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Big Data and Hadoop

Lesson 1.1: Hive, HBase and Hadoop Ecosystem Components

Objectives

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By the end of this lesson, you will be able to:

- Describe the basics of Hive

- Explain HBase and Cloudera

- Discuss the commercial distributions of Hadoop

- Explain the components of the Hadoop ecosystem

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Hive can be defined as follows:

Hive is a data warehouse system for Hadoop that facilitates ad-hoc queries and the analysis of large data sets stored in Hadoop.

Image source: hive.apache.org
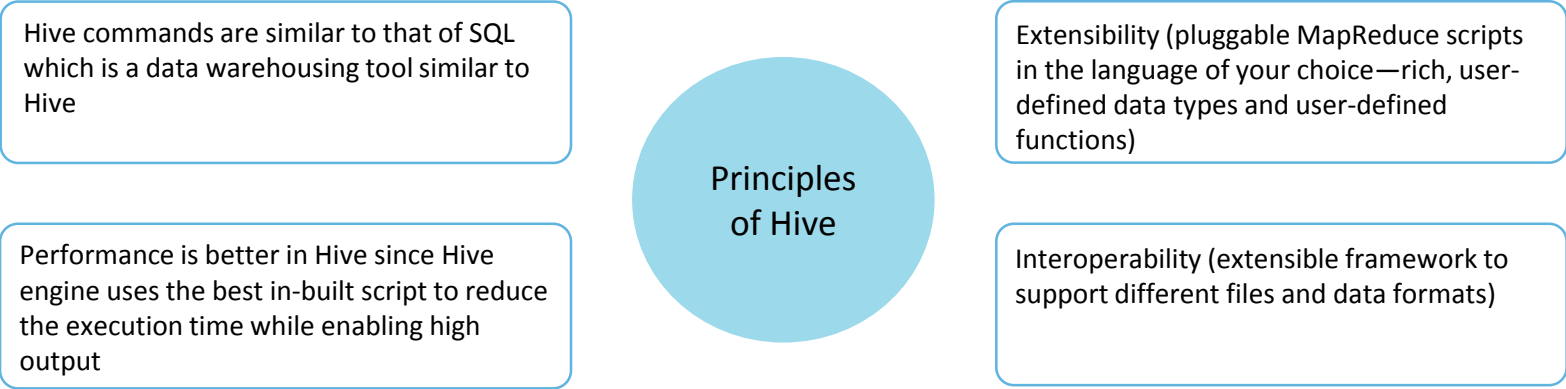
Following are the facts related to Hive:

- It provides an SQL-like language called HiveQL (HQL). Due to its SQL-like interface, Hive is a popular choice for Hadoop analytics.

- It provides massive scale-out and fault tolerance capabilities for data storage and processing of commodity hardware.

- Relying on MapReduce for execution, Hive is batch-oriented and has high latency for query execution.

Hive is a system for managing and querying unstructured data into a structured format. It uses the concept of:

- MapReduce for execution; and

- the Hadoop Distributed File System (HDFS) for storage and retrieval of data.

Hive commands are similar to that of SQL which is a data warehousing tool similar to Hive

Performance is better in Hive since Hive engine uses the best in-built script to reduce the execution time while enabling high output

Principles of Hive

Extensibility (pluggable MapReduce scripts in the language of your choice—rich, user-defined data types and user-defined functions)

Interoperability (extensible framework to support different files and data formats)

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The image illustrates the architecture of the Hive system. It also displays the role of Hive and Hadoop in the development process.

Basics of Hive Query Language
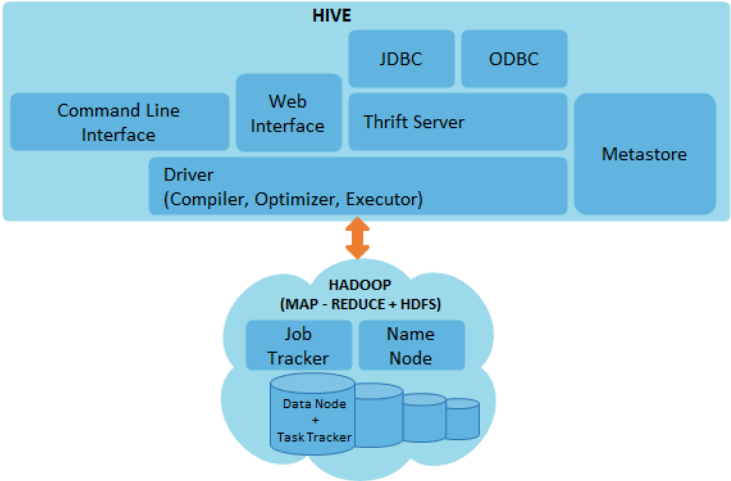
Hive Query Language (HQL) is the query language for Hive engine.

Hive supports the basic SQL queries such as:

- From clause sub-query;

- ANSI JOIN (only equi-join);

- multi-table insert;

- multi group-by;

- sampling; and

- objects traversal.

> **!** HQL provides support to pluggable MapReduce scripts using TRANSFORM.

Tables in Hive are analogous to tables in relational databases. A Hive table logically comprises the data that is stored and the associated meta data. Each table has a corresponding directory in HDFS.

Two types of tables in Hive
Managed tables   External tables
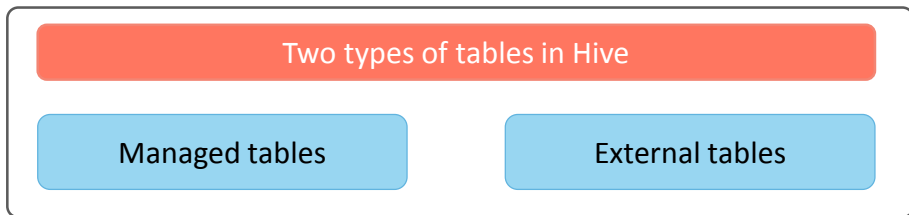
There are three data types in Hive. They are as follows:

- Primitive types

- Complex types

- User-defined types

Serialization can be defined as:

> Serialization takes a Java object that Hive has been working with, and turns it into something that Hive can write to HDFS or another supported system.

Serialization is used when writing data, for example, through an INSERT-SELECT statement.
De-serialization is used during query time to execute SELECT statements.

Following are the other facts related to serialization and de-serialization:

- The interface used for performing serialization and de-serialization is SerDe.
- In some situations, the interface used for de-serialization is LazySerDe.
- Unstructured data gets converted into structured data due to the flexibility of LazySerDe interface.
- While using the LazySerDe interface, data is read based on the separation by different delimiter characters.
- The SerDe interface is located in 'hive_contrib.jar'.

The table shows the comparison of User-Defined and User-Defined Aggregate Functions with MapReduce scripts:

Attribute	UDF/UDAF	MapReduce scripts
Language	UDF is written in Java	Any language
1/1 input/output	Supported via UDF	Supported
n/1 input/output	Supported via UDAF	Supported
1/n input/output	Supported via User-Defined Table Generating Function (UDTF)	Supported
Speed	UDF is faster (in same process)	Slower (spawns new process)

HBase—Introduction

Apache HBase is a distributed, column-oriented database built on top of HDFS.

Apache HBase is an open-source, distributed, versioned, non-relational database modeled after Google's Bigtable: A Distributed Storage System for Structured Data.

Just as Bigtable leverages the distributed data storage provided by the Google File System, Apache HBase provides Bigtable-like capabilities on top of Hadoop and HDFS. HBase is used when random, real-time read/write access is needed for Big Data.

! The goal of HBase is to host very large tables with billions of rows and millions of columns, atop clusters of commodity hardware.

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HBase is a type of NoSQL and is classified as a key value store.

In HBase:

- value is identified with a key.

- both key and value are byte-array.

- values are stored in key-orders.

- values can be accessed quickly by their keys.

! HBase is a database in which tables have no schema. Column families and not columns are defined at the time of table creation.

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HBase has two types of Nodes—Master and RegionServer. Following are the characteristics of the two nodes.

Master	RegionServer
• Only one Master node runs at a time. Its high availability is maintained with ZooKeeper. • It manages cluster operations like assignment, load balancing, and splitting. • It is not a part of the read/write path.	• One or more RegionServers can exist at a time. • It hosts tables, performs reads, and buffers writes. • Clients communicate with RegionServers for read/write operation.

! A region in HBase is the subset of a table's rows. The Master node detects the status of RegionServers and assigns regions to RegionServers.

HBase vs. RDBMS

The table shows a comparison between HBase and Relational Database Management System (RDBMS):

HBase	RDBMS
Automatic partitioning	Usually manual, admin-driven partitions
Scales linearly and automatically with new nodes	Usually scales vertically by adding more hardware resources
Uses commodity hardware	Relies on expensive servers
Has fault tolerance	Fault tolerance may or may not be present
Leverages batch processing with MapReduce distributed processing	Relies on multiple threads or processes rather than MapReduce distributed processing

Cloudera—Introduction

Cloudera is a commercial vendor for deploying Hadoop in an enterprise.

Following are the salient features of Cloudera:

It uses 100% open-source distribution of Apache Hadoop and related projects—Apache Pig, Apache Hive, Apache HBase, Apache Sqoop, and so on.

It offers the user-friendly Cloudera Manager for system management, Cloudera Navigator for data management, dedicated technical support, and so on.

Cloudera's distribution is known as CDH (Cloudera Distribution Including Apache Hadoop) which delivers the core elements of Hadoop.

The core elements include:

- scalable storage;
- distributed computing and additional components; and
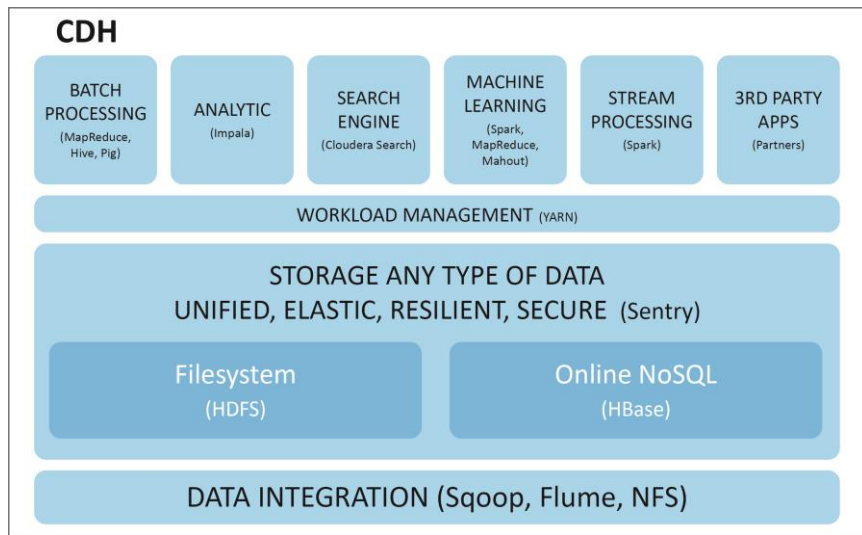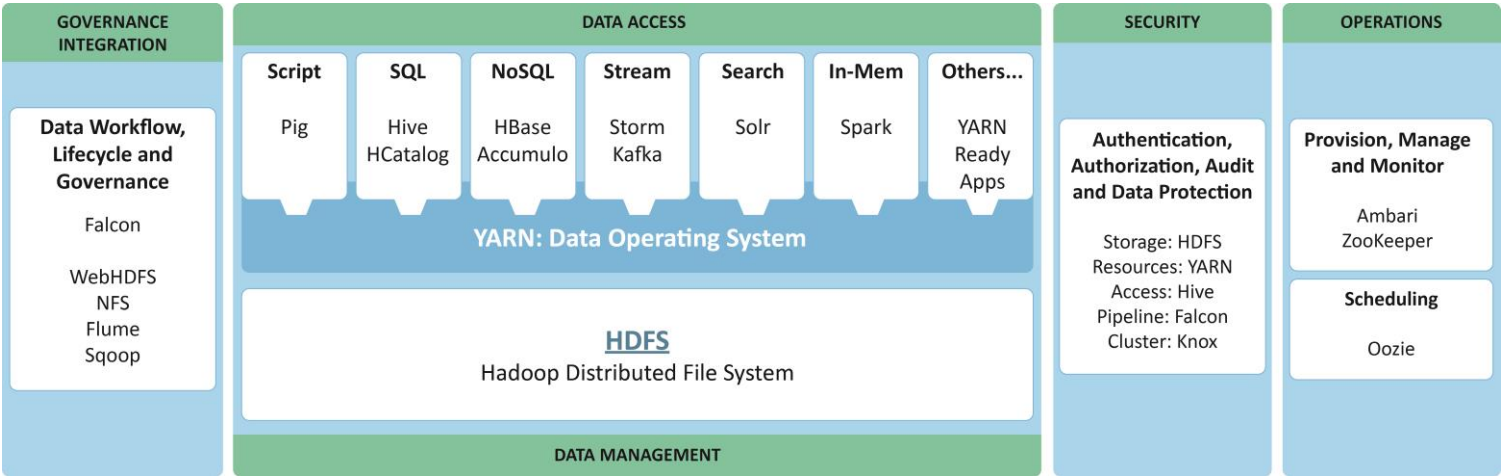- necessary enterprise capabilities such as security.

Image source: cloudera.com

Cloudera Manager is used to administer Apache Hadoop. It helps in the configuration of the following components but is not limited to them:

- HDFS
- Hive engine
- Hue
- MapReduce
- Oozie
- ZooKeeper
- Flume
- HBase
- Cloudera Impala
- Cloudera Search
- YARN

Hortonworks Data Platform

Hortonworks Data Platform (HDP) enables enterprise Hadoop with a suite of essential capabilities that serve as the functional definition of any data platform technology.

GOVERNANCE INTEGRATION	DATA ACCESS							SECURITY	OPERATIONS
Data Workflow, Lifecycle and Governance Falcon WebHDFS NFS Flume Sqoop	**Script** Pig	**SQL** Hive HCatalog	**NoSQL** HBase Accumulo	**Stream** Storm Kafka	**Search** Solr	**In-Mem** Spark	**Others...** YARN Ready Apps	**Authentication, Authorization, Audit and Data Protection** Storage: HDFS Resources: YARN Access: Hive Pipeline: Falcon Cluster: Knox	**Provision, Manage and Monitor** Ambari ZooKeeper **Scheduling** Oozie

YARN: Data Operating System

HDFS
Hadoop Distributed File System

DATA MANAGEMENT

Download available on http://hortonworks.com/hdp/downloads/

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MapR data platform supports more than 20 open source projects. It also supports multiple versions of the individual projects, thereby allowing users to migrate to the latest versions at their own pace.


Download available on: https://www.mapr.com/products/hadoop-download
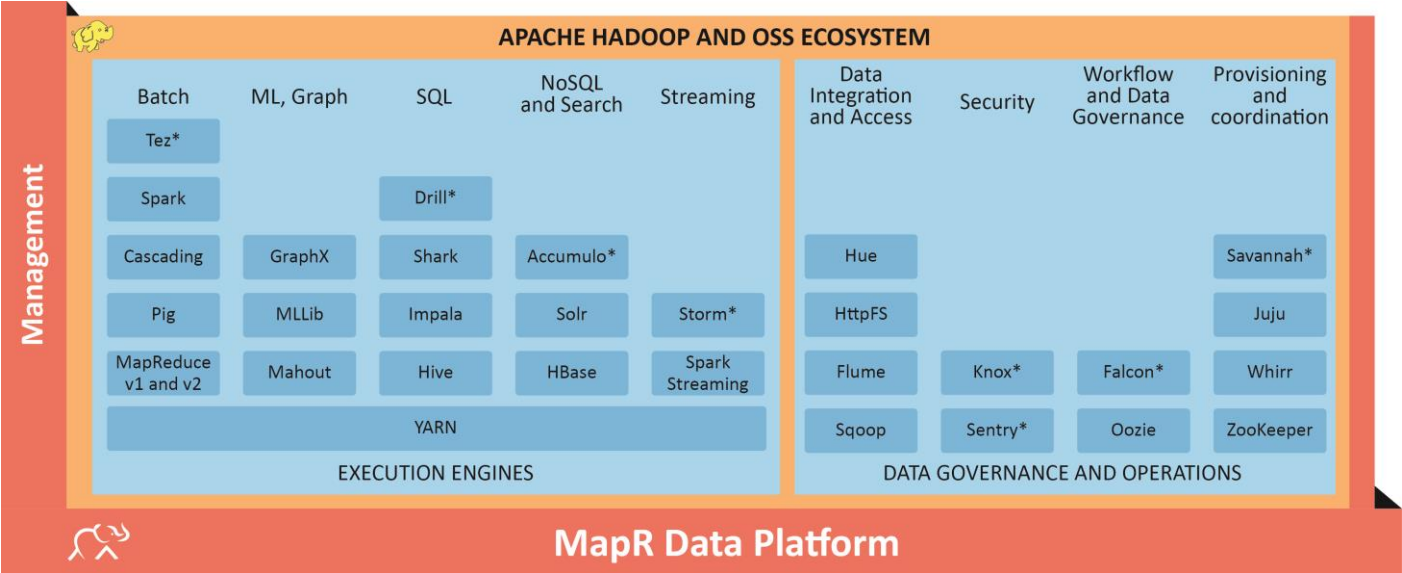
Pivotal HD

Pivotal HD is a commercially supported, enterprise-capable distribution of Hadoop. It consists of GemFire XD® along with toolsets through HAWQ, MADlib, OpenMPI, GraphLab, and Spring XD.

Pivotal HD aims to accelerate data analytics projects, and significantly expands Hadoop's capabilities. Pivotal GemFire brings real-time analytics to Hadoop, enabling businesses to process and make critical decisions immediately.

Download available on: https://network.pivotal.io/products/big-data

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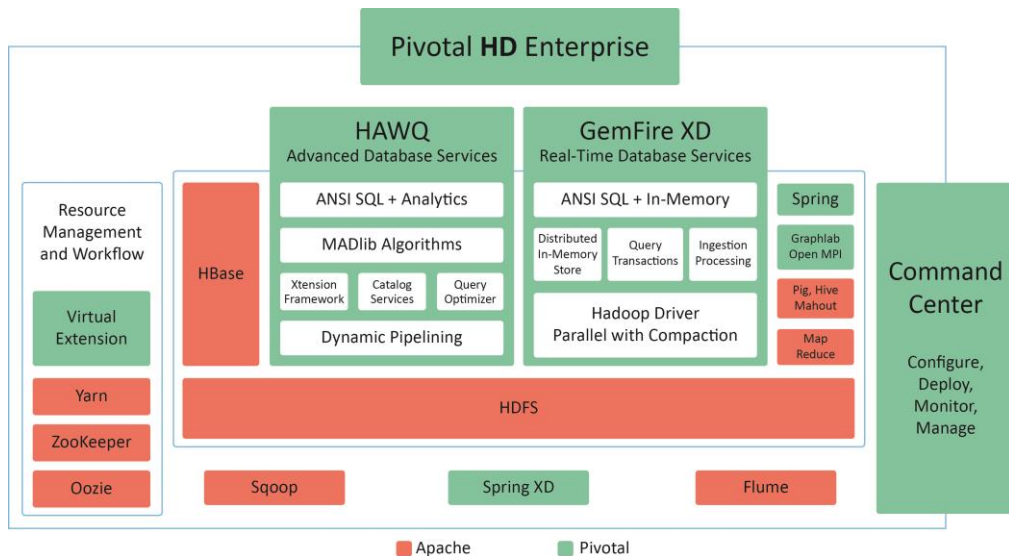
ZooKeeper is an open-source and high performance co-ordination service for distributed applications.

It offers the following services:

Naming

Group services

Locks and synchronization

Configuration Management

Features of ZooKeeper

Some of the salient features of ZooKeeper are as follows:

Provides a simple and high performance kernel for building more complex coordination primitives at the client

Allows for distributed processing

Applies multi-processing approach to avoid the wait-time for process execution

Takes care of problems by using in-built algorithms for deadlock detection and prevention

Provides distributed co-ordination services for distributed applications

Follows First-in-First-Out (FIFO) approach for executing jobs

Allows synchronization, serialization, and co-ordination of nodes in Hadoop cluster

Comes with pipeline architecture to achieve a wait-free approach

Goals of ZooKeeper

The following are the goals of ZooKeeper:

- Serialization ensures avoidance of delay in read or write operations.

- Reliability persists when an update is applied by a user in the cluster.

- Atomicity does not allow partial results. Any user update can either succeed or fail.

- Simple Application Programming Interface or API provides an interface for development and implementation.

Uses of ZooKeeper

The uses of ZooKeeper are as follows:

Configuration	It refers to ensuring that the nodes in the cluster are in sync with each other and also with the NameNode server.

Message queue	It is the communication with nodes present in the cluster.

Notification	It is the process of notifying the NameNode of any failure that occurs in the cluster so that the specific task can be restarted from another node.

Synchronization	It refers to ensuring that all the nodes in the cluster are in sync with each other, and the services are up and running.

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Sqoop is an Apache Hadoop ecosystem project whose responsibility is to import or export operations across relational databases. Some reasons to use Sqoop are as follows:

- SQL servers are deployed worldwide.

- Nightly processing is done on SQL servers.

- It allows moving certain parts of data from traditional SQL DB to Hadoop.

- Transferring data using script is inefficient and time-consuming.

- It allows to handle large data through Ecosystem.

- It helps to bring the processed data from Hadoop to the applications like database engine or web services.

Sqoop—Reasons to Use It (contd.)

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Sqoop is required when database is imported from Relational Database (RDB) to Hadoop or vice versa.

Users must consider details such as ensuring consistency of data, consuming production system resources, and preparing data for provisioning downstream pipeline.

Exporting database from RDB to Hadoop

Users must keep in mind that directly accessing data residing on external systems within MapReduce framework complicates applications, and exposes the production system to excessive loads originating from cluster nodes.

Importing database from Hadoop to RDB

Benefits of Sqoop

The following are the benefits of using Sqoop:

Tool designed to transfer data from Hadoop to RDB and vice versa

Transforms data in Hadoop with MapReduce or Hive without extra coding

Exports data back into RDB

Used to import data from a relational database to the Hadoop Distributed File System

The image displays the Hadoop ecosystem components as part of Apache Software Foundation projects.

The components are categorized into file system and data store, serialization, job execution, and others as shown on the image.
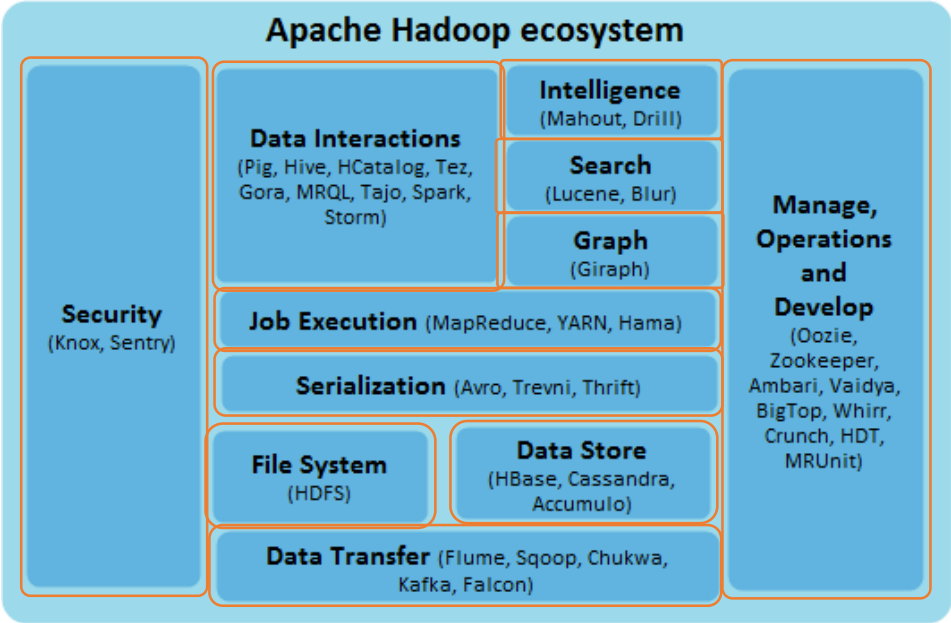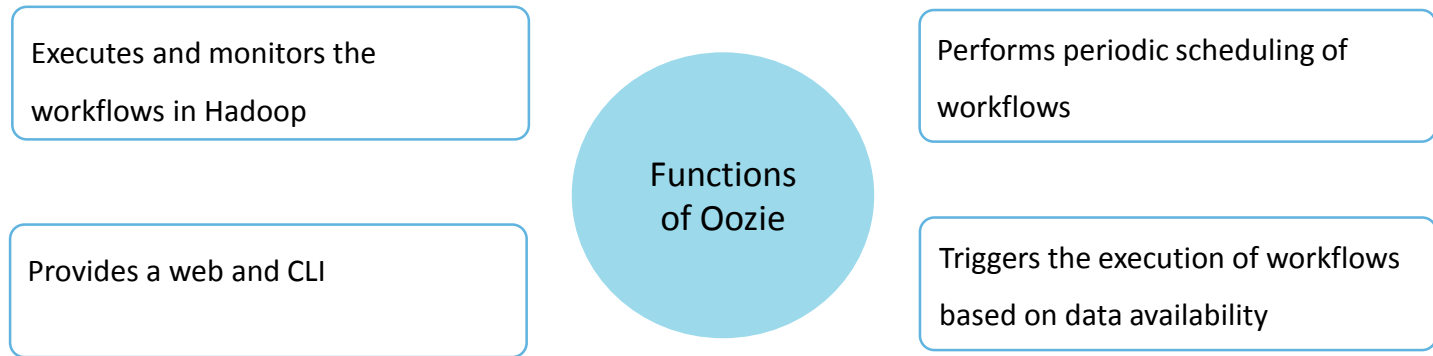

Apache Hadoop ecosystem

Security (Knox, Sentry)

Data Interactions (Pig, Hive, HCatalog, Tez, Gora, MRQL, Tajo, Spark, Storm)

Intelligence (Mahout, Drill)

Search (Lucene, Blur)

Graph (Giraph)

Job Execution (MapReduce, YARN, Hama)

Serialization (Avro, Trevni, Thrift)

File System (HDFS)

Data Store (HBase, Cassandra, Accumulo)

Data Transfer (Flume, Sqoop, Chukwa, Kafka, Falcon)

Manage, Operations and Develop (Oozie, Zookeeper, Ambari, Vaidya, BigTop, Whirr, Crunch, HDT, MRUnit)

Image source: hadoopshere.com

Apache Oozie

Apache Oozie is a workflow scheduler system used to manage Apache Hadoop jobs (MapReduce jobs).

Executes and monitors the workflows in Hadoop

Provides a web and CLI

Functions of Oozie

Performs periodic scheduling of workflows

Triggers the execution of workflows based on data availability

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Apache Mahout is dedicated to machine learning.

The three modes of machine learning are:

Machine learning

Supervised

Unsupervised

Semi-supervised
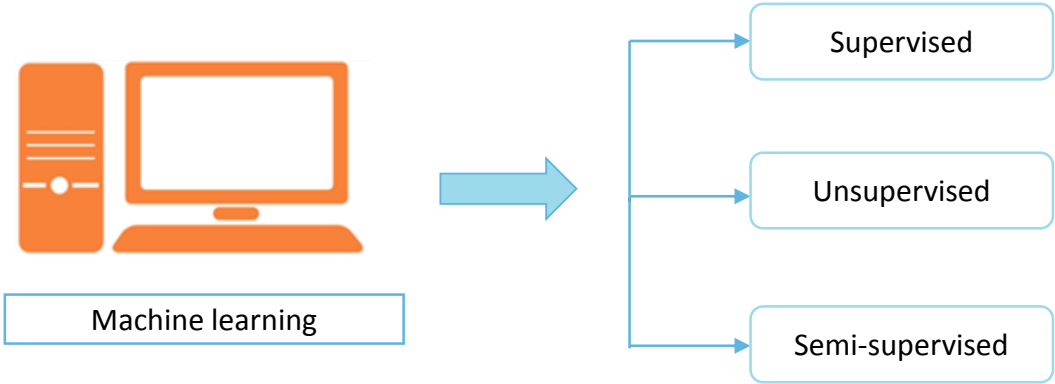
Mahout helps in clustering, which is one of the most popular techniques of machine learning.

Clustering allows the system to group numerous entities into separate clusters or groups based on certain characteristics or features of the entities.

News Aggregator

McCain the show horse: Way off track
Seattle Post Intelligencer - 36 minutes ago
By JOEL CONNELLY ABOARD THE now-jettisoned "Straight Talk Express," Sen. John McCain loved to talk with reporters about go-to heroes in history, none more than Theodore Roosevelt and Winston Churchill.
Candidates scramble to prepare for debate amid bailout crisis CNN International
McCain Decides to Participate in Debate New York Times
BBC News - Voice of America - Washington Post - AFP
all 5,183 news articles »

BBC News

WaMu's Bank Split From Holding Company, Sparing FDIC (Update1)
Bloomberg - 46 minutes ago
By Linda Shen Sept. 26 (Bloomberg) -- Washington Mutual Inc.'s holding company was detached from its branches and deposits when JPMorgan Chase & Co.
Video: Wall Street watches Washington ReutersVideo
Update: JPMorgan takes over WaMu after snapping up assets Bizjournals.com
Los Angeles Times - CNNMoney.com - Wall Street Journal - MarketWatch
all 2,791 news articles »

Telegraph.co.uk

Russia warship heads to Africa after pirate attack
The Associated Press - 1 hour ago
MOSCOW (AP) - A Russian warship on Friday rushed to intercept a Ukrainian vessel carrying 33 battle tanks and a hoard of ammunition that was seized by pirates off the Horn of Africa - a bold hijacking that again heightened fears about surging piracy ...
Russian Navy ship sent to combat pirates ABC Online
Somali pirates grab Ukrainain ship loaded with tanks Reuters
International Herald Tribune - Voice of America - CNN - Bloomberg
all 561 news articles »

The Southern Ledger

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Apache Cassandra is a freely distributed, high-performance, extremely scalable, and fault-tolerant post-relational database. Its features are as follows:

- It is designed keeping in mind that system or hardware failures can occur.

- It follows read or write-anywhere design.

The benefits of Cassandra are as follows:

- It performs Online Transaction Processing (OLTP) operations and Online Analytical Processing (OLAP) operations.

- It helps to modify real-time data and perform data analytics.

Apache Spark is a fast and general MapReduce-like engine used for large-scale data processing. The key advantages of Spark are as follows:

Speed	Ease of use	Generality	Integration with Hadoop
• Runs programs up to 100x faster than Hadoop MapReduce in memory, or 10x faster on disk • Has an advanced DAG execution engine that supports cyclic data flow and in-memory computing	• Helps to write applications quickly in Java, Scala, or Python • Offers interactive Scala and Python shells	• Can combine SQL, streaming, and complex analytics • Powers a stack of high-level tools including Spark SQL, MLlib for machine learning, GraphX, and Spark Streaming	• Can run on YARN cluster manager on Hadoop 2 • Can read any existing Hadoop data

Apache Ambari

Apache Ambari is a completely open operational framework for provisioning, managing, and monitoring Apache Hadoop clusters. It enables system administrators to:

- provision a Hadoop cluster;

- manage a Hadoop cluster;

- monitor a Hadoop cluster; and

- integrate Hadoop with the Enterprise operational tools.
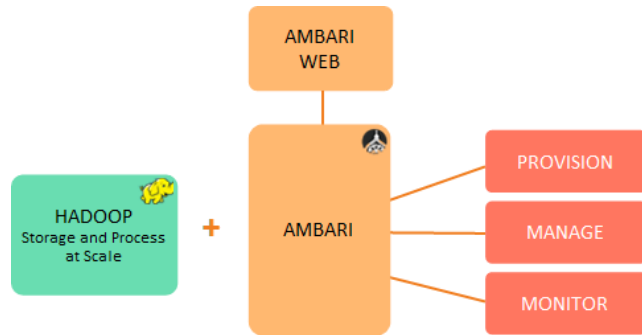
Some of the key features of Apache Ambari are as follows:

- Wizard-driven installation of Hadoop across any number of hosts
- API-driven installation of Hadoop via Ambari Blueprints for automated provisioning
- Granular control of Hadoop service and component lifecycles
- Management of Hadoop service configurations
- Advanced job diagnostic and visualization tools
- Robust RESTful APIs for customization and integration with enterprise systems
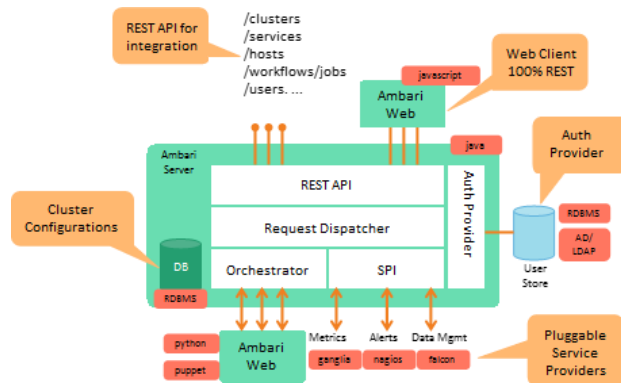
Kerberos is a third-party authentication mechanism in which users and services that users wish to access rely on Kerberos server to authenticate each to the other.

The Kerberos server, Key Distribution Center (KDC), has three parts:

Principals	It is a database of the users and services their respective Kerberos passwords.
Authentication Server (AS)	It is meant for initial authentication and issuing a Ticket Granting Ticket (TGT).
Ticket Granting Server (TGS)	It is meant for issuing subsequent service tickets based on the initial TGT.

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Let us summarize the topics covered in this lesson:

- Hive is a data warehouse system facilitating the analysis of large data sets in Hadoop.

- HBase is a distributed column-oriented database built on top of HDFS.

- Cloudera offers the user-friendly Cloudera Manager for system management.

- Hortonworks Data Platform, MapR data platform, and Pivotal HD are some of the commercial distributions of Hadoop.

- Some of the components of the Hadoop ecosystem are Oozie, Cassandra, and Spark.