Apache Spark

Crash Course - DataWorks Summit – Berlin 2018

Robert Hryniewicz

Data Evangelist

@RobHryniewicz

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POWERING THE FUTURE OF DATA

Data

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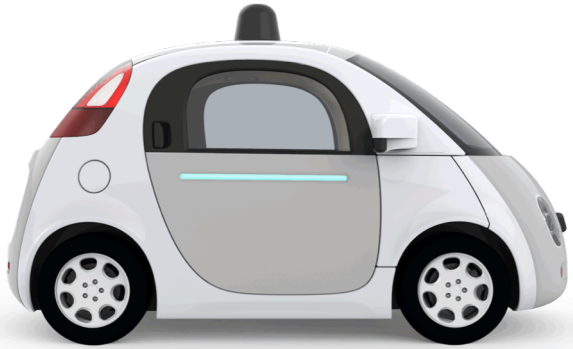
Data Sources

- Internet of Things (IoT)
  - Wind Turbines, Oil Rigs
  - Beacons, Wearables
  - Smart Cars

- User Generated Content (Social, Web & Mobile)
  - Twitter, Facebook, Snapchat
  - Clickstream
  - Paypal, Venmo



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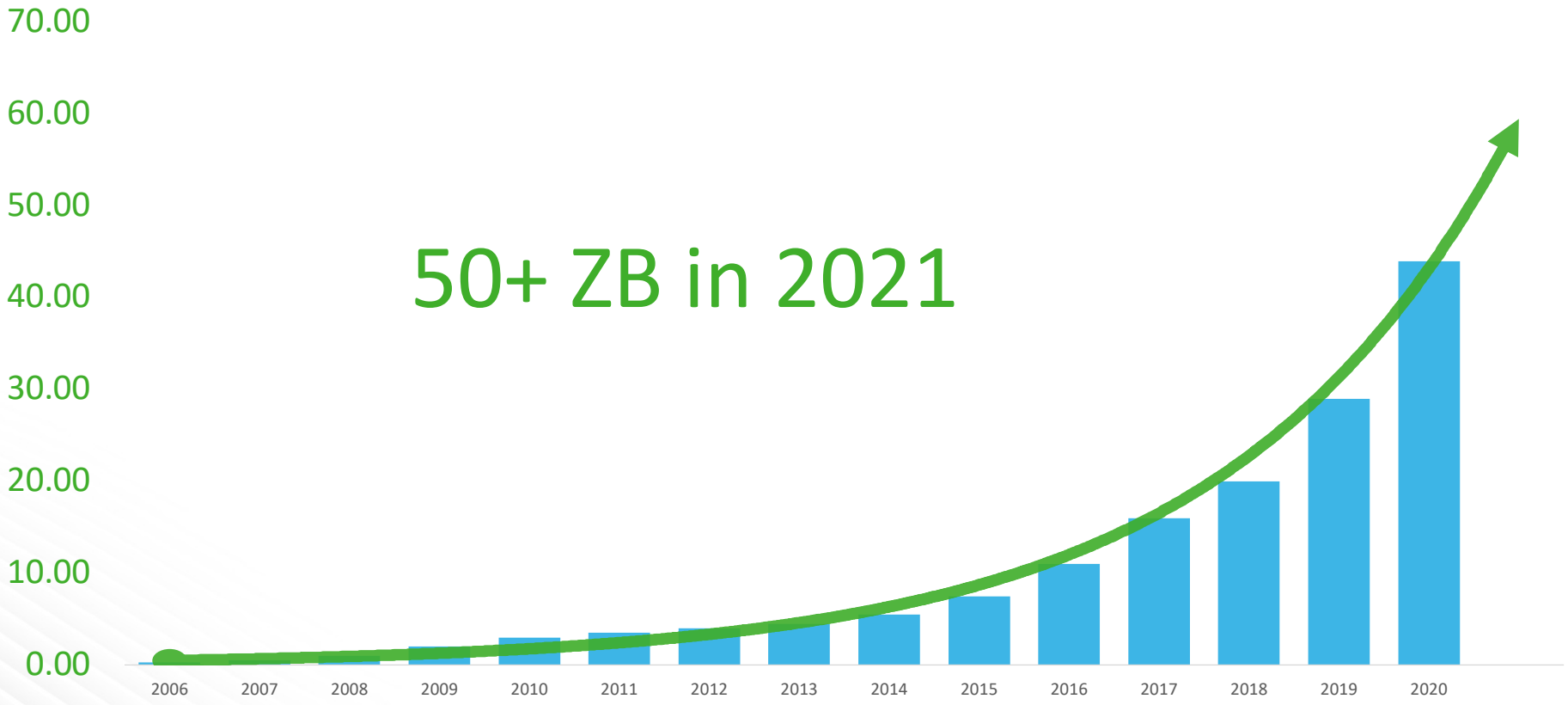
Data Growth in Zeta Bytes (ZB)



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The “Big Data” Problem

Problem

- A single machine cannot process or even store all the data!

Solution

- Distribute data over large clusters

Difficulty

- How to split work across machines?
- Moving data over network is expensive
- Must consider data & network locality
- How to deal with failures?
- How to deal with slow nodes?

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Apache Spark

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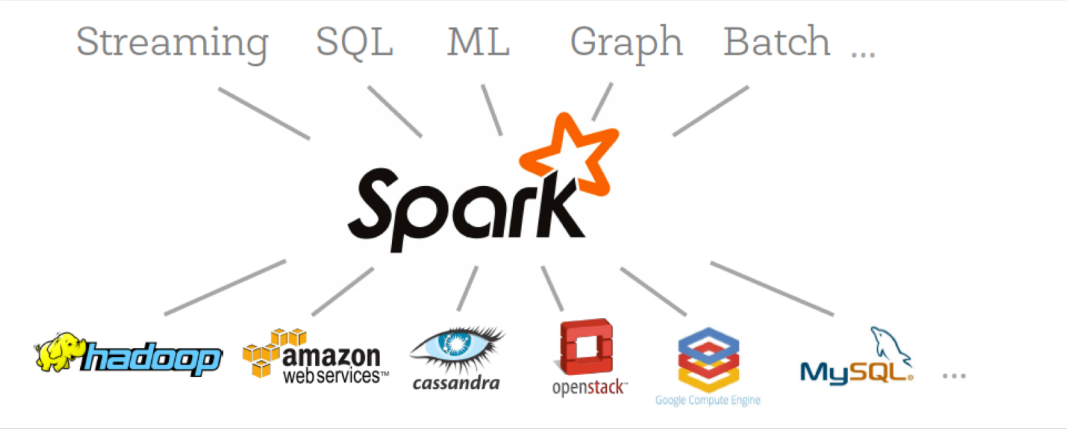
What Is Apache Spark?

- **Apache open source project** originally developed at AMPLab (University of California Berkeley)
- **Unified, general data processing engine** that operates across varied data workloads and platforms



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Why Apache Spark?

- **Elegant Developer APIs**
  - Single environment for data munging, data wrangling, and Machine Learning (ML)
- **In-memory computation model – Fast!**
  - Effective for iterative computations and ML
- **Machine Learning**
  - Implementation of distributed ML algorithms
  - Pipeline API (Spark MLlib)
  - External libraries via open & commercial projects (H2Os Sparkling Water)

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Spark SQL	Spark Streaming	Spark MLlib	GraphX
Structured Data	Real-time	Machine Learning	Graph Analysis

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Spark SQL

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Spark SQL
Structured Data

Spark Streaming
Near Real-time

Spark MLlib
Machine Learning

GraphX
Graph Analysis

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Spark SQL Overview

- Spark module for ***structured data*** processing (e.g. ORC, Parquet, Avro, MySQL)
- Two ways to manipulate data:
  - DataFrame/Dataset API
  - SQL query

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SparkSession

What is it?

- Main entry point for Spark functionality
- Allows programming with DataFrame and Dataset APIs
- Represented as **spark** and auto-initialized in a notebook type env. (Zeppelin or Jupyter)

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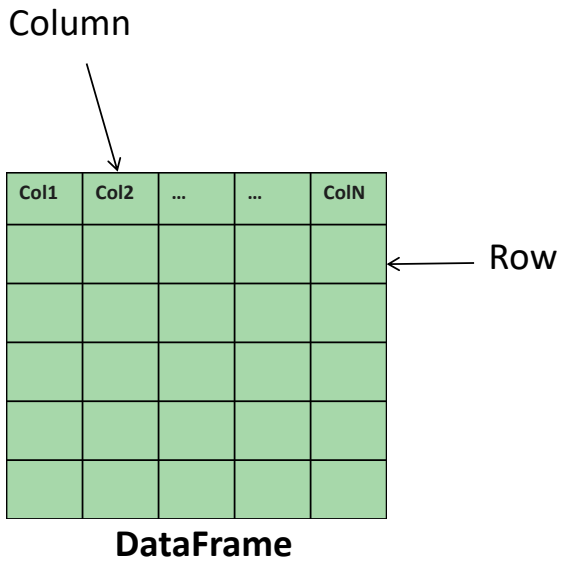
DataFrames

- **Distributed collection** of **data organized** into ***named columns***
- Conceptually equivalent to a table in **relational DB** or a **data frame in R/Python**
- API available in Scala, Java, Python, and R



Data is described as a DataFrame with **rows, columns,** and a **schema**

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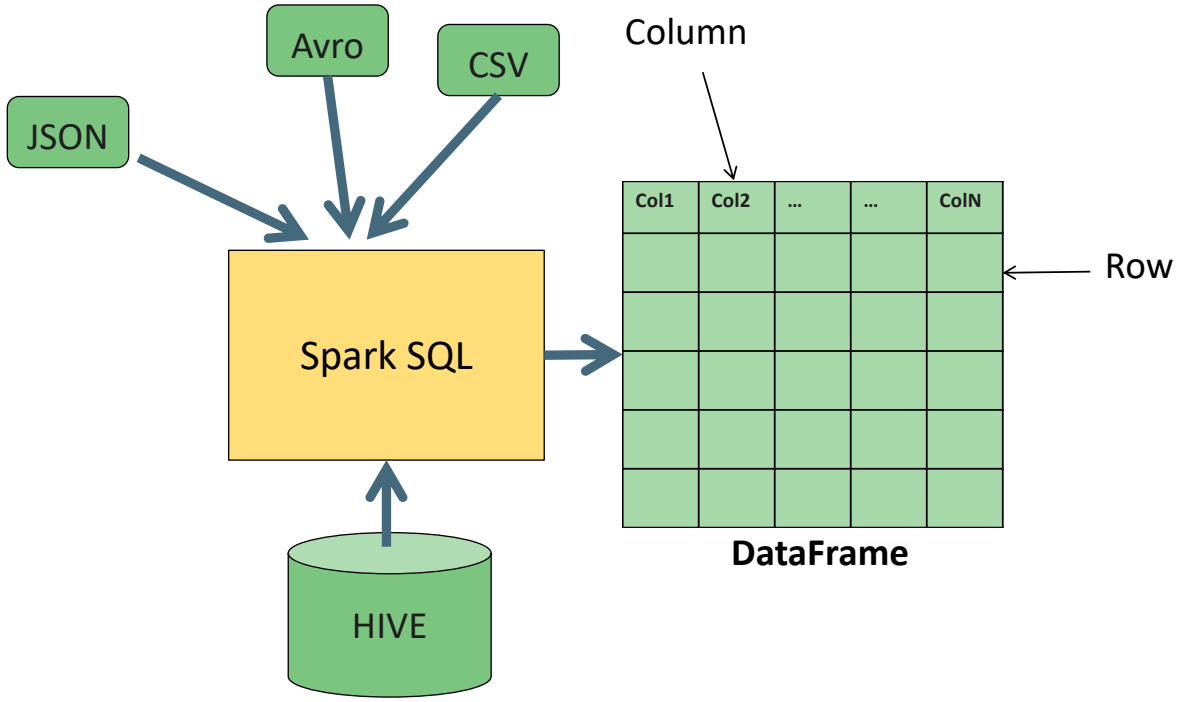
Sources



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Create a DataFrame

Example

```
val path = "examples/flights.json"
val flights = spark.read.json(path)
```


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Register a Temporary View (SQL API)

Example

```
flights.createOrReplaceTempView("flightsView")
```


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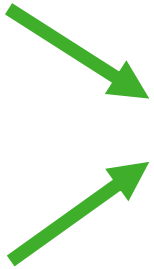
Two API Examples: DataFrame and SQL APIs

DataFrame API

```
flights.select("Origin", "Dest", "DepDelay”)
       .filter($"DepDelay" > 15).show(5)
```

SQL API

```
SELECT Origin, Dest, DepDelay
FROM flightsView
WHERE DepDelay > 15 LIMIT 5
```



Results

```
+------+----+--------+
|Origin|Dest|DepDelay|
+------+----+--------+
|   IAD| TPA|      19|
|   IND| BWI|      34|
|   IND| JAX|      25|
|   IND| LAS|      67|
|   IND| MCO|      94|
+------+----+--------+
```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Spark Streaming

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Spark SQL
Structured Data

Spark Streaming
Real-time

Spark MLlib
Machine Learning

GraphX
Graph Analysis

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What is Stream Processing?

Batch Processing

- Ability to process and analyze data at-rest (stored data)
- Request-based, bulk evaluation and short-lived processing
- Enabler for **Retrospective, Reactive and On-demand Analytics**

Stream Processing

- Ability to ingest, process and analyze data in-motion in real- or near-real-time
- Event or micro-batch driven, continuous evaluation and long-lived processing
- Enabler for **real-time Prospective, Proactive and Predictive Analytics** for Next Best Action

Stream Processing + Batch Processing = All Data Analytics
real-time (now) historical (past)

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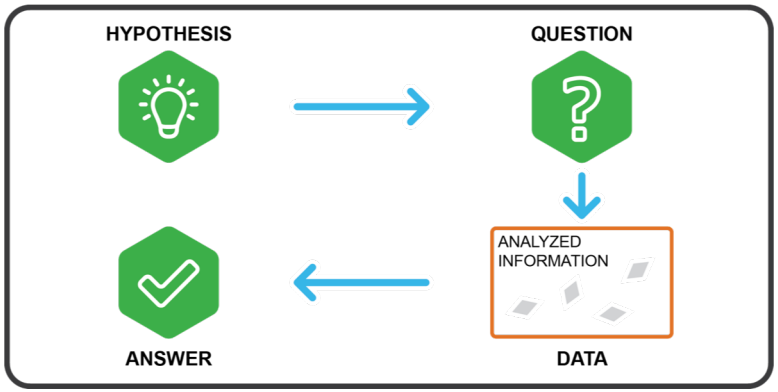
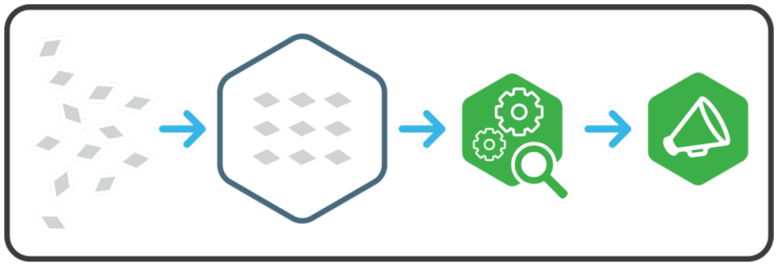
Modern Data Applications approach to Insights

Traditional Analytics

Structured & Repeatable
Structure built to store data



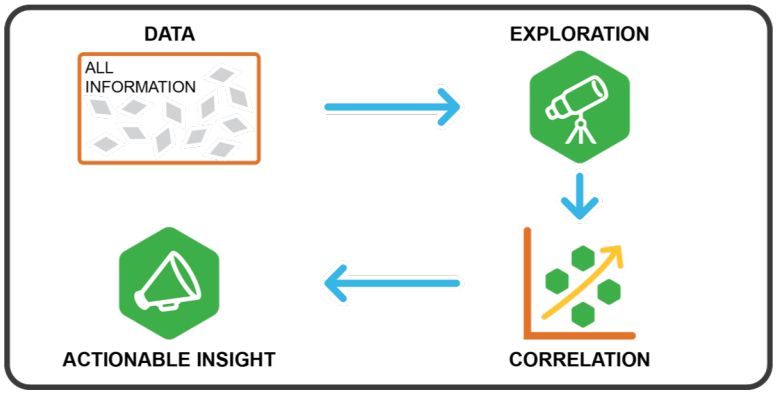
Start with hypothesis
Test against selected data



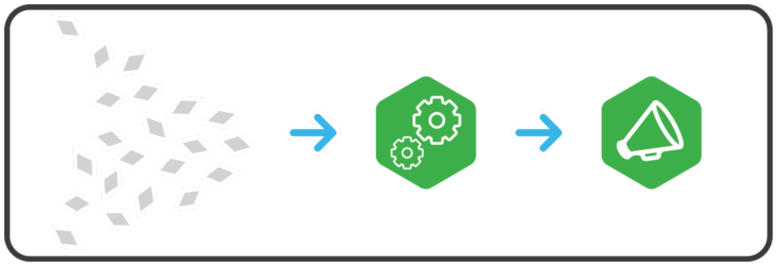
Analyze after landing…

Next Generation Analytics

Iterative & Exploratory
Data is the structure



Data leads the way
Explore *all* data, identify correlations

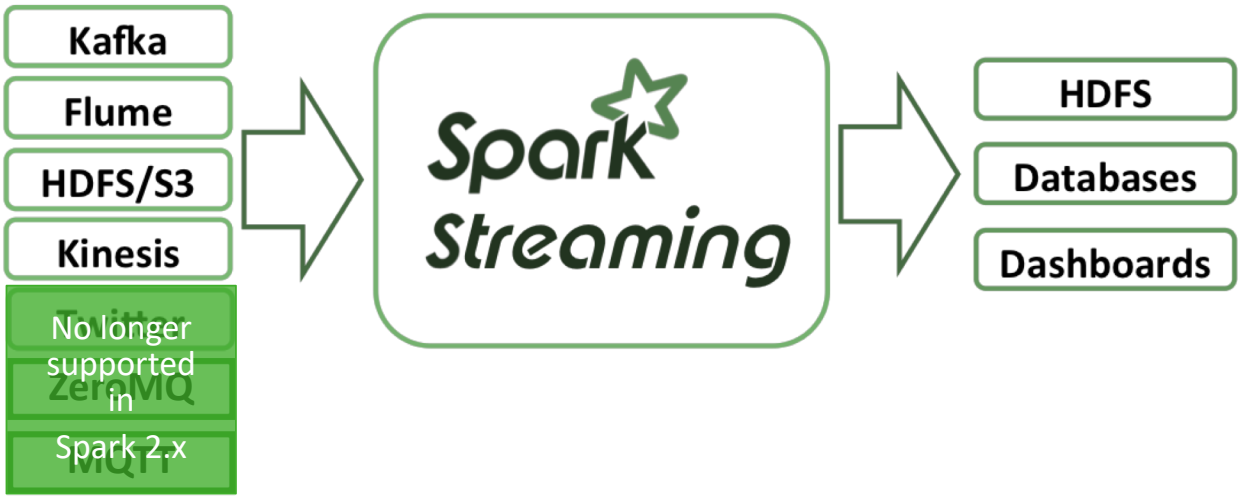


Analyze in motion…

Spark Streaming

Overview

- Extension of Spark Core API
- Stream processing of live data streams
  - Scalable
  - High-throughput
  - Fault-tolerant



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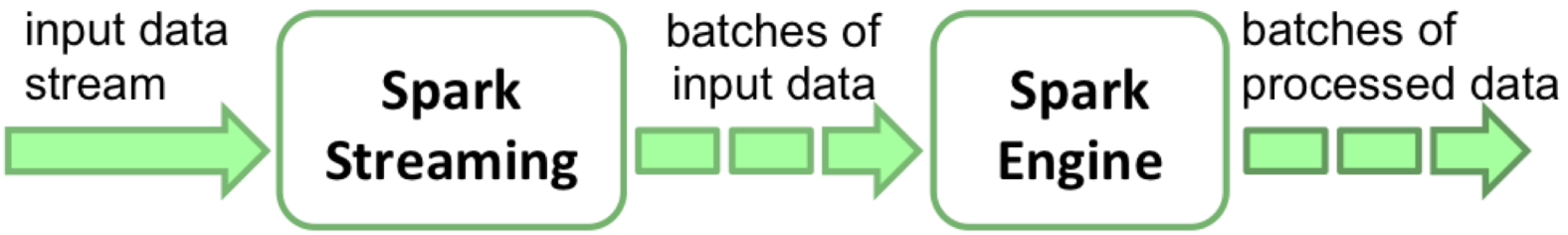
Spark Streaming



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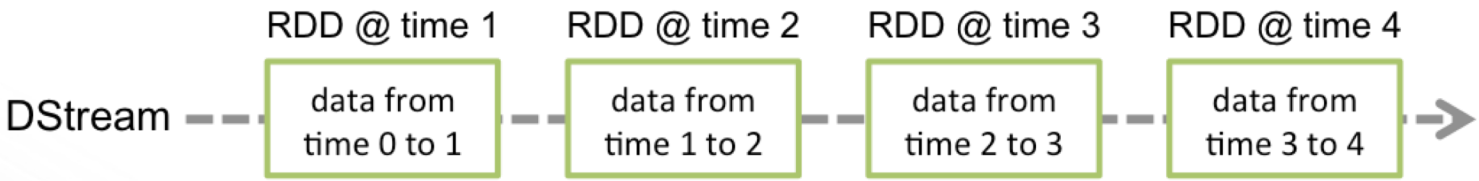
Spark Streaming

Discretized Streams (DStreams)

- High-level abstraction representing **continuous stream of data**
- Internally represented as a sequence of RDDs
- Operation applied on a DStream translates to operations on the underlying RDDs



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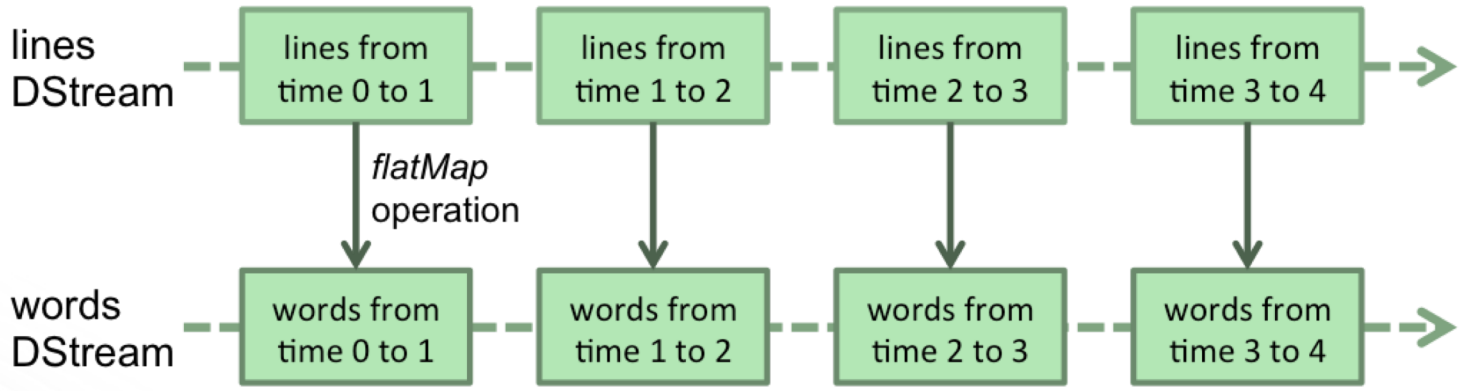
Spark Streaming

Example: *flatMap* operation



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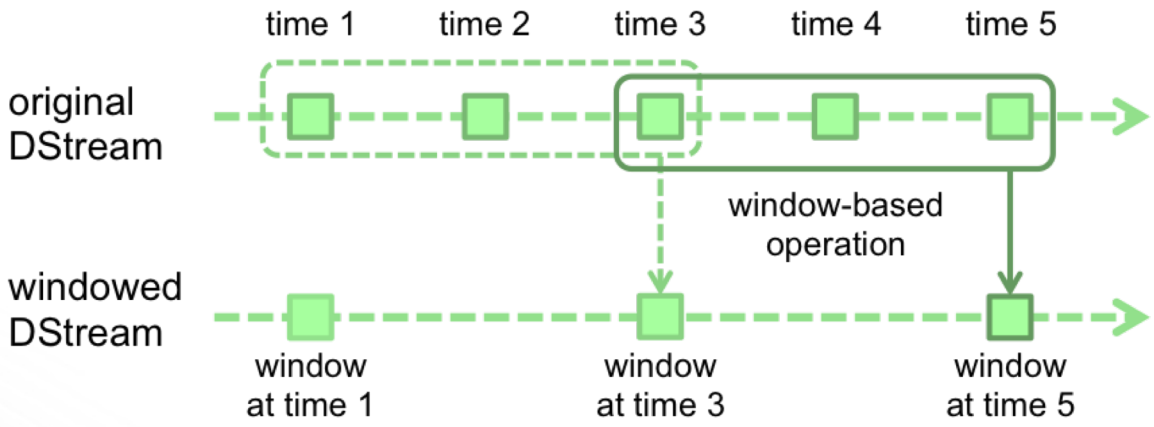
Spark Streaming

Window Operations

- Apply transformations over a sliding window of data, e.g. rolling average




```
// Reduce last 30 seconds of data, every 10 seconds
val windowedWordCounts = pairs.reduceByKeyAndWindow((a:Int,b:Int) => (a + b), Seconds(30), Seconds(10))
```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Challenges in Streaming Data

- Consistency
- Fault tolerance
- Out-of-order data

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Structured Streaming

- High-Level APIs - DataFrames, Datasets and SQL. Same in streaming and in batch
- Event-time Processing - Native support for working w/ out -of-order and late data
- End-to-end Exactly Once - Transactional both in processing and output

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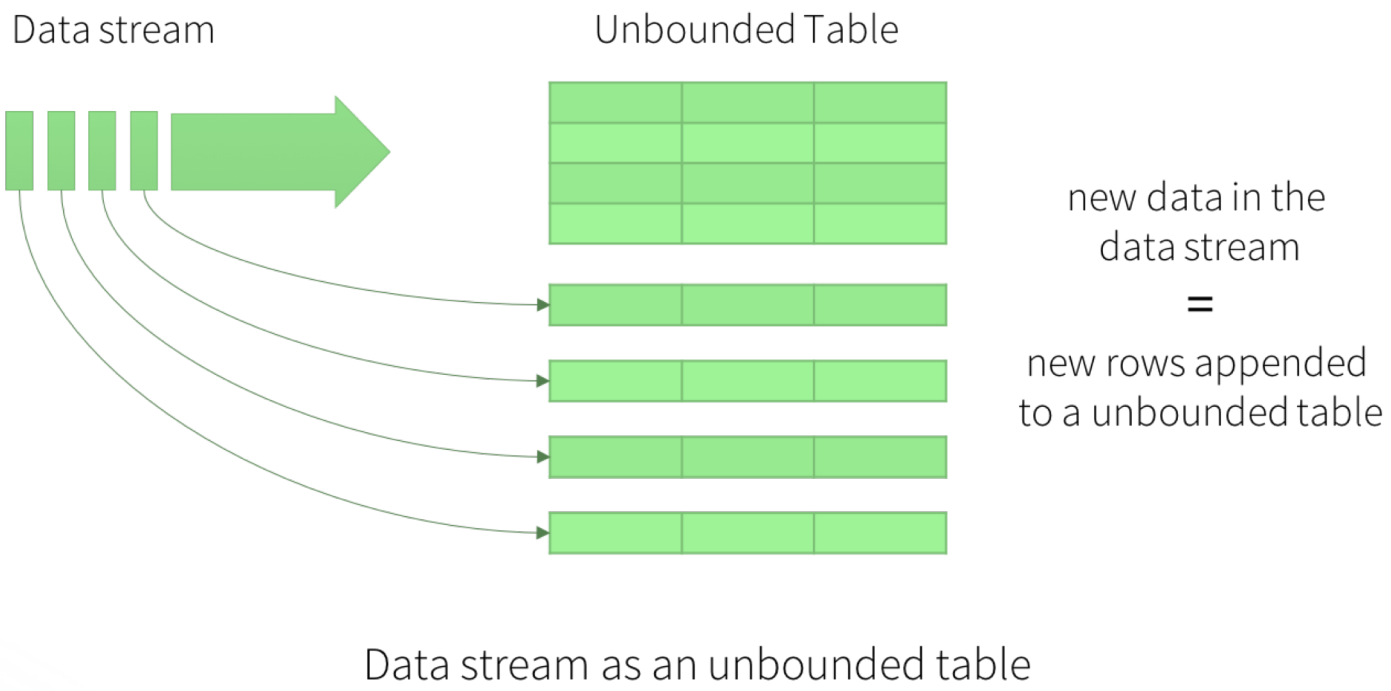
Structured Streaming: Basics



Data stream as an unbounded table

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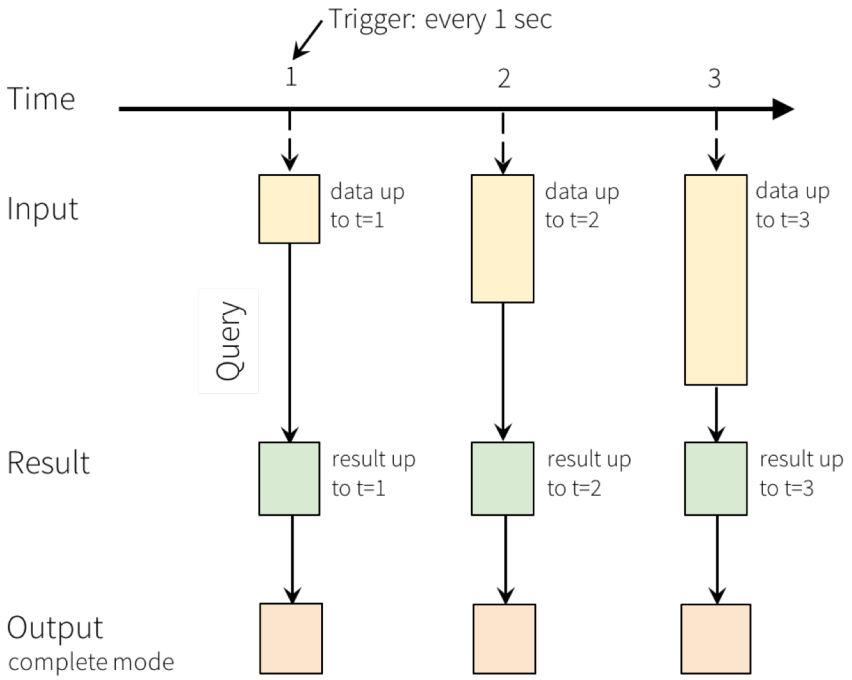
Structured Streaming: Model



Programming Model for Structured Streaming

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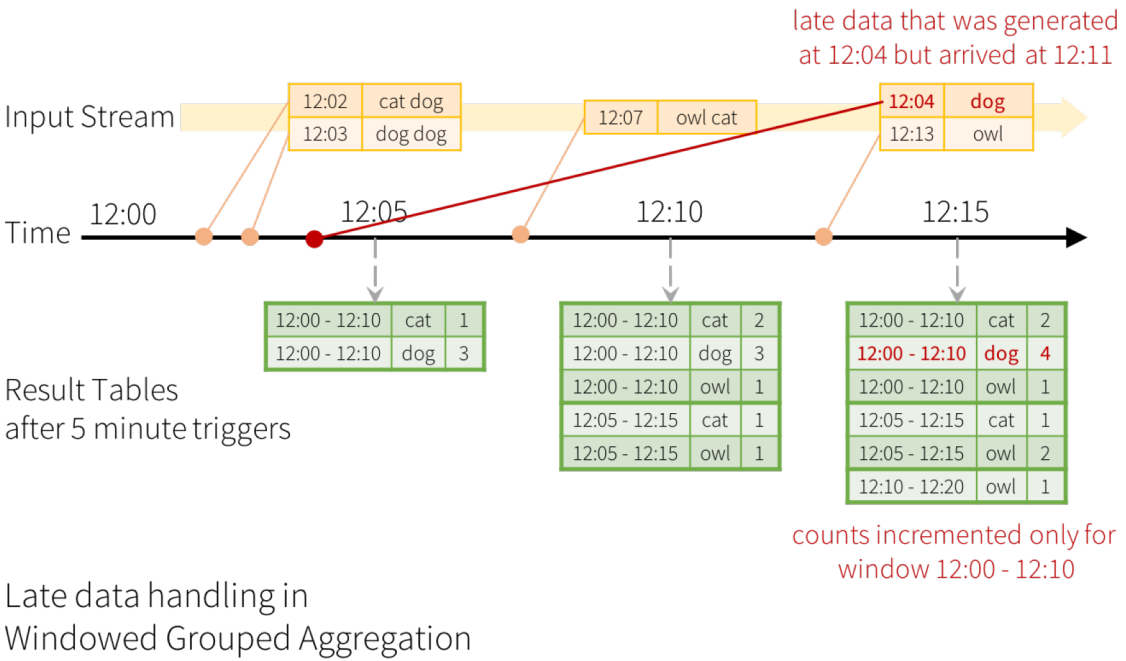
Handling late arriving data



Late data handling in
Windowed Grouped Aggregation

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Spark MLlib

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Spark SQL
Structured Data

Spark Streaming
Near Real-time

Spark MLlib
Machine Learning

GraphX
Graph Analysis

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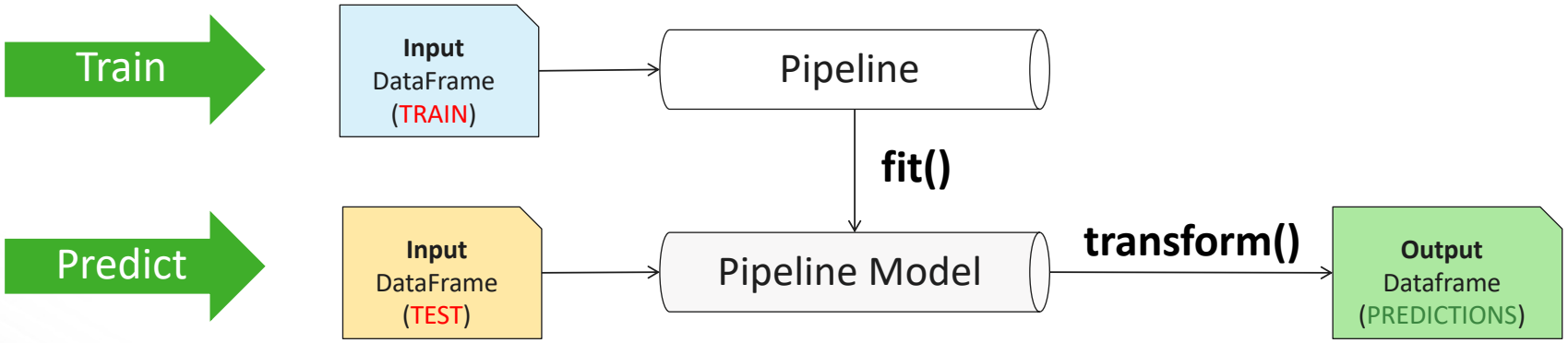
Spark ML Pipeline

- **fit()** is for **training**
- **transform()** is for **prediction**



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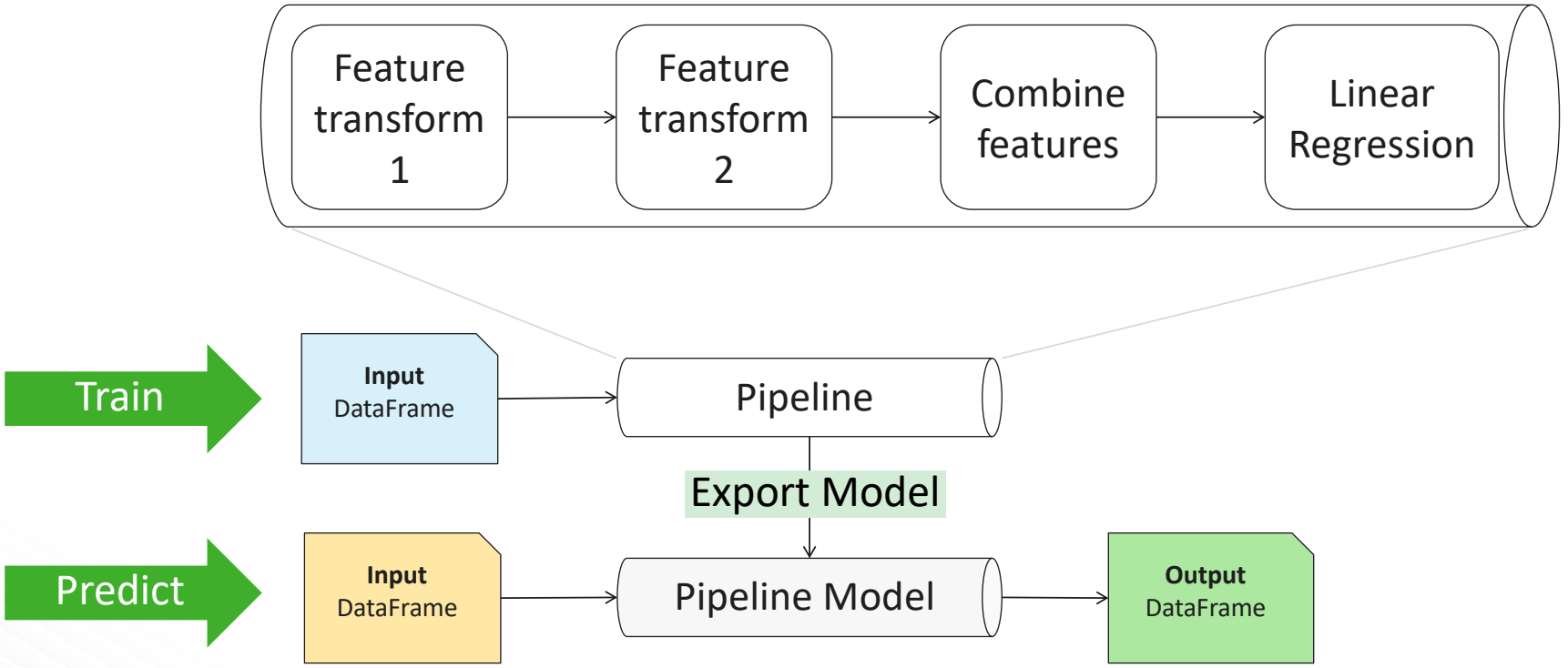
Spark ML Pipeline



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Sample Spark ML Pipeline

```
indexer = …
parser = …
hashingTF = …
vecAssembler = …


rf = RandomForestClassifier(numTrees=100)
pipe = Pipeline(stages=[indexer, parser, hashingTF, vecAssembler, rf])


model = pipe.fit(trainData)                # Train model
results = model.transform(testData)        # Test model
```

Exporting ML Models - PMML

- Predictive Model Markup Language (PMML)
  - –> XML-based predictive model interchange format
- Supported models
  - – K-Means
  - – Linear Regression
  - – Ridge Regression
  - – Lasso
  - – SVM
  - – Binary

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Spark GraphX

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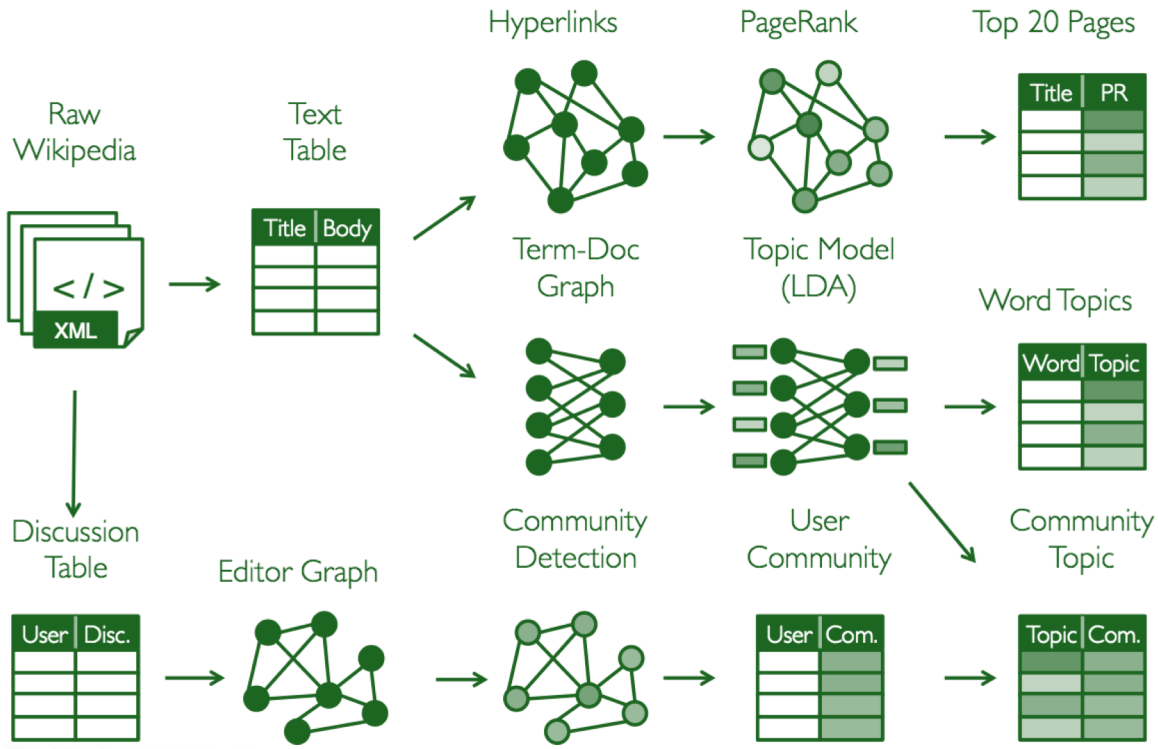

- Page Rank
- Topic Modeling (LDA)
- Community Detection

Source: ampcamp.berkeley.edu

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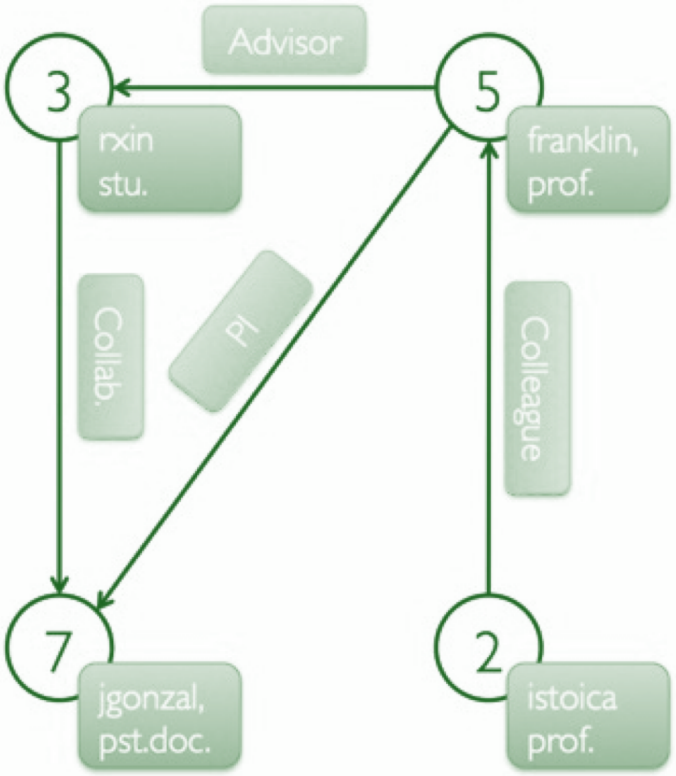
Property Graph



Vertex Table

Id	Property (V)
3	(rxin, student)
7	(jgonzal, postdoc)
5	(franklin, professor)
2	(istoica, professor)

Edge Table

SrcId	DstId	Property (E)
3	7	Collaborator
5	3	Advisor
2	5	Colleague
5	7	PI

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GraphX Algorithms

- PageRank
- Connected components
- Label propagation
- SVD++
- Strongly connected components
- Triangle count

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Sample GraphX Code in Scala

```
graph = Graph(vertices, edges)
messages = spark.textFile("hdfs://...")
graph2 = graph.joinVertices(messages) {
   (id, vertex, msg) => ...
}
```


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Apache Zeppelin

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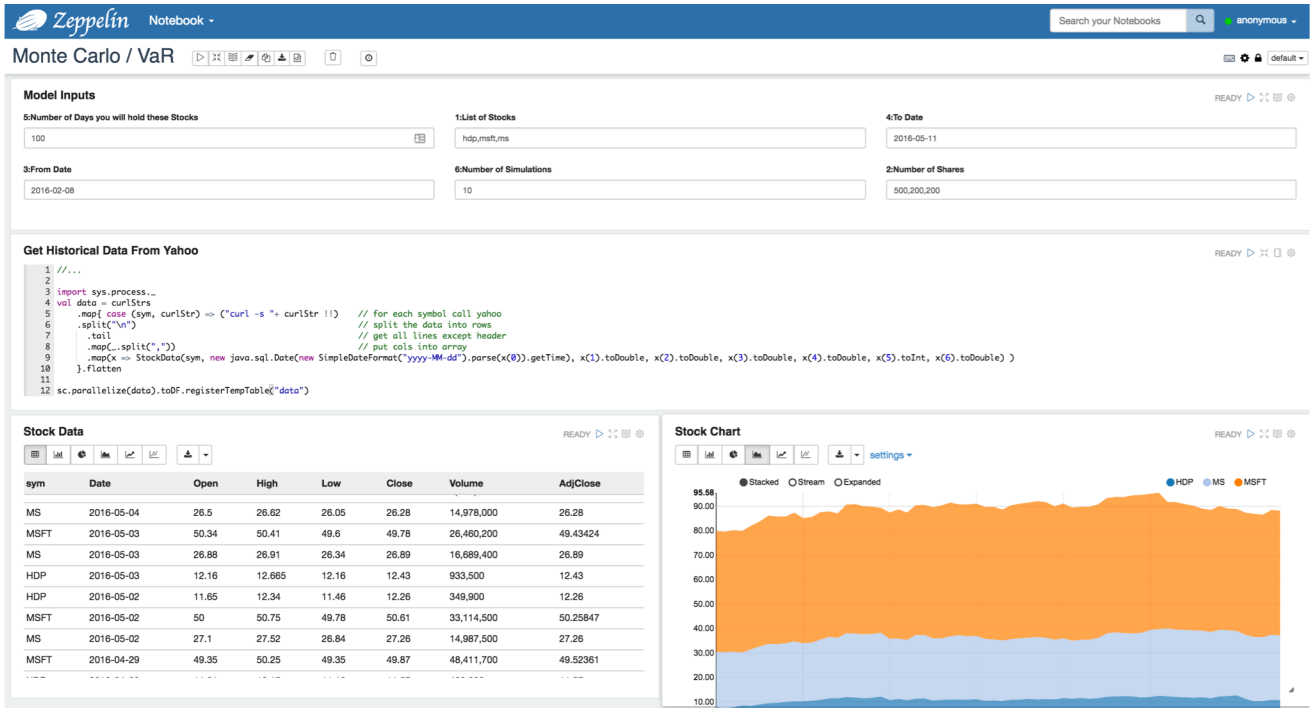
What's Apache Zeppelin?

Web-based notebook that enables interactive data analytics.

You can make beautiful data-driven, interactive and collaborative documents with SQL, Python, Scala and more



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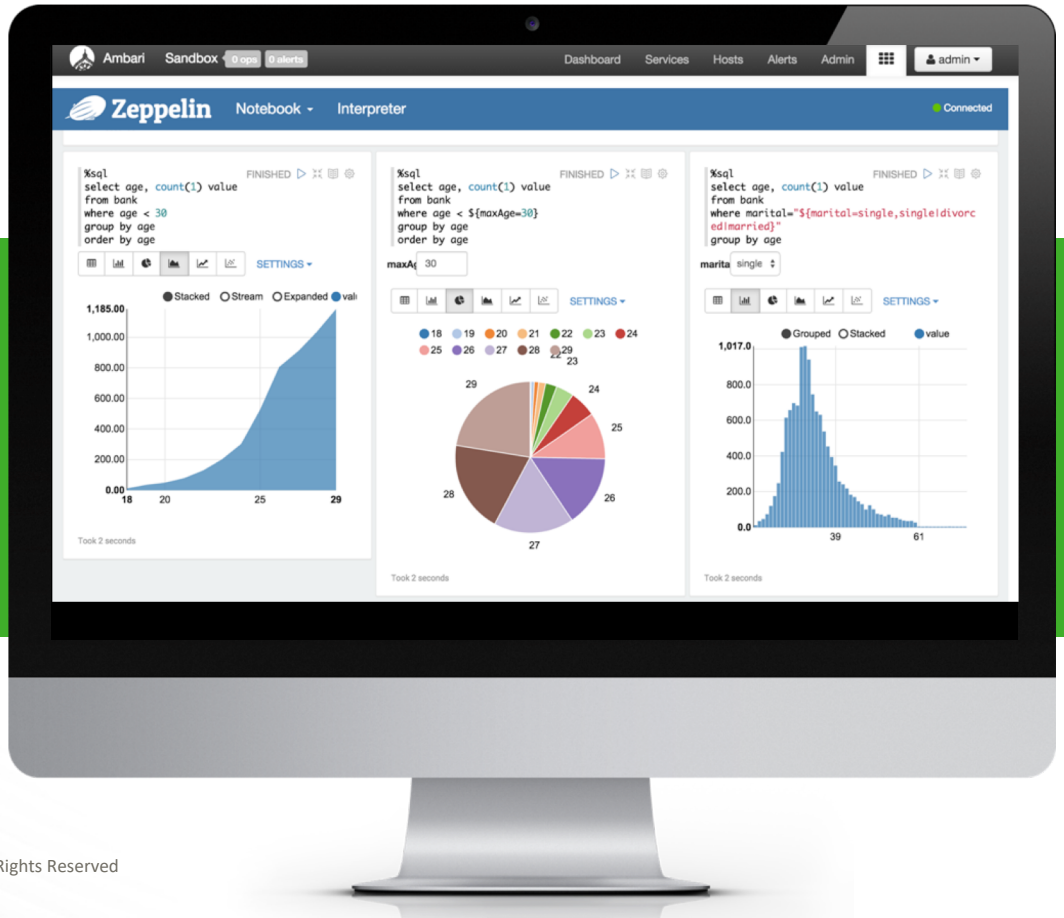
Apache Zeppelin with HDP 2.6+

Web-based Notebook for interactive analytics

Features

- Ad-hoc experimentation
- Deeply integrated with Spark + Hadoop
- Supports multiple language backends
- Incubating at Apache



Use Case

- Data exploration and discovery
- Visualization
- Interactive snippet-at-a-time experience
- "Modern Data Science Studio"

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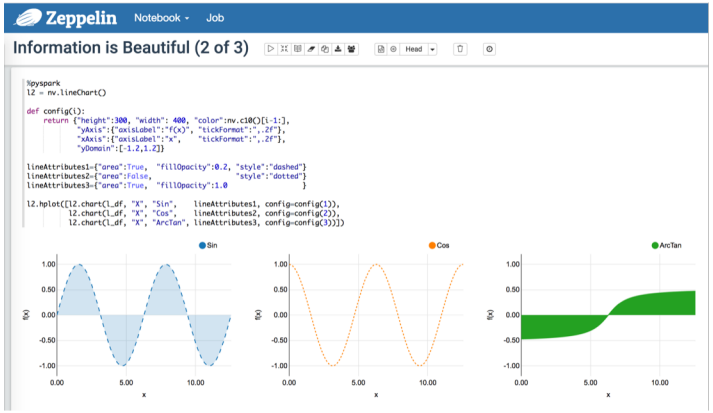

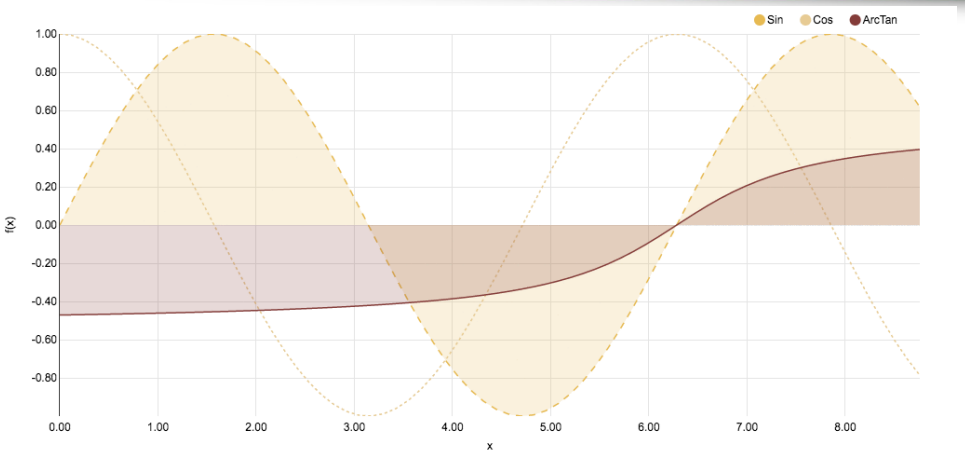

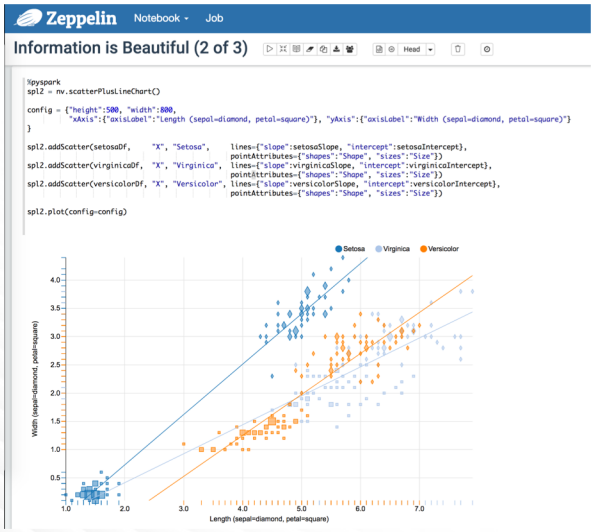

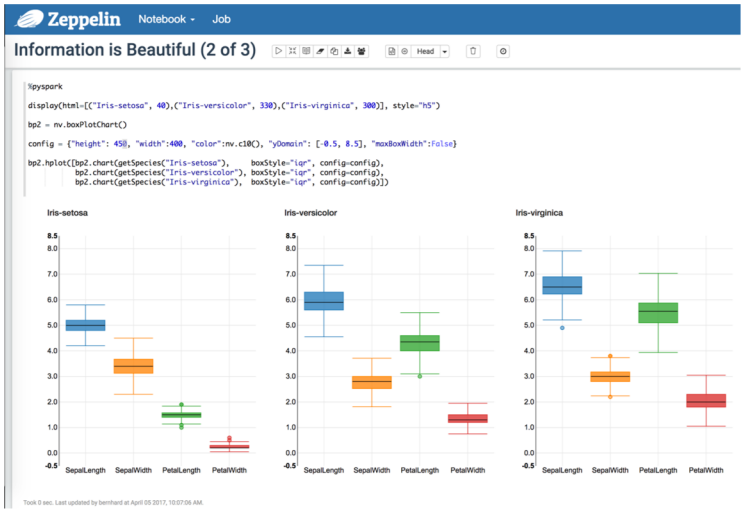

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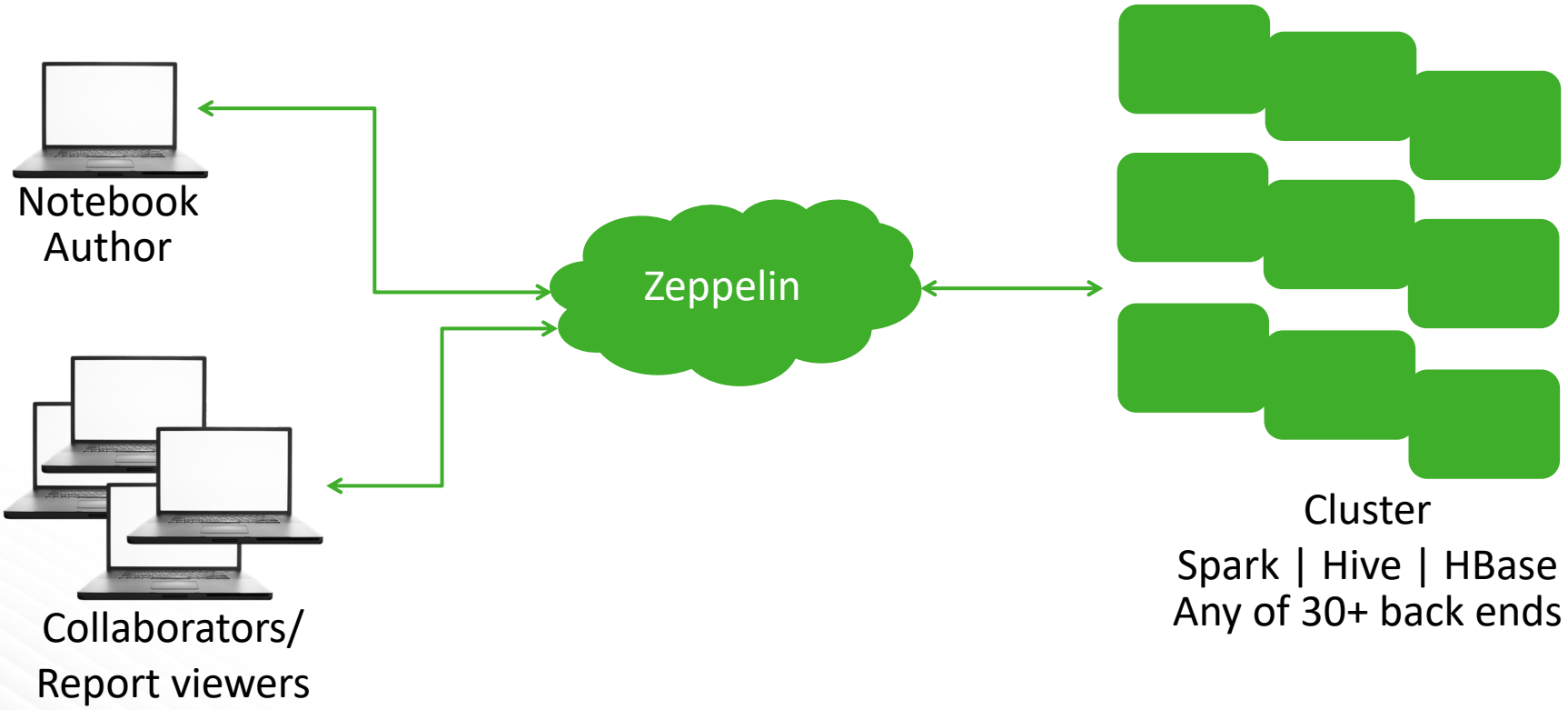
How does Zeppelin work?



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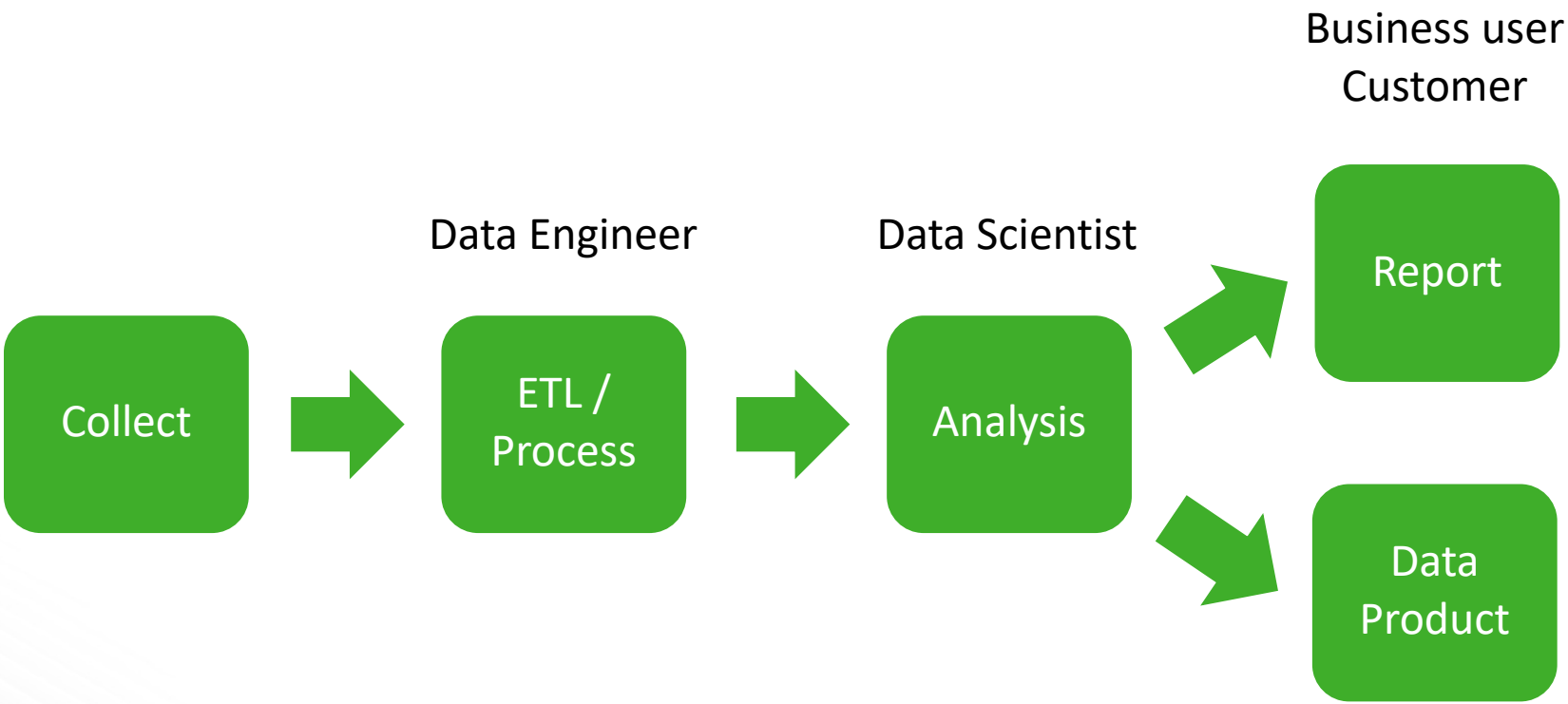
Big Data Lifecycle



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Zeppelin Multitenancy

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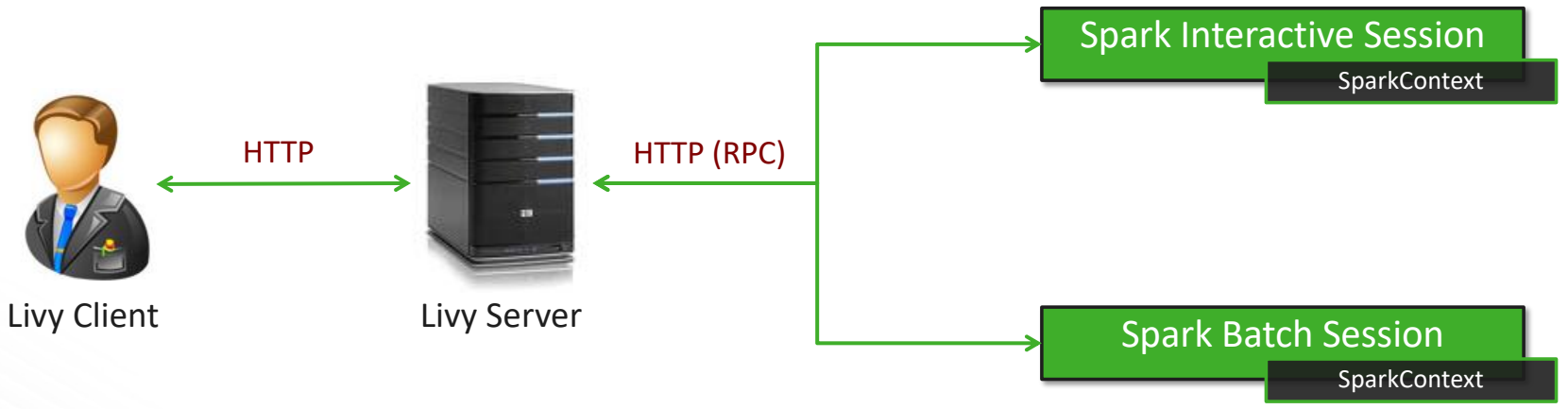
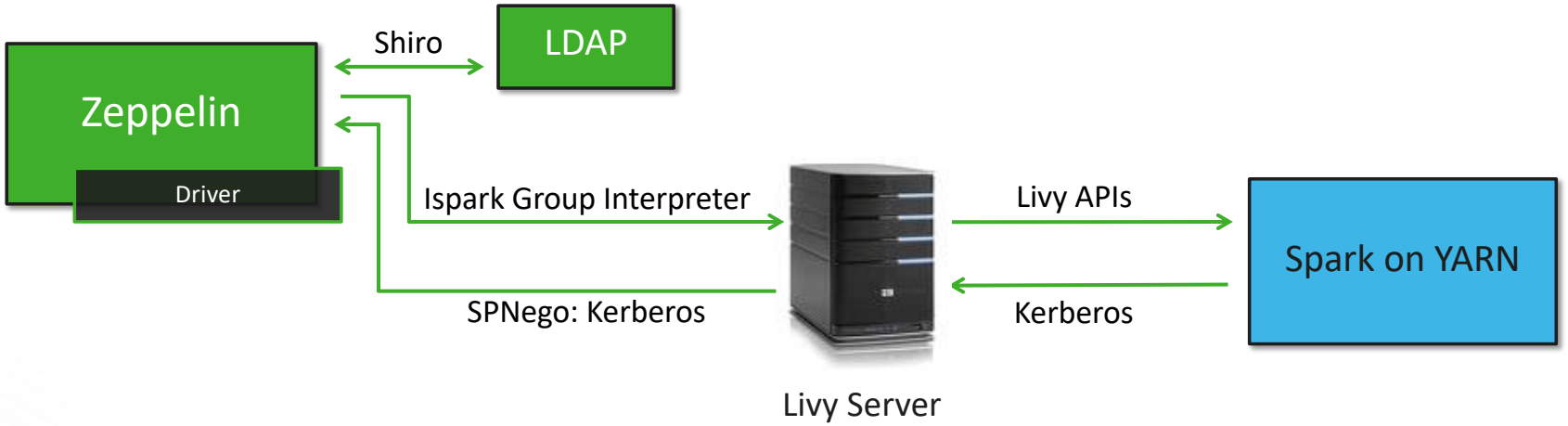
Livy

- Livy is the open source REST interface for interacting with Apache Spark from anywhere
- Installed as Spark Ambari Service



Security Across Zeppelin-Livy-Spark



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Reasons to Integrate with Livy

- **Bring Sessions to Apache Zeppelin**
  - Isolation
  - Session sharing
- **Enable efficient cluster resource utilization**
  - Default Spark interpreter keeps YARN/Spark job running forever
  - Livy interpreter recycled after 60 minutes of inactivity (controlled by livy.server.session.timeout)
- **To Identity Propagation**
  - Send user identity from Zeppelin > Livy > Spark on YARN

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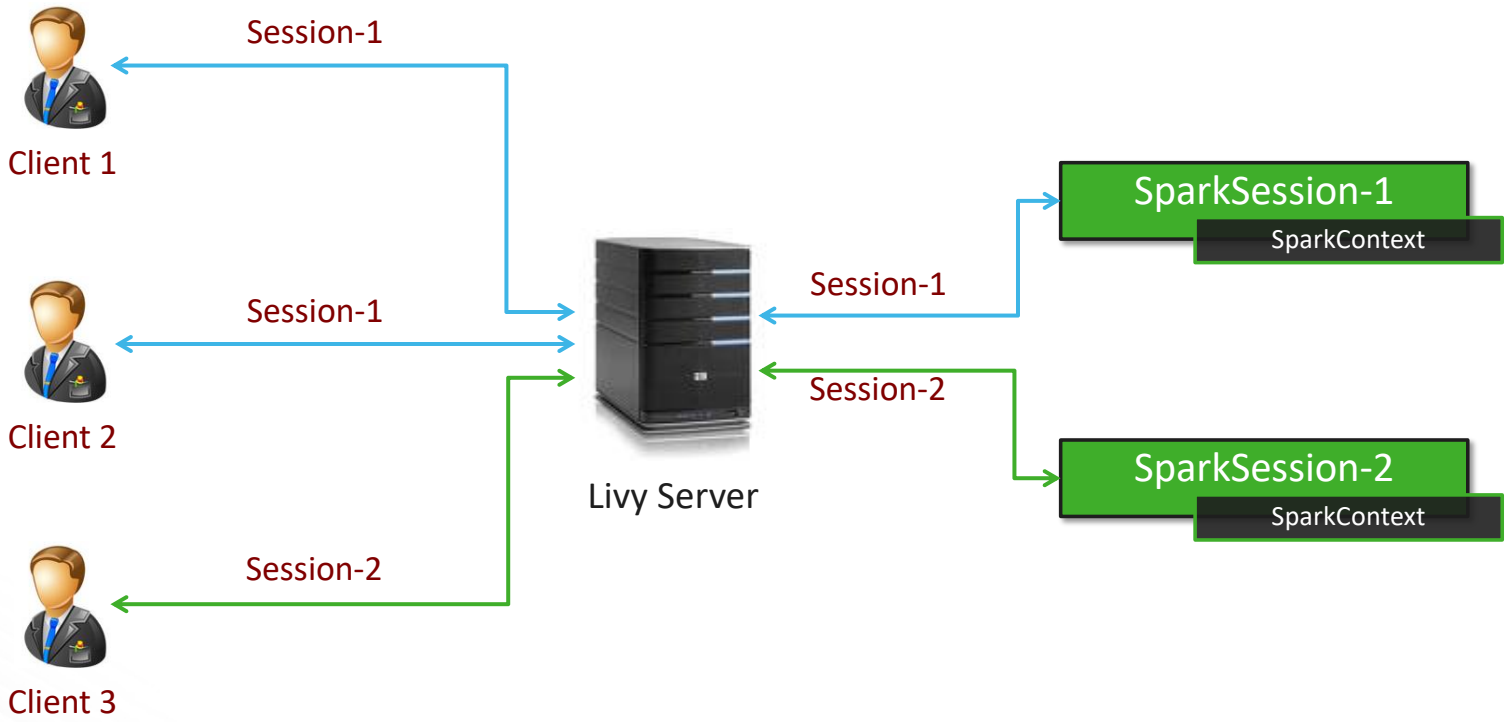
SparkSession Sharing



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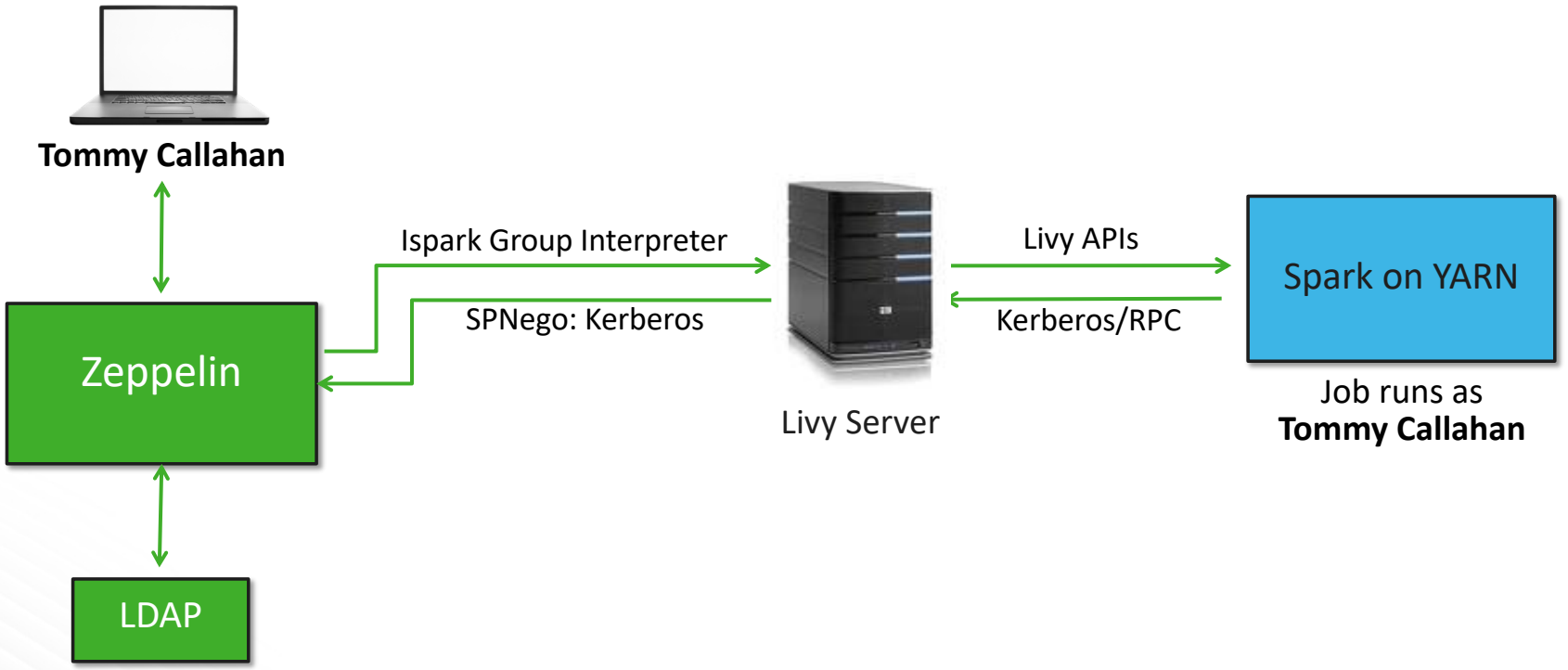
Apache Zeppelin + Livy End-to-End Security



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HDP Basics

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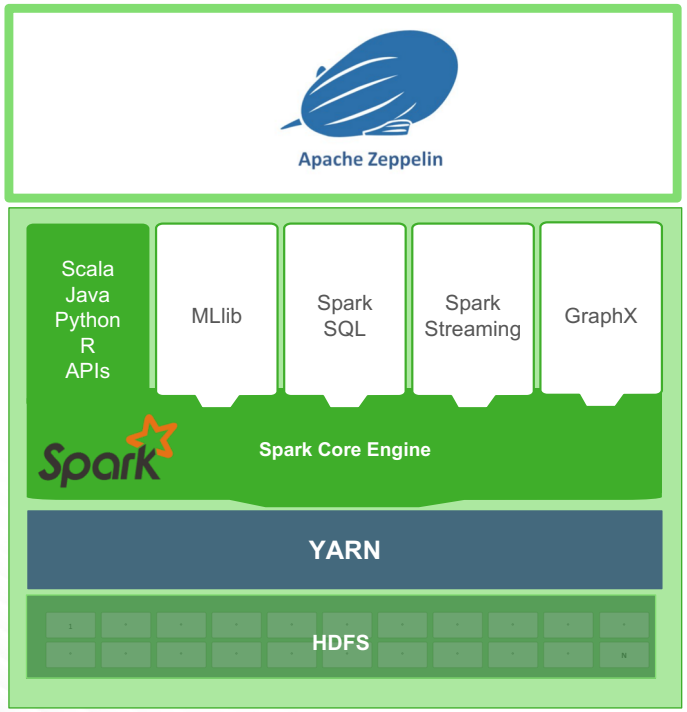

- Zeppelin ➔ Interactive notebook
- Spark
- YARN ➔ Resource Management
- HDFS ➔ Distributed Storage Layer (4M files)
  - Future: Ozone object store

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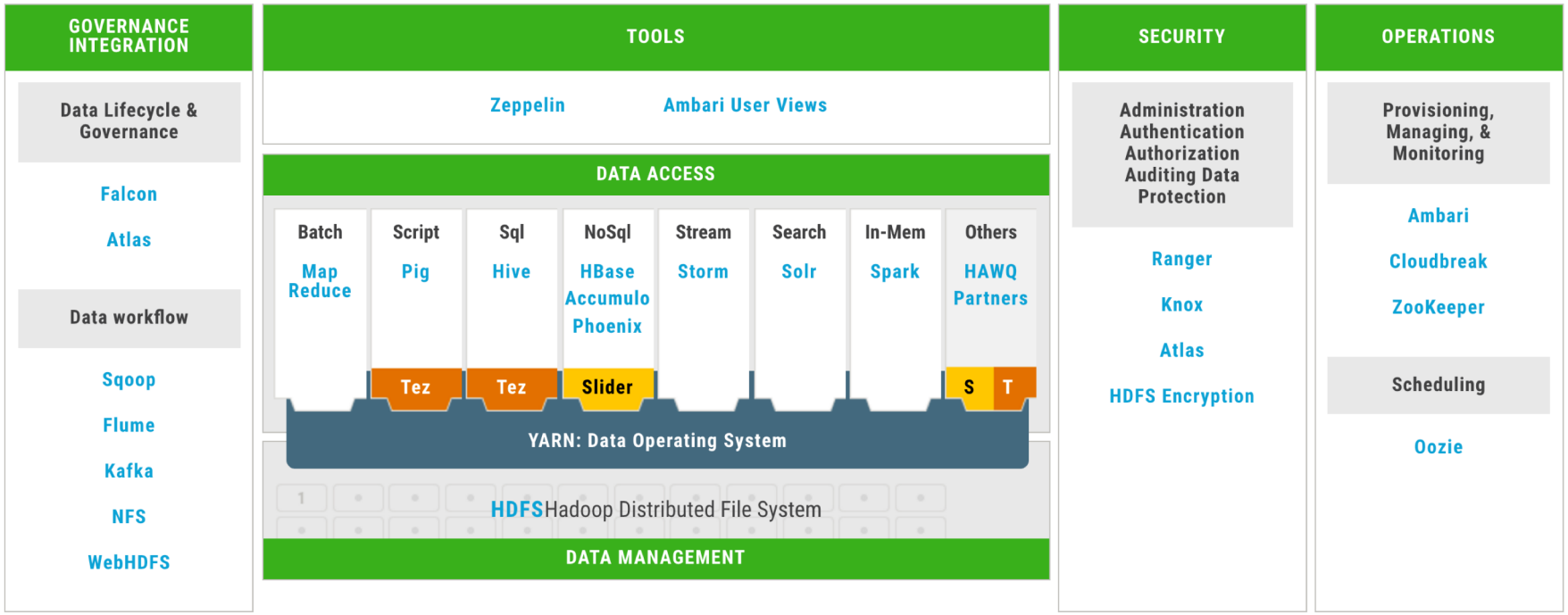
Hortonworks Data Platform



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Sample Architecture

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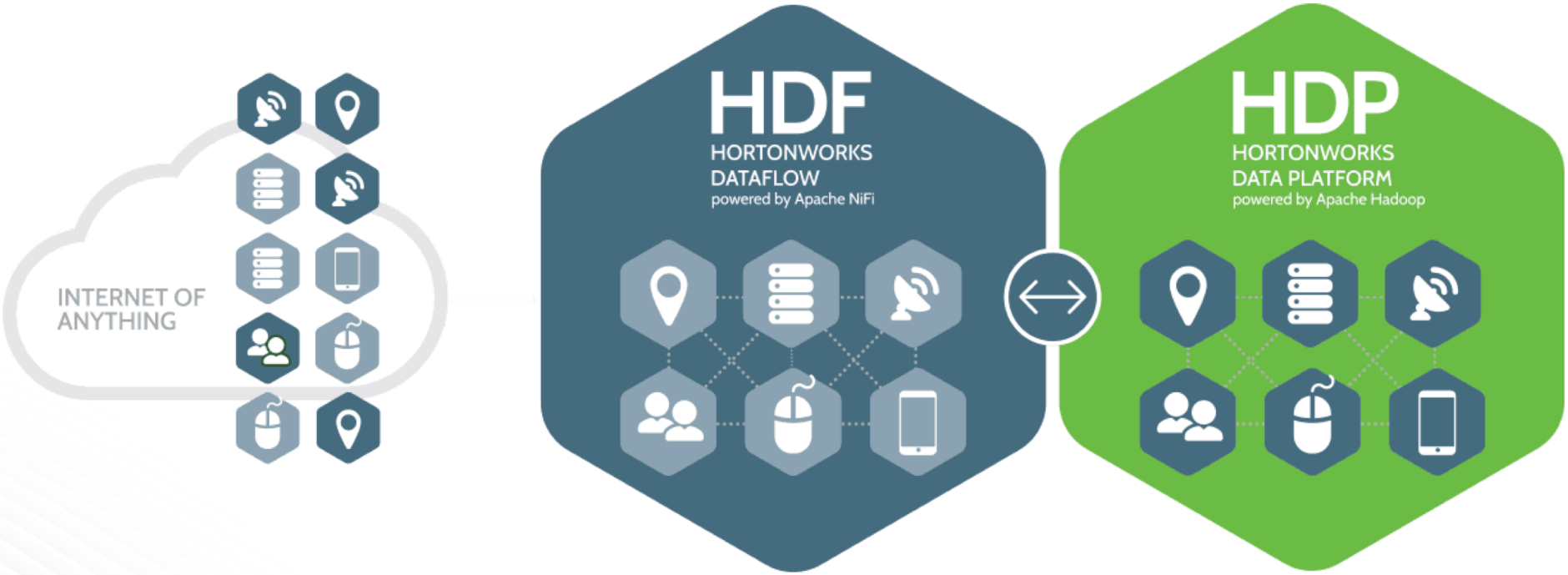

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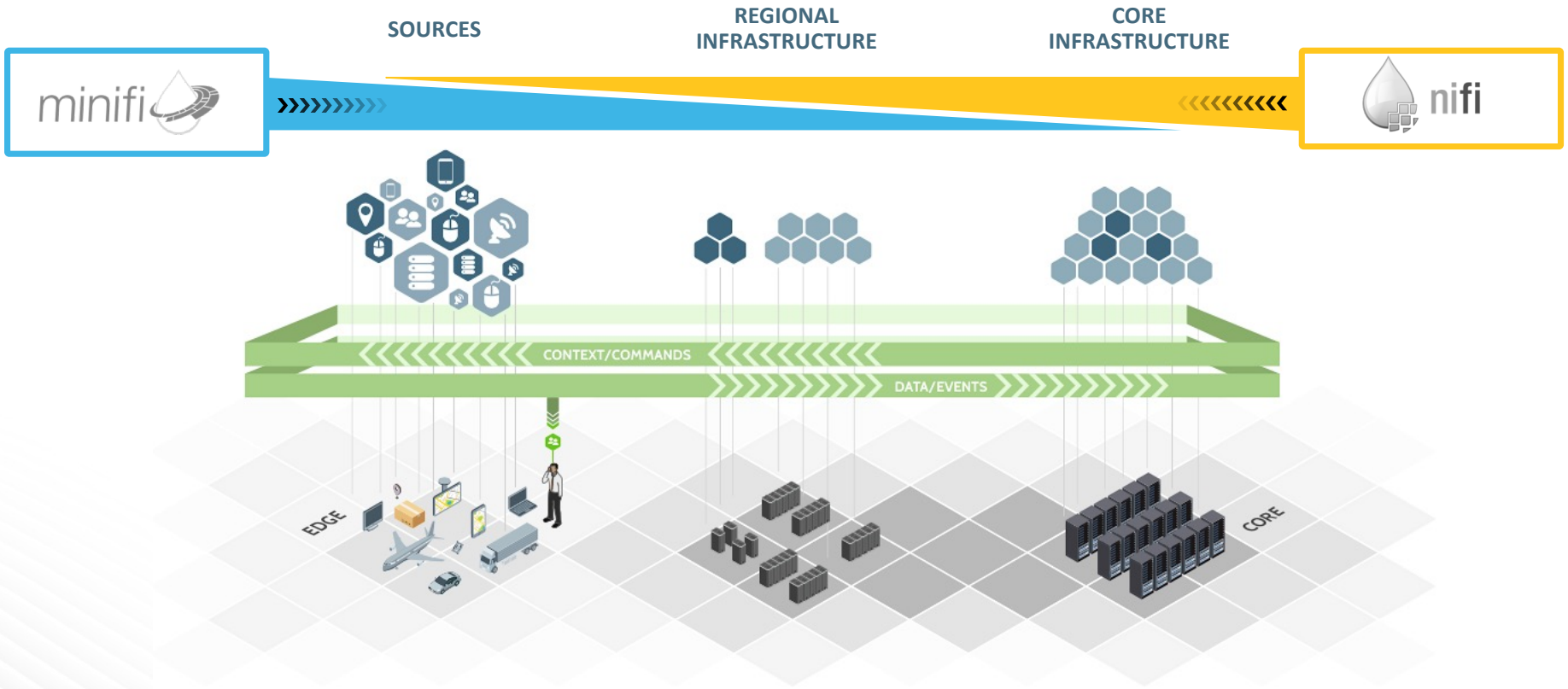
Managed Dataflow



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High-Level Overview

Live Dashboard

minifi

IoT Devices

nifi

IoT Edge
(single node)

minifi

IoT Devices

nifi

IoT Edge
(single node)

nifi

NiFi Hub

kafka

Data Broker

Spark Streaming

Data Store

HDFS/Ozone

Spark MLlib

Column DB

HBase/Cassandra

Data Center
(on prem/cloud)

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Spark 2.x & HDP 2.x
What's New?

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What's New

- Future HDP / Spark 2.3
  - Spark **Structured Streaming latency** in single-digit **milliseconds** in **continuous mode** in stream processing (instead of 100ms we'd normally see with micro batching)
  - stream-to-stream joins
  - PySpark boost by improving performance with pandas UDFs
  - runs on Kubernetes clusters by providing native support for Apache Spark applications
- HDP 2.6.4 / Spark 2.2
  - Structured Streaming GA
  - Yahoo! Benchmark: 65M rec/s
  - ORC feature & performance improvements → Parquet Parity
- HDP 2.6.3 / Spark 2.1
  - Spark SQL Ranger integration for row and column security
  - DataSet API GA
  - GraphX GA

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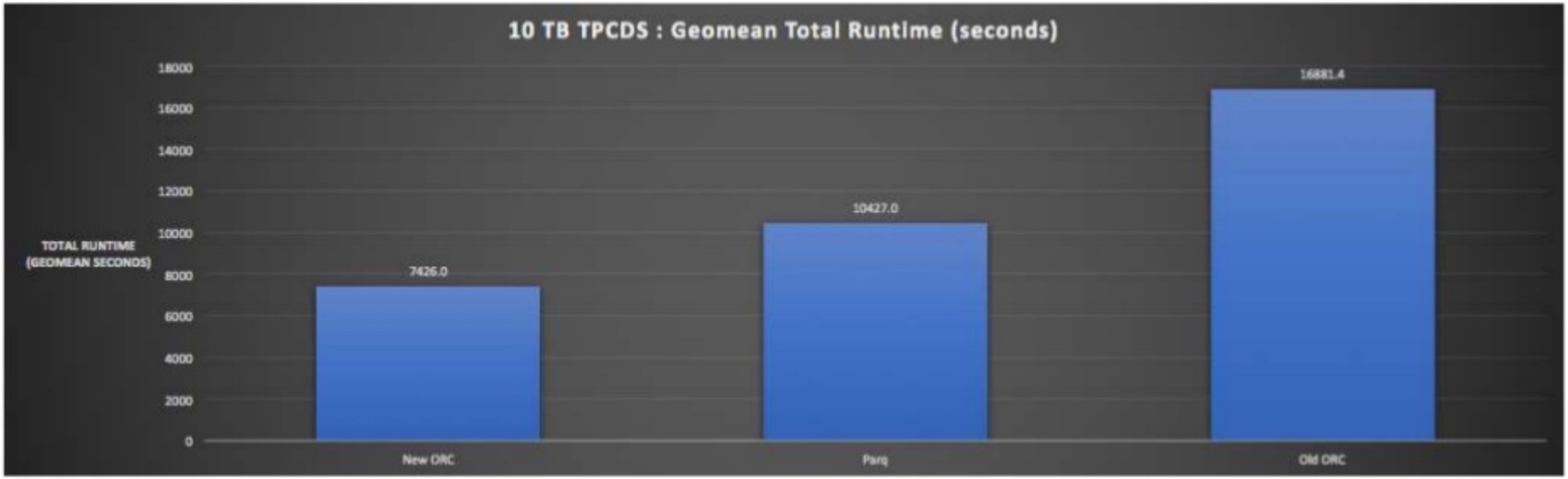
Comparison of New ORC vs Old ORC vs Parquet (10 TB Scale)



* Total runtime of 74 queries in TPC-DS
* 10 TB Scale (15 executors, 170 GB, 25 cores)

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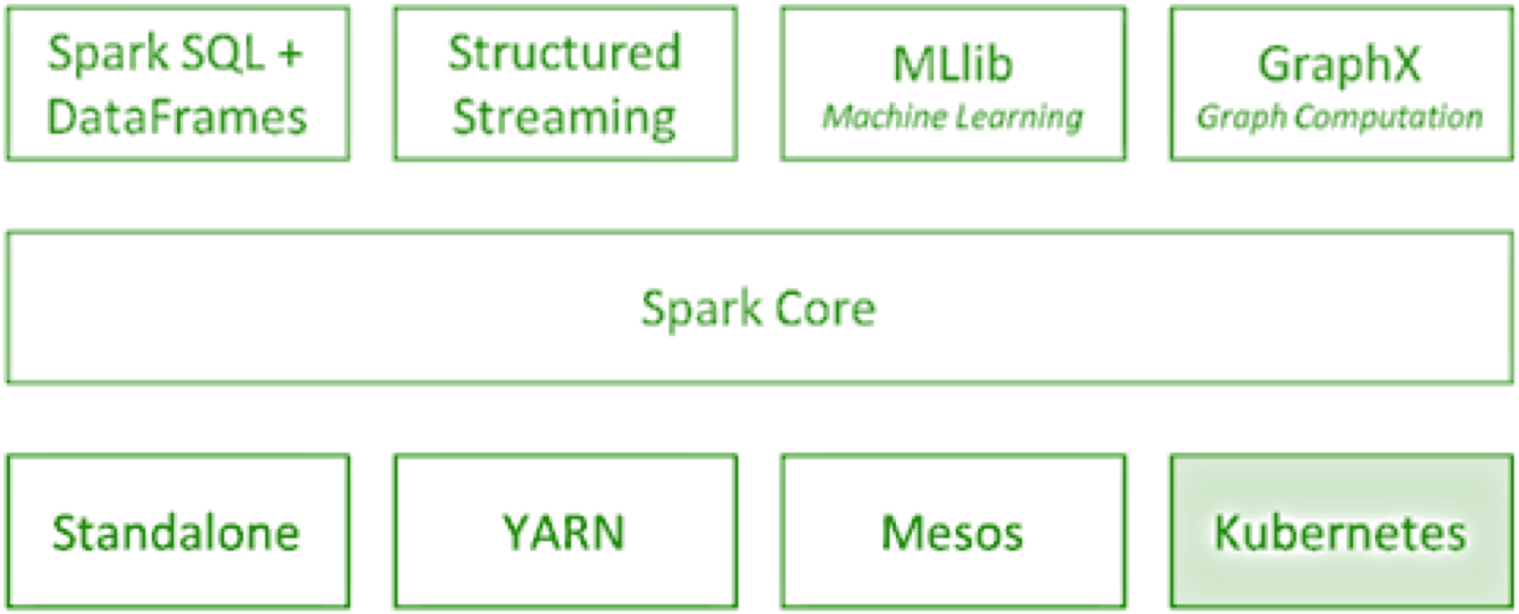
Spark 2.3



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Spark SQL	Spark Streaming	Spark MLlib	GraphX
Structured Data	Near Real-time	Machine Learning	Graph Analysis

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DSX + HDP

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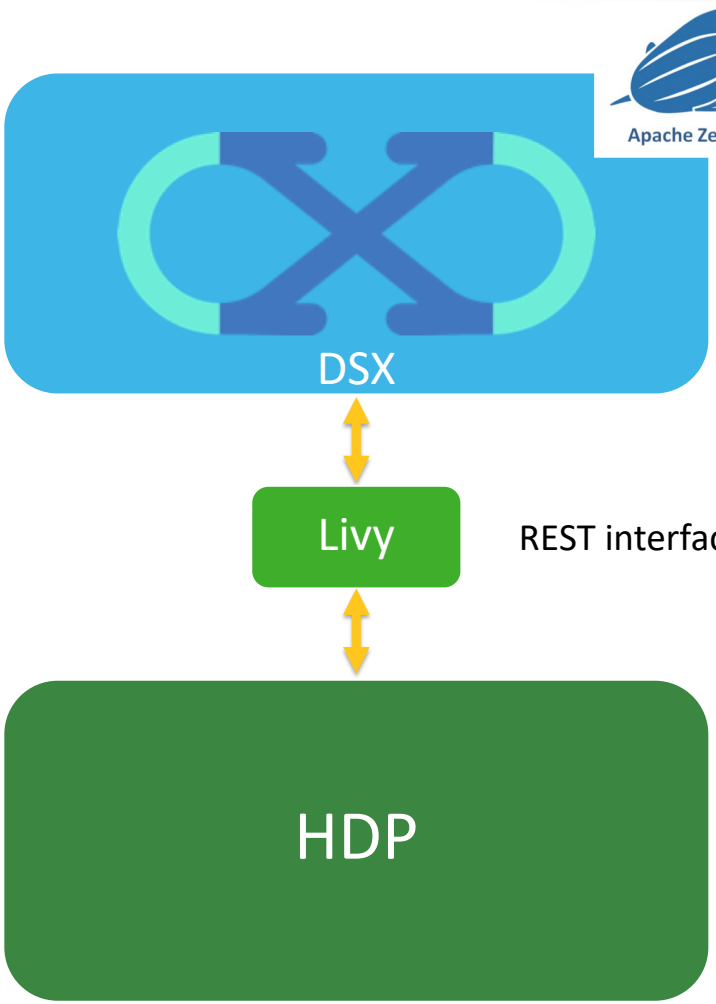

Data Science Experience (DSX) Local
Enterprise Data Science platform for teams

Hortonworks Data Platform (HDP)
Enterprise compute (Spark/Hive) & storage (HDFS/Ozone)

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Lab

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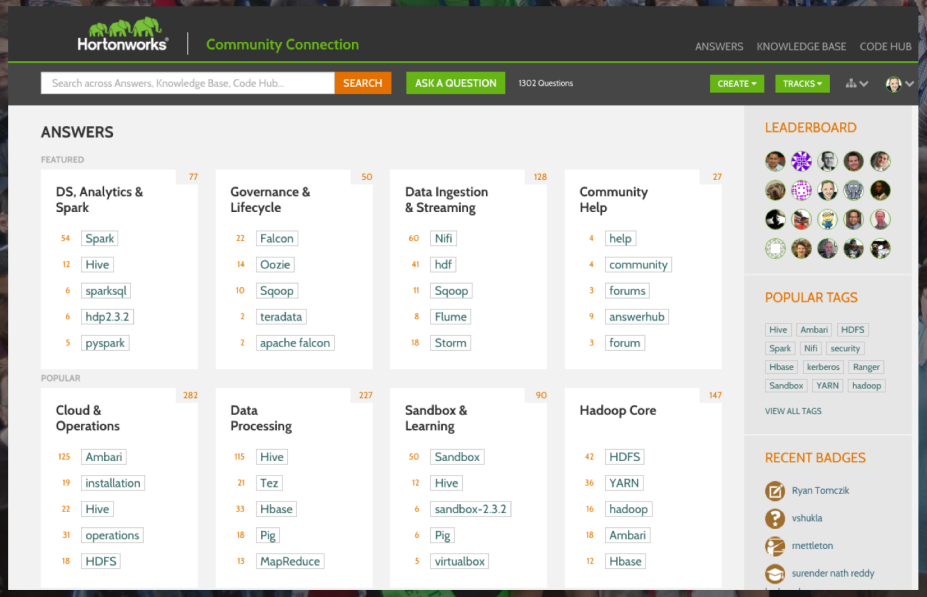
Hortonworks Community Connection

community.hortonworks.com



- Full Q&A Platform (like StackOverflow)
- Knowledge Base Articles
- Code Samples and Repositories

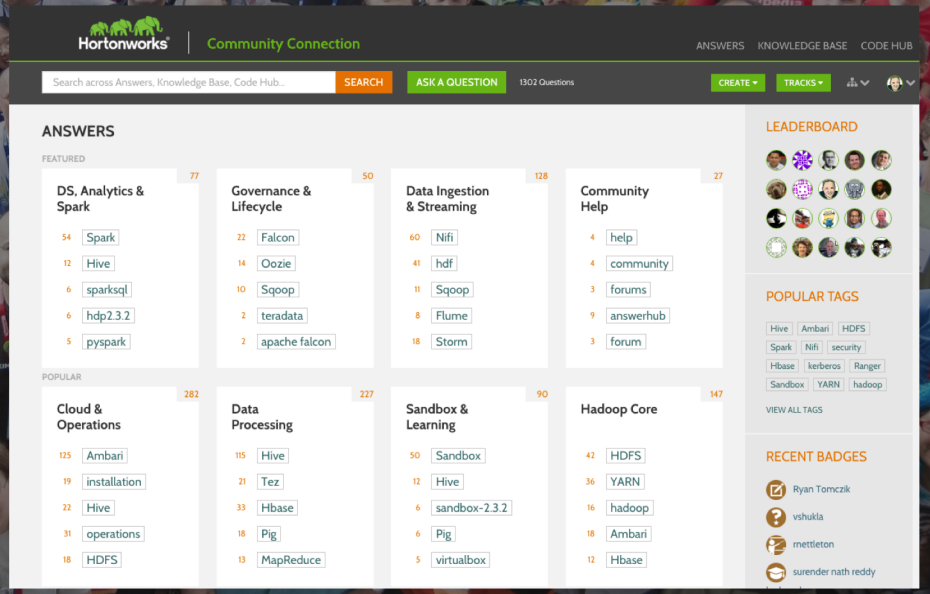
Community Engagement

community.hortonworks.com

20k+
Registered Users

45k+
Answers

100k+
Technical Assets



Future of Data Meetups

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Thanks!
Robert Hryniewicz
@RobHryniewicz
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POWERING THE FUTURE OF DATA