Big data: architectures and data analytics

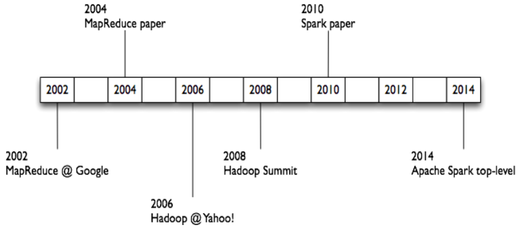
Introduction to Spark

Spark

- Apache Spark™ is a fast and general-purpose engine for large-scale data processing
- Spark aims at achieving the following goals in the Big data context
  - Generality: diverse workloads, operators, job sizes
  - Low latency: sub-second
  - Fault tolerance: faults are the norm, not the exception
  - Simplicity: often comes from generality

Spark History

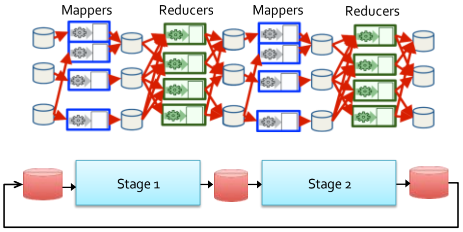
- Originally developed at the University of California - Berkeley's AMPLab



Spark: Motivations

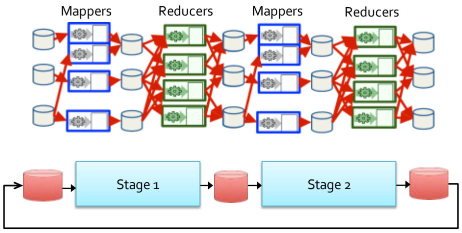
MapReduce and Iterative Jobs

- Iterative jobs, with MapReduce, involve a lot of disk I/O for each iteration and stage



MapReduce and Iterative Jobs

- Disk I/O is very slow (even if it is local I/O)

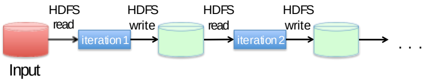


Apache Spark: Motivation and Opportunity

- Motivation
  - Using MapReduce for complex iterative jobs or multiple jobs on the same data involves lots of disk I/O
- Opportunity
  - The cost of main memory decreased
    - Hence, large main memories are available in each server
- Solution
  - Keep more data in main memory
    - Basic idea of Spark

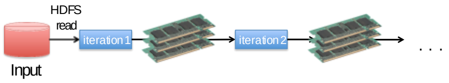
From MapReduce to Spark

- MapReduce: Iterative job



From MapReduce to Spark

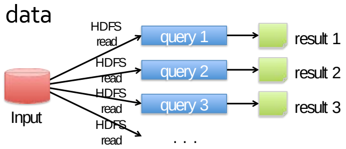
- Spark: Iterative job



- Data are shared between the iterations by using the main memory
  - Or at least part of them
- 10 to 100 times faster than disk

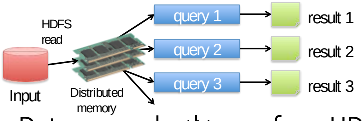
From MapReduce to Spark

- MapReduce: Multiple analyses of the same data



From MapReduce to Spark

- Spark: Multiple analyses of the same data



- Data are read only once from HDFS and stored in main memory
  - Split of the data across the main memory of each server

Spark: Resilient Distributed Data sets (RDDs)

- Data are represented as Resilient Distributed Datasets (RDDs)
  - Partitioned/Distributed collections of objects spread across the nodes of a clusters
  - Stored in main memory (when it is possible) or on local disk
- Spark programs are written in terms of operations on resilient distributed data sets

Spark: Resilient Distributed Data sets (RDDs)

- RDDs are built and manipulated through a set of parallel
  - Transformations
    - map, filter, join, …
  - Actions
    - count, collect, save, …
- RDDs are automatically rebuilt on machine failure

Spark Computing Framework

- Provides a programming abstraction (based on RDDs) and transparent mechanisms to execute code in parallel on RDDs
  - Hides complexities of fault-tolerance and slow machines
  - Manages scheduling and synchronization of the jobs

MapReduce vs Spark

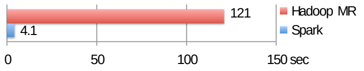
	Hadoop Map Reduce	Spark
Storage	Disk only	In-memory or on disk
Operations	Map and Reduce	Map, Reduce, Join, Sample, etc…
Execution model	Batch	Batch, interactive, streaming
Programming environments	Java	Scala, Java, Python, and R

MapReduce vs Spark

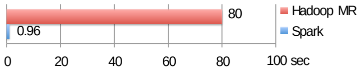
- Lower overhead for starting jobs
- Less expensive shuffles

In-Memory RDDs Can Make a Big Difference

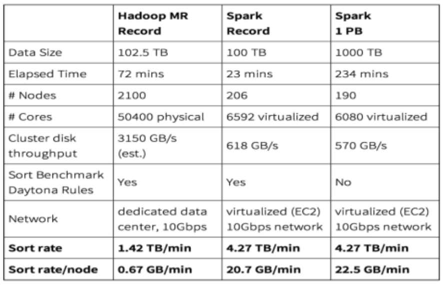
- Two iterative Machine Learning algorithms:
  - K-means Clustering



  - Logistic Regression



Petabyte Sort Challenge

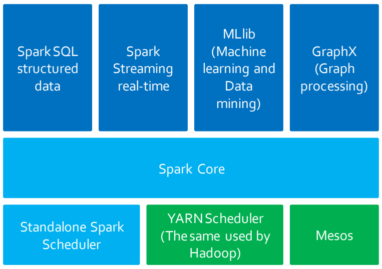


	Hadoop MR Record	Spark Record	Spark 1 PB
Data Size	102.5 TB	100 TB	1000 TB
Elapsed Time	72 mins	23 mins	234 mins
# Nodes	2100	206	190
# Cores	50400 physical	6592 virtualized	6080 virtualized
Cluster disk throughput	3150 GB/s (est.)	618 GB/s	570 GB/s
Sort Benchmark Daytona Rules	Yes	Yes	No
Network	dedicated data center, 10Gbps	virtualized (EC2) 10Gbps network	virtualized (EC2) 10Gbps network
Sort rate	**1.42 TB/min**	**4.27 TB/min**	**4.27 TB/min**
Sort rate/node	**0.67 GB/min**	**20.7 GB/min**	**22.5 GB/min**

Daytona Gray 100 TB sort benchmark record (tied for 1st place)

Spark: Main components

Spark Components


Spark SQL structured data
Spark Streaming real-time
MLlib (Machine learning and Data mining)
GraphX (Graph processing)
Spark Core
Standalone Spark Scheduler
YARN Scheduler (The same used by Hadoop)
Mesos

Spark Components

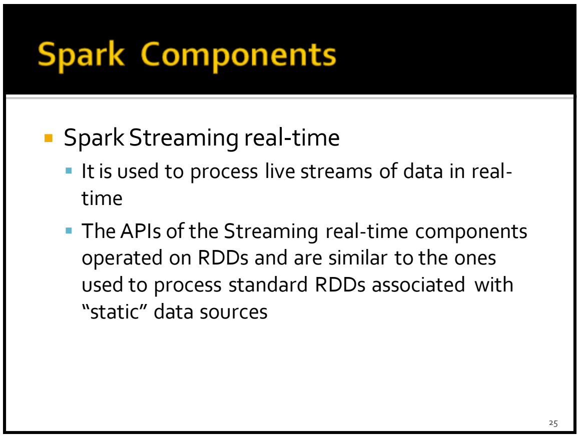
- Spark is based on a basic component (the Spark Core component) that is exploited by all the high-level data analytics components
  - This solution provides a more uniform and efficient solution with respect to Hadoop where many non-integrated tools are available
- When the efficiency of the core component is increased also the efficiency of the other high-level components increases

Spark Components

- Spark Core
  - Contains the basic functionalities of Spark exploited by all components
    - Task scheduling
    - Memory management
    - Fault recovery
    - …
  - Provides the APIs that are used to create RDDs and applies transformations and actions on them

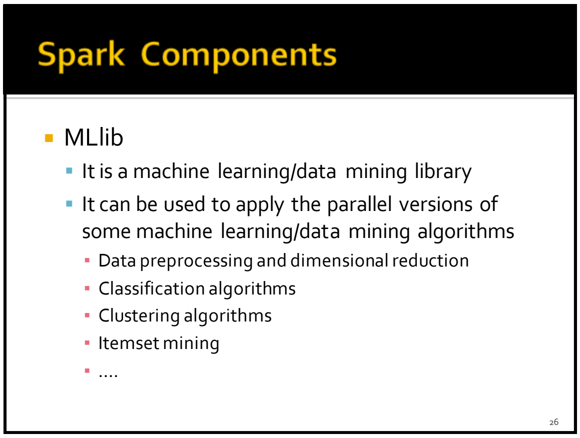
Spark Components

- Spark SQL structured data
  - This component is used to interact with structured datasets by means of the SQL language
  - It supports also
    - Hive Query Language (HQL)
  - It interacts with many data sources
    - Hive Tables
    - Parquet
    - JSON



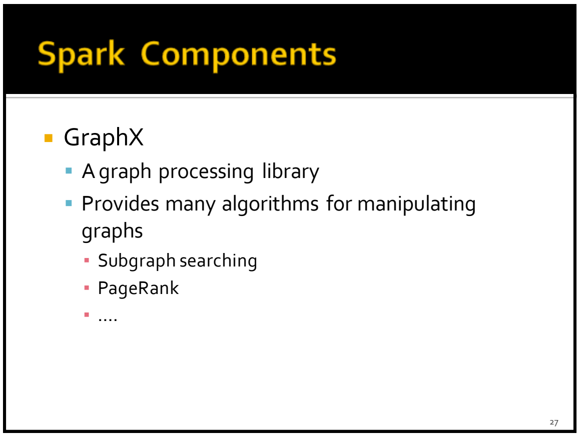
Spark Components

- Spark Streaming real-time
  - It is used to process live streams of data in real-time
  - The APIs of the Streaming real-time components operated on RDDs and are similar to the ones used to process standard RDDs associated with "static" data sources



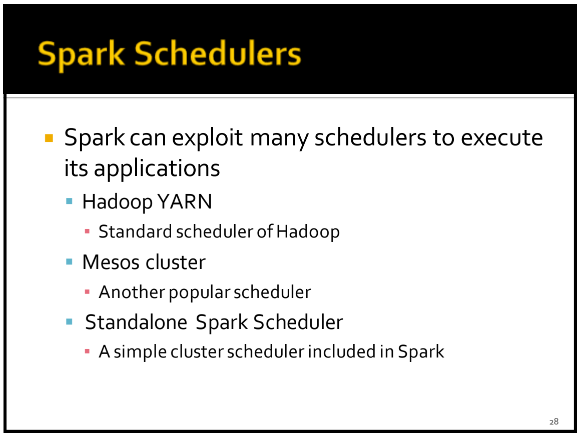
Spark Components

- MLlib
  - It is a machine learning/data mining library
  - It can be used to apply the parallel versions of some machine learning/data mining algorithms
    - Data preprocessing and dimensional reduction
    - Classification algorithms
    - Clustering algorithms
    - Itemset mining
    - ....



Spark Components

- GraphX
  - A graph processing library
  - Provides many algorithms for manipulating graphs
    - Subgraph searching
    - PageRank
    - ....



Spark Schedulers

- Spark can exploit many schedulers to execute its applications
  - Hadoop YARN
    - Standard scheduler of Hadoop
  - Mesos cluster
    - Another popular scheduler
  - Standalone Spark Scheduler
    - A simple cluster scheduler included in Spark