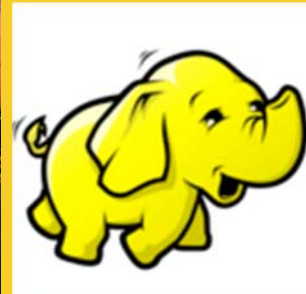
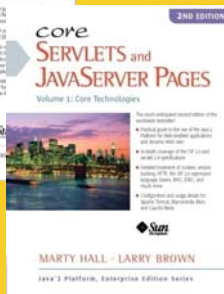
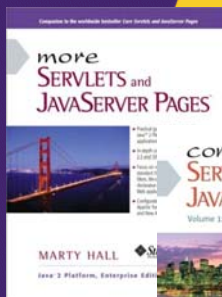




Map Reduce on YARN Overview

Originals of slides and source code for examples: <http://www.coreservlets.com/hadoop-tutorial/>
Also see the customized Hadoop training courses (onsite or at public venues) – <http://courses.coreservlets.com/hadoop-training.html>

Customized Java EE Training: <http://courses.coreservlets.com/>
Hadoop, Java, JSF 2, PrimeFaces, Servlets, JSP, Ajax, jQuery, Spring, Hibernate, RESTful Web Services, Android.
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For live customized Hadoop training (including prep for the Cloudera certification exam), please email info@coreservlets.com

Taught by recognized Hadoop expert who spoke on Hadoop several times at JavaOne, and who uses Hadoop daily in real-world apps. Available at public venues, or customized versions can be held on-site at your organization.

- Courses developed and taught by Marty Hall
 - JSF 2.2, PrimeFaces, servlets/JSP, Ajax, jQuery, Android development, Java 7 or 8 programming, custom mix of topics
 - Courses available in any state or country. Maryland/DC area companies can also choose afternoon/evening courses.
- Courses developed and taught by coreservlets.com experts (edited by Marty)
 - Spring, Hibernate/JPA, GWT, Hadoop, HTML5, RESTful Web Services

Contact info@coreservlets.com for details

Agenda

- **MapReduce Introduction**
- **MapReduce Model**
- **YARN and MapReduce 2.0 Daemons**
- **MapReduce on YARN single node installation**
- **MapReduce and YARN command line tools**

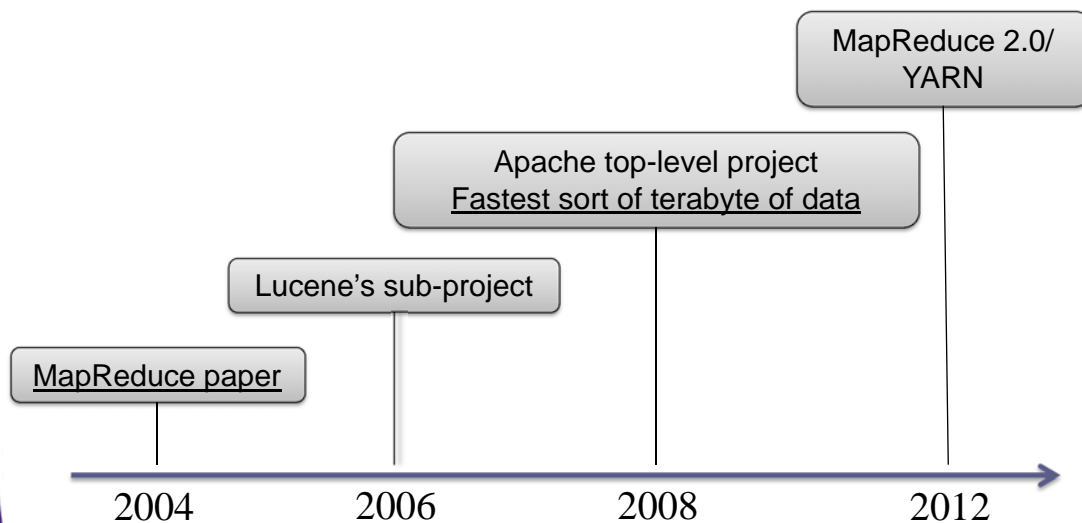
4

Hadoop MapReduce

- **Model for processing large amounts of data in parallel**
 - On commodity hardware cheap servers
 - Lots of nodes
- **Derived from functional programming**
 - Map and reduce functions
- **Can be implemented in multiple languages**
 - Java, C++, Ruby, Python (etc...)

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Hadoop MapReduce History



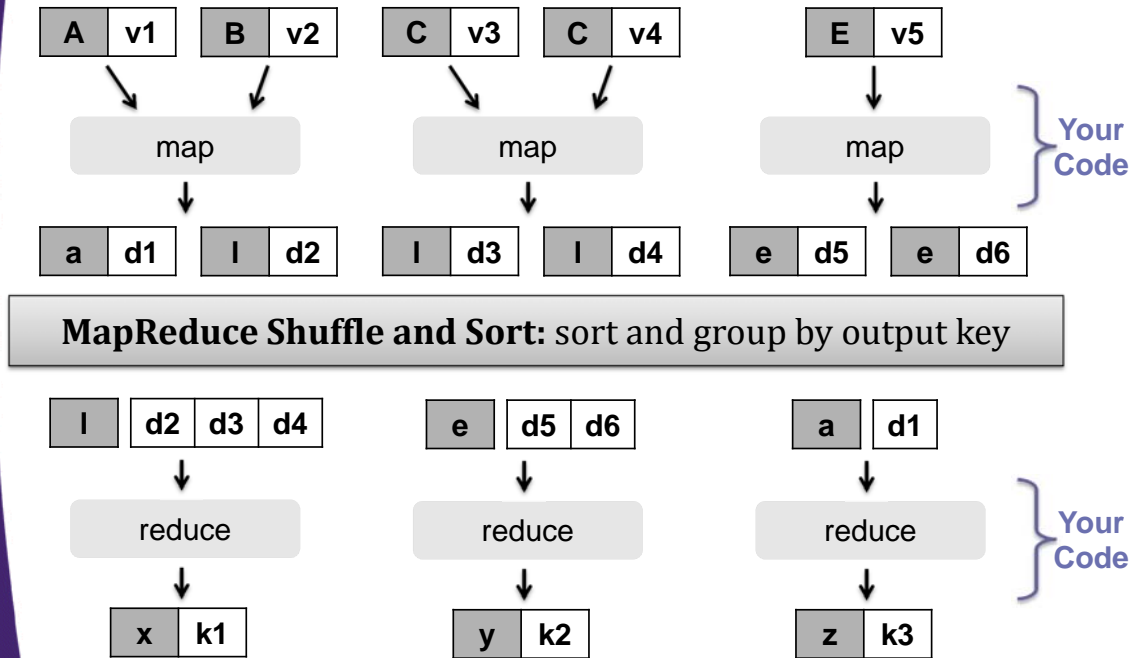
6

MapReduce Model

- **Imposes key-value input/output**
- **Defines map and reduce functions**
 $\text{map: } (K1, V1) \rightarrow \text{list } (K2, V2)$
 $\text{reduce: } (K2, \text{list}(V2)) \rightarrow \text{list } (K3, V3)$
 1. Map function is applied to every input key-value pair
 2. Map function generates intermediate key-value pairs
 3. Intermediate key-values are sorted and grouped by key
 4. Reduce is applied to sorted and grouped intermediate key-values
 5. Reduce emits result key-values

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MapReduce Model/Framework



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Source: Jimmy Lin, Chris Dyer. *Data-Intensive Text Processing with MapReduce*. Morgan & Claypool. 2010.

MapReduce Framework

- **Takes care of distributed processing and coordination**
- **Scheduling**
 - Jobs are broken down into smaller chunks called tasks. These tasks are scheduled
- **Task Localization with Data**
 - Framework strives to place tasks on the nodes that host the segment of data to be processed by that specific task
 - Code is moved to where the data is

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Source: Jimmy Lin, Chris Dyer. *Data-Intensive Text Processing with MapReduce*. Morgan & Claypool. 2010.

MapReduce Framework

- **Error Handling**
 - Failures are an expected behavior so tasks are automatically re-tried on other machines
- **Data Synchronization**
 - Shuffle and Sort barrier re-arranges and moves data between machines
 - Input and output are coordinated by the framework

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Map Reduce 2.0 on YARN

- **Yet Another Resource Negotiator (YARN)**
- **Various applications can run on YARN**
 - MapReduce is just one choice (the main choice at this point)
 - <http://wiki.apache.org/hadoop/PoweredByYarn>
- **YARN was designed to address issues with MapReduce1**
 - Scalability issues (max ~4,000 machines)
 - Inflexible Resource Management
 - MapReduce1 had slot based model

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MapReduce1 vs. YARN

- **MapReduce1 runs on top of JobTracker and TaskTracker daemons**
 - JobTracker schedules tasks, matches task with TaskTrackers
 - JobTracker manages MapReduce Jobs, monitors progress
 - JobTracker recovers from errors, restarts failed and slow tasks
- **MapReduce1 has inflexible slot-based memory management model**
 - Each TaskTracker is configured at start-up to have N slots
 - A task is executed in a single slot
 - Slots are configured with maximum memory on cluster start-up
 - The model is likely to cause over and under utilization issues

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MapReduce1 vs. YARN

- **YARN addresses shortcomings of MapReduce1**
 - JobTracker is split into 2 daemons
 - ResourceManager - administers resources on the cluster
 - ApplicationMaster - manages applications such as MapReduce
 - Fine-Grained memory management model
 - ApplicationMaster requests resources by asking for “containers” with a certain memory limit (ex 2G)
 - YARN administers these containers and enforces memory usage
 - Each Application/Job has control of how much memory to request

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Daemons

- **YARN Daemons**

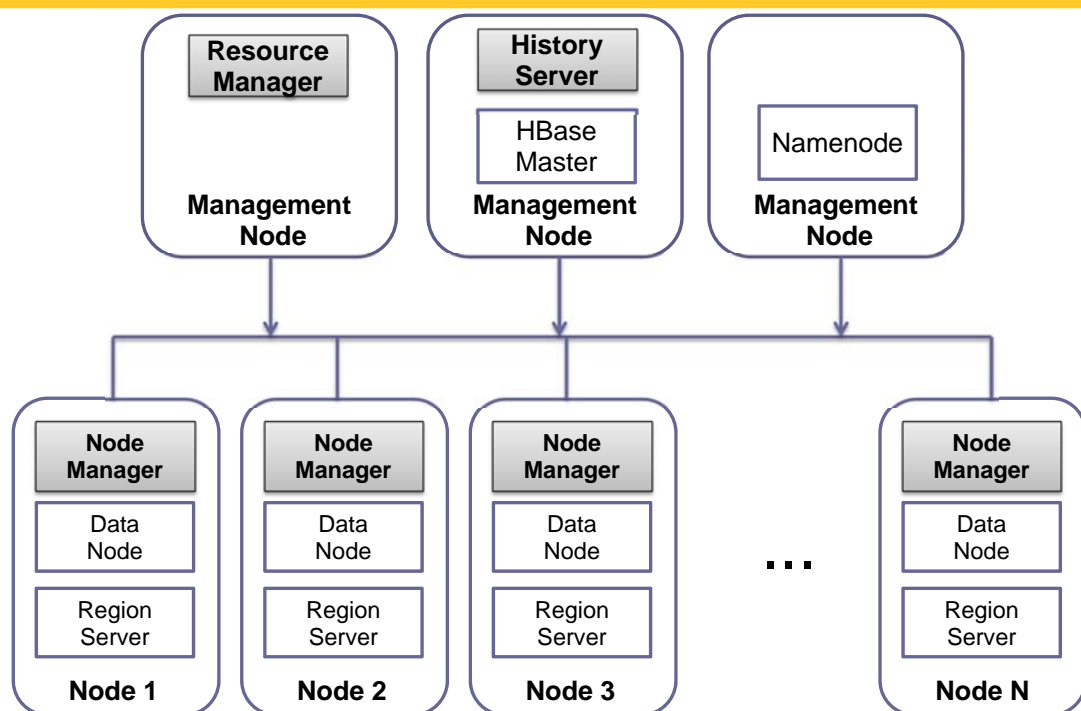
- Node Manager
 - Manages resources of a single node
 - There is one instance per node in the cluster
- Resource Manager
 - Manages Resources for a Cluster
 - Instructs Node Manager to allocate resources
 - Application negotiates for resources with Resource Manager
 - There is only one instance of Resource Manager

- **MapReduce Specific Daemon**

- MapReduce History Server
 - Archives Jobs' metrics and meta-data

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Sample YARN Daemons Deployments with HDFS and HBase



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Old vs. New Java API

- There are two flavors of MapReduce API which became known as Old and New
- Old API classes reside under
 - org.apache.hadoop.mapred
- New API classes can be found under
 - org.apache.hadoop.mapreduce
 - org.apache.hadoop.mapreduce.lib
- We will use new API exclusively
- New API was re-designed for easier evolution
- Early Hadoop versions deprecated old API but recently deprecation was removed
- Do not mix new and old API

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YARN with MapReduce 2.0 Installation

- **Single Node Installation**
 - Mimics Fully-Distributed Cluster but runs on just one host
 - Good for testing, debugging and prototyping
 - Not production use or performance benchmarking!
 - Used in this class
- **Cluster**
 - Run YARN on many nodes
 - Great for production and development clusters

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Set Up Pseudo-Distributed Mode

- 1. Verify Prerequisites**
 - Java, SSH, etc...
- 2. Configure YARN**
 - Settings inside of yarn-site.xml and yarn-env.sh
- 3. Configure MapReduce**
 - Settings inside of mapred-site.xml
- 4. Start YARN and MapReduce History Server**

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1: Verify Prerequisites

- **Java version 6+**
 - It is written in Java after all
 - Oracle JDK is the most popular
- **Linux is the only production platform**
- **Supports all other Operating Systems for development**
 - Windows, OS X
 - Cygwin is required for Windows development
- **Password-less SSH is setup**
 - Already had to do this for HDFS



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2: Configure YARN

- **Configuration Files are discovered by looking in the directory specified in YARN_CONF_DIR environment property**
 - `export YARN_CONF_DIR=$HADOOP_CONF_DIR`

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2: Configure YARN

Config File	Description
yarn-env.sh	A bash script where YARN environment variables are specified. For example, configure log directory here.
yarn-site.xml	Hadoop configuration file where majority of properties are specified for YARN daemons. Configures Resource Manager, Node Manager and History Server.
slaves	A list of nodes where Node Manager daemons are started; one host per line.
mapred-site.xml	MapReduce specific properties go here. This is the application specific configuration file; an application is MapReduce in this case.

Note: YARN will also utilize core-site.xml and hadoop-env.sh which were covered in HDFS lecture

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2: Configure YARN - yarn-env.sh

- **Bash Script executed by YARN start script**
- **Sets things like daemons'**
 - heap size
 - log location(s)
 - pid file locations
 - etc...

```
export YARN_LOG_DIR=/home/hadoop/Training/logs/yarn
export YARN_PID_DIR=$TRAINING_HOME/hadoop_work/pids
```

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2: Configure YARN - yarn-site.xml

- **Configure host and ports for daemons, data output locations, auxiliary services, security, etc....**
 - Configure hosts and ports for Resource Manager, Node Manager and MapReduce History Server
 - Configure local storage directories for Node Managers
 - Configure any application specific services

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2: Configure YARN - yarn-site.xml

```
<property>
  <name>yarn.resourcemanager.address</name>
  <value>localhost:10040</value>
  <description>In Server specified the port that Resource
Manager will run on. In client is used for connecting to
Resource Manager</description>
</property>

<property>
  <name>yarn.resourcemanager.resource-tracker.address</name>
  <value>localhost:8025</value>
  <description>Utilized by Node Manager for communication
with Resource Manager</description>
</property>
```

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2: Configure YARN - yarn-site.xml

```
<property>
  <name>yarn.resourcemanager.scheduler.address</name>
  <value>localhost:8030</value>
  <description>Utilized by Application Masters to
communicate with Resource Manager; in our case for
MRAppMaster (MapReduce Application Master) to communicate
with Resource Manager</description>
</property>

<property>
  <name>yarn.resourcemanager.admin.address</name>
  <value>localhost:8141</value>
  <description>Utilized by administrative clients ($yarn
radmin) to communicate with Resource Manager</description>
</property>
```

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2: Configure YARN - yarn-site.xml

```
<property>
  <name>yarn.nodemanager.local-dirs</name>
  <value>/home/hadoop/Training/hadoop_work/mapred/nodemanager</value>
  <final>true</final>
  <description>Comma separated list of directories, where
local data is persisted by Node Manager</description>
</property>

<property>
  <name>yarn.nodemanager.aux-services</name>
  <value>mapreduce.shuffle</value>
  <description>Long running service which executes on Node
Manager(s) and provides MapReduce Sort and Shuffle
functionality.</description>
</property>
```

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2: Configure YARN - yarn-site.xml

```
<property>
  <name>yarn.log-aggregation-enable</name>
  <value>true</value>
  <description>Enable log aggregation so application logs are
moved onto hdfs and are viewable via web UI after the
application completed. The default location on hdfs is '/log'
and can be changed via yarn.nodemanager.remote-app-log-dir
property</description>
</property>

<property>
  <name>hadoop.security.authorization</name>
  <value>>false</value>
  <description>Disable authorization for development and
clusters that do not require security</description>
</property>
```

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3: Configure MapReduce - mapred-site.xml

```
<configuration>
  <property>
    <name>mapreduce.cluster.temp.dir</name>
    <value>/home/hadoop/Training/hadoop_work/mapred/temp</value>
    <final>true</final>
  </property>

  <property>
    <name>mapreduce.cluster.local.dir</name>
    <value>/home/hadoop/Training/hadoop_work/mapred/local</value>
    <final>true</final>
  </property>

  <property>
    <name>mapreduce.framework.name</name>
    <value>yarn</value>
    <description>Use YARN as the servicer of MapReduce, if
not specified Local Job Runner is used</description>
  </property>
</configuration>
```

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4: Start YARN and MapReduce History Server

```
$ cd $HADOOP_HOME/sbin
$ ./start-yarn.sh
$ ./mr-jobhistory-daemon.sh start historyserver
```

- **start-yarn.sh script starts all the YARN related daemons on the cluster**
 - Resource Manager is started on the machine that start-yarn.sh script is executed on
 - Delegates to \$yarn-daemon.sh start resourcemanager
 - Node Manager is started for each machine specified in the <YARN_CONF_DIR>/slaves
 - Delegates to \$yarn-daemon.sh start nodemanager

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YARN Web-UI

- **Resource Manager Web-UI**
 - Cluster resource usage, job scheduling, and current running jobs
 - Runs on port 8088 by default
- **Application Proxy Web-UI**
 - Provides information about the current job
 - Runs as a part of Resource Manager Web-UI by default
 - After completion, jobs get exposed by History Server
- **Node Manager Web-UI**
 - Single Node information and current containers being executed
 - Runs on port 8042 by default
- **MapReduce History Server Web-UI**
 - Provides history and details of past MapReduce jobs
 - Runs on port 19888 by default

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MapReduce 2.0 Web-UI

The screenshot displays the Hadoop MapReduce 2.0 Web-UI interface. The top navigation bar includes the Hadoop logo and the title "All Applications". The left sidebar contains navigation links for Cluster, NodeManager, and Tools. The main content area is divided into two sections: "Cluster Metrics" and "JobHistory".

Cluster Metrics

Apps Submitted	Apps Pending	Apps Running	Apps Completed	Containers Running	Memory Used	Memory Total	Memory Reserved	Active Nodes	Decommissioned Nodes	Lost Nodes	Unhealthy Nodes	Rebooted Nodes
2	0	1	1	3	3.5 GB	8 GB	0 KB	1	0	0	0	0

JobHistory

Start Time	Finish Time	Job ID	Name	User	Queue	State	Maps Total	Maps Completed	Reducers Total	Reducers Completed
2012-06-15 23:27:48 EDT	2012-06-15 23:28:06 EDT	job_1339817050993_0001	StartsWithCount-HBase	hadoop	default	SUCCEEDED	2	2	1	1
2012-06-16 01:07:01 EDT	2012-06-16 01:07:22 EDT	job_1339817050993_0002	StartsWithCount	hadoop	default	FAILED	0	0	0	0
2012-06-16 01:09:48 EDT	2012-06-16 01:10:08 EDT	job_1339817050993_0003	StartsWithCount	hadoop	default	FAILED	0	0	0	0
2012-06-16 01:12:54 EDT	2012-06-16 01:13:14 EDT	job_1339817050993_0004	StartsWithCount	hadoop	default	FAILED	0	0	0	0
2012-06-16 01:15:55 EDT	2012-06-16 01:16:09 EDT	job_1339817050993_0005	StartsWithCount	hadoop	default	SUCCEEDED	1	1	1	1
2012-06-16 01:18:23 EDT	2012-06-16 01:18:43 EDT	job_1339817050993_0006	StartsWithCount	hadoop	default	FAILED	0	0	0	0
2012-06-16 01:19:04 EDT	2012-06-16 01:19:25 EDT	job_1339817050993_0007	StartsWithCount	hadoop	default	FAILED	0	0	0	0
2012-06-16 01:20:13 EDT	2012-06-16 01:20:44 EDT	job_1339817050993_0008	StartsWithCount	hadoop	default	SUCCEEDED	1	1	1	1

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Command Line Tools

- **<hadoop_install>/bin/yarn**
 - Execute code with a jar
 - \$yarn jar jarFile [mainClass] args...
 - Print out CLASSPATH: \$yarn classpath
 - Resource Manager admin: \$yarn rmadmin
- **<hadoop_install>/bin/mapred**
 - \$mapred job
 - Get information about jobs
 - Kill Jobs

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\$ yarn jar jarFile [mainClass] args...

- **Execute code in the provided jar**

```
$ yarn jar
$HADOOP_HOME/share/hadoop/mapreduce/hadoop-
mapreduce-examples-2.0.0-cdh4.0.0.jar pi 5 5
```

Examples jar files shipped with hadoop

pi is the program that computes pi

Specify number of mappers

Number of samples; artifact of pi application

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\$ yarn radmin

- **Runs ResourceManager admin client**
- **Allows to refresh and clear resources**

```
$ yarn radmin -refreshNodes
```

Resource Manager will refresh its information
about all the Node Managers

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\$mapred job

- **Command line interface to view job's attributes**
- **Most of the information is available on Web-UI**

```
$ mapred job -list
```

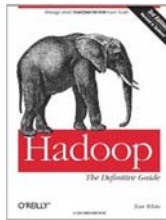
List Jobs that are currently running

```
$ mapred job -status job_1340417316008_0001
```

Retrieve job's status by Job ID

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Resources: Books



Hadoop: The Definitive Guide

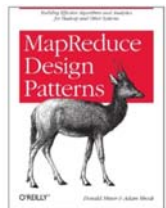
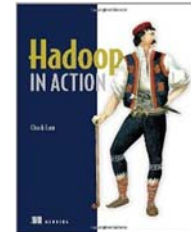
Tom White (Author)

O'Reilly Media; 3rd Edition (May 6, 2012)

Hadoop in Action

Chuck Lam (Author)

Manning Publications; 1st Edition (December, 2010)



MapReduce Design Patterns

Donald Miner (Author), Adam Shook (Author)

O'Reilly Media (November 22, 2012)

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Resources: Books



HBase: The Definitive Guide

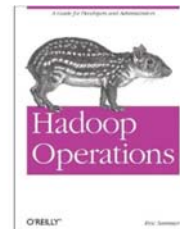
Lars George (Author)

O'Reilly Media; 1 edition (September 20, 2011)

Hadoop Operations

Eric Sammer (Author)

O'Reilly Media (October 22, 2012)



Data-Intensive Text Processing with MapReduce

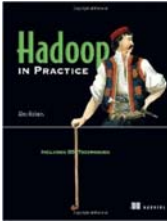
Jimmy Lin and Chris Dyer (Authors) (April, 2010)

Download for FREE:

<http://lintool.github.com/MapReduceAlgorithms/index.html>

37

Resources: Books



Hadoop in Practice

Alex Holmes (Author)

Manning Publications; (October 10, 2012)

Resources

- **Home Page**
 - <http://hadoop.apache.org>
- **Mailing Lists**
 - http://hadoop.apache.org/mailling_lists.html
- **Wiki**
 - <http://wiki.apache.org/hadoop>
- **Documentation:**
 - <http://hadoop.apache.org/docs/r2.0.2-alpha>



Wrap-Up

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Summary

- **We learned about**
 - MapReduce Model
 - YARN/MapReduce 2.0 Daemons
 - MapReduce on YARN single node installation
 - MapReduce and YARN command line tools



Questions?

More info:

<http://www.coreservlets.com/hadoop-tutorial/> – Hadoop programming tutorial

<http://courses.coreservlets.com/hadoop-training.html> – Customized Hadoop training courses, at public venues or onsite at *your* organization

<http://courses.coreservlets.com/Course-Materials/java.html> – General Java programming tutorial

<http://www.coreservlets.com/java-8-tutorial/> – Java 8 tutorial

<http://www.coreservlets.com/JSF-Tutorial/jsf2/> – JSF 2.2 tutorial

<http://www.coreservlets.com/JSF-Tutorial/primefaces/> – PrimeFaces tutorial

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