MapReduce, Hadoop and Amazon AWS

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What is Hadoop?

- A software framework that supports data-intensive distributed applications.
- It enables applications to work with thousands of nodes and petabytes of data.
- Hadoop was inspired by Google's MapReduce and Google File System (GFS).
- Hadoop is a top-level Apache project being built and used by a global community of contributors, using the Java programming language.
- Yahoo! has been the largest contributor to the project, and uses Hadoop extensively across its businesses.



Who uses Hadoop?

























Who uses Hadoop?

Yahoo!

More than 100,000 CPUs in >36,000 computers.

Facebook

- Used in reporting/analytics and machine learning and also as storage engine for logs.
- A 1100-machine cluster with 8800 cores and about 12 PB raw storage.
- A 300-machine cluster with 2400 cores and about 3 PB raw storage.
- Each (commodity) node has 8 cores and 12 TB of storage.

Very Large Storage Requirements

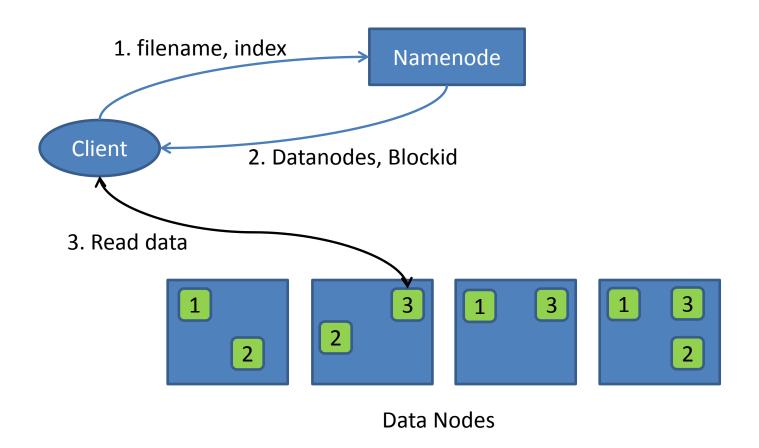
 Facebook has Hadoop clusters with 15 PB of raw storage (15,000,000 GB).

 No single storage can handle this amount of data.

• We need a large set of nodes each storing part of the data.



HDFS: Hadoop Distributed File System

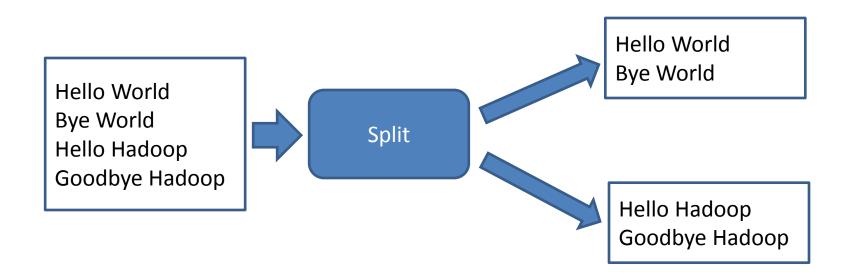


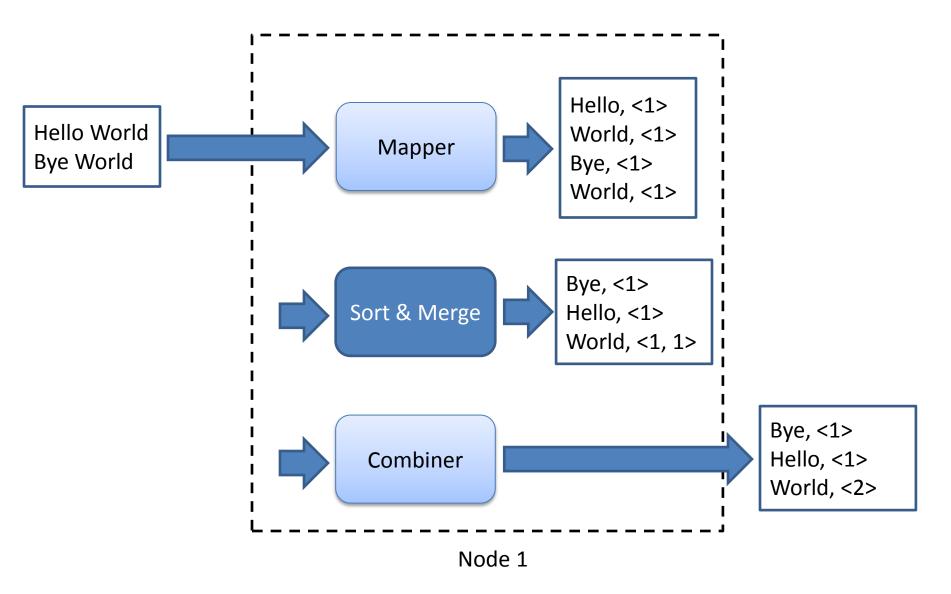
Terabyte Sort Benchmark

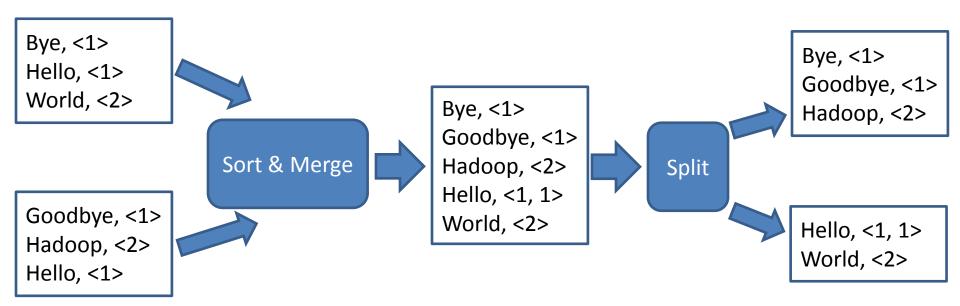
- http://sortbenchmark.org/
- Task: Sorting 100TB of data and writing results on disk (10^12 records each 100 bytes).

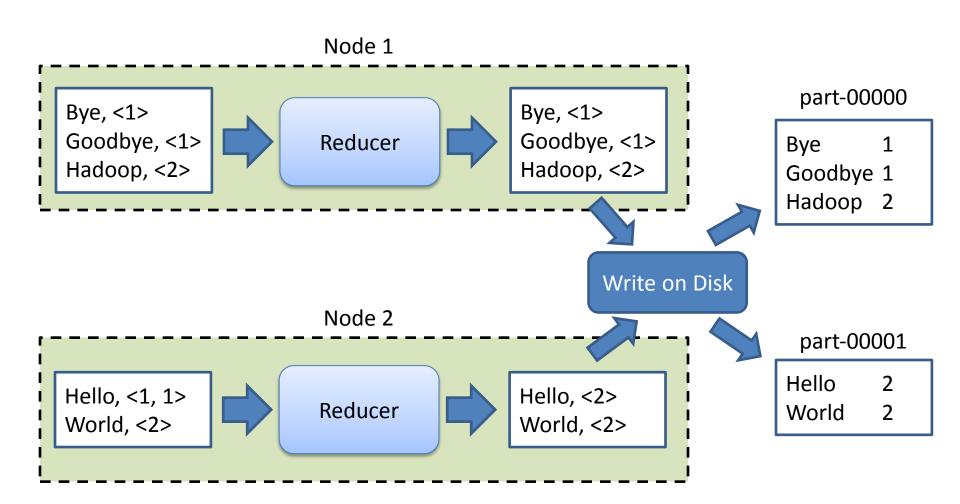
- Yahoo's Hadoop Cluster is the current winner:
 - 173 minutes
 - 3452 nodes x (2 Quadcore Xeons, 8 GB RAM)

This is the first time that a **Java** program has won this competition.









Writing Word Count in Java

- Download hadoop core (version 0.20.2):
 - http://www.apache.org/dyn/closer.cgi/hadoop/core/
- It would be something like:
 - hadoop-0.20.2.tar.gz
- Unzip the package and extract:
 - hadoop-0.20.2-core.jar
- Add this jar file to your project class path

Warning! Most of the sample codes on web are for older versions of Hadoop.

Word Count: Mapper

```
public class WordCountMapper extends Mapper<LongWritable, Text, Text, IntWritable> {
    private final static IntWritable one = new IntWritable(1);
    private Text word = new Text();

    @Override
    public void map(LongWritable key, Text value, final Context context) throws IOException,
        InterruptedException {
        String line = value.toString().toLowerCase();
        StringTokenizer tokenizer = new StringTokenizer(line);
        while (tokenizer.hasMoreTokens()) {
            word.set(tokenizer.nextToken());
            context.write(word, one);
        }
    }
}
```

Word Count: Reducer

```
public class WordCountReducer extends Reducer<Text, IntWritable, Text, IntWritable> {
    @Override
    public void reduce(Text key, Iterable<IntWritable> values, Context context)
        throws IOException, InterruptedException {
        int sum = 0;
        for (IntWritable value : values) {
            sum += value.get();
        }
        context.write(key, new IntWritable(sum));
    }
}
```

Word Count: Main Class

```
public class WordCount extends Configured implements Tool {
    @Override
    public int run(String[] args) throws Exception {
        Configuration conf = new Configuration();
        Job job = new Job(conf, "Word Count");
        job.setJarByClass(WordCount.class);
        job.setMapperClass (WordCountMapper.class);
        iob.setReducerClass(WordCountReducer.class);
        job.setOutputKeyClass(Text.class);
        job.setOutputValueClass(IntWritable.class);
        job.setInputFormatClass(TextInputFormat.class);
        job.setOutputFormatClass(TextOutputFormat.class);
        FileInputFormat.addInputPath(job, new Path(args[0]));
        FileOutputFormat.setOutputPath(job, new Path(args[1]));
        return (job.waitForCompletion(true) ? 0: 1);
    }
    public static void main(String[] args) throws Exception {
        int res = ToolRunner.run(new Configuration(), new WordCount(), args);
        System.exit(res);
```

My Small Test Cluster

- 3 nodes
 - 1 master (ip address: 50.17.65.29)
 - 2 slaves
- Copy your jar file to master node:
 - Linux:
 - scp WordCount.jar john@50.17.65.29:WordCount.jar
 - Windows (you need to download pscp.exe):
 - pscp.exe WordCount.jar john@50.17.65.29:WordCount.jar
- Login to master node:
 - ssh john@50.17.65.29

Counting words in U.S. Constitution!

Download text version:

wget http://www.usconstitution.net/const.txt

Put input text file on HDFS:
 hadoop dfs -put const.txt const.txt

Run the job:

hadoop jar WordCount.jar edu.uci.hadoop.WordCount const.txt word-count-result

Counting words in U.S. Constitution!

- List my files on HDFS:
 - Hadoop dfs -ls

- List files in word-count-result folder:
 - Hadoop dfs -ls word-count-result/

```
john@ip-10-118-55-229:~$ hadoop dfs -ls word-count-result/
Found 1 items
-rw-r--r- 1 john supergroup 15644 2011-02-23 05:54 /user/john/word-count-result/part-r-00000
```

Counting words in U.S. Constitution!

Downloading results from HDFS:

hadoop dfs -cat word-count-result/part-r-00000 > word-count.txt

Sort and view results:

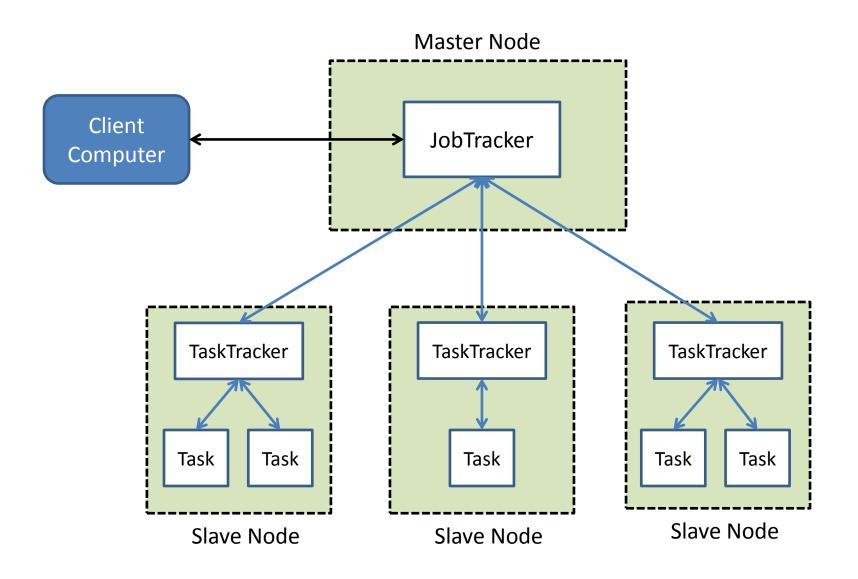
sort -k2 -n -r word-count.txt | more

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shall
and
             262
to
             201
be
             178
or
in
             101
\mathbf{b}\mathbf{y}
             97
             82
```

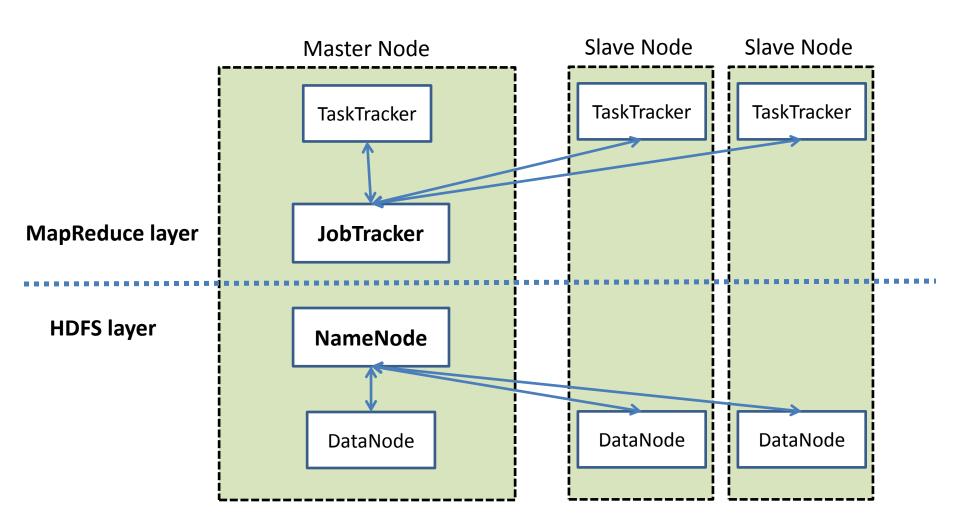
Hadoop Map/Reduce - Terminology

- Running "Word Count" across 20 files is one
 job
- Job Tracker initiates some number of map tasks and some number of reduce tasks.
- For each map task at least one task attempt will be performed... more if a task fails (e.g., machine crashes).

High Level Architecture of MapReduce



High Level Architecture of Hadoop



Web based User interfaces

- JobTracker: http://50.17.65.29:9100/
- NameNode: http://50.17.65.29:9101/

Hadoop Job Scheduling

- FIFO queue matches incoming jobs to available nodes
 - No notion of fairness
 - Never switches out running job

Warning! Start your job as soon as possible.

Reporting Progress

If your tasks don't report anything in 10 minutes they would be killed by Hadoop!

```
public enum MyCounters {
    MAPPER LINE COUNTER, REDUCER INVOCATION COUNTER
}
@Override
public void map (LongWritable key, Text value, final Context context) throws IOException,
    InterruptedException {
    String line = value.toString().toLowerCase();
    StringTokenizer tokenizer = new StringTokenizer(line, " \"()-.[],::/?");
    while (tokenizer.hasMoreTokens()) {
        word.set(tokenizer.nextToken());
        context.write(word, one);
    context.getCounter(MyCounters.MAPPER LINE COUNTER).increment(1);
```

Source files are available at: http://www.ics.uci.edu/~yganjisa/files/2011/hadoop-presentation/WordCount-v2-src.zip

Distributed File Cache

 The Distributed Cache facility allows you to transfer files from the distributed file system to the local file system (for reading only) of all participating nodes before the beginning of a job.

DistributedCache.addCacheFile(new URI("/user/john/crawler4j.properties"), conf);

TextInputFormat

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- InputSplit
- RecordReader
- InputFormat

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Part 2: Amazon Web Services (AWS)



What is AWS?

- A collection of services that together make up a cloud computing platform:
 - S3 (Simple Storage Service)
 - EC2 (Elastic Compute Cloud)
 - Elastic MapReduce
 - Email Service
 - SimpleDB
 - Flexibile Payments Service

— ...

Case Study:

- Yelp uses Amazon S3 to store daily logs and photos, generating around 100GB of logs per day.
- Features powered by Amazon Elastic MapReduce include:
 - People Who Viewed this Also Viewed
 - Review highlights
 - Auto complete as you type on search
 - Search spelling suggestions
 - Top searches
 - Ads
- Yelp runs approximately 200 Elastic MapReduce jobs per day, processing 3TB of data.

Amazon S3

- Data Storage in Amazon Data Center
- Web Service interface
- 99.99% monthly uptime guarantee
- Storage cost: \$0.15 per GB/Month

 S3 is reported to store more than 102 billion objects as of March 2010.

Amazon S3

- You can think of S3 as a big HashMap where you store your files with a unique key:
 - HashMap: key -> File

References

 Hadoop Project Page: http://hadoop.apache.org/

Amazon Web Services:

http://aws.amazon.com/