

Hands-on Big Data

Rutgers University has made this article freely available. Please share how this access benefits you.
Your story matters. [\[https://rucore.libraries.rutgers.edu/rutgers-lib/46836/story/\]](https://rucore.libraries.rutgers.edu/rutgers-lib/46836/story/)

This work is an **UNIDENTIFIED VERSION OF A PUBLISHED WORK**

Citation to Publisher No citation available.

Version:

Citation to *this* Version: Womack, Ryan. *Hands-on Big Data*, 2015. Retrieved from [doi:10.7282/T3ZW1NPZ](https://doi.org/10.7282/T3ZW1NPZ).



Terms of Use: Copyright for scholarly resources published in RUcore is retained by the copyright holder. By virtue of its appearance in this open access medium, you are free to use this resource, with proper attribution, in educational and other non-commercial settings. Other uses, such as reproduction or republication, may require the permission of the copyright holder.

Article begins on next page

HANDS-ON BIG DATA

IASSIST WORKSHOP, MINNEAPOLIS, MN

JUNE 2, 2015

Ryan Womack

Data Librarian, Rutgers University, <http://ryanwomack.com>



This work is licensed under a [Creative Commons Attribution-NonCommercial-ShareAlike 4.0 International License](https://creativecommons.org/licenses/by-nc-sa/4.0/).

Introduction

Big Data

*Hadoop +
MapReduce*

*AWS (Amazon
Web Services)*

Pig and Hive

*More Hadoop
Ecosystem Tools*

Other Providers

R and Big Data

*High-
Dimensional
and Sparse Data*

*Big Data in
Practice*

Termination

INTRODUCTION

*Hands-On Big
Data*

Ryan Womack

Introduction

Big Data

*Hadoop +
MapReduce*

*AWS (Amazon
Web Services)*

Pig and Hive

*More Hadoop
Ecosystem Tools*

Other Providers

R and Big Data

*High-
Dimensional
and Sparse Data*

*Big Data in
Practice*

Termination

What this workshop IS:

- ▶ Fun, hopefully
- ▶ Introduction to the big data landscape
- ▶ Reviews major technologies
- ▶ Will familiarize you with some of the main players in the ecosystem
- ▶ Uses real interactions and environments to give a feel for working with Big Data

INTRODUCTION

*Hands-On Big
Data*

Ryan Womack

Introduction

Big Data

*Hadoop +
MapReduce*

*AWS (Amazon
Web Services)*

Pig and Hive

*More Hadoop
Ecosystem Tools*

Other Providers

R and Big Data

*High-
Dimensional
and Sparse Data*

*Big Data in
Practice*

Termination

What this workshop is NOT:

- ▶ a complete guide to big data
- ▶ an in-depth programming tutorial
- ▶ Does not provide “instant” big data expertise
- ▶ Does not give thorough theoretical background

Introduction

Big Data

*Hadoop +
MapReduce*

*AWS (Amazon
Web Services)*

Pig and Hive

*More Hadoop
Ecosystem Tools*

Other Providers

R and Big Data

*High-
Dimensional
and Sparse Data*

*Big Data in
Practice*

Termination

What you can hope to gain:

- ▶ Exposure to a wide-range of big data packages
- ▶ A sampling of tools and methods
- ▶ Understanding of the power, potential, and limitations of big data
- ▶ May help you decide how far and in which direction you want to go with big data
- ▶ Pathways for further learning

INTRODUCTION

*Hands-On Big
Data*

Ryan Womack

Introduction

Big Data

*Hadoop +
MapReduce*

*AWS (Amazon
Web Services)*

Pig and Hive

*More Hadoop
Ecosystem Tools*

Other Providers

R and Big Data

*High-
Dimensional
and Sparse Data*

*Big Data in
Practice*

Termination

What you can hope to gain, part 2:

- ▶ Hadoop, HDFS, MapReduce, MongoDB

INTRODUCTION

*Hands-On Big
Data*

Ryan Womack

Introduction

Big Data

*Hadoop +
MapReduce*

*AWS (Amazon
Web Services)*

Pig and Hive

*More Hadoop
Ecosystem Tools*

Other Providers

R and Big Data

*High-
Dimensional
and Sparse Data*

*Big Data in
Practice*

Termination

What you can hope to gain, part 2:

- ▶ Hadoop, HDFS, MapReduce, MongoDB
- ▶ HBase, Pig, Pig Latin, Hive, Spark, Scala, Sqoop

INTRODUCTION

*Hands-On Big
Data*

Ryan Womack

What you can hope to gain, part 2:

- ▶ Hadoop, HDFS, MapReduce, MongoDB
- ▶ HBase, Pig, Pig Latin, Hive, Spark, Scala, Sqoop
- ▶ Oozie, ZooKeeper, Flume, Ambari, Hue

Introduction

Big Data

*Hadoop +
MapReduce*

*AWS (Amazon
Web Services)*

Pig and Hive

*More Hadoop
Ecosystem Tools*

Other Providers

R and Big Data

*High-
Dimensional
and Sparse Data*

*Big Data in
Practice*

Termination

INTRODUCTION

*Hands-On Big
Data*

Ryan Womack

Introduction

Big Data

*Hadoop +
MapReduce*

*AWS (Amazon
Web Services)*

Pig and Hive

*More Hadoop
Ecosystem Tools*

Other Providers

R and Big Data

*High-
Dimensional
and Sparse Data*

*Big Data in
Practice*

Termination

What you can hope to gain, part 2:

- ▶ Hadoop, HDFS, MapReduce, MongoDB
- ▶ HBase, Pig, Pig Latin, Hive, Spark, Scala, Sqoop
- ▶ Oozie, ZooKeeper, Flume, Ambari, Hue
- ▶ Hortonworks, Cloudera, Tesseract, RHadoop

INTRODUCTION

*Hands-On Big
Data*

Ryan Womack

Introduction

Big Data

*Hadoop +
MapReduce*

*AWS (Amazon
Web Services)*

Pig and Hive

*More Hadoop
Ecosystem Tools*

Other Providers

R and Big Data

*High-
Dimensional
and Sparse Data*

*Big Data in
Practice*

Termination

What you can hope to gain, part 2:

- ▶ Hadoop, HDFS, MapReduce, MongoDB
- ▶ HBase, Pig, Pig Latin, Hive, Spark, Scala, Sqoop
- ▶ Oozie, ZooKeeper, Flume, Ambari, Hue
- ▶ Hortonworks, Cloudera, Tesseract, RHadoop
- ▶ AWS, EMR, EC2, Azure

What you can hope to gain, part 2:

- ▶ Hadoop, HDFS, MapReduce, MongoDB
- ▶ HBase, Pig, Pig Latin, Hive, Spark, Scala, Sqoop
- ▶ Oozie, ZooKeeper, Flume, Ambari, Hue
- ▶ Hortonworks, Cloudera, Tesseract, RHadoop
- ▶ AWS, EMR, EC2, Azure
- ▶ Tesseract, Trelliscope, Lasso, PCA, SVD

- ▶ Workshop materials, including scripts and data, are available for download from <http://github.com/ryandata/bigdata>
- ▶ The script files contain working demonstrations of the concepts mentioned here.
- ▶ You should have some familiarity with the workings of your OS to complete some of the steps involved.

Introduction

Big Data

*Hadoop +
MapReduce*

*AWS (Amazon
Web Services)*

Pig and Hive

*More Hadoop
Ecosystem Tools*

Other Providers

R and Big Data

*High-
Dimensional
and Sparse Data*

*Big Data in
Practice*

Termination

ABOUT ME

*Hands-On Big
Data*

Ryan Womack

Introduction

Big Data

*Hadoop +
MapReduce*

*AWS (Amazon
Web Services)*

Pig and Hive

*More Hadoop
Ecosystem Tools*

Other Providers

R and Big Data

*High-
Dimensional
and Sparse Data*

*Big Data in
Practice*

Termination

- ▶ I am also new to big data, and wanted to get beyond the slogan
- ▶ If I can do it, you can too!
- ▶ Taking the data librarian perspective, not the computer science perspective
- ▶ What can we learn about how Big Data really works?
- ▶ Enabling ongoing learning beyond this workshop

WHAT IS BIG DATA?

A buzzword...

A concept...

A set of practices...

An ecosystem...

Image of Big Data

Reality of Big Data

Big Data Landscape

*Hands-On Big
Data*

Ryan Womack

Introduction

Big Data

*Hadoop +
MapReduce*

*AWS (Amazon
Web Services)*

Pig and Hive

*More Hadoop
Ecosystem Tools*

Other Providers

R and Big Data

*High-
Dimensional
and Sparse Data*

*Big Data in
Practice*

Termination

BIG DATA IS ...

*Hands-On Big
Data*

Ryan Womack

Big Data is typically defined by the 3 V's

1. Velocity
2. Variety
3. Volume
4. to which a 4th is often added, Veracity

Some say Value is the 4th V

Computing definition: Big Data is data that is too big for a single computing instance to handle.

Personal Definition: Big Data is any data bigger than you know what to do with.

4 V's of Big Data

Introduction

Big Data

*Hadoop +
MapReduce*

*AWS (Amazon
Web Services)*

Pig and Hive

*More Hadoop
Ecosystem Tools*

Other Providers

R and Big Data

*High-
Dimensional
and Sparse Data*

*Big Data in
Practice*

Termination

WHAT TO DO WITH BIG DATA

*Hands-On Big
Data*

Ryan Womack

Introduction

Big Data

*Hadoop +
MapReduce*

*AWS (Amazon
Web Services)*

Pig and Hive

*More Hadoop
Ecosystem Tools*

Other Providers

R and Big Data

*High-
Dimensional
and Sparse Data*

*Big Data in
Practice*

Termination

One way to handle big data is with more powerful hardware.
Some problems are amenable to this.

Structured data, well-formulated modelling, interactions

E.g, a bank's central transaction database, some modeling
problems

High-performance computing, parallel computing, and large
scale databases

Processor is the bottleneck, not the data

This is expensive, not new (mainframe)

This kind of big data is not our focus here.

WHAT'S NEW IN BIG DATA

*Hands-On Big
Data*

Ryan Womack

Internet-scale activity produces large volumes of dispersed, unstructured data.

Log files, search records, user activity.

Facebook, Yahoo, Google, and others have pioneered this work.

"The Cloud"

How Big Data relates to Data Science

This workshop focuses on techniques developed to deal with this kind of data.

Introduction

Big Data

*Hadoop +
MapReduce*

*AWS (Amazon
Web Services)*

Pig and Hive

*More Hadoop
Ecosystem Tools*

Other Providers

R and Big Data

*High-
Dimensional
and Sparse Data*

*Big Data in
Practice*

Termination

“Doug Cutting, Cloudera’s Chief Architect, helped create Apache Hadoop out of necessity as data from the web exploded, and grew far beyond the ability of traditional systems to handle it. Hadoop was initially inspired by papers published by Google outlining its approach to handling an avalanche of data, and has since become the de facto standard for storing, processing and analyzing hundreds of terabytes, and even petabytes of data.

Apache Hadoop is 100% open source, and pioneered a fundamentally new way of storing and processing data. Instead of relying on expensive, proprietary hardware and different systems to store and process data, Hadoop enables distributed parallel processing of huge amounts of data across inexpensive, industry-standard servers that both store and process the data, and can scale without limits. With Hadoop, no data is too big.”

<http://www.cloudera.com/content/cloudera/en/about/hadoop-and-big-data.html>

Introduction

Big Data

*Hadoop +
MapReduce*

*AWS (Amazon
Web Services)*

Pig and Hive

*More Hadoop
Ecosystem Tools*

Other Providers

R and Big Data

*High-
Dimensional
and Sparse Data*

*Big Data in
Practice*

Termination

HADOOP AND HDFS ARCHITECTURE

Hands-On Big Data

Ryan Womack

- ▶ **Hadoop** is an environment that enables a cluster of computers to function as a single large scale storage unit, with redundancy in case of failure, and centralized management. **Name story**.
- ▶ The Hadoop environment enables other processing and analytical jobs to run across the cluster in ways that are (relatively) transparent to the user.
- ▶ **HDFS (Hadoop Distributed File System)** is the underlying file system for Hadoop clusters.
- ▶ **Hadoop Architecture**
- ▶ A lot goes into actual administration of Hadoop cluster that we will abstract away from.

Introduction

Big Data

Hadoop + MapReduce

AWS (Amazon Web Services)

Pig and Hive

More Hadoop Ecosystem Tools

Other Providers

R and Big Data

High-Dimensional and Sparse Data

Big Data in Practice

Termination

- ▶ MapReduce is the paradigm for many operations across a Hadoop cluster
- ▶ The Map component of the operation goes out to each node and performs its task, returning a result
- ▶ The Reduce component collects these results and aggregates/summarizes them from all nodes
- ▶ MapReduce functions are often written as Java programs and require both programming expertise and familiarity with the data

Introduction

Big Data

*Hadoop +
MapReduce*

*AWS (Amazon
Web Services)*

Pig and Hive

*More Hadoop
Ecosystem Tools*

Other Providers

R and Big Data

*High-
Dimensional
and Sparse Data*

*Big Data in
Practice*

Termination

MAPREDUCE EXAMPLES

*Hands-On Big
Data*

Ryan Womack

Introduction

Big Data

*Hadoop +
MapReduce*

*AWS (Amazon
Web Services)*

Pig and Hive

*More Hadoop
Ecosystem Tools*

Other Providers

R and Big Data

*High-
Dimensional
and Sparse Data*

*Big Data in
Practice*

Termination

- ▶ MapReduce Illustration
- ▶ MapReduce WordCount Program
- ▶ A short intro to MapReduce (great place to start)
- ▶ A longer intro to Hadoop ecosystem

WORKING WITH HADOOP

- ▶ All elements of the Hadoop ecosystem come with their own sets of command line tools.
- ▶ E.g., to place something into the hadoop file system, the command `hadoop fs -put` can be used.
- ▶ This workshop uses shortcuts and tools to avoid some of the inevitable command line work required for a production system.
- ▶ [A toy Hadoop cluster](#), [Yahoo Hadoop cluster](#)
- ▶ Yahoo and Facebook were early large users of these technologies.
- ▶ Google has its own file system and more proprietary approaches. See [Google BigQuery](#).

Introduction

Big Data

*Hadoop +
MapReduce*

*AWS (Amazon
Web Services)*

Pig and Hive

*More Hadoop
Ecosystem Tools*

Other Providers

R and Big Data

*High-
Dimensional
and Sparse Data*

*Big Data in
Practice*

Termination

AMAZON WEB SERVICES

*Hands-On Big
Data*

Ryan Womack

Amazon Web Services (AWS) provides

- ▶ a variety of hosting environments
- ▶ quick start and stop of a variety of servers
- ▶ both raw computing power and pre-configured computing

Downside:

- ▶ Metered access - cheap for a short while, expensive in the long term
- ▶ Not as flexible as a self-hosted installation

We will use AWS for the bulk of our Hadoop/Hue/Pig/Hive demo.

AWS provides a feel for many of the issues involved in self-hosting, but with time-saving steps.

Introduction

Big Data

*Hadoop +
MapReduce*

*AWS (Amazon
Web Services)*

Pig and Hive

*More Hadoop
Ecosystem Tools*

Other Providers

R and Big Data

*High-
Dimensional
and Sparse Data*

*Big Data in
Practice*

Termination

AWS SETUP

- ▶ You must obtain an AWS account from aws.amazon.com
- ▶ Follow the registration steps, then login.
- ▶ Setting up an account requires use of a phone for two-factor authentication. Please have one available.
- ▶ If needed, this is a reference to setting up [AWS Command Line Interface](#)

Hands-On Big Data

Ryan Womack

Introduction

Big Data

Hadoop + MapReduce

AWS (Amazon Web Services)

Pig and Hive

More Hadoop Ecosystem Tools

Other Providers

R and Big Data

High-Dimensional and Sparse Data

Big Data in Practice

Termination

AWS EC2, EMR

Hands-On Big Data

Ryan Womack

- ▶ EC2 is Amazon's Elastic Compute Cloud. This allows you to create "instances", which are actual running computers with memory and disk storage, on the fly.
- ▶ You can create the number and size of machines that you need for your job, and pay a metered rate based on the number, size, and duration of the compute resources you use.
- ▶ EMR is Elastic Map Reduce. This uses EC2 computing resources to automate the creation of a Hadoop cluster that can perform MapReduce jobs.
- ▶ It should cost around \$5 to run the standard EMR cluster for 2-3 hours in this workshop.
- ▶ Please be sure to terminate your instances when you are done. Leaving computers on is expensive in AWS!

Introduction

Big Data

Hadoop + MapReduce

AWS (Amazon Web Services)

Pig and Hive

More Hadoop Ecosystem Tools

Other Providers

R and Big Data

High-Dimensional and Sparse Data

Big Data in Practice

Termination

AWS SETUP, KEY PAIR

- ▶ To create an Amazon EC2 key pair ([Help Guide](#))
- ▶ Sign in to the AWS Management Console and open the Amazon EC2 console at <https://console.aws.amazon.com/ec2/>.
- ▶ From the Amazon EC2 console, select a Region.
- ▶ In the Navigation pane, click Key Pairs.
- ▶ On the Key Pairs page, click Create Key Pair.
- ▶ In the Create Key Pair dialog box, enter a name for your key pair, such as, mykeypair.
- ▶ Click Create.
- ▶ Save the resulting PEM file in a safe location.
- ▶ Your Amazon EC2 key pair and an associated PEM file are created.

Introduction

Big Data

*Hadoop +
MapReduce*

*AWS (Amazon
Web Services)*

Pig and Hive

*More Hadoop
Ecosystem Tools*

Other Providers

R and Big Data

*High-
Dimensional
and Sparse Data*

*Big Data in
Practice*

Termination

AWS SETUP, CREATE EMR CLUSTER

Hands-On Big Data

Ryan Womack

- ▶ From the EMR page (<https://console.aws.amazon.com/elasticmapreduce>), click “Create Cluster”
- ▶ Accept default options, except under “Security and Access” choose the key that you just generated.
- ▶ Under EC2 Security group, click “Create Security Group”
- ▶ click “Create Security Group” again, fill out the fields, and click “Yes, Create”
- ▶ You want to create an open security group for ease of setup, not recommended in production environment
- ▶ Edit the rules to allow all inbound traffic from all locations - set “Source” field to the security group id just created (just for convenience - again, not recommended)
- ▶ Click “Create Cluster” and wait.

Introduction

Big Data

Hadoop + MapReduce

AWS (Amazon Web Services)

Pig and Hive

More Hadoop Ecosystem Tools

Other Providers

R and Big Data

High-Dimensional and Sparse Data

Big Data in Practice

Termination

AWS SETUP, CONNECTIONS

- ▶ Click on the SSH link next to Master public DNS, and follow instructions to connect.
- ▶ On Windows Systems, use PuttyGEN to convert you .pem key to a .ppk key on Windows systems. Import the .pem key, then “Save private key”.
- ▶ Then use PuttyExe to SSH in.
- ▶ On Mac/Linux systems, just use ssh.
- ▶ This will enable you to access the master node on your cluster directly and run command line operations.
- ▶ Next click “Enable Web Connection”.
- ▶ Follow the instructions provided.
- ▶ Now you can click on Hue and the other web management interfaces.
- ▶ Congratulations, you are running a Hadoop cluster!

AMAZON S3

Hands-On Big Data

Ryan Womack

- ▶ Amazon provides low cost, accessible storage through S3.
- ▶ One advantage of Amazon EMR is that it can use S3 storage.
- ▶ Items in s3 buckets can be made public.
- ▶ But be sure to edit the properties of the bucket itself to make sure the contents are listable by everyone.

Introduction

Big Data

Hadoop + MapReduce

AWS (Amazon Web Services)

Pig and Hive

More Hadoop Ecosystem Tools

Other Providers

R and Big Data

High-Dimensional and Sparse Data

Big Data in Practice

Termination

As mentioned earlier, writing MapReduce programs in native Java, Python or other languages requires a high-level of expertise and can be time-consuming.

- ▶ **Pig** is designed to remove some of this barrier.
- ▶ Pig was developed at Yahoo!
- ▶ The language of Pig is Pig Latin.
- ▶ Pig is somewhat open-ended in structure and syntax (compared to Hive).
- ▶ Pig masks the parallelization of its actions behind simpler code.

Introduction

Big Data

*Hadoop +
MapReduce*

*AWS (Amazon
Web Services)*

Pig and Hive

*More Hadoop
Ecosystem Tools*

Other Providers

R and Big Data

*High-
Dimensional
and Sparse Data*

*Big Data in
Practice*

Termination

- ▶ For our Pig example, we will use the [Hue](#) administration interface for AWS EMR, which runs through the browser.
- ▶ Run a word count on the [Complete Works of Shakespeare](#)
- ▶ Default login: hue, password: 1111
- ▶ The Pig Editor is available here.
- ▶ There is also a command line interface called Grunt.
- ▶ You can see a more full-featured Hue environment at <http://demo.gethue.com>

Introduction

Big Data

*Hadoop +
MapReduce*

*AWS (Amazon
Web Services)*

Pig and Hive

*More Hadoop
Ecosystem Tools*

Other Providers

R and Big Data

*High-
Dimensional
and Sparse Data*

*Big Data in
Practice*

Termination

- ▶ The [Hive](#) language was developed at Facebook.
- ▶ Hive is very similar to standard SQL. Here is an [SQL-to-Hive cheat sheet](#).
- ▶ Like Pig, it masks the complexity of working with a Hadoop cluster behind simpler code. Hive can handle less structured sources as if they were relational databases.
- ▶ The log files, however, show the complexity - also apparent when things break!
- ▶ The manuals at the Hive site are the most complete reference to the language.
- ▶ Again, we use Hue to access the Beeswax editor.

Introduction

Big Data

*Hadoop +
MapReduce*

*AWS (Amazon
Web Services)*

Pig and Hive

*More Hadoop
Ecosystem Tools*

Other Providers

R and Big Data

*High-
Dimensional
and Sparse Data*

*Big Data in
Practice*

Termination

- ▶ **Spark** is a newer project that is getting a lot of **attention**. Spark can use Hadoop data stores, but is its own stand-alone system.
- ▶ Can mix SQL-type queries with more programming language type functions.
- ▶ Accepts Java, Python, and Scala functions. Spark is written in the Scala programming language.
- ▶ Generally much faster than Hadoop.
- ▶ The Spark demo requires access to command line tools.
 - ▶ This is much easier in Mac/Linux environments, but if you have Cygwin on Windows, you may be able to perform the same steps.
- ▶ **Introduction to Big Data with Apache Spark** started June 1 on EdX.

Introduction

Big Data

*Hadoop +
MapReduce*

*AWS (Amazon
Web Services)*

Pig and Hive

*More Hadoop
Ecosystem Tools*

Other Providers

R and Big Data

*High-
Dimensional
and Sparse Data*

*Big Data in
Practice*

Termination

MORE SPARK MATERIALS

- ▶ Spark in CDH
- ▶ Stanford Spark Class
- ▶ Spark on an EMR Cluster
- ▶ See p. 234 of *Guide to High Performance Computing* for Spark linear regression code

Hands-On Big Data

Ryan Womack

Introduction

Big Data

Hadoop + MapReduce

AWS (Amazon Web Services)

Pig and Hive

More Hadoop Ecosystem Tools

Other Providers

R and Big Data

High-Dimensional and Sparse Data

Big Data in Practice

Termination

- ▶ We have already seen Hue.
- ▶ **Oozie** is a workflow scheduler for Hadoop jobs. You have already seen it in action in Hue.
- ▶ **Zookeeper** is a coordination service to help configure and manage distributed applications.
- ▶ **Ganglia** is a monitoring system for Hadoop clusters.
- ▶ **Ambari** is a web-based interface to several different monitoring and administration tools. We will see it in more detail in the Hortonworks Sandbox on Azure.

Introduction

Big Data

*Hadoop +
MapReduce*

*AWS (Amazon
Web Services)*

Pig and Hive

*More Hadoop
Ecosystem Tools*

Other Providers

R and Big Data

*High-
Dimensional
and Sparse Data*

*Big Data in
Practice*

Termination

OTHER DATA FRAMEWORKS

- ▶ **Cassandra** is a large-scale database with a focus on column performance.
- ▶ **HBase** is a large-scale data store modeled on Google's BigTable for storing sparse data.
- ▶ **MongoDB** is a NoSQL database designed for large-scale operation.
- ▶ **Sqoop** is a tool for transferring data between Hadoop and traditional relational databases.
- ▶ **Flume** is a tool for automating the flow of data (such as server logs) from live systems into Hadoop data stores.
- ▶ The presence of so many tools and techniques (Impala, Mahout) for almost any big data task is what has made "Hadoop" a go-to solution for big data needs.

AN ASIDE ON ACID vs. BASE

Hands-On Big Data

Ryan Womack

“Eventually consistent services are often classified as providing **BASE** (Basically Available, Soft state, Eventual consistency) semantics, in contrast to traditional **ACID** (Atomicity, Consistency, Isolation, Durability) guarantees. Eventual consistency is a consistency model used in distributed computing that informally guarantees that, if no new updates are made to a given data item, eventually all accesses to that item will return the last updated value. Eventual consistency is widely deployed in distributed systems ”

R for Cloud Computing, p. 210

Introduction

Big Data

Hadoop + MapReduce

AWS (Amazon Web Services)

Pig and Hive

More Hadoop Ecosystem Tools

Other Providers

R and Big Data

High-Dimensional and Sparse Data

Big Data in Practice

Termination

MICROSOFT AZURE, GOOGLE CLOUD

Hands-On Big Data

Ryan Womack

Other cloud services are available to support big data.

- ▶ **Microsoft Azure** provides free trial access to Hortonworks, albeit with highly aggressive scripting. See also Portal.azure.com.
- ▶ **Google Cloud** can also be used to provision **Hadoop** clusters.
- ▶ These services are newer and (perhaps) less robust than Amazon, with fewer help resources and more hoops to jump through.
- ▶ Azure has more Microsoft server options than Linux options.

Introduction

Big Data

Hadoop + MapReduce

AWS (Amazon Web Services)

Pig and Hive

More Hadoop Ecosystem Tools

Other Providers

R and Big Data

High-Dimensional and Sparse Data

Big Data in Practice

Termination

- ▶ Cloudera (<http://www.cloudera.com>)
- ▶ A leading provider of Hadoop-based big data solutions. Founded 2009.
- ▶ Distributes CDH (Cloudera Distribution with Hadoop). This means rolling together a number of projects in a coherent "stack", distributing, and providing support. Contributes to HBase and other Apache projects.
- ▶ [Cloudera Live](#) Click "Try the Demo" or directly to <http://demo.gethue.com>
- ▶ Hue is one management interface for Hadoop.

Introduction

Big Data

*Hadoop +
MapReduce*

*AWS (Amazon
Web Services)*

Pig and Hive

*More Hadoop
Ecosystem Tools*

Other Providers

R and Big Data

*High-
Dimensional
and Sparse Data*

*Big Data in
Practice*

Termination

- ▶ Hortonworks (<http://www.hortonworks.com>)
- ▶ Founded in 2011 by 24 Yahoo! engineers from the original Hadoop team. Like Cloudera, Hortonworks manages a "stack" of Hadoop applications and provides support. In some ways, like a linux distribution. Hortonworks is a leading contributor to Hive and other Apache projects.
- ▶ Hortonworks is available in Sandbox mode for Virtual Machines and in the Azure cloud (with free one month trial).

Introduction

Big Data

*Hadoop +
MapReduce*

*AWS (Amazon
Web Services)*

Pig and Hive

*More Hadoop
Ecosystem Tools*

Other Providers

R and Big Data

*High-
Dimensional
and Sparse Data*

*Big Data in
Practice*

Termination

AMBARI REVISITED

*Hands-On Big
Data*

Ryan Womack

Introduction

Big Data

*Hadoop +
MapReduce*

*AWS (Amazon
Web Services)*

Pig and Hive

*More Hadoop
Ecosystem Tools*

Other Providers

R and Big Data

*High-
Dimensional
and Sparse Data*

*Big Data in
Practice*

Termination

Using Hortonworks, either via downloaded Virtual Machine, or with the Azure cloud trial, try out Ambari.

Launch the instance, then navigate to the browser interface.

- ▶ 127.0.0.1:8888 provides starter interface on a VM (use URL provide if on Azure)
- ▶ 127.0.0.1:8000 provides script interface
- ▶ 127.0.0.1:8080 provides Ambari interface (login: admin, password: admin)

- ▶ R is the leading open source statistical programming platform, and so provides a natural complement to open source big data software.
- ▶ Some R projects and extensions are devoted to providing large file access, parallel computation, and other aspects of HPC.
- ▶ There are many of these ([listing on Task Views](#)), not the focus here.
- ▶ We will discuss two projects that fit in with Hadoop-style big data on clusters:
 - ▶ RHadoop
 - ▶ Tesseract

Introduction

Big Data

*Hadoop +
MapReduce*

*AWS (Amazon
Web Services)*

Pig and Hive

*More Hadoop
Ecosystem Tools*

Other Providers

R and Big Data

*High-
Dimensional
and Sparse Data*

*Big Data in
Practice*

Termination

- ▶ **RHadoop** is a collection of five packages developed by Revolution Analytics:
 - ▶ `ravro`, `rhbase`, `rhdfs` are packages to write and read data for their respective formats.
 - ▶ `rmr` provides an interface to the map reduce framework through R
 - ▶ `plymr` provides a higher-level set of functions that reduces the programming requirements of `rmr`, “plyr meets MapReduce”
- ▶ Other packages include **SparkR**, RHive, RCassandra, and more
- ▶ See p. 203 and following in *R for Cloud Computing*

Introduction

Big Data

*Hadoop +
MapReduce*

*AWS (Amazon
Web Services)*

Pig and Hive

*More Hadoop
Ecosystem Tools*

Other Providers

R and Big Data

*High-
Dimensional
and Sparse Data*

*Big Data in
Practice*

Termination

- ▶ One way to run R in the cloud is with an Amazon Machine Image (AMI).
- ▶ These pre-built installations make it easy to get R up and running in seconds in AWS.
- ▶ See [Louis Aslett's RStudio Server](#) versions for a particularly useful version.
- ▶ Here are some [more instructions](#) (not personally tested).
- ▶ [RHadoop in EC2](#) instructions (not personally tested).

Introduction

Big Data

*Hadoop +
MapReduce*

*AWS (Amazon
Web Services)*

Pig and Hive

*More Hadoop
Ecosystem Tools*

Other Providers

R and Big Data

*High-
Dimensional
and Sparse Data*

*Big Data in
Practice*

Termination

TESSERA

[Tessera](#) is developed by Purdue, Pacific Northwest National Laboratory, and Mozilla. Launched in November 2014, this project holds a lot of promise.

- ▶ Running in the R environment, Tessera provides its own commands that execute across a cluster, easing the burden of analysis in this environment.
- ▶ The [datadr](#) package “divides and recombines” in a manner similar to MapReduce, providing a simplified interface to Hadoop.
- ▶ RHIFE is the package that interacts directly with Hadoop.
- ▶ Tessera also provides a visualization interface, [Trelliscope](#), that can handle views across many variables and observations. Described in this [paper](#).
- ▶ Tessera’s [Bootcamp](#) is a good introduction, or try the [quickstart](#).

HIGH-DIMENSIONAL DATA

*Hands-On Big
Data*

Ryan Womack

- ▶ Many data analysis problems exhibit high dimensionality.
- ▶ When the number of variables is greater than the number of observations, this is high-dimensional data ($p > n$).
- ▶ A typical problem - trying to determine which of 10,000 gene SNPs (single nucleotide polymorphisms) helps to explain 100 occurrences of a rare cancer.
- ▶ **Principal Component Analysis** (PCA) is a classic, early method of selecting the most relevant elements in the dataset to explain variation, and is still widely used [prcomp in R, SAS PROC FACTOR].

Introduction

Big Data

*Hadoop +
MapReduce*

*AWS (Amazon
Web Services)*

Pig and Hive

*More Hadoop
Ecosystem Tools*

Other Providers

R and Big Data

*High-
Dimensional
and Sparse Data*

*Big Data in
Practice*

Termination

HIGH-DIMENSIONAL DATA, CONT.

- ▶ The Lasso is another popular method that performs variable reduction and selection simultaneously.

$$\hat{\beta}^{\text{lasso}} = \arg \min_{\beta} \left\{ \sum_{i=1}^n (y_i - \beta_0 - \sum_{j=1}^p x_{ij} \beta_j)^2 + \lambda \sum_{j=1}^p |\beta_j| \right\}$$

- ▶ see “Absolute Penalty Estimation”, *International Encyclopedia of Statistical Science*.
- ▶ We (artificially) penalize having large numbers of variables, so the model will shrink to include only variables with significant influence on the outcome.
- ▶ Accurate prediction and computational feasibility make Lasso and variants popular [lars in R, SAS GLMSELECT].
- ▶ Many, many other variant methods have been introduced, e.g. ℓ_1/ℓ_2 penalty procedures. See *Modern Multivariate Statistical Techniques* and *Statistics for High-Dimensional Data*.

SPARSE DATA

“In numerical analysis, a [sparse matrix](#) is a matrix in which most of the elements are zero. By contrast, if most of the elements are nonzero, then the matrix is considered dense. The fraction of zero elements over the total number of elements in a matrix is called the sparsity (density)” [Wikipedia]

- ▶ An example, [Netflix movie ratings](#) data. Only a small percentage of all movies are rated by any one user.
- ▶ Squeeze the zeros out of the matrix and represent it more compactly [Matrix or sparseMatrix packages in R].
- ▶ Singular value decomposition (SVD) and other mathematical/computational techniques can then be applied to solve the problem [svd or irlba in R].
- ▶ An active area of research.
- ▶ There is a [sparse matrix collection on AWS](#) if you would like examples to explore.

BIG DATA IN PRACTICE

*Hands-On Big
Data*

Ryan Womack

We will run one quick example of querying an actual big dataset.

- ▶ Over 500 TB of web crawl data are available through the [Common Crawl](#) project, also available via Amazon S3.
- ▶ This is a [quick way to use the index](#). The [Support Library](#) provides more extensive access.
- ▶ Some more [tutorials here](#).
- ▶ Need boto (execute `pip install boto`) for this, per [this link](#).

Introduction

Big Data

*Hadoop +
MapReduce*

*AWS (Amazon
Web Services)*

Pig and Hive

*More Hadoop
Ecosystem Tools*

Other Providers

R and Big Data

*High-
Dimensional
and Sparse Data*

*Big Data in
Practice*

Termination

BIG DATA IN PRACTICE, CONT.

Hands-On Big Data

Ryan Womack

- ▶ AWS provides other [public datasets](#) such as the [1000 Genomes](#) project, which has a [tutorial](#) and a [browser search interface](#) too.
- ▶ Building a cluster would allow you to use MapReduce type functions to analyze the data.
- ▶ Another AWS example on using [R on EC2](#) to analyze global weather.

Introduction

Big Data

Hadoop + MapReduce

AWS (Amazon Web Services)

Pig and Hive

More Hadoop Ecosystem Tools

Other Providers

R and Big Data

High-Dimensional and Sparse Data

Big Data in Practice

Termination

CONCLUSION

- ▶ Today's examples are meant to give exposure to and a feeling for big data computing.
- ▶ To actually use these technologies to good effect requires greater immersion and training.
- ▶ Setting up a large data store takes time and expertise.
- ▶ Developing analytics on top of that data store takes expertise and time.
- ▶ Preferably a committed *team* effort.

TERMINATION

- ▶ Remember to *terminate* any AWS instances you have created!
- ▶ Otherwise you will continue to be billed for usage, \$30/day and up.

REFERENCES

1. Peter Bühlmann and Sara van de Geer. *Statistics for High-Dimensional Data: Methods, Theory and Applications*. Springer, 2011.
2. Michael Frampton. *Big Data Made Easy: A Working Guide to the Complete Hadoop Toolset*. Apress, 2015.
3. Thilina Gunarathne. *Hadoop v2 MapReduce Cookbook*. Second Edition. Packt, 2015.
4. Richard Hill, Laurie Hirsch, Peter Lake, and Siavash Moshiri. *Guide to Cloud Computing: Principles and Practice*. Computer Communications and Networks. Springer, 2013.
5. Alan J. Izenman. *Modern Multivariate Statistical Techniques: Regression, Classification, and Manifold Learning*. Springer, 2008.
6. A. Ohri. *R for Cloud Computing: an Approach for Data Scientists*. Computer Communications and Networks. Springer, 2014.
7. K. G. Srinivasa and Anil Kumar Muppalla. *Guide to High Performance Distributed Computing: Case Studies with Hadoop, Scalding, and Spark*. Computer Communications and Networks. Springer, 2015.

Hands-On Big Data

Ryan Womack

Introduction

Big Data

Hadoop + MapReduce

AWS (Amazon Web Services)

Pig and Hive

More Hadoop Ecosystem Tools

Other Providers

R and Big Data

High-Dimensional and Sparse Data

Big Data in Practice

Termination