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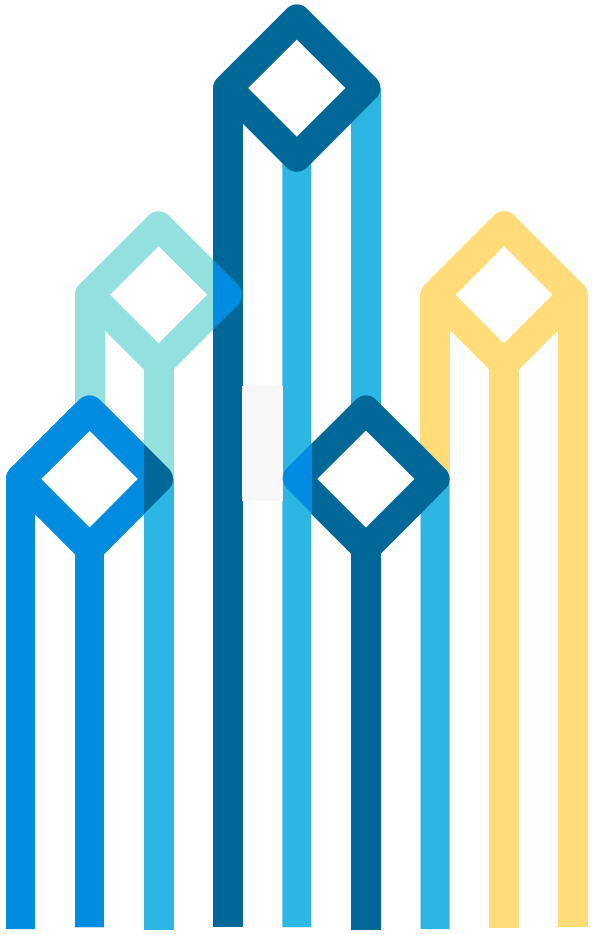
Spark
Lightning-Fast Cluster Computing



Cloudera Improvements in Apache Spark

Brian Baillod | Sales Engineer

Agenda

- Introduction
- Spark One Platform Initiative
- Spark Overview and Improvements
- Spark Proof of Concept
- Kudu and Record Service

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Cloudera company snapshot

Founded	2008, by former employees of ORACLE YAHOO! facebook Google
Employees Today	900+ worldwide
World Class Support	More than 75 24x7 global staff
Cloudera University	Over 40,000 trained
We help code Hadoop	Cloudera employees are leading developers & contributors to the complete Apache Hadoop ecosystem of projects
We help fix Hadoop	Cloudera fixed 60% of all Hadoop JIRA bugs

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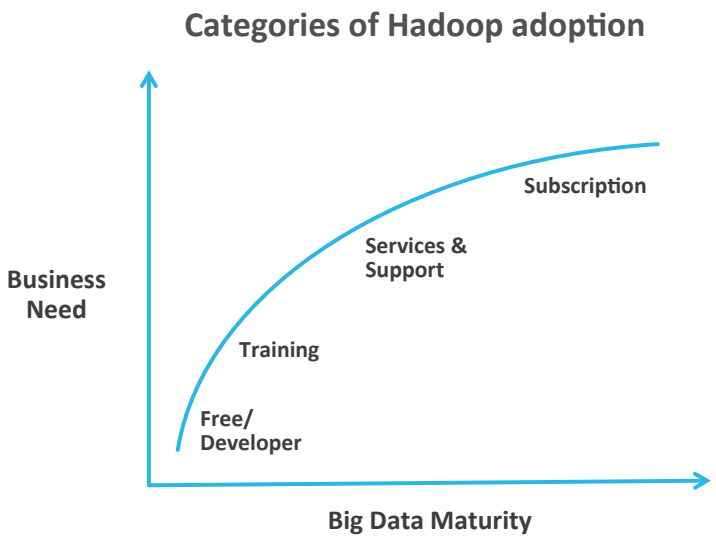
Hadoop Adoption



Free/Developer → Over **2.5 million** downloads

Training → **60% of Fortune 100** attended Cloudera training, **over 40,000** trained since 2009

Service & Support → **9/10** for support satisfaction, ability to solve technical issues **#1 recommendation**

Subscription → Over **2x** revenue of nearest competitor, **90%** renewal rate

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What is Spark

- Fast general purpose processing engine for large data
- Provides API's in Java, Scala and Python
- Includes an advanced DAG execution engine that supports in-memory computing
- Includes high level tools like SparkSQL, Mllib, GraphX, and Spark Streaming
- Can run in a cluster, standalone, or local
- Latest version is 1.5.1
- Spark.apache.org
- LOTS of momentum

Cloudera One Platform Initiative

- Cloudera is doubling down on Spark
- Outlining a vision for the future
  - Kudu, Record Service, Auto-tuning, Security, Kafka integration
- Challenging other vendors to participate in Spark Development

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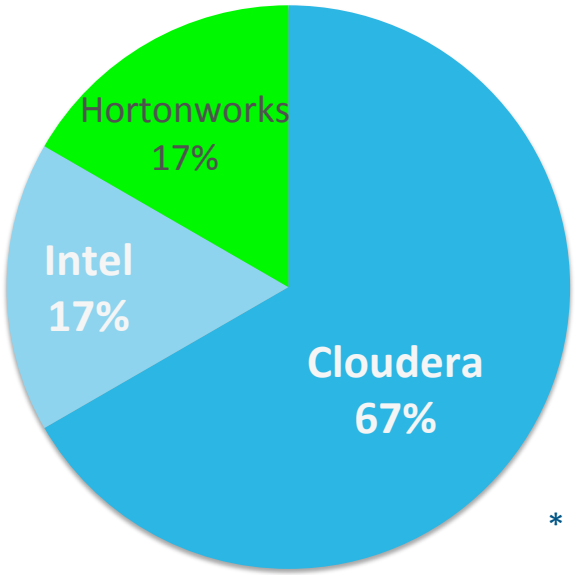
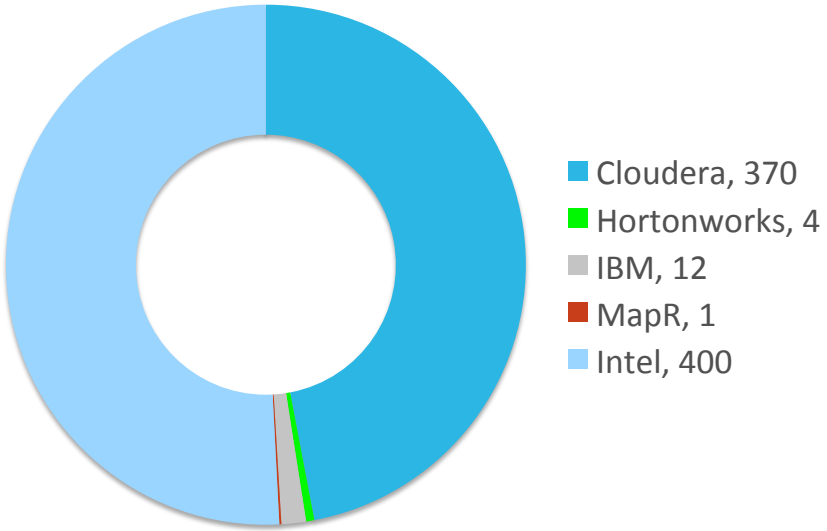
Cloudera's Engineering Commitment to Spark

Spark Committers by Hadoop Distribution*



* IBM and MapR have **0 committers**

Spark Patches by Hadoop Distribution



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Spark will replace MapReduce

To become the standard execution engine for Hadoop

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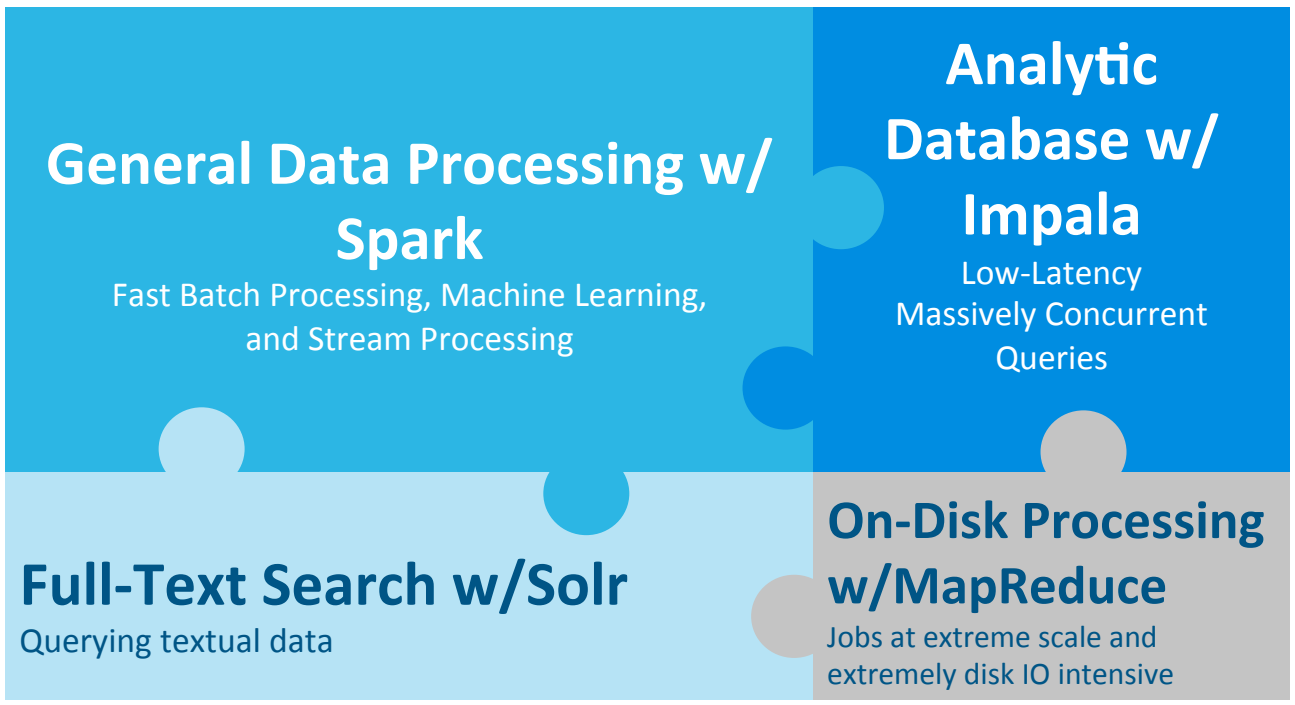
The Future of Data Processing on Hadoop

Spark complemented by specialized fit-for-purpose engines



Shared:

- Data Storage
- Metadata
- Resource Management
- Administration
- Security
- Governance

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Why is Cloudera leading this initiative?

- Cloudera was the **first** Hadoop vendor to ship and support Spark
- Spark is a **fully integrated** part of Cloudera's platform
  - Shared data, metadata, resource management, administration, security, and governance
- Cloudera is the **first** Hadoop vendor to offer Spark training
  - Trained more customers than any other vendor
- Cloudera has **more Spark customers** in production than all other companies combined

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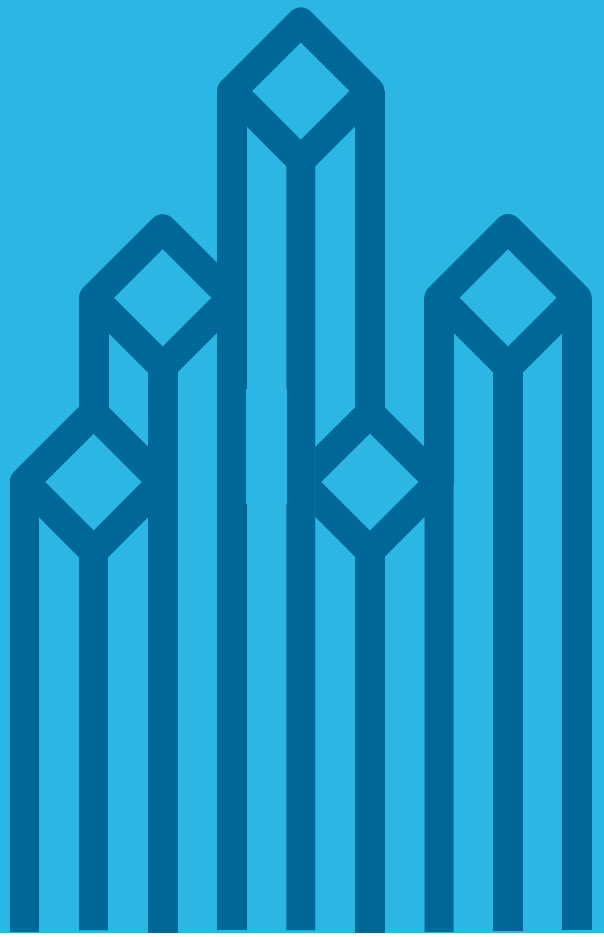
Spark Overview and Improvements



Apache Spark

Flexible, in-memory data processing for Hadoop

Easy Development	Flexible Extensible API	Fast Batch & Stream Processing

• Rich APIs for Scala, Java, and Python
• Interactive shell
	• APIs for different types of workloads:
	  • Batch
	  • Streaming
	  • Machine Learning
	  • Graph
		• In-Memory processing and caching

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Easy Development

High Productivity Language Support

Python

```
lines = sc.textFile(...)
lines.filter(lambda s: "ERROR" in s).count()
```

Scala

```
val lines = sc.textFile(...)
lines.filter(s => s.contains("ERROR")).count()
```

Java

```
JavaRDD<String> lines = sc.textFile(...);
lines.filter(new Function<String, Boolean>() {
  Boolean call(String s) {
    return s.contains("error");
  }
}).count();
```

- Native support for multiple languages with identical APIs
  - Scala, Java, Python
- Use of closures, iterations, and other common language constructs to minimize code
  - 2-5x less code

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Python Or Scala?

- Use Python for prototyping
- Spark Python API is slower than Scala

- Use Scala for development
  - Steep learning curve for functional programming

Easy Development
Use Interactively

```
percolateur:spark srowen$ ./bin/spark-shell --master local[*]
...
Welcome to
      ____              __
     / __/__  ___ _____/ /__
    _\ \/ _ \/ _ `/ __/  '_/
   /___/ .__/\_,_/_/ /_/\_\   version 1.5.0-SNAPSHOT
      /_/

Using Scala version 2.10.4
 (Java HotSpot(TM) 64-Bit Server VM, Java 1.8.0_51)
Type in expressions to have them evaluated.
Type :help for more information.
...

scala> val words = sc.textFile("file:/usr/share/dict/words")
...
words: org.apache.spark.rdd.RDD[String] =
 MapPartitionsRDD[1] at textFile at <console>:21

scala> words.count
...
res0: Long = 235886

scala>
```

- Interactive exploration of data for data scientists
  - No need to develop "applications"
- Developers can prototype application on live system

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Easy Development

Expressive API

- map
- filter
- groupBy
- sort
- union
- join
- leftOuterJoin
- rightOuterJoin
- reduce
- count
- fold
- reduceByKey
- groupByKey
- cogroup
- cross
- zip
- sample
- take
- first
- partitionBy
- mapWith
- pipe
- save
- …

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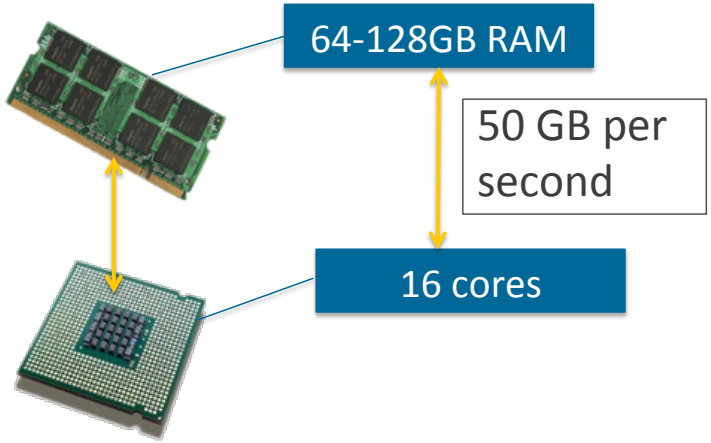
Memory Management for Greater Performance

Memory can be enabler for high performance big data applications



Trends:

- ½ price every 18 months
- 2x bandwidth every 3 years

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Spark Concepts

- RDD – Resilient Distributed Dataset
- Transformations
- Actions
- Caching
- DataFrames
- Spark Streaming
- SparkSQL
- Pluggable Spark

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Resilient Distributed Dataset (RDD)

- Read-only partitioned collection of records
- Created through:
  - Transformation of data in storage
  - Transformation of RDDs
- Contains lineage to compute from storage
- Lazy materialization
- Users control persistence and partitioning

RDD Operations

- **Transformations** create new RDD from an existing one
- **Actions** run computation on RDD and return a value

- Transformations are lazy
- Actions materialize RDDs by computing transformations
- RDDs can be cached to avoid re-computing

Example Operations

Transformations

- `Map`
- `Filter`
- `Sample`
- `Join`

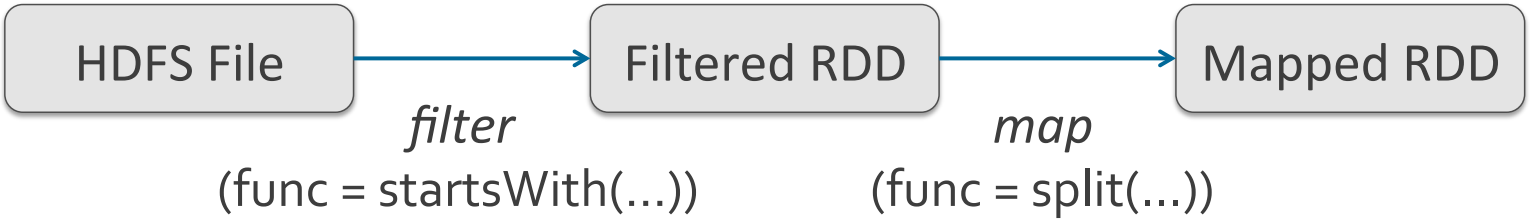
Actions

- `Reduce`
- `Count`
- `First, Take`
- `SaveAs`

Fault-Tolerance

- RDDs contain lineage
  - Lineage: Source location and list of transformations
  - Lost partitions can be re-computed from source data

```
msgs = textFile.filter(lambda s: s.startsWith("ERROR"))
               .map(lambda s: s.split("\t")[2])
```



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Caching – Storage Levels

Different options provide tradeoffs between memory usage and CPU efficiency. Cache when using iterative algorithms.

- MEMORY_ONLY – most CPU efficient, data has to fit in memory
- MEMORY_ONLY_SER – More space efficient but still reasonably fast
- MEMORY_AND_DISK
- MEMORY_AND_DISK_SER
- DISK_ONLY
- MEMORY_ONLY_2, MEMORY_AND_DISK_2…

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Data Frames

- Distributed collection of rows organized into named columns
- Spark SQL's Data Source API can read and write Data Frames using a variety of formats
  - Hive, JSON, Parquet, HDFS
- Calling the DataFrame API can let you
  - Select the columns you want
  - Join data sources
  - Aggregate and Filter

- Spark 1.5 lets you access the Hive Metastore to read/write schemas directly.

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Spark Streaming

What is it?

- Run *continuous* processing of data using Spark's core API
- Extends Spark concepts to fault-tolerant, transformable streams
- Adds "rolling window" operations
  - Example: Compute rolling averages or counts for data over last five minutes

Common Use Cases:

- "On-the-fly" ETL as data is ingested into Hadoop/HDFS
- Detect anomalous behavior and trigger alerts
- Continuous reporting of summary metrics for incoming data

Benefits:

- Same programming paradigm for streaming and batch
- Excellent throughput
  - Scale easily to support large volumes of data ingest

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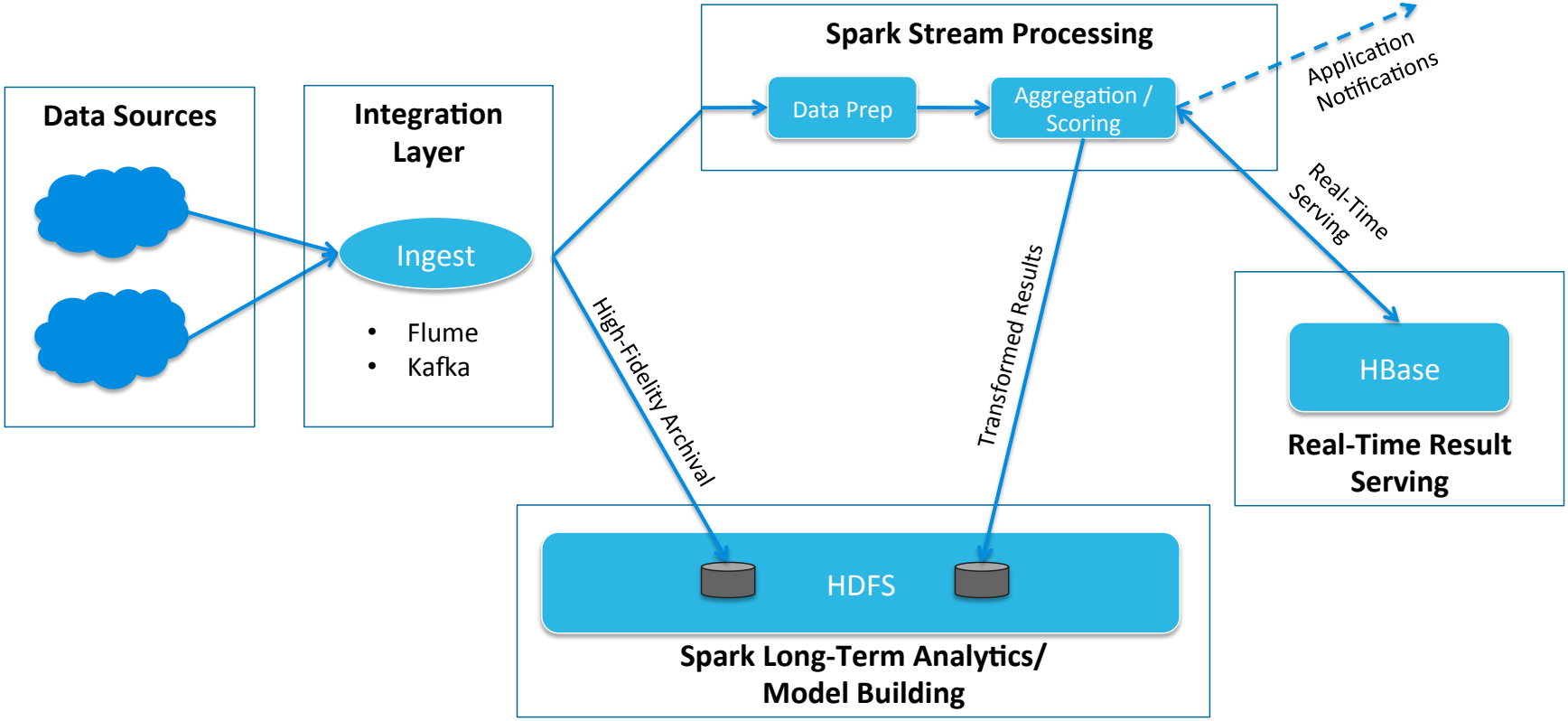
Spark Streaming Architectures



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SparkSQL
Machine Learning Applications

- Goal:
  - Spark/Java Developers and Data Scientists can inline SQL into Spark apps
- Designed for:
  - Ease of development for Spark developers
  - Handful of concurrent Spark jobs
- Strengths:
  - Ease of embedding SQL into Java or Scala applications
  - SQL for common functionality in developer flow (eg. aggregations, filters, samples)

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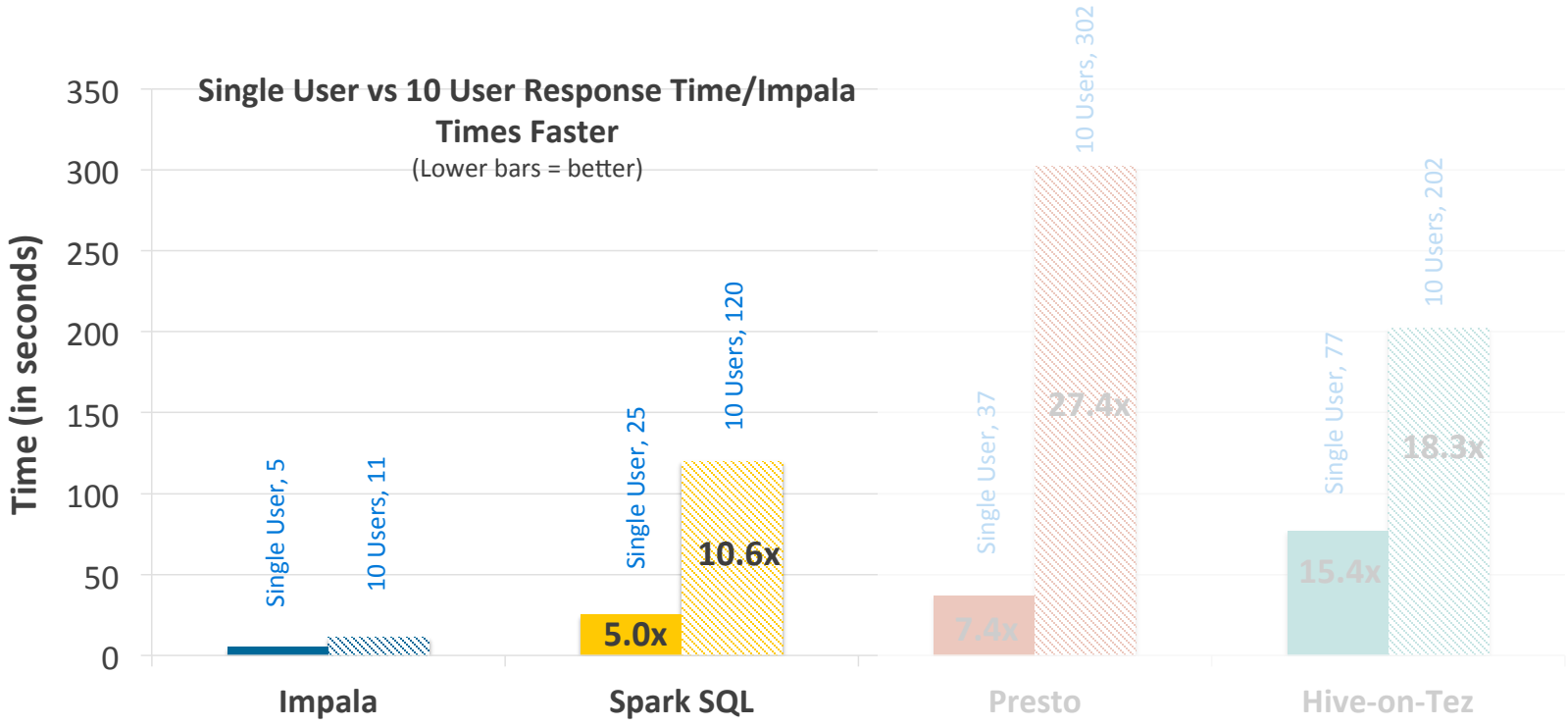
Impala Remains Tool of Choice for Interactive SQL



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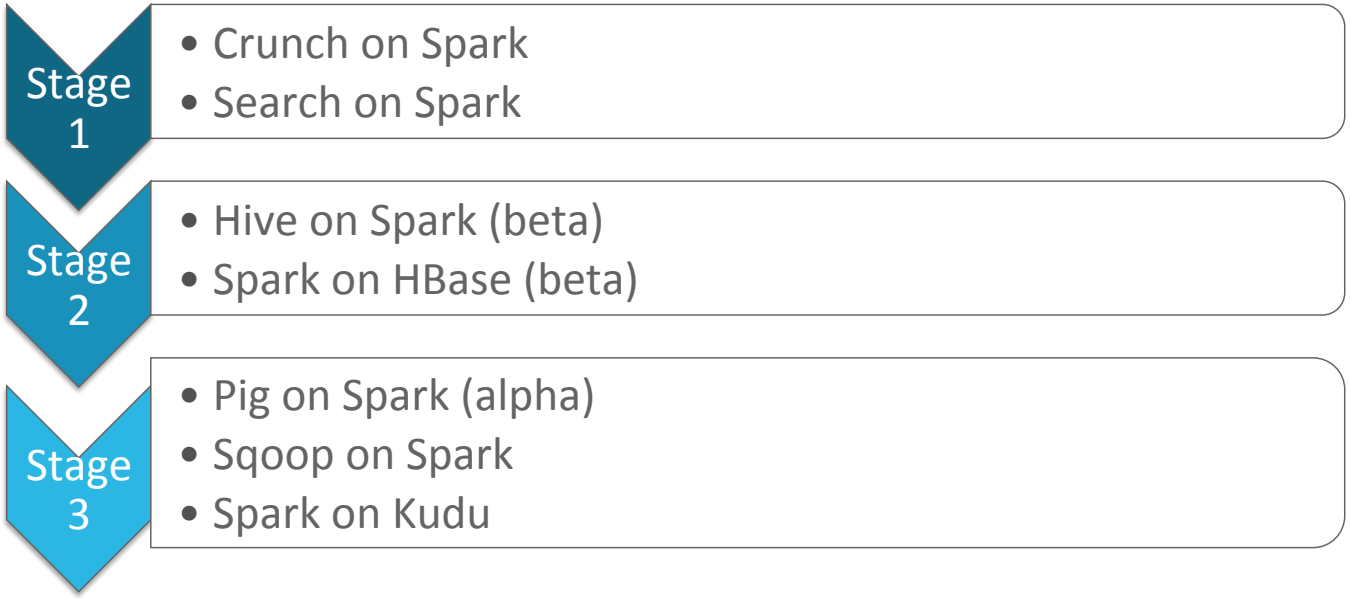
Pluggable Spark – replace MapReduce

Cloudera is leading community development to port components to Spark:



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Spark Customer Use Cases

Core Spark

Financial Services

- Portfolio Risk Analysis
- ETL Pipeline Speed-Up
- 20+ years of stock data

Health

- Identify disease-causing genes in the full human genome
- Calculate Jaccard scores on health care data sets

ERP

- Optical Character Recognition and Bill Classification

Data Services

- Trend analysis
- Document classification (LDA)
- Fraud analytics

Spark Streaming

Financial Services

- Online Fraud Detection

Health

- Incident Prediction for Sepsis

Retail

- Online Recommendation Systems
- Real-Time Inventory Management

Ad Tech

- Real-Time Ad Performance Analysis

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Doing the Math – Executors and Cores

Determine the optimal resource allocation for the Spark job

16 Total Cores in Cluster

C 1 Core for Application Master

1 15 Cores for Executors

Core Allocation

$$\frac{1 \text{ Executor}}{4 \text{ Cores}} \times 15 \text{ Cores} =$$

3 Executors with 4 Cores Each

(Leaves 3 Cores un-utilized)

Other Ratios may lead to better resource utilization

$$\frac{1 \text{ Executor}}{2 \text{ Cores}} \times 15 \text{ Cores} =$$

7 Executors with 2 Cores Each

(Leaves 1 Core un-utilized)

Don't exceed= 5 Cores per Executor

http://blog.cloudera.com/blog/2015/03/how-to-tune-your-apache-spark-jobs-part-2/

Allocate Executors

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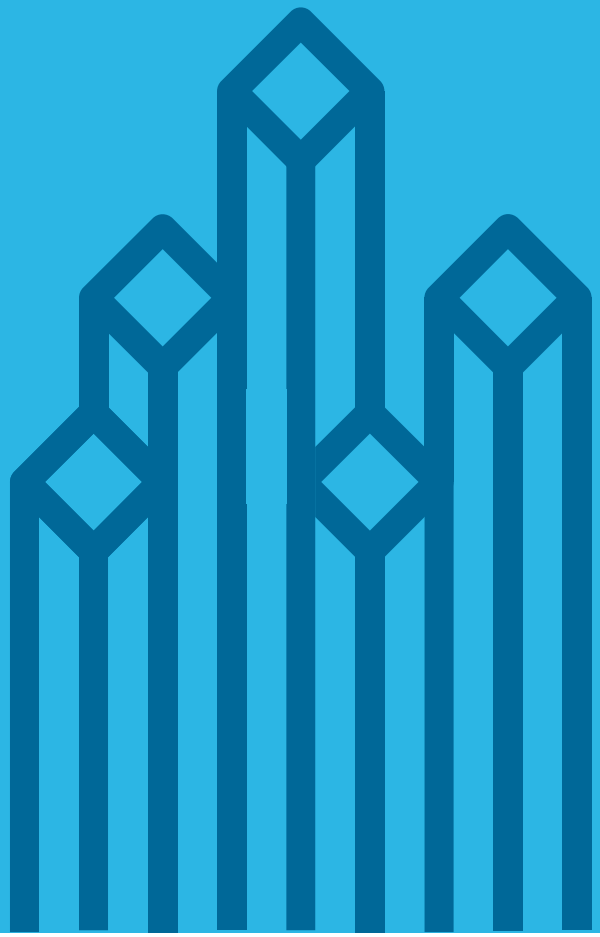
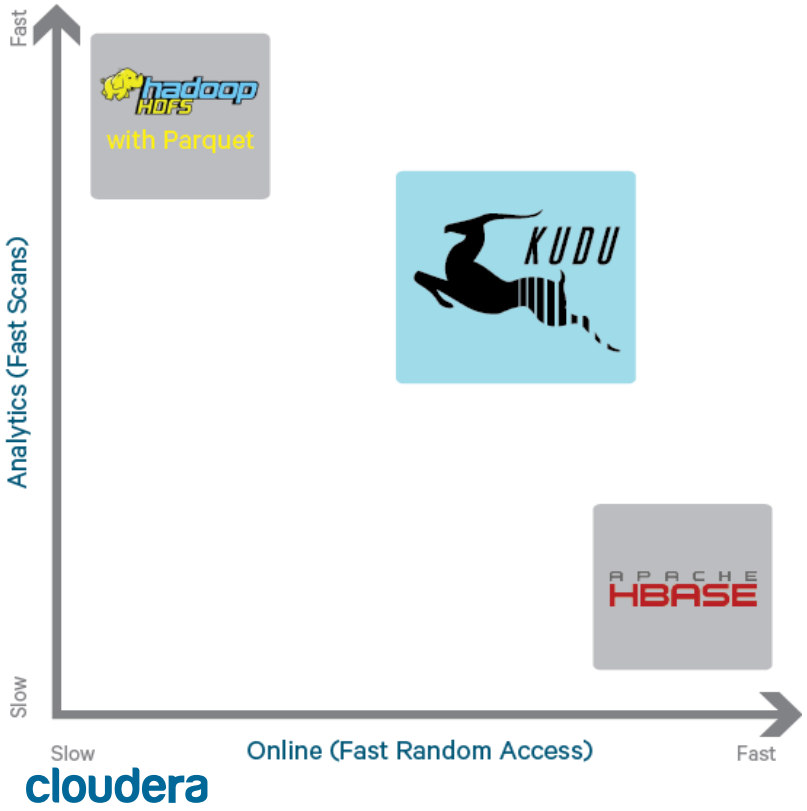
Kudu

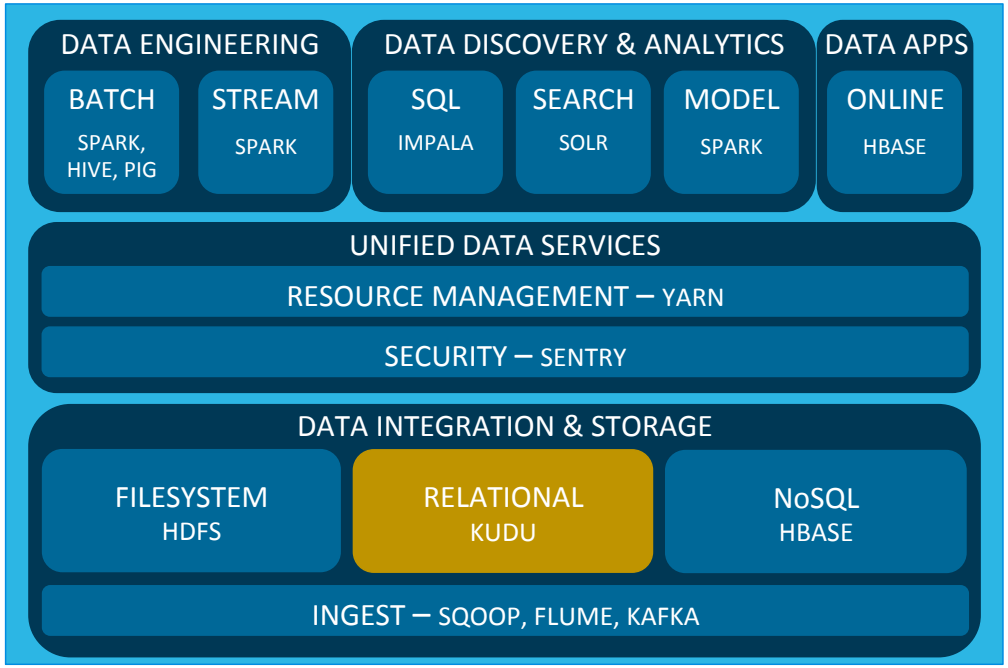


Kudu Design Goals



- **High throughput** for big scans (columnar storage and replication)
  Goal: Within 2x of Parquet
- **Low-latency** for short accesses (primary key indexes and quorum design)
  Goal: 1ms read/write on SSD
- **Database-like** semantics (initially single-row ACID)
- **Relational data model**
  - SQL query
  - "NoSQL" style scan/insert/update (Java client)

Kudu
Storage for Fast Analytics on Fast Data



- New updating column store for Hadoop
  - Simplifies the architecture for building analytic applications on changing data
  - Designed for fast analytic performance
  - Natively integrated with Hadoop
- Apache-licensed open source (intent to donate to ASF)
- Beta now available

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Kudu Trade-Offs

- Random updates will be slower
  - HBase model allows random updates without incurring a disk seek
  - Kudu requires a key lookup before update, Bloom lookup before insert

- Single-row reads may be slower
  - Columnar design is optimized for scans
  - Future: may introduce “column groups” for applications where single-row access is more important

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Resources

Join the community

http://getkudu.io

Download the Beta

cloudera.com/downloads

Read the Whitepaper

getkudu.io/kudu.pdf

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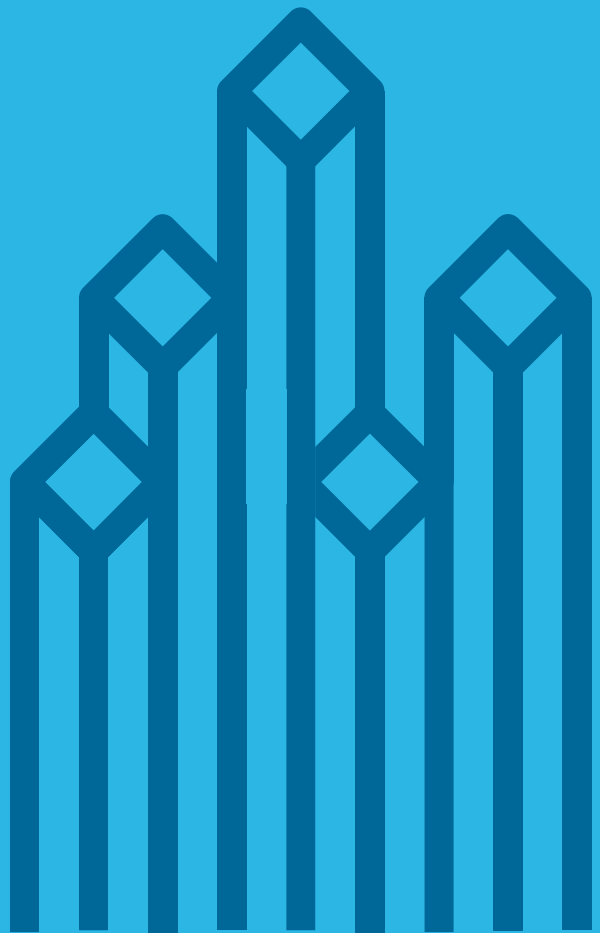
RecordService



Hadoop started out with zero security

- Didn’t need it for the Silicon Valley applications
- Does need it for Corporate applications
- Cloudera is working on providing full featured Spark Security

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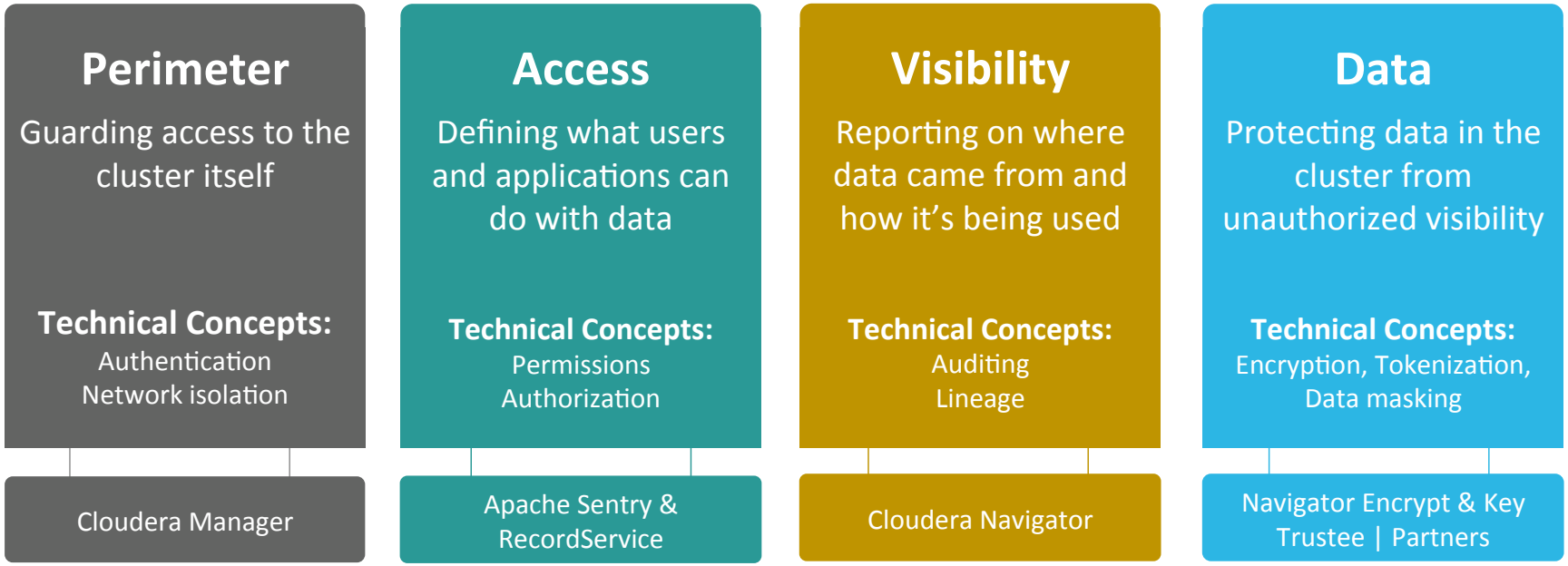
Comprehensive, Compliance-Ready Security

Authentication, Authorization, Audit, and Compliance



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Active Directory and Kerberos

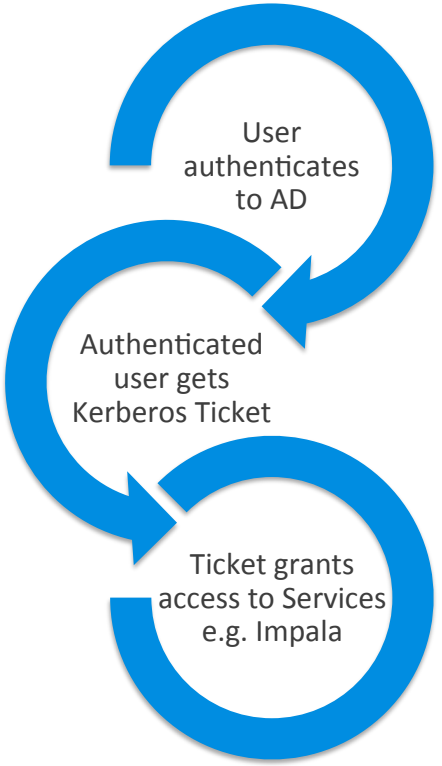
Active Directory

- Manages Users, Groups, and Services
- Provides username / password authentication
- Group membership determines Service access

Kerberos

- Trusted and standard third-party
- Authenticated users receive “Tickets”
- “Tickets” gain access to Services

User [ssmith]
Password[*****]



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Fine-Grained Access Control in HDFS

Across All Hadoop Paths

Columns:

Sensitive column visibility varies by role (Ex. credit card numbers)

- Managers: 1234 5678 1234 5678
- Call Center: XXXX XXXX XXXX 5678
- Analysts: XXXX XXXX XXXX XXXX
- Others: No access to credit card column

Rows:

Different user groups need access to different records

- European privacy laws
- Government security clearance
- Financial information restrictions

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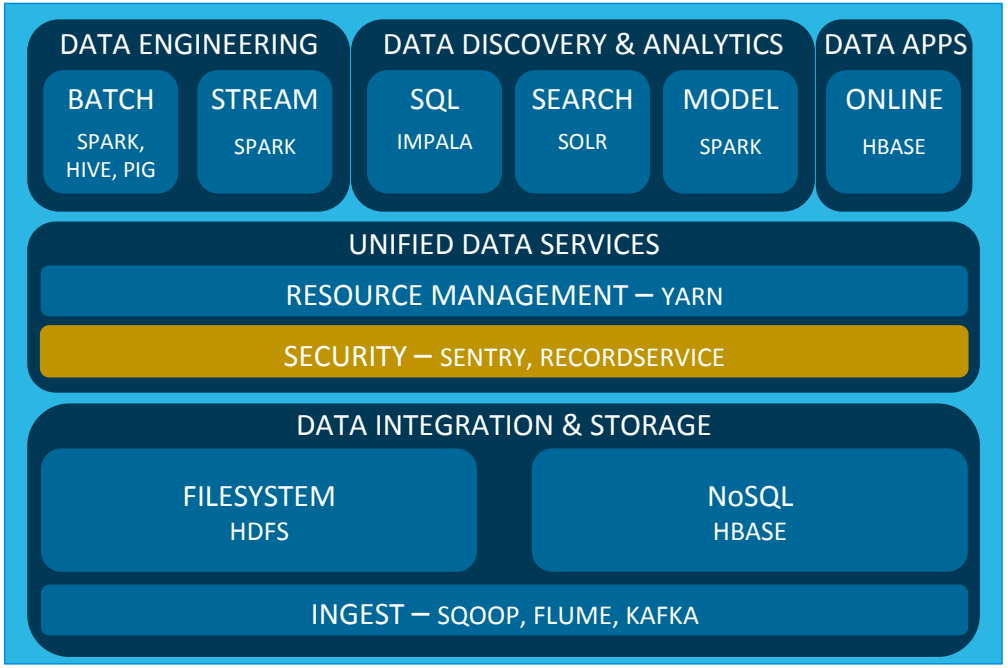
RecordService
Unified Access Control Enforcement



- New high performance security layer that centrally enforces access control policies across Hadoop
  - Complements Apache Sentry's unified policy definition
  - Row- and column-based security
  - Dynamic data masking
- Apache-licensed open source
- Beta now available

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Fine-Grained HDFS Access without RecordService

Split the original file
Use HDFS permissions to limit access

Date/time	Accnt #	SSN	Asset	Trade	Country
09:33:11 16-Feb-2015	0234837823	238-23-9876	AAPL	Sell	US
11:33:01 16-Feb-2015	3947848494	329-44-9847	TBT	Buy	EU
14:12:34 16-Feb-2015	4848367383	123-56-2345	IBM	Sell	UK
09:22:03 16-Feb-2015	3485739384	585-11-2345	INTC	Buy	US
11:55:33 16-Feb-2015	3847598390	234-11-8765	F	Buy	US
10:22:55 16-Feb-2015	8765432176	344-22-9876	UA	Buy	UK
13:45:24 16-Feb-2015	3456789012	412-22-8765	AMZN	Sell	EU
09:03:44 16-Feb-2015	4857389329	123-44-5678	TMV	Buy	US
15:55:55 16-Feb-2015	4756983234	234-76-9274	MA	Buy	UK

Date/time	Accnt #	SSN	Asset	Trade	Country
09:33:11 16-Feb-2015	0234837823	238-23-9876	AAPL	Sell	US
09:22:03 16-Feb-2015	3485739384	585-11-2345	INTC	Buy	US
11:55:33 16-Feb-2015	3847598390	234-11-8765	F	Buy	US
09:03:44 16-Feb-2015	4857389329	123-44-5678	TMV	Buy	US

Date/time	Accnt #	SSN	Asset	Trade	Country
11:33:01 16-Feb-2015	3947848494	329-44-9847	TBT	Buy	EU
13:45:24 16-Feb-2015	3456789012	412-22-8765	AMZN	Sell	EU

Date/time	Accnt #	SSN	Asset	Trade	Country
14:12:34 16-Feb-2015	4848367383	123-56-2345	IBM	Sell	UK
10:22:55 16-Feb-2015	8765432176	344-22-9876	UA	Buy	UK
15:55:55 16-Feb-2015	4756983234	234-76-9274	MA	Buy	UK

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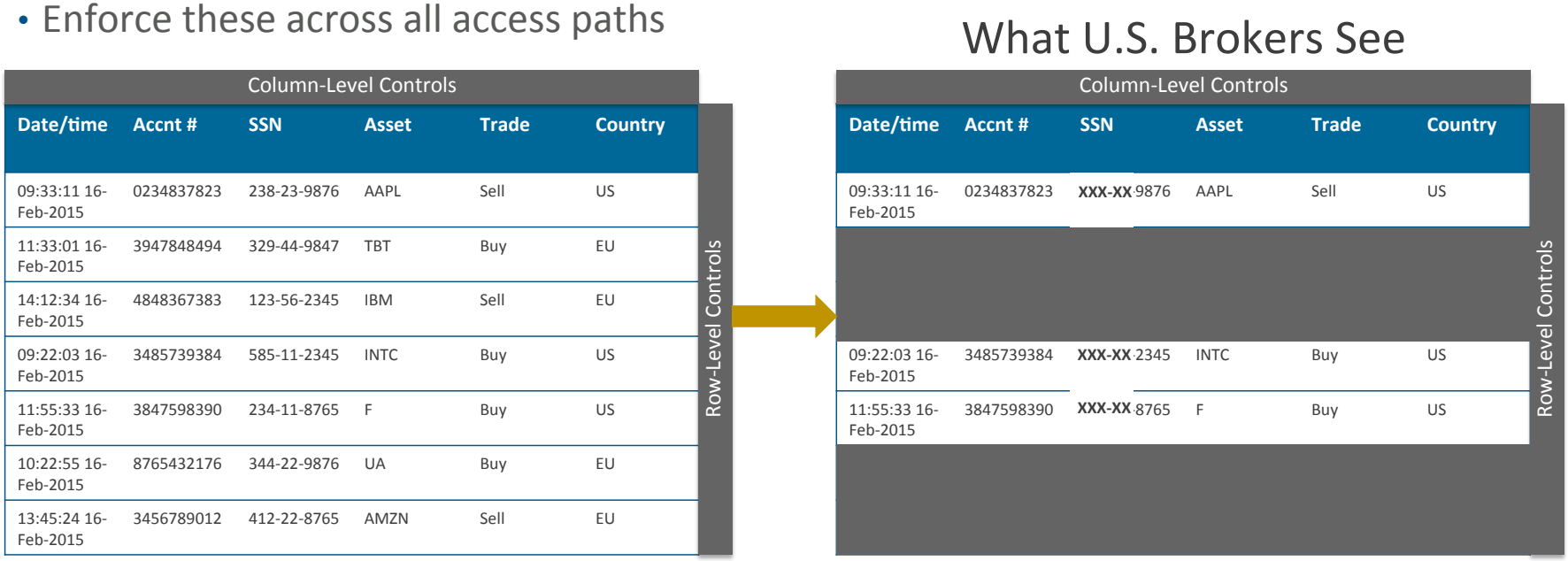
Fine-Grained HDFS Access Control with RecordService

- Apply controls to the master data file
- Row, column, and sub-column (masking) controls
- Enforce these across all access paths



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Spark Resources

- Learn Spark
  - Spark Cookbook – by Rishi Yadav
  - O'Reilly Advanced Analytics with Spark eBook (written by Clouderans)
  - Cloudera Developer Blog
  - cloudera.com/spark
- Get Trained
  - Cloudera Spark Training

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