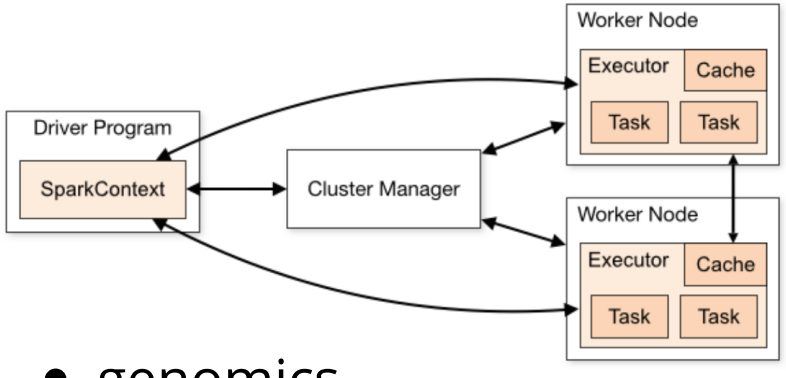
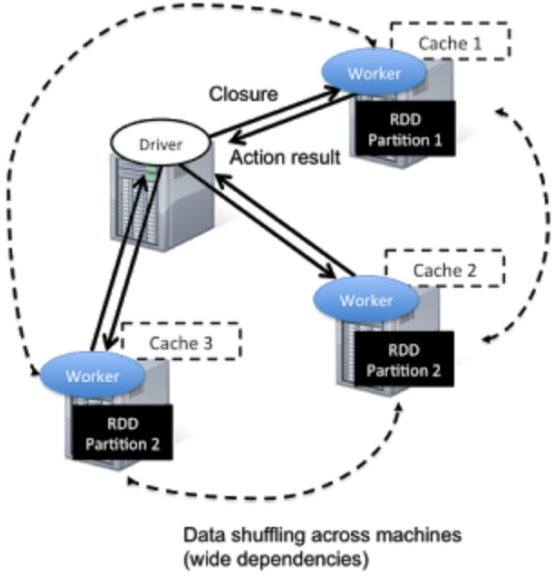

Spark
Marilyn Waldman
@mdwaldman

Agenda

- What is Spark - Why Spark
- lab 1 - review of map and reduce
- lab 2 - RDD's
- lab 3 - Word Count
- lab 4 - Spark SQL
- Conclusions

Cluster computing platform, a ***distributed system***

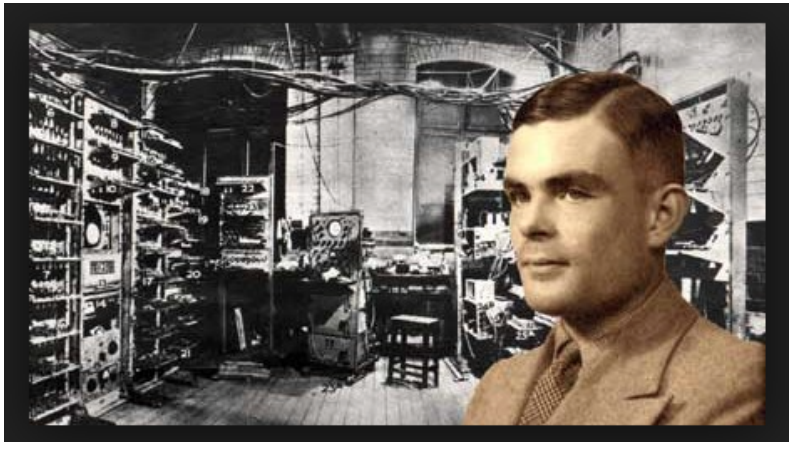




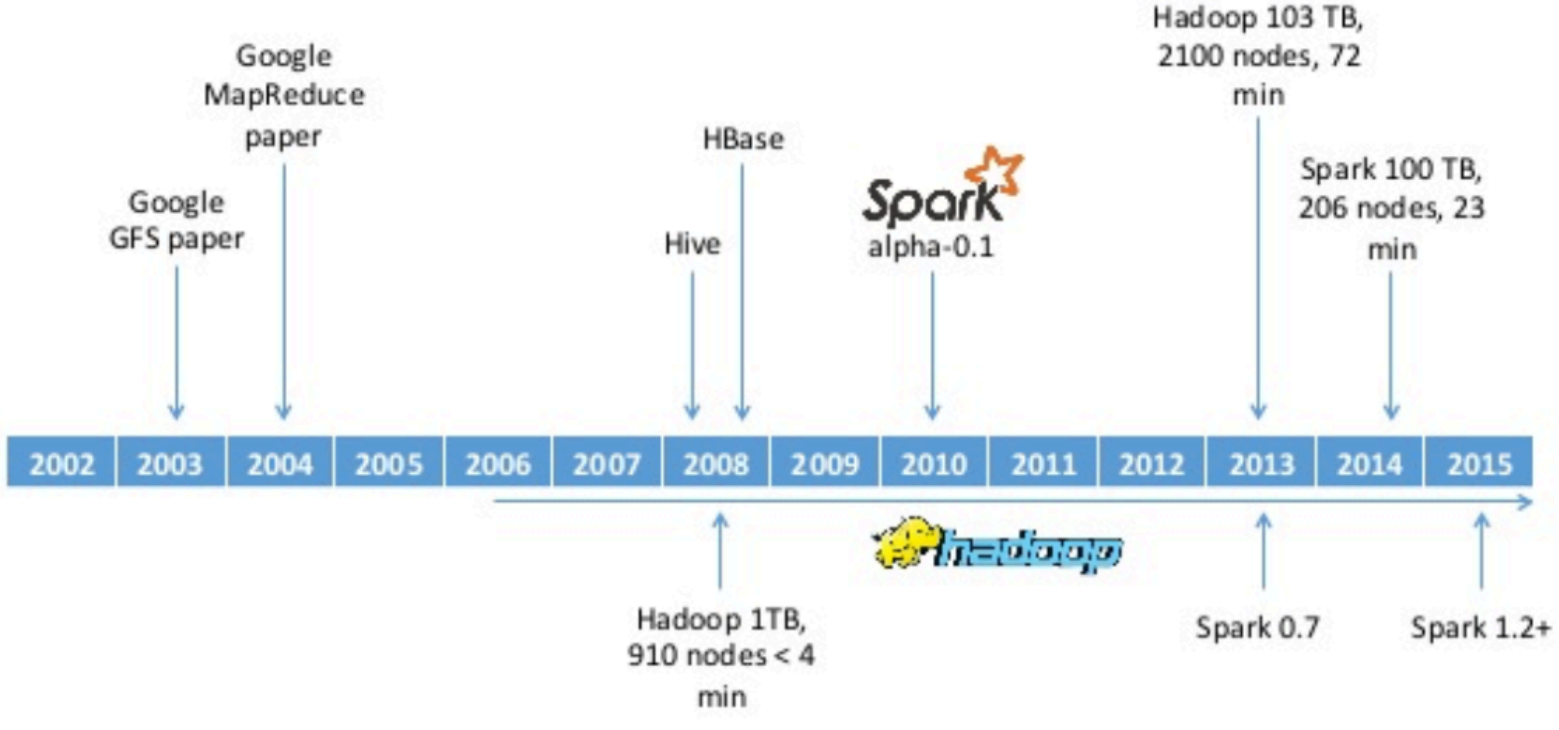
- genomics
- regression - optimization
- real-time data
- anomaly detection
- fraud detection
- codeneuro

Dijkstra - Cooperating Sequential Processes

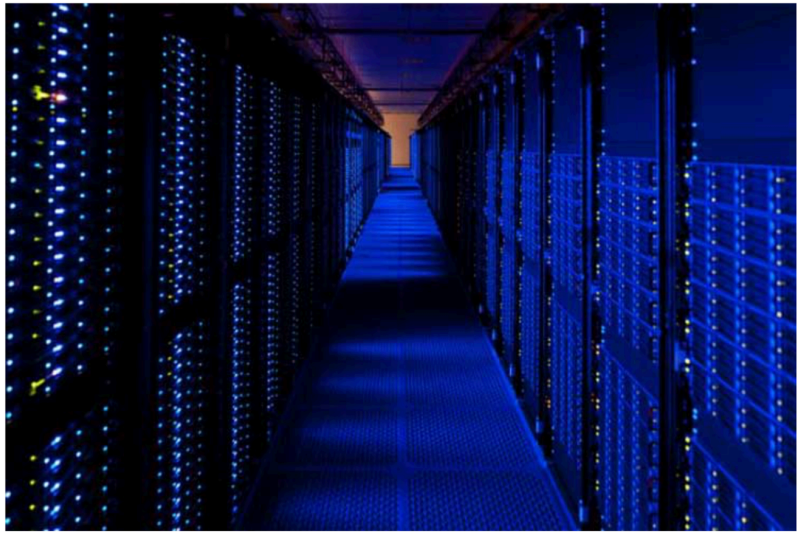
- communicate
- cooperate
- synchronize

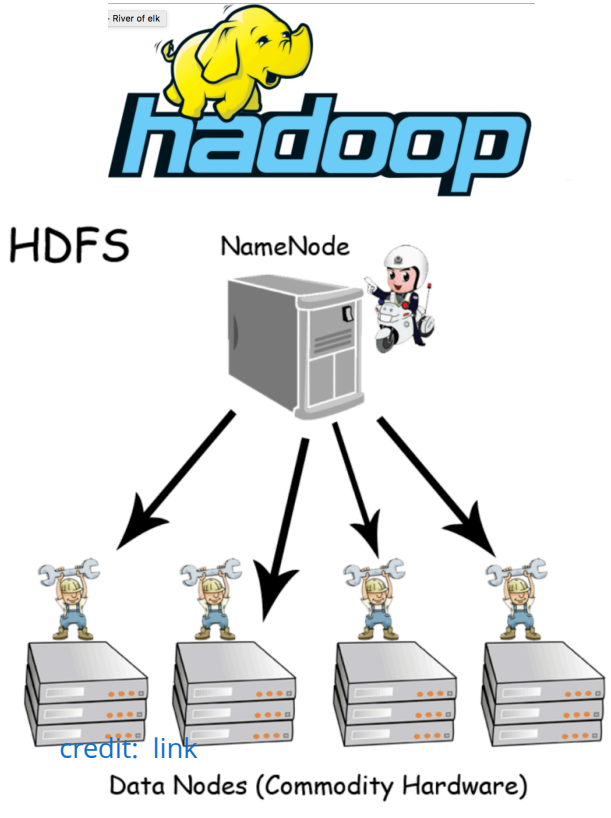


Timeline



credit : Adios hadoop, Hola Spark! T3chfest 2015





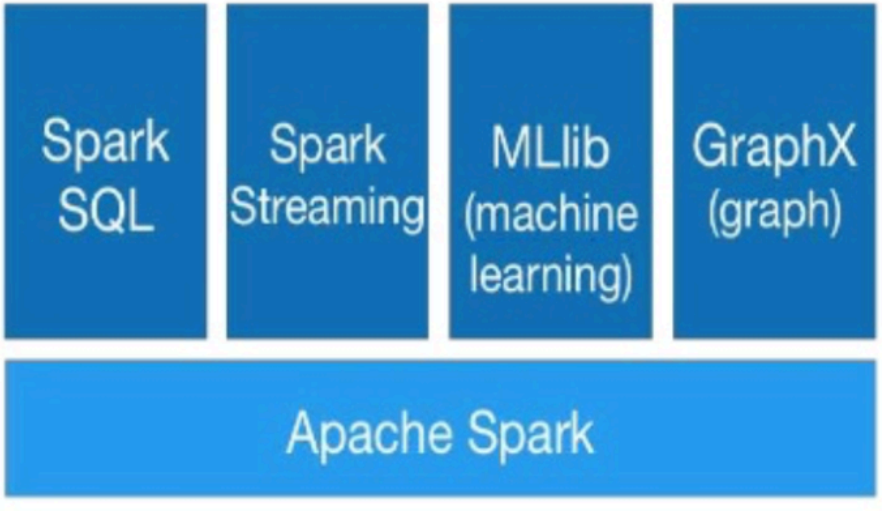
The project includes these modules:

- **Hadoop Common**: The common utilities that support the other Hadoop modules.
- **Hadoop Distributed File System (HDFS™)**: A distributed file system that provides high-throughput access to application data.
- **Hadoop YARN**: A framework for job scheduling and cluster resource management.
- **Hadoop MapReduce**: A YARN-based system for parallel processing of large data sets.

- Began at UC Berkeley in 2009
- Fast and general purpose cluster computing
- 10x faster on disk. 100x faster in-memory
- Integrates with Hadoop and can read existing data
- API's - Java, Python, Scala
- Deeply embraced due to ***elegance*** of use

Spark Stack

- Spark SQL
  - For SQL and unstructured data processing
- MLib
  - Machine Learning Algorithms
- GraphX
  - Graph Processing
- Spark Streaming
  - stream processing of live data streams



http://spark.apache.org

1. Most machine learning programs are iterative. Each iteration improves results
2. With MapReduce each iteration is written to disk. This is expensive.
3. Spark runs **in memory** using an abstraction known as an **RDD**

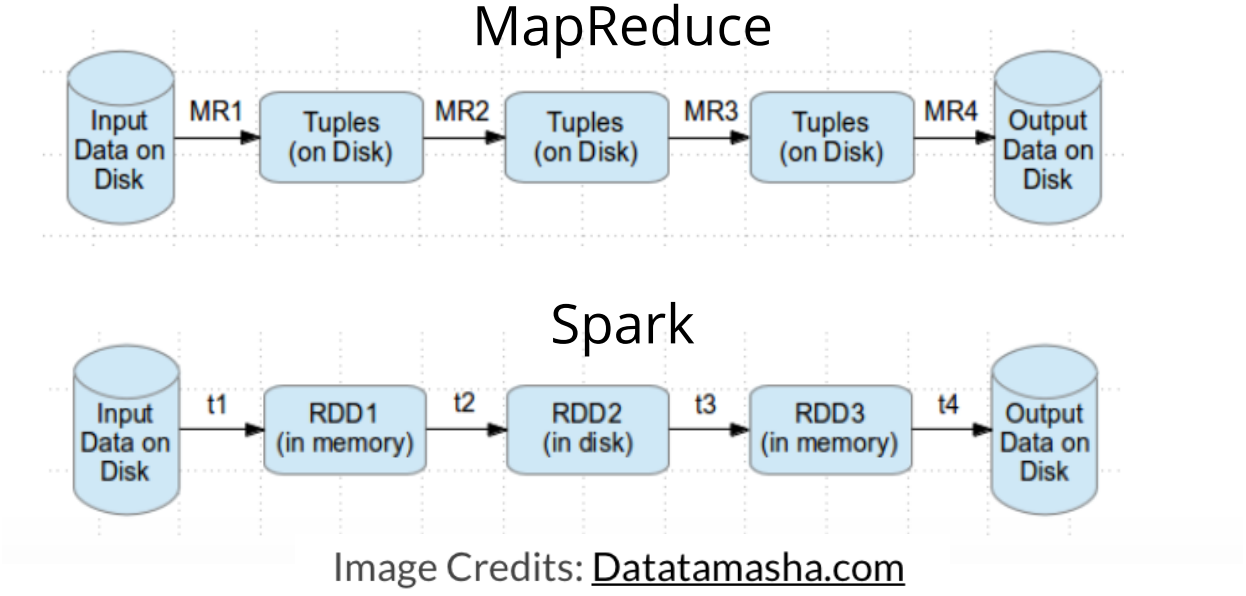
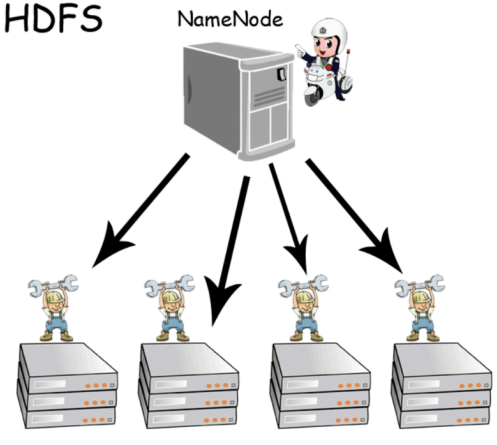
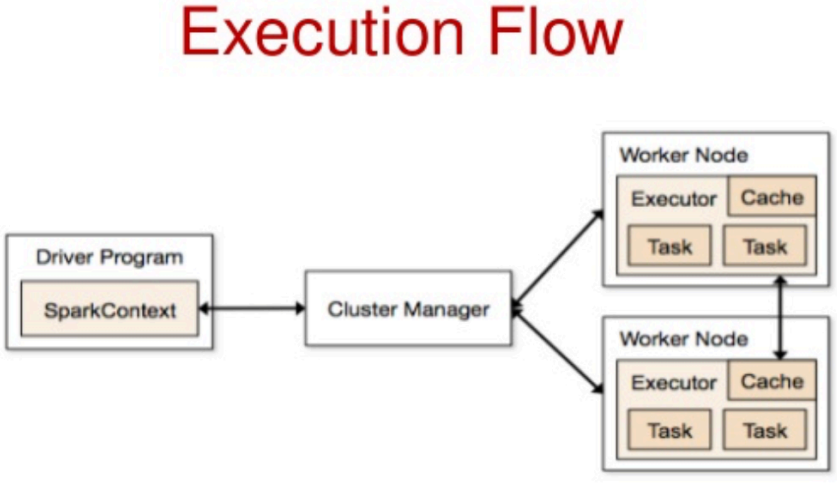


Image Credits: Datatamasha.com

Take the compute to the data



HDFS (Hadoop Distributed File System)



http://spark.apache.org/docs/latest/cluster-overview.html

Coding Exercise: *WordCount*

```
public class WordCount {
  public static class TokenizerMapper
       extends Mapper<Object, Text, Text, IntWritable>{

    private final static IntWritable one = new IntWritable(1);
    private Text word = new Text();

    public void map(Object key, Text value, Context context
                    ) throws IOException, InterruptedException {
      StringTokenizer itr = new StringTokenizer(value.toString());
      while (itr.hasMoreTokens()) {
        word.set(itr.nextToken());
        context.write(word, one);
      }
    }
  }

  public static class IntSumReducer
       extends Reducer<Text,IntWritable,Text,IntWritable> {
    private IntWritable result = new IntWritable();

    public void reduce(Text key, Iterable<IntWritable> values,
                       Context context
                       ) throws IOException, InterruptedException {
      int sum = 0;
      for (IntWritable val : values) {
        sum += val.get();
      }
      result.set(sum);
      context.write(key, result);
    }
  }

  public static void main(String[] args) throws Exception {
    Configuration conf = new Configuration();
    String[] otherArgs = new GenericOptionsParser(conf, args).getRemainingArgs();
    if (otherArgs.length < 2) {
      System.err.println("Usage: wordcount <in> [<in>...] <out>");
      System.exit(2);
    }
    Job job = new Job(conf, "word count");
    job.setJarByClass(WordCount.class);
    job.setMapperClass(TokenizerMapper.class);
    job.setCombinerClass(IntSumReducer.class);
    job.setReducerClass(IntSumReducer.class);
    job.setOutputKeyClass(Text.class);
    job.setOutputValueClass(IntWritable.class);
    for (int i = 0; i < otherArgs.length - 1; ++i) {
      FileInputFormat.addInputPath(job, new Path(otherArgs[i]));
    }
    FileOutputFormat.setOutputPath(job,
      new Path(otherArgs[otherArgs.length - 1]));
    System.exit(job.waitForCompletion(true) ? 0 : 1);
  }
}
```

WordCount in 50+ lines of Java MR

```
1  val f = sc.textFile(inputPath)
2  val w = f.flatMap(l => l.split(" ")).map(word => (word, 1)).cache()
3  w.reduceByKey(_ + _).saveAsText(outputPath)
```

WordCount in 3 lines of Spark

credit: Sparkcamp @ Strata CA: Intro to Apache Spark with Hands-on Tutorials

The Magic of Spark

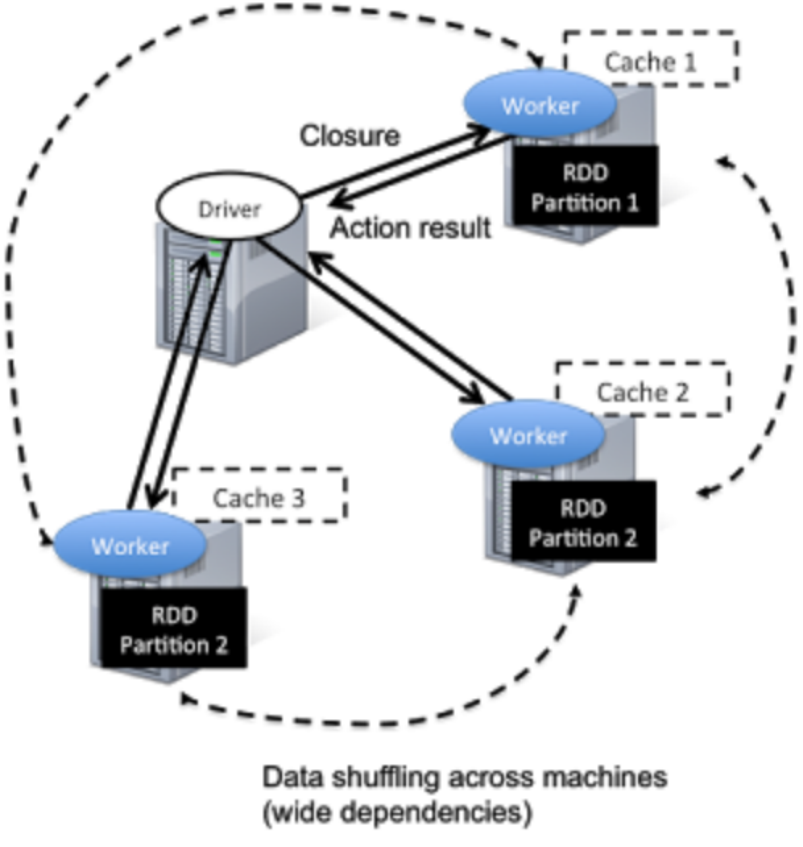
RDD's

Transformations

Actions

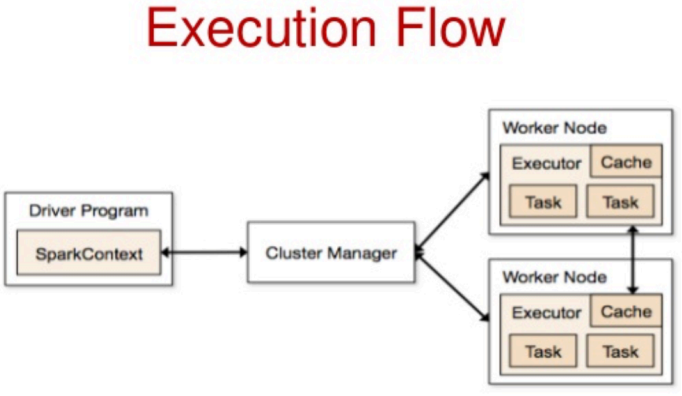
Resilient Distributed Dataset (RDD)

- ***RDD*** is a basic abstraction
- ***Immutable***, partitioned collection of elements that can be operated in parallel
- Basic operations - map, filter, persist
- Multiple implementations - PairRDD <key,value> and Sequence Files



How do I create an RDD?

1. **Parallelized Collections**
2. **External Datasets**
3. **Streaming Data**




```
data = [1, 2, 3, 4, 5]
distData = sc.parallelize(data)
```

http://spark.apache.org/docs/latest/cluster-overview.html

```
>>> distFile = sc.textFile("data.txt")
```

What can I do with an RDD?

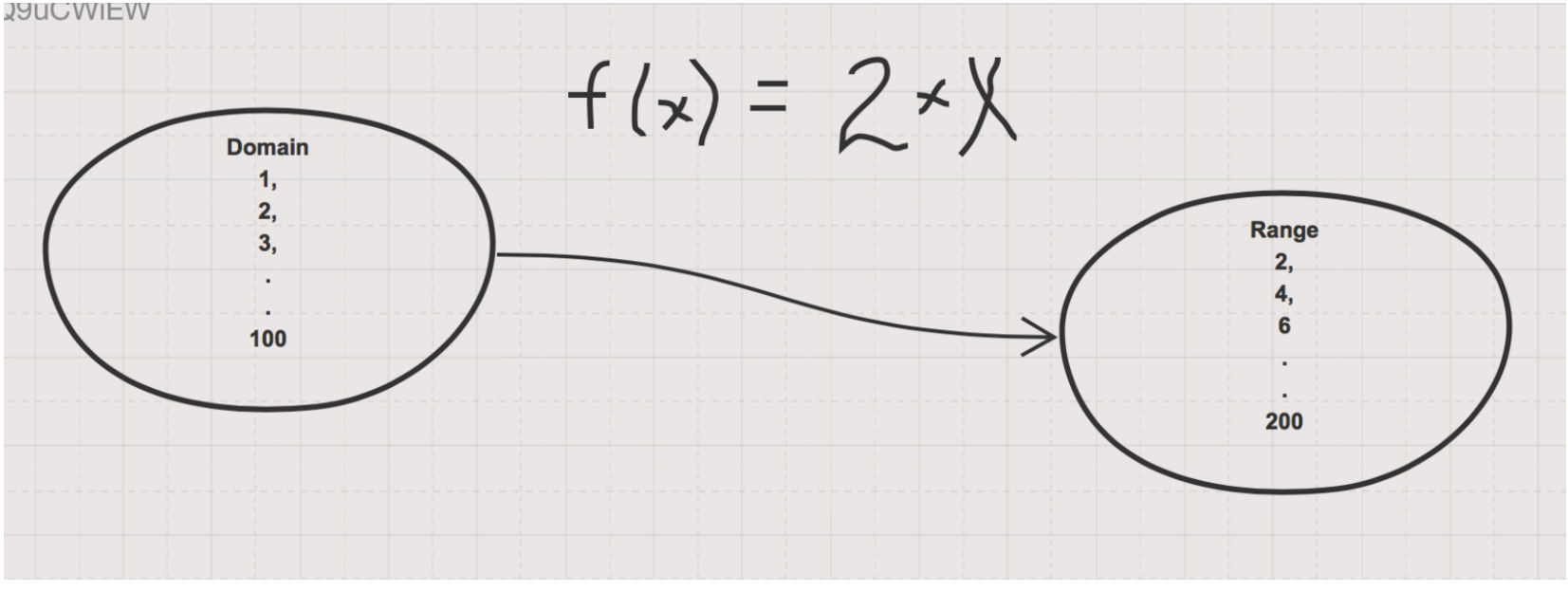
RDD Operations

RDDs support two types of operations: *transformations*, which create a new dataset from an existing one, and *actions*, which return a value to the driver program after running a computation on the dataset.

Map is a transformation that passes each dataset element through a function and returns a new RDD representing the results.

Reduce is an action that aggregates all the elements of the RDD using some function and returns the final result to the driver program.

What functions? *Monoids*



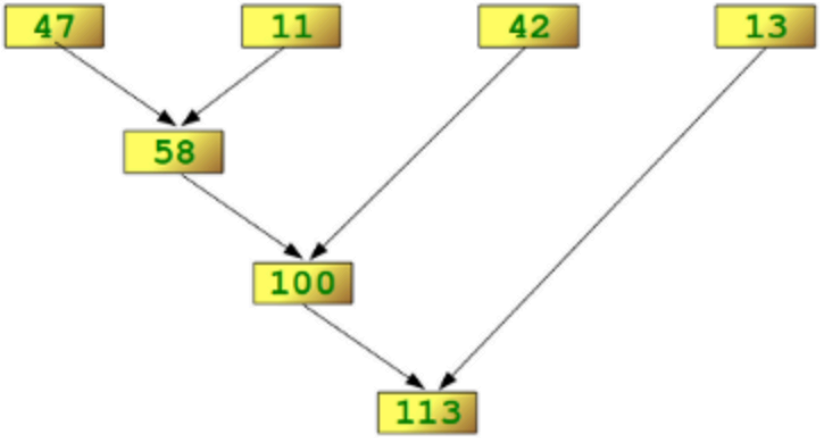
range = domain.map(lambda x : 2*x)

sum = domain.reduce(lambda x,y : x+y)

We illustrate this process in the following example:

```
>>> reduce(lambda x,y: x+y, [47,11,42,13])
113
```

The following diagram shows the intermediate steps of the calculation:



credit: http://www.python-course.eu/lambda.php

In [17]:
```
reduced = mappedRdd.reduce(lambda x, y: x+y)
print type(reduced)
print reduced
```

```
<type 'int'>
328350
```

The Map and Reduce Abstraction

Lab 1

In [19]:
```
nums = range(10)
print nums
```

```
[0, 1, 2, 3, 4, 5, 6, 7, 8, 9]
```

In [20]:
```
#Python only

map(lambda x: x*x, nums)
```

Out[20]:
```
[0, 1, 4, 9, 16, 25, 36, 49, 64, 81]
```

In [27]:
```
#Spark - push nums list onto five executors
sparkNums = sc.parallelize(nums, 5)
#map - this is a transformation
squares = sparkNums.map(lambda x: x*x)
#print result - this is an action - push results back to the driver
print squares.collect()
```

```
[0, 1, 4, 9, 16, 25, 36, 49, 64, 81]
```

RDD's are a collection of records

```
rdd = sc.parallelize(range(1000),5)
```

Transformations create new RDD's from existing ones

```
errors = rdd.filter(lambda line: "ERROR" in line)
```

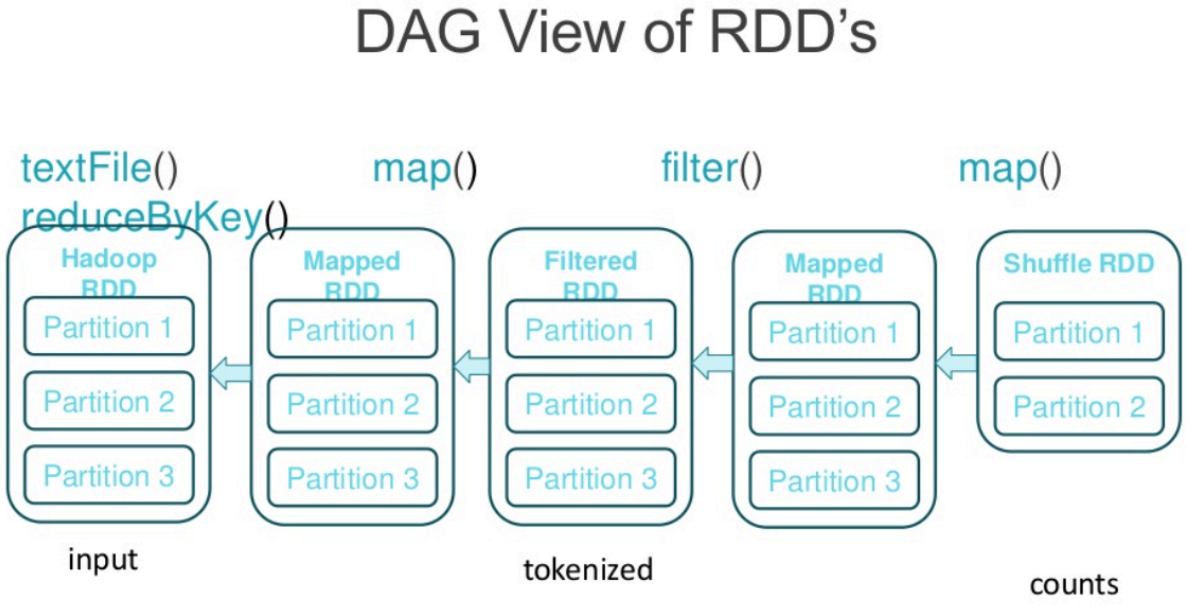
Actions materialize a value in the user program

```
size = errors.count()
```

THE DAG

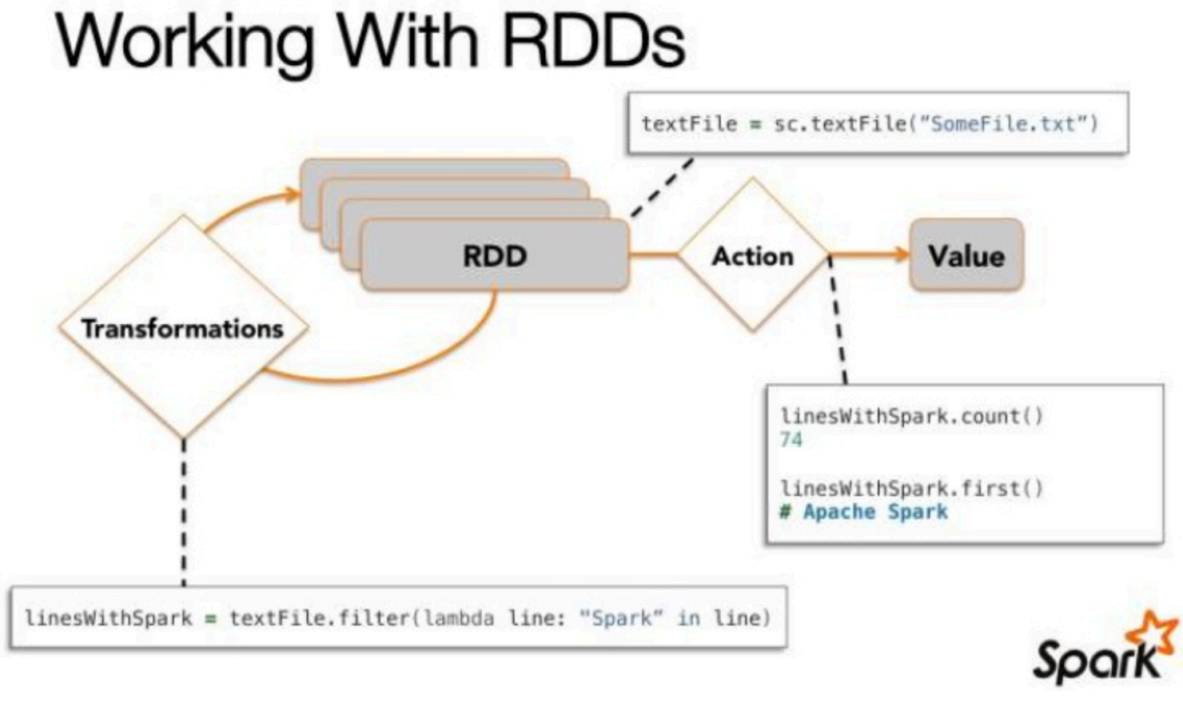
(directed acyclic graph)

sc.textFile().map().filter().map().reduceByKey()



credit: data bricks

Lazy Evaluation



Code runs only upon encountering an action

credit: link

Persistence layers for Spark

Distributed

- Hadoop (HDFS)
- Local file system
- Cassandra
- Amazon S3
- Hive
- Base

File formats

- Text - CSV, Plain Txt
- Sequence File
- AvRO
- Parquet

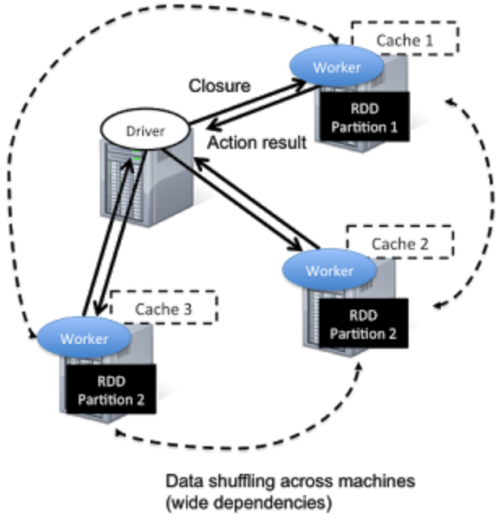
WHEN IS the DAG EXECUTED?

```
import sys
import os

logFile = os.path.join('data', 'logfile')

""" Read and parse log file """
parsed_logs = (sc
          .textFile(logFile)
          .filter(lambda line: 'GET' in line))

print parsed_logs.count()
```




```
in24.inetnebr.com - - 01/Aug/1995:00:00:01 -0400 "GET /shuttle/missions/sts-6.txt HTTP/1.0" 200 1839
uplherc.upl.com - - 01/Aug/1995:00:00:07 -0400 "GET / HTTP/1.0" 304 0
uplherc.upl.com - - 01/Aug/1995:00:00:08 -0400 "GET /images/ksc.gif HTTP/1.0" 304 0
uplherc.upl.com - - 01/Aug/1995:00:00:08 -0400 "GET /images/MOSAIC.gif HTTP/1.0" 304 0
```

Transformations

```
map(func)
filter(func)
flatMap(func)
mapPartitions(func)
mapPartitionsWithIndex(func)
union(otherDataset)
intersection(otherDataset)
distinct([numTasks]))
groupByKey([numTasks])
sortByKey([ascending], [numTasks])
```

```
reduceByKey(func, [numTasks])
aggregateByKey(zeroValue)(seqOp,
     combOp, [numTasks])
join(otherDataset, [numTasks])
cogroup(otherDataset, [numTasks])
cartesian(otherDataset)
pipe(command, [envVars])
coalesce(numPartitions)
sample(withReplacement,fraction, seed)
repartition(numPartitions)
```

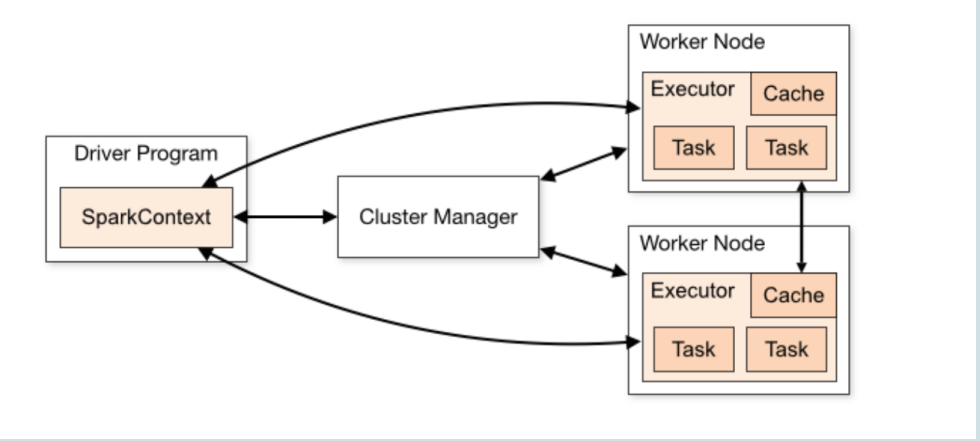
Actions

```
reduce(func)
collect()
count()
first()
countByKey()
foreach(func)
```

```
take(n)
takeSample(withReplacement,num, [seed])
takeOrdered(n, [ordering])
saveAsTextFile(path)
saveAsSequenceFile(path)
                    (Only Java and Scala)
saveAsObjectFile(path)
                    (Only Java and Scala)
```

Lab1: sparkRDDs

how many executors?




```
#range(start, end=None, step=1, numSlices=None)

rdd = sc.parallelize(xrange(0, 100, 1), 5)
print rdd.collect()
```

Text

```
[0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31
, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 50, 51, 52, 53, 54, 55, 56, 57, 58, 59, 60,
61, 62, 63, 64, 65, 66, 67, 68, 69, 70, 71, 72, 73, 74, 75, 76, 77, 78, 79, 80, 81, 82, 83, 84, 85, 86, 87, 88, 89, 9
0, 91, 92, 93, 94, 95, 96, 97, 98, 99]
```

What does this look like?

- `glom`: Returns an RDD list from each partition of an RDD.
- `collect`: Returns a list from all elements of an RDD.

```
for x in rdd.glom().collect():
    print x
```

```
[0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19]
[20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39]
[40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 50, 51, 52, 53, 54, 55, 56, 57, 58, 59]
[60, 61, 62, 63, 64, 65, 66, 67, 68, 69, 70, 71, 72, 73, 74, 75, 76, 77, 78, 79]
[80, 81, 82, 83, 84, 85, 86, 87, 88, 89, 90, 91, 92, 93, 94, 95, 96, 97, 98, 99]
```

Key Value Pairs

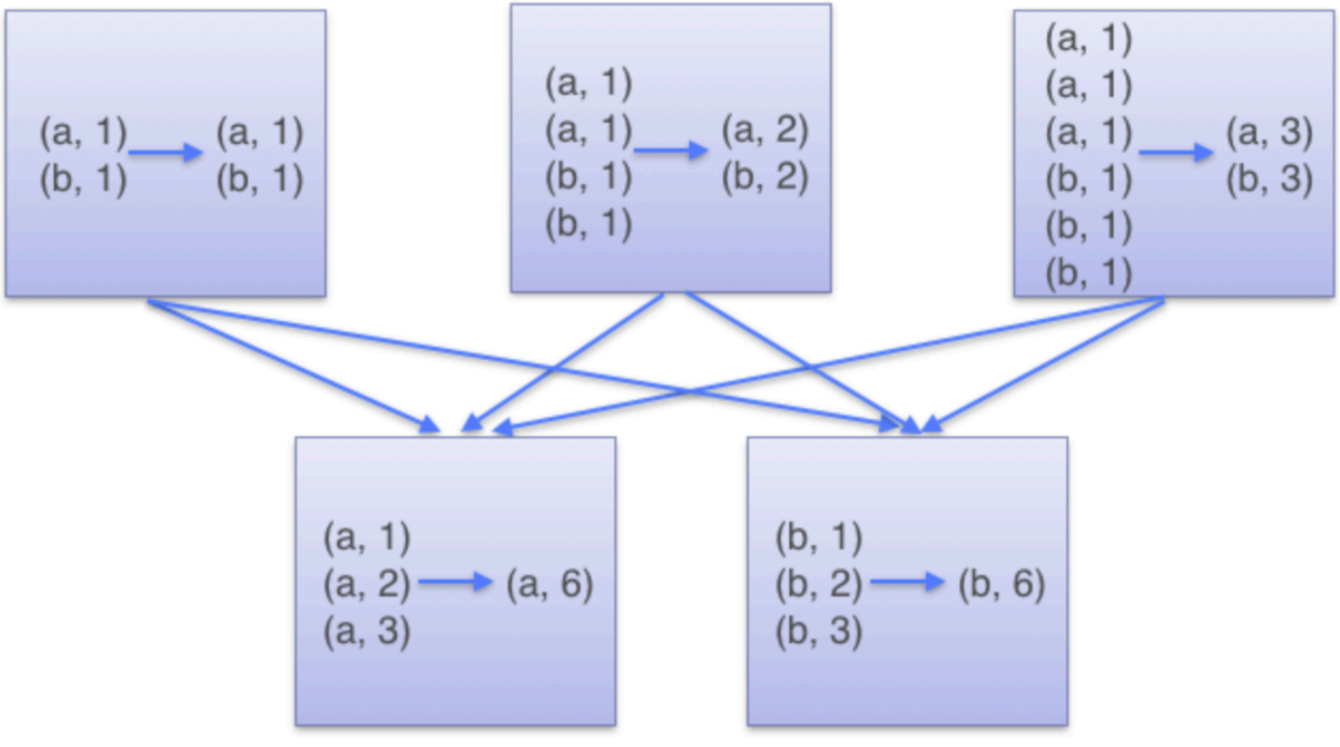
Transformations

- rdd.reduceByKey(func)
- rdd.groupByKey()
- rdd.mapValues(fund)
- rdd.keys()
- rdd.values()
- rdd.sortByKey()

Actions

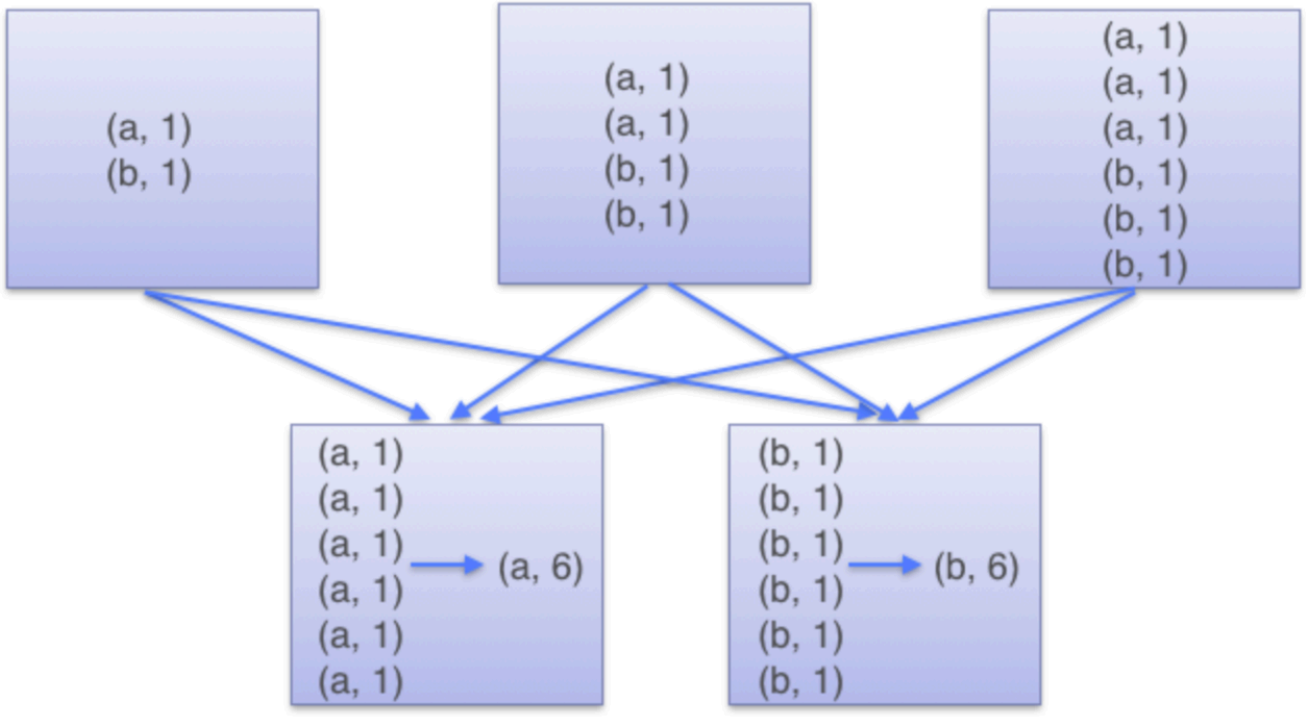
- rdd.countByKey()
- rdd.collectAsMap()
- rdd.lookup(key)

ReduceByKey



credit: https://databricks.gitbooks.io/databricks-spark-knowledge-base/content/best_practices/prefer_reducebykey_over_groupbykey.html

GroupByKey



credit: https://databricks.gitbooks.io/databricks-spark-knowledge-base/content/best_practices/prefer_reducebykey_over_groupbykey.html

```
val lines   =  sc.textFile("input.txt")
val words =  lines.flatMap(line => line.split(" "))
val ones   =  words.map(s => (s,1))
val count  =  ones.reduceByKey((a,b) => a + b)
val result =   count.collectAsMap( )
```

RDD lineage DAG built on driver side

data source RDD

transformation RDD, transformation

action, action RDD

Lab 3 WordCount

Cluster Deployment

- Standalone Deploy Mode
  - simplest way to deploy Spark on a private cluster
- Amazon EC2
  - EC2 scripts are available
  - Very quick launching a new cluster
- Apache Mesos
- Hadoop YARN