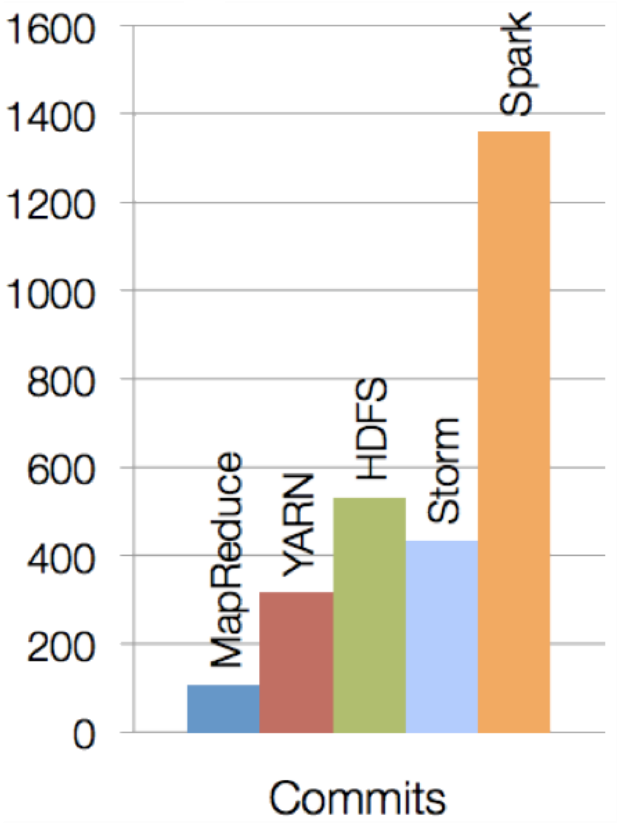
Power of data. Simplicity of design. Speed of innovation.

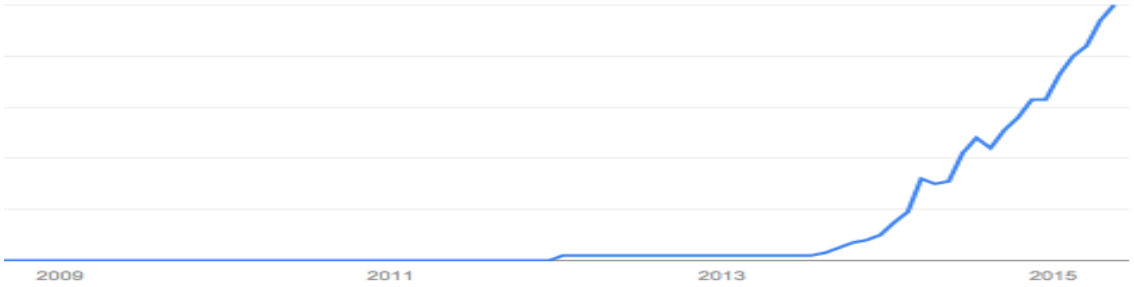
Hands on Introduction to Apache Spark for Data Engineers, Data Scientists, and Developers

Spark is new, but evolving quickly and has gained tremendous traction in a short amount of time

Spark is one of the most active open source projects



Interest over time (Google Trends)



Job Trends (Indeed.com)

What is Spark?

Spark is an **open** source **in-memory** **application** framework for **distributed** data processing and **iterative** analysis on **massive** data volumes

“**Analytic Operating System**”

Key reasons for interest in Spark

Performant

- In-memory architecture greatly reduces disk I/O
- Anywhere from **20-100x faster** for common tasks

Productive

- **Concise and expressive syntax**, especially compared to prior approaches
- **Single programming model** across a range of use cases and steps in data lifecycle
- **Integrated with common programming languages** – Java, Python, Scala
- **New tools** continually reduce skill barrier for access (e.g. SQL for analysts)

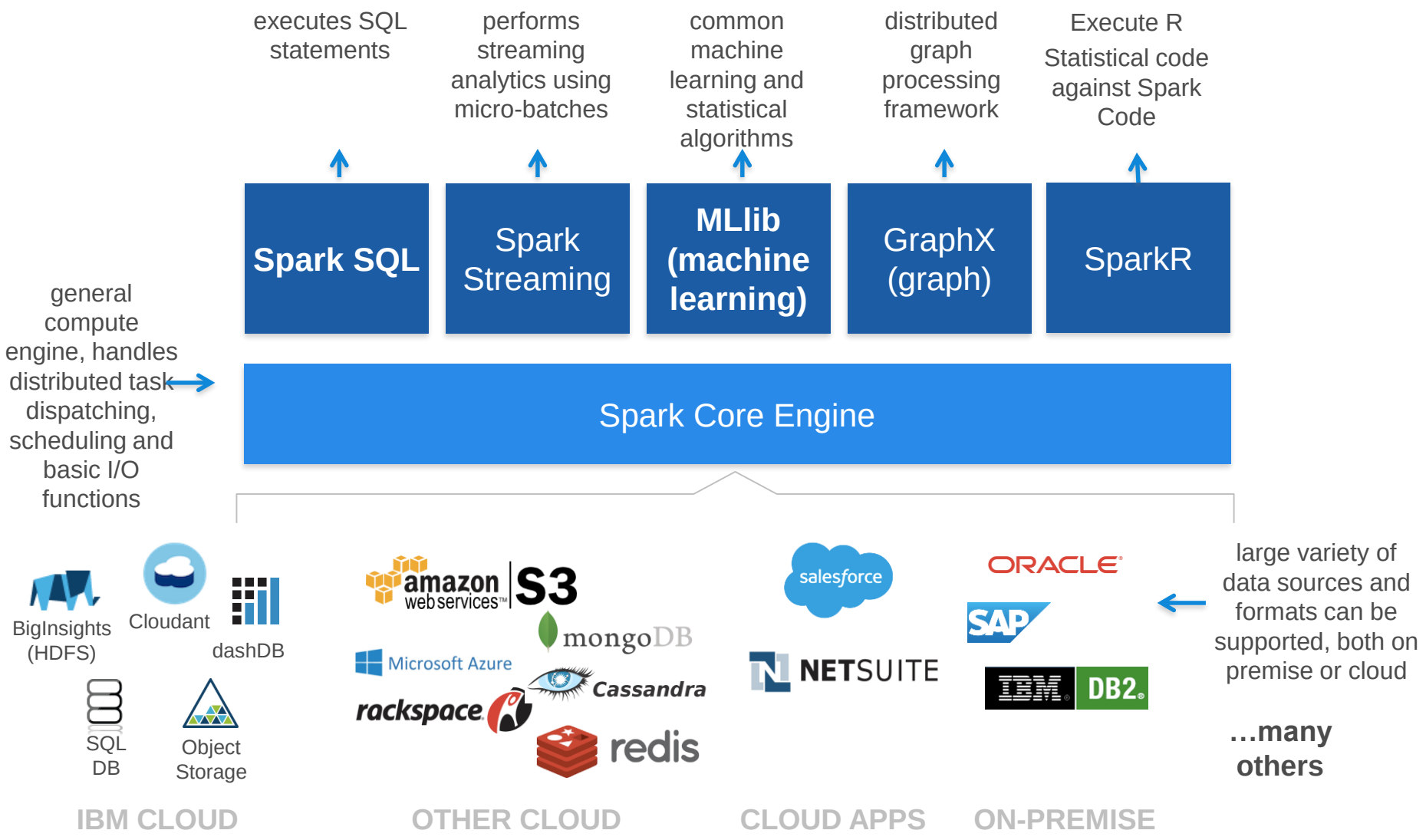
Leverages existing investments

- Works well within **existing Hadoop ecosystem**

Improves with age

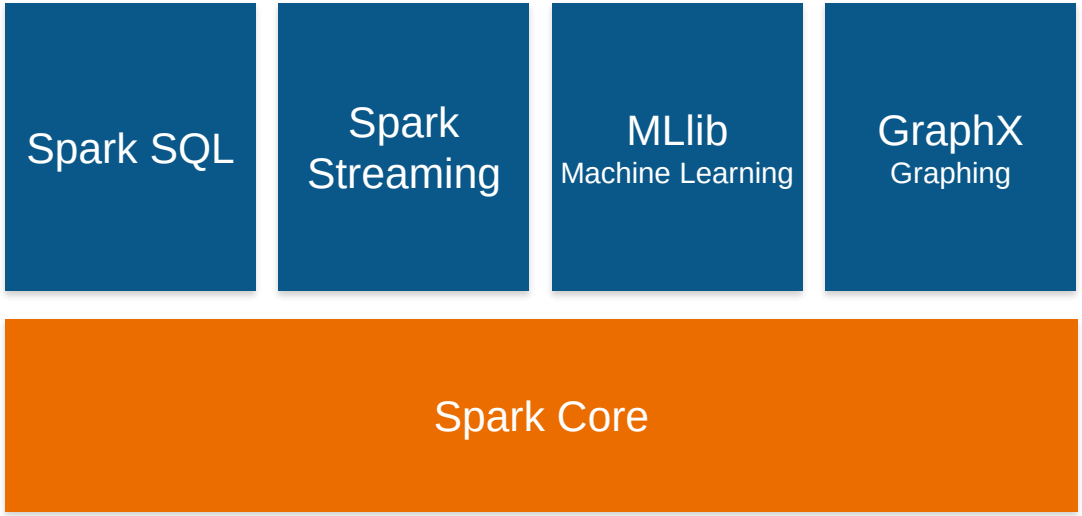
- **Large and growing community** of contributors continuously improve full analytics stack and extend capabilities

Spark includes a set of core libraries that enable various analytic methods which can process data from many sources



Libraries Usage[1]

- **SparkSQL – 69%**
- **DataFrames – 62%**
- **Spark Streaming – 58%**
- **MLlib/GraphX – 58%**



75% of users use more than one component

[1] From a survey done by Databricks, summer 2015

Spark Programming Languages

- **Scala**
  - Functional programming
  - Spark written in Scala
  - Scala compiles into Java byte code
- **Java**
  - New features in Java 8 makes for more compact coding (lambda expressions)
- **Python**
  - Most widely used API with Spark today
- **R**
  - Functional programming language used to create and manipulate functions

Language	2014	2015
Scala	84%	71%
Java	38%	31%
Python	38%	58%
R	unknown	18%

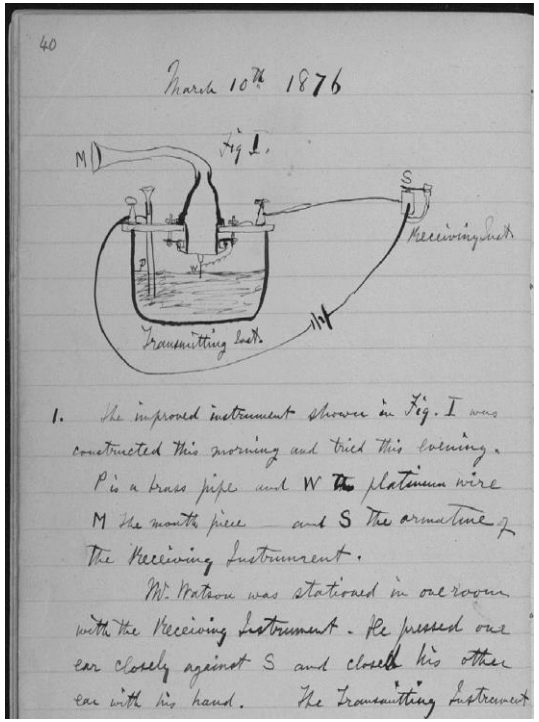
Survey done by Databricks, Summer 2015

This probably means that more "data scientists" are starting to use Spark DataFrames make all languages equally performant

What is a “Notebook”?

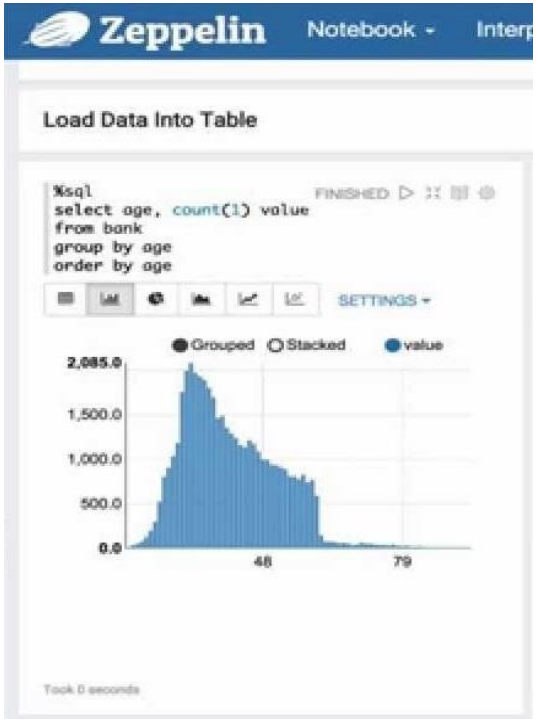
Pen and Paper

- **Pen and paper has long provided the rich experience that scientists need to document progress through notes and drawings:**
  - Expressive
  - Cumulative
  - Collaborative



Notebooks

- **Notebooks are the digital equivalent of the “pen and paper” lab notebook, enabling data scientists to document reproducible analysis:**
  - Markdown and visualization
  - Iterative exploration
  - Easy to share

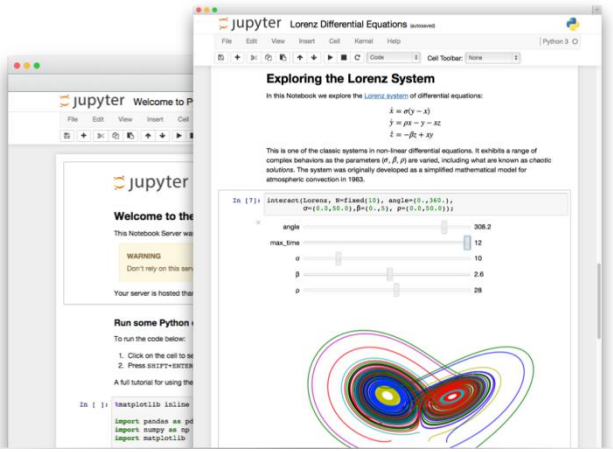


Open Source Web-Based Notebooks

- **Notebooks:**
  "interactive computational environment, in which you can combine code execution, rich text, mathematics, plots and rich media"

- **Zeppelin**
  - Classified by Apache with a status of "incubator"
  - Current version: 0.5.5 (Nov 18, 2015)
  - Support multiple interpreters
    - Scala, Python, SparkSQL

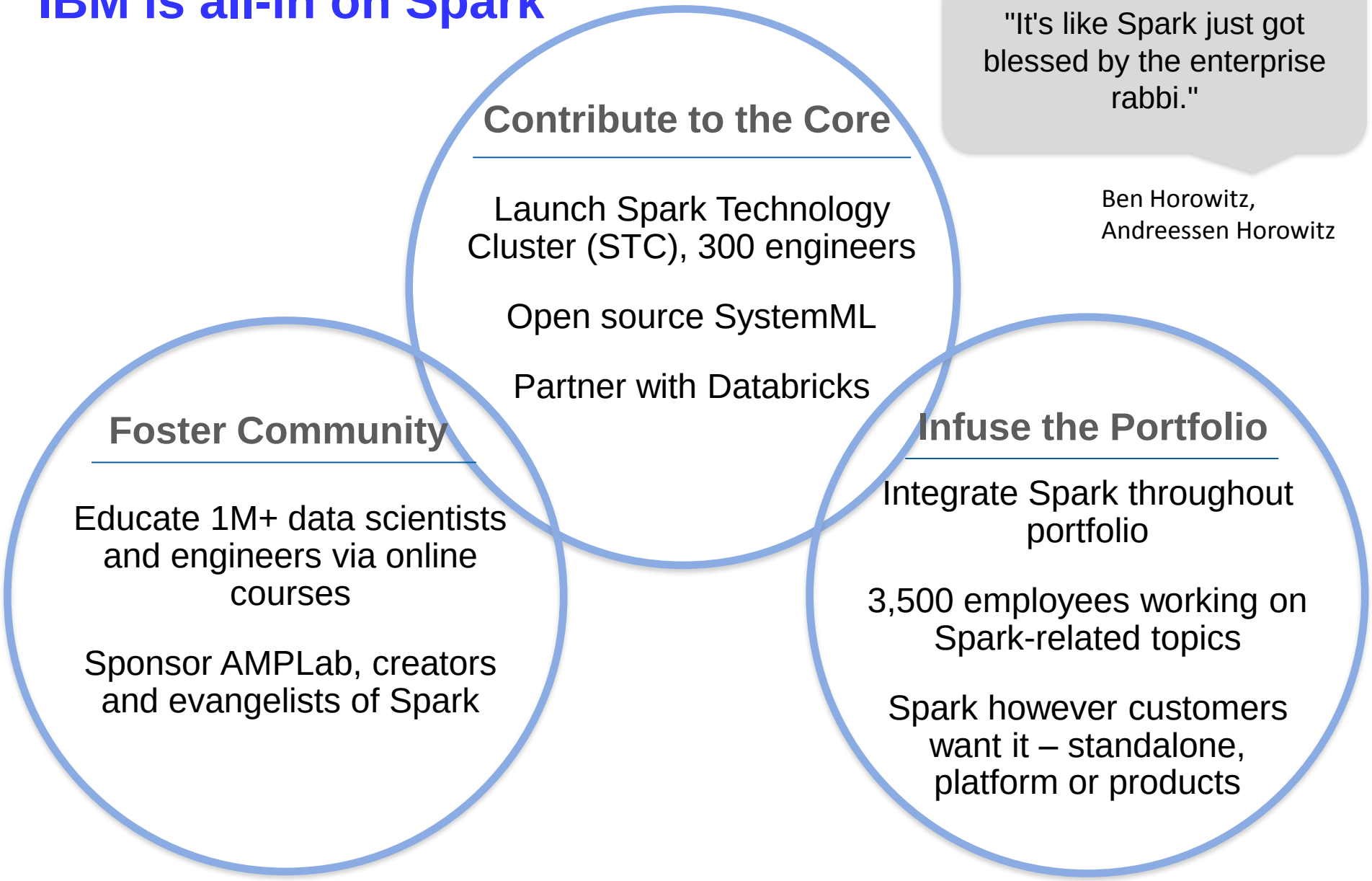
- **Jupyter**
  - Based on IPython
  - Current version: 4.1.0b1
  - Supports multiple interpreters
    - Python, Scala



IBM is all-in on Spark

"It's like Spark just got blessed by the enterprise rabbi."

Ben Horowitz, Andreessen Horowitz



IBM Contribute to core Apache Spark Project

WWW.SPARK.TC

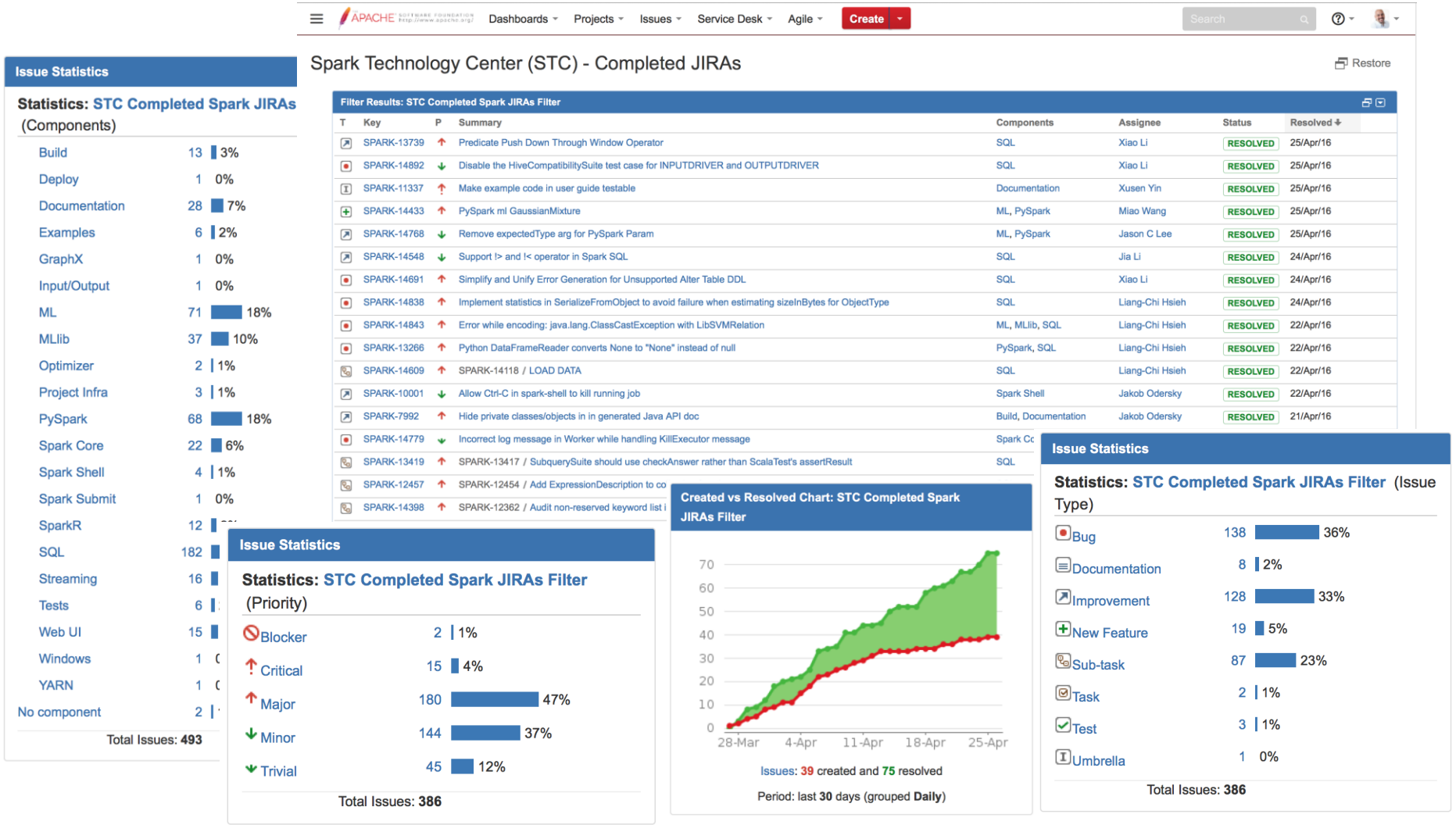
IBM has the largest investment in Spark of any company in the world

IBM Spark Technology Center

- Launched in June of 2015
- Goal to hire 300 Engineers.
- Goal to Contribute to Apache Spark Apache community
- Contributed SystemML technology to Apache community
- STC continues to grow...

STC - JIRAs, check out what we are doing at apache.org

https://issues.apache.org/jira/secure/Dashboard.jspa?selectPageId=12326761



IBM driving SQL and Machine Learning innovation..

Filter Results: STC Completed Spark JIRAs Filter

T	Key	P	Summary	Components
	SPARK-13996	↑	Add more not null attributes for Filter codegen	SQL
	SPARK-14308	↓	SPARK-12326 / Remove unused mllib tree classes and move private classes to ML	ML, MLlib
	SPARK-13241	↓	add long--formatted timestamps to org.apache.spark.status.api.v1.ApplicationAttemptInfo	Web UI
	SPARK-13674	↑	Add wholestage codegen support to Sample	SQL
	SPARK-14191	↑	Fix Expand operator constraints	SQL
	SPARK-13995	↑	Extract correct IsNotNull constraints for Expression	SQL
	SPARK-14264	↓	Add feature importances for GBTs in Pyspark	ML, PySpark
	SPARK-14182	↑	Parse DDL command: Alter View	SQL
	SPARK-11892	↑	SPARK-6725 / Model export/import for spark.ml: OneVsRest	ML
	SPARK-14181	↓	TrainValidationSplit should have HasSeed	ML
	SPARK-14124	↑	SPARK-14118 / Database related commands	SQL
	SPARK-10570	↓	Add Spark version endpoint to standalone JSON API	Spark Core, Web UI
	SPARK-13963	↓	SPARK-13964 / Add binary toggle Param to ml.HashingTF	ML
	SPARK-14071	↓	SPARK-11939 / Change MLWritable.write to be a property	ML, PySpark
	SPARK-11730	↑	Feature Importance for GBT	ML, MLlib
	SPARK-11893	↑	SPARK-6725 / Model export/import for spark.ml: TrainValidationSplit	ML
	SPARK-14156	↓	Use executedPlan for HiveComparisonTest	SQL
	SPARK-13742	↑	Add non-iterator interface to RandomSampler	Spark Core
	SPARK-14177	↑	Parse DDL command: "DESCRIBE DATABASE" and "ALTER DATABASE SET DBPROPERTIES"	SQL
	SPARK-14157	↑	Parse Drop Function DDL command	SQL
	SPARK-14161	↑	Parse Drop Database DDL command	SQL
	SPARK-12443	↑	encoderFor should support Decimal	SQL

Issue Statistics

Statistics: STC Completed Spark JIRAs Filter
(Components)

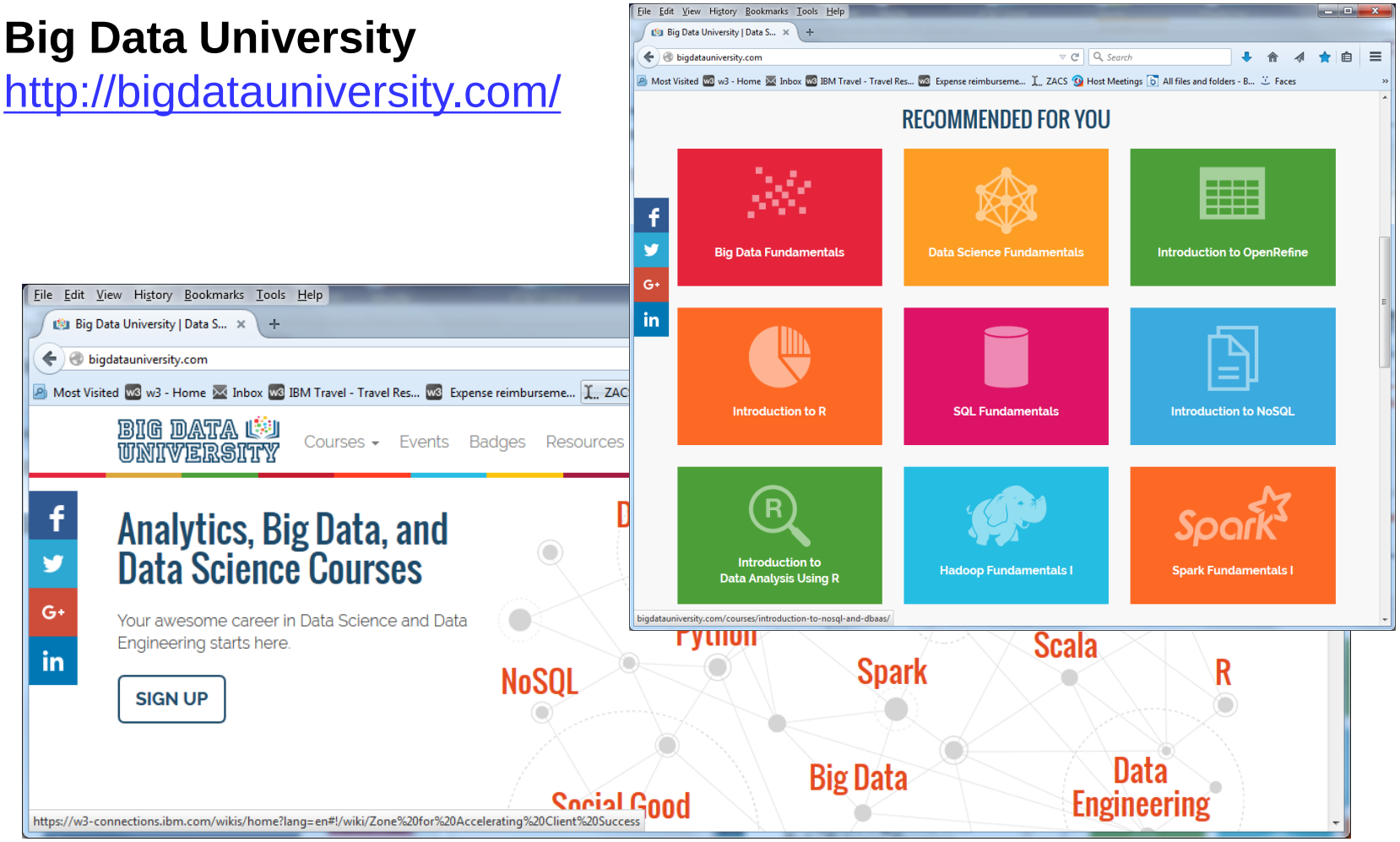
Build	13	3%
Deploy	1	0%
Documentation	28	7%
Examples	6	2%
GraphX	1	0%
Input/Output	1	0%
ML	71	18%
MLlib	37	10%
Optimizer	2	1%
Project Infra	3	1%
PySpark	68	18%
Spark Core	22	6%
Spark Shell	4	1%
Spark Submit	1	0%
SparkR	12	3%
SQL	182	47%
Streaming	16	4%
Tests	6	2%
Web UI	15	4%
Windows	1	0%
YARN	1	0%
No component	2	1%

Total Issues: **493**

http://www.spark.tc/blog/

Foster Community - Free Education

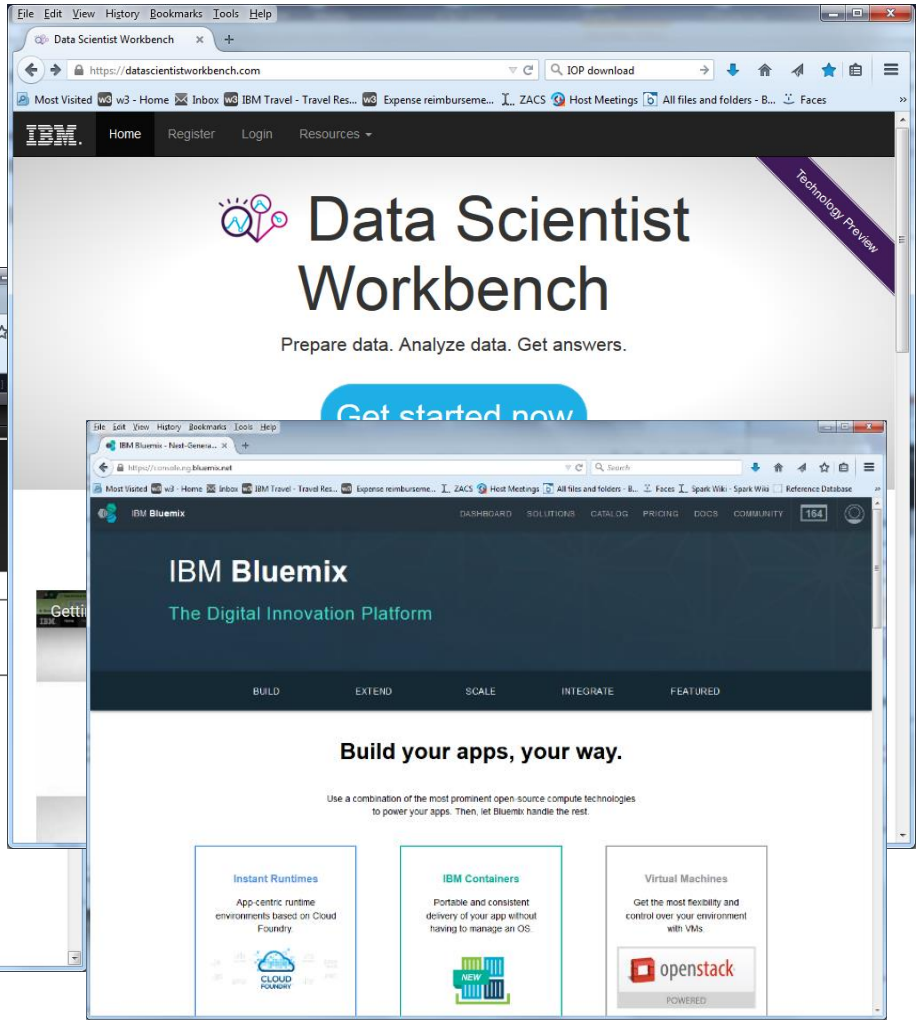
Big Data University
http://bigdatauniversity.com/

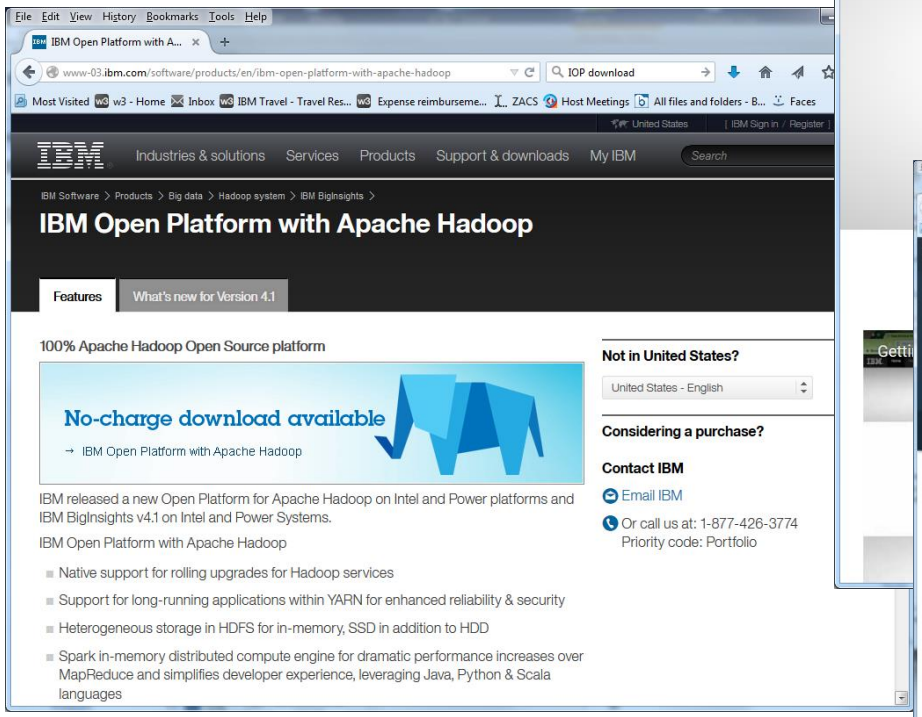


Foster Community – Free Platforms

Data Sciencist Work Bench
https://datascientistworkbench.com/

Spark as a Service
www.bluemix.net





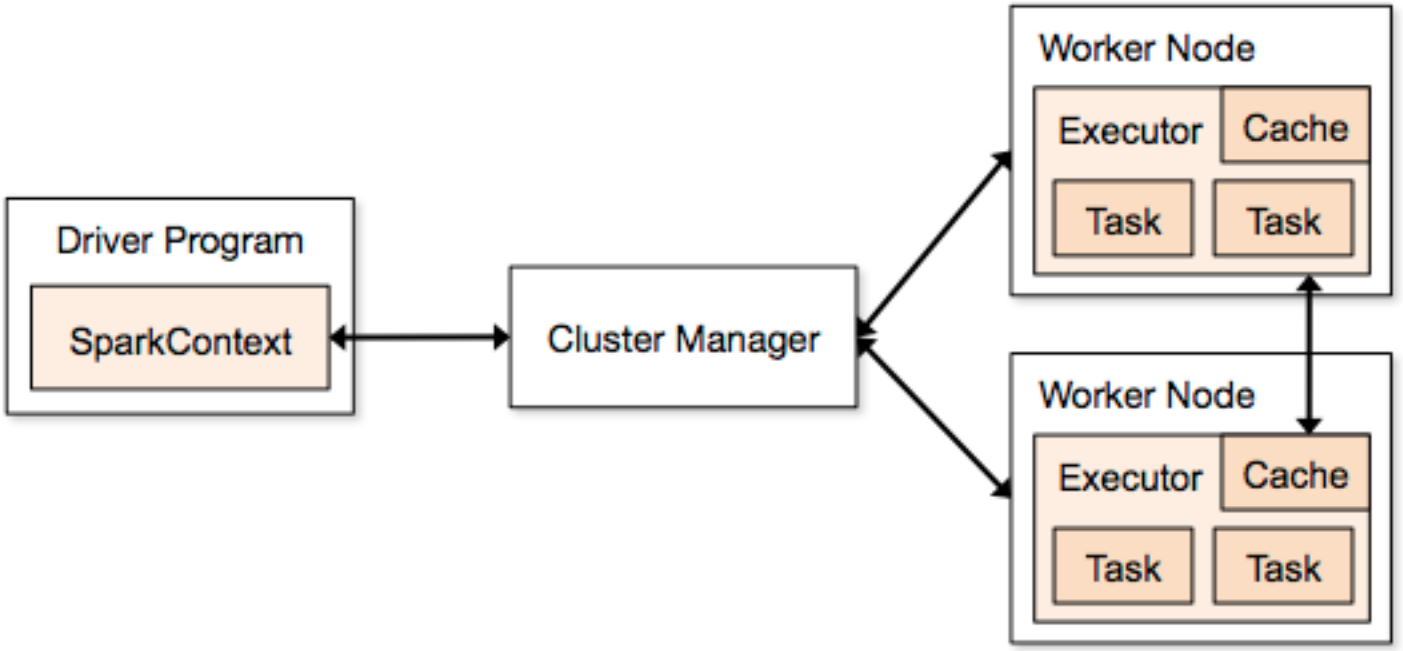
IBM Open Platform
http://www-03.ibm.com/software/products/en/ibm-open-platform-with-apache-hadoop

Apache Spark Under the hood!

Spark Application Architecture

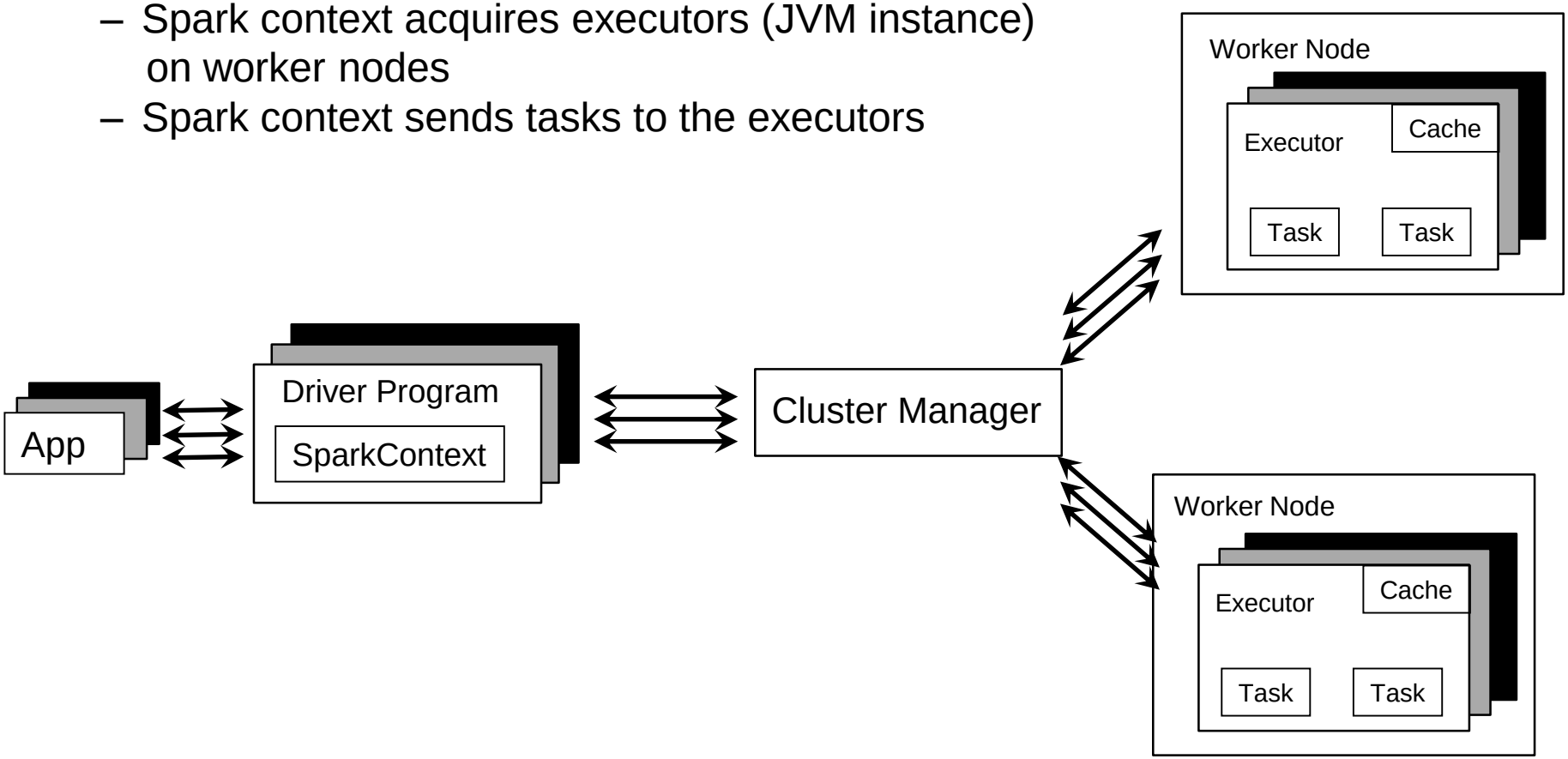
- **A Spark application is initiated from a driver program**

- **Spark execution modes:**
  - Standalone with the built-in cluster manager
  - Use Mesos as the cluster manager
  - Use YARN as the cluster manager
  - Standalone cluster on any cloud (BlueMix, IBM Softlayer, Amazon, Azure, …)



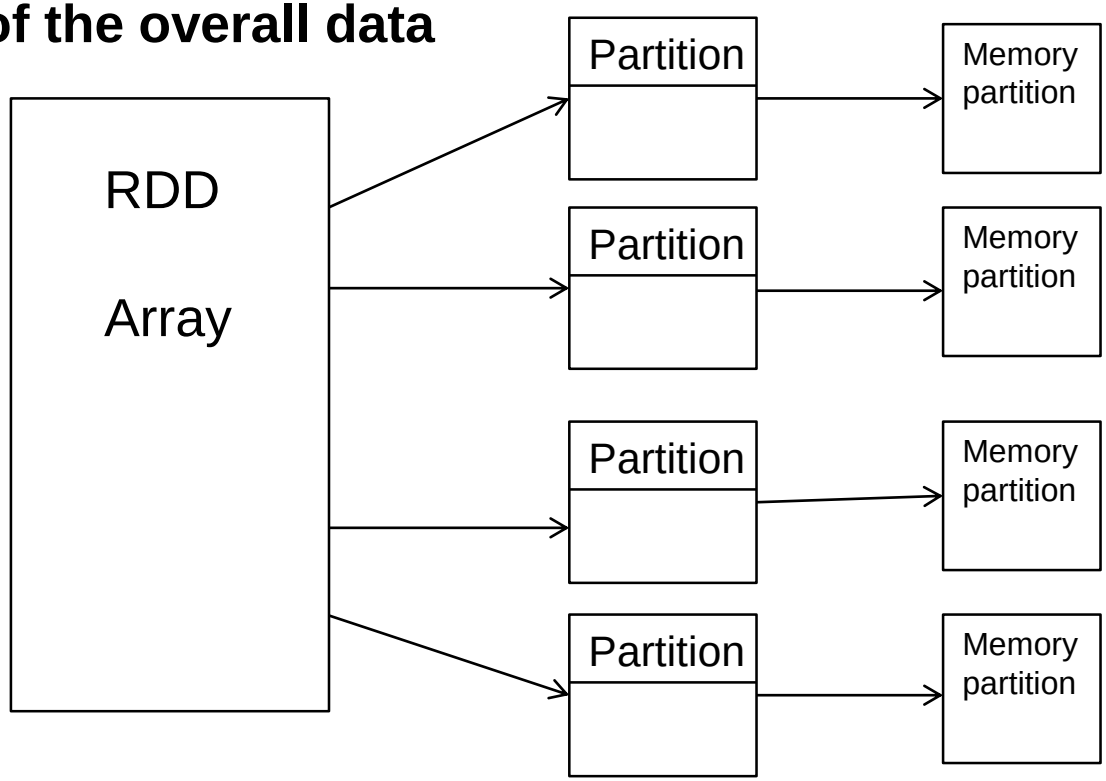
Showing multiple applications

- Each Spark application runs as a set of processes coordinated by the Spark context object (driver program)
  - Spark context connects to Cluster Manager (standalone, Mesos/Yarn)
  - Spark context acquires executors (JVM instance) on worker nodes
  - Spark context sends tasks to the executors



Resilient Distributed Dataset (RDD)

- **RDDs are immutable**
  - Modifications create new RDDs
- **Holds references to partition objects**
- **Each partition is a subset of the overall data**
- **Partitions are assigned to nodes on the cluster**
- **Partitions are in memory by default**
- **RDDs keep information on their lineage**



More about RDDs

- **Immutable**

- **Two types of operations**
  - **Transformations ~ DDL (Create View V2 as…) – Lazy Evaluation**
    - **val rddNumbers = sc.parallelize(1 to 10): Numbers from 1 to 10**
    - **val rddNumbers2 = rddNumbers.map (x => x+1): Numbers from 2 to 11**
    - The LINEAGE on how to obtain rddNumbers2 from rddNumber is recorded
    - It's a Directed Acyclic Graph (DAG)
    - No actual data processing does take place ➔ **Lazy evaluations**
  - **Actions ~ Select (Select * From V2…) – Perform Computations**
    - **rddNumbers2.collect(): Array [2, 3, 4, 5, 6, 7, 8, 9, 10, 11]**
    - Performs transformations and action
    - Returns a value (or write to a file)

- **Fault tolerance**
  - If data in memory is lost it will be recreated from lineage

Code Execution (2)

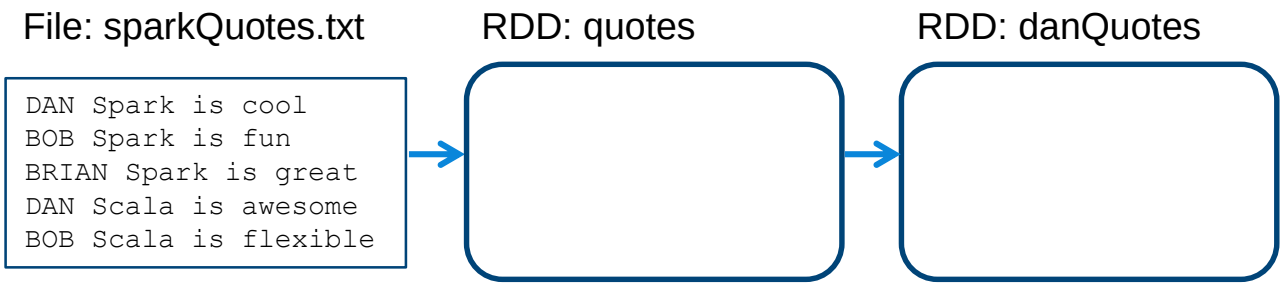
```
// Create RDD
val quotes =
sc.textFile("hdfs:/sparkdata/sparkQuotes.txt")
// Transformations
val danQuotes = quotes.filter(_.startsWith("DAN"))
val danSpark = danQuotes.map(_.split(" ")).map(x =>
x(1))
// Action
danSpark.filter(_.contains("Spark")).count()
```

File: sparkQuotes.txt

```
DAN Spark is cool
BOB Spark is fun
BRIAN Spark is great
DAN Scala is awesome
BOB Scala is flexible
```

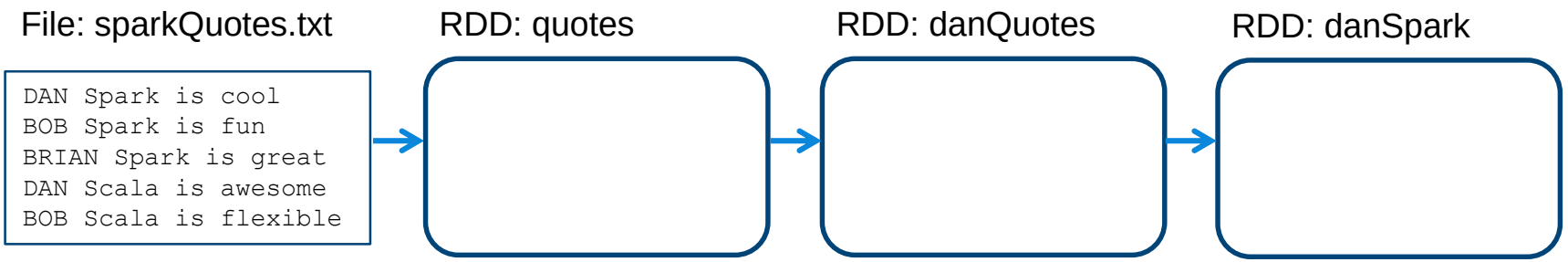
Code Execution (3)

```
// Create RDD
val quotes =
sc.textFile("hdfs:/sparkdata/sparkQuotes.txt")
// Transformations
val danQuotes = quotes.filter(_.startsWith("DAN"))
val danSpark = danQuotes.map(_.split(" ")).map(x =>
x(1))
// Action
danSpark.filter(_.contains("Spark")).count()
```



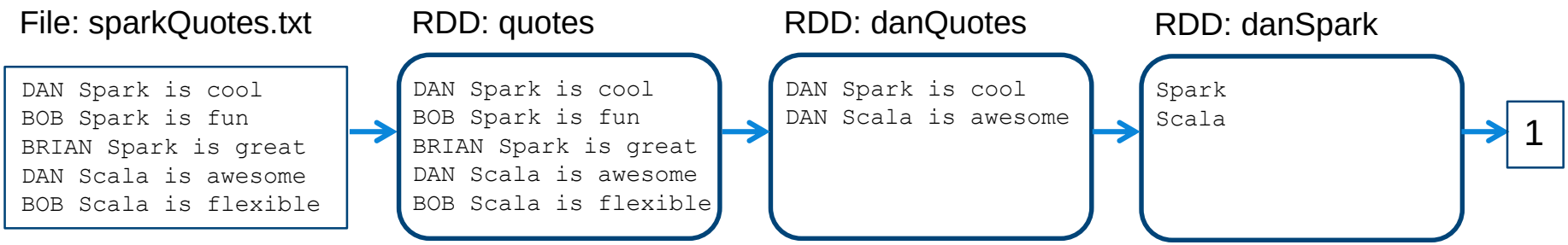
Code Execution (4)

```
// Create RDD
val quotes =
sc.textFile("hdfs:/sparkdata/sparkQuotes.txt")
// Transformations
val danQuotes = quotes.filter(_.startsWith("DAN"))
val danSpark = danQuotes.map(_.split(" ")).map(x =>
x(1))
// Action
danSpark.filter(_.contains("Spark")).count()
```



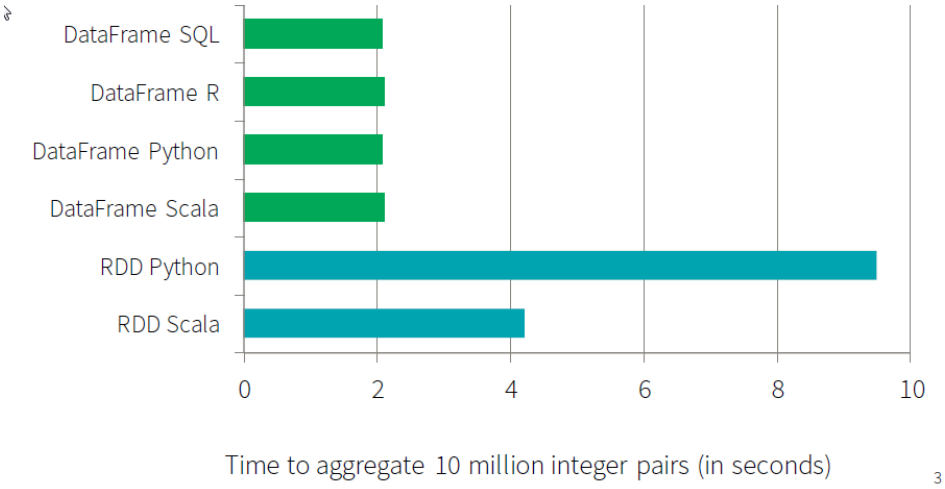
Code Execution (5)

```
// Create RDD
val quotes =
sc.textFile("hdfs:/sparkdata/sparkQuotes.txt")
// Transformations
val danQuotes = quotes.filter(_.startsWith("DAN"))
val danSpark = danQuotes.map(_.split(" ")).map(x =>
x(1))
// Action
danSpark.filter(_.contains("Spark")).count()
```



SparkSQL, DataFrames and DataSets

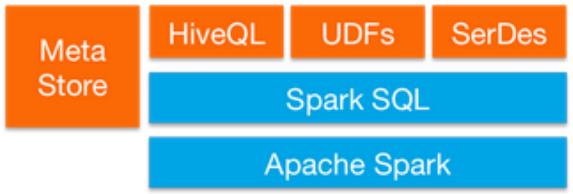
- **A rich set of functionality that allows "Database-like" processing**
- **Share single optimizer, called "Catalyst" (at the driver)**
  - An open-source extensible query optimizer
- **Because it is the same engine, it has exactly the same performance for different APIs**
  - And performance is much better than for RDD
- **Much less code**
- **All SparkSQL, DF, and DataSets are essentially using the same engine**

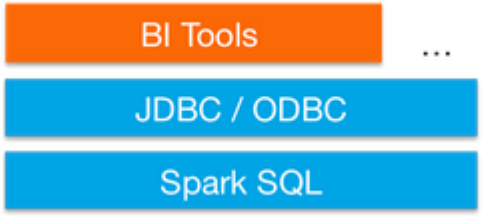


Picture credit: databricks.com

SparkSQL

- **Provide for relational queries expressed in SQL, HiveQL using Scala, Python, and Java API's**
- **Seamlessly mix SQL queries with Spark programs**
- **SchemaRDD provide a single interface for efficiently working with structured data including Apache Hive, Parquet and JSON files**
- **Graduated from alpha status with Spark 1.3**
  - DataFrames API marked as experimental in 2013
- **Standard connectivity through JDBC/ODBC**





Spark Streaming

- **Component of Spark**
  - Project started in 2012
  - First alpha release in Spring 2013
  - Out of alpha with Spark 0.9.0
  - More enhancements targeted for Spark 2.0

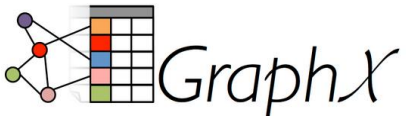
- **Discretized Stream (DStream) programming abstraction**
  - Represented as a sequence of RDDs (micro-batches)
  - RDD: set of records for a specific time interval
  - Supports Scala, Java, and Python (with limitations)

- **Fundamental architecture: batch processing of datasets**

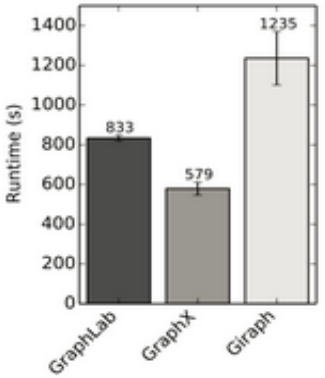
Spark MLlib

- **Spark MLlib for machine learning library**
  - Marked as under active development
- **Provides common algorithm and utilities**
  - Classification
  - Regression
  - Clustering
  - Collaborative filtering
  - Dimensionality reduction
- **Leverages iteration and yields better results than one-pass approximations sometimes used with MapReduce**

Spark GraphX



- **Flexible Graphing**
  - GraphX unifies ETL, exploratory analysis, and iterative graph computation
  - You can view the same data as both graphs and collections, transform and join graphs with RDDs efficiently, and write custom iterative graph algorithms with the API
  - GraphFrames - graph library based on Data Frames
- **Speed**
  - Comparable performance to the fastest specialized graph processing systems.
- **Algorithms**
  - Choose from a growing library of graph algorithms
  - In addition to a highly flexible API, GraphX comes with a variety of graph algorithms



Spark R

- **Spark R is an R package that provides a light-weight front-end to use Apache Spark from R**
- **Spark R exposes the Spark API through the RDD class and allows users to interactively run jobs from the R shell or RStudio on a cluster.**
- **Goals**
  - Make Spark R production ready
    - Efforts from AlteryX and DataBricks
  - Integration with MLlib
  - Consolidations to the data frame and RDD concepts

Links and Labs

- **Lecture / Slides** Introduction To Apache Spark

Jupyter Notebooks

- Lab 1 - Hello Spark - Student Notebook.ipynb
- Lab 2 - Spark SQL - Student Notebook.ipynb
- Lab 3 - Machine Learning - Student Notebook.ipynb

Instructors Notebooks appear after completion of survey

- https://ibm.box.com/IntroApacheSpark-Lectures