Large scale PCAP Analysis Using Apache Hadoop

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We do big data …

- K-root (15.000 qps)
  - 1.5TB of compressed PCAP data every month
  - And that is only queries
- F-reverse (6.000 qps)
- AS112 (2.000 qps)
- Auth DNS (26.000 qps)
- RIS (BGP updates from back in 2000 onwards)
- You get the idea …

Why not libtrace, PacketQ, <you name it>

- Vertical scaling does not work for terabytes of data

- Running those tools in parallel is hard
  - This is what Hadoop is good at

What is HDFS?

- Open-source implementation of Google Filesystem (GFS) as detailed in a whitepaper
  - http://labs.google.com/papers/gfs-sosp2003.pdf

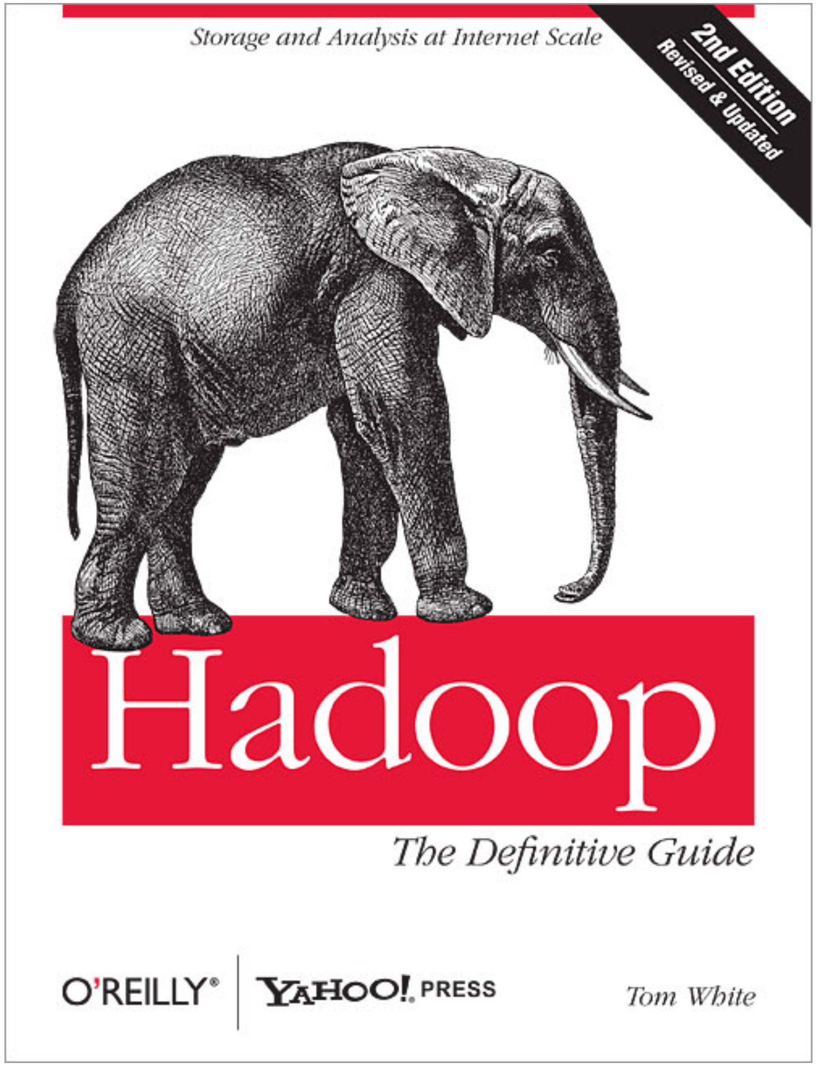
- Hadoop Distributed Filesystem (HDFS)
  - Namenode holding filesystem registry
  - Datanodes holding filesystem blocks

What is MapReduce?

- Another whitepaper from Google:
  - http://labs.google.com/papers/mapreduce-osdi04.pdf

- Essentially: A programming pattern
  - Allows distribution of large computational tasks

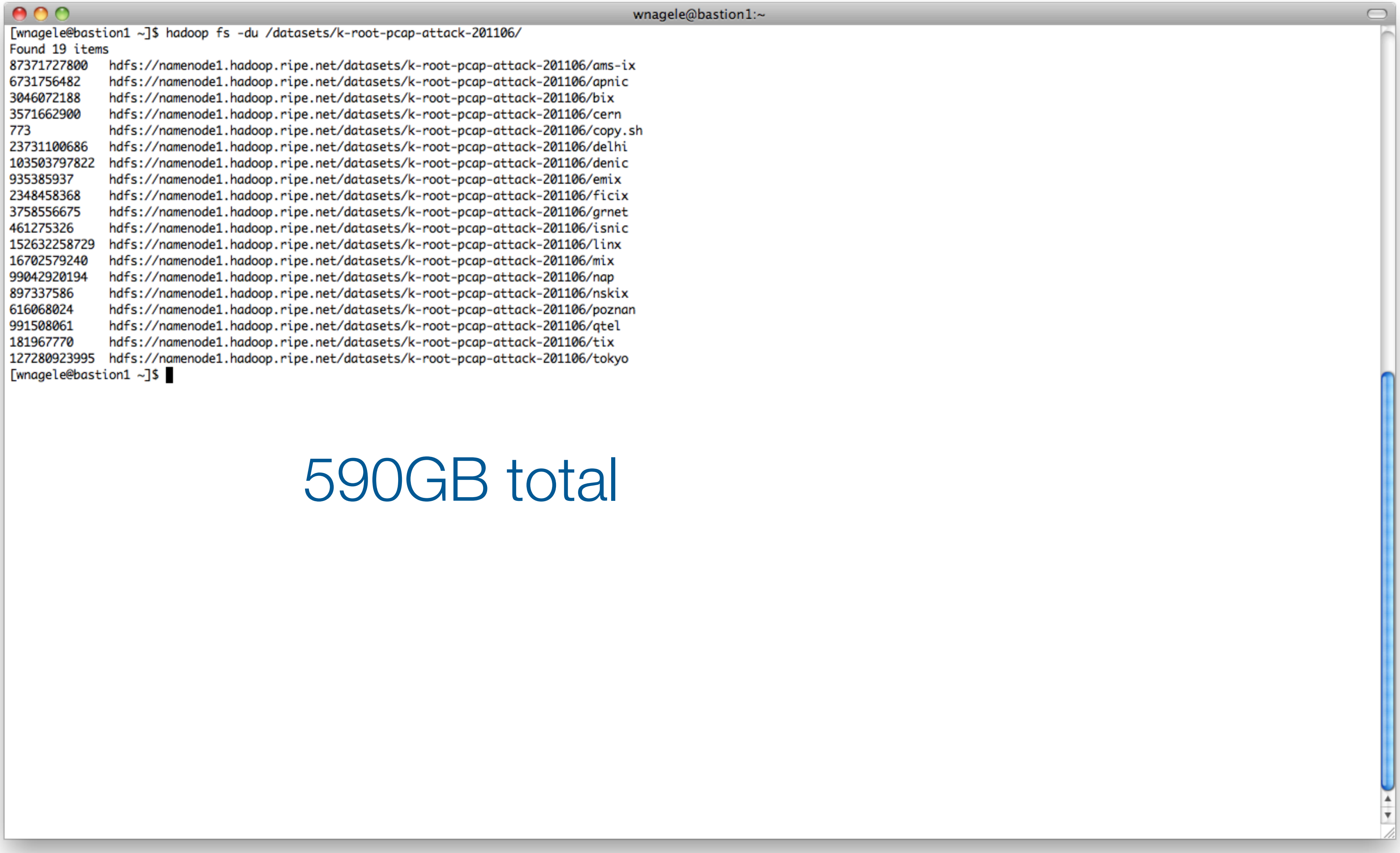
Start with a good read …



Native PCAP reading in Java

- Open source under the LGPL
- Available at: http://github.com/RIPE-NCC/hadoop-pcap

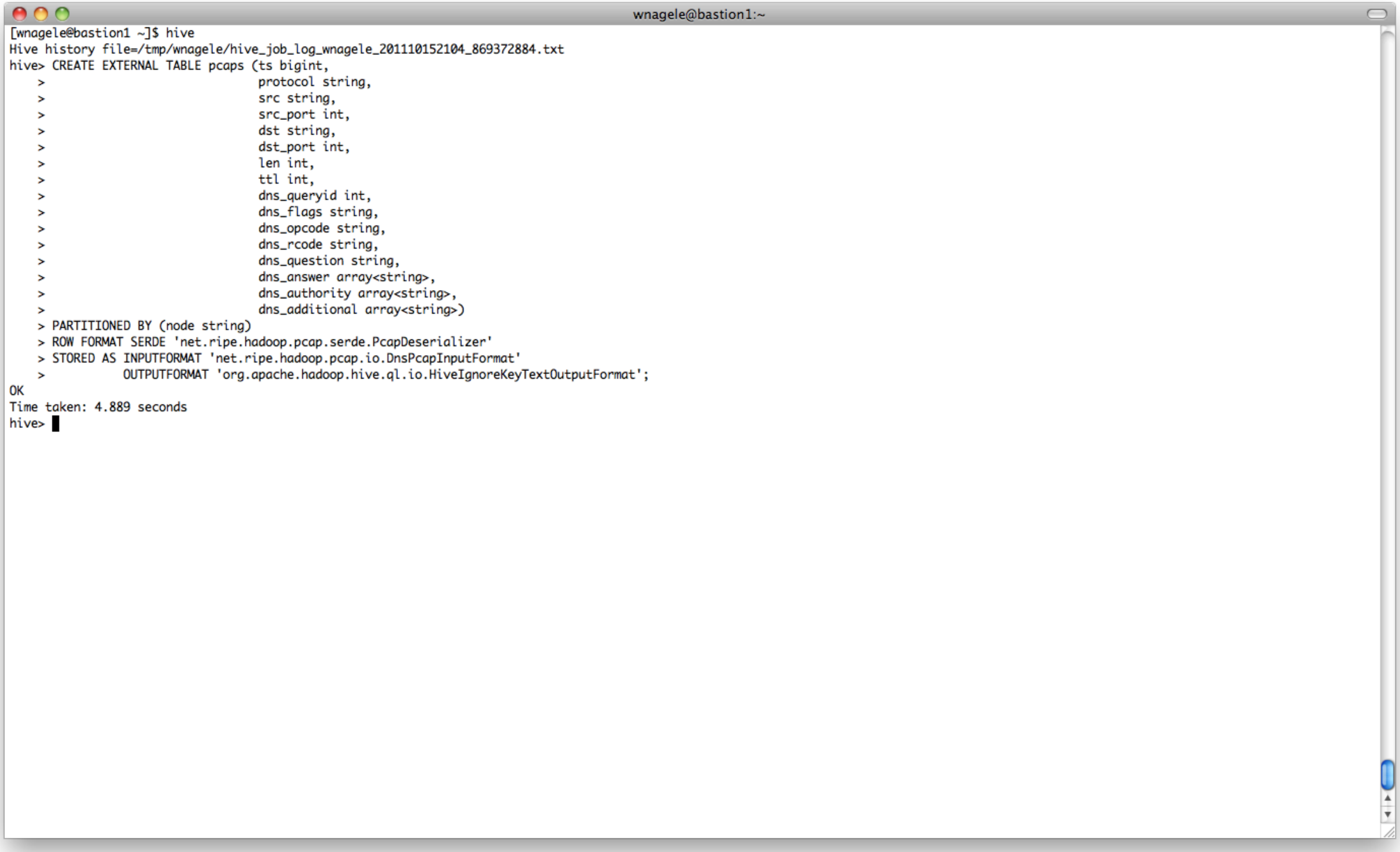
Live Demo: The data



```
[wnagele@bastion1 ~]$ hadoop fs -du /datasets/k-root-pcap-attack-201106/
Found 19 items
87371727800   hdfs://namenode1.hadoop.ripe.net/datasets/k-root-pcap-attack-201106/ams-ix
6731756482    hdfs://namenode1.hadoop.ripe.net/datasets/k-root-pcap-attack-201106/apnic
3046072188    hdfs://namenode1.hadoop.ripe.net/datasets/k-root-pcap-attack-201106/bix
3571662900    hdfs://namenode1.hadoop.ripe.net/datasets/k-root-pcap-attack-201106/cern
773           hdfs://namenode1.hadoop.ripe.net/datasets/k-root-pcap-attack-201106/copy.sh
23731100686   hdfs://namenode1.hadoop.ripe.net/datasets/k-root-pcap-attack-201106/delhi
103503797822  hdfs://namenode1.hadoop.ripe.net/datasets/k-root-pcap-attack-201106/denic
935385937     hdfs://namenode1.hadoop.ripe.net/datasets/k-root-pcap-attack-201106/emix
2348458368    hdfs://namenode1.hadoop.ripe.net/datasets/k-root-pcap-attack-201106/ficix
3758556675    hdfs://namenode1.hadoop.ripe.net/datasets/k-root-pcap-attack-201106/grnet
461275326     hdfs://namenode1.hadoop.ripe.net/datasets/k-root-pcap-attack-201106/isnic
152632258729  hdfs://namenode1.hadoop.ripe.net/datasets/k-root-pcap-attack-201106/linx
16702579240   hdfs://namenode1.hadoop.ripe.net/datasets/k-root-pcap-attack-201106/mix
99042920194   hdfs://namenode1.hadoop.ripe.net/datasets/k-root-pcap-attack-201106/nap
897337586     hdfs://namenode1.hadoop.ripe.net/datasets/k-root-pcap-attack-201106/nskix
616068024     hdfs://namenode1.hadoop.ripe.net/datasets/k-root-pcap-attack-201106/poznan
991508061     hdfs://namenode1.hadoop.ripe.net/datasets/k-root-pcap-attack-201106/qtel
181967770     hdfs://namenode1.hadoop.ripe.net/datasets/k-root-pcap-attack-201106/tix
127280923995  hdfs://namenode1.hadoop.ripe.net/datasets/k-root-pcap-attack-201106/tokyo
[wnagele@bastion1 ~]$ █
```

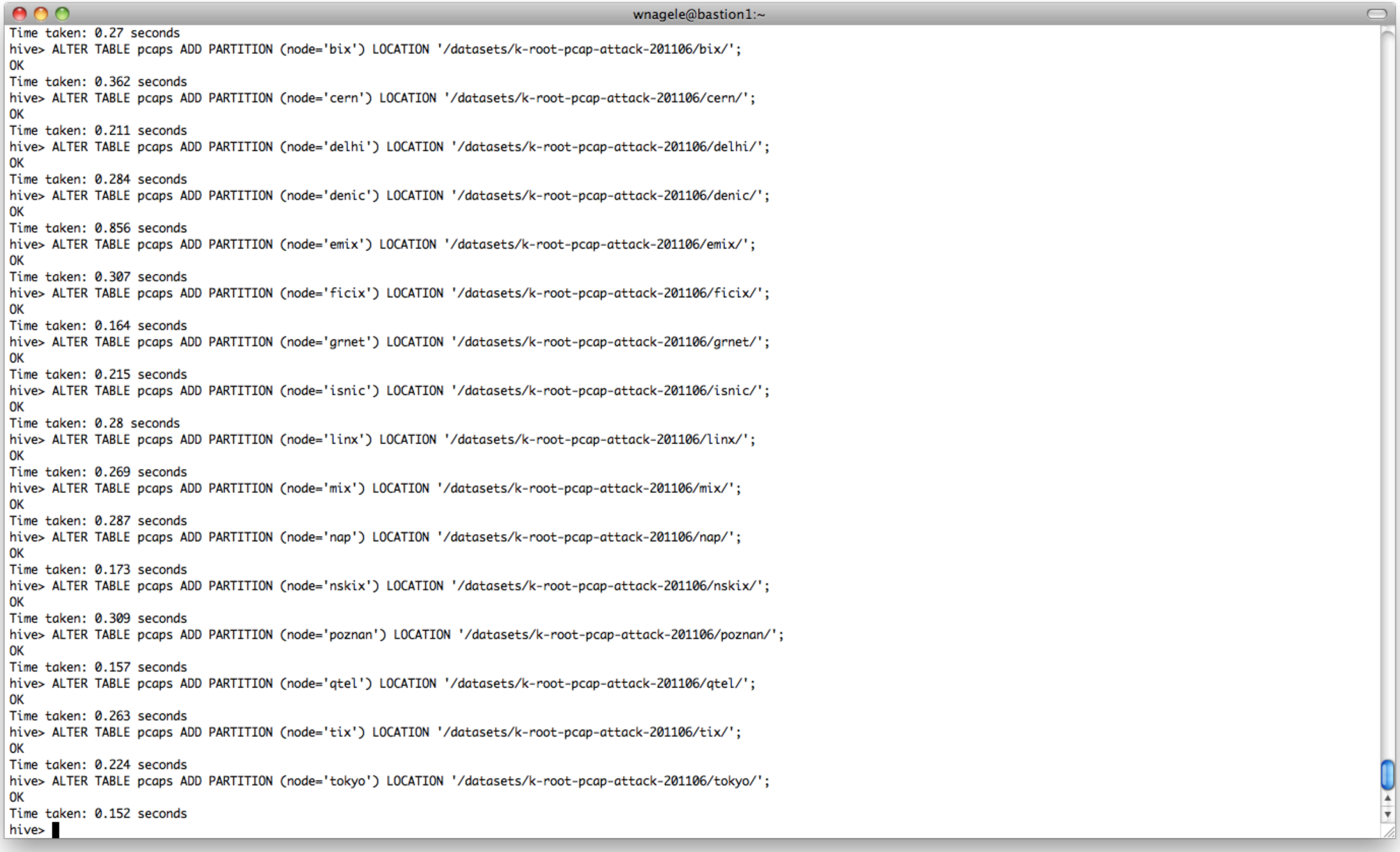
590GB total

Live Demo: Create table



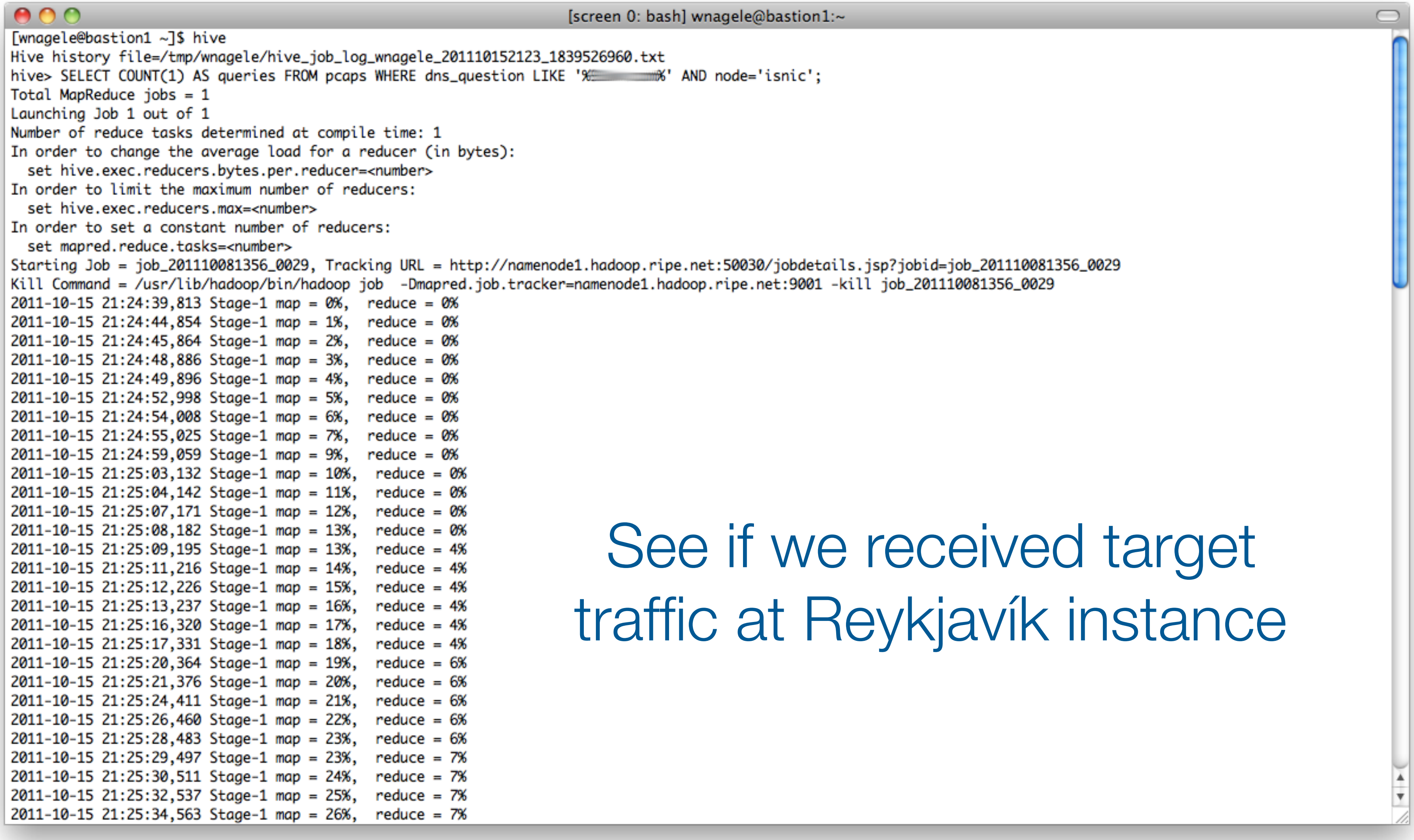
```
[wnagele@bastion1 ~]$ hive
Hive history file=/tmp/wnagele/hive_job_log_wnagele_201110152104_869372884.txt
hive> CREATE EXTERNAL TABLE pcaps (ts bigint,
    >                             protocol string,
    >                             src string,
    >                             src_port int,
    >                             dst string,
    >                             dst_port int,
    >                             len int,
    >                             ttl int,
    >                             dns_queryid int,
    >                             dns_flags string,
    >                             dns_opcode string,
    >                             dns_rcode string,
    >                             dns_question string,
    >                             dns_answer array<string>,
    >                             dns_authority array<string>,
    >                             dns_additional array<string>)
    > PARTITIONED BY (node string)
    > ROW FORMAT SERDE 'net.ripe.hadoop.pcap.serde.PcapDeserializer'
    > STORED AS INPUTFORMAT 'net.ripe.hadoop.pcap.io.DnsPcapInputFormat'
    >           OUTPUTFORMAT 'org.apache.hadoop.hive.ql.io.HiveIgnoreKeyTextOutputFormat';
OK
Time taken: 4.889 seconds
hive> 
```

Live Demo: Add partitions



```
Time taken: 0.27 seconds
hive> ALTER TABLE pcaps ADD PARTITION (node='bix') LOCATION '/datasets/k-root-pcap-attack-201106/bix/';
OK
Time taken: 0.362 seconds
hive> ALTER TABLE pcaps ADD PARTITION (node='cern') LOCATION '/datasets/k-root-pcap-attack-201106/cern/';
OK
Time taken: 0.211 seconds
hive> ALTER TABLE pcaps ADD PARTITION (node='delhi') LOCATION '/datasets/k-root-pcap-attack-201106/delhi/';
OK
Time taken: 0.284 seconds
hive> ALTER TABLE pcaps ADD PARTITION (node='denic') LOCATION '/datasets/k-root-pcap-attack-201106/denic/';
OK
Time taken: 0.856 seconds
hive> ALTER TABLE pcaps ADD PARTITION (node='emix') LOCATION '/datasets/k-root-pcap-attack-201106/emix/';
OK
Time taken: 0.307 seconds
hive> ALTER TABLE pcaps ADD PARTITION (node='ficix') LOCATION '/datasets/k-root-pcap-attack-201106/ficix/';
OK
Time taken: 0.164 seconds
hive> ALTER TABLE pcaps ADD PARTITION (node='grnet') LOCATION '/datasets/k-root-pcap-attack-201106/grnet/';
OK
Time taken: 0.215 seconds
hive> ALTER TABLE pcaps ADD PARTITION (node='isnic') LOCATION '/datasets/k-root-pcap-attack-201106/isnic/';
OK
Time taken: 0.28 seconds
hive> ALTER TABLE pcaps ADD PARTITION (node='linx') LOCATION '/datasets/k-root-pcap-attack-201106/linx/';
OK
Time taken: 0.269 seconds
hive> ALTER TABLE pcaps ADD PARTITION (node='mix') LOCATION '/datasets/k-root-pcap-attack-201106/mix/';
OK
Time taken: 0.287 seconds
hive> ALTER TABLE pcaps ADD PARTITION (node='nap') LOCATION '/datasets/k-root-pcap-attack-201106/nap/';
OK
Time taken: 0.173 seconds
hive> ALTER TABLE pcaps ADD PARTITION (node='nskix') LOCATION '/datasets/k-root-pcap-attack-201106/nskix/';
OK
Time taken: 0.309 seconds
hive> ALTER TABLE pcaps ADD PARTITION (node='poznan') LOCATION '/datasets/k-root-pcap-attack-201106/poznan/';
OK
Time taken: 0.157 seconds
hive> ALTER TABLE pcaps ADD PARTITION (node='qtel') LOCATION '/datasets/k-root-pcap-attack-201106/qtel/';
OK
Time taken: 0.263 seconds
hive> ALTER TABLE pcaps ADD PARTITION (node='tix') LOCATION '/datasets/k-root-pcap-attack-201106/tix/';
OK
Time taken: 0.224 seconds
hive> ALTER TABLE pcaps ADD PARTITION (node='tokyo') LOCATION '/datasets/k-root-pcap-attack-201106/tokyo/';
OK
Time taken: 0.152 seconds
hive> █
```

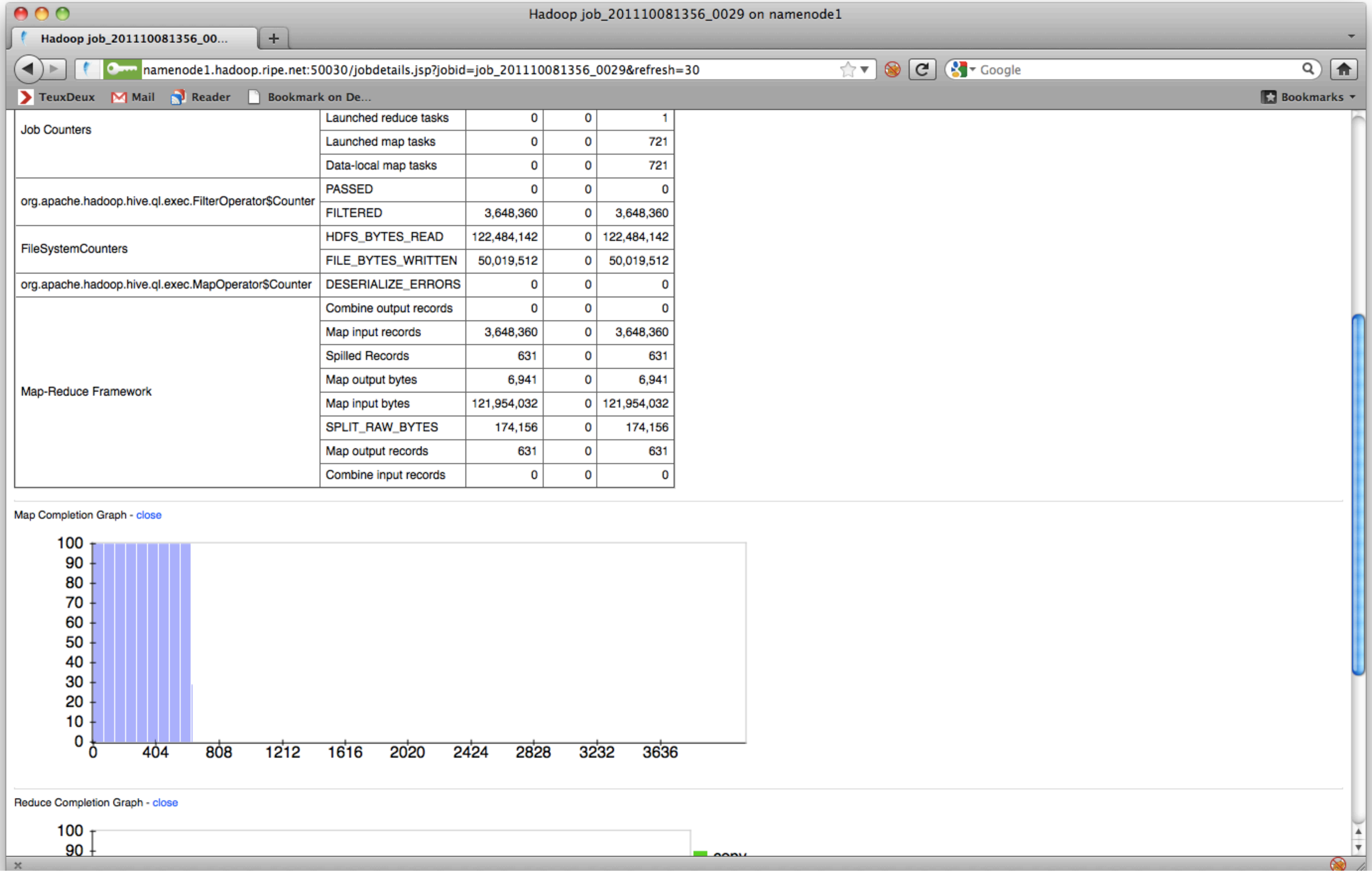
Live Demo: Run query



```
[wnagele@bastion1 ~]$ hive
Hive history file=/tmp/wnagele/hive_job_log_wnagele_201110152123_1839526960.txt
hive> SELECT COUNT(1) AS queries FROM pcaps WHERE dns_question LIKE '%[redacted]%' AND node='isnic';
Total MapReduce jobs = 1
Launching Job 1 out of 1
Number of reduce tasks determined at compile time: 1
In order to change the average load for a reducer (in bytes):
  set hive.exec.reducers.bytes.per.reducer=<number>
In order to limit the maximum number of reducers:
  set hive.exec.reducers.max=<number>
In order to set a constant number of reducers:
  set mapred.reduce.tasks=<number>
Starting Job = job_201110081356_0029, Tracking URL = http://namenode1.hadoop.ripe.net:50030/jobdetails.jsp?jobid=job_201110081356_0029
Kill Command = /usr/lib/hadoop/bin/hadoop job  -Dmapred.job.tracker=namenode1.hadoop.ripe.net:9001 -kill job_201110081356_0029
2011-10-15 21:24:39,813 Stage-1 map = 0%,  reduce = 0%
2011-10-15 21:24:44,854 Stage-1 map = 1%,  reduce = 0%
2011-10-15 21:24:45,864 Stage-1 map = 2%,  reduce = 0%
2011-10-15 21:24:48,886 Stage-1 map = 3%,  reduce = 0%
2011-10-15 21:24:49,896 Stage-1 map = 4%,  reduce = 0%
2011-10-15 21:24:52,998 Stage-1 map = 5%,  reduce = 0%
2011-10-15 21:24:54,008 Stage-1 map = 6%,  reduce = 0%
2011-10-15 21:24:55,025 Stage-1 map = 7%,  reduce = 0%
2011-10-15 21:24:59,059 Stage-1 map = 9%,  reduce = 0%
2011-10-15 21:25:03,132 Stage-1 map = 10%,  reduce = 0%
2011-10-15 21:25:04,142 Stage-1 map = 11%,  reduce = 0%
2011-10-15 21:25:07,171 Stage-1 map = 12%,  reduce = 0%
2011-10-15 21:25:08,182 Stage-1 map = 13%,  reduce = 0%
2011-10-15 21:25:09,195 Stage-1 map = 13%,  reduce = 4%
2011-10-15 21:25:11,216 Stage-1 map = 14%,  reduce = 4%
2011-10-15 21:25:12,226 Stage-1 map = 15%,  reduce = 4%
2011-10-15 21:25:13,237 Stage-1 map = 16%,  reduce = 4%
2011-10-15 21:25:16,320 Stage-1 map = 17%,  reduce = 4%
2011-10-15 21:25:17,331 Stage-1 map = 18%,  reduce = 4%
2011-10-15 21:25:20,364 Stage-1 map = 19%,  reduce = 6%
2011-10-15 21:25:21,376 Stage-1 map = 20%,  reduce = 6%
2011-10-15 21:25:24,411 Stage-1 map = 21%,  reduce = 6%
2011-10-15 21:25:26,460 Stage-1 map = 22%,  reduce = 6%
2011-10-15 21:25:28,483 Stage-1 map = 23%,  reduce = 6%
2011-10-15 21:25:29,497 Stage-1 map = 23%,  reduce = 7%
2011-10-15 21:25:30,511 Stage-1 map = 24%,  reduce = 7%
2011-10-15 21:25:32,537 Stage-1 map = 25%,  reduce = 7%
2011-10-15 21:25:34,563 Stage-1 map = 26%,  reduce = 7%
```

See if we received target traffic at Reykjavík instance

Live Demo: Query in progress



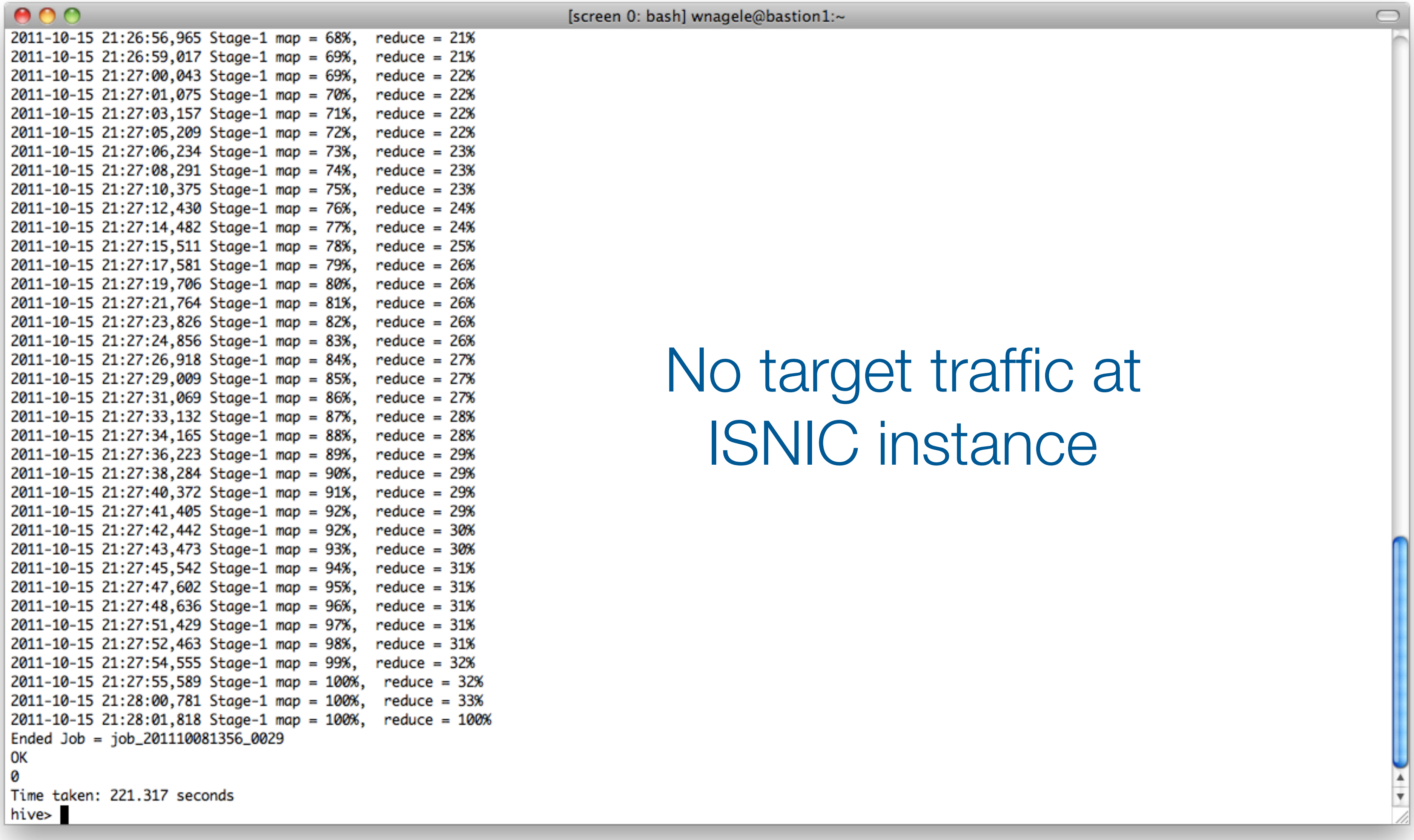
Hadoop job_201110081356_0029 on namenode1
Hadoop job_201110081356_00...
namenode1.hadoop.ripe.net:50030/jobdetails.jsp?jobid=job_201110081356_0029&refresh=30
Google
TeuxDeux
Mail
Reader
Bookmark on De...
Bookmarks

Job Counters	Launched reduce tasks	0	0	1
	Launched map tasks	0	0	721
	Data-local map tasks	0	0	721
org.apache.hadoop.hive.ql.exec.FilterOperator$Counter	PASSED	0	0	0
	FILTERED	3,648,360	0	3,648,360
FileSystemCounters	HDFS_BYTES_READ	122,484,142	0	122,484,142
	FILE_BYTES_WRITTEN	50,019,512	0	50,019,512
org.apache.hadoop.hive.ql.exec.MapOperator$Counter	DESERIALIZE_ERRORS	0	0	0
Map-Reduce Framework	Combine output records	0	0	0
	Map input records	3,648,360	0	3,648,360
	Spilled Records	631	0	631
	Map output bytes	6,941	0	6,941
	Map input bytes	121,954,032	0	121,954,032
	SPLIT_RAW_BYTES	174,156	0	174,156
	Map output records	631	0	631
	Combine input records	0	0	0

Map Completion Graph - close

Reduce Completion Graph - close

Live Demo: Result



```
2011-10-15 21:26:56,965 Stage-1 map = 68%,  reduce = 21%
2011-10-15 21:26:59,017 Stage-1 map = 69%,  reduce = 21%
2011-10-15 21:27:00,043 Stage-1 map = 69%,  reduce = 22%
2011-10-15 21:27:01,075 Stage-1 map = 70%,  reduce = 22%
2011-10-15 21:27:03,157 Stage-1 map = 71%,  reduce = 22%
2011-10-15 21:27:05,209 Stage-1 map = 72%,  reduce = 22%
2011-10-15 21:27:06,234 Stage-1 map = 73%,  reduce = 23%
2011-10-15 21:27:08,291 Stage-1 map = 74%,  reduce = 23%
2011-10-15 21:27:10,375 Stage-1 map = 75%,  reduce = 23%
2011-10-15 21:27:12,430 Stage-1 map = 76%,  reduce = 24%
2011-10-15 21:27:14,482 Stage-1 map = 77%,  reduce = 24%
2011-10-15 21:27:15,511 Stage-1 map = 78%,  reduce = 25%
2011-10-15 21:27:17,581 Stage-1 map = 79%,  reduce = 26%
2011-10-15 21:27:19,706 Stage-1 map = 80%,  reduce = 26%
2011-10-15 21:27:21,764 Stage-1 map = 81%,  reduce = 26%
2011-10-15 21:27:23,826 Stage-1 map = 82%,  reduce = 26%
2011-10-15 21:27:24,856 Stage-1 map = 83%,  reduce = 26%
2011-10-15 21:27:26,918 Stage-1 map = 84%,  reduce = 27%
2011-10-15 21:27:29,009 Stage-1 map = 85%,  reduce = 27%
2011-10-15 21:27:31,069 Stage-1 map = 86%,  reduce = 27%
2011-10-15 21:27:33,132 Stage-1 map = 87%,  reduce = 28%
2011-10-15 21:27:34,165 Stage-1 map = 88%,  reduce = 28%
2011-10-15 21:27:36,223 Stage-1 map = 89%,  reduce = 29%
2011-10-15 21:27:38,284 Stage-1 map = 90%,  reduce = 29%
2011-10-15 21:27:40,372 Stage-1 map = 91%,  reduce = 29%
2011-10-15 21:27:41,405 Stage-1 map = 92%,  reduce = 29%
2011-10-15 21:27:42,442 Stage-1 map = 92%,  reduce = 30%
2011-10-15 21:27:43,473 Stage-1 map = 93%,  reduce = 30%
2011-10-15 21:27:45,542 Stage-1 map = 94%,  reduce = 31%
2011-10-15 21:27:47,602 Stage-1 map = 95%,  reduce = 31%
2011-10-15 21:27:48,636 Stage-1 map = 96%,  reduce = 31%
2011-10-15 21:27:51,429 Stage-1 map = 97%,  reduce = 31%
2011-10-15 21:27:52,463 Stage-1 map = 98%,  reduce = 31%
2011-10-15 21:27:54,555 Stage-1 map = 99%,  reduce = 32%
2011-10-15 21:27:55,589 Stage-1 map = 100%,  reduce = 32%
2011-10-15 21:28:00,781 Stage-1 map = 100%,  reduce = 33%
2011-10-15 21:28:01,818 Stage-1 map = 100%,  reduce = 100%
Ended Job = job_201110081356_0029
OK
0
Time taken: 221.317 seconds
hive> 
```

No target traffic at ISNIC instance

Live Demo: Conclusions

- Works well at scale
  - 100+ CPU cores
- High processing overhead
  - Example took 200 seconds total
  - Only 50% of it spent on actual computation
  - Small input files (only 500MB total)
  - See Screencast – 80GB in 3 minutes

Step by Step Screencast

- Zero setup using Amazon EC2

http://goo.gl/8uvlX

Questions?

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