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CS47300: Web Information Search and Management

Scaling

Prof. Chris Clifton

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(Some material from Yahoo!, Berkeley Spark project)

Introduction to Hadoop

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Problem

- How do you scale up applications?
  - Run jobs processing 100's of terabytes of data
  - Takes 11 days to read on 1 computer
- Need lots of cheap computers
  - Fixes speed problem (15 minutes on 1000 computers), but…
  - Reliability problems
    - In large clusters, computers fail every day
    - Cluster size is not fixed
- Need common infrastructure
  - Must be efficient and reliable

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Solution

- Open Source Apache Project
- Hadoop Core includes:
  - Distributed File System - distributes data
  - Map/Reduce - distributes application
- Written in Java
- Runs on
  - Linux, Mac OS/X, Windows, and Solaris
  - Commodity hardware

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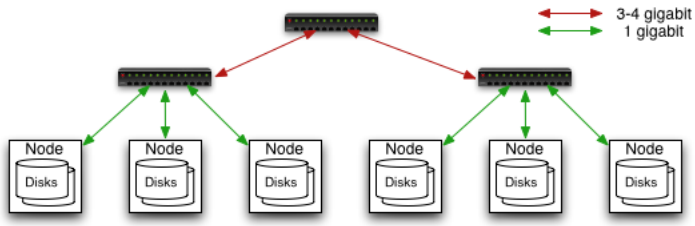
Commodity Hardware Cluster



- Typically in 2 level architecture
  - Nodes are commodity PCs
  - 40 nodes/rack
  - Uplink from rack is 8 gigabit
  - Rack-internal is 1 gigabit

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Distributed File System

- Single namespace for entire cluster
  - Managed by a single *namenode*.
  - Files are single-writer and append-only.
  - Optimized for streaming reads of large files.
- Files are broken in to large blocks.
  - Typically 128 MB
  - Replicated to several *datanodes*, for reliability
- Client talks to both namenode and datanodes
  - Data is not sent through the namenode.
  - Throughput of file system scales nearly linearly with the number of nodes.
- Access from Java, C, or command line.

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Running Production WebMap

- Search needs a graph of the “known” web
  - Invert edges, compute link text, whole graph heuristics
- Periodic batch job using Map/Reduce
  - Uses a chain of ~100 map/reduce jobs
- Scale
  - 1 trillion edges in graph
  - Largest shuffle is 450 TB
  - Final output is 300 TB compressed
  - Runs on 10,000 cores
  - Raw disk used 5 PB
- Written mostly using Hadoop’s C++ interface

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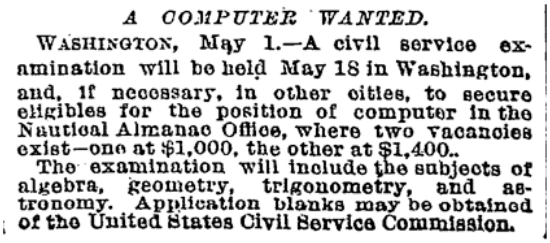
NY Times

- Needed offline conversion of public domain articles from 1851-1922.
- Used Hadoop to convert scanned images to PDF
- Ran 100 Amazon EC2 instances for around 24 hours
- 4 TB of input
- 1.5 TB of output



A COMPUTER WANTED.

WASHINGTON, May 1.—A civil service examination will be held May 18 in Washington, and, if necessary, in other cities, to secure eligibles for the position of computer in the Nautical Almanac Office, where two vacancies exist—one at $1,000, the other at $1,400.

The examination will include the subjects of algebra, geometry, trigonometry, and astronomy. Application blanks may be obtained of the United States Civil Service Commission.

Published 1892, copyright New York Times

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Hadoop Community

- Apache is focused on project communities
  - Users
  - Contributors
    - write patches
  - Committers
    - can commit patches too
  - Project Management Committee
    - vote on new committers and releases too
- Apache is a meritocracy
- Use, contribution, and diversity is growing
  - But we need and want more!

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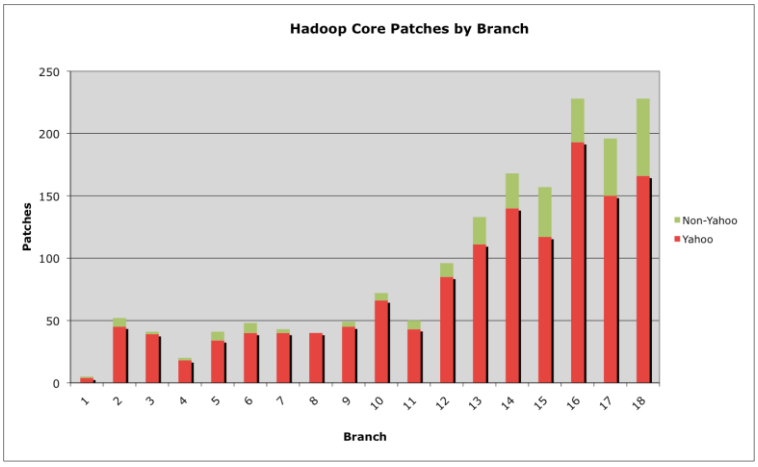
Size of Releases



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Who Uses Hadoop?

- Amazon/A9
- AOL
- Facebook
- Fox interactive media
- Google / IBM
- New York Times
- PowerSet (now Microsoft)
- Quantcast
- Rackspace/Mailtrust
- Veoh
- Yahoo!
- More at http://wiki.apache.org/hadoop/PoweredBy

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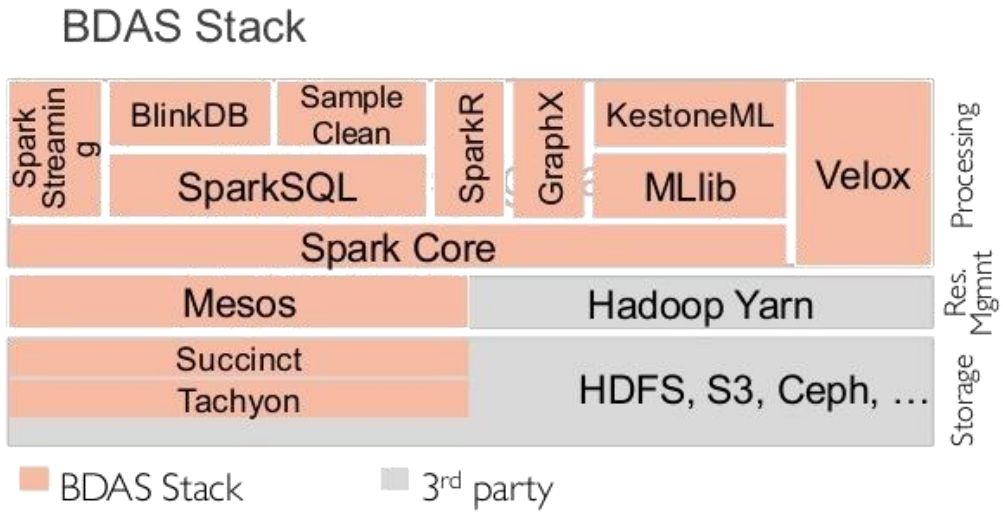
Spark: Another Implementation of this Programming Model



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Select word, count(*) from doc group by word;

```
public class WordCount {
public static class Map 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 {
        String line = value.toString();
        StringTokenizer tokenizer = new StringTokenizer(line);
        while (tokenizer.hasMoreTokens()) {
                word.set(tokenizer.nextToken());
                output.collect(word, one);
                }
        }
}
```

```
public static class Reduce extends
MapReduceBase implements Reducer<Text,
IntWritable, Text, 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();
        }
        output.collect(key, new IntWritable(sum));
}
}
```


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Select word, count(*) from doc group by word;

```
public static void main(String[] args) throws Exception {
        JobConf conf = new JobConf(WordCount.class);
        conf.setJobName("wordcount");
        conf.setOutputKeyClass(Text.class);
        conf.setOutputValueClass(IntWritable.class);
        conf.setMapperClass(Map.class);
        conf.setCombinerClass(Reduce.class);
        conf.setReducerClass(Reduce.class);
        conf.setInputFormat(TextInputFormat.class);
        conf.setOutputFormat(TextOutputFormat.class);
        FileInputFormat.setInputPaths(conf, new Path(args[0]));
        FileOutputFormat.setOutputPath(conf, new Path(args[1]));
        JobClient.runJob(conf);
}
}
```


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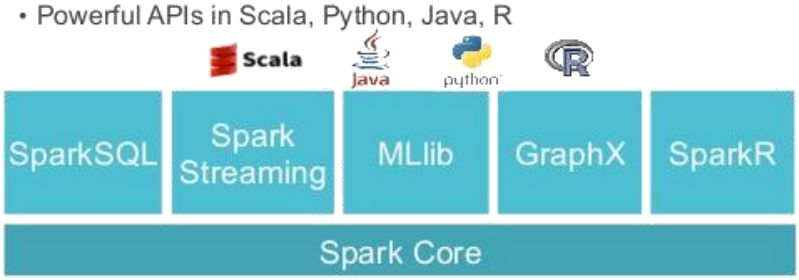
Spark Applications

Spark

Unifies ***batch, interactive, streaming*** computations

Easy to build sophisticated applications

- Support iterative, graph-parallel algorithms
- Powerful APIs in Scala, Python, Java, R



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Spark 101

- Apache Spark
  - Open Source
  - Extensive developer community
  - Growing commercial use
- Somewhat heavy to set up
  - *First, you need a cloud…*

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Creating a Data Object

```
>>> sc
<pyspark.context.SparkContext object at 0x10ea7d4d0>
>>> pagecounts = sc.textFile("data/pagecounts")
>>> pagecounts
MapPartitionsRDD[1] at textFile at NativeMethodAccessorImpl.java:-2
```

- *Assume data/pagecounts is pageviews of Wikipedia pages*

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Viewing Data (first 10 records)

```
>>> pagecounts.take(10)
...
[u'20090505-000000 aa.b ?71G4Bo1cAdWyg 1 14463', u'20090505-000000 aa.b
Special:Statistics 1 840', u'20090505-000000 aa.b Special:Whatlinkshere/MediaWiki:Returnto 1
1019', u'20090505-000000 aa.b Wikibooks:About 1 15719', u'20090505-000000 aa
?14mFX1ildVnBc 1 13205', u'20090505-000000 aa ?53A%2FuYP3FfnKM 1 13207',
u'20090505-000000 aa ?93HqrnFc%2EiqRU 1 13199', u'20090505-000000 aa
?95iZ%2Fjuimv31g 1 13201', u'20090505-000000 aa File:Wikinews-logo.svg 1 8357',
u'20090505-000000 aa Main_Page 2 9980']
```


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Prettier:

```
>>> for x in pagecounts.take(10):
...   print x
...
20090505-000000 aa.b ?71G4Bo1cAdWyg 1 14463
20090505-000000 aa.b Special:Statistics 1 840
20090505-000000 aa.b Special:Whatlinkshere/MediaWiki:Returnto 1 1019
20090505-000000 aa.b Wikibooks:About 1 15719
20090505-000000 aa ?14mFX1ildVnBc 1 13205
20090505-000000 aa ?53A%2FuYP3FfnKM 1 13207
20090505-000000 aa ?93HqrnFc%2EiqRU 1 13199
20090505-000000 aa ?95iZ%2Fjuimv31g 1 13201
20090505-000000 aa File:Wikinews-logo.svg 1 8357
20090505-000000 aa Main_Page 2 9980
```


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Caching Results

>>> pagecounts.count()

- May take a long time

>>> enPages = pagecounts.filter(lambda x: x.split(" ")[1] == "en").cache()

- doesn't actually do anything

>>> enPages.count()

- slow the first time, fast in later calls

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Histogram of page views

- First, divide the data

```
>>> enTuples = enPages.map(lambda x: x.split(" "))
```

- And create a count for each date

```
>>> enKeyValuePairs = enTuples.map(lambda x: (x[0][:8], int(x[3])))
```

- Then combine

```
>>> enKeyValuePairs.reduceByKey(lambda x, y: x + y, 1).collect()
[(u'20090507', 6175726), (u'20090505', 7076855)]
```


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Single command to do it all
(and only return where >200k)

```
>>> enPages.map(lambda x: x.split(" ")).
map(lambda x: (x[2],int(x[3]))).
reduceByKey(lambda x, y: x + y, 40).
filter(lambda x: x[1] > 200000).
map(lambda x: (x[1], x[0])).collect()


[(451126, u'Main_Page'), (1066734, u'404_error/'), (468159,
u'Special:Search')]
```


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Summary

- Map/Reduce framework enables high throughput on large data
  - Provided you can frame the solution as a map / reduce
  - Simple, but somewhat different, programming model
- Distributed data, distributed processing
  - Distribution handled by underlying software
- Multiple implementations available
  - Hadoop, Spark, others…

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