mapred.JobClient:  map 3% reduce 0%
09/03/20 10:44:49 INFO mapred.JobClient:  map 5% reduce 0%
09/03/20 10:44:51 INFO mapred.JobClient:  map 6% reduce 0%
09/03/20 10:44:55 INFO mapred.JobClient:  map 7% reduce 0%
09/03/20 10:44:59 INFO mapred.JobClient:  map 8% reduce 0%
09/03/20 10:45:04 INFO mapred.JobClient:  map 9% reduce 0%
09/03/20 10:45:05 INFO mapred.JobClient:  map 10% reduce 0%
09/03/20 10:45:08 INFO mapred.JobClient:  map 11% reduce 0%
09/03/20 10:45:10 INFO mapred.JobClient:  map 12% reduce 0%
09/03/20 10:45:11 INFO mapred.JobClient:  map 13% reduce 0%
09/03/20 10:45:16 INFO mapred.JobClient:  map 14% reduce 0%
09/03/20 10:45:21 INFO mapred.JobClient:  map 15% reduce 0%
09/03/20 10:45:25 INFO mapred.JobClient:  map 16% reduce 0%
09/03/20 10:45:29 INFO mapred.JobClient:  map 17% reduce 0%
09/03/20 10:45:38 INFO mapred.JobClient:  map 18% reduce 0%
09/03/20 10:45:39 INFO mapred.JobClient:  map 19% reduce 0%
09/03/20 10:45:43 INFO mapred.JobClient:  map 20% reduce 0%
09/03/20 10:45:51 INFO mapred.JobClient:  map 21% reduce 0%
09/03/20 10:45:55 INFO mapred.JobClient:  map 22% reduce 0%
09/03/20 10:46:06 INFO mapred.JobClient:  map 23% reduce 0%
09/03/20 10:46:20 INFO mapred.JobClient:  map 24% reduce 0%
09/03/20 10:46:23 INFO mapred.JobClient:  map 25% reduce 0%
```



ip-10-250-74-242 Hadoop Map/Reduce Administration

Need help? Visit Cloudera Community Support

State:	RUNNING
Started:	Fri Mar 20 10:31:35 EDT 2009
Version:	Unknown, rUnknown
Compiled:	Unknown by Unknown
Identifier:	200903201031

Cluster Summary

Maps	Reduces	Total Submissions	Nodes	Map Task Capacity	Reduce Task Capacity	Avg. Tasks/Node
0	0	1	10	20	10	3.00

Running Jobs

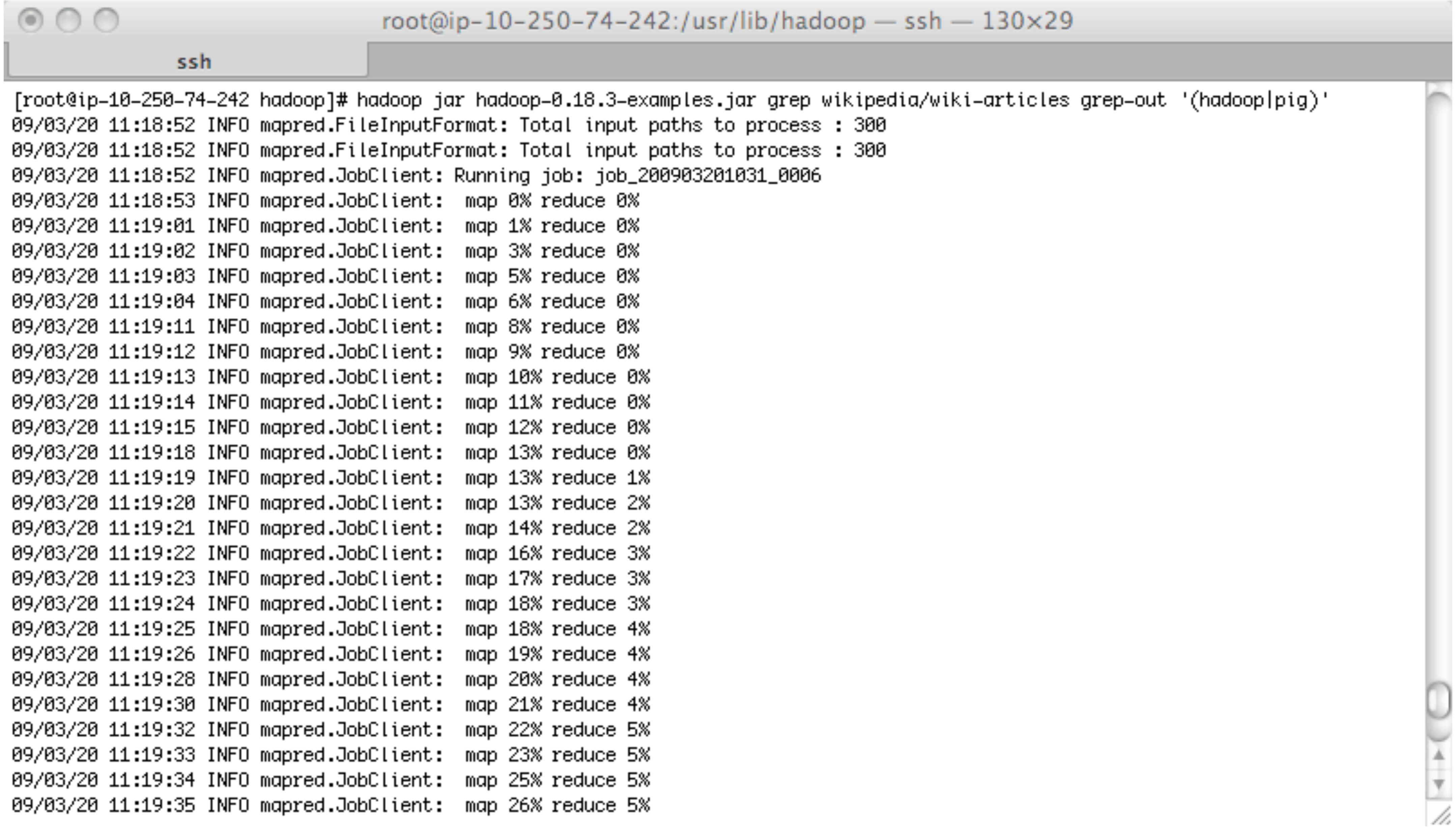
Running Jobs
none

Completed Jobs

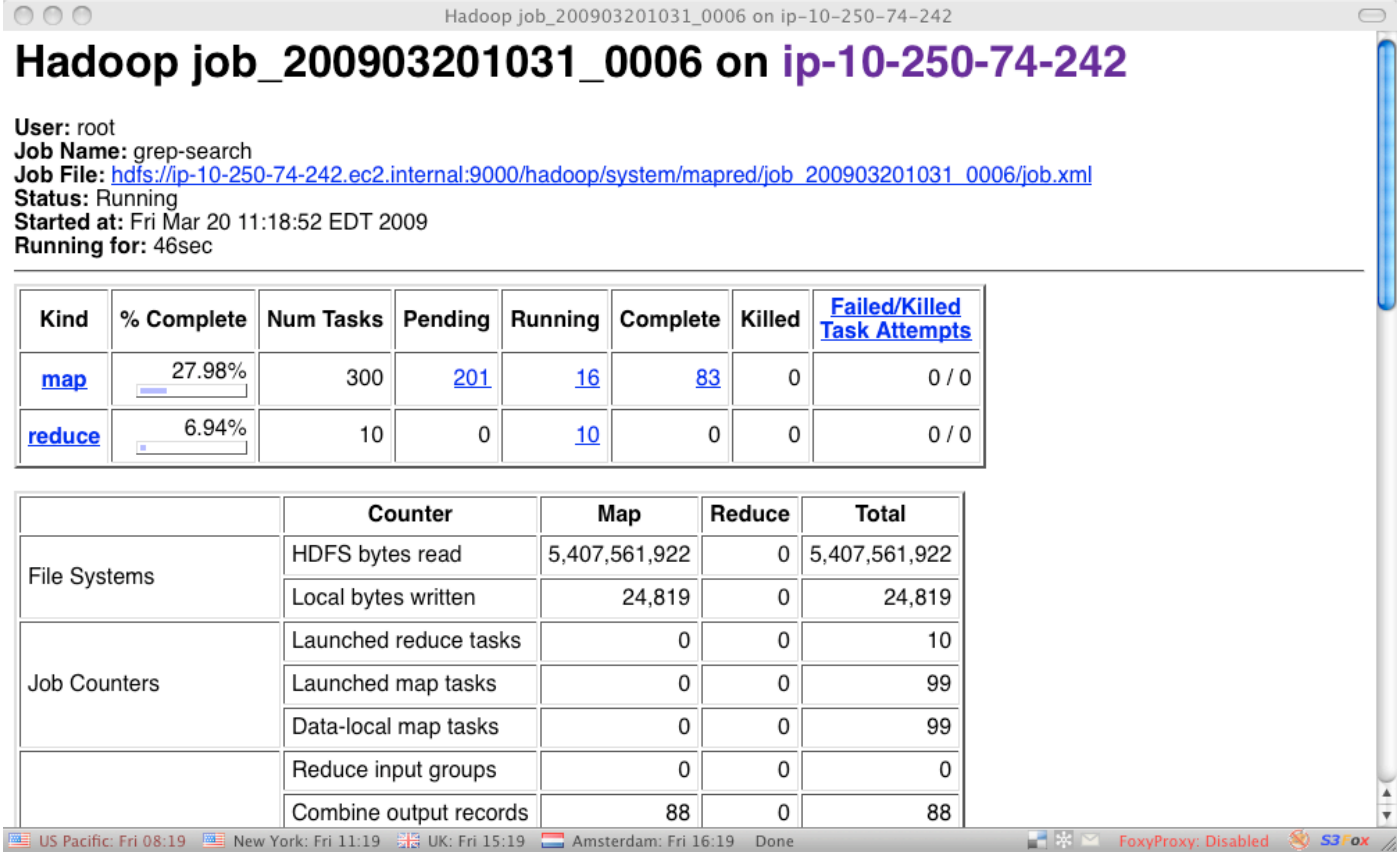
Completed Jobs								
Jobid	User	Name	Map % Complete	Map Total	Maps Completed	Reduce % Complete	Reduce Total	Reduces Completed
job_200903201031_0001	root	distcp	100.00%	75	75	100.00%	0	0

Failed Jobs

Failed Jobs
none



```
[root@ip-10-250-74-242 hadoop]# hadoop jar hadoop-0.18.3-examples.jar grep wikipedia/wiki-articles grep-out '(hadoop|pig)'
09/03/20 11:18:52 INFO mapred.FileInputFormat: Total input paths to process : 300
09/03/20 11:18:52 INFO mapred.FileInputFormat: Total input paths to process : 300
09/03/20 11:18:52 INFO mapred.JobClient: Running job: job_200903201031_0006
09/03/20 11:18:53 INFO mapred.JobClient:  map 0% reduce 0%
09/03/20 11:19:01 INFO mapred.JobClient:  map 1% reduce 0%
09/03/20 11:19:02 INFO mapred.JobClient:  map 3% reduce 0%
09/03/20 11:19:03 INFO mapred.JobClient:  map 5% reduce 0%
09/03/20 11:19:04 INFO mapred.JobClient:  map 6% reduce 0%
09/03/20 11:19:11 INFO mapred.JobClient:  map 8% reduce 0%
09/03/20 11:19:12 INFO mapred.JobClient:  map 9% reduce 0%
09/03/20 11:19:13 INFO mapred.JobClient:  map 10% reduce 0%
09/03/20 11:19:14 INFO mapred.JobClient:  map 11% reduce 0%
09/03/20 11:19:15 INFO mapred.JobClient:  map 12% reduce 0%
09/03/20 11:19:18 INFO mapred.JobClient:  map 13% reduce 0%
09/03/20 11:19:19 INFO mapred.JobClient:  map 13% reduce 1%
09/03/20 11:19:20 INFO mapred.JobClient:  map 13% reduce 2%
09/03/20 11:19:21 INFO mapred.JobClient:  map 14% reduce 2%
09/03/20 11:19:22 INFO mapred.JobClient:  map 16% reduce 3%
09/03/20 11:19:23 INFO mapred.JobClient:  map 17% reduce 3%
09/03/20 11:19:24 INFO mapred.JobClient:  map 18% reduce 3%
09/03/20 11:19:25 INFO mapred.JobClient:  map 18% reduce 4%
09/03/20 11:19:26 INFO mapred.JobClient:  map 19% reduce 4%
09/03/20 11:19:28 INFO mapred.JobClient:  map 20% reduce 4%
09/03/20 11:19:30 INFO mapred.JobClient:  map 21% reduce 4%
09/03/20 11:19:32 INFO mapred.JobClient:  map 22% reduce 5%
09/03/20 11:19:33 INFO mapred.JobClient:  map 23% reduce 5%
09/03/20 11:19:34 INFO mapred.JobClient:  map 25% reduce 5%
09/03/20 11:19:35 INFO mapred.JobClient:  map 26% reduce 5%
```

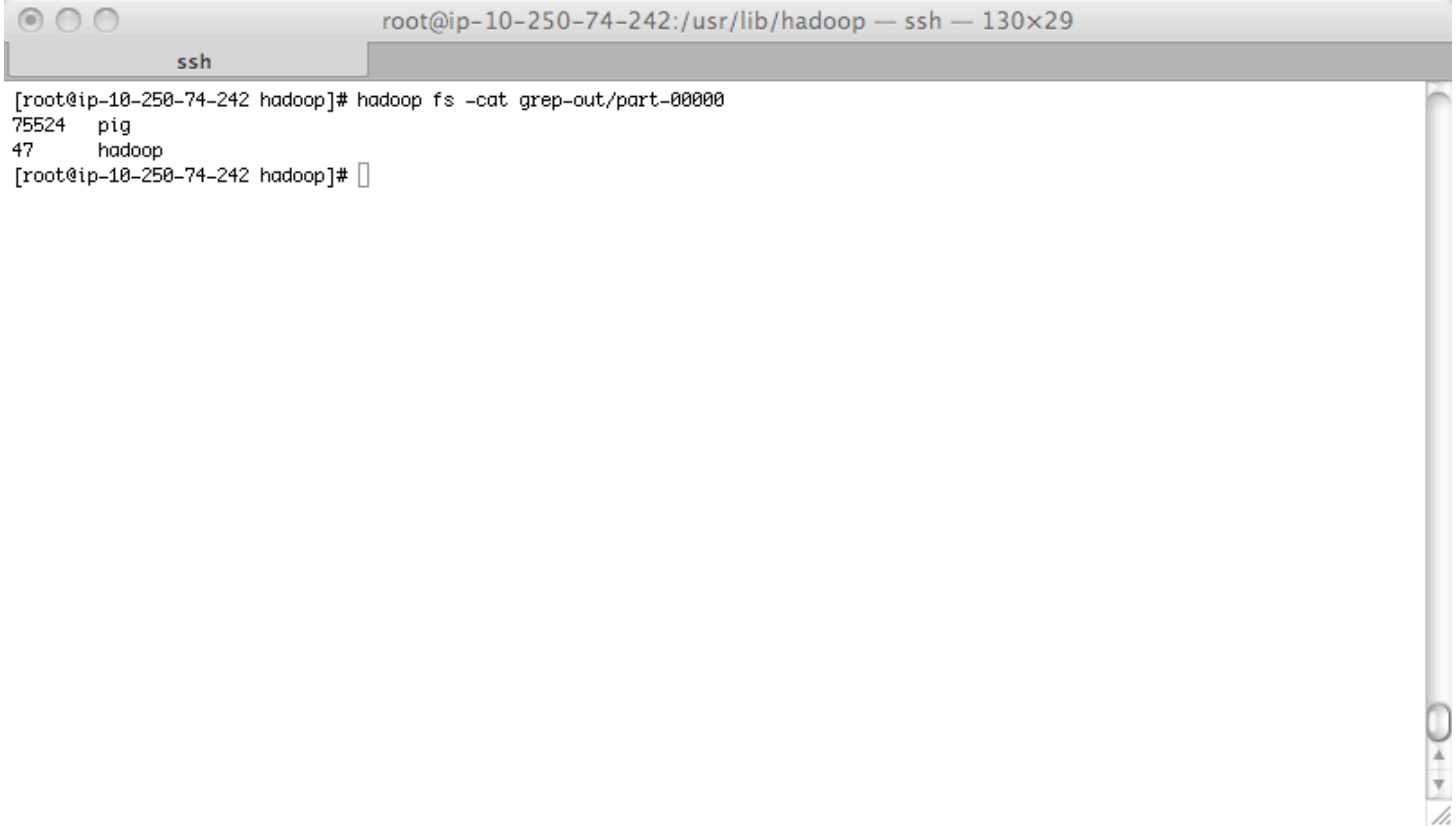


Hadoop job_200903201031_0006 on ip-10-250-74-242

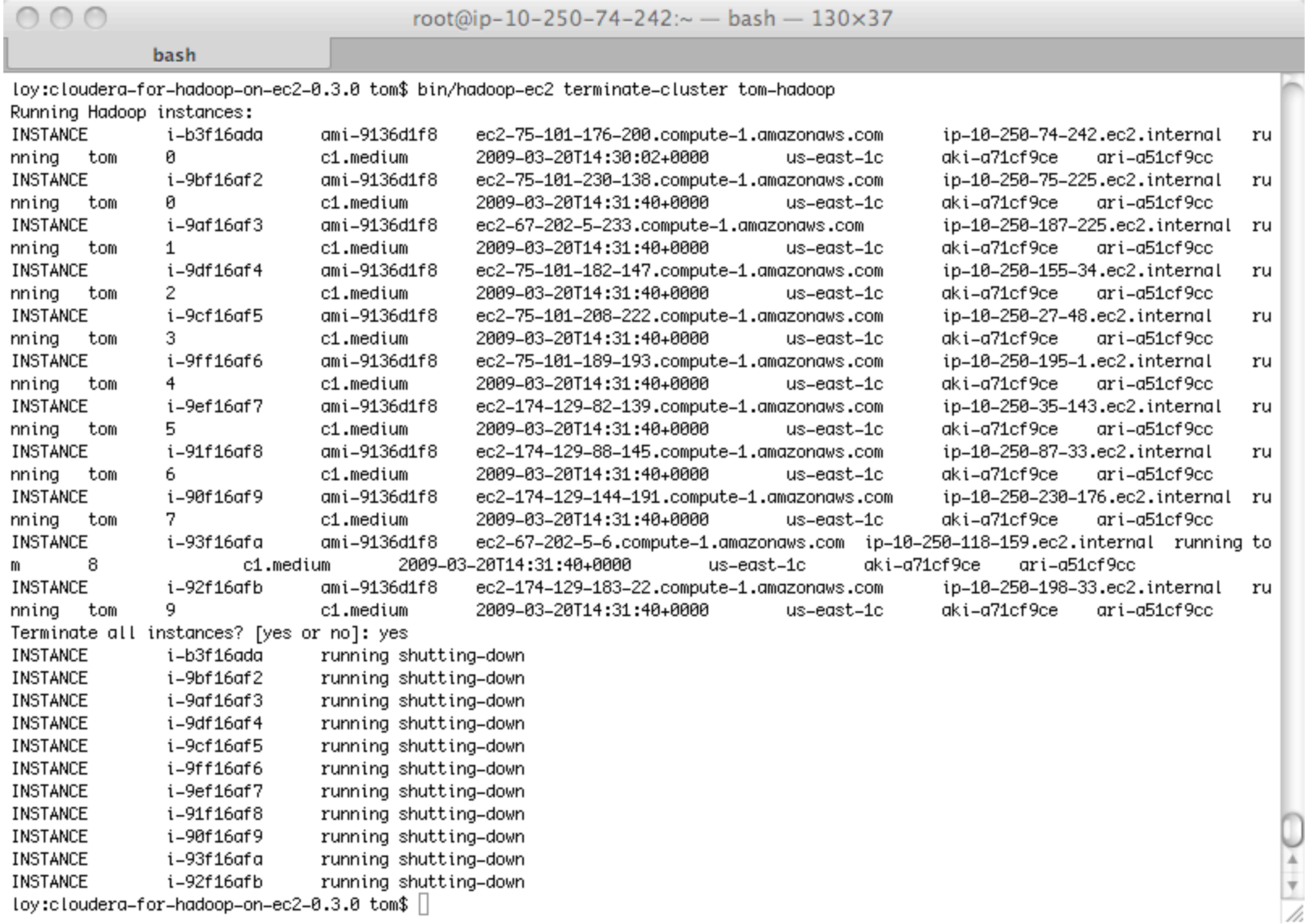
User: root
Job Name: grep-search
Job File: hdfs://ip-10-250-74-242.ec2.internal:9000/hadoop/system/mapred/job_200903201031_0006/job.xml
Status: Running
Started at: Fri Mar 20 11:18:52 EDT 2009
Running for: 46sec

Kind	% Complete	Num Tasks	Pending	Running	Complete	Killed	Failed/Killed Task Attempts
map	27.98%	300	201	16	83	0	0 / 0
reduce	6.94%	10	0	10	0	0	0 / 0

	Counter	Map	Reduce	Total
File Systems	HDFS bytes read	5,407,561,922	0	5,407,561,922
	Local bytes written	24,819	0	24,819
Job Counters	Launched reduce tasks	0	0	10
	Launched map tasks	0	0	99
	Data-local map tasks	0	0	99
	Reduce input groups	0	0	0
	Combine output records	88	0	88



```
[root@ip-10-250-74-242 hadoop]# hadoop fs -cat grep-out/part-00000
75524   pig
47      hadoop
[root@ip-10-250-74-242 hadoop]# 
```



```
loy:cloudera-for-hadoop-on-ec2-0.3.0 tom$ bin/hadoop-ec2 terminate-cluster tom-hadoop
Running Hadoop instances:
INSTANCE        i-b3f16ada      ami-9136d1f8    ec2-75-101-176-200.compute-1.amazonaws.com      ip-10-250-74-242.ec2.internal   ru
nning   tom     0               c1.medium       2009-03-20T14:30:02+0000        us-east-1c      aki-a71cf9ce    ari-a51cf9cc
INSTANCE        i-9bf16af2      ami-9136d1f8    ec2-75-101-230-138.compute-1.amazonaws.com      ip-10-250-75-225.ec2.internal   ru
nning   tom     0               c1.medium       2009-03-20T14:31:40+0000        us-east-1c      aki-a71cf9ce    ari-a51cf9cc
INSTANCE        i-9af16af3      ami-9136d1f8    ec2-67-202-5-233.compute-1.amazonaws.com        ip-10-250-187-225.ec2.internal  ru
nning   tom     1               c1.medium       2009-03-20T14:31:40+0000        us-east-1c      aki-a71cf9ce    ari-a51cf9cc
INSTANCE        i-9df16af4      ami-9136d1f8    ec2-75-101-182-147.compute-1.amazonaws.com      ip-10-250-155-34.ec2.internal   ru
nning   tom     2               c1.medium       2009-03-20T14:31:40+0000        us-east-1c      aki-a71cf9ce    ari-a51cf9cc
INSTANCE        i-9cf16af5      ami-9136d1f8    ec2-75-101-208-222.compute-1.amazonaws.com      ip-10-250-27-48.ec2.internal    ru
nning   tom     3               c1.medium       2009-03-20T14:31:40+0000        us-east-1c      aki-a71cf9ce    ari-a51cf9cc
INSTANCE        i-9ff16af6      ami-9136d1f8    ec2-75-101-189-193.compute-1.amazonaws.com      ip-10-250-195-1.ec2.internal    ru
nning   tom     4               c1.medium       2009-03-20T14:31:40+0000        us-east-1c      aki-a71cf9ce    ari-a51cf9cc
INSTANCE        i-9ef16af7      ami-9136d1f8    ec2-174-129-82-139.compute-1.amazonaws.com      ip-10-250-35-143.ec2.internal   ru
nning   tom     5               c1.medium       2009-03-20T14:31:40+0000        us-east-1c      aki-a71cf9ce    ari-a51cf9cc
INSTANCE        i-91f16af8      ami-9136d1f8    ec2-174-129-88-145.compute-1.amazonaws.com      ip-10-250-87-33.ec2.internal    ru
nning   tom     6               c1.medium       2009-03-20T14:31:40+0000        us-east-1c      aki-a71cf9ce    ari-a51cf9cc
INSTANCE        i-90f16af9      ami-9136d1f8    ec2-174-129-144-191.compute-1.amazonaws.com     ip-10-250-230-176.ec2.internal  ru
nning   tom     7               c1.medium       2009-03-20T14:31:40+0000        us-east-1c      aki-a71cf9ce    ari-a51cf9cc
INSTANCE        i-93f16afa      ami-9136d1f8    ec2-67-202-5-6.compute-1.amazonaws.com  ip-10-250-118-159.ec2.internal  running to
m       8               c1.medium       2009-03-20T14:31:40+0000        us-east-1c      aki-a71cf9ce    ari-a51cf9cc
INSTANCE        i-92f16afb      ami-9136d1f8    ec2-174-129-183-22.compute-1.amazonaws.com      ip-10-250-198-33.ec2.internal   ru
nning   tom     9               c1.medium       2009-03-20T14:31:40+0000        us-east-1c      aki-a71cf9ce    ari-a51cf9cc
Terminate all instances? [yes or no]: yes
INSTANCE        i-b3f16ada      running shutting-down
INSTANCE        i-9bf16af2      running shutting-down
INSTANCE        i-9af16af3      running shutting-down
INSTANCE        i-9df16af4      running shutting-down
INSTANCE        i-9cf16af5      running shutting-down
INSTANCE        i-9ff16af6      running shutting-down
INSTANCE        i-9ef16af7      running shutting-down
INSTANCE        i-91f16af8      running shutting-down
INSTANCE        i-90f16af9      running shutting-down
INSTANCE        i-93f16afa      running shutting-down
INSTANCE        i-92f16afb      running shutting-down
loy:cloudera-for-hadoop-on-ec2-0.3.0 tom$ 
```

Case Study

Case Study: Adknowledge

- Ad network broker www.adknowledge.com
- Already using AWS for some time
- Use Hadoop and AWS to analyze clickstream events

Adknowledge Data Flow

- Continually loading clickstream data into S3. 1TB/month (compressed).
- Daily batch jobs on a Hadoop cluster of 100 EC2 extra large instances
- Map to load data into HDFS from S3
- 9 MapReduce jobs take 3.5 hours to run
- Final result 1.5 GB (compressed) copied back to S3 before tearing down cluster

Adknowledge Lessons Learned

- 2% of EC2 instances fail. Problem if one's a namenode.
- System was not stable until Hadoop 0.18 (previously 2-3 complete failures per week)
- Error handling between dependent jobs is not robust
  - Hadoop Workflow System (HADOOP-5303) will improve this

Future

- Hadoop on EBS
- Use a hybrid local disk/EBS storage model
  - 1 replica on EBS, 2 local
- Share HDFS clusters
  - Use EBS snapshot facility
  - Like Amazon Public Datasets but for HDFS
- Hadoop on more cloud providers

Questions

- Apache Hadoop on EC2 and S3
  - http://wiki.apache.org/hadoop/AmazonEC2
  - http://wiki.apache.org/hadoop/AmazonS3
- Cloudera's Distribution for Hadoop
  - http://www.cloudera.com/hadoop
  - http://www.cloudera.com/community-support
- Tom White
  - tomwhite@apache.org
  - tom@cloudera.com