Build COMPETENCY
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Implementing Big Data Real-time processing solutions using Apache Spark on Hadoop

Chandrashekhar Deshpande

Google Cloud Platform
Windows Azure

amazon web services · HIBERNATE · Apache · Spark · Java · hadoop

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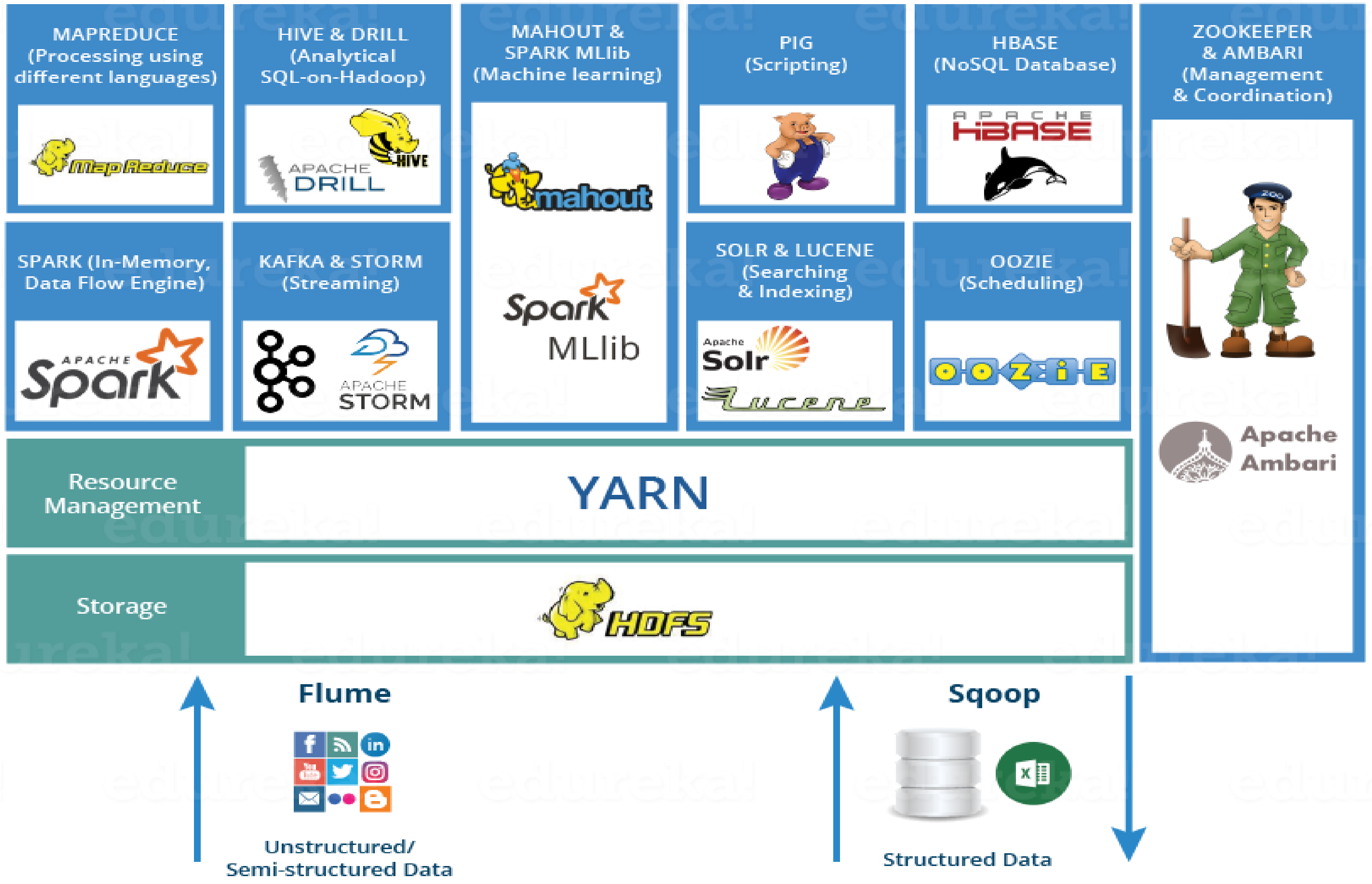
Module 1

Introduction to Apache Spark

Hadoop ecosystem

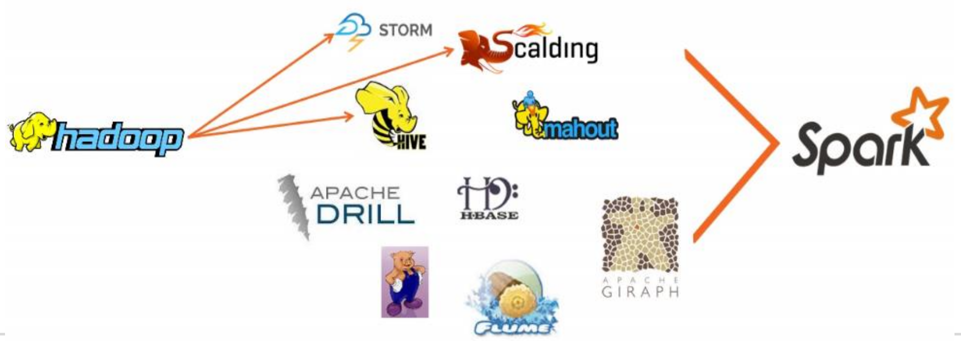

MAPREDUCE (Processing using different languages)
Map Reduce
HIVE & DRILL (Analytical SQL-on-Hadoop)
HIVE
APACHE DRILL
MAHOUT & SPARK MLlib (Machine learning)
mahout
Spark MLlib
PIG (Scripting)
HBASE (NoSQL Database)
APACHE HBASE
ZOOKEEPER & AMBARI (Management & Coordination)
Apache Ambari
SPARK (In-Memory, Data Flow Engine)
APACHE Spark
KAFKA & STORM (Streaming)
APACHE STORM
SOLR & LUCENE (Searching & Indexing)
Apache Solr
Lucene
OOZIE (Scheduling)
OOZIE
Resource Management
YARN
Storage
HDFS
Flume
Unstructured/ Semi-structured Data
Sqoop
Structured Data

Hadoop ecosystem

Project	Description
MapReduce	A distributed data processing model and execution environment that runs on large cluster.
Pig	*A dataflow language and execution environment* for exploring very large datasets. It runs on HDFS and MapReduce cluster.
Hive	*A distributed data ware house*. It manages data stored in HDFS and provides a query language based on SQL.
HBase	*A distributed column oriented data base*. It uses HDFS for underlying storage. It supports both batch style computation using MapReduce as well point queries for random read.
Zookeeper	A distributed, highly available coordination service. It provides primitives like distributed locks for building distributed applications.
Sqoop	A tool for efficiently moving data between relational data bases and HDFS.
Common	Set of components and interfaces for distributed file system and general IO.
Avro	Serialization system for cross-language RPC and persistent data storage.

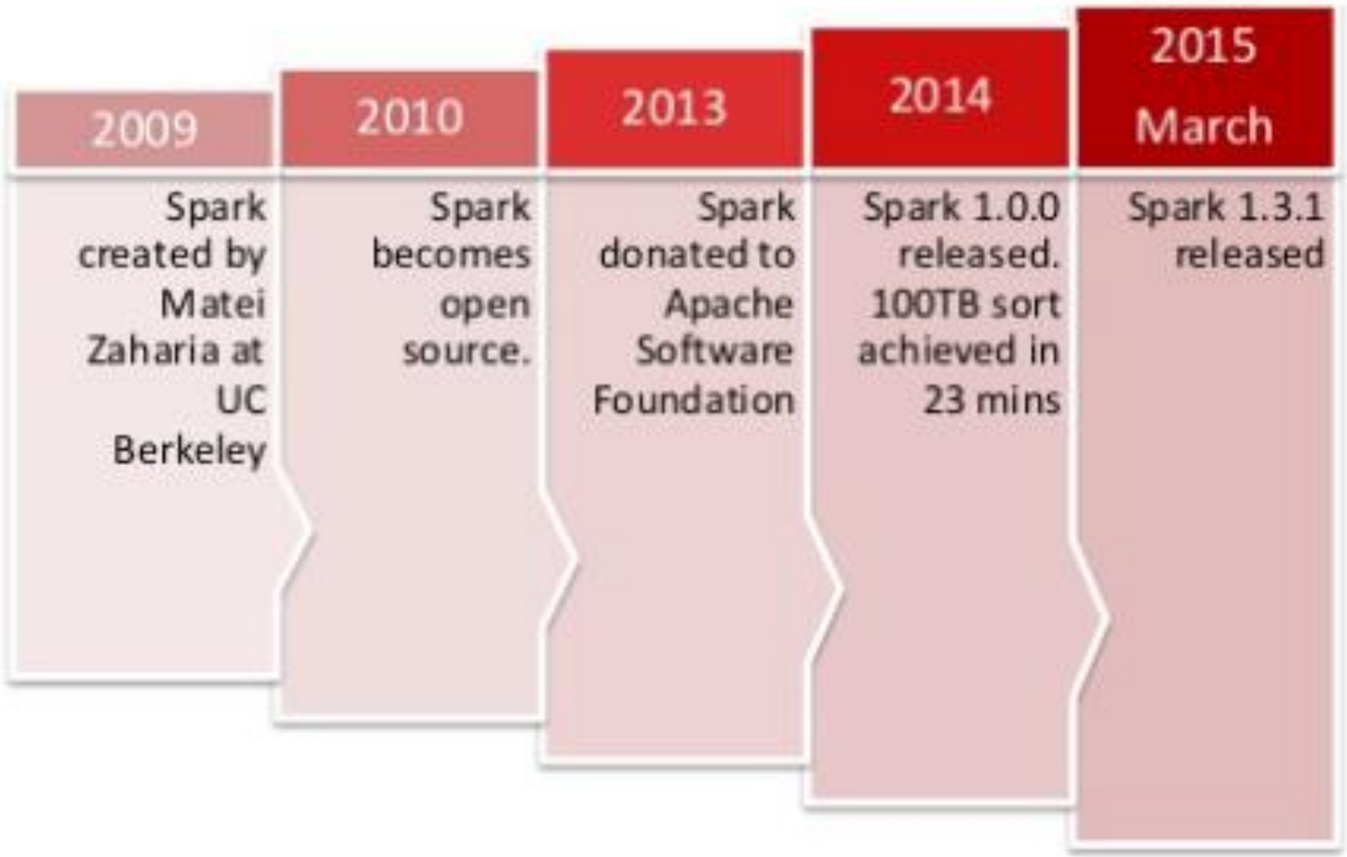
Apache Spark Overview

- An Engine to process big data in faster(than MR), easy and extremely scalable way
- An Open Source, parallel, in-memory processing, cluster computing framework
- Solution for loading, processing and end to end analyzing large scale data
- Iterative and Interactive : Scala, Java, Python, R and with Command line interface
- Stream Processing (Real time streams and DStreams)
- Unifies Big Data with Batch processing, Streaming and Machine Learning
- Appreciated and Widely used by: Amazon, eBay, Yahoo
- Can very well go with Apache Kafka, ZeroMQ, Cassandra etc.
- Powerful platform to implement **Lambda and Kappa Architecture**



Spark Evolution

- Recent release of Spark is 2.3
- We will work on 2.1.1


2009
Spark created by Matei Zaharia at UC Berkeley
2010
Spark becomes open source.
2013
Spark donated to Apache Software Foundation
2014
Spark 1.0.0 released. 100TB sort achieved in 23 mins
2015 March
Spark 1.3.1 released

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Spark Framework

Prog. Inter	Scala	Java	Python	R		
Library	SQL	ML Lib	Graph X	Streaming		
Engine	Spark Core					
Platforms	YARN	MESOS	Scheduler	Standalone		
Storage	Local	HDFS	HBase	RDBMS	NoSQL	AWS S3
	Azure Blob Storage / Data Lake Store					

Tuples of MR Vs. RDDs of Spark

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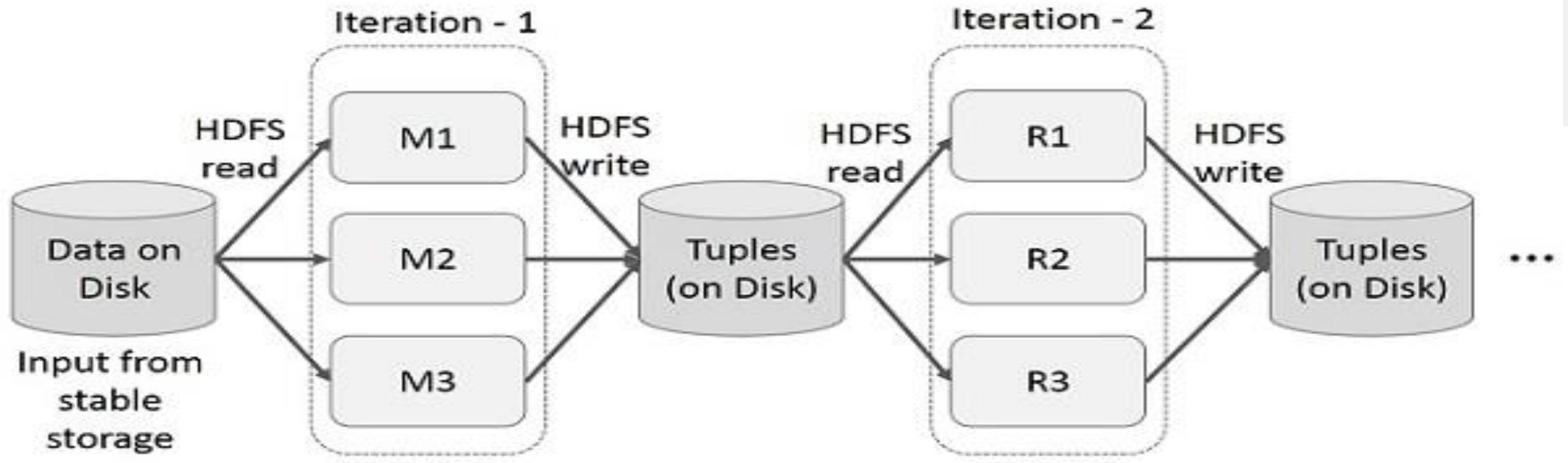
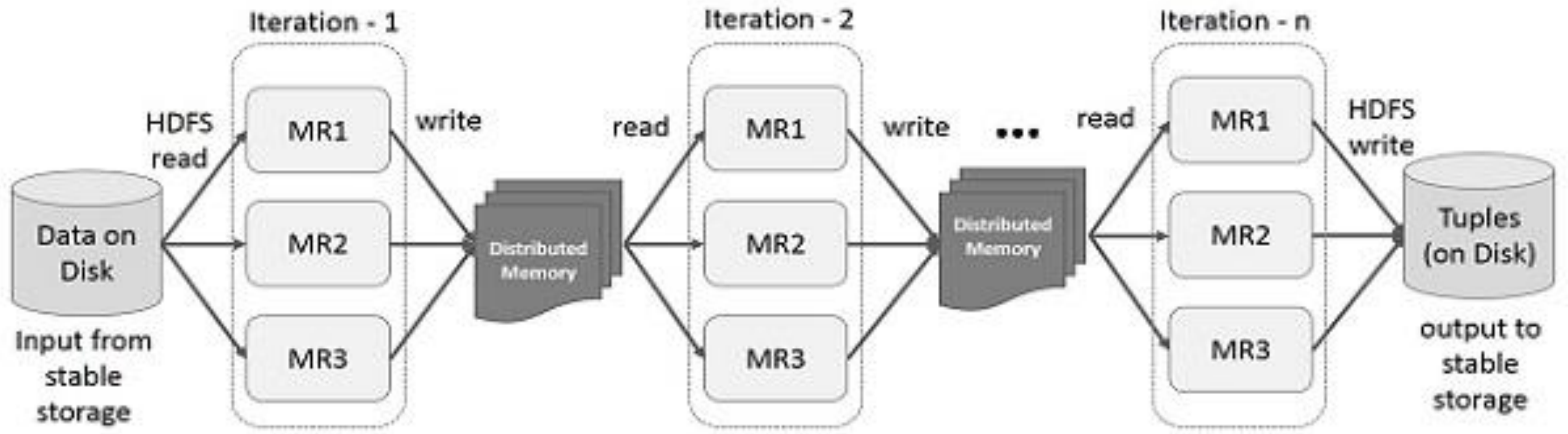
Tuples in Map Reduce



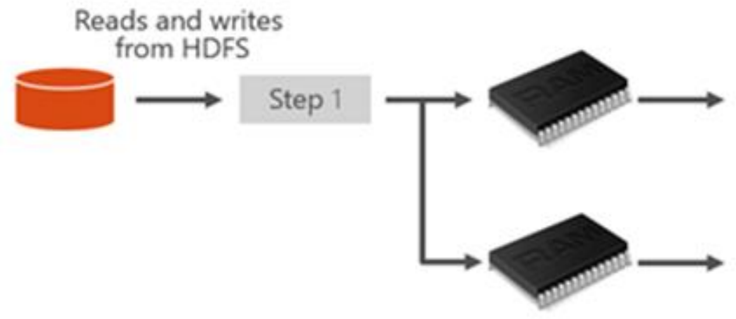
RDDs in Spark



Spark in-memory

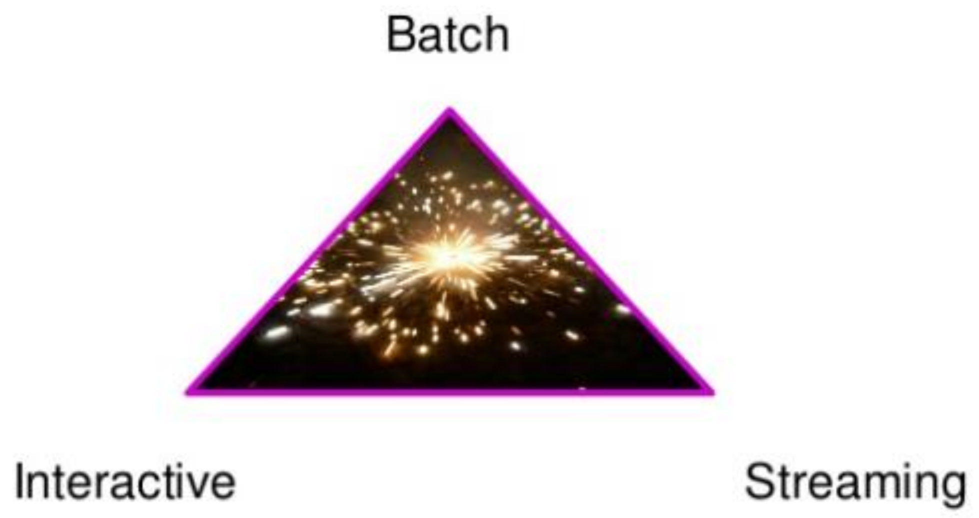
Spark does all intermediate steps in-memory…

- Faster in execution with fewer Secondary Storage r/w.
- Memory extensive
- The memory objects are called as Resilient Distributed Datasets.
- RDD’s are partitioned memory objects existing in multiple worker machines along with their replicas.



Spark Modes

- **Batch mode:** A scheduled program executed through scheduler in periodic manner to process data.
- **Interactive mode**: Execute spark commands through Spark Interactive command interface.
  - The Shell provides default Spark Context and works as a Driver Program. The Spark context runs tasks on Cluster.
- **Stream mode:** Process stream data in real time fashion.



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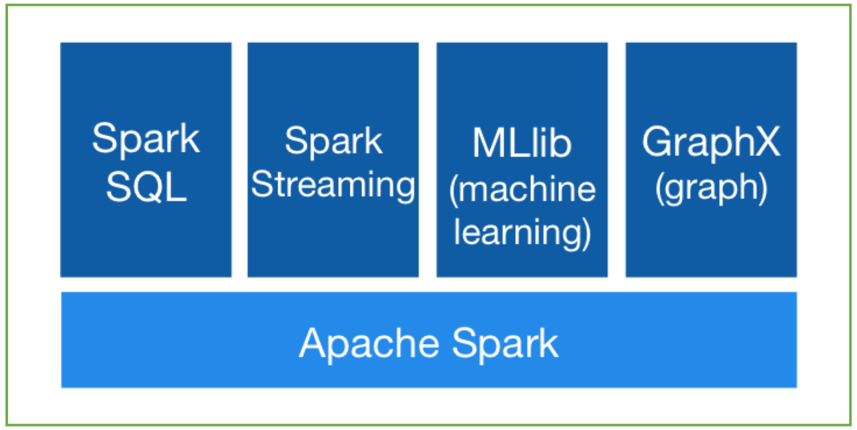
Spark Libraries

- Spark SQL: For SQL like operations. Built at the top of RDDS and eliminates low level RDD API. Seamless mix of SQL queries with Spark programs.
- Spark Streaming: Micro-batch operations on Discretized Stream
- MLib: Easy with standard API for different ML algorithms. Two libraries available Mlib and ML.
- Graph X: Extends RDDs with Resilient Distributed Property Graphs.

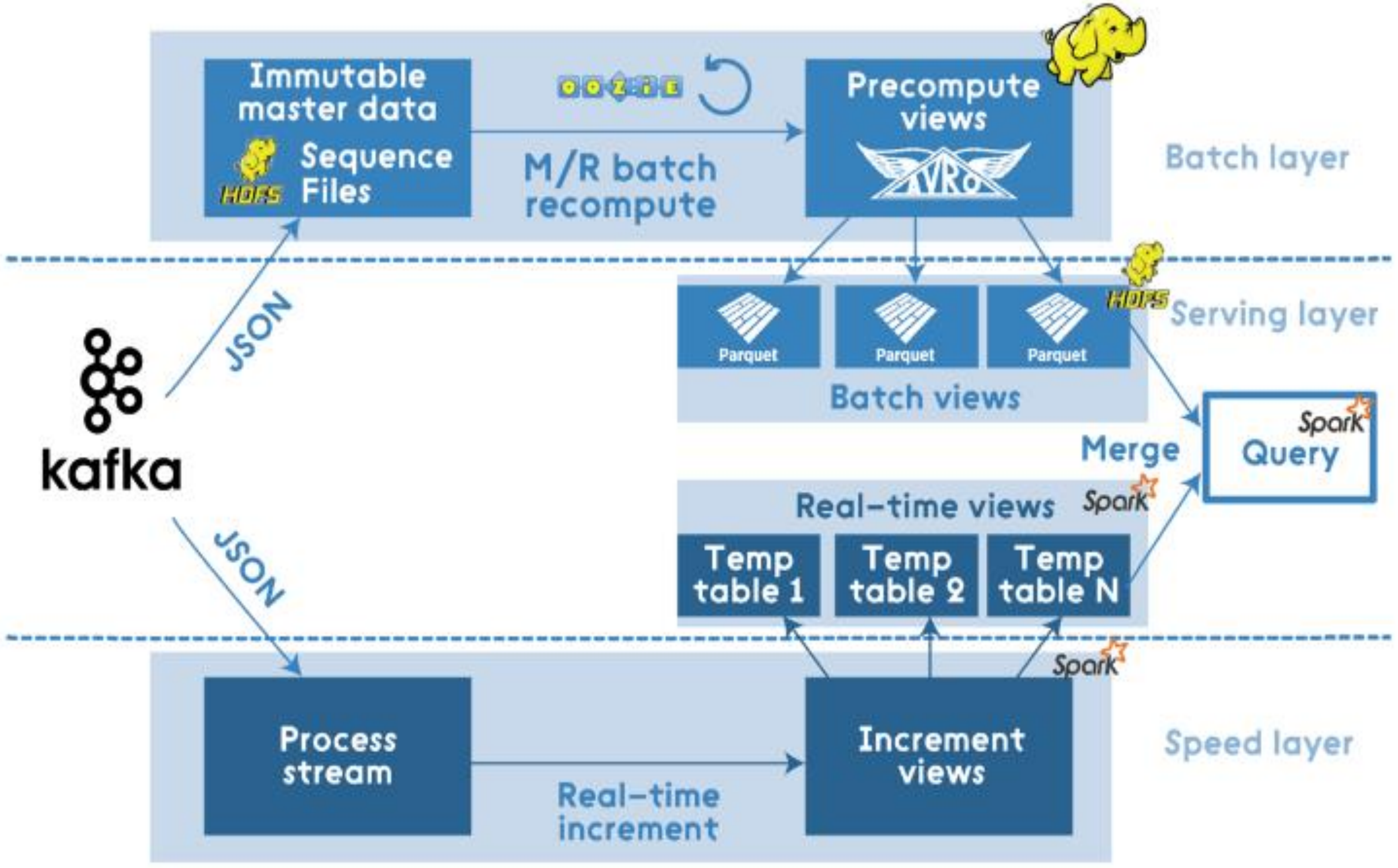


Spark Scalability

- Single Cluster, Stand-alone, Single Box
  - All components (Driver, Executors) run within same JVM.
  - Partitions data for multiple core.
  - Runs as Single Threaded mode.

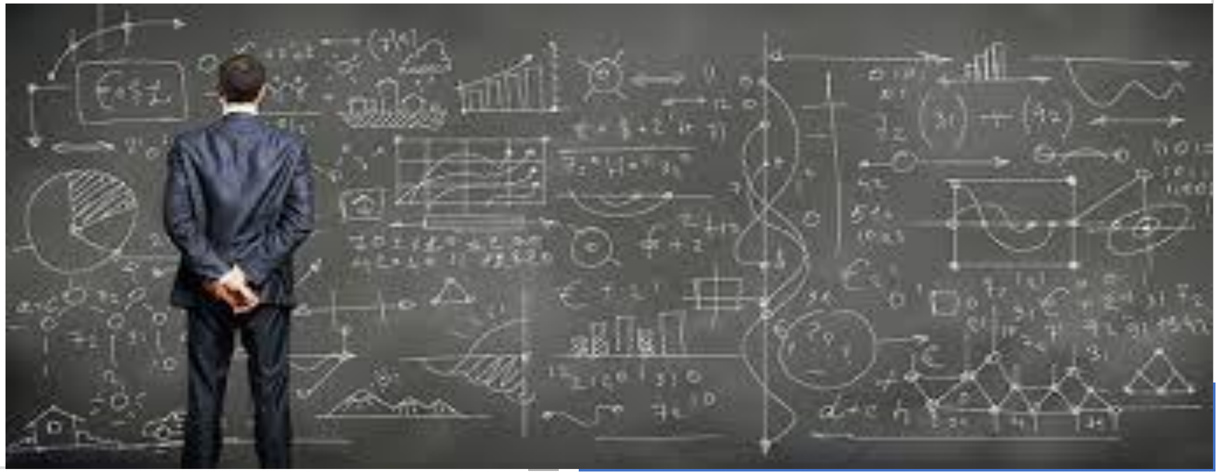
- Managed Clustered
  - Can scale from 2 to 1000 nodes.
  - Can use different cluster managers like- YARN, MESOS etc.
  - Partitions data for all nodes.

Spark in Lambda Architecture



Area of applicability

- Data Integration and ETL
- Interactive Analytics
- High performance batch and micro-batch computations
- Advanced and complex analytics
- Machine learning
- Real time stream processing including IoT
- Example:
  - Market trends and patterns
  - Predicting sales
  - Credit card frauds detection
  - Network intrusion detection
  - Advertisement targeting
  - Customer's 360 analysis



Module 2

YARN and Sparks Architecture

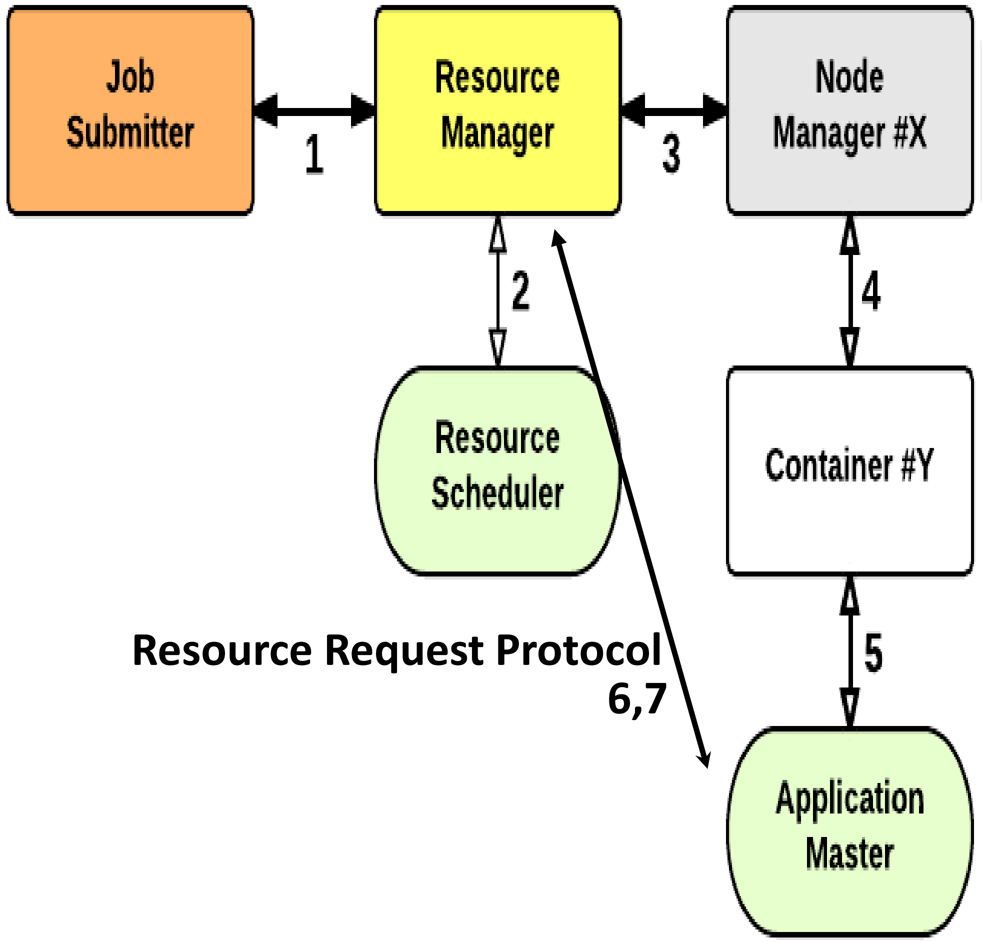
YARN Overview

Yet Another Resource Negotiator

- Key feature of Hadoop IInd Generation.
- Split architecture of MR into two functionalities: Resource Management and Job Scheduling.
- Improved cluster management technology.
- For variety of processing approaches and broader array of applications.
- Simultaneous working of Interactive query and data streaming.
- Supports Multi-tenancy.

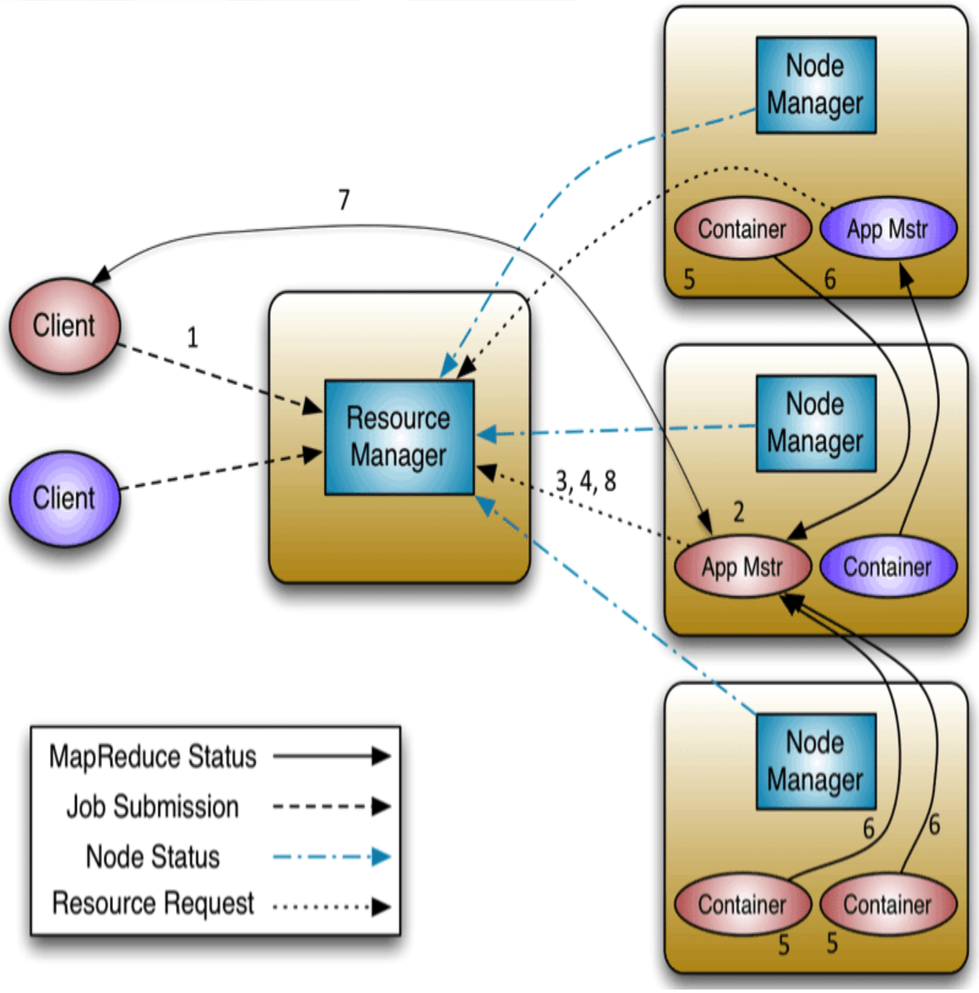
YARN Overview

1. Client submits a job to Resource Manager.
2. The Resource Manager consults Resource Scheduler and allocates a container.
3. Resource Manager contacts related Node Manager.
4. Node manager launches Container.
5. Container executes Application Master i.e. Job.
6. On execution, Application Master may ask for more containers to execute Tasks.
7. Application Master executes complete workflow of an application.

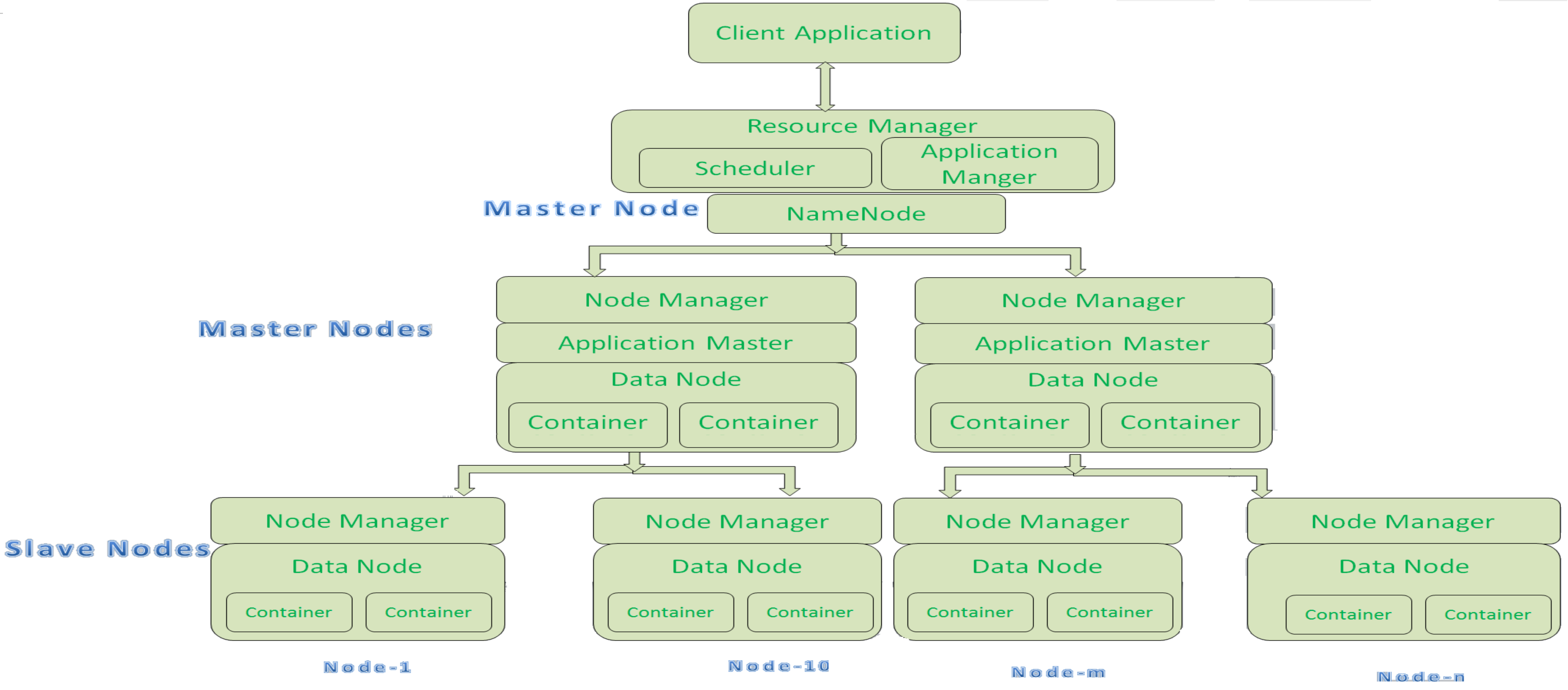


YARN Overview

1. Client program submits application to Resource Manager along with necessary specifications to launch application specific Application Master.
2. Resource Manager negotiate a container and launches an Application Master in it.
3. Application Master creates a bridge between Resource Manager and application to let appl access RM context.
4. Appl. Master negotiate with RM for more containers to run Tasks concurrently (Uses Resource Request Protocol).
5. Appl Master provides container specifications to Node Manager and launches container.
6. Time to time, the appl. code records progress status with Appl Master (Using Appl Protocol).
7. Client directly communicates with Appl Master to track progress and status of appl.
8. On Job finish, Appl Manager shuts down releasing all containers to re-purpose.



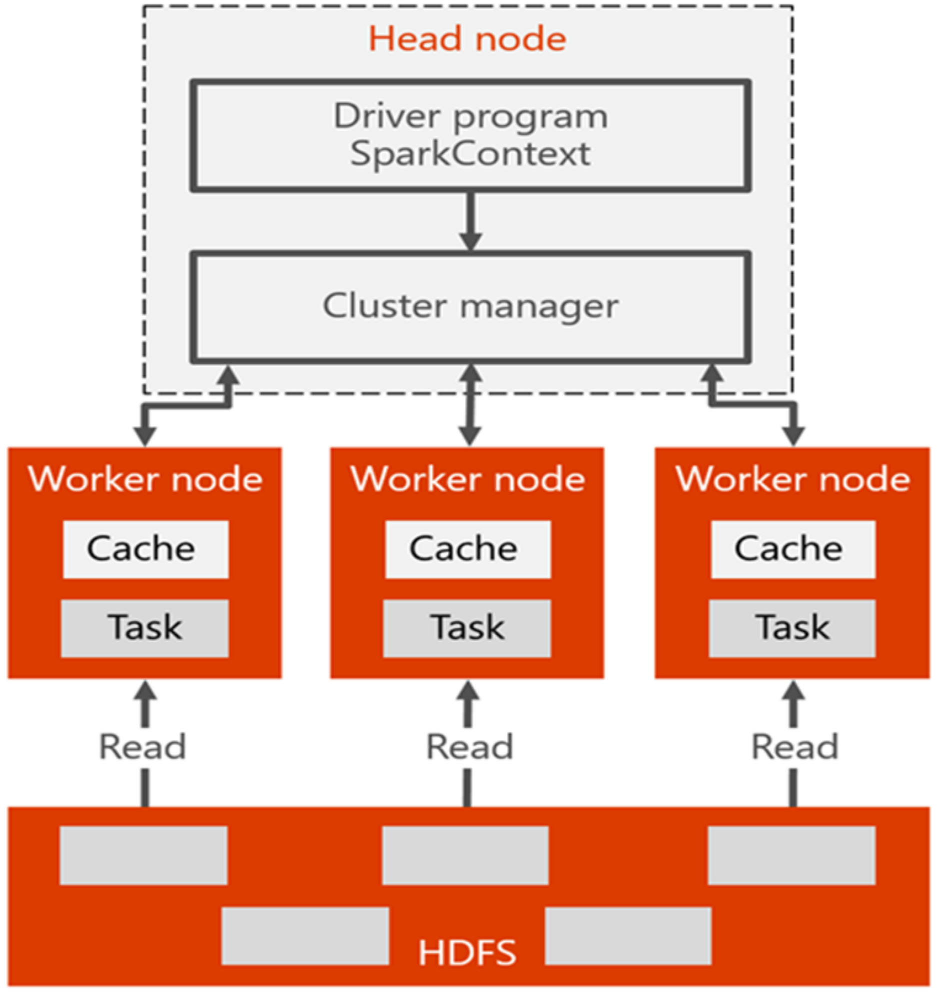
YARN Overview



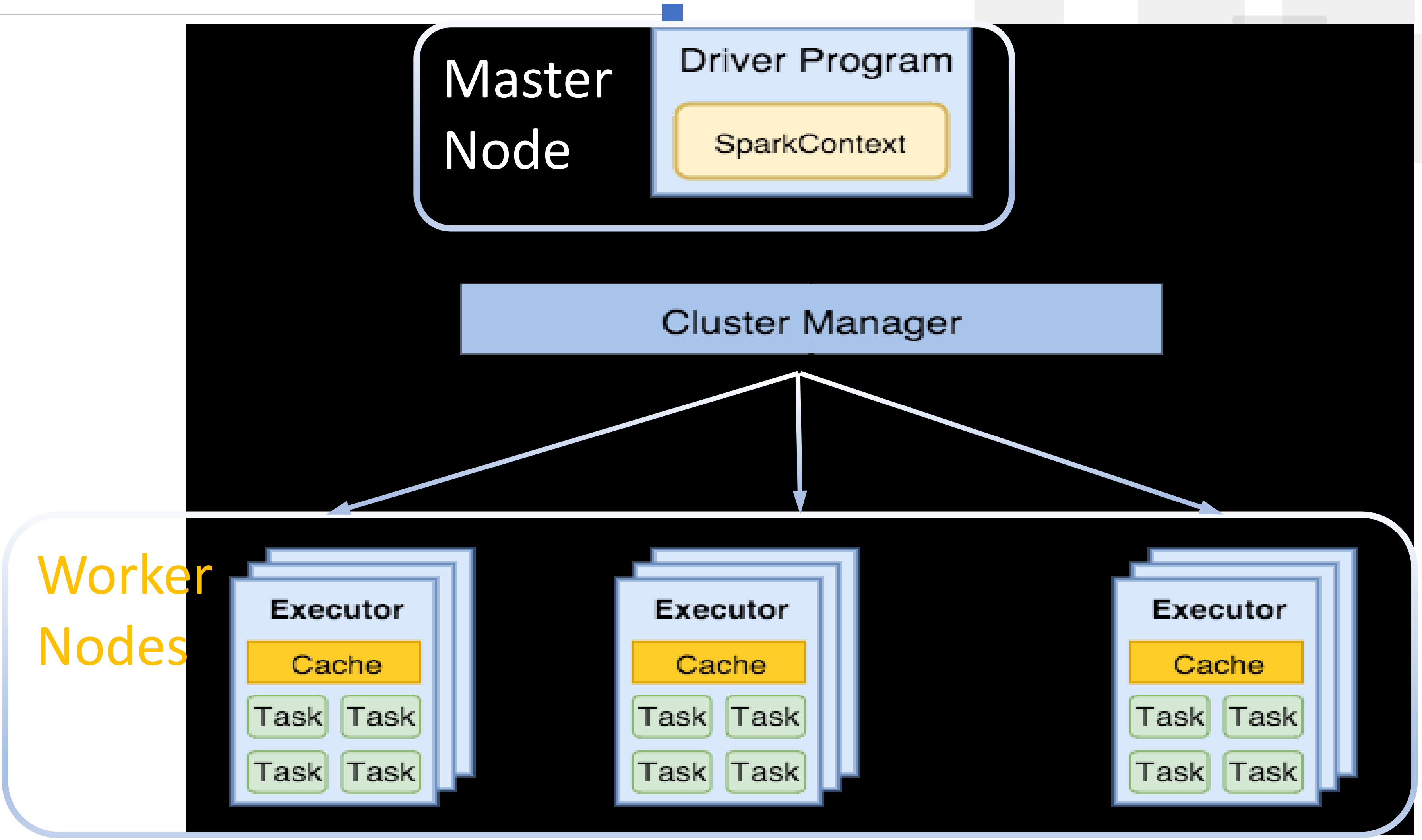
Hadoop 2.x In-Detail Architecture

Spark Architecture

- Spark Master: Manages number of applications. In HDInsight, it also manages resources at cluster level.
- Spark Driver: Per application to manage workflow of an application.
- Spark Context: Created by driver and keeps track and metadata of RDDs. Gives API to exercise various features of Spark.
- Worker Node: Read and write data from and to HDFS/Storage.



Spark architecture



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Module 3

Resilient Distributed Dataset: A spinal cord

A data frame- Sugar coated RDD.

Resilient Distributed Datasets

- Operations with spark are mostly with RDDs. We create, transform, analyze and store RDDs in Spark operations.
- RDDs are fast in access as stored in memory.
- Partitioned and Distributed as divided in parts and each part exist in a cluster.
- The data sets are formed of Strings, rows, objects, collection.
- **They are immutable.**
- To change, apply transformation and create new RDD.
- They can be cached and persisted.
- Actions produce summarized results.

Loading data.

- RDD Loading sources…
  - Text files
  - JSON files
  - Sequence files of HDFS
  - Parallelize on collection
    - Java Collection
    - Python Lists
    - R data frames
  - RDBMS/NoSQL
    - Use direct API
    - Bring it first as Collection (DAO Classes) and then create RDD.
  - Very large data sets
    - Create HDFS out side spark and then create RDDs using Apache Sqoop.
    - Spark aligns its own partitioning techniques to the partitioning of Hadoop.

Storing data

- Storing of RDD in variety of data sinks.
  - Text files
  - JSON
  - Sequence Files
  - Collection
  - RDBMS/NoSQL
- For persistence
  - Spark Utilities
  - Language specific support

Spark power lies in processing data in distribute manner. Though Spark provides API for Loading and sinking of data, here where its real power does not lay. Out side capabilities are recommended for simplicity and performance.

Lazy Evaluation

- Spark will not load or transform data unless action is encountered.
  - Step 1: Load a file content into RDD.
  - Step 2: Apply filtration
  - Step 3: Count for number of records (Now Step 1 to 3 are executed).
- **The above statement is true even for interactive mode.**
- The lazy evaluation helps spark to optimize operations and manage resources in better way.
- Makes trouble shooting difficult: Any problem in loading is detected while executing Action.

Transformations

- Recall: RDDs are immutable.
- Transformation: Operation on RDD to create a new RDD.
- Examples: Maps, Flat map, Filter etc.
- Operate on one element at a time.
- Evaluates lazily.
- Distributed across multiple nodes and executed by Executor within a cluster on local RDD independently.
- Creates its own subset of resultant RDD.

Overview

Spark SQL

- It’s a library built on Spark to support SQL Like operations.
- Facilitate eliminating RDDs from API for simplicity.
- Traditional RDBMS developers can easily transit to Big Data.
- Works with Structured Data that has a Schema.
- Seamlessly mix SQL Queries with Spark Programs.
- Supports JDBC.
- Mix with RDBMS and NoSQL.

Data Frames

Spark Session

- Like SparkContext for RDDs.
- Gives Data Frames and Temp Tables.

Data Frames

- RDDs are for Spark Core while Data Frames are for Spark SQL.
- Built upon RDDs
- It’s a distributed collection of data organized as Rows and Columns.
- Has a schema with column names and column types.
- Interoperability with…
    - Collections, CSV, Data Bases, Hive/NoSQL tables, JSON, RDD etc.

Spark SQL

- **Spark SQL :**
  - Not intended for interactive/exploratory analysis.
  - Spark SQL reuses the Hive frontend and meta-store.
  - Gives full compatibility with existing Hive data, queries, and UDFs.
  - Spark SQL includes a cost-based optimizer, columnar storage and code generation to make queries fast.
  - It scales to thousands of nodes and multi hour queries using the Spark engine. Performance is its biggest advantage.
  - Provides full mid-query fault tolerance.

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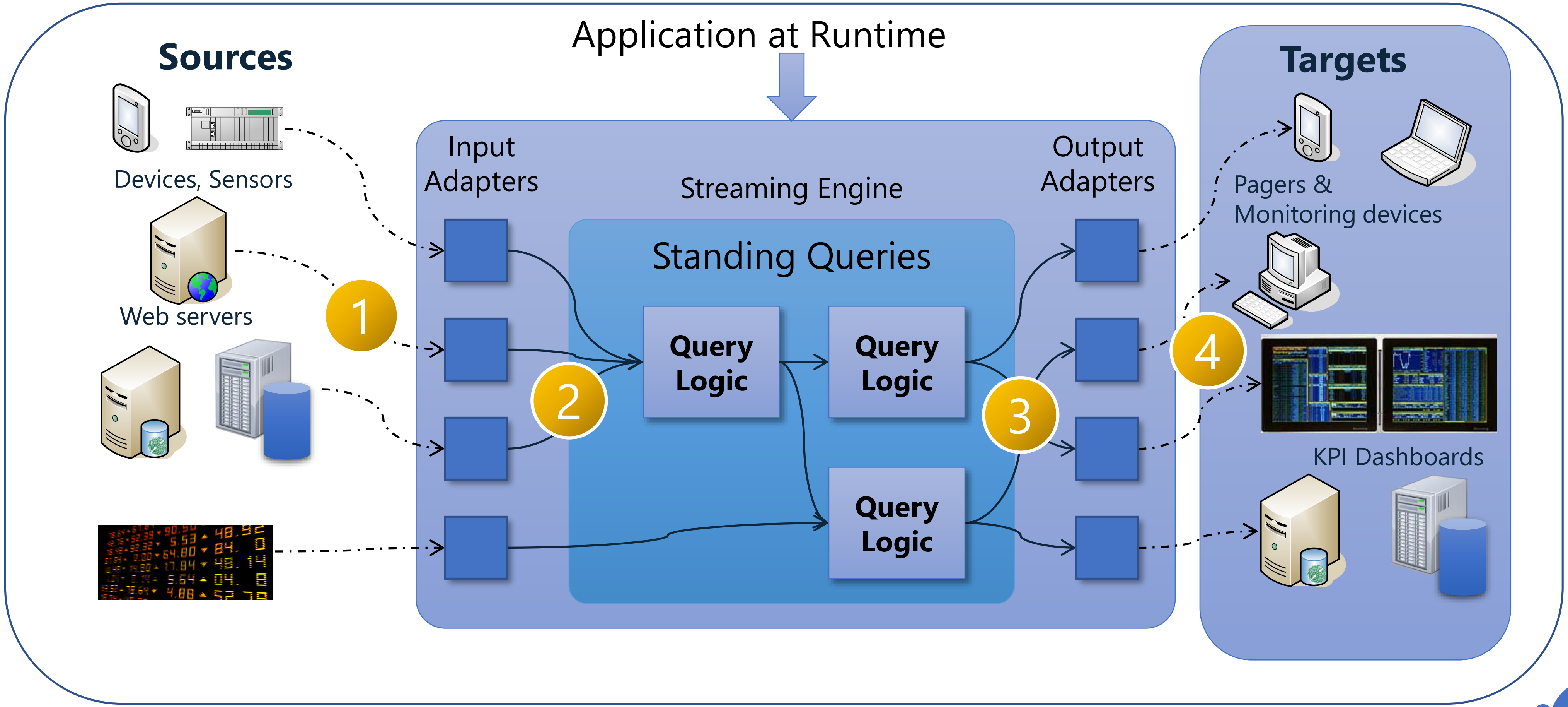
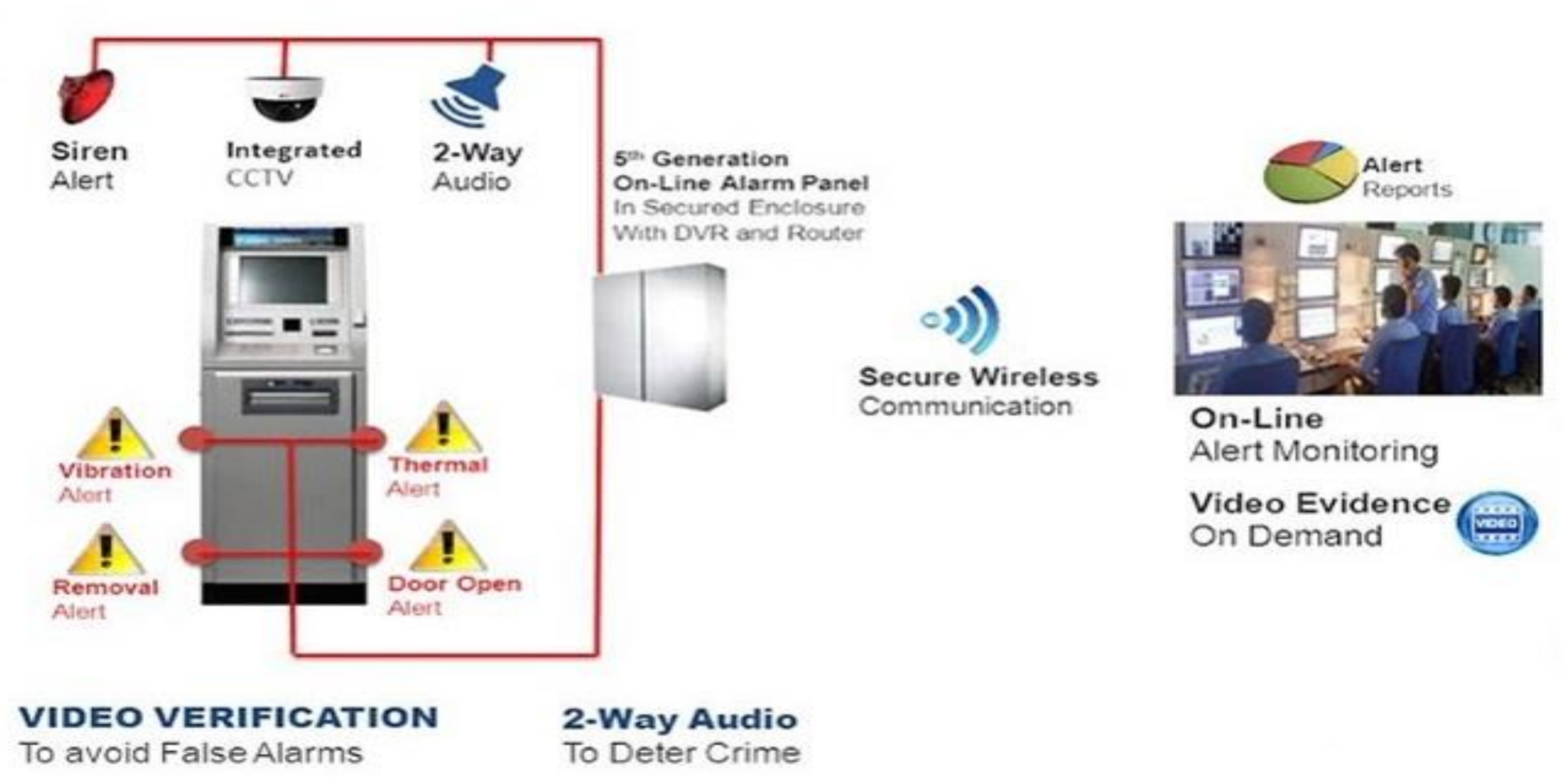
Module 4

Apache Spark Streaming

What is Streaming?



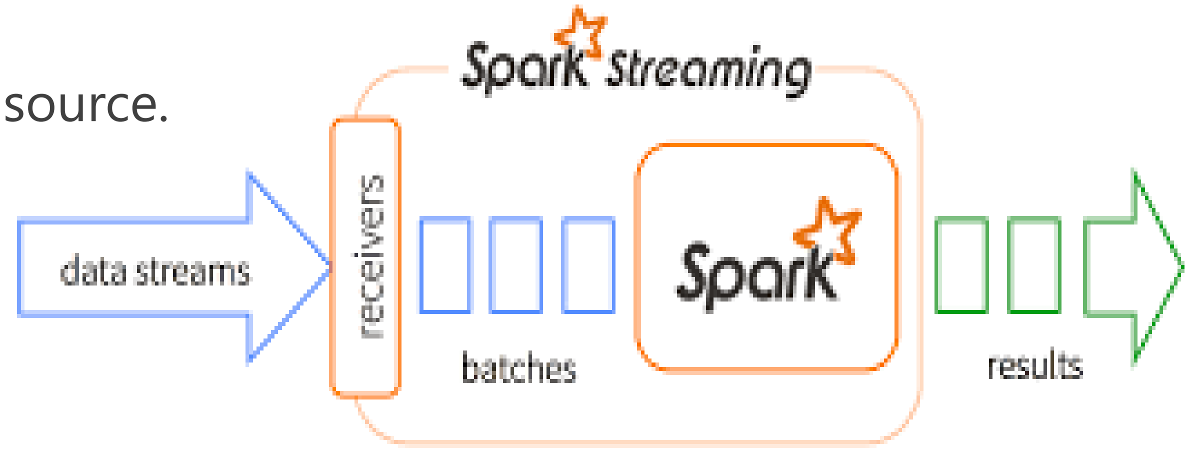
ATM Security



Why Spark Streaming?

- One of the real powers of Spark
- Typically analytics is performed on data at rest:
  - Databases, Flat files. The historical data, survey data etc.
- The real time analytics is performed on data the moment generated
  - Complex Event Processing, Fraud detections, click stream processing etc.

- What Spark Stream can do?
  - Look at data the moment it is arrived from source.
  - Transform, summarize, analyze
  - Perform machine learning
  - Prediction in real time



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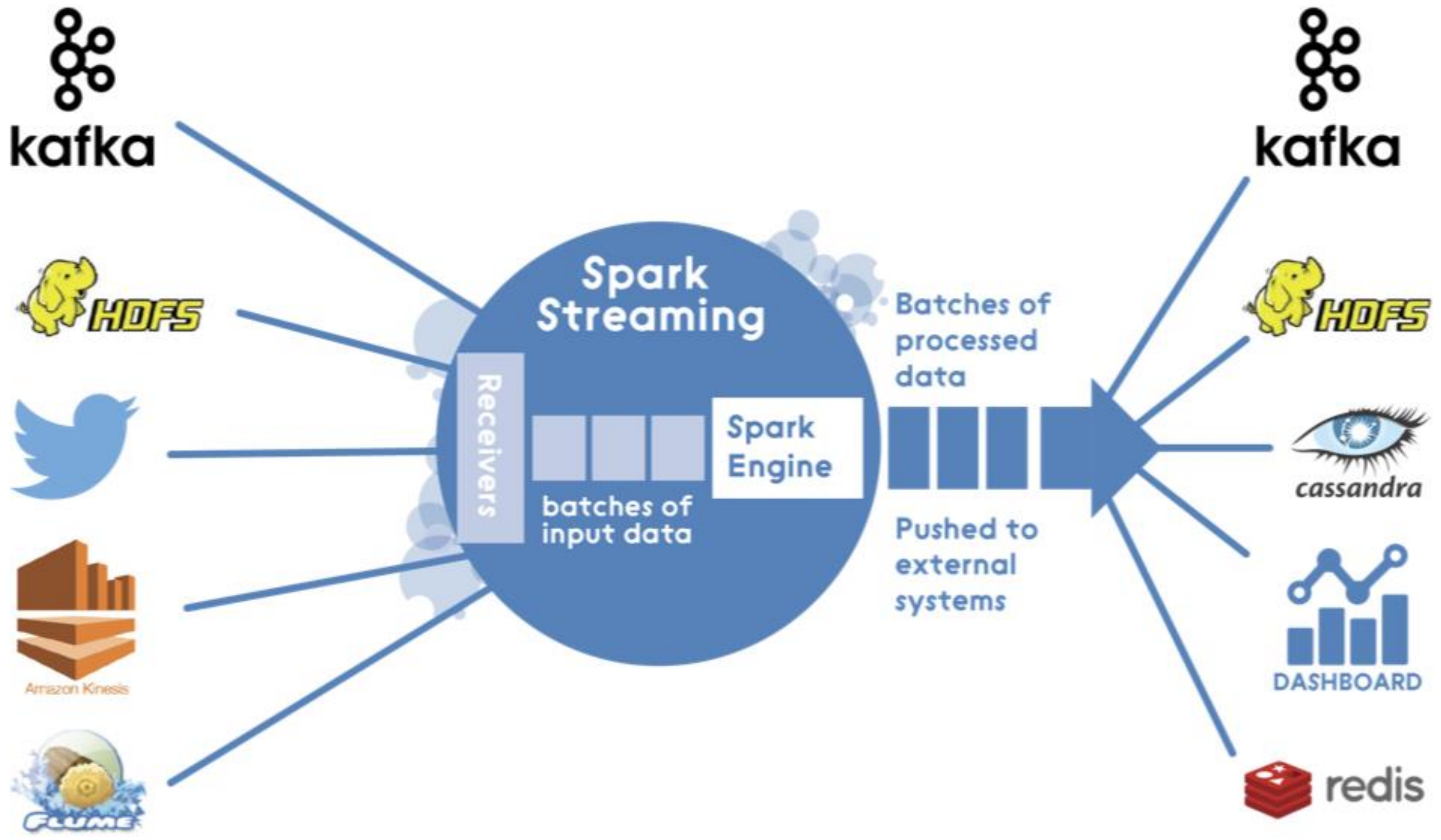
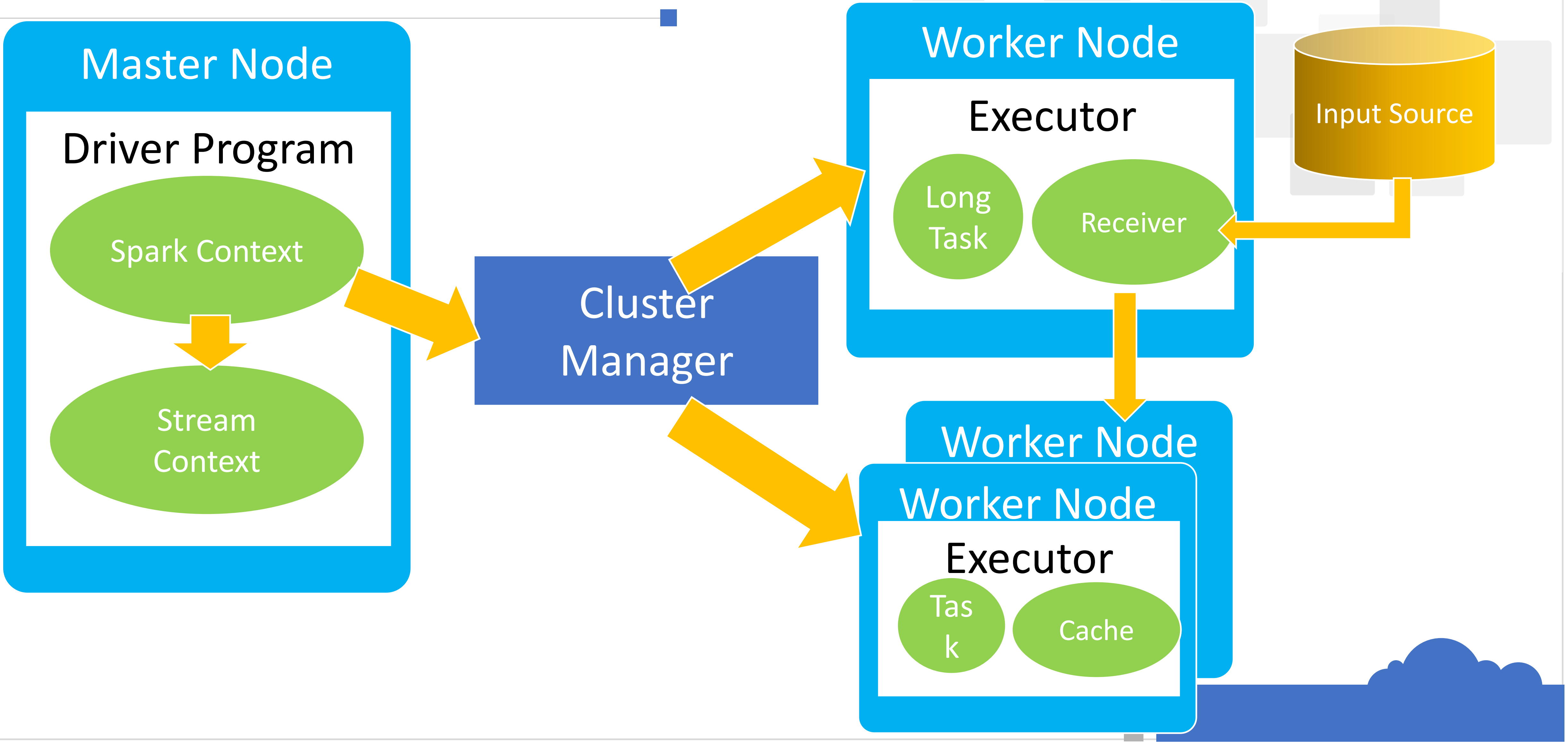
Spark Streaming and MicroBatch Processing



Spark Streaming

- Credit card fraud detection with high scalability and parallelism.
- Spam filtering
- Network intrusion detection
- Real time social media analytics
- Click Stream analytics
- Stock market analysis
- Advertise analytics

Spark Streaming architecture



Spark Streaming architecture

- A master node is with driver program with Spark Context.
- Create a streaming context from Spark Context.
- One of the worker node is assigned a long task of listening a source.
- The receiver keeps receiving data from input source.
- The receiver propagate data to worker nodes.
- The normal tasks in worker node act upon data.

The DStream

- Discretized stream
- Created from Stream context
- The micro batch window is set up for Dstream (Normally in secords)
- The micro batch window is a small time slice (around 3 sec) in which generated real time data is accumulated as batch and wrapped in RDD called Dstream.
- The Dstream allows all RDD operations.
- A common data can be shared across Global Variables

The Dstream windowing functions

- They are for computing across multiple Dstreams.
- All RDD functions are applicable on data accumulated from last X batches.
- Ex: Accumulate last 3 batches together, Average of something of last 5 batches.

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Module 5

Apache Spark : Analytics and Machine Learning

Types of Analytics

- Descriptive Analytics : Defining problem statement. What exactly happened.
- Exploratory Data Analytics: Why something is happening.
- Inferential Analytics: Understand population from the sample. Take sample and extrapolate to whole population.
- Predictive Analytics: Forecast what will happen.
- Causal Analytics: Variables are related. Understanding effect of change in one variable to another variable.
- Deep Analytics: Analytics uses multi-source data sources, combining some or all above analytics.

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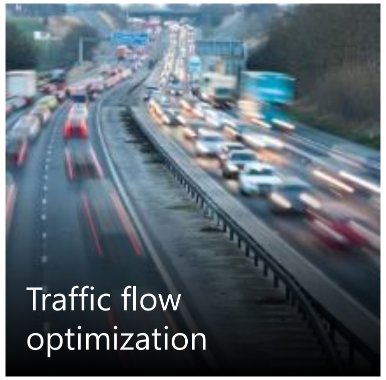
Data Analytics is needed everywhere –

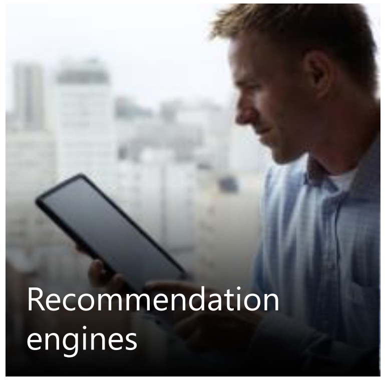
Intelligence Gathering

IT infrastructure & Web App optimization

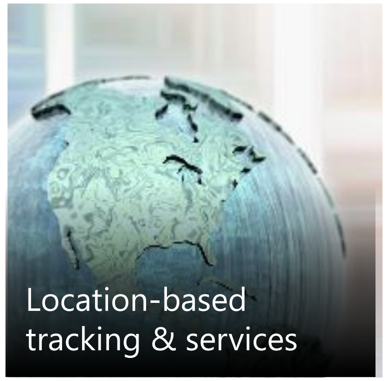
Legal discovery and document archiving

Social network analysis


Traffic flow optimization

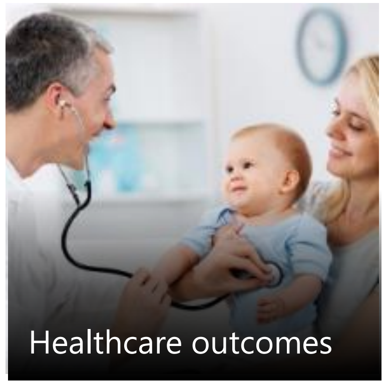

Recommendation engines

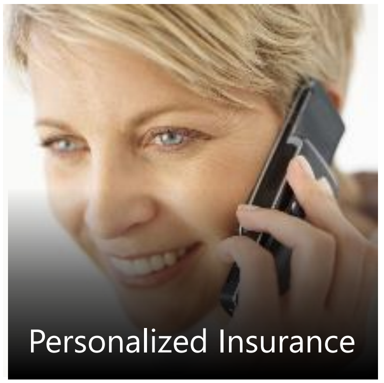
Churn analysis


Location-based tracking & services

Oil & Gas exploration

Weather forecasting for business planning

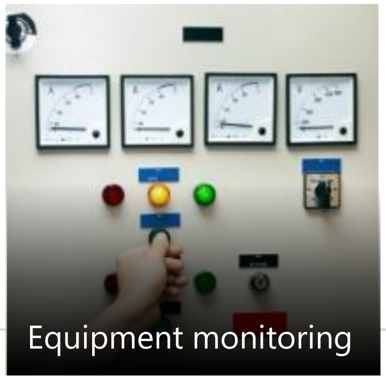

Healthcare outcomes

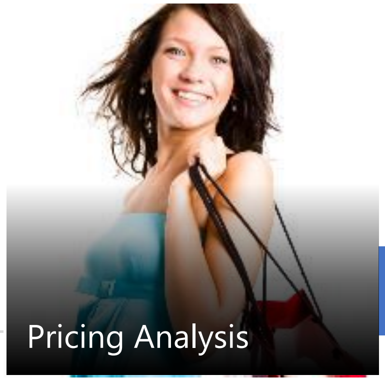

Personalized Insurance

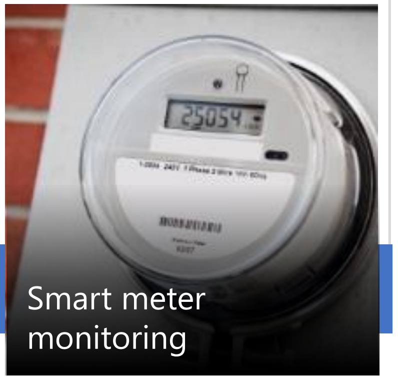
Fraud detection

Life sciences research

Advertising analysis


Equipment monitoring


Pricing Analysis


Smart meter monitoring

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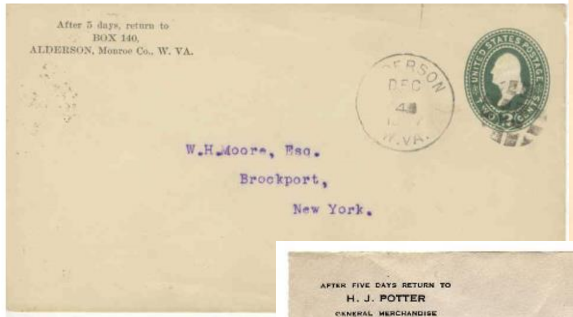
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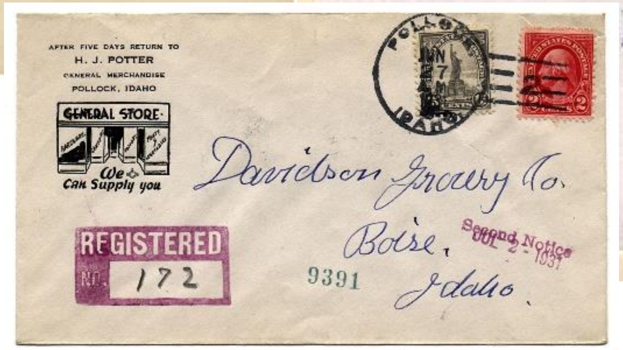
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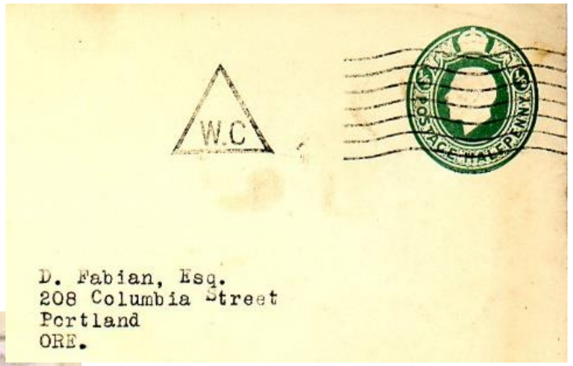
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AIR MAIL VIA NYRBA
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Mr. George S. Chapman
c/o Administrador de Correos
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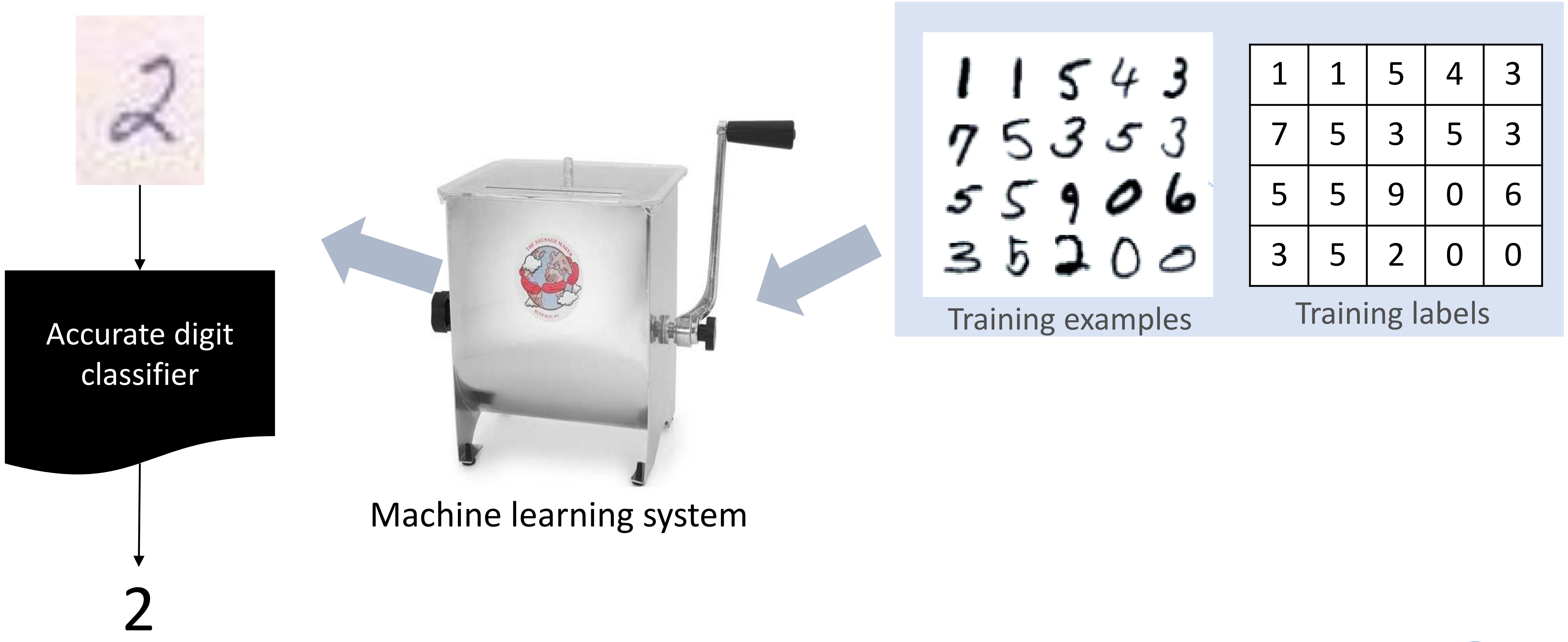

1	1	5	4	3
7	5	3	5	3
5	5	9	0	6
3	5	2	0	0

Machine Learning in Sparks

- Makes ML easy
- Standard and common interface for different ML algorithms.
- Contains algorithms and utilities.
- It has two machine learning libraries.
  - The spark.mllib: Original API built on RDDs. May be deprecated soon.
  - The spark.ml: New higher level API built on Data Frames.
- The Machine Learning Algorithms of Spark uses these data types…
  - Local Vector
  - Labeled Point
- Every data to be submitted to ML must be converted to these data types.

Other algorithms supported

- Decision Tree
- Dimensionality Reduction
- Random Forest
- Linear Regression
- Naïve Bayes Classification
- K-Means Clustering
- Recommendation Engines
- …. And many more

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Q & A

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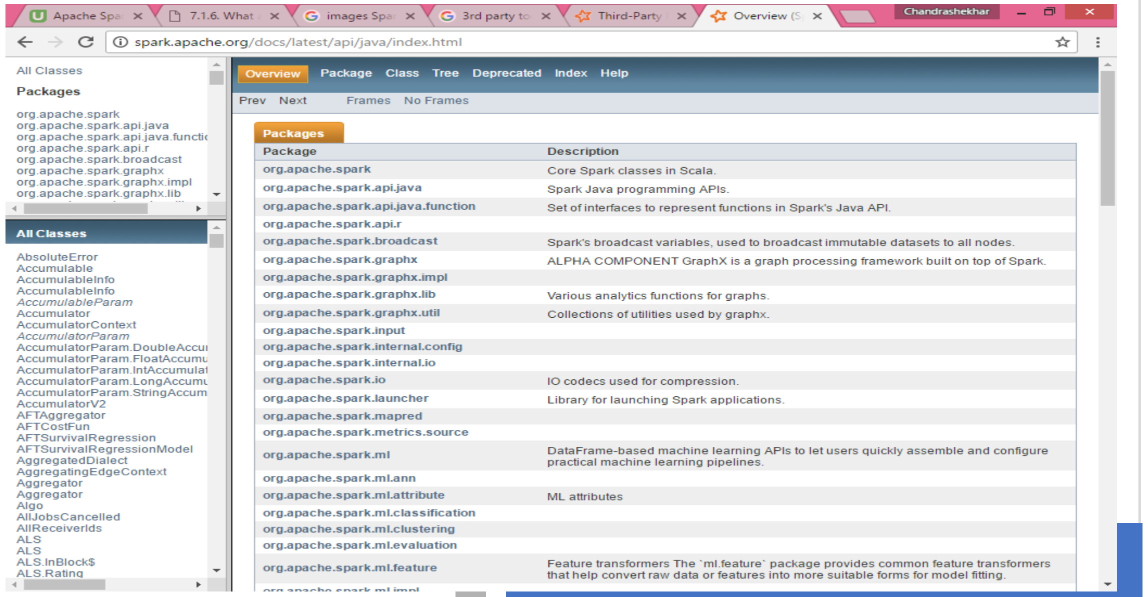
References

- Online reference:
  - http://spark.apache.org/docs/latest/index.html
  - http://spark.apache.org/docs/latest/programming-guide.html
  - http://spark.apache.org/docs/latest/api/java/index.html



All Classes

Packages

org.apache.spark
org.apache.spark.api.java
org.apache.spark.api.java.functic
org.apache.spark.api.r
org.apache.spark.broadcast
org.apache.spark.graphx
org.apache.spark.graphx.impl
org.apache.spark.graphx.lib

All Classes

AbsoluteError
Accumulable
AccumulableInfo
AccumulableInfo
AccumulableParam
Accumulator
AccumulatorContext
AccumulatorParam
AccumulatorParam.DoubleAccu
AccumulatorParam.FloatAccumu
AccumulatorParam.IntAccumulat
AccumulatorParam.LongAccumu
AccumulatorParam.StringAccum
AccumulatorV2
AFTAggregator
AFTCostFun
AFTSurvivalRegression
AFTSurvivalRegressionModel
AggregatedDialect
AggregatingEdgeContext
Aggregator
Aggregator
Algo
AllJobsCancelled
AllReceiverIds
ALS
ALS
ALS.InBlock$
ALS.Rating

Packages

Package	Description
org.apache.spark	Core Spark classes in Scala.
org.apache.spark.api.java	Spark Java programming APIs.
org.apache.spark.api.java.function	Set of interfaces to represent functions in Spark's Java API.
org.apache.spark.api.r	
org.apache.spark.broadcast	Spark's broadcast variables, used to broadcast immutable datasets to all nodes.
org.apache.spark.graphx	ALPHA COMPONENT GraphX is a graph processing framework built on top of Spark.
org.apache.spark.graphx.impl	
org.apache.spark.graphx.lib	Various analytics functions for graphs.
org.apache.spark.graphx.util	Collections of utilities used by graphx.
org.apache.spark.input	
org.apache.spark.internal.config	
org.apache.spark.internal.io	
org.apache.spark.io	IO codecs used for compression.
org.apache.spark.launcher	Library for launching Spark applications.
org.apache.spark.mapred	
org.apache.spark.metrics.source	
org.apache.spark.ml	DataFrame-based machine learning APIs to let users quickly assemble and configure practical machine learning pipelines.
org.apache.spark.ml.ann	
org.apache.spark.ml.attribute	ML attributes
org.apache.spark.ml.classification	
org.apache.spark.ml.clustering	
org.apache.spark.ml.evaluation	
org.apache.spark.ml.feature	Feature transformers The `ml.feature` package provides common feature transformers that help convert raw data or features into more suitable forms for model fitting.

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