Hands-on Introduction to Apache Hadoop and Spark

Douglas Eadline

(Part 1)

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Presenter

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- HPC/Hadoop Consultant/Writer/Educator
- Teach several graduate courses as part of Masters in Data Science

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Outline Day 1

- **Segment 1:** Introduction and Quick Overview of Hadoop, Spark, Kafka (45 mins)
- **Segment 2:** Installing and Running the Linux Hadoop Minimal Virtual Machine (20 mins)
- **Segment 3:** Using the Hadoop Distributed File System (HDFS) (25 mins)
- Break 10 minutes
- **Segment 4:** Running and Monitoring Hadoop Applications (40 mins)
- **Segment 5:** Running Apache Sqoop (40 mins)

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Outline Day 2

- **Segment 6:** Using Apache Hive (30 mins)
- **Segment 7:** Running Apache Spark (50 mins)
- Break: 10 minutes
- **Segment 8:** Running Apache Kafka (50 mins)
- **Segment 9:** Introduction and Example Analytics Application using Apache Zeppelin (30 mins)
- **Segment 10:** Wrap-up/ Resources/Where to Go Next (10 mins)

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Recommended Approach To Class

- Course covers a lot of material!
- Designed to get you started (“hello.c” approach)
- Sit back and watch the examples
- All examples are provided in a notes file
- I will refer to file throughout the class (cut and paste)
- The notes files are available for download along with some help on installing software (URL on class web page) https://www.clustermonkey.net/scalable-analytics/doku.php

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User Programming Environment

There are four options (URLs provided at end of course):

1. Use the Linux Hadoop Minimal Sandbox virtual machine that can run under VirtualBox or VMWare.
2. Use the Hortonworks Sandbox, a full featured Hadoop/Spark virtual machine that runs under Docker, VirtualBox, or VMWare.
3. Install software from Apache.org (instructions provided) Best for Linux machines/laptops
4. Use a resource available to you: local cluster/cloud

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Courses In Scalable Data Pipelines

1. Apache Hadoop, Spark, and Kafka Foundations (3 hours-1 day)
2. Bash Programming Quick-start for Data Science (4 hours-1 day)
3. **Hands-on Introduction to Apache Hadoop, Spark, and Kafka Programming (6 hours-2 days)**
4. Getting Started with Apache Kafka (4 hours-1 day)
5. Kafka Methods and Administration in Practice (4 hours-1 day)

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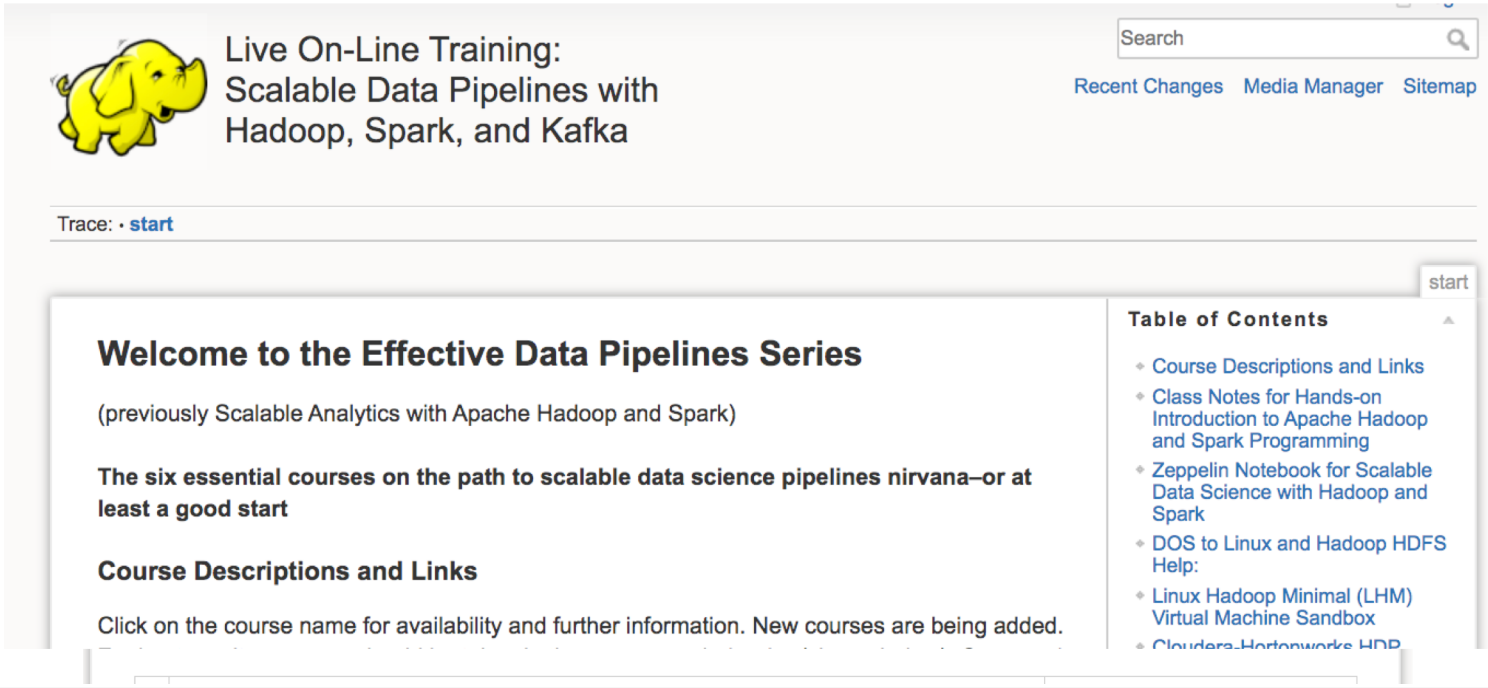
Course Webpage

https://www.clustermonkey.net/scalable-analytics



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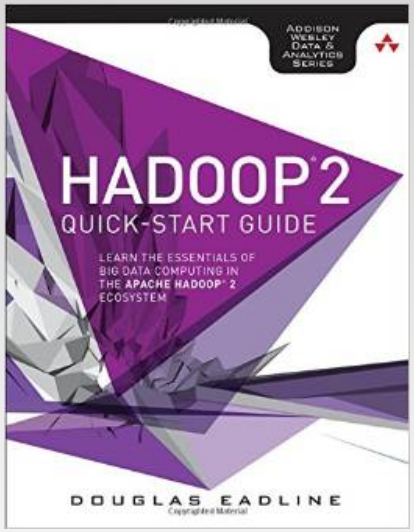
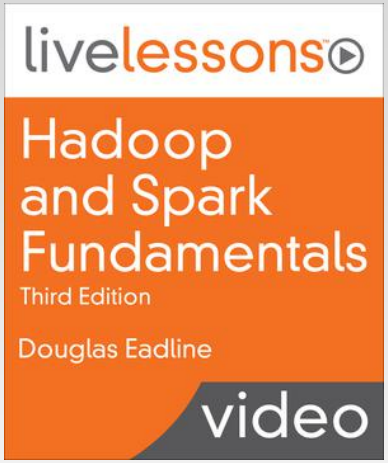
Supporting Materials

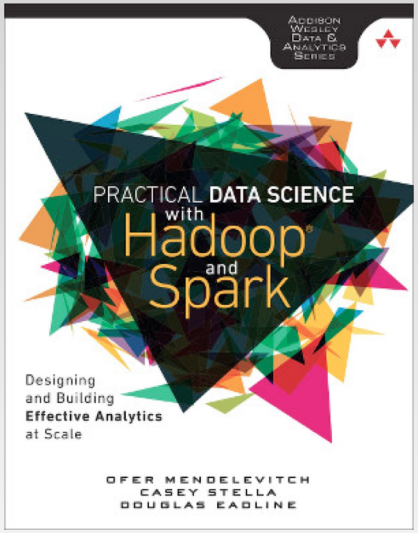
Hadoop 2 Quick-Start

Hadoop Fundamentals (Video Course)

Practical Data Science with Hadoop and Spark







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Cluster Used for Class

Limulus™ Desk-side Hadoop/Spark Cluster

- Up to 64 physical fast cores (+64 hyper-threads) on 8 motherboards
- Up to 512 GBytes of Memory
- Up to 64 TB of SSD Hadoop HDFS storage
- Up to 112 TB of central HDD (RAID 6) storage
- Full internal 25 GbE Ethernet networking
- Residential/office/classroom power
- Cool and quiet operation
- Turn-key ready to run Linux appliance fully installed HPC and Hadoop/Spark

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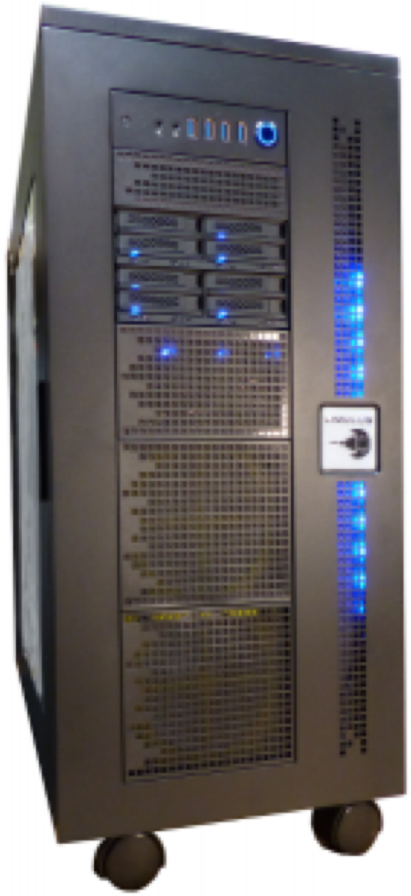

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Segment 1

Quick Overview of Hadoop and Spark

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Big Data Analytics

- Three V's (Volume, Velocity, Variability)
- Data that are large (lake), growing fast (waterfall), unstructured (recreation) - not all may apply.
- May not fit in a "relational model and method"
- Can Include: video, audio, photos, system/web logs, click trails, IoT, text messages/email/tweets, documents, books, research data, stock transactions, customer data, public records, human genome, and many others.

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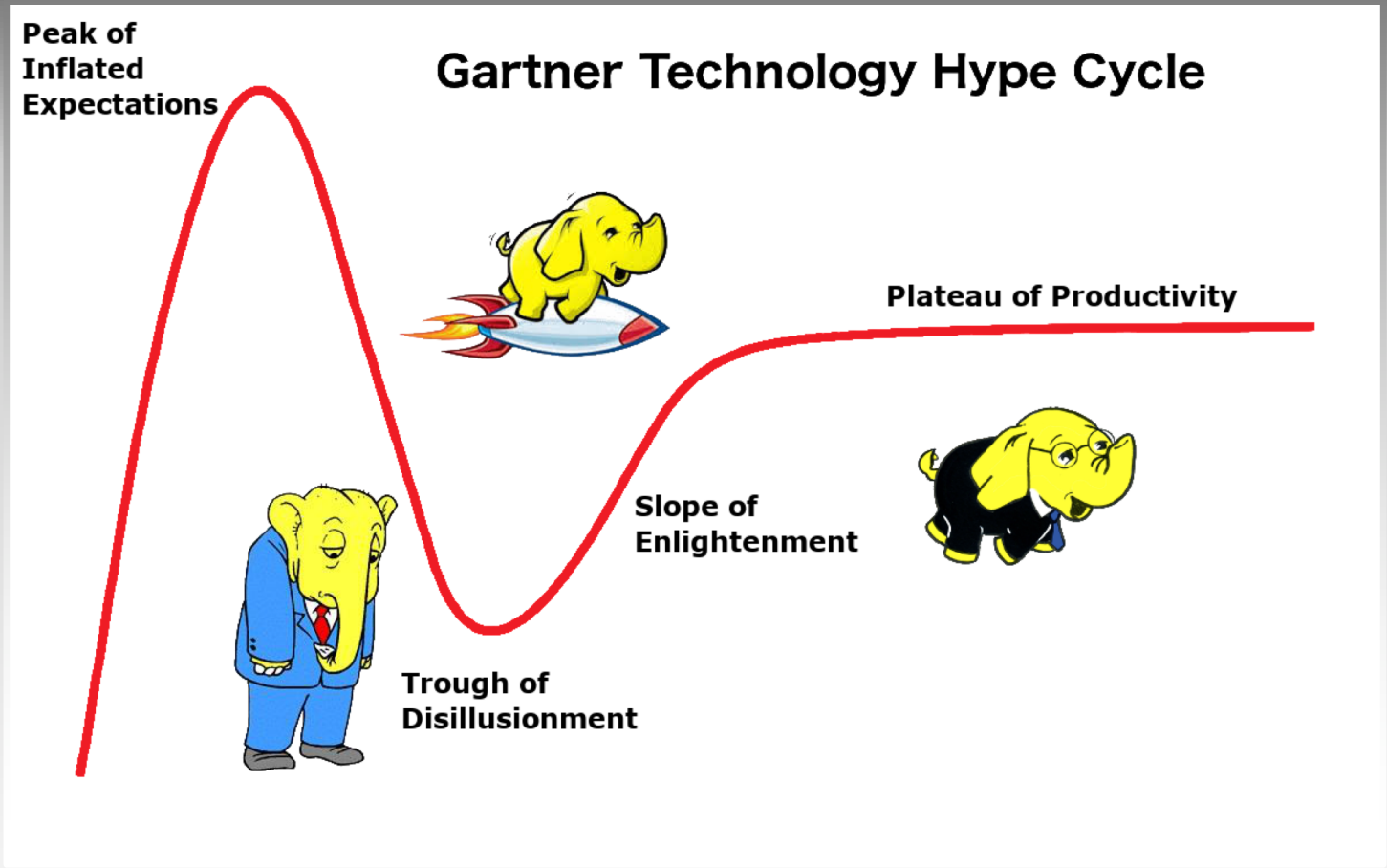
Is Hadoop Going Away ? (No)



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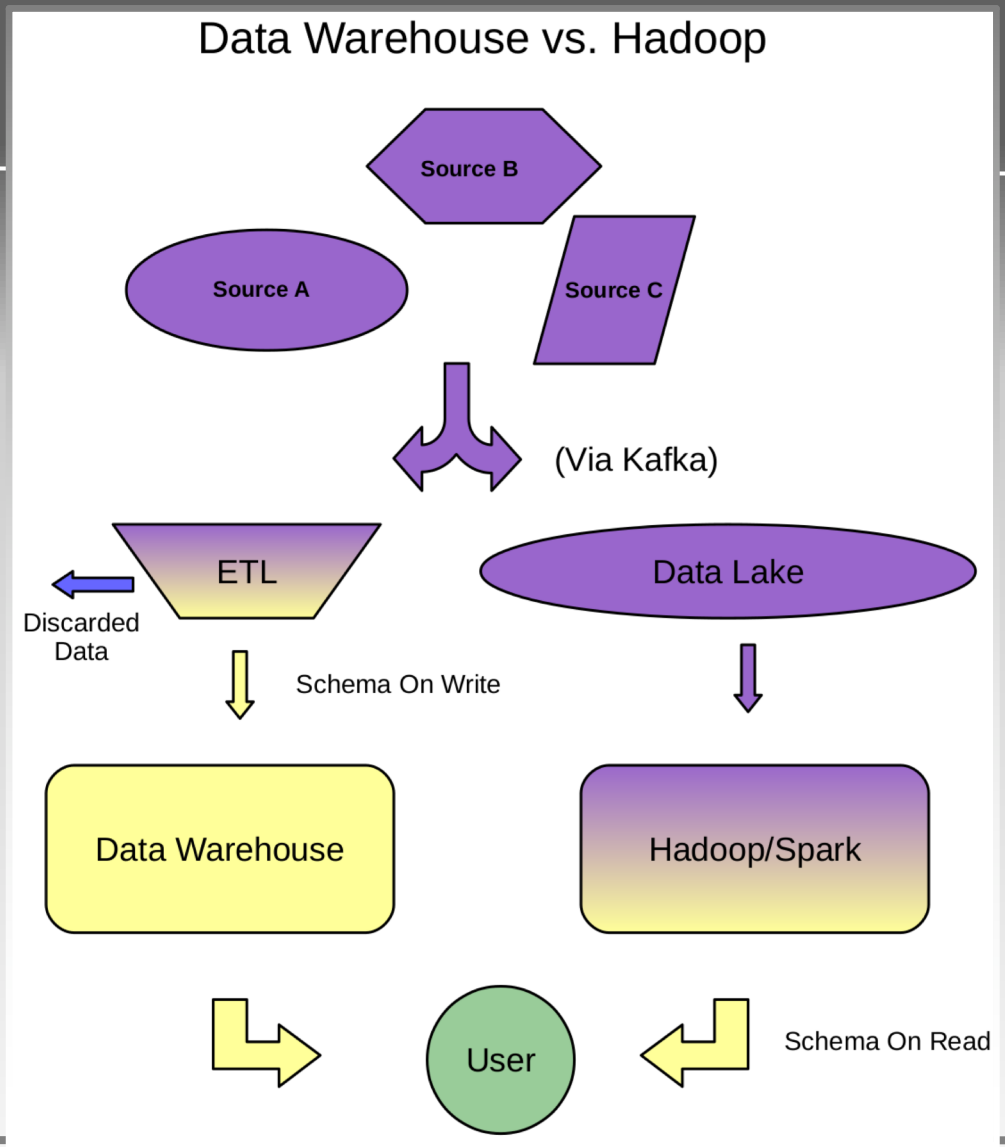
Hadoop Data Lake

Data Warehouse applies "schema on write" and has an Extract, Transform, and Load (ETL) step.

Hadoop/Spark applies "schema on read" and the ETL step is part of processing. All input data are placed in the lake in raw form.



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Defining Hadoop (Version 2+)

A PLATFORM for data lake analysis that supports software tools, libraries, and methodologies

- Core and most tools are open source (Apache License)
- Written in Java, but not exclusively a Java platform
- Primarily GNU/Linux, Windows versions available
- Scalable from single server to thousands of machines
- Runs on commodity hardware and in the cloud
- Application level fault tolerance possible
- Multiple processing models and libraries (Frameworks)
- Current Version is 3.x

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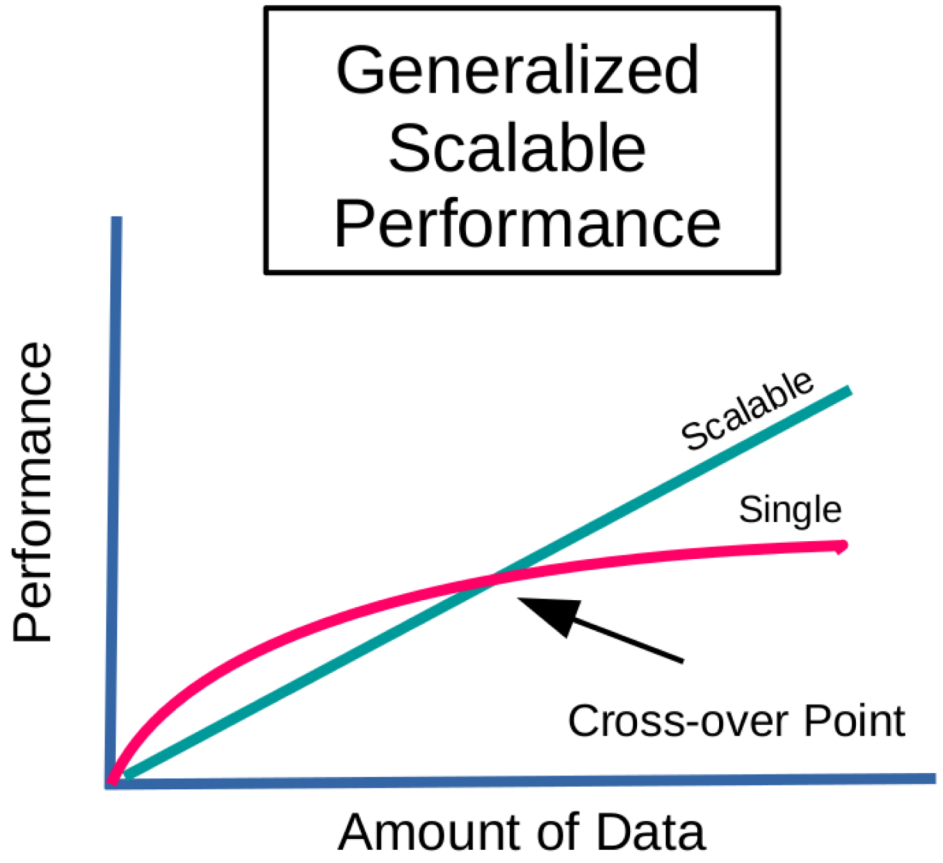
Scalable Behavior

Scalable Systems

The ability to apply resources (servers, VM Instances) to a problem as a means to increase performance (green line) over single server (red line)

But, initially performance may lag due to overhead



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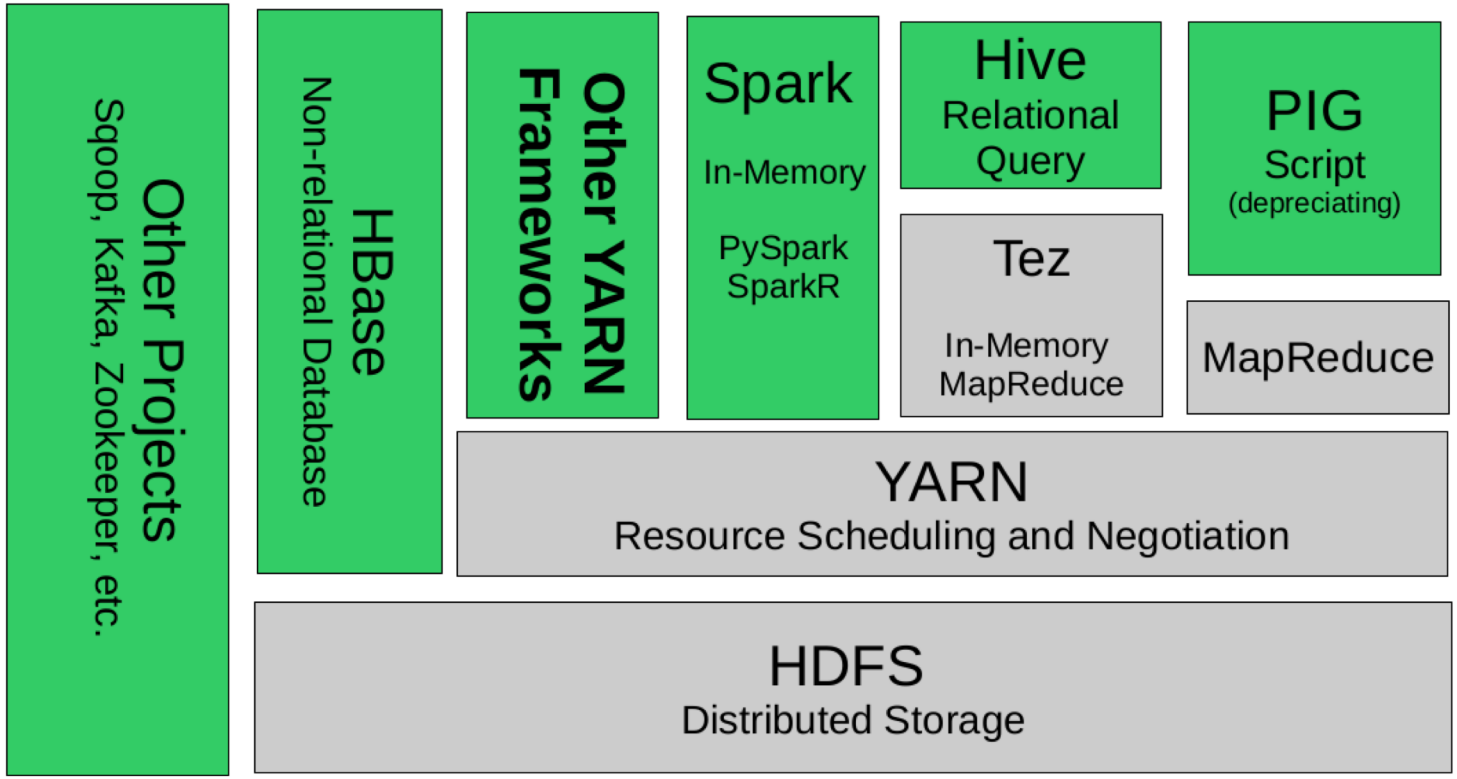
Hadoop Components



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Hadoop Core Components

- **HDFS – Hadoop Distributed File System.** Designed to be a fault tolerant streaming file system. Default block size is 64 MB vs. 4 KB for Linux ext4. Runs on commodity servers, director "NameNode" and multiple "DataNodes." Data are replicated on multiple servers.
- **YARN – Yet Another Resource Negotiator.** Master scheduler and resource allocator for the entire Hadoop cluster. User jobs ask YARN for resources (containers) and data locality. Provides dynamic resource allocation(run-time). Runs on commodity servers, master "ResouceManager" and multiple "NodeManagers."
- **MapReduce/Tez – YARN Application.** Provides classic MapReduce and optimized MapReduce processing.
- **Cluster servers (nodes) are usually both DataNodes and NodeManagers (Hyperconverged) Move processing to data.**

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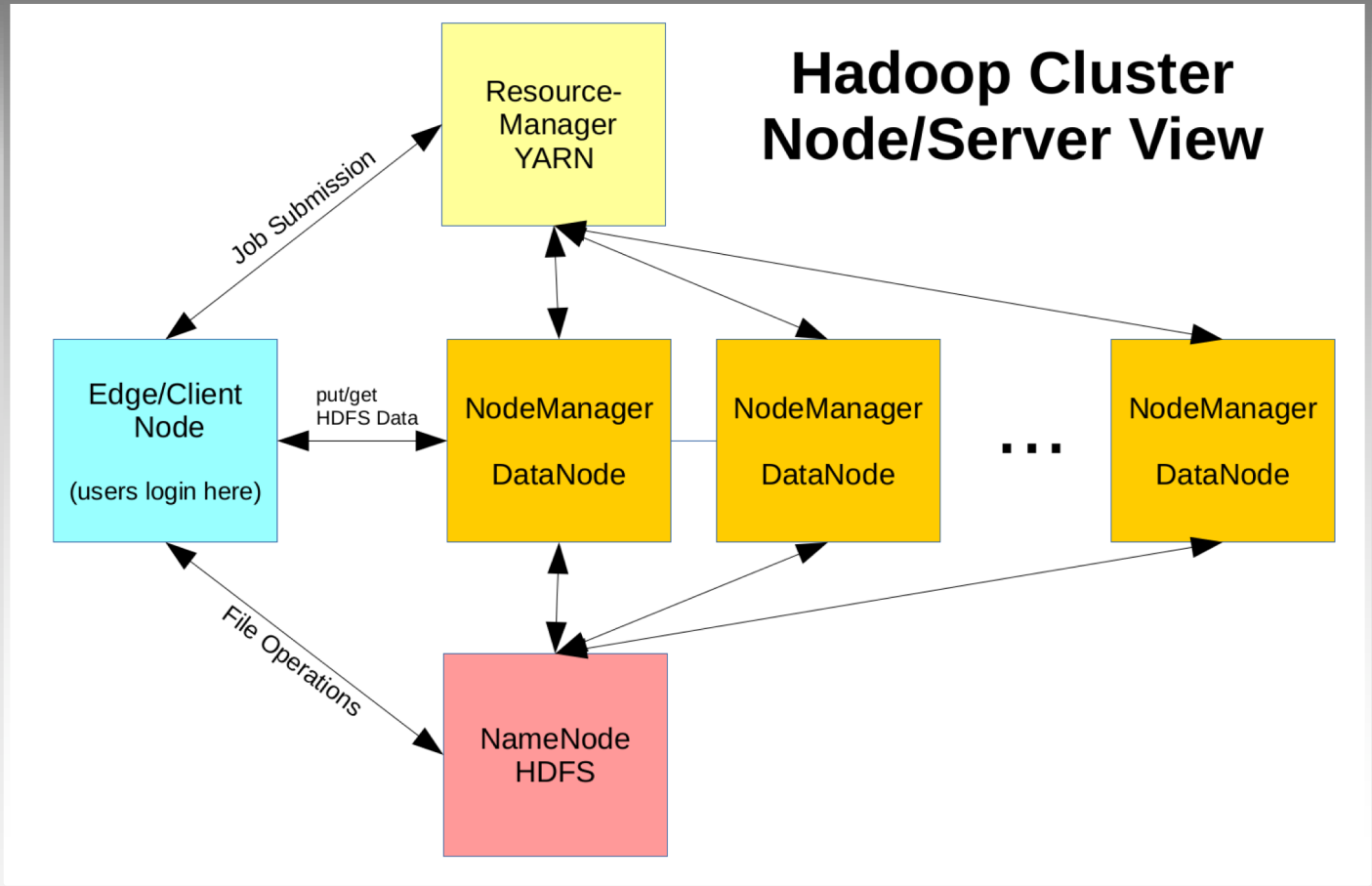
Hadoop Core Components Node View



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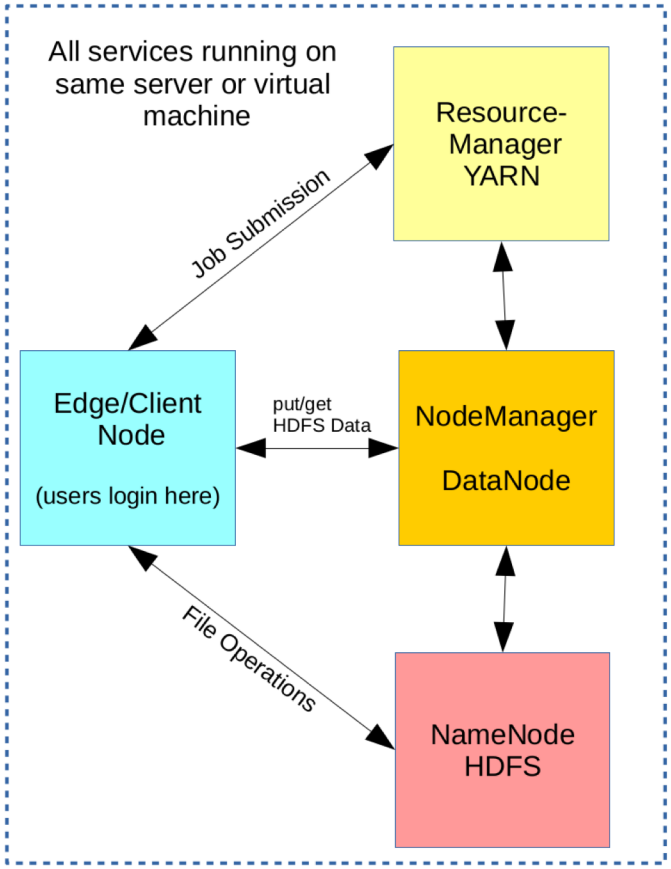
Hadoop Core Components on Single Node

Hadoop Single Node/Server View

(Linux Hadoop Minimal Virtual Machine)



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Apache Components We Will Use

- **Apache Sqoop** is a tool for transferring bulk data between Hadoop and relational databases.
- **Apache Hive** is an SQL compatible language for data summarization, ad-hoc queries, and the analysis of large datasets
- **Apache Spark** is an easy to use language for writing analytics applications that includes MapReduce, SQL queries and other tools.
- **Apache Kafka** Kafka is a high throughput, scalable, service that records all kinds of data in real-time (a message broker)
- **Apache Zeppelin** is web-GUI front end for creating data analytics applications

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Questions ?

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Segment 2

The Linux Hadoop Minimal VM

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LHM: Your Personal Linux Server

- Use a virtual machine (VM) to create a real Linux environment.
- Run on Laptop or Desktop with Virtual Box
- The Linux Hadoop Minimal VM is designed to be a small, single server Hadoop/Spark system (used in other courses)
- An x86_64 based Notebook or Laptop with at least 4 cores/threads, 4 GB of Memory, 70 GB of disk space.
- Linux CentOS 7 (Red Hat rebuild) image
- Walks and talks like a separate computer

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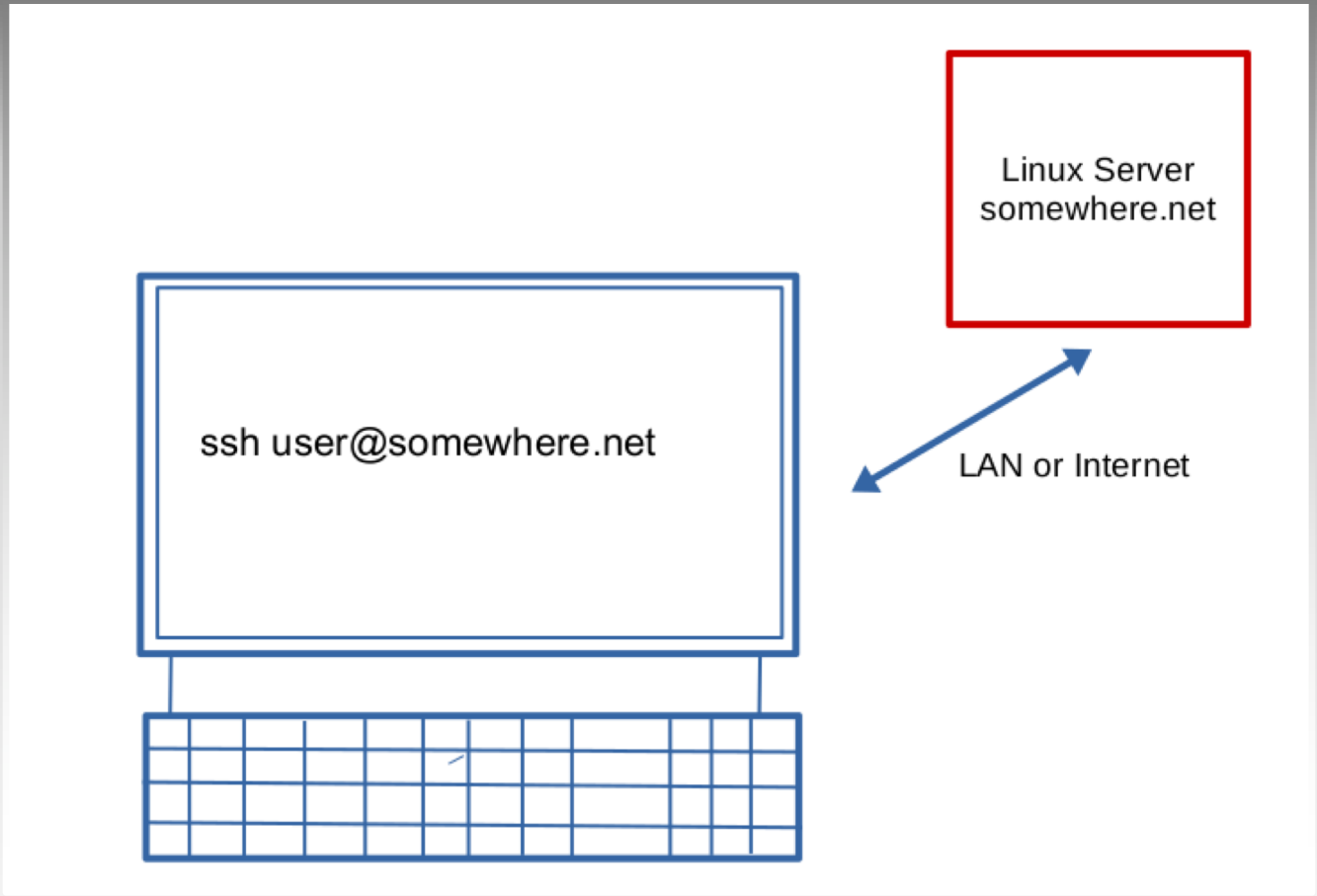
ssh Out to LAN/Internet



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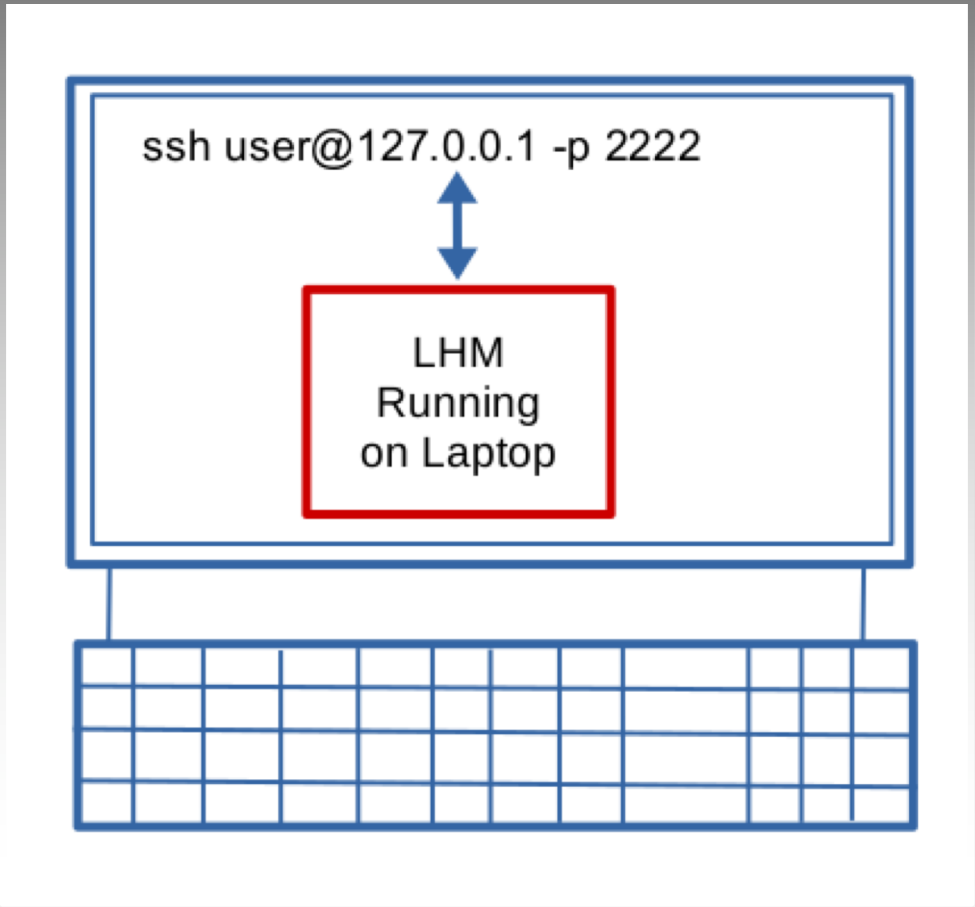
Connect to the LHM



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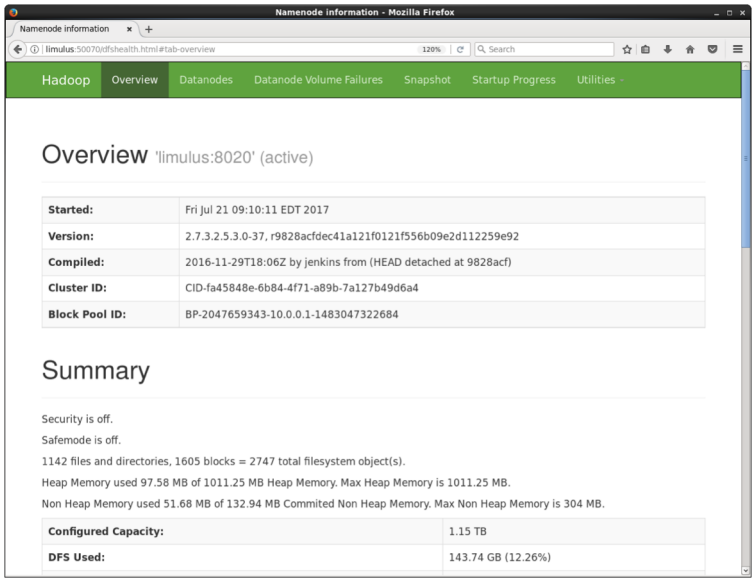
Segment 3

Using the Hadoop Distributed File System



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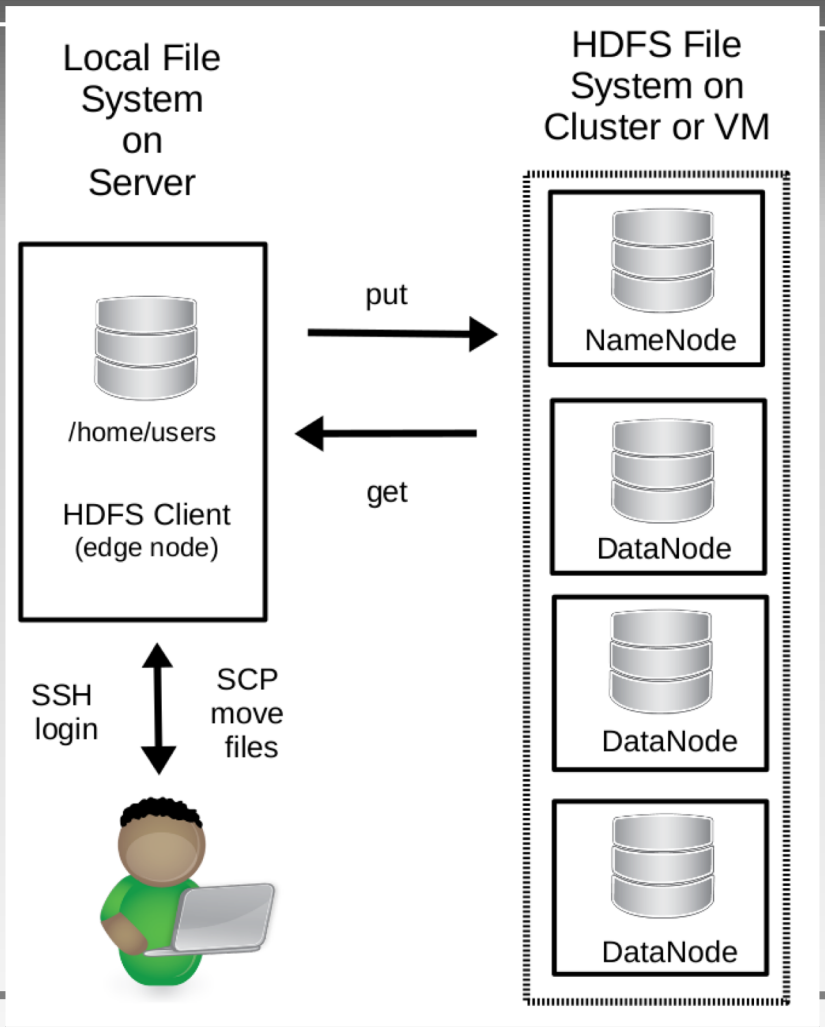
How the User "Sees" HDFS

- HDFS is a separate file system from the host server
- Data must be moved to server (from user source or another server/web)
- Data must be moved to HDFS using `put` and `get` commands
- All Hadoop processing happens in HDFS



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HDFS Notes

1. All user HDFS commands start with `"hdfs dfs"` because it operates a separate file system.
2. User ***hdfs*** is "root" for HDFS. Only user ***hdfs*** can perform certain administrative tasks.
3. Data files are sliced and distributed over HDFS DataNodes (default set by admin or user can override) and **data splits** are defined programmatically.

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Questions ?

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10 Minute BREAK

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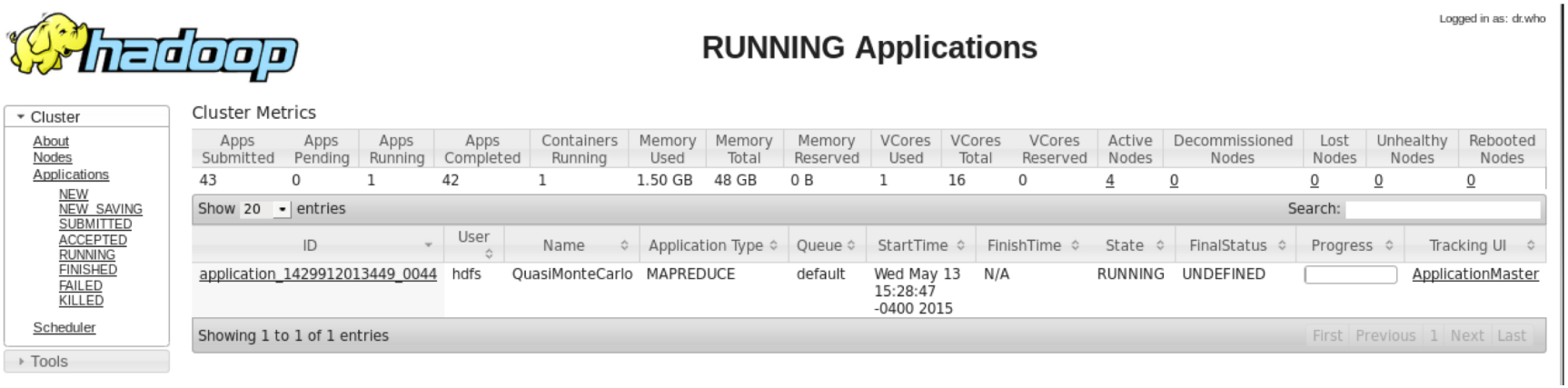
Segment 4

Running and Monitoring Hadoop Applications



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What Is Map-Reduce?

Map Reduce Is a Simple Algorithm

(and can run in parallel due to no side-effects)

- Distinct steps and one-way communication
- Map then Reduce
- Uses (key, value) pair
- Hadoop Map-Reduce used in Pig and Hive
- Spark uses it own Map-Reduce library
- Works great in many cases (even for some HPC applications), but it is not the only algorithm for parallel computing.

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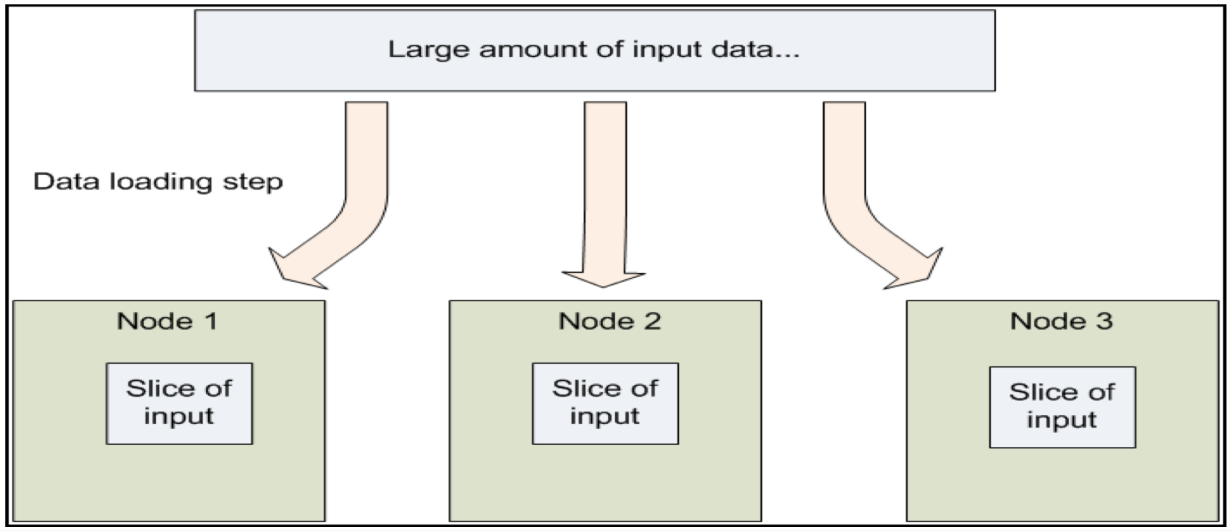
Hadoop MapReduce Big Picture

1. When data are moved into HDFS files are sliced and placed on different servers (nodes).
2. Queries are applied (mapped) to each distributed data set defined by "data splits"
3. Then, if needed, results are reduced to single single answer



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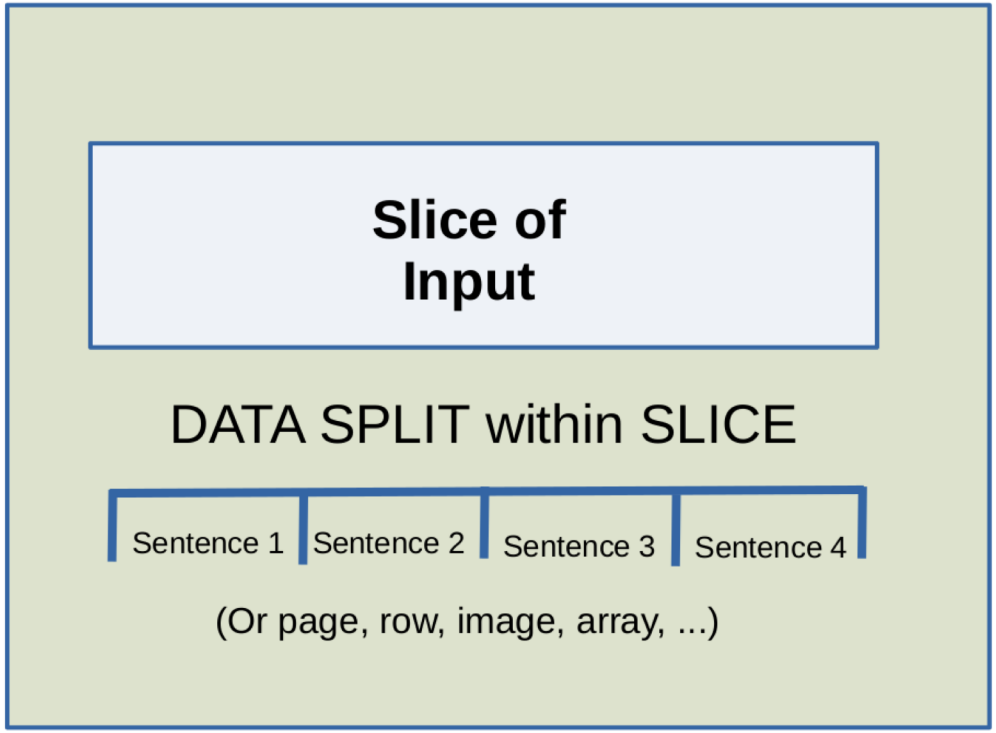
Slices and Splits

Each Slice will have programmatically defined data splits



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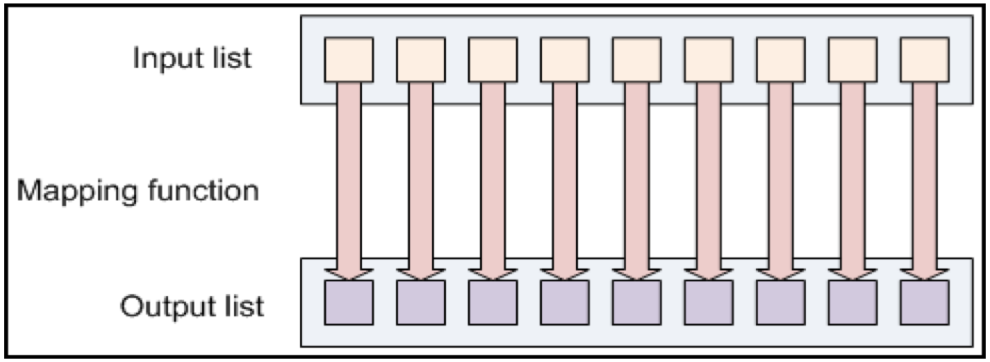
Scalable Mapping Step

1. Slice data into parts.
2. Apply the same **Mapping** function to Input List (user defined splits)



3. Each step provides a separate set of results (Output list).

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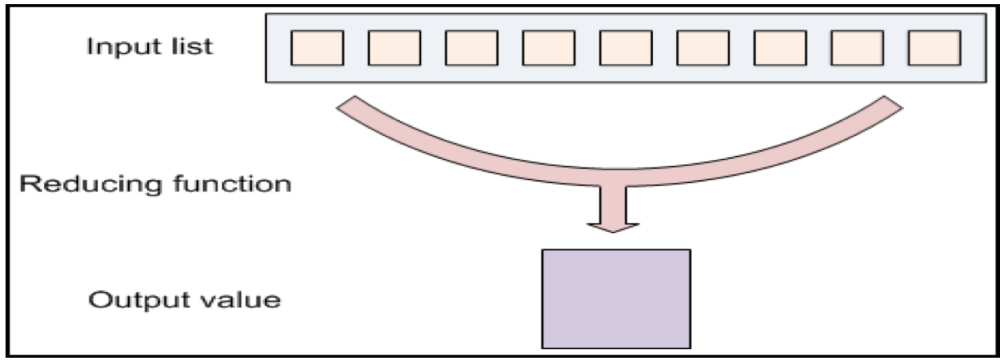
Reduction Step

- Results from each **map** (as applied to each split) are combined and **reduced** to a single Output value.



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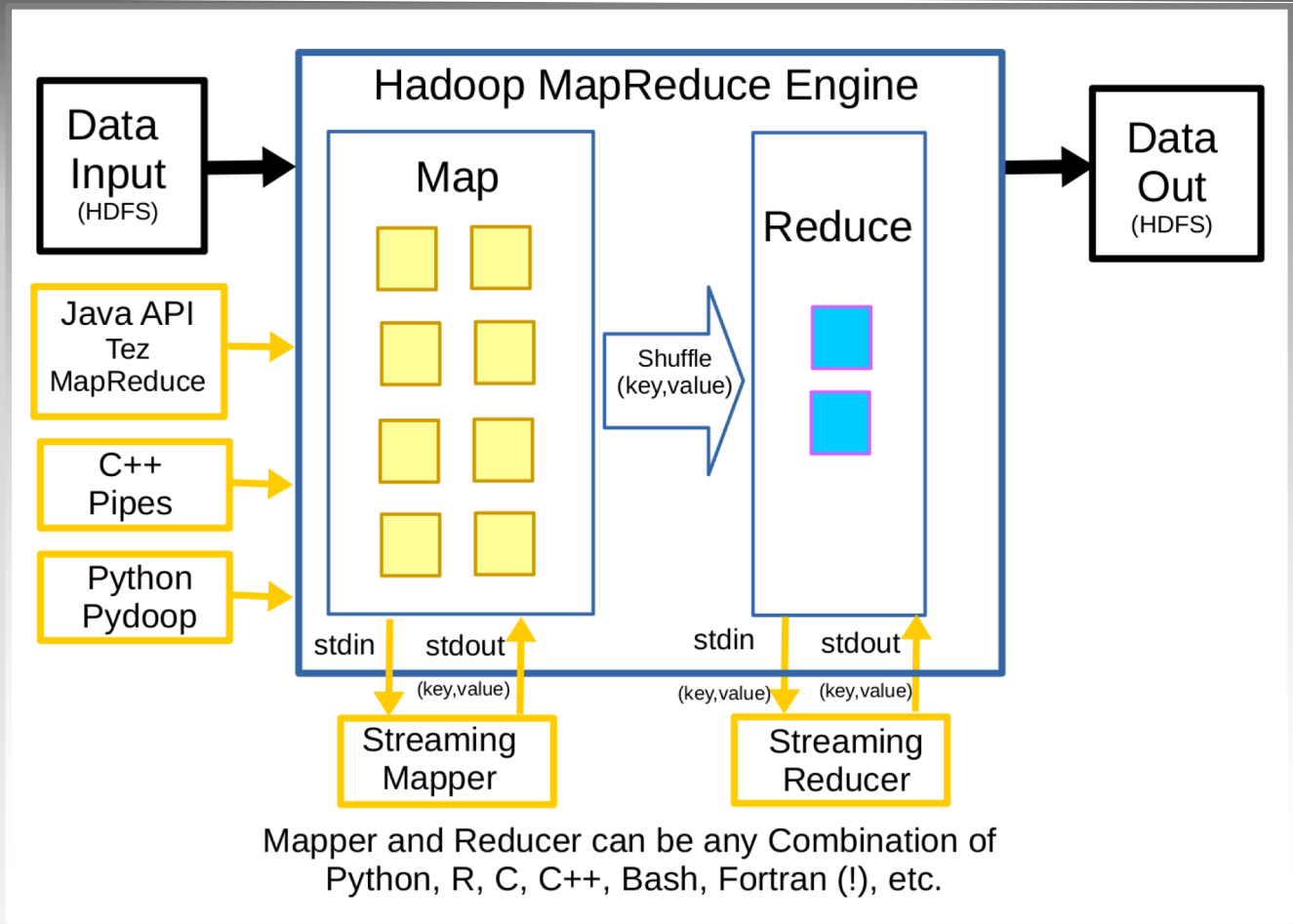
Programming Hadoop MapReduce



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Questions ?

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Segment 7

Running Apache Sqoop

http://sqoop.apache.org

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Apache Sqoop Background

Sqoop is a tool designed to transfer data between Hadoop and relational databases or mainframes. You can use Sqoop to import data from a relational database management system (RDBMS) such as MySQL or Oracle or a mainframe into the Hadoop Distributed File System (HDFS), transform the data in Hadoop MapReduce, and then export the data back into an RDBMS.

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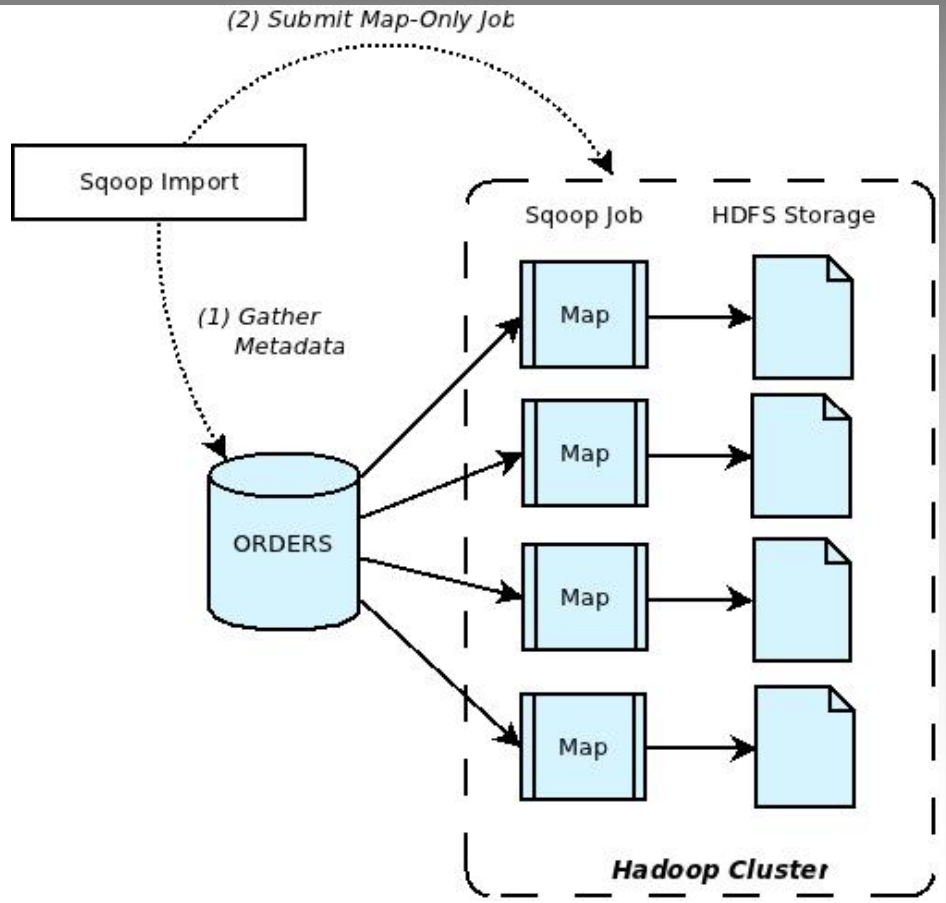
Sqoop Data Import

- Sqoop works with local RDBMS
- Sqoop gathers metadata about DB
- Can work sequentially or in parallel
- In parallel each map process contacts the RDBMS system and "pulls" it's slice of data



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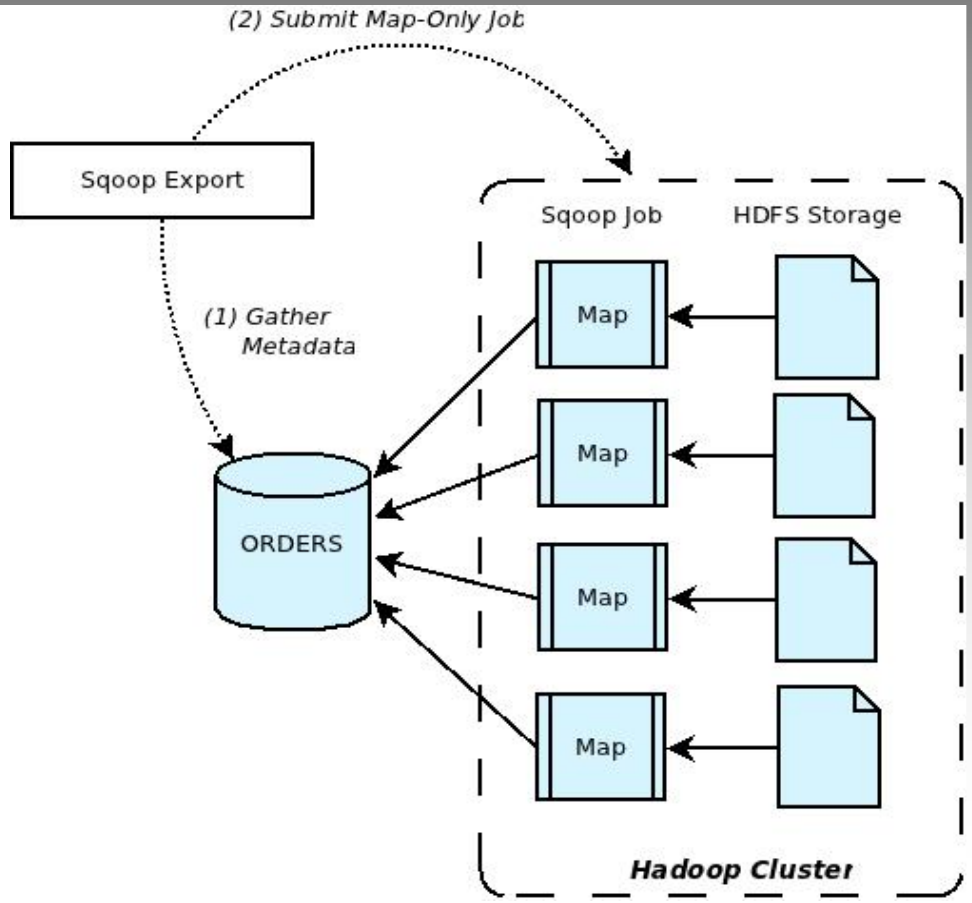
Sqoop Data Export

- Sqoop works with local RDBMS
- Sqoop gathers metadata about DB
- Can work sequentially or in parallel
- In parallel each map process contacts the RDBMS system and "pushes" it's slice of data



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Questions ?

Continue Tomorrow

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