Big Data Processing

Patrick Wendell
Databricks

About me

Committer and PMC member of Apache Spark

“Former” PhD student at Berkeley

Left Berkeley to help found Databricks

Now managing open source work at Databricks

Focus is on networking and operating systems

Outline

Overview of today

The Big Data problem

The Spark Computing Framework

Straw poll. Have you:

- Written code in a numerical programming environment (R/Matlab/Weka/etc)?
- Written code in a general programming language (Python/Java/etc)?
- Written multi-threaded or distributed computer programs?

Today’s workshop

Overview of trends in large-scale data analysis

Introduction to the Spark cluster-computing engine with a focus on numerical computing

Hands-on workshop with TA’s covering Scala basics and using Spark for machine learning

Hands-on Exercises

You'll be given a cluster of 5 machines*

(a) Text mining of full text of Wikipedia

(b) Movie recommendations with ALS

5 machines * 200 people = 1,000 machines

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The Big Data Problem

Data is growing faster than computation speeds

Growing data sources
- » Web, mobile, scientific, …

Cheap storage
- » Doubling every 18 months

Stalling CPU speeds

Storage bottlenecks

The Economist
Obama the warrior
Misgoverning Argentina
The economic shift from West to East
Genetically modified crops blossom
The right to eat cats and dogs
The data deluge
AND HOW TO HANDLE IT: A 14-PAGE SPECIAL REPORT
nature
THE BITER BIT
Viral infections for viruses
TROPICAL CYCLONES
The strong get stronger
BLACK HOLE PHYSICS
A new window on the Galactic Centre
BIG DATA
NATUREJOBS
Minnesota musings
SCIENCE IN THE PETABYTE ERA
POPULAR SCIENCE
THE FUTURE NOW
THE CONTROL CENTERS
Using Data to Feed the World, Solve Cold Cases, Battle Malware, Predict Our Fate
OFFICER ALGORITHM
Can a Crime Be Prevented Before It Begins?
NEW WAYS OF SEEING
A Gallery of Extraordinary Infographics
PLUS
Juan Enriquez Reprograms Life
James Gleick Unsplits the Bit
AND Lawrence Weschler Questions the Cloud
SPECIAL ISSUE
DATA IS POWER
HOW INFORMATION IS DRIVING THE FUTURE

Examples

Facebook’s daily logs: 60 TB

1000 genomes project: 200 TB

Google web index: 10+ PB

Cost of 1 TB of disk: $50

Time to read 1 TB from disk: 6 hours (50 MB/s)

The Big Data Problem

Single machine can no longer process or even store all the data!

Only solution is to **distribute** over large clusters

Google Datacenter

How do we program this thing?

What's hard about cluster computing?

How to divide work across nodes?

- Must consider network, data locality
- Moving data may be very expensive

How to deal with failures?

- 1 server fails every 3 years => 10K nodes see 10 faults/day
- Even worse: stragglers (node is not failed, but slow)

A comparison:

How to divide work across nodes?

What if certain elements of a matrix/array became 1000 times slower to access than others?

How to deal with failures?

What if with 10% probability certain variables in your program became undefined?

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The Spark Computing Framework

Provides a programming abstraction and parallel runtime to hide this complexity.

“Here’s an operation, run it on all of the data”

» I don’t care *where* it runs (you schedule that)

» In fact, feel free to run it *twice* on different nodes

Resilient Distributed Datasets

Key programming abstraction in Spark

Think “parallel data frame”

Supports collections/set API’s

```
# get variance of 5th field of a tab-delimited dataset
rdd = spark.hadoopFile(“big-file.txt”)

rdd.map(line => line.split(“\t”)(4))
   .map(cell => cell.toDouble())
   .variance()
```

RDD Execution

Automatically split work into many small, idempotent *tasks*

Send tasks to nodes based on data locality

Load-balance dynamically as tasks finish

Fault Recovery

1. If a task crashes:
   - » Retry on another node
     - OK for a map because it had no dependencies
     - OK for reduce because map outputs are on disk

Requires user code to be **deterministic**

Fault Recovery

2. If a node crashes:
   - » Relaunch its current tasks on other nodes
   - » Relaunch any maps the node previously ran
     - • Necessary because their output files were lost

Fault Recovery

3. If a task is going slowly (straggler):
   - » Launch second copy of task on another node
   - » Take the output of whichever copy finishes first, and kill the other one

Spark Compared with Earlier Approaches

Higher level, declarative API.

Built from the “ground up” for performance – including support for leveraging distributed cluster memory.

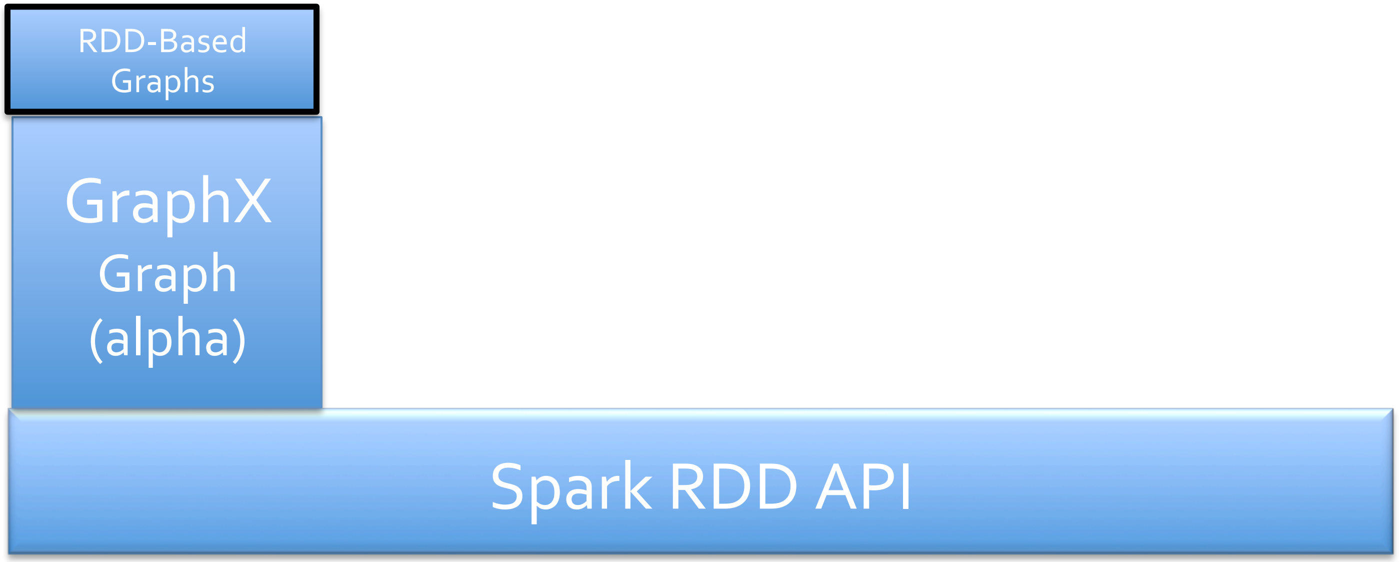
Optimized for iterative computations (e.g. machine learning)

Spark Platform

Spark RDD API

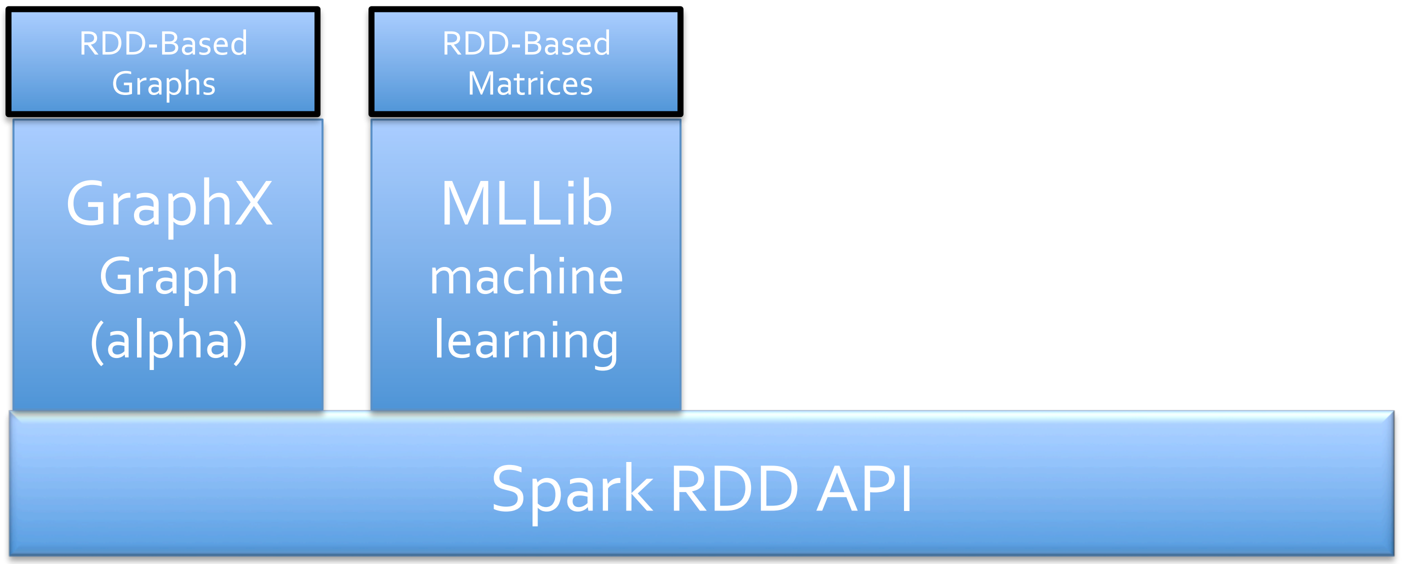
Spark Platform: GraphX

```
graph = Graph(vertexRDD, edgeRDD)
graph.connectedComponents() # returns a new RDD
```



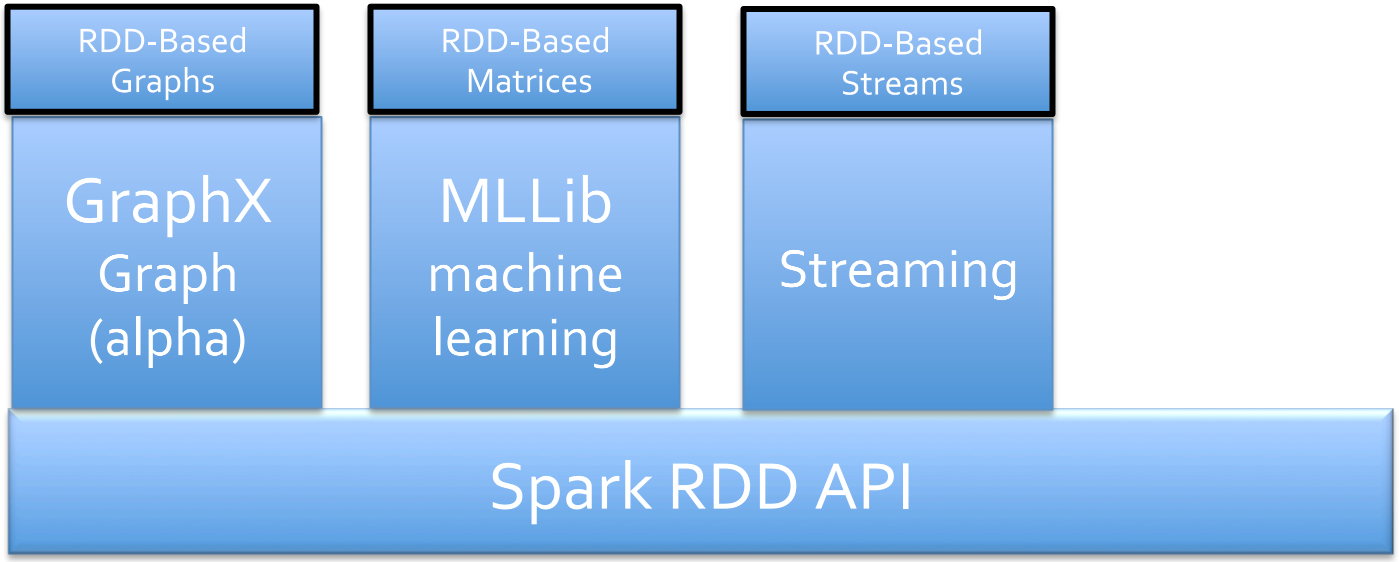
Spark Platform: MLLib

```
model = LogisticRegressionWithSGD.train(trainRDD)
dataRDD.map(point => model.predict(point))
```



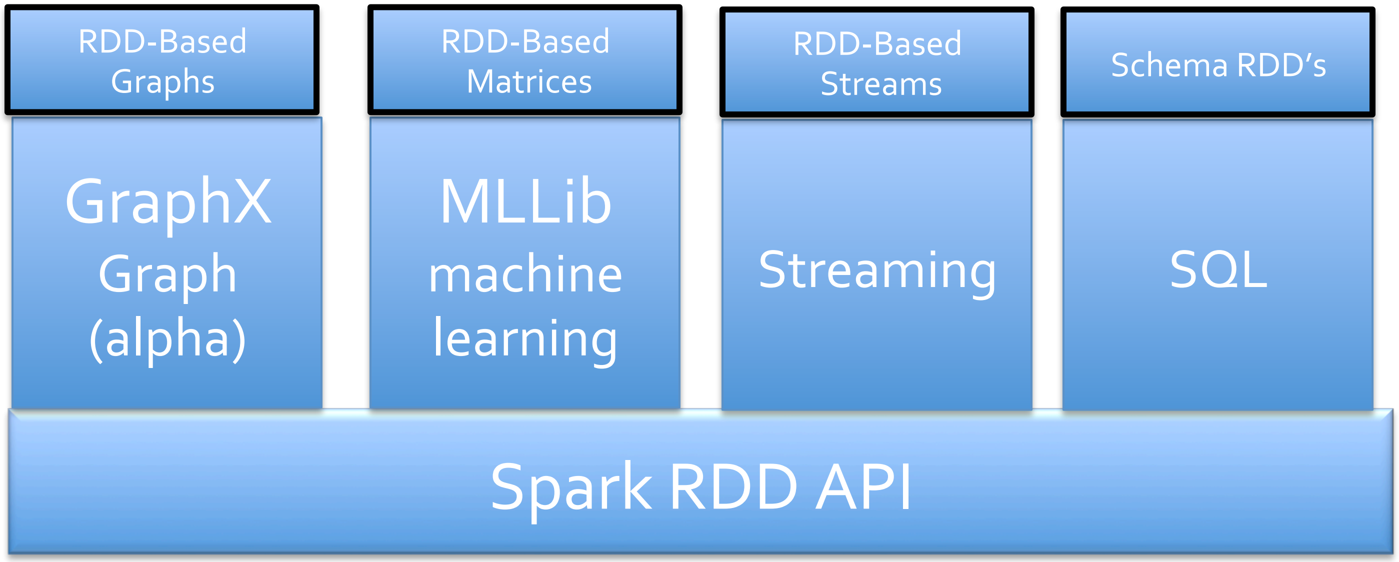
Spark Platform: Streaming

```
dstream = spark.networkInputStream()
dstream.countByWindow(Seconds(30))
```

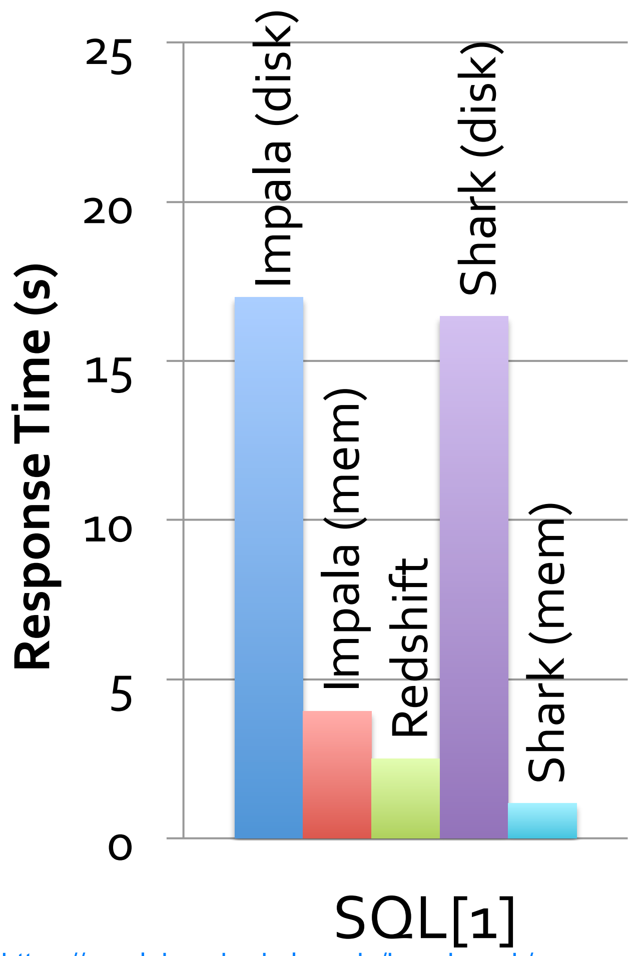


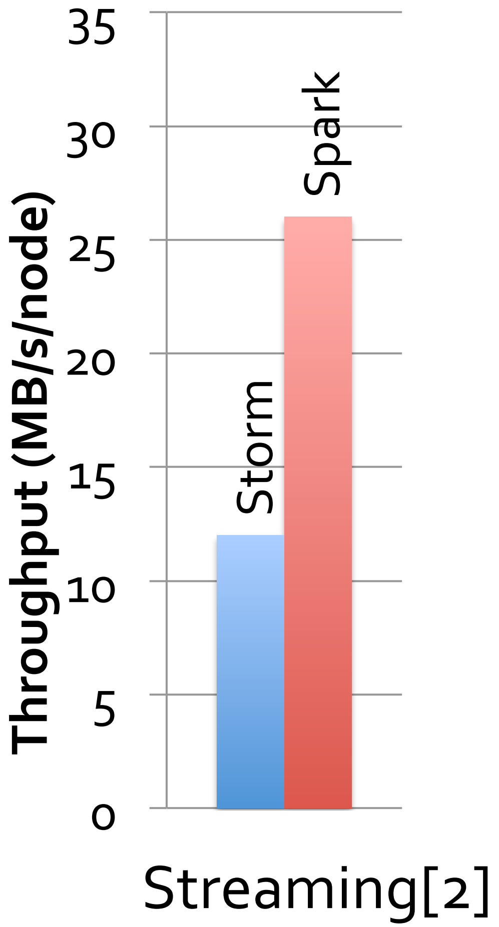
Spark Platform: SQL

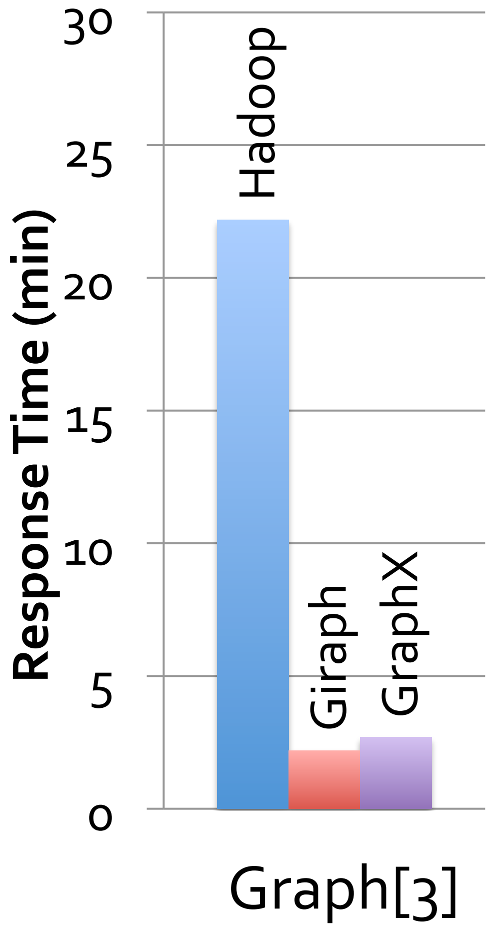
```
rdd = sql“select * from rdd1 where age > 10”
```



Performance







[1] https://amplab.cs.berkeley.edu/benchmark/
[2] Discretized Streams: Fault-Tolerant Streaming Computation at Scale. At SOSP 2013.
[3] https://amplab.cs.berkeley.edu/publication/graphx-grades/

Composition

Most large-scale data programs involve parsing, filtering, and cleaning data.

Spark allows users to compose patterns elegantly. E.g.:

Select input dataset with SQL, then run machine learning on the result.

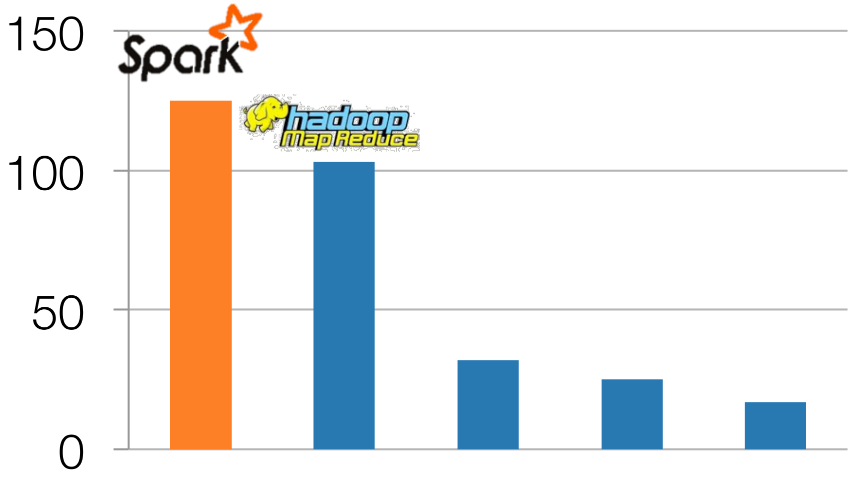
Spark Community

One of the largest open source projects in big data

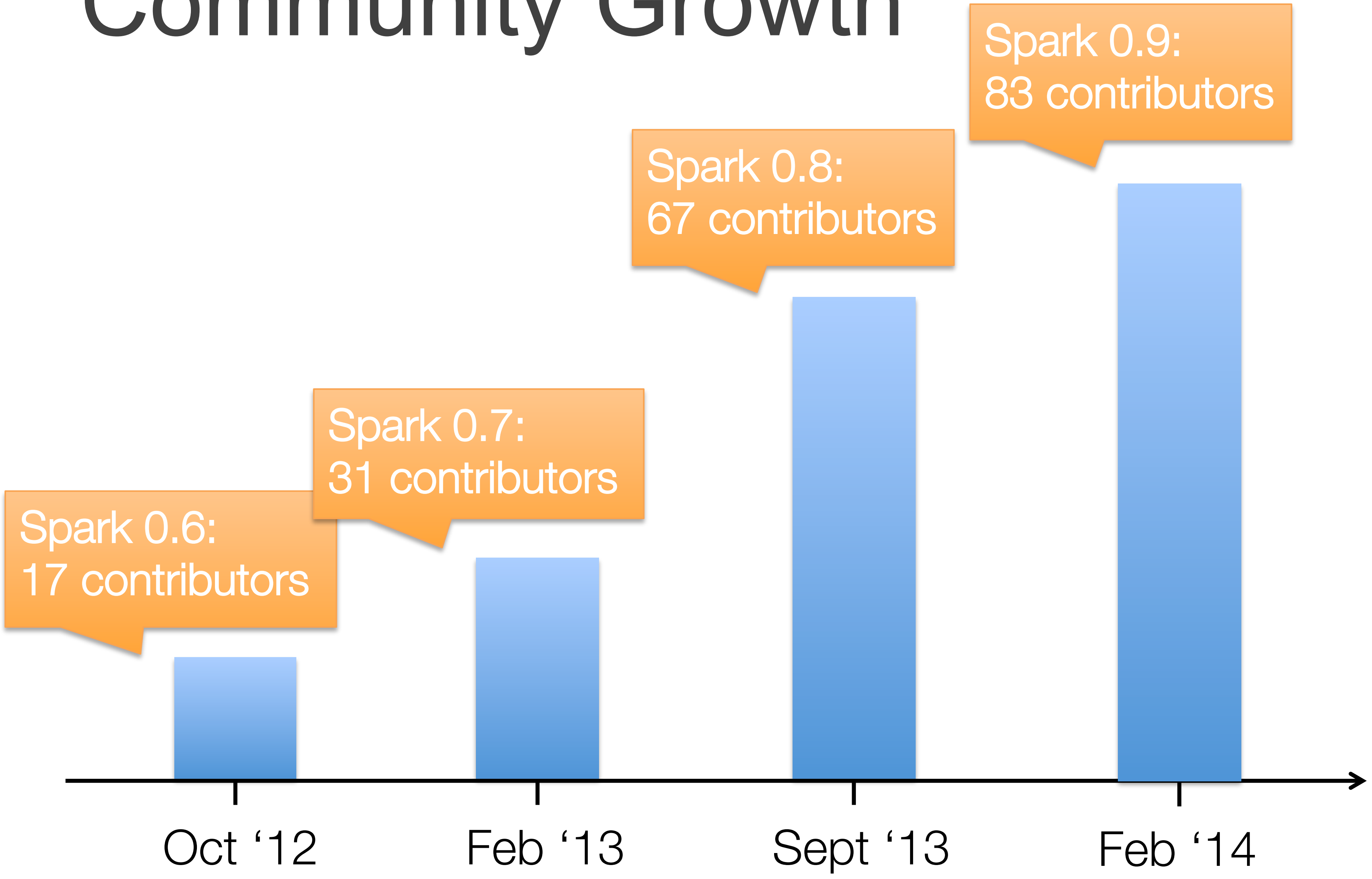
150+ developers contributing

30+ companies contributing

Contributors in past year



Community Growth



Databricks

Primary developers of Spark today

Founded by Spark project creators

A nexus of several research areas:

→ OS and computer architecture

→ Networking and distributed systems

→ Statistics and machine learning

Today's Speakers

Holden Karau – Worked on large-scale storage infrastructure @ Google.

Intro to Spark and Scala

Hossein Falaki – Data scientist at Apple.

Numerical Programming with Spark

Xiangrui Meng – PhD from Stanford ICME. Lead contributor on MLLib.

Deep dive on Spark's MLLib

Questions?