Labs: Intro to HDFS/YARN & Apache Spark on CDH 5.2

Lab created on: Dec, 2014
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Estimated lab completion time: **2.5 hours** (spread throughout the day)

Objective:

This lab will introduce you to using 3 Hadoop ecosystem components in Cloudera's distribution: HDFS, Spark 1.1.0 and YARN. The lab will first walk you through the Cloudera Manager installation on a VM in AWS, followed by a CDH 5.2 binaries deployment on the same node. Then the lab will introduce students to Hadoop in a DevOps manner: experimenting with the distributed file system, looking at the XML config files, running a batch analytics workload with Spark from disk and from memory, writing some simple scala Spark code, running SQL commands with Spark SQL, breaking things and troubleshooting issues, etc.

The following high level steps are in the initial part of this lab:

- Connect via SSH to your Amazon instance
- Install Cloudera Manager and CDH 5.2
- Create a new folder in HDFS and add data files to it
- Start the scala based Spark shell
- Import the fresh data into Spark a RDD
- Persist an RDD to memory
- Write a transformed RDD back into HDFS
- Use the Spark Python shell and inject Spark SQL commands into it

Each student in class will be provided one m3.xlarge EC2 instance running in the us-west-2c (Oregon) data center.

The m3.xlarge instance type comes with 4 vCPUs, 15 GB of RAM and two 40 GB SSDs.

The instructor should have given you the following:

- Public DNS hostname of your specific instance
- .pem and .ppk key pairs to authenticate you to your instance

Resources to learn more about Spark

++ Apache Documentation ++
Spark homepage @ Apache:
https://spark.apache.org

Here are the official Apache docs for Spark 1.1.1:
https://spark.apache.org/docs/latest/index.html

Link to user + dev mailing lists:
https://spark.apache.org/community.html#mailing-lists

++ Developer/API Documentation ++
Spark Core Scala docs:
https://spark.apache.org/docs/latest/api/scala/index.html

Spark Core Java docs:
https://spark.apache.org/docs/latest/api/java/index.html

Spark Core Python docs:
https://spark.apache.org/docs/latest/api/python/index.html

++ Cloudera Documentation ++
Cloudera's docs for CDH 5.2 includes guides for a quick start, installation, security and HA:
http://www.cloudera.com/content/cloudera/en/documentation/cdh5/latest/CDH5-Release-Notes/CDH5-Release-Notes.html

Here is the exact version of all the Apache projects (16+) included in CDH 5.2.1:
http://www.cloudera.com/content/cloudera/en/documentation/core/latest/topics/cdh_vd_cdh_package_tarball.html

The specific section of Cloudera's docs that refers to Spark Installation and configuration:
http://www.cloudera.com/content/cloudera/en/documentation/cdh5/latest/CDH5-Installation-Guide/cdh5ig_spark_installation.html

++ Spark Training Videos ++
From Spark Summit 2013: http://spark-summit.org/2013
From Spark Summit 2014: http://spark-summit.org/2014

++ Databricks Resources for Spark ++
Databricks will be releasing free videos, docs and labs to learn Spark here:
http://databricks.com/spark-training-resources

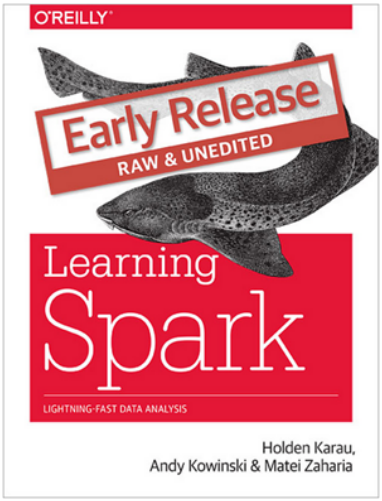
++ Spark Certification ++
Note, when you're ready to get certified as a Spark Developer, check out the joint Spark certification program between Databricks & O'Reilly:

http://radar.oreilly.com/2014/09/announcing-spark-certification.html

http://www.oreilly.com/data/sparkcert.html?cmp=ex-strata-na-lp-na_apache_spark_certification

One Special Resource

A good portion of the steps in this lab come from the following book, so it is worth pointing out separately. If you want to dive deeper into Spark after completing this lab, then this is the best technical resource to get started with:



Learning Spark
Early Release version available now.
http://shop.oreilly.com/product/0636920028512.do

CDH 5.2.1 and Cloudera Manager Information

Cloudera Distribution of Hadoop (CDH) consists of 100% open source Apache Hadoop plus about 20 other open source projects from the Hadoop ecosystem. Cloudera claims that "CDH is thoroughly tested and certified to integrate with the widest range of operating systems, hardware and databases."

CDH has been around for years, as CDH2, CDH3, CDH4, and now CDH5.

Although CDH is a production-ready distribution of Apache Hadoop, it can be tricky to install, manage and monitor via cmd-line tools. To ease the burden of deploying and managing CDH/Hadoop, Cloudera released Cloudera Manager (CM). There are two types of CM: Free/Express and Enterprise (which comes in basic, flex & data hub editions). CM Express used to be limited to clusters under 50 nodes, but starting with CM 4.5 it can be used with unlimited nodes. Both editions of CM help with deployment of binaries and Hadoop services/configurations (XML files) management. CM Enterprise includes more features like rolling upgrades, LDAP integration, operational reports, automated disaster recovery, data auditing and tech support integration.

To see a detailed comparison between CM Express vs. CM Enterprise, visit this page: http://www.cloudera.com/content/cloudera/en/products-and-services/product-comparison.html

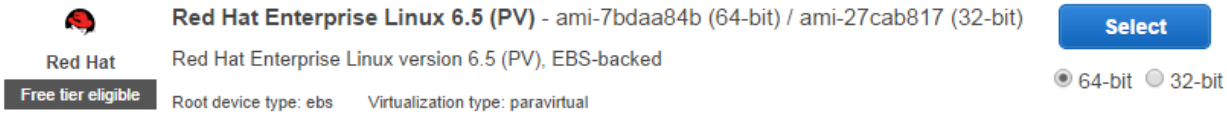
This lab uses Cloudera Manager Express (CM) to push the CDH binaries (packages). In a real, production cluster, Cloudera Manager would typically run on a separate server from the Hadoop cluster. Then the Cloudera Manager software would be used to push the CDH binaries (parcels) externally to a 10, 50 or even 1,000 node Hadoop cluster (with the nodes running various roles like Master daemons or Slave daemons). However, *in this lab*, we will keep things simple and cheap and use the same EC2 node for Cloudera Manager and CDH5.

Connect to Amazon EC2 Instance

Each student will get 1 virtual server in Amazon use for the duration of the lab. The server has had nothing special done with it (no boot scripts, so silent installs, etc). No one has logged into this 1-node cluster via SSH or a web UI since it launched. You will be the first to do so in the next section. So, after this class if finished, you can launch the same server type in AWS and re-do this entire lab if you wish and then build your skills by trying new things with the environment.

Note that this lab is being released via a Creative Commons license so you are free to print it and share it, as long as it is not for commercial purposes.

This 64-bit AMI was launched in the us-west-2 (Oregon) datacenter to build your EC2-instance (*this AMI is not accessible in other regions*):



Note this AMI is a ParaVirtualization (PV) type, which traditionally performs better than Hardware Virtual Machines (HVM).

To launch your specific m3.xlarge node, a 40 GB general purpose SSD (with 30 baseline IOPS / 3000 burst IOPS for 30 minutes) was used. There is only one root storage device configured under `/dev/sda1`.

Pick your favorite SSH client and connect to the Amazon instance with the connection details below:

Port: 22
Username: ec2-user
Hostname: *<public DNS hostname that AWS or the instructor provided you with>*
Key Pair: .pem (for OS X) or .ppk (for Windows)

I recommend using **PuTTY** on Windows and **iTerm2 (**or Terminal) on OS X.

The general instructions to log in via OS X Terminal are:

Open up your terminal app of choice and type in the following…

Change the permissions of the .pem key file like this: **chmod 400 my-key-pair.pem**

SSH into the VM using this command: **ssh -i Amazon-Private-Key.pem ec2-user@<public hostname of VM>**

Say Yes to this prompt:
```
The authenticity of host 'ec2-198-51-100-x.compute-1.amazonaws.com
(10.254.142.33)'can't be established.RSA key fingerprint is
1f:51:ae:28:bf:89:e9:d8:1f:25:5d:37:2d:7d:b8:ca:9f:f5:f1:6f.Are you sure you
want to continue connecting (yes/no)? yes
```

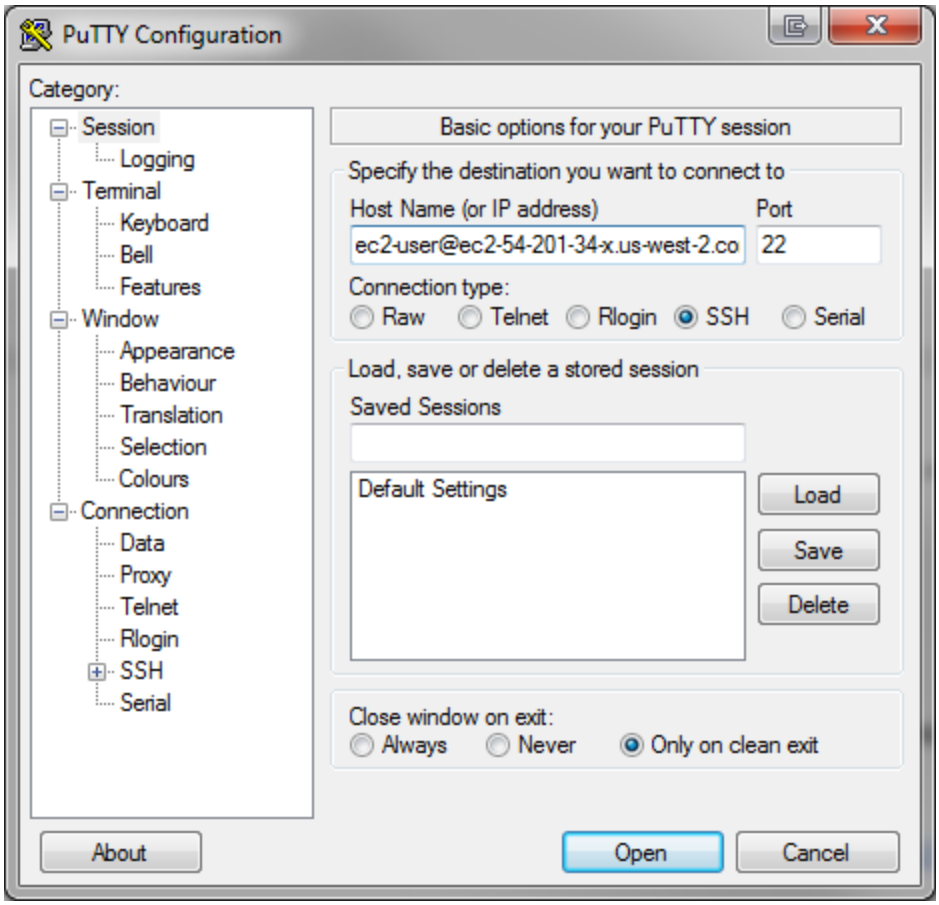
Here are the official details on how to log in via Mac:
http://docs.aws.amazon.com/AWSEC2/latest/UserGuide/

Connection Settings screenshots for PuTTY (on Windows):

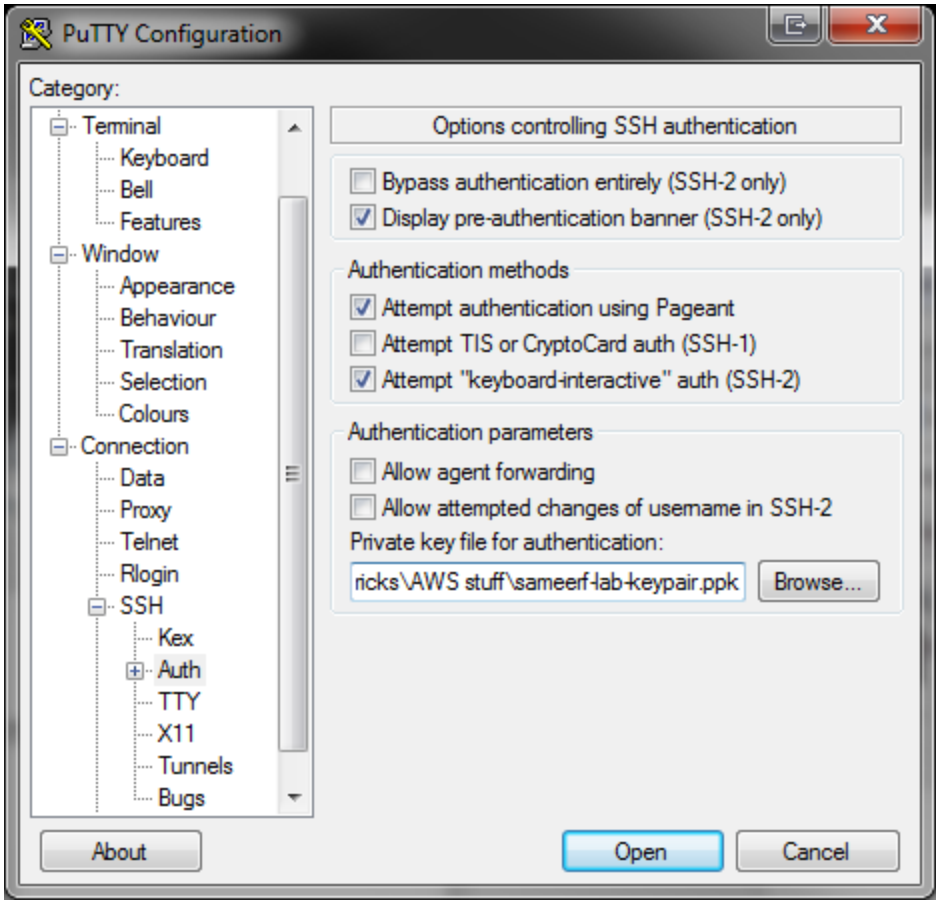
Download PuTTY.exe from:
http://www.chiark.greenend.org.uk/~sgtatham/putty/download.html

There is no installation for PuTTY. You can just run it from the downloaded `.exe` file.

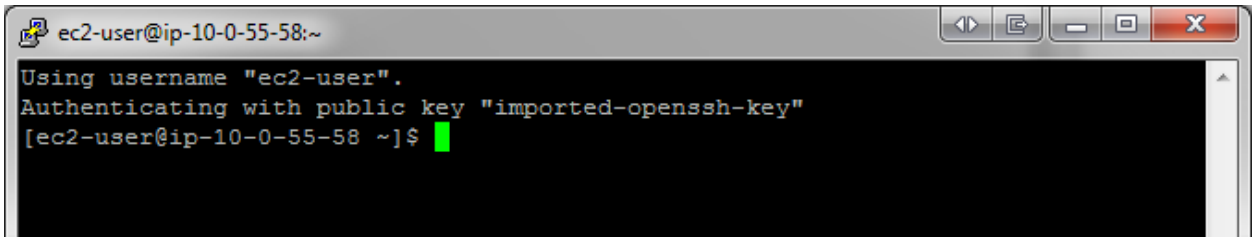
Notice that appending '`ec2-user@`' to the Host Name will automatically log you into the VM:



In the left pane, under Connection > SSH > Auth, you can provide the location to the private .ppk key on your Windows machine:



This is what you'll see once you are successfully logged in:



Prepwork + Install Cloudera Manager

Let's begin by checking a few parameters on the EC2 virtual machine and then installing Cloudera Manager (CM).

First verify that this server has about 15 GB of RAM and only 200 MB or so are currently being used:

```
[ec2-user@ip-10-0-72-36 ~]$ free -m
             total       used       free     shared    buffers     cached
Mem:         14882        263      14618          0         18         60
-/+ buffers/cache:        184      14697
Swap:            0          0          0
```

Check what type of file systems are running in the VM:

```
[ec2-user@ip-10-0-72-36 ~]$ df -Th
Filesystem     Type   Size  Used Avail Use% Mounted on
/dev/xvda1     ext3    40G  1.1G   37G   3% /
tmpfs          tmpfs  7.4G     0  7.4G   0% /dev/shm
```

Notice that the main file system is `/dev/xvda1`, which is of type ext3 and of size 40GB total with 37GB still available. To keep things simple, we will store the HDFS blocks on the same xvda1 partition, even though in production it is best to keep the HDFS blocks on a separate spindle.

All of the Hadoop daemons require Java JVMs to run. Check if Java's installed:

```
[ec2-user@ip-10-0-72-36 ~]$ java -version
java version "1.7.0_65"
OpenJDK Runtime Environment (rhel-2.5.1.2.el6_5-x86_64 u65-b17)
OpenJDK 64-Bit Server VM (build 24.65-b04, mixed mode)
```

Well, the OpenJDK version of Java is installed, but CDH prefers to run with the Oracle JDK 1.7 version. So, during the CDH 5 install, when we see an option to install Oracle Java SE Development Kit (JDK), we'll accept it.

iptables is an administrative tool/command for IPv4 packet filtering and NAT. It's essentially a firewall mechanism for linux. **Just so we don't have to worry about opening up two dozen specific ports, let's make sure iptables is turned off entirely:**

```
[ec2-user@ip-10-0-60-107 ~]$ chkconfig --list iptables
iptables        0:off   1:off   2:off   3:off   4:off   5:off   6:off

[ec2-user@ip-10-0-60-107 ~]$ sudo service iptables status
iptables: Firewall is not running.
```

Security-Enhanced Linux (SELinux) is a Linux kernel security module that provides the mechanism for supporting access control security policies, including United States Department of Defense–style mandatory access controls (MAC). **Having SELinux enabled can complicate things, so if it is enabled, let's turn it off:**

```
[ec2-user@ip-10-0-60-107 ~]$ sestatus
SELinux status:                 enabled
SELinuxfs mount:                /selinux
Current mode:                   enforcing
Mode from config file:          enforcing
Policy version:                 24
Policy from config file:        targeted
```

Turn off SELinux by editing line 7 of the following file by changing the parameter 'enforcing' to 'disabled':

```
[ec2-user@ip-10-0-60-107 ~]$ sudo vi /etc/selinux/config

# This file controls the state of SELinux on the system.
# SELINUX= can take one of these three values:
#     enforcing - SELinux security policy is enforced.
#     permissive - SELinux prints warnings instead of enforcing.
#     disabled - No SELinux policy is loaded.
SELINUX=disabled
# SELINUXTYPE= can take one of these two values:
#     targeted - Targeted processes are protected,
#     mls - Multi Level Security protection.
SELINUXTYPE=targeted
```

Save and Quit out of the file. We will need to reboot to make the SELinux changes take effect, but first...

Check if Memory Swapping is turned on. If it is on, let's turn it off since it's not recommended to use this linux feature with Hadoop:

```
[ec2-user@ip-10-0-60-107 ~]$ cat /proc/sys/vm/swappiness
60
```

Swapping is on and set to 60. **Turn swapping off by opening the following file and adding the appending the line 'vm.swappiness = 0' to the end of the file:**

```
[ec2-user@ip-10-0-60-107 ~]$ sudo vi /etc/sysctl.conf
<beginning of file truncated>
# Controls the maximum shared segment size, in bytes
kernel.shmmax = 68719476736

# Controls the maximum number of shared memory segments, in pages
kernel.shmall = 4294967296

vm.swappiness = 0
```

Save and Quit out of the file.

Reboot the server to make the SELinux and swap changes take effect:

```
[ec2-user@ip-10-0-60-107 ~]$ sudo reboot

Broadcast message from ec2-user@ip-10-0-60-107
        (/dev/pts/1) at 2:18 ...

The system is going down for reboot NOW!
```

Once you are reconnected, verify SELinux and swapping are disabled:

```
[ec2-user@ip-10-0-60-107 ~]$ sestatus
SELinux status:                 disabled

[ec2-user@ip-10-0-60-107 ~]$ cat /proc/sys/vm/swappiness
0
```

Finally, we are ready to download and install Cloudera Manager:

```
[ec2-user@ip-10-0-72-36 ~]$ pwd
/root

[ec2-user@ip-10-0-72-36 ~]$ wget
http://blueplastic.com/databricks/cloudera-manager-installer.bin
--2014-10-27 03:27:04--
http://blueplastic.com/databricks/cloudera-manager-installer.bin
Resolving blueplastic.com... 74.220.207.68
Connecting to blueplastic.com|74.220.207.68|:80... connected.
HTTP request sent, awaiting response... 200 OK
Length: 510569 (499K) [application/octet-stream]
Saving to: “cloudera-manager-installer.bin”

100%[======================================>] 510,569      717K/s   in 0.7s

2014-10-27 03:27:05 (717 KB/s) - “cloudera-manager-installer.bin” saved
[510569/510569]
```

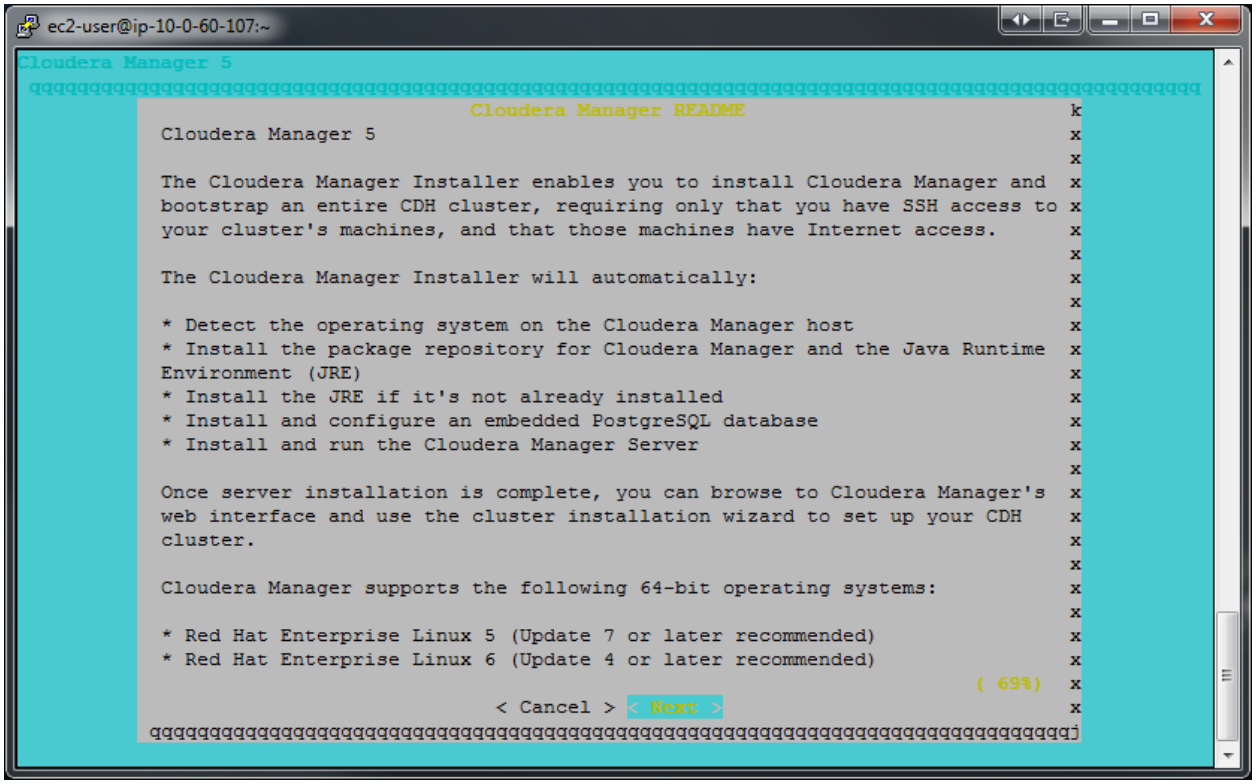
Set the installer file to have executable permissions:

```
[ec2-user@ip-10-0-72-36 ~]$ ls -l
total 504
-rw-r--r-- 1 root root 510569 Sep 30 21:13 cloudera-manager-installer.bin

[ec2-user@ip-10-0-72-36 ~]$ chmod u+x cloudera-manager-installer.bin

[ec2-user@ip-10-0-72-36 ~]$ ls -l
total 504
-rwxr--r-- 1 root root 510569 Sep 30 21:13 cloudera-manager-installer.bin
```

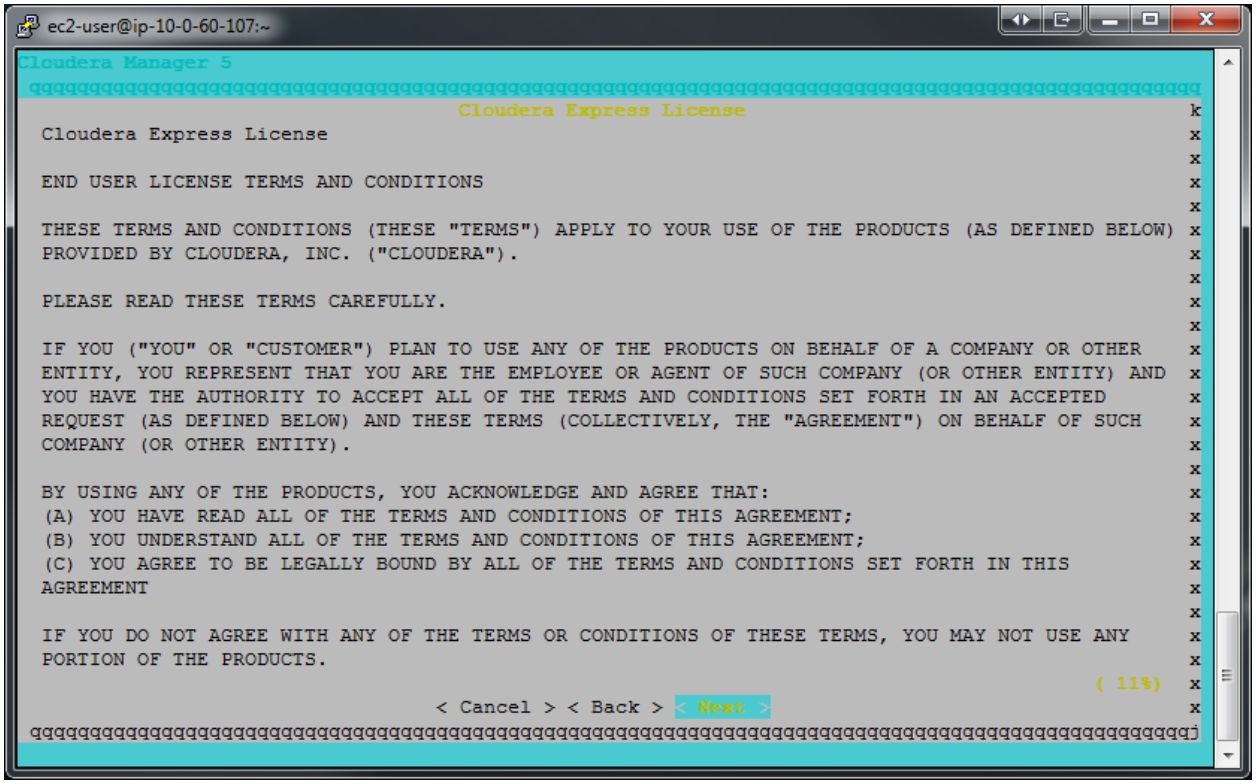
Run the Cloudera Manager installer:

```
[ec2-user@ip-10-0-72-36 ~]$ sudo ./cloudera-manager-installer.bin
```

Press Enter to choose Next for the Readme file:



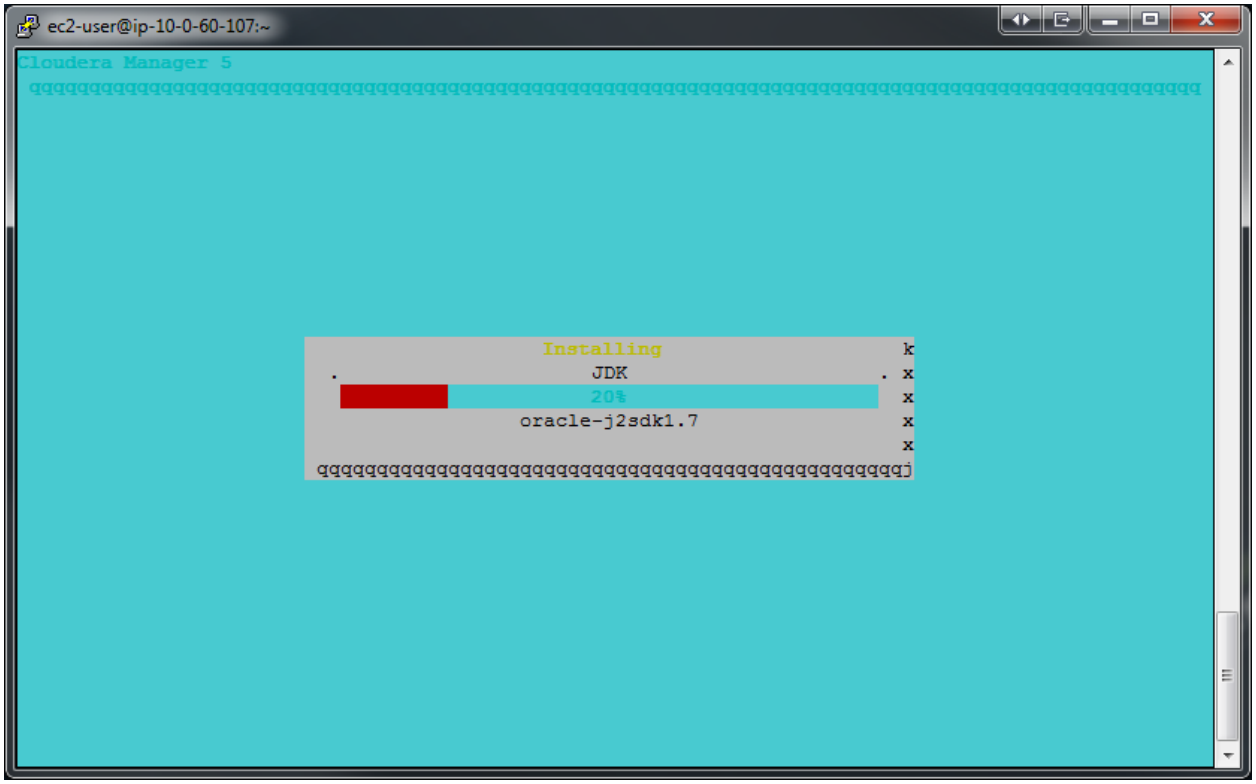
Then you will see this, simply hit enter to choose Next again:



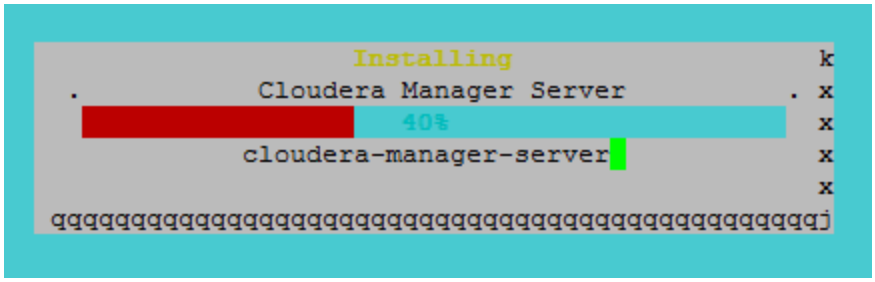
Now use the right arrow key to choose Yes for the license agreement.

The Oracle Binary Code License Agreement appears now. Press Enter to choose Next and then choose Yes on the 'Accept this license' screen.

The Oracle JDK installation will begin:

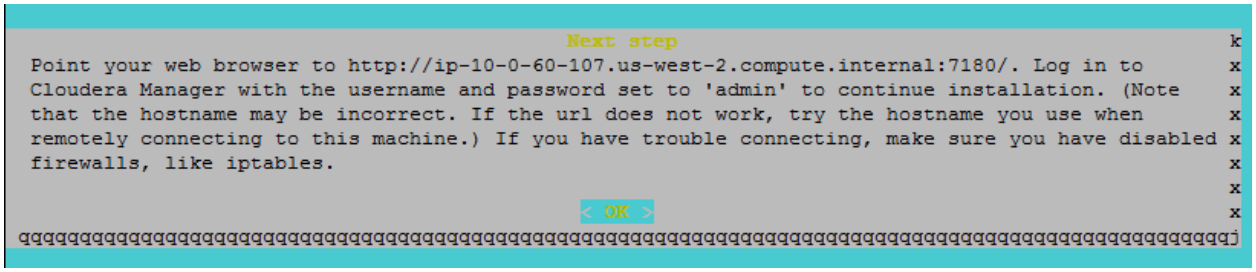


Followed by the CM installation:



The installer will also install an embedded PostgreSQL database server.

When the installation is finished, you will see this prompt. **Note that the URL is an internal hostname, so you will not be able to use it to access the GUI for Cloudera Manager (instead you'll have to use the *public* hostname). Hit Enter to return to the linux cmd prompt:**



Choose OK on the final installation screen:

You should now be returned to the linux cmd prompt.

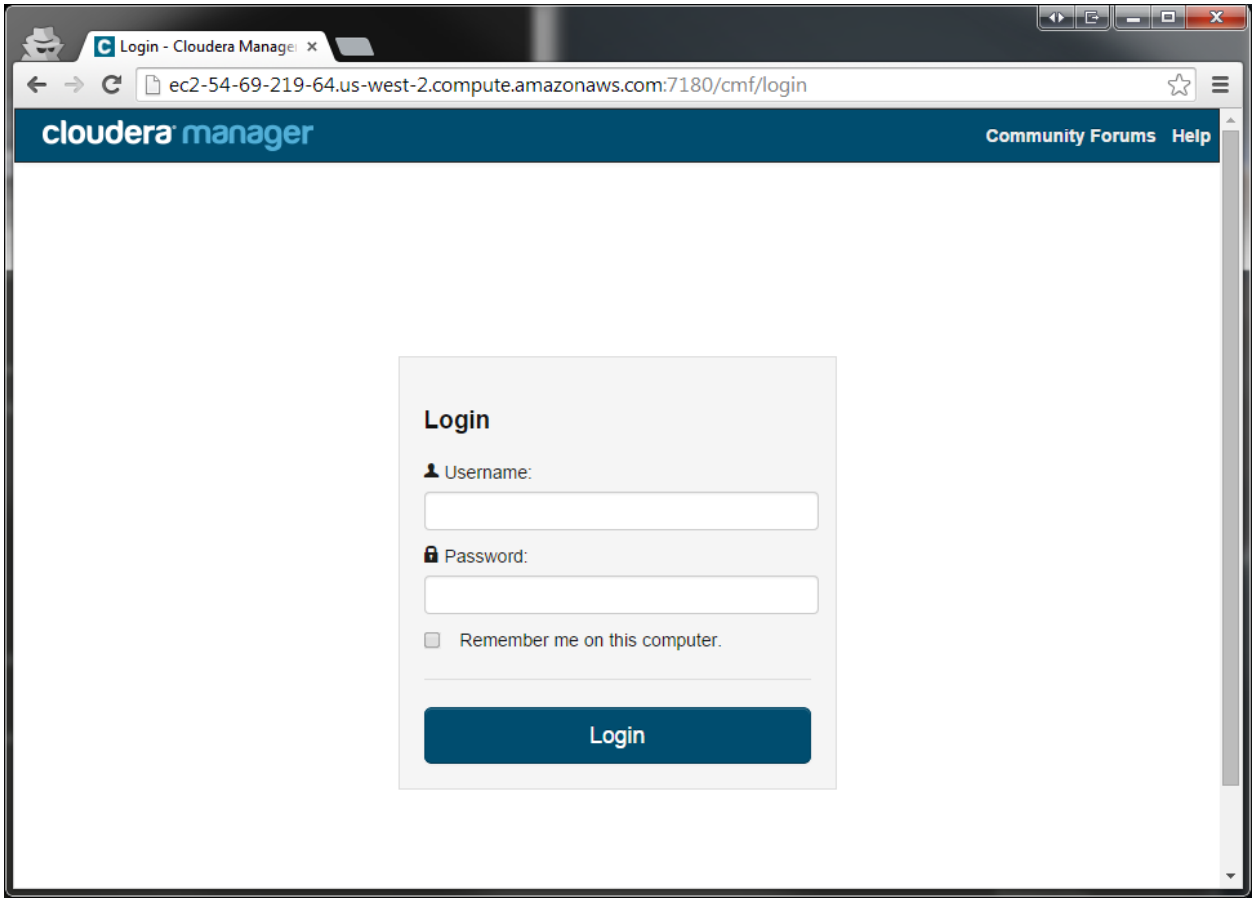
Connect to Cloudera Manager Admin Console to install CDH

So far, only Cloudera Manager has been installed on the Amazon VM. CDH5 has not been installed yet. Time to do that now.

Note, once you start this section, it is very important not to close your browser tab or to click 'back' in the browser while the installation is happening.

Wait for about 45 seconds for the Cloudera Manager web site service to start up and then…

From Chrome or Firefox, go to the server URL for Cloudera Manager:
`http://<your public hostname or ip>:7180`

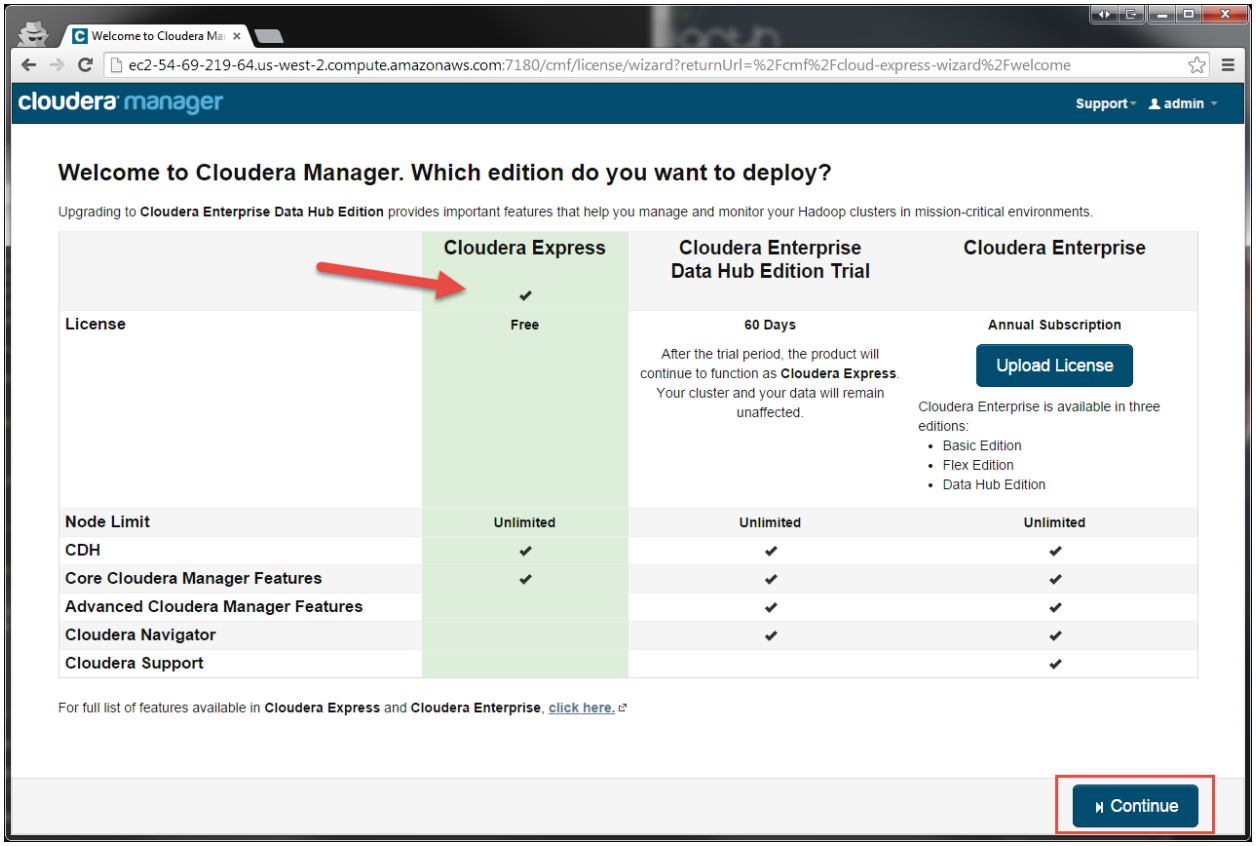


Log in to Cloudera Manager using the default credentials:

Username: **admin**
Password: **admin**

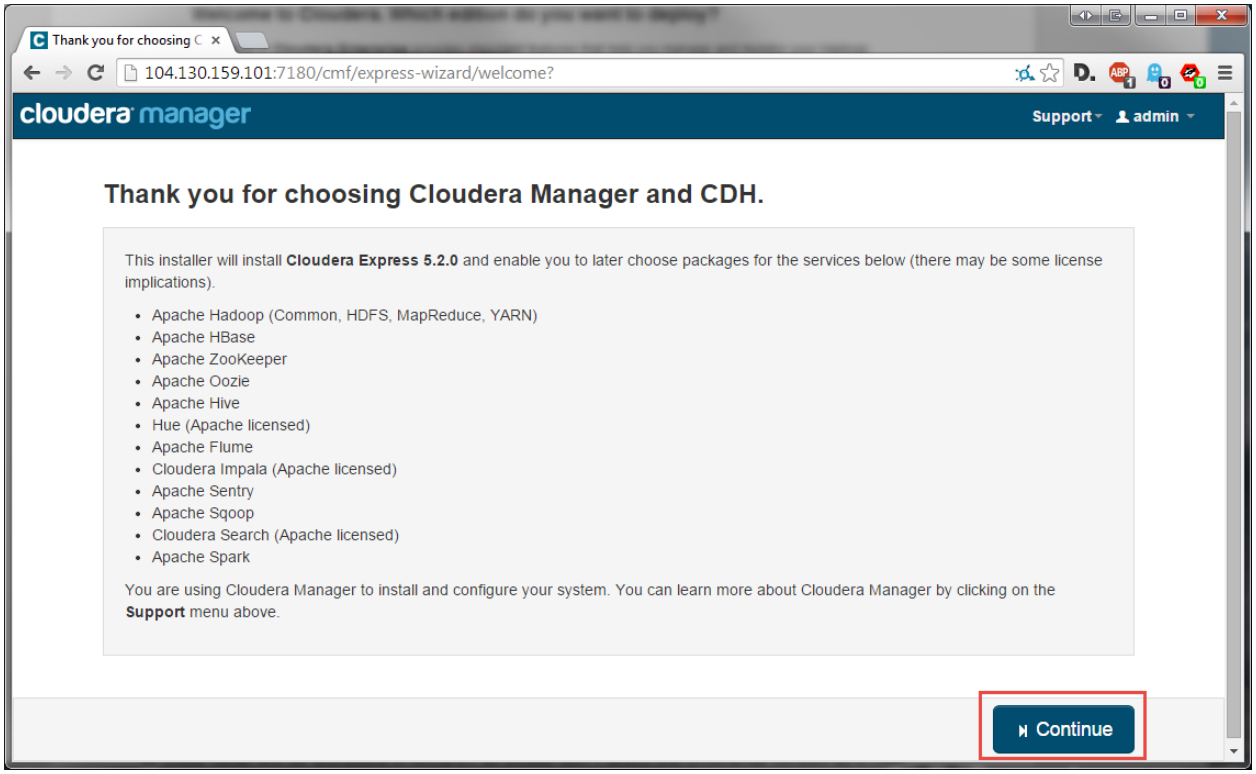
Put a tick mark next to "**Remember me on this computer**".

The Cloudera Manager welcome screen and edition selector now appears. **Click on Cloudera Express and then Continue at the bottom of the screen:**

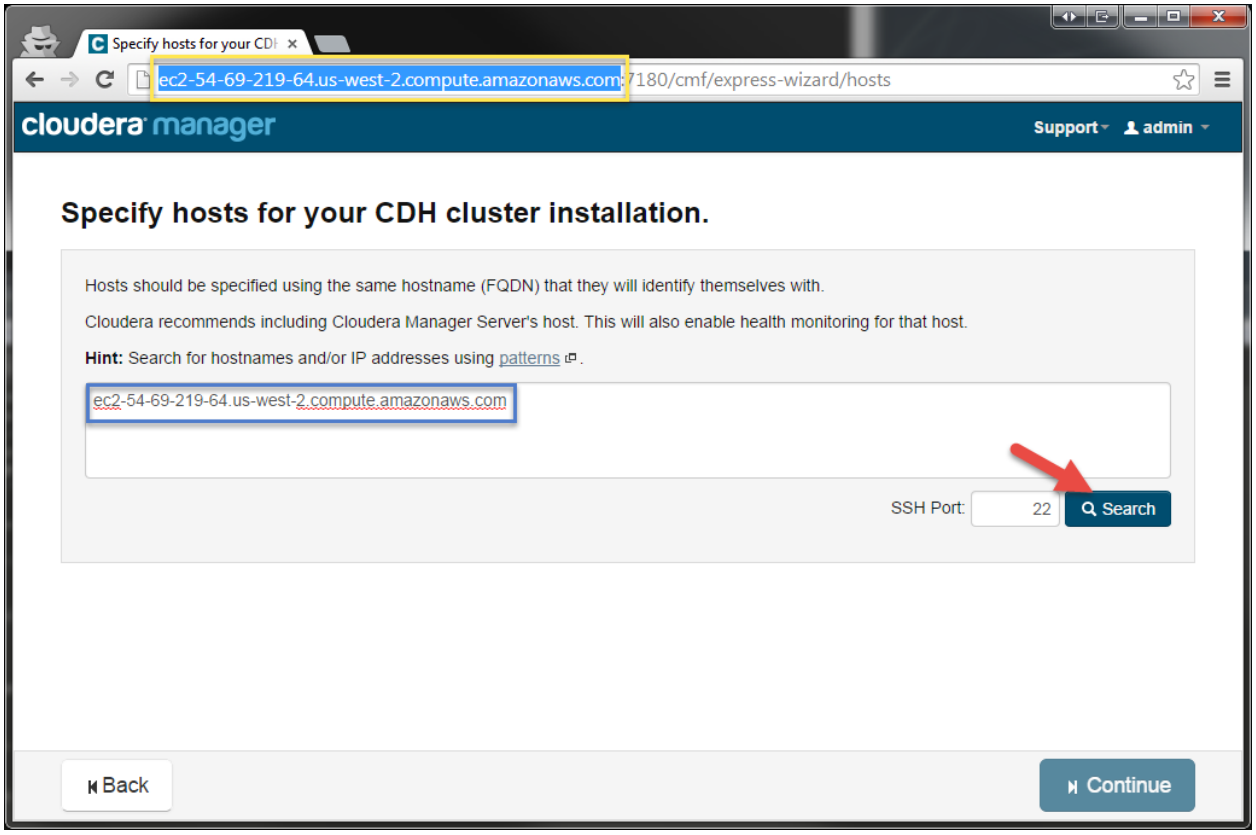


Note, we will not be using the Cloudera Enterprise features in this lab, so please don't select the Enterprise version as it may add more memory overhead to the install.

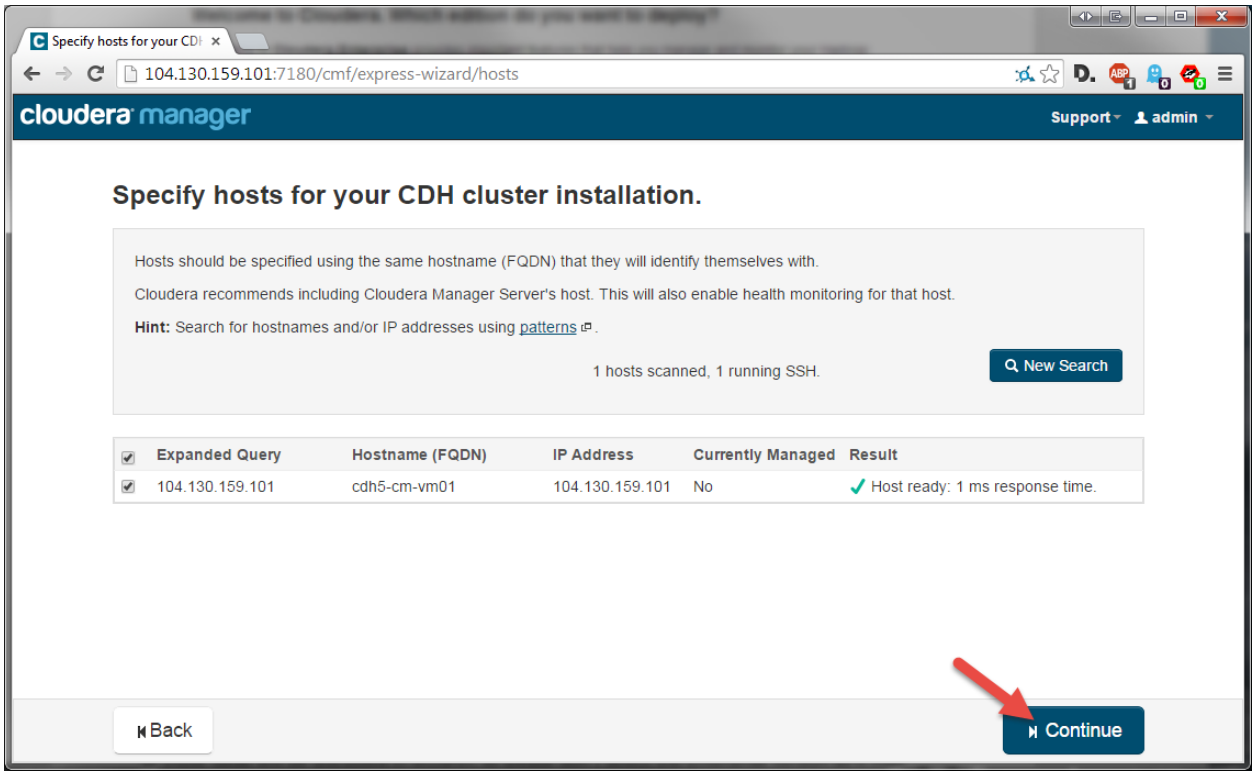
On the Thank you screen, just click Continue:



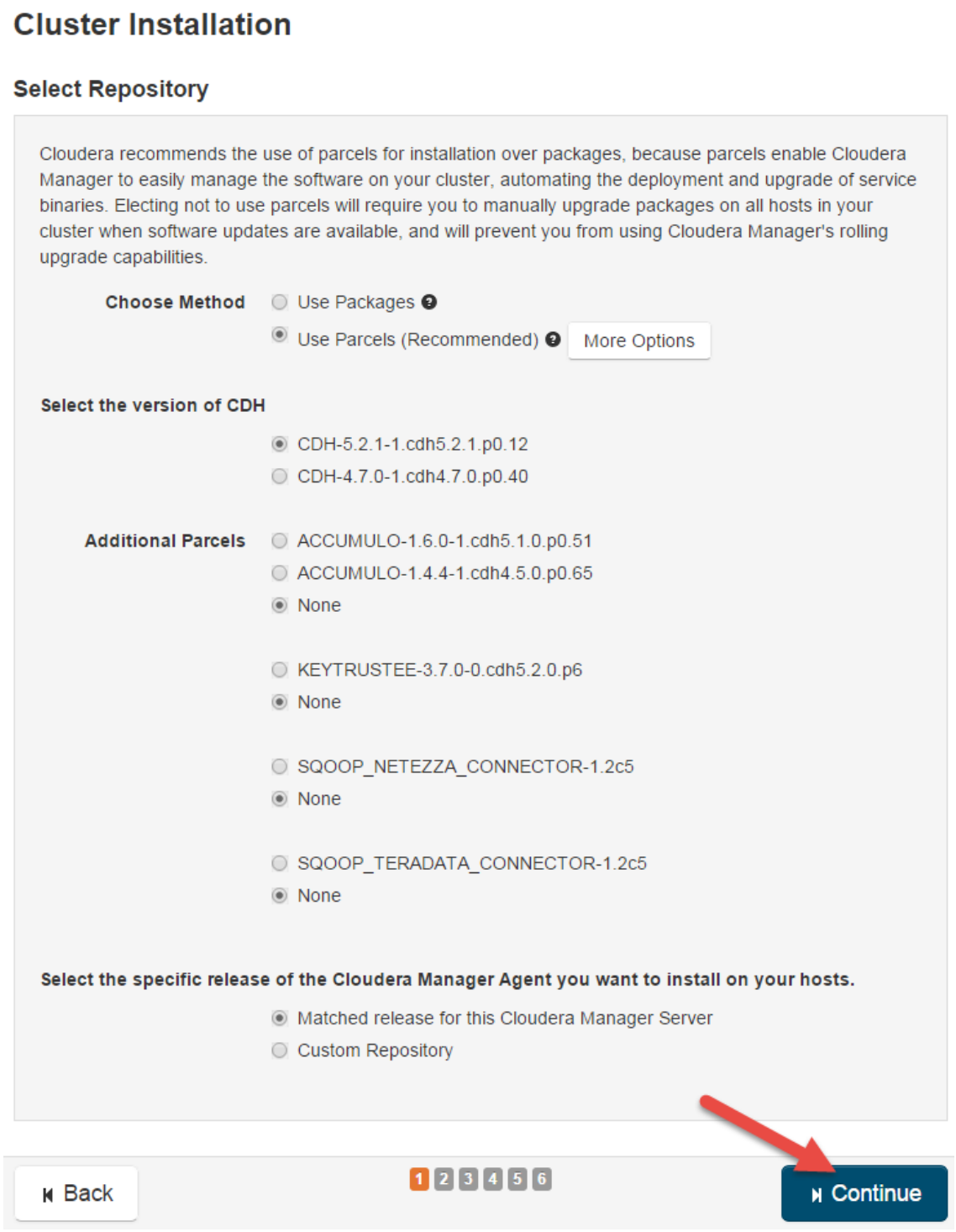
Type in your public IP and click Search. You can copy + paste the IP from the URL:



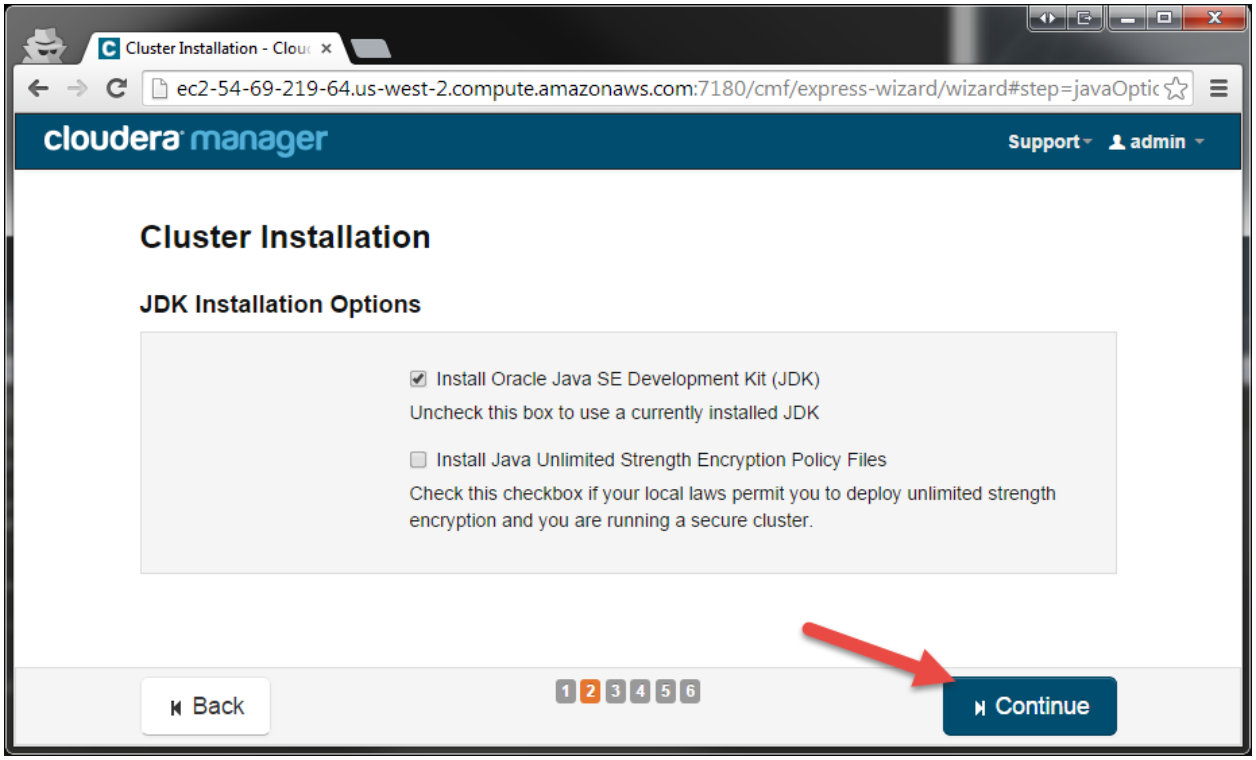
Your local Virtual Machine should now be found and automatically checked. **Click Continue**:



On the Cluster Installation screen, verify that your settings are the same as the screenshot below and click Continue. Do NOT install Accumulo, or the Sqoop connectors at this time as they will not be used in this lab and will consume extra resources on the VM. This lab was created using CDH 5.2.1 and it is highly recommended that you stick with this version of this lab, so you have a consistent environment as the instructor and other students.

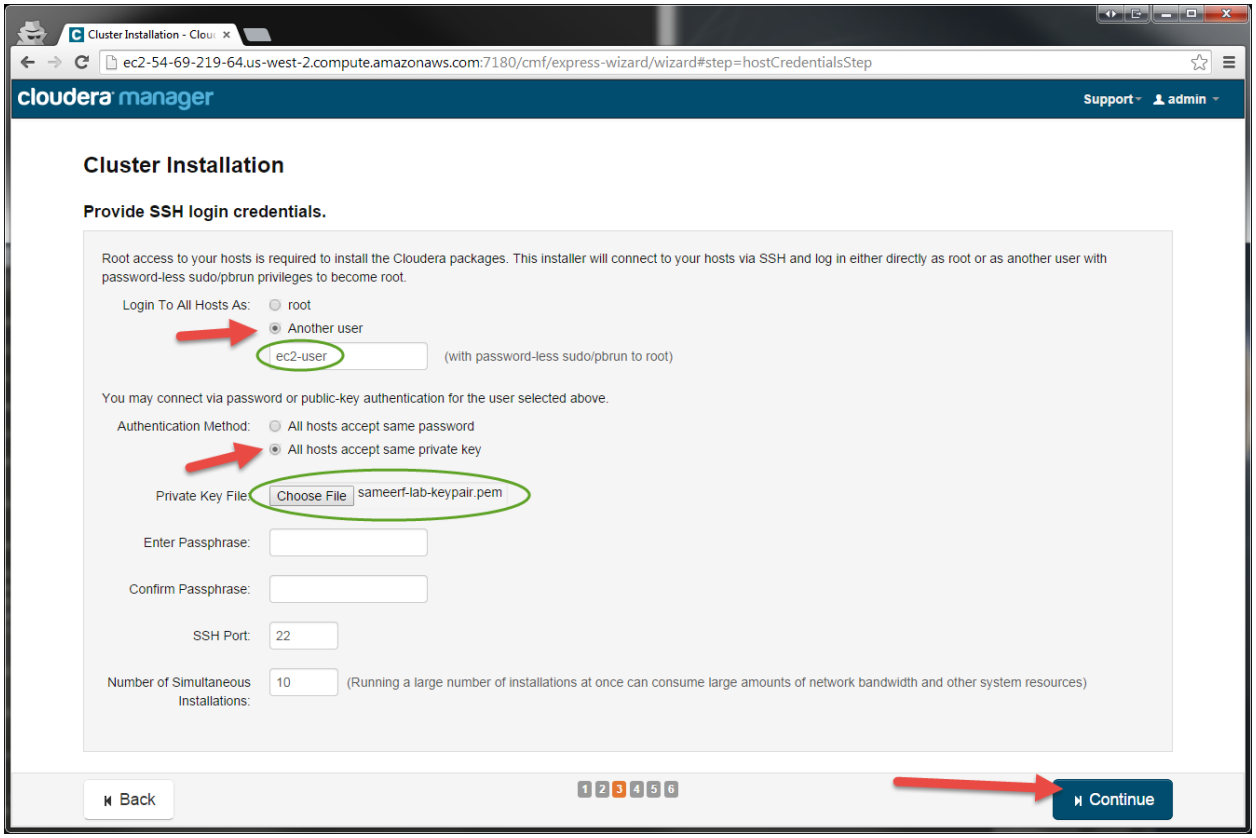


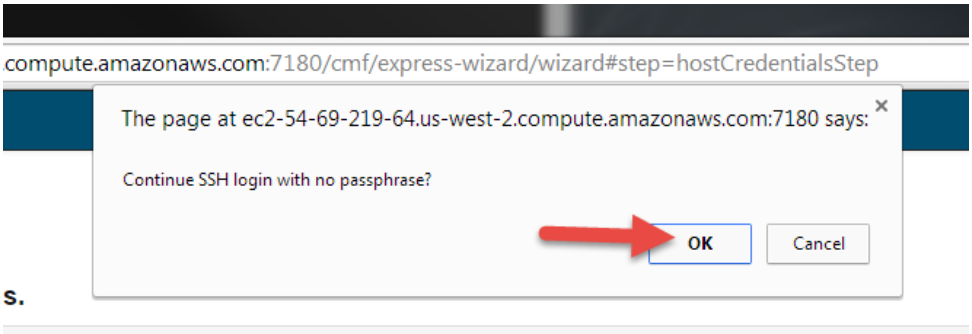
The next screen gives you the option to install Oracle JDK. Since the Oracle JDK is the most widely deployed and tested JDK for Hadoop, we'll also run with the Oracle version. **Just click Continue:**



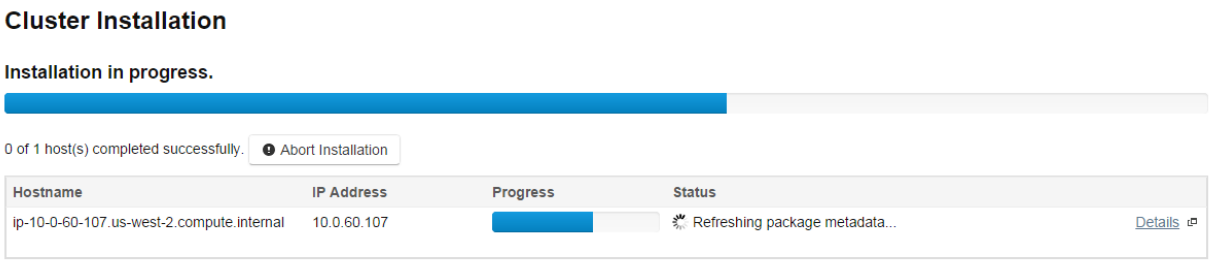
On the 'SSH login credentials' page, choose to:

- **Login To All Hosts As: Another user (type in this username: ec2-user)**
- **Authentication Method: All hosts accept same private key (then click Choose File and select the `.pem` file the instructor gave you)**
- **In the pop-up to 'Continue SSH login with no passphrase?', just click OK**

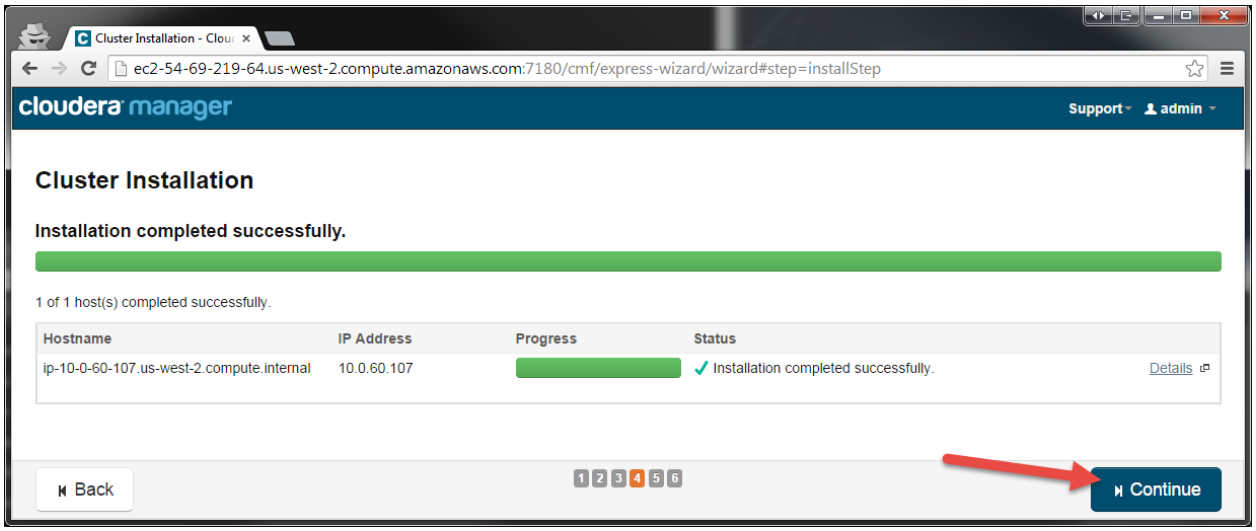




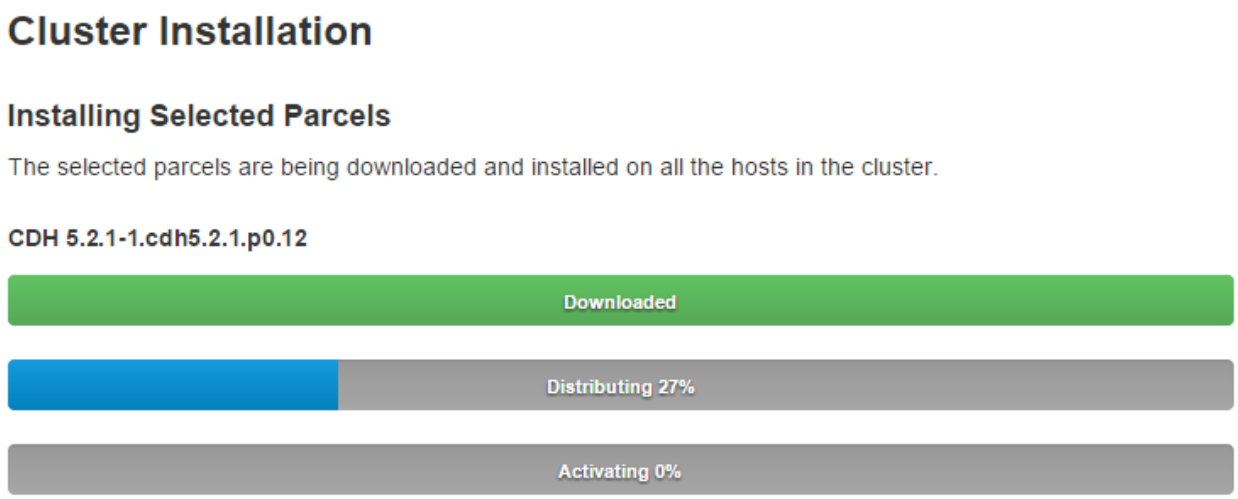
The cluster installation will now kick off and run for ~1 minute:



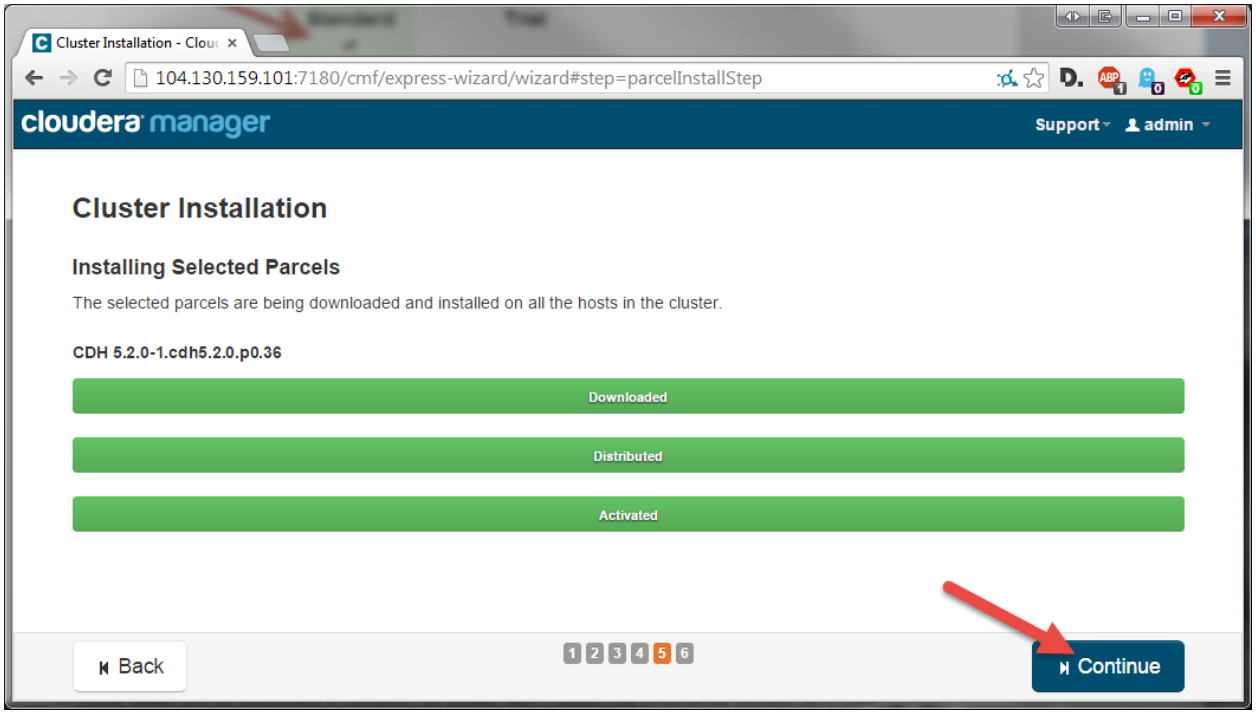
When it is finished, click Continue:



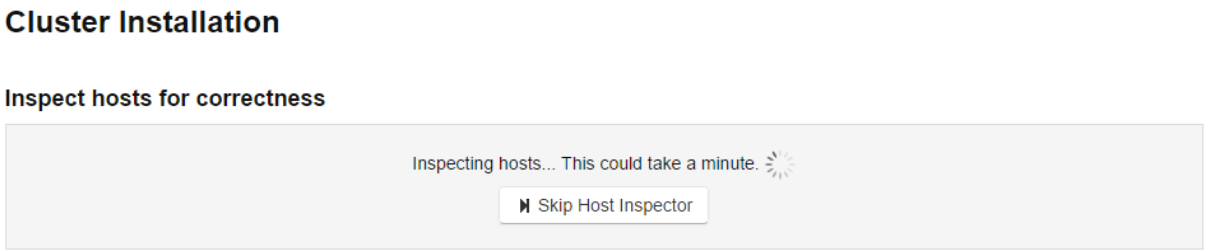
The Parcels installation will now start (note this part will take about 2 - 3 minutes):



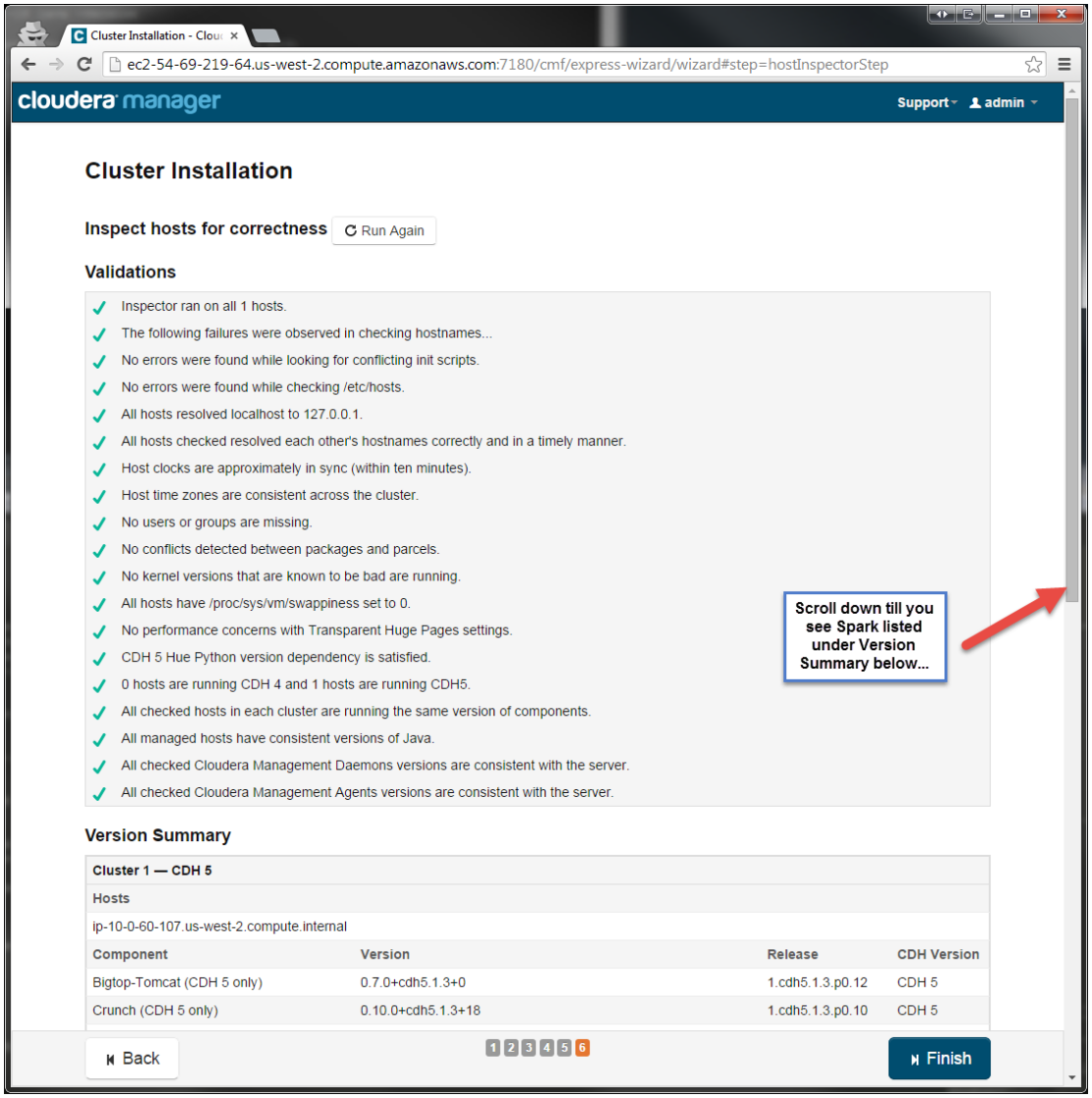
When the Parcels installation is complete, click Continue to proceed:



The host inspector will automatically run. It should find nothing wrong and automatically take you to the following page of Validations:



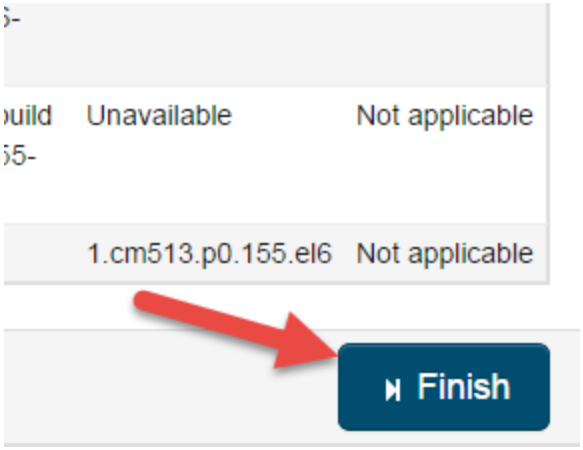
Scroll down till you see the different versions of the various Apache projects listed under Version Summary below:



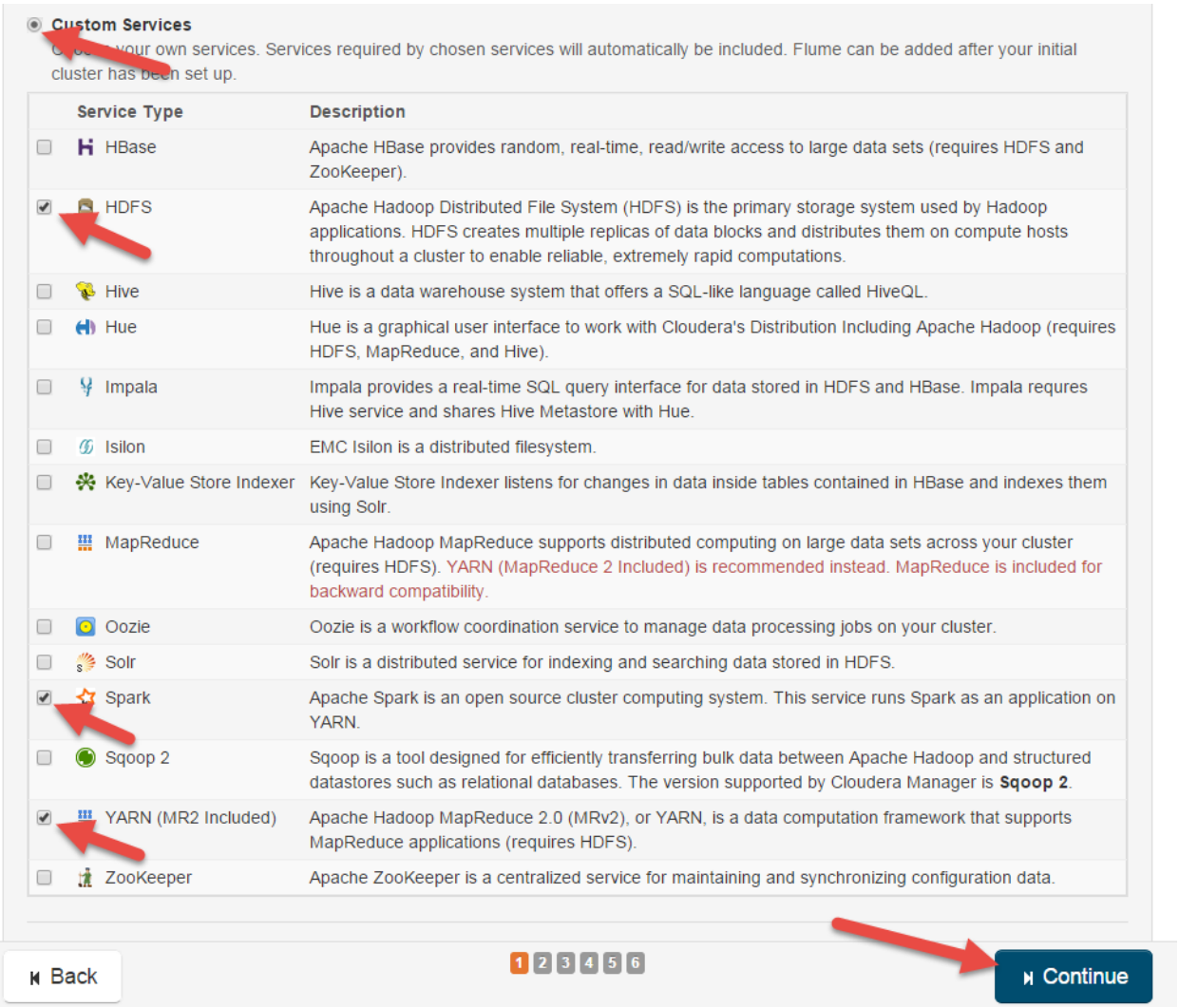
Notice that we are running Spark 1.1.0:

CDH 5.2 also comes with HDFS 2.5 and YARN 2.5.

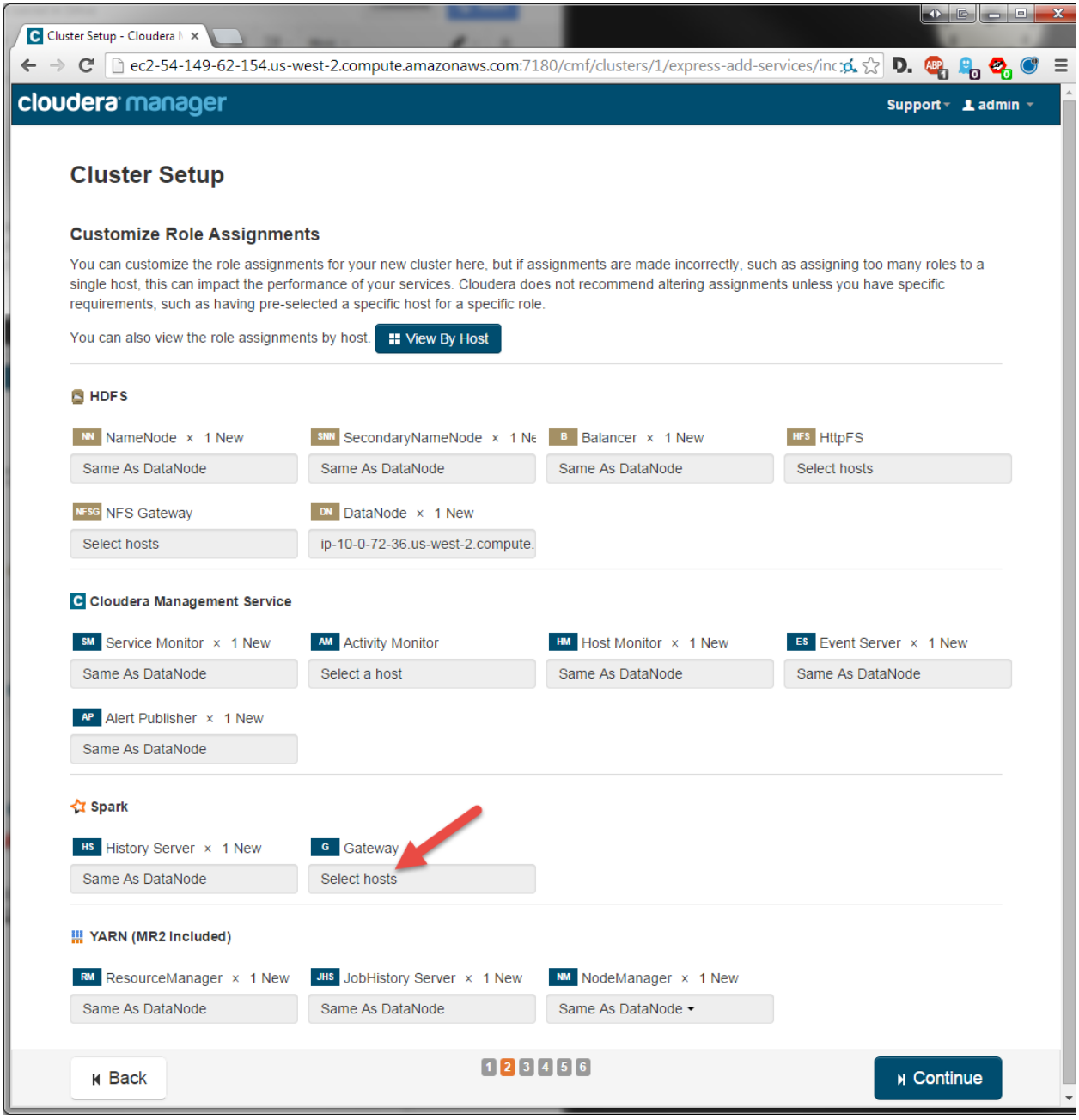
Click Finish:



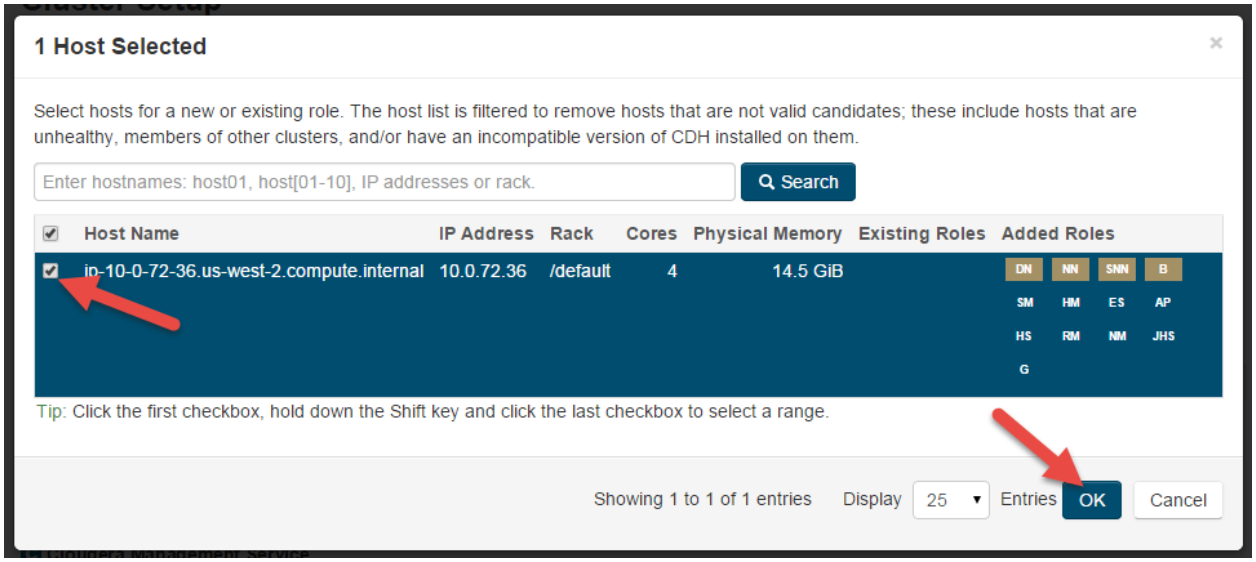
We are almost finished with the CDH installation wizard. Now we have to choose which of the CDH 5 servers we want to start. **Click on 'Custom Services' and *only select the items selected in the screenshot below*. Then click Continue.**



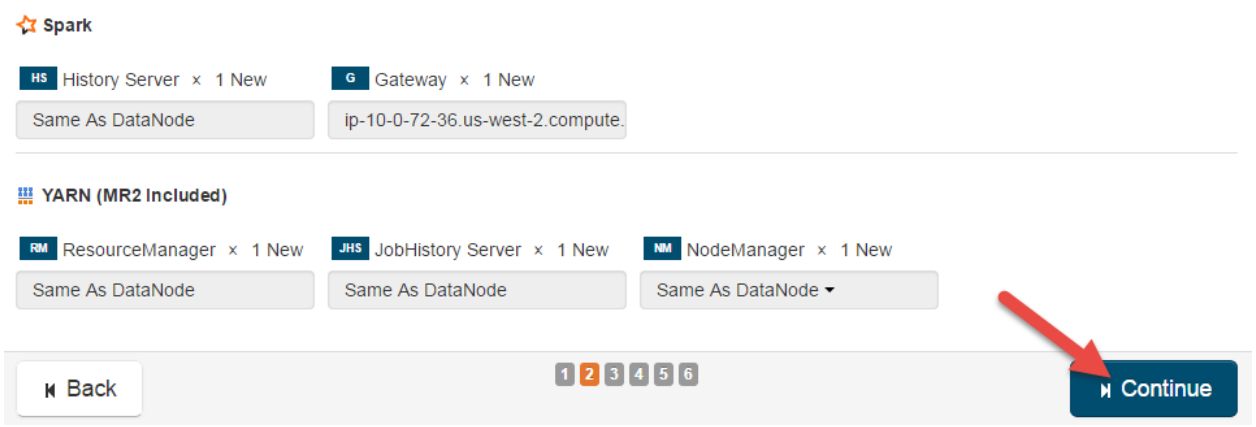
On the Customize Role Assignments page, we have to make 1 change. For the Spark service, we will want to Select a host for the Gateway. **Click Select a host under Spark's Gateway Server:**



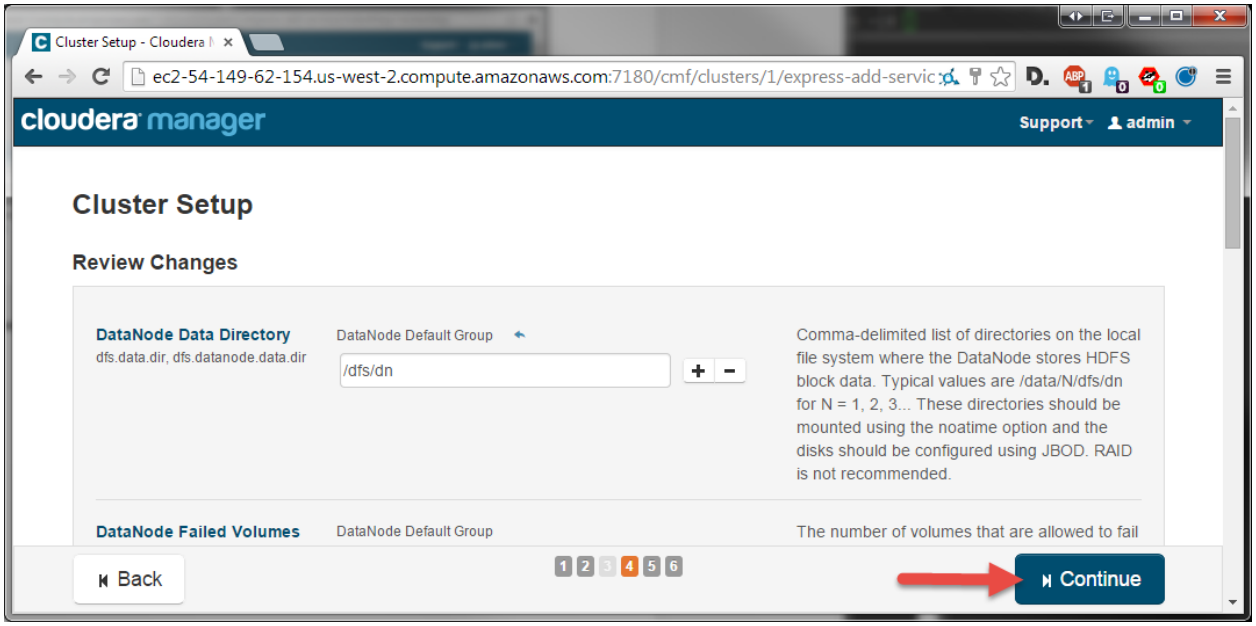
When a pop-up appears, click on the only Host Name that you see and click OK:



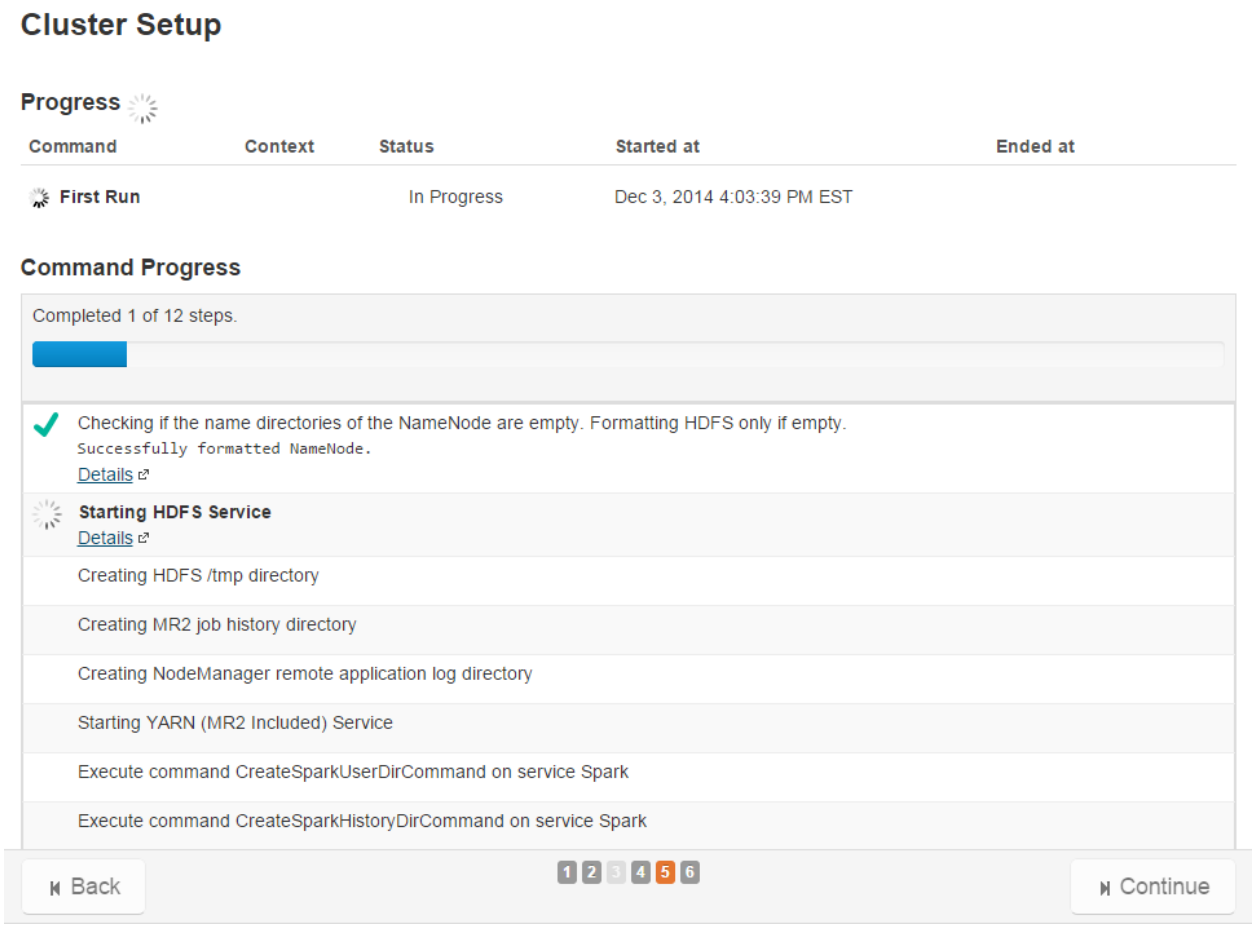
Almost done. Click Continue:



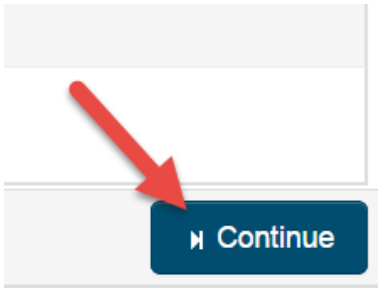
There's no need to make changes on this page (but feel free to review the settings if you'd like as an FYI)**. Click Continue:**



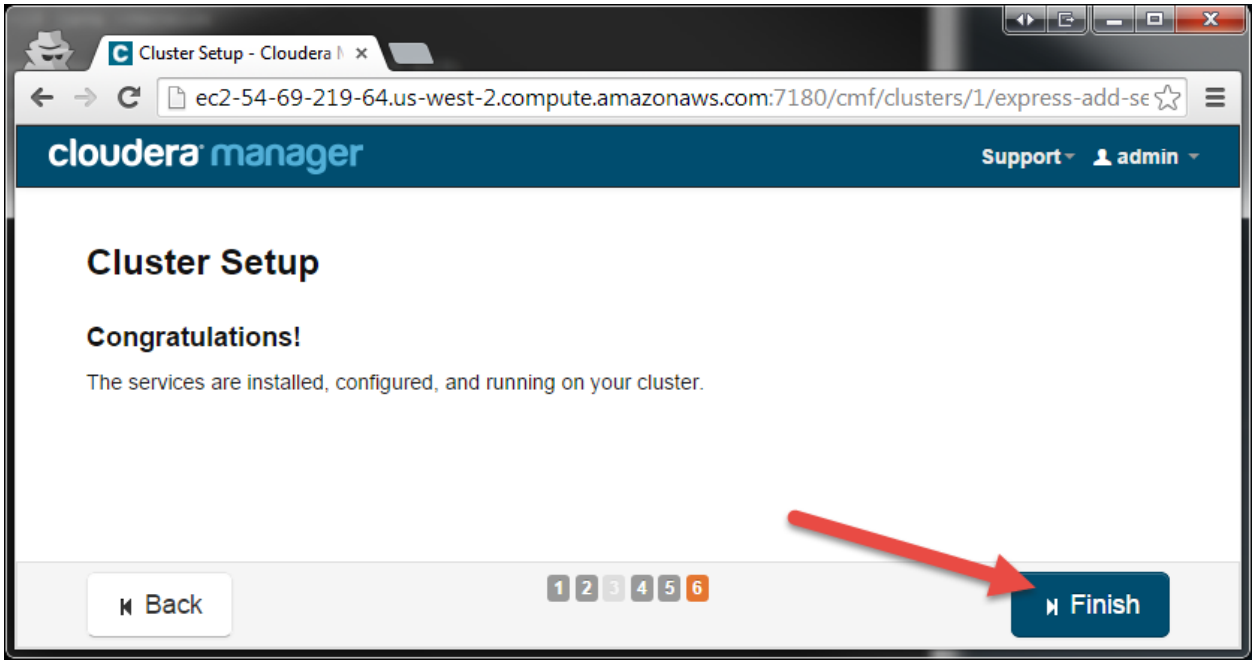
The Cluster Setup will run through 12 steps as seen here:



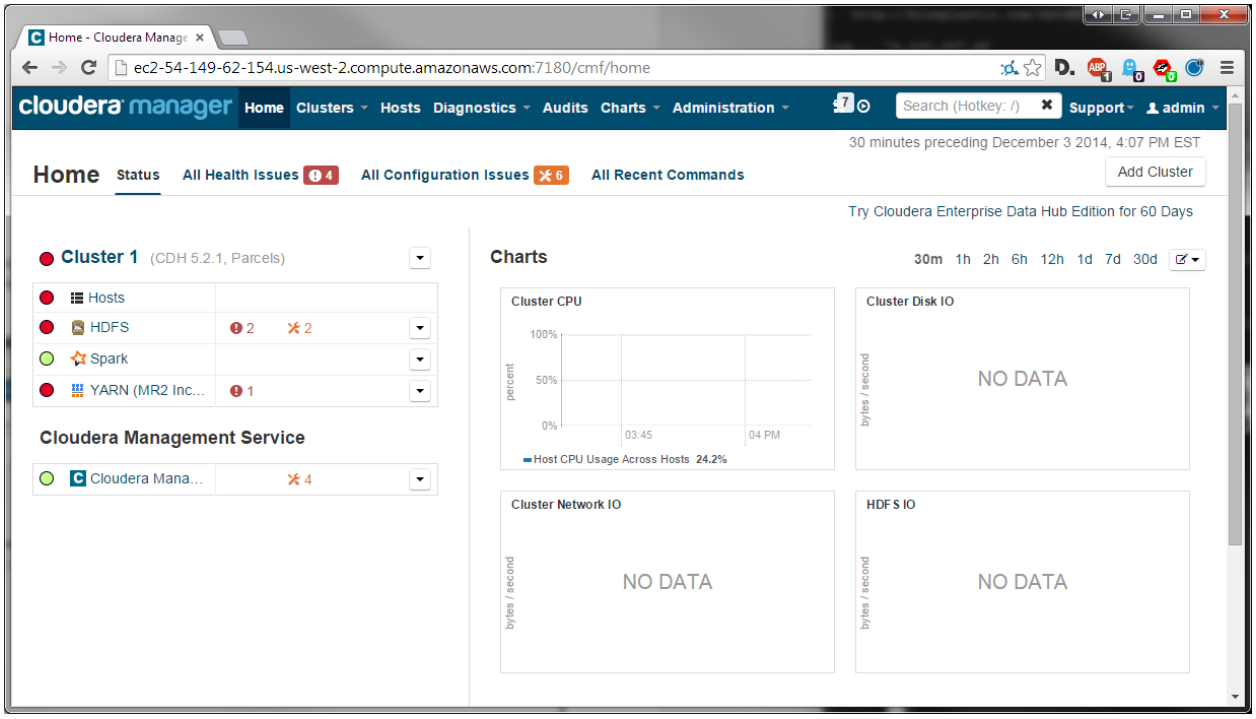
Click Continue when the 12 steps are finished:



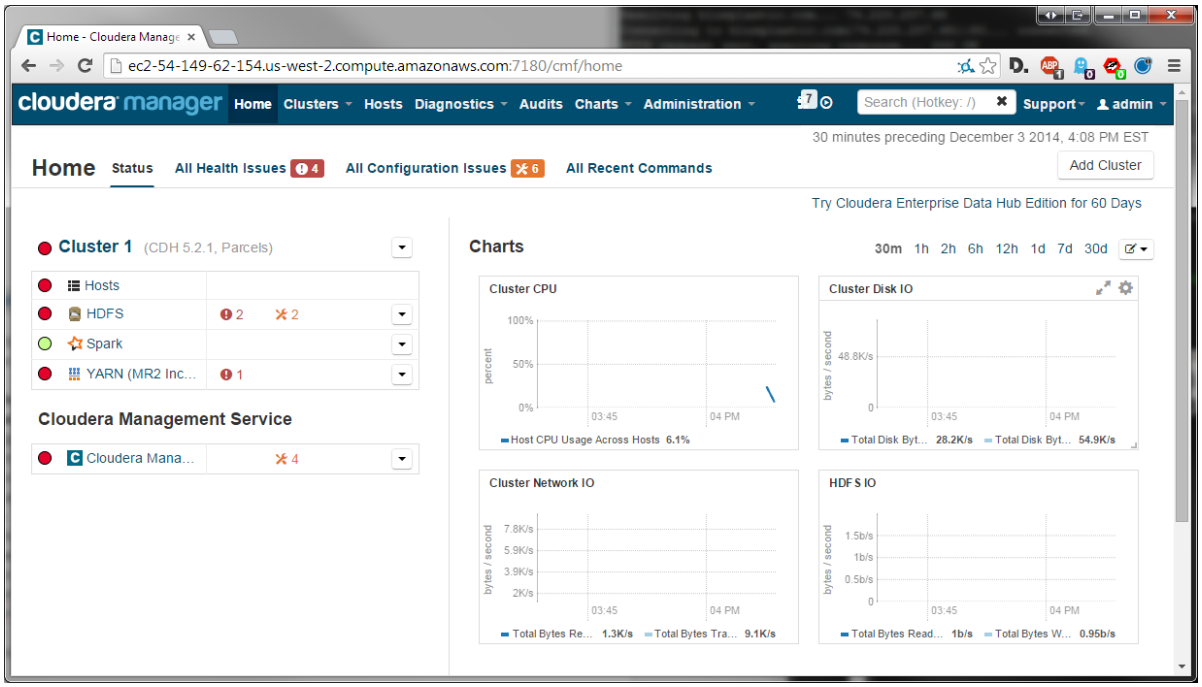
You are now finished with the CDH 5 installation and services startup! Click Finish:


Cluster Setup - Cloudera
ec2-54-69-219-64.us-west-2.compute.amazonaws.com:7180/cmf/clusters/1/express-add-se
cloudera manager
Support
admin
Cluster Setup
Congratulations!
The services are installed, configured, and running on your cluster.
Back
1 2 3 4 5 6
Finish

When you see the Cloudera Manager GUI, there will be some warnings and critical health issues displayed in red. We will address these in the next section.



After a few seconds the graphs will start to become populated:



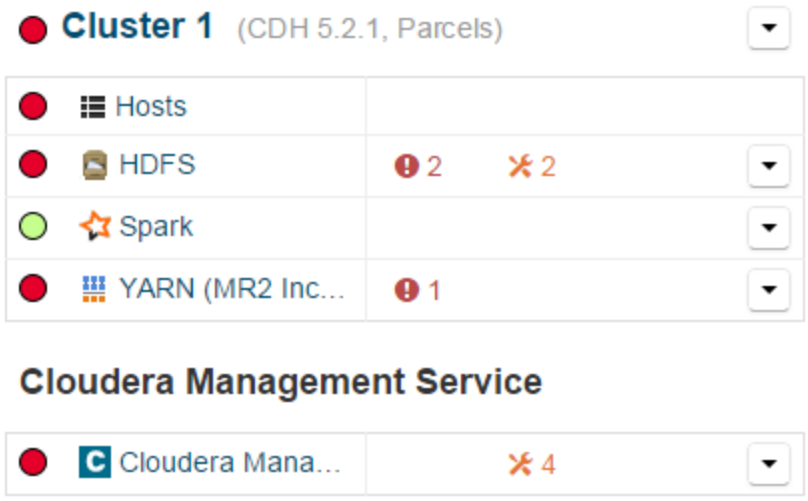
Post-install work & exploring Cloudera Manager

Now that the CDH installation is finished, run the jps command to see which Java daemons have started up:

```
[ec2-user@ip-10-0-72-36 ~]$ sudo /usr/java/jdk1.7.0_67-cloudera/bin/jps
8653 AlertPublisher
8445 HistoryServer
9345 Jps
7334 NodeManager
7377 JobHistoryServer
8591 Main
6455 DataNode
7562 ResourceManager
1649 Main
8608 EventCatcherService
8630 Main
6414 NameNode
6507 SecondaryNameNode
```

We will study these later on in the class.

Let's begin exploring Cloudera Manager by reviewing which services have been started for us by Cloudera Manager:



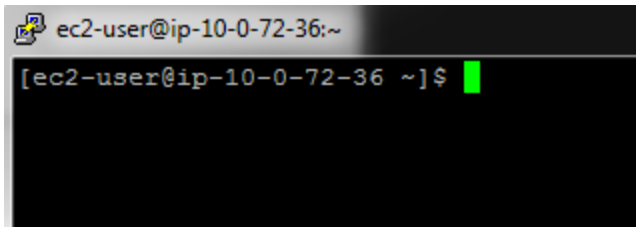
Note above that all services have actually started for us, including HDFS. HDFS & YARN are in a warning state, though, so we'll address that in the HDFS lab.

HDFS Command Line

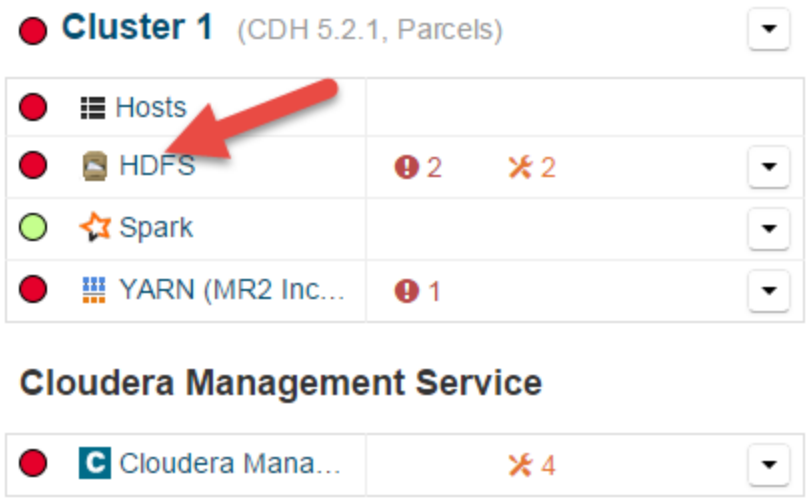
This 30 min lab introduces you to the HDFS command line. We will:

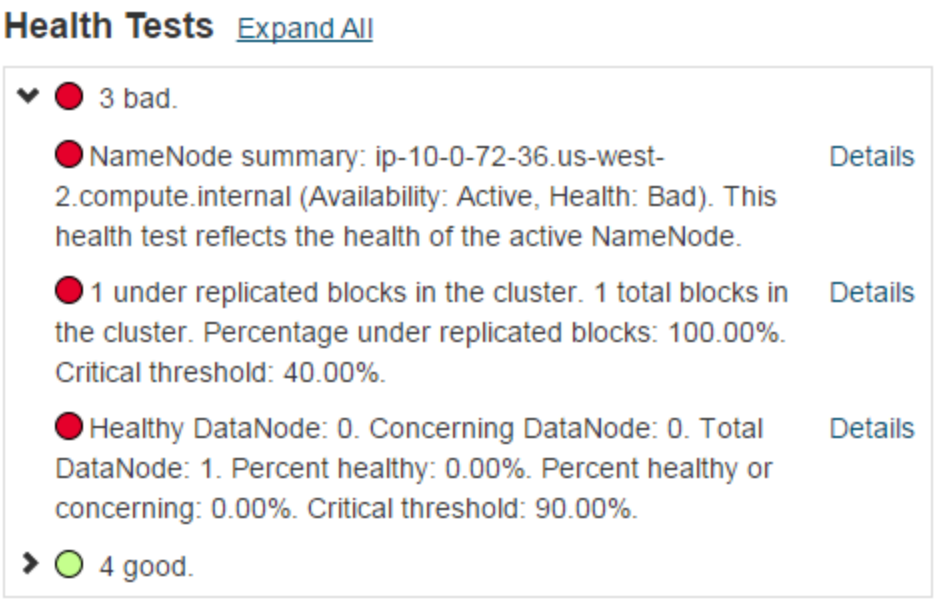
- change the replication factor in HDFS
- create directories in HDFS
- move files from the Linux file system to HDFS
- run a file system health check and look at the Block Scanner report
- explore the HDFS web GUIs

Following the end of the last lab, you should be at the EC2 VM command prompt as user 'ec2-user':



HDFS occasionally shows as in bad health b/c of under-replicated blocks. You can see this error if you click on the HDFS service and on the resulting page look under the Health Tests panel:





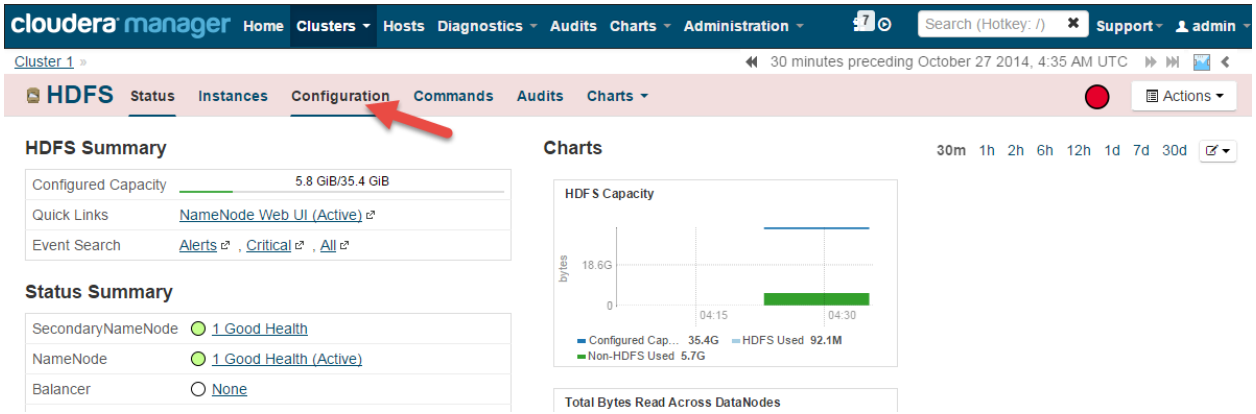
But just ignore this issue for now, we'll revisit it later.

First, we will do a few housekeeping tasks to get our 1-node cluster ready for business.

The default replication factor for HDFS is 3 and Cloudera Manager sets this as the default even though we have a 1-node cluster. Let's change the replication factor down to 1, since that makes more sense for our setup.

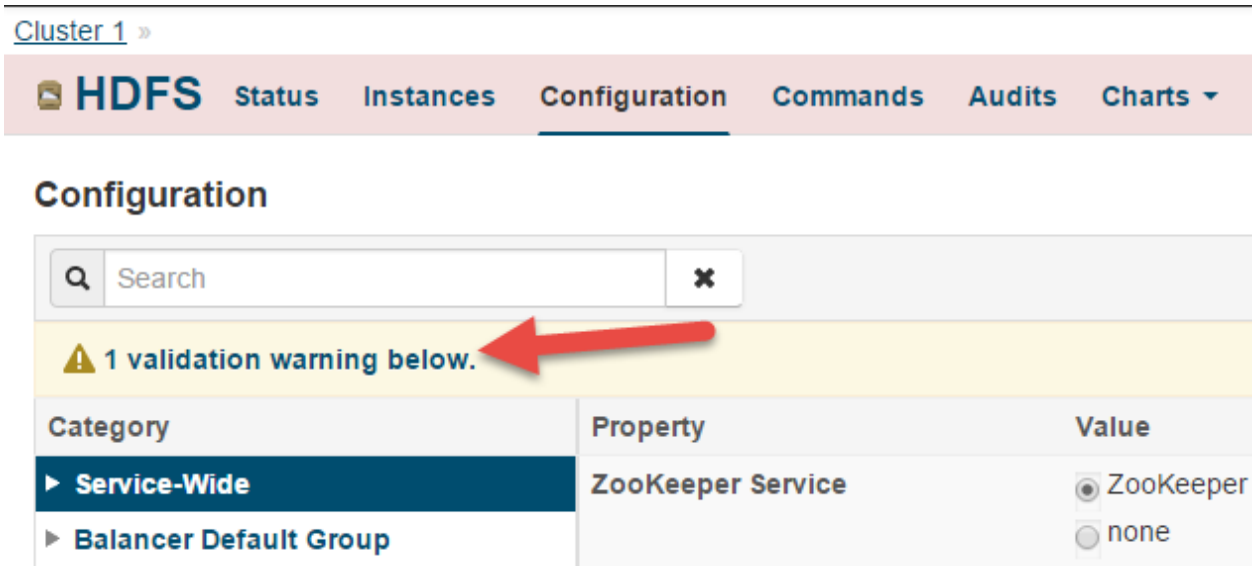
Note, that the replication factor change from 3 down to 1 will not affect the pre-existing files in HDFS, but only any new files that are added. The CDH5 install added about 11 files to HDFS and those files will remain with replication factor 3. We will change the replication factor for THOSE files later.

Under the HDFS service page, click on Configuration:



Here you will see 1 validation check and 1 validation warning.

Click on the validation warning:



You'll see that Cloudera Manager recommends at least 1 GB for the HDFS NameNode JVM, but b/c of low memory conditions, the NN has been restricted to using only 391 MB or so. This is actually fine for our lab's purposes. Notice in the warning (in the screenshot) that 1 GB of RAM supports 1 million HDFS blocks. We will not be even close to this in our lab.

Just so we're aware, take a look at how much free memory (in GB) and disk space is left on the server after the CM + CDH installations:

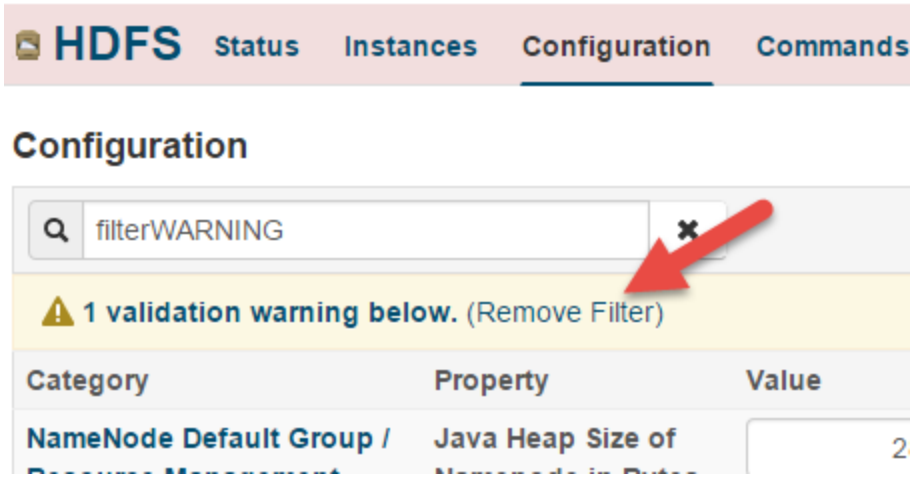
Switch to the CMD line and:

```
[ec2-user@ip-10-0-72-36 ~]$ free -g
             total       used       free     shared    buffers     cached
Mem:            14         10          4          0          0          6
-/+ buffers/cache:          3         11
Swap:            0          0          0
```

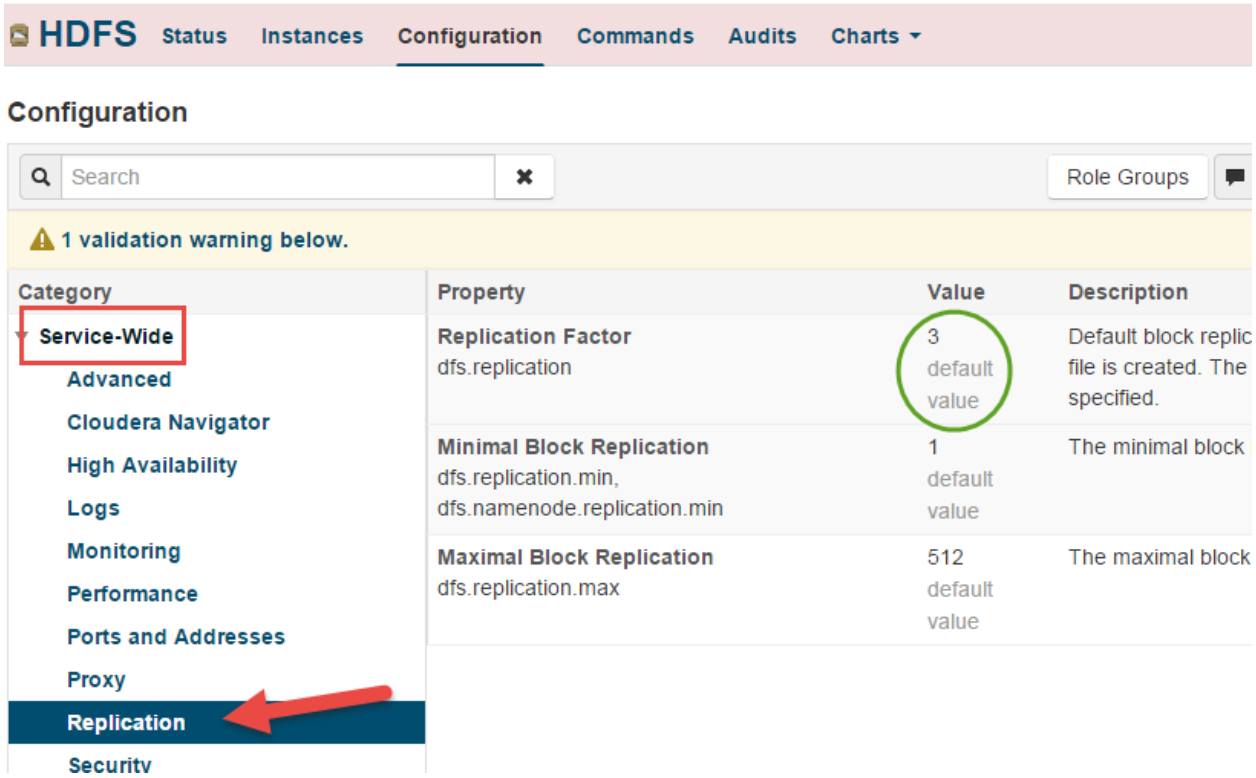
```
[ec2-user@ip-10-0-72-36 ~]$ df -Th
Filesystem     Type   Size  Used Avail Use% Mounted on
/dev/xvda1     ext4    40G  8.5G   29G  23% /
tmpfs          tmpfs  7.3G     0  7.3G   0% /dev/shm
cm_processes   tmpfs  7.3G  2.9M  7.3G   1%
```

Switch back to the web UI and:

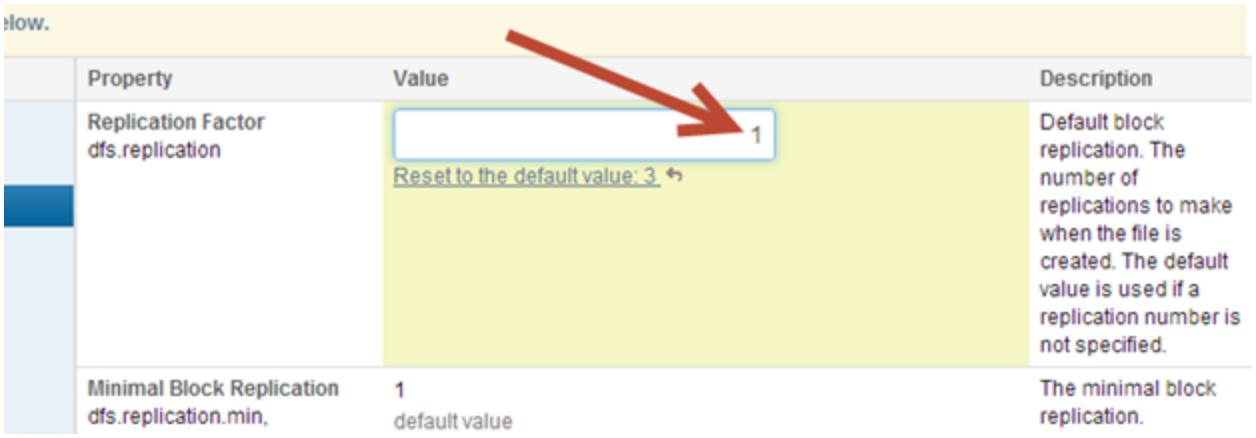
Click **Remove Filter** on the validation warning:



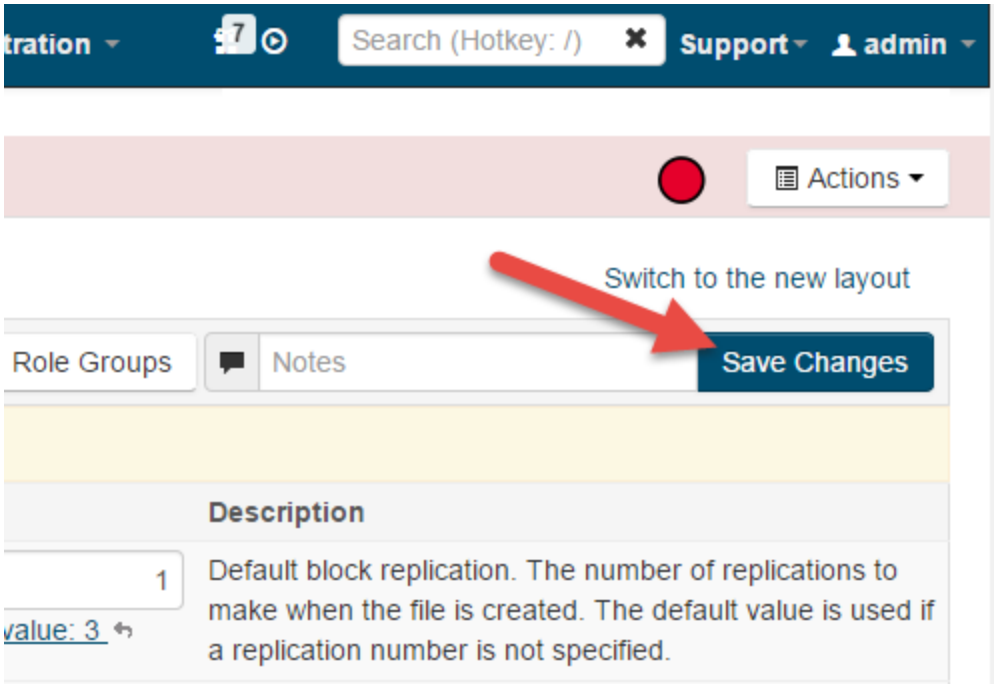
In the left pane, expand **Service-Wide** and click on **Replication**:



You'll notice that the dfs.replication is set to 3. But since we have only one node, we need to reduce this to 1. Click on 3 and change the value to 1.



Then click on **Save Changes** at the top of the screen:

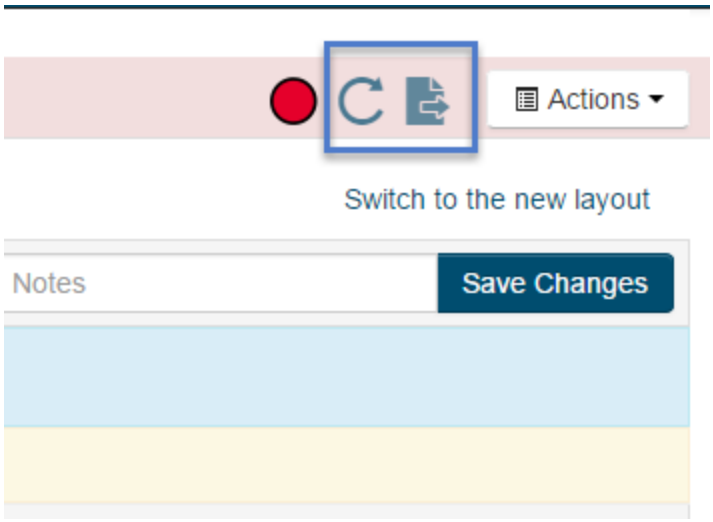


Saving the changes only applies it to Cloudera Manager's settings (stored in PostgreSQL) but not to the underlying Hadoop XML configuration files. We have to Deploy Client Configuration for the entire cluster and restart the HDFS service… then the new setting will take effect.

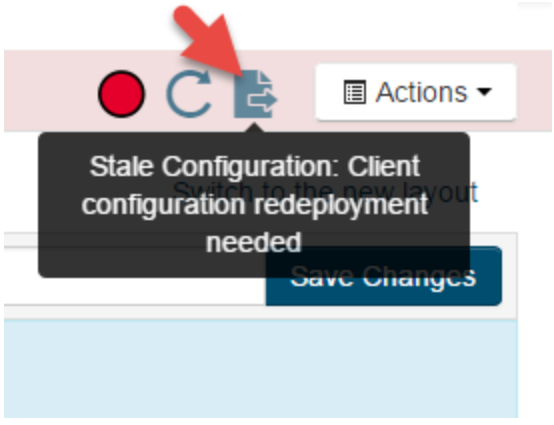
According to Cloudera: “Although Cloudera Manager will deploy client configuration files automatically in many cases, if you have modified the configurations for a service, you may need to redeploy those configuration files.”

Later in this lab, we will open the hdfs-site.xml file to verify that the replication factor is indeed set to 1.

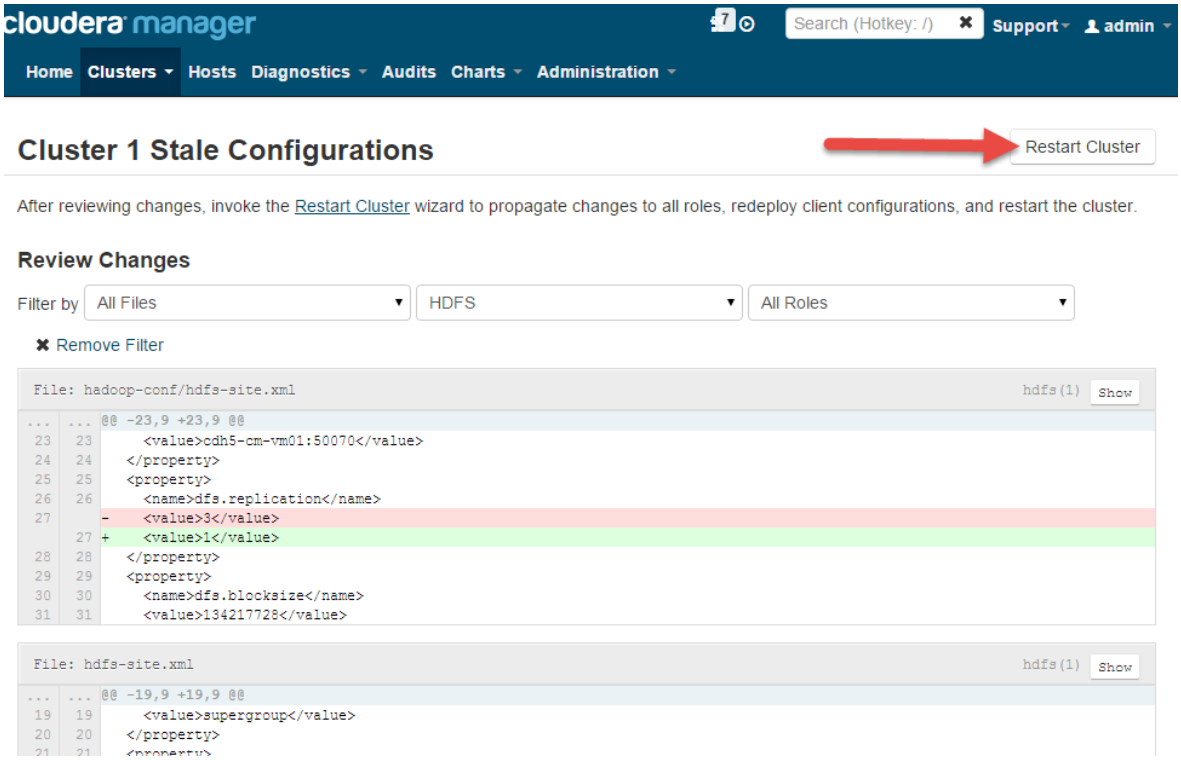
Notice that a couple of new icons have appeared to deploy client configuration and restart the HDFS service:



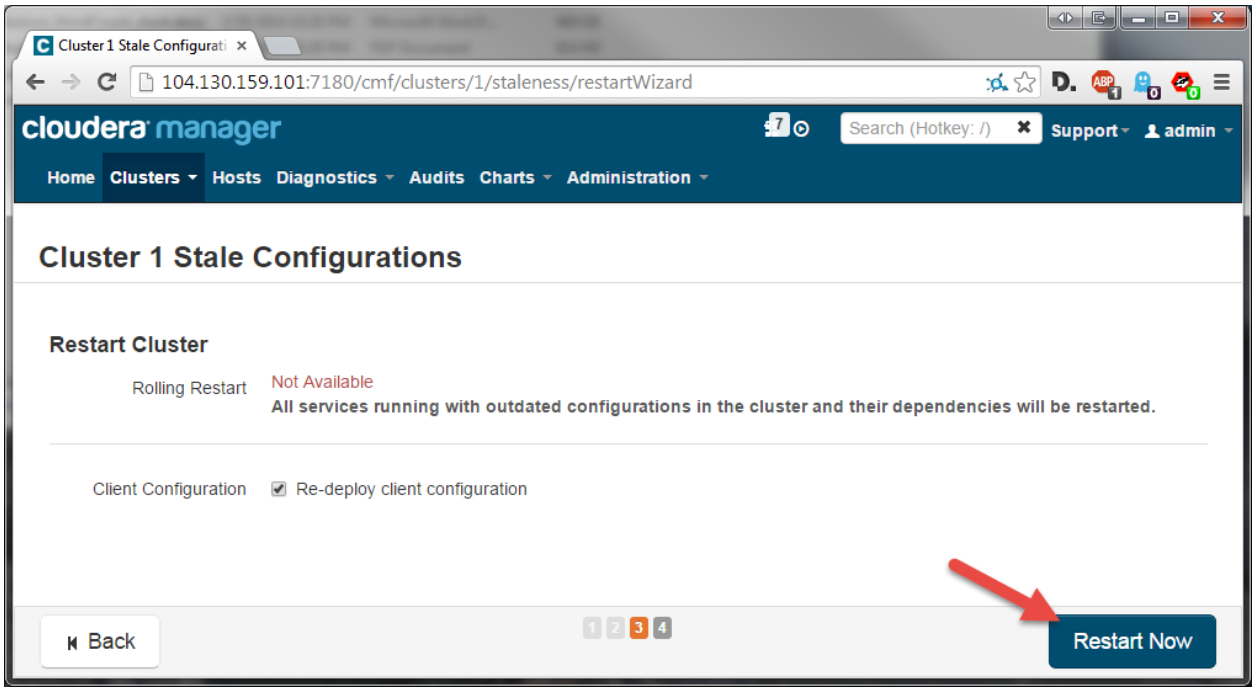
Click the Deploy Client Configuration button:



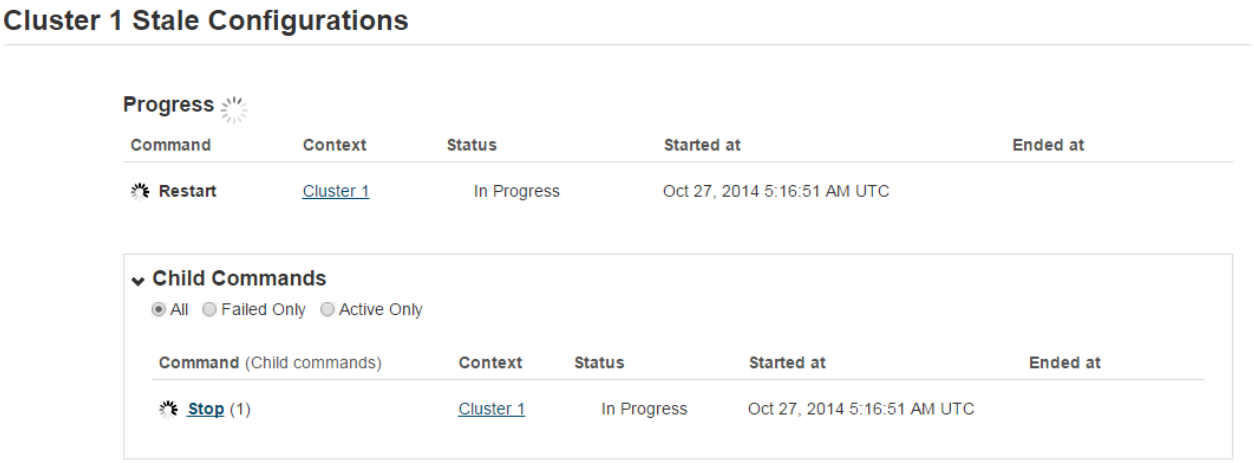
On the next page, click **Restart Cluster**:



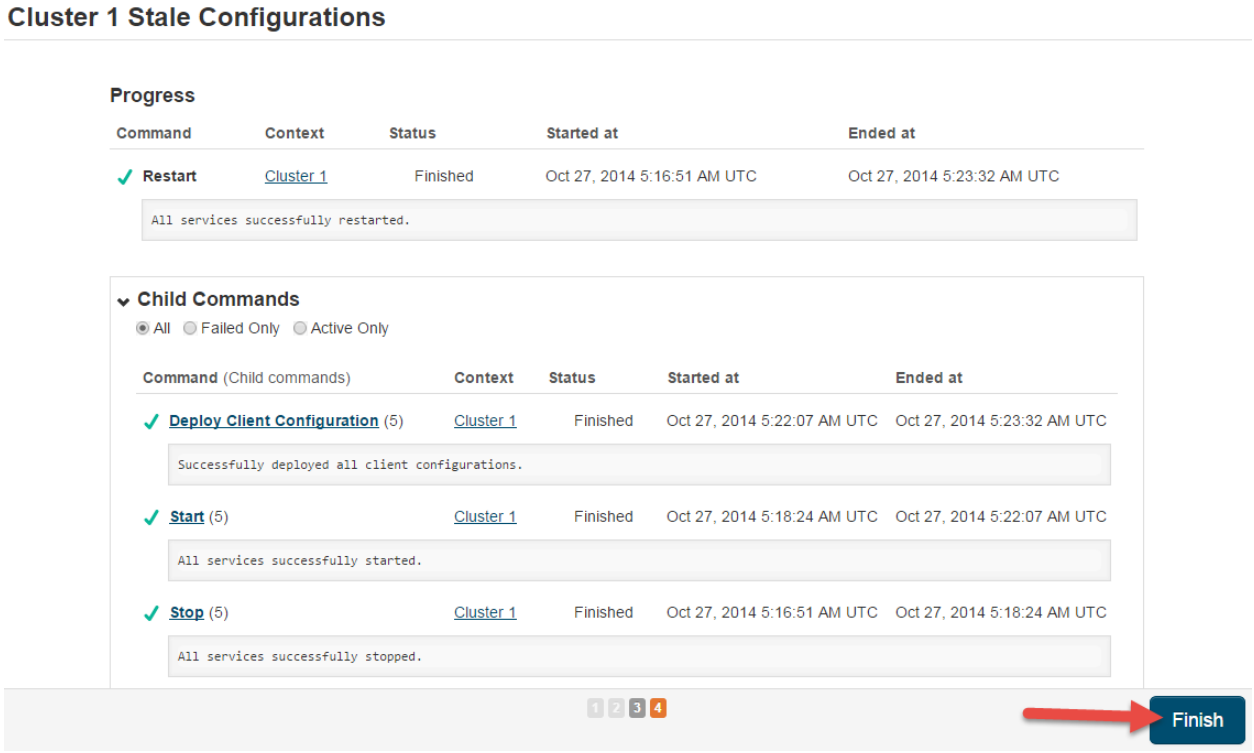
Click Restart Now:



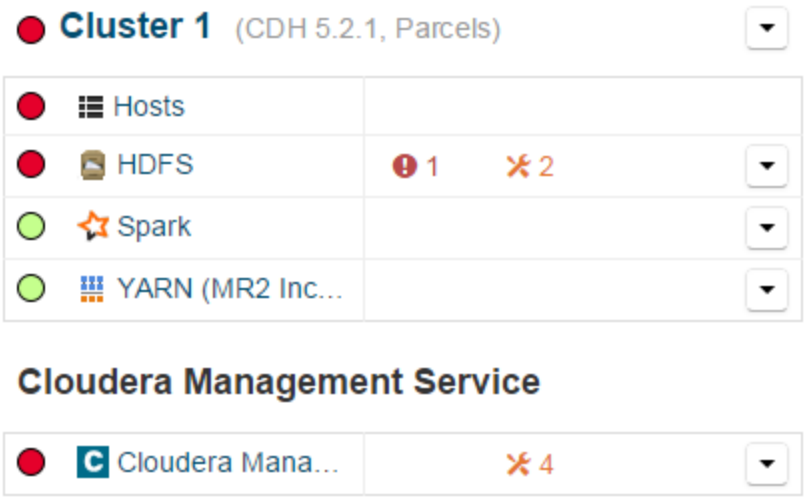
You will now see the Progress screen. This will take about 2 - 3 mins:



When it completes, click on Finish:



The HDFS health issue will still remain as we have not changed the replication factor for the EXISTING files, only for FUTURE files. We will change the replication factor for existing files soon.



(The YARN ResourceManager service may alternate between green and red health at this time)

Switch to the cmd line and:

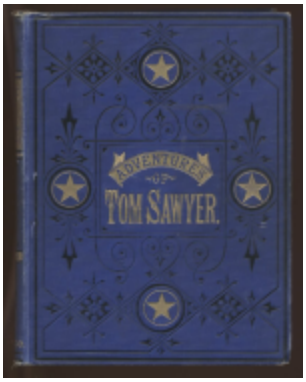
All three HDFS daemons (NameNode / DataNode/ SecondaryNameNode) start under the 'hdfs' user. To list all processes started under 'hdfs', run this command:

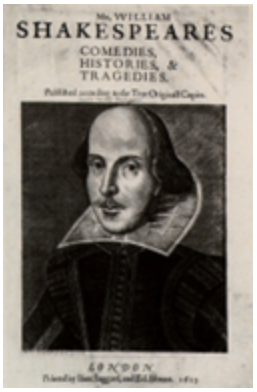
```
[ec2-user@ip-10-0-72-36 ~]$ ps U hdfs
  PID TTY      STAT   TIME COMMAND
32390 ?        Sl     0:11 /usr/java/jdk1.7.0_67-cloudera/bin/java
-Dproc_namenode -Xmx1000m -Dhdfs.audit.logger=INFO,
32436 ?        Sl     0:08 /usr/java/jdk1.7.0_67-cloudera/bin/java
-Dproc_datanode -Xmx1000m -Dhdfs.audit.logger=INFO,
32492 ?        Sl     0:06 /usr/java/jdk1.7.0_67-cloudera/bin/java
-Dproc_secondarynamenode -Xmx1000m -Dhdfs.audit.log
```

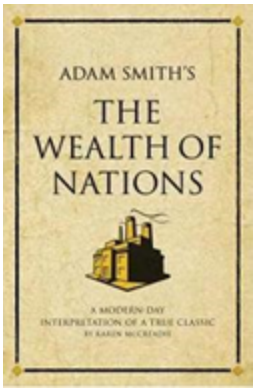
You will notice that these 3 daemons were started with the "java –D command" as JVMs. The –Xmx1000m option means that these JVMs were started with a max heap size of about 1 GB. However, the initial heap size is not necessarily that large.

Let's start by downloading the following three books from Project Gutenberg:

- **The Adventures of Tom Sawyer** by Mark Twain
- **The Complete Works of William Shakespeare** by William Shakespeare
- **An Inquiry into the Nature and Causes of the Wealth of Nations** by Adam Smith







Wget is free software for retrieving files using HTTP or FTP. We will use Wget to download these three files to the Rackspace VM. In the next section we will move the 3 files from the Rackspace VM's /ext3 file system to HDFS (which is coincidentally running on the same node and ultimately also persisting its data to /ext3)

You should now be in the `/home/ec2-user` folder:

```
[ec2-user@ip-10-0-72-36 ~]$ pwd
/home/ec2-user
```

Create a new folder to store the eBooks:

```
[ec2-user@ip-10-0-72-36 ~]$ mkdir ebooks

[ec2-user@ip-10-0-72-36 ~]$ ls
cloudera-manager-installer.bin  ebooks

[ec2-user@ip-10-0-72-36 ~]$ cd ebooks
```

Download the three eBooks:

```
[ec2-user@ip-10-0-72-36 ebooks]$ wget
http://blueplastic.com/hadoop/tom_sawyer.txt
--2012-08-27 06:58:43--  http://blueplastic.com/hadoop/tom_sawyer.txt
Resolving blueplastic.com... 74.220.207.68
Connecting to blueplastic.com|74.220.207.68|:80... connected.
HTTP request sent, awaiting response... 200 OK
Length: 416148 (406K) [text/plain]
Saving to: âtom_sawyer.txtâ

100%[======================================================>] 416,148
1009K/s   in 0.4s

2012-08-27 06:58:44 (1009 KB/s) - âtom_sawyer.txtâ

[ec2-user@ip-10-0-72-36 ebooks]$ wget
http://blueplastic.com/hadoop/shakespeare.txt
--2012-08-27 06:59:17--  http://blueplastic.com/hadoop/shakespeare.txt
Resolving blueplastic.com... 74.220.207.68
Connecting to blueplastic.com|74.220.207.68|:80... connected.
HTTP request sent, awaiting response... 200 OK
Length: 5590193 (5.3M) [text/plain]
Saving to: âshakespeare.txtâ

100%[======================================================>] 5,590,193   1.66M/s
in 3.2s

2012-08-27 06:59:20 (1.66 MB/s) - âshakespeare.txtâ

[ec2-user@ip-10-0-72-36 ebooks]$ wget
http://blueplastic.com/hadoop/wealth_of_nations.txt
--2012-08-27 06:59:34--  http://blueplastic.com/hadoop/wealth_of_nations.txt
Resolving blueplastic.com... 74.220.207.68
Connecting to blueplastic.com|74.220.207.68|:80... connected.
HTTP request sent, awaiting response... 200 OK
Length: 2276935 (2.2M) [text/plain]
Saving to: âwealth_of_nations.txtâ

100%[======================================================>] 2,276,935   1.55M/s
in 1.4s

2012-08-27 06:59:36 (1.55 MB/s) - âwealth_of_nations.txtâ
```

Take a glance at the first 10 lines of one of the books:

```
[ec2-user@ip-10-0-72-36 ebooks]$ ls
shakespeare.txt  tom_sawyer.txt  wealth_of_nations.txt

[ec2-user@ip-10-0-72-36 ebooks]$ head -10 shakespeare.txt
ï»¿The Project Gutenberg EBook of The Complete Works of William Shakespeare,
by
William Shakespeare

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```

That's just the license part of the file. Try running `head -200 shakespeare.txt` to see some of the actual book contents.

These files are basically unstructured data, because it's just a blob of words.

The wc command will tell you how many lines, words and bytes are in a file:

```
[ec2-user@ip-10-0-72-36 ebooks]$ wc shakespeare.txt
 124796  904087 5590193 shakespeare.txt
```

Finally, let's get deeper into HDFS.

All Hadoop commands, including HDFS and MapReduce, are run as an option under the 'hadoop' command. **To see the full list of options:**

```
[ec2-user@ip-10-0-72-36 ebooks]$ hadoop
Usage: hadoop [--config confdir] COMMAND
      where COMMAND is one of:
  fs                   run a generic filesystem user client
  version              print the version
  jar <jar>            run a jar file
  checknative [-a|-h]  check native hadoop and compression libraries
availability
  distcp <srcurl> <desturl> copy file or directories recursively
  archive -archiveName NAME -p <parent path> <src>* <dest> create a hadoop
archive
  classpath            prints the class path needed to get the
                      Hadoop jar and the required libraries
  daemonlog            get/set the log level for each daemon
 or
  CLASSNAME            run the class named CLASSNAME

Most commands print help when invoked w/o parameters.
```

We will specifically use the 'fs' option to run most of our HDFS commands.

To see all of the Hadoop Filesystem commands:

```
[ec2-user@ip-10-0-72-36 ebooks]$ hadoop fs
Usage: hadoop fs [generic options]
      [-cat [-ignoreCrc] <src> ...]
      [-chgrp [-R] GROUP PATH...]
      [-chmod [-R] <MODE[,MODE]... | OCTALMODE> PATH...]
      [-chown [-R] [OWNER][:[GROUP]] PATH...]
      [-copyFromLocal <localsrc> ... <dst>]
      [-copyToLocal [-ignoreCrc] [-crc] <src> ... <localdst>]
        [-count [-q] <path> ...]
      [-cp <src> ... <dst>]
      [-df [-h] [<path> ...]]
      [-du [-s] [-h] <path> ...]
      [-expunge]
      [-get [-ignoreCrc] [-crc] <src> ... <localdst>]
      [-getmerge [-nl] <src> <localdst>]
      [-help [cmd ...]]
      [-ls [-d] [-h] [-R] [<path> ...]]
      [-mkdir [-p] <path> ...]
      [-moveFromLocal <localsrc> ... <dst>]
      [-moveToLocal <src> <localdst>]
      [-mv <src> ... <dst>]
      [-put <localsrc> ... <dst>]
        [-rm [-f] [-r|-R] [-skipTrash] <src> ...]
      [-rmdir [--ignore-fail-on-non-empty] <dir> ...]
      [-setrep [-R] [-w] <rep> <path/file> ...]
      [-stat [format] <path> ...]
      [-tail [-f] <file>]
      [-test -[ezd] <path>]
      [-text [-ignoreCrc] <src> ...]
      [-touchz <path> ...]
      [-usage [cmd ...]]
```

There really aren't all that many HDFS commands. If you have a linux administration background, these should mostly look familiar.

Let's begin by doing a listing of the root HDFS folder:

```
[ec2-user@ip-10-0-72-36 ebooks]$ hadoop fs -ls /
Found 2 items
drwxrwxrwt   - hdfs supergroup          0 2014-12-03 16:06 /tmp
drwxr-xr-x   - hdfs supergroup          0 2014-12-03 16:05 /user
```

We can see that there are two directories or folders here. Note that the above command is NOT the same as the linux 'ls' command. It doesn't matter which local directory you are in when running the above "hadoop fs -ls" command as it will always contact the NameNode to get the directory metadata for display at the command prompt. The "hadoop fs -ls" is different from the linux 'ls' command which runs on the local file system's current directory.

Next, let's take a peek inside the /user folder:

```
[ec2-user@ip-10-0-72-36 ebooks]$ hadoop fs -ls /user
Found 2 items
drwxrwxrwx   - mapred hadoop          0 2014-12-03 16:04 /user/history
drwxr-x--x   - spark  spark           0 2014-12-03 16:05 /user/spark
```

If you don't specify a specific directory to list, it will default to `/user/<current user>` and in this case, the current linux user is 'root':

```
[ec2-user@ip-10-0-72-36 ebooks]$ hadoop fs -ls
ls: `.': No such file or directory
```

This error was to be expected, since the `/user/ec2-user` folder does not exist under `/user` in HDFS as we saw in a command above.

So, let's create a `/user/root` folder and retry the default `-ls` command:
(Also, note that we're running this command as the hdfs user b/c this is the superuser for HDFS, not the local 'root' user)

```
[ec2-user@ip-10-0-72-36 ebooks]$ sudo -u hdfs hadoop fs -mkdir /user/ec2-user

[root@cdh4-cm-vm01 ebooks]$ hadoop fs -ls
```

No output from the `-ls` command means that at least the folder exists now, but there's nothing in it. From now on, if you don't provide an absolute path (starting with /), a relative path will be assumed under `/user/ec2-user/`.

Check the permissions for the /user/root folder in HDFS:

```
[ec2-user@ip-10-0-72-36 ebooks]$ hadoop fs -ls /user
Found 3 items
drwxr-xr-x   - hdfs   supergroup          0 2014-12-03 16:31 /user/ec2-user
drwxrwxrwx   - mapred hadoop              0 2014-12-03 16:04 /user/history
drwxr-x--x   - spark  spark               0 2014-12-03 16:05 /user/spark
```

The owner of the `/user/ec2-user/` folder is the user hdfs and the group is supergroup.

Change the owner of /user/root to be root:

```
[ec2-user@ip-10-0-72-36 ebooks]$ sudo -u hdfs hadoop fs -chown ec2-user
/user/ec2-user

[ec2-user@ip-10-0-72-36 ebooks]$ hadoop fs -ls /user
Found 3 items
drwxr-xr-x   - ec2-user supergroup          0 2014-12-03 16:31 /user/ec2-user
drwxrwxrwx   - mapred   hadoop              0 2014-12-03 16:04 /user/history
drwxr-x--x   - spark    spark               0 2014-12-03 16:05 /user/spark
```

Next, we will create a folder in HDFS to store these three eBooks. This folder will be used as the input for a MapReduce job in a future lab:

```
[ec2-user@ip-10-0-72-36 ebooks]$ hadoop fs -mkdir gutenberg_input
[ec2-user@ip-10-0-72-36 ebooks]$ hadoop fs -ls /user/ec2-user
Found 1 items
drwxr-xr-x   - root supergroup            0 2013-03-26 23:58
/user/root/gutenberg_input
```

Notice how in the above mkdir command since you didn't provide a full path starting with /, it automatically appended `/user/ec2-user/` to the beginning of '`gutenberg_input`'.

A full list of the HDFS commands can be found here:
https://hadoop.apache.org/docs/current/hadoop-project-dist/hadoop-common/FileSystemShell.html

We will explore a handful of them in this lab.

Make sure you place all the backslashes in the commands below!

The copyFromLocal command copies files from the Linux Filesystem to HDFS (Note the case SenSiTiviTy for the copyFromLocal command):

```
[ec2-user@ip-10-0-72-36 ebooks]$ hadoop fs -copyFromLocal tom_sawyer.txt
/user/ec2-user/gutenberg_input/

[ec2-user@ip-10-0-72-36 ebooks]$ hadoop fs -copyFromLocal shakespeare.txt
/user/ec2-user/gutenberg_input/

[ec2-user@ip-10-0-72-36 ebooks]$ hadoop fs -copyFromLocal
wealth_of_nations.txt /user/ec2-user/gutenberg_input/

[ec2-user@ip-10-0-72-36 ebooks]$ hadoop fs -ls gutenberg_input
Found 3 items
-rw-r--r--   1 ec2-user supergroup    5590193 2014-12-03 16:36
gutenberg_input/shakespeare.txt
-rw-r--r--   1 ec2-user supergroup     416148 2014-12-03 16:35
gutenberg_input/tom_sawyer.txt
-rw-r--r--   1 ec2-user supergroup    2276935 2014-12-03 16:36
gutenberg_input/wealth_of_nations.txt
```

You will notice in the above ls command that if the absolute path is not given with /, then `/user/ec2-user` is assumed.

To see the size for all three files in human readable form:

```
[ec2-user@ip-10-0-72-36 ebooks]$ hadoop fs -du -h gutenberg_input
5.3m    gutenberg_input/shakespeare.txt
406.4k  gutenberg_input/tom_sawyer.txt
2.2m    gutenberg_input/wealth_of_nations.txt
```

We can also count the # of files in the gutenberg_input directory:

```
[ec2-user@ip-10-0-72-36 ebooks]$ hadoop fs -count gutenberg_input
           1            3            8283276 gutenberg_input
```

The output columns show: DIR_COUNT, FILE_COUNT, CONTENT_SIZE, DIR_NAME

And finally to display the end of the shakespeare.txt file from HDFS:

```
[ec2-user@ip-10-0-72-36 ebooks]$ hadoop fs -tail
gutenberg_input/shakespeare.txt
<output not shown>
```

Time to look into some important HDFS commands and settings.

Let's explore the deletion and trash features of the command line. Remember that if you delete a file at the command line, it will actually move to the trash folder in HDFS. Then you have to expunge trash to really delete the file.

Let's create an empty file with touchz and then delete it with rm:

```
[ec2-user@ip-10-0-72-36 ebooks]$ hadoop fs -touchz zerofile.txt

[ec2-user@ip-10-0-72-36 ebooks]$ hadoop fs -ls
Found 2 items
drwxr-xr-x   - ec2-user supergroup          0 2014-12-03 16:36
gutenberg_input
-rw-r--r--   1 ec2-user supergroup          0 2014-12-03 16:37 zerofile.txt
```

```
[ec2-user@ip-10-0-72-36 ebooks]$ hadoop fs -rm zerofile.txt
14/12/03 16:37:51 INFO fs.TrashPolicyDefault: Namenode trash configuration:
Deletion interval = 1440 minutes, Emptier interval = 0 minutes.
```

```
Moved:
'hdfs://ip-10-0-72-36.us-west-2.compute.internal:8020/user/ec2-user/zerofile.
txt' to trash at:
hdfs://ip-10-0-72-36.us-west-2.compute.internal:8020/user/ec2-user/.Trash/Cur
rent
```

So, looks like Trash was enabled by default in this CDH5 installation. Therefore deleting anything from the CMD-line via the rm command will just move the file to trash. If you REALLY want to delete the file, you could have provided the `-skipTrash` option after `-rm`. Or you can empty/expunge the trash folder manually after the –rm command. In our lab environment, the fs.trash.interval setting for HDFS is 1 day, so if we don't expunge trash this file should be deleted at this time tomorrow.

Verify that the zerofile really is in the hidden .Trash folder:

```
[ec2-user@ip-10-0-72-36 ebooks]$ hadoop fs -ls
Found 2 items
drwx------   - ec2-user supergroup          0 2014-12-03 16:37 .Trash
drwxr-xr-x   - ec2-user supergroup          0 2014-12-03 16:36
gutenberg_input

[ec2-user@ip-10-0-72-36 ebooks]$ hadoop fs -ls
/user/ec2-user/.Trash/Current/user/ec2-user/
Found 1 items
-rw-r--r--   1 ec2-user supergroup          0 2014-12-03 16:37
/user/ec2-user/.Trash/Current/user/ec2-user/zerofile.txt
```

Now delete everything in Trash:

```
[ec2-user@ip-10-0-72-36 ~]$ hadoop fs -expunge
13/01/29 06:18:19 INFO fs.TrashPolicyDefault: Created trash checkpoint:
/user/root/.Trash/1301290619
```

Hit the up arrow twice to verify that the file really got deleted:

```
[ec2-user@ip-10-0-72-36 ebooks]$ hadoop fs -ls
/user/ec2-user/.Trash/Current/user/ec2-user/
ls: `/user/ec2-user/.Trash/Current/user/ec2-user/': No such file or directory
```

Great, the .Trash directory is gone.

Let's move on to some other common HDFS commands…

To check the health of the HDFS Filesystem at root:

```
[root@cdh5-cm-vm01 ebooks]# sudo -u hdfs hdfs fsck /
14/10/27 05:50:40 WARN ssl.FileBasedKeyStoresFactory: The property
'ssl.client.truststore.location' has not been set, no TrustStore will be
loaded
Connecting to namenode via http://cdh5-cm-vm01:50070
FSCK started by hdfs (auth:SIMPLE) from /104.130.159.101 for path / at Mon
Oct 27 05:50:41 UTC 2014
.
/user/spark/share/lib/spark-assembly.jar:  Under replicated
BP-747346709-10.0.72.36-1417640622514:blk_1073741825_1001. Target Replicas is
3 but found 1 replica(s).

Status: HEALTHY
 Total size:    103854959 B
 Total dirs:    18
 Total files:   5
 Total symlinks:                0
 Total blocks (validated):      4 (avg. block size 25963739 B)
 Minimally replicated blocks:   4 (100.0 %)
 Over-replicated blocks:        0 (0.0 %)
 Under-replicated blocks:       1 (25.0 %)
 Mis-replicated blocks:         0 (0.0 %)
 Default replication factor:    1
 Average block replication:     1.0
 Corrupt blocks:                0
 Missing replicas:              2 (33.333332 %)
 Number of data-nodes:          1
 Number of racks:               1
FSCK ended at Wed Dec 03 16:40:26 EST 2014 in 8 milliseconds

The filesystem under path '/' is HEALTHY
```

You will notice that there are currently 5 files in HDFS and the block replication factor is 1 (as opposed to 3 in production clusters). There is 1 under replicated blocks and 2 missing replicas. 3 out of the 14 files are the Project Gutenberg eBooks that we uploaded.

It is possible to use the HDFS setrep command to change the replica factor for all pre-existing files from 3 down to 1. Let's try that:

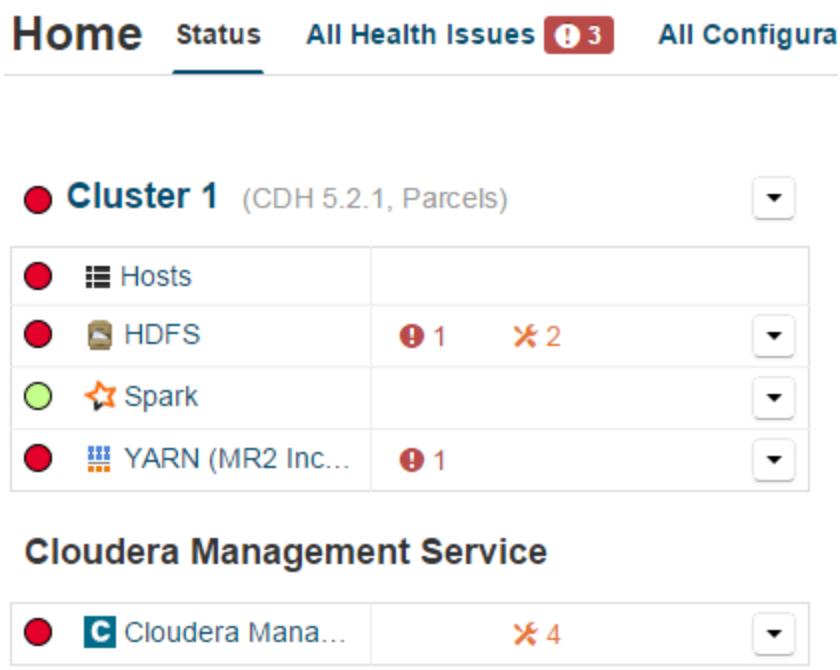
```
[ec2-user@ip-10-0-72-36 ebooks]$ sudo -u hdfs hadoop fs -setrep -R -w 1 /
Replication 1 set:
/user/ec2-user/.Trash/141203163939/user/ec2-user/zerofile.txt
Replication 1 set: /user/ec2-user/gutenberg_input/shakespeare.txt
Replication 1 set: /user/ec2-user/gutenberg_input/tom_sawyer.txt
Replication 1 set: /user/ec2-user/gutenberg_input/wealth_of_nations.txt
Replication 1 set: /user/spark/share/lib/spark-assembly.jar
Waiting for /user/ec2-user/.Trash/141203163939/user/ec2-user/zerofile.txt ...
done
Waiting for /user/ec2-user/gutenberg_input/shakespeare.txt ... done
Waiting for /user/ec2-user/gutenberg_input/tom_sawyer.txt ... done
Waiting for /user/ec2-user/gutenberg_input/wealth_of_nations.txt ... done
Waiting for /user/spark/share/lib/spark-assembly.jar ... done
```

Now, check the health status of HDFS again:

```
[ec2-user@ip-10-0-72-36 ebooks]$ sudo -u hdfs hdfs fsck /
14/10/27 05:56:31 WARN ssl.FileBasedKeyStoresFactory: The property
'ssl.client.truststore.location' has not been set, no TrustStore will be
loaded
Connecting to namenode via
http://ip-10-0-72-36.us-west-2.compute.internal:50070
FSCK started by hdfs (auth:SIMPLE) from /10.0.72.36 for path / at Wed Dec 03
16:44:40 EST 2014
.....Status: HEALTHY
 Total size:    103854959 B
 Total dirs:    18
 Total files:   5
 Total symlinks:                0
 Total blocks (validated):      4 (avg. block size 25963739 B)
 Minimally replicated blocks:   4 (100.0 %)
 Over-replicated blocks:        0 (0.0 %)
 Under-replicated blocks:       0 (0.0 %)
 Mis-replicated blocks:         0 (0.0 %)
 Default replication factor:    1
 Average block replication:     1.0
 Corrupt blocks:                0
 Missing replicas:              0 (0.0 %)
 Number of data-nodes:          1
```

```
 Number of racks:               1
FSCK ended at Wed Dec 03 16:44:40 EST 2014 in 5 milliseconds


The filesystem under path '/' is HEALTHY
```

There we go…. a healthier cluster. That red annoying HDFS Bad Health warning in the Cloudera Manager GUI will not go away yet (as a few configurations warnings may remain). HOWEVER, we are now running our cluster in a very sensitive environment! If even one of these blocks gets corrupted because of some guy walking around with a large magnet in the Amazon datacenter, then the repercussions could mean data loss for us. Cross your fingers and continue the lab…



The default replication factor setting is stored in the following file:
`/etc/hadoop/conf/hdfs-site.xml`

Let's open that file to see its contents, specifically the default replication factor and the location for where HDFS stored the 3 Project Gutenberg files in the Linux file system.

You can use either nano, vi, vim or emacs to open the XML file and all future files. If you are unfamiliar with the arcane vi/vim or emacs syntax, I recommend using nano, one of the simplest text editors to use on Linux. My preference is vi, so you will see me opening all files with vi for the rest of the labs, but feel free to replace the word 'vi' with 'nano' or 'emacs' on your end.

If you want a 3 min crash course in vim, go to this link and graduate levels 1 and 2 and then come back: http://yannesposito.com/Scratch/en/blog/Learn-Vim-Progressively/

Going back to our original goal of reviewing the XML file, let's do that now. Choose of the following two commands (or use emacs):

If using VI:
```
[ec2-user@ip-10-0-72-36 ebooks]$ vi /etc/hadoop/conf/hdfs-site.xml
```

If using nano:
```
[ec2-user@ip-10-0-72-36 ebooks]$ nano /etc/hadoop/conf/hdfs-site.xml
```
(Note, when you want to exit nano, hit CTRL + X and choose y or n if prompted to save the file)

On line 27 of the file, or about 6 settings down, you can see that the default replication factor is set to 1:

```
<property>
  <name>dfs.replication</name>
    <value>1</value>
</property>
```

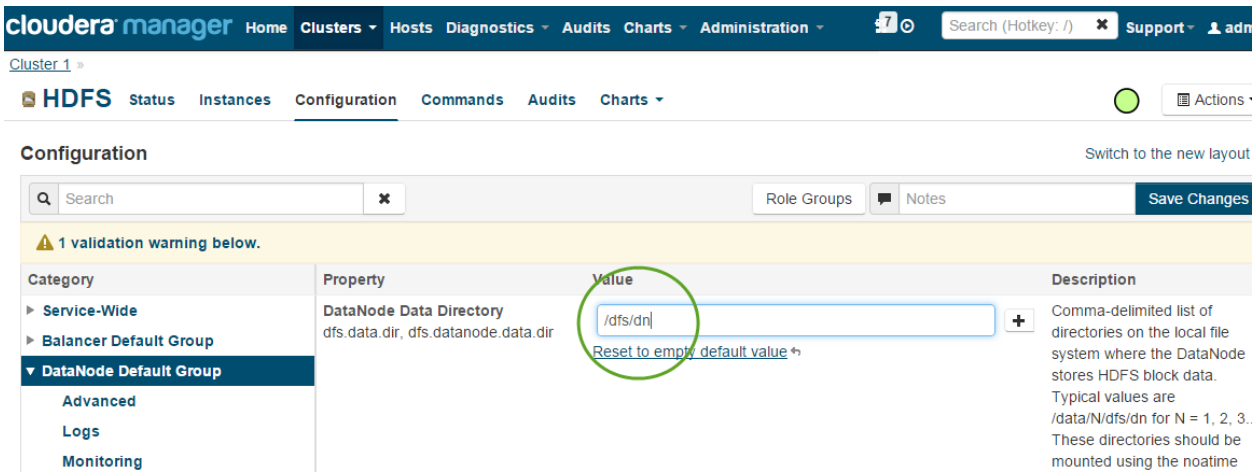
The setting is not marked as 'final' so a developer writing via the HDFS API can choose to overwrite this setting to something higher for a specific file. It is the Hadoop administrator's job to decide which settings should be final and untamperable, and which should be allowed to be overwritten by a developer.

In this file, you will also notice the dfs.blocksize set to 134217728 bytes (128 MB) on line 31. This is the default block size in Hadoop, and it can also be overwritten individually for files.

Cloudera Manager makes it easy to update these settings via the CM web UI and then just Deploy Client Configuration to all the nodes and restart the affected service. If you were using Hadoop straight from apache.org, you would have to use something like rsync to update all of the XML files if you wanted to change the replication factor and then maybe a bash script to restart the HDFS daemons across the cluster nodes.

Go ahead and **exit out of vim or nano** and don't save any changes. (In VI, you can do this by hitting **<ESC>,** then type **:q!**)

Another interesting directory to look at is `/dfs/dn`. Note that in the Cloudera Manager GUI, `/dfs/dn` is the location of the DataNode Data Directory:



There is the directory in ext3 where HDFS stores its blocks. The following commands track down the blocks:

```
[ec2-user@ip-10-0-72-36 ~]$ sudo -u hdfs ls /dfs/dn/current/
BP-747346709-10.0.72.36-1417640622514  VERSION
```

WARNING: In the command below, you will have to replace the # with whatever unique # appears in your machine!

```
[ec2-user@ip-10-0-72-36 ~]$ sudo -u hdfs ls
/dfs/dn/current/BP-747346709-10.0.72.36-1417640622514/current/finalized/subdi
r0/subdir0
blk_1073741825            blk_1073741855            blk_1073741856
blk_1073741857
blk_1073741825_1001.meta  blk_1073741855_1031.meta  blk_1073741856_1032.meta
blk_1073741857_1033.meta
```

You will notice that each block file has a corresponding meta file with the checksum and generation stamp for the block. There can also be many sub directories named 'subdir#', depending on the amount of files in HDFS.

At this point though, it is hard to tell which block # corresponds to which file in HDFS.

How would we find the block that corresponds to the Tom Sawyer file? Continue on to the next section to find out.

Next, let's try to figure out what the block ID is for the ebook tom_sawyer.txt:

The Tom Sawyer ebook is just half a MB in size, so it will be able to fit on 1 block. It will not take up the entire 128 MB max block size and instead the block will be < 1 MB in size and the underlying file in ext3 will also just be a < 1 MB in size.

```
[ec2-user@ip-10-0-72-36 ~]$ sudo -u hdfs hdfs fsck
/user/ec2-user/gutenberg_input/tom_sawyer.txt -files -blocks -racks
14/12/03 20:03:03 WARN ssl.FileBasedKeyStoresFactory: The property
'ssl.client.truststore.location' has not been set, no TrustStore will be
loaded
Connecting to namenode via
http://ip-10-0-72-36.us-west-2.compute.internal:50070
FSCK started by hdfs (auth:SIMPLE) from /10.0.72.36 for path
/user/ec2-user/gutenberg_input/tom_sawyer.txt at Wed Dec 03 20:03:04 EST 2014
/user/ec2-user/gutenberg_input/tom_sawyer.txt 416148 bytes, 1 block(s):  OK
0. BP-747346709-10.0.72.36-1417640622514:blk_1073741855_1031 len=416148
repl=1 [/default/10.0.72.36:50010]

Status: HEALTHY
 Total size:    416148 B
 Total dirs:    0
 Total files:   1
 Total symlinks:                0
 Total blocks (validated):      1 (avg. block size 416148 B)
 Minimally replicated blocks:   1 (100.0 %)
 Over-replicated blocks:        0 (0.0 %)
 Under-replicated blocks:       0 (0.0 %)
 Mis-replicated blocks:         0 (0.0 %)
 Default replication factor:    1
 Average block replication:     1.0
 Corrupt blocks:                0
 Missing replicas:              0 (0.0 %)
```

```
 Number of data-nodes:          1
 Number of racks:               1
FSCK ended at Wed Dec 03 20:03:04 EST 2014 in 1 milliseconds


The filesystem under path '/user/ec2-user/gutenberg_input/tom_sawyer.txt' is
HEALTHY
```

In the above output, we can see this file is made of one block with block ID: `blk_1073741855_1031`

Well, the actual block id is just the # preceding the underscore, so: `blk_1073741855`

Note, the block ID will be different for your instance of the block.

While at the linux command line, under the finalized folder, run this command to search for the Tom Sawyer block:

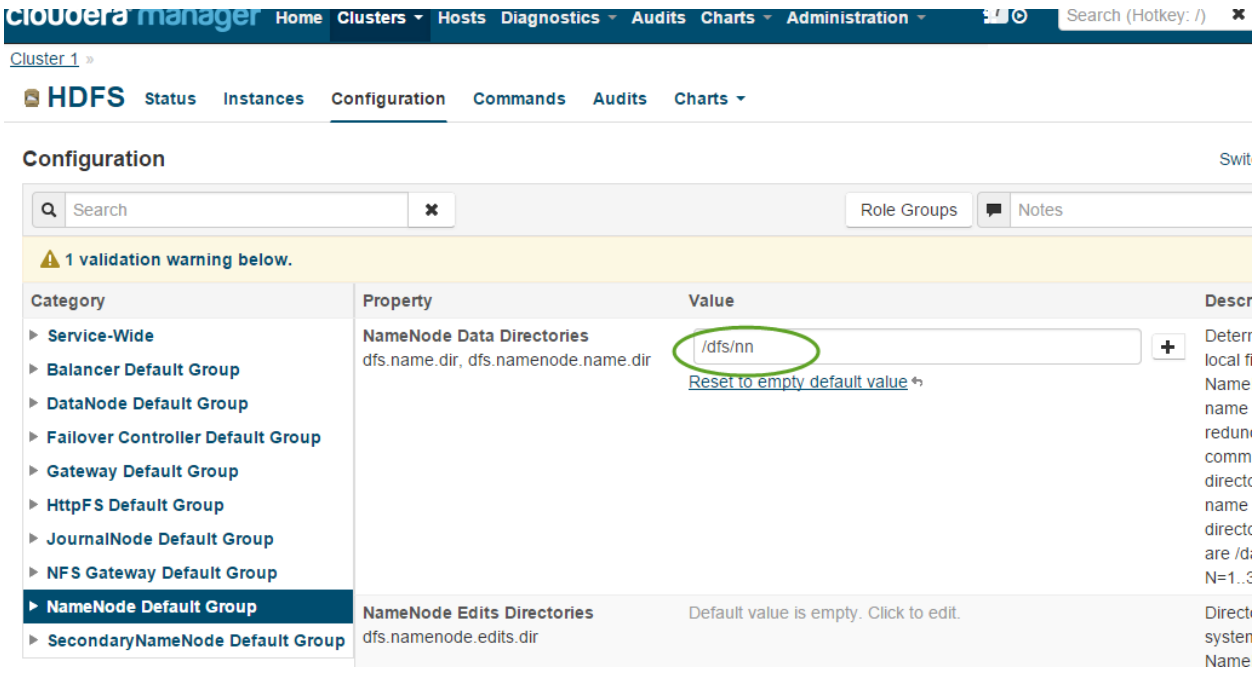
```
[ec2-user@ip-10-0-72-36 ~]$ sudo -u root find / -name "blk_1073741855"
/dfs/dn/current/BP-747346709-10.0.72.36-1417640622514/current/finalized/subdi
r0/subdir0/blk_1073741855
```

So, this is file in ext3 representing the Tom Sawyer block. You can verify this by opening the block/file like this:

```
[ec2-user@ip-10-0-72-36 ~]$ sudo -u hdfs vi
/dfs/dn/current/BP-747346709-10.0.72.36-1417640622514/current/finalized/subdi
r0/subdir0/blk_1073741855
```

[output of file not shown]

The NameNode stores its file system metadata files under /dfs/nn. I know this because that is how it is configured in the Cloudera Manager GUI



Let's explore that now.

```
[ec2-user@ip-10-0-72-36 ~]$ sudo -u hdfs ls /dfs/nn/current
edits_0000000000000000001-0000000000000000106
edits_0000000000000000107-0000000000000000200
edits_0000000000000000201-0000000000000000588
edits_0000000000000000589-0000000000000000944
edits_0000000000000000945-0000000000000001300
edits_0000000000000001301-0000000000000001656
edits_0000000000000001657-0000000000000002018
edits_0000000000000002019-0000000000000002374
edits_0000000000000002375-0000000000000002724
edits_0000000000000002725-0000000000000003080
edits_0000000000000003081-0000000000000003436
edits_0000000000000003437-0000000000000003792
edits_0000000000000003793-0000000000000004148
edits_0000000000000004149-0000000000000004504
edits_0000000000000004505-0000000000000004860
edits_0000000000000004861-0000000000000005216
edits_0000000000000005217-0000000000000005572
edits_0000000000000005573-0000000000000005928
edits_inprogress_0000000000000005929
fsimage_0000000000000005572
fsimage_0000000000000005572.md5
```

```
fsimage_0000000000000005928
fsimage_0000000000000005928.md5
seen_txid
VERSION
```

These Journal (edits) and Checkpoint (fsimage) files are the most critical files to backup in the cluster. Typically multiple directories are defined in Cloudera Manager for the NN Data Directory so that Hadoop automatically writes them to multiple locations (or disks). One of the locations should ideally be a remote NAS.

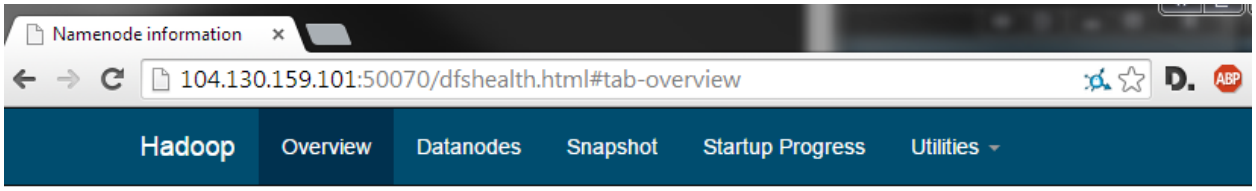
Hadoop dfsadmin is a useful command to see a report of basic statistics for the file system:

```
[ec2-user@ip-10-0-72-36 ~]$ sudo -u hdfs hdfs dfsadmin -report
Configured Capacity: 38048189645 (35.44 GB)
Present Capacity: 30903599104 (28.78 GB)
DFS Remaining: 30798868480 (28.68 GB)
DFS Used: 104730624 (99.88 MB)
DFS Used%: 0.34%
Under replicated blocks: 0
Blocks with corrupt replicas: 0
Missing blocks: 0

-------------------------------------------------
Live datanodes (1):

Name: 10.0.72.36:50010 (ip-10-0-72-36.us-west-2.compute.internal)
Hostname: ip-10-0-72-36.us-west-2.compute.internal
Rack: /default
Decommission Status : Normal
Configured Capacity: 38048189645 (35.44 GB)
DFS Used: 104730624 (99.88 MB)
Non DFS Used: 7144590541 (6.65 GB)
DFS Remaining: 30798868480 (28.68 GB)
DFS Used%: 0.28%
DFS Remaining%: 80.95%
Configured Cache Capacity: 1505755136 (1.40 GB)
Cache Used: 0 (0 B)
Cache Remaining: 1505755136 (1.40 GB)
Cache Used%: 0.00%
Cache Remaining%: 100.00%
```

```
Xceivers: 2
Last contact: Thu Dec 04 08:47:27 EST 2014
```

Apache Hadoop comes with several web GUIs to monitor the cluster.

To access the HDFS web GUI, visit the following URL: `<ip address>:50070`



Overview 'cdh5-cm-vm01:8020' (active)

Started:	Mon Oct 27 05:18:43 UTC 2014
Version:	2.5.0-cdh5.2.0, re1f20a08bde76a33b79df026d00a0c91b2298387
Compiled:	2014-10-11T21:00Z by jenkins from Unknown
Cluster ID:	cluster14
Block Pool ID:	BP-1545055139-104.130.159.101-1414383262813

Summary

Security is off.

Safemode is off.

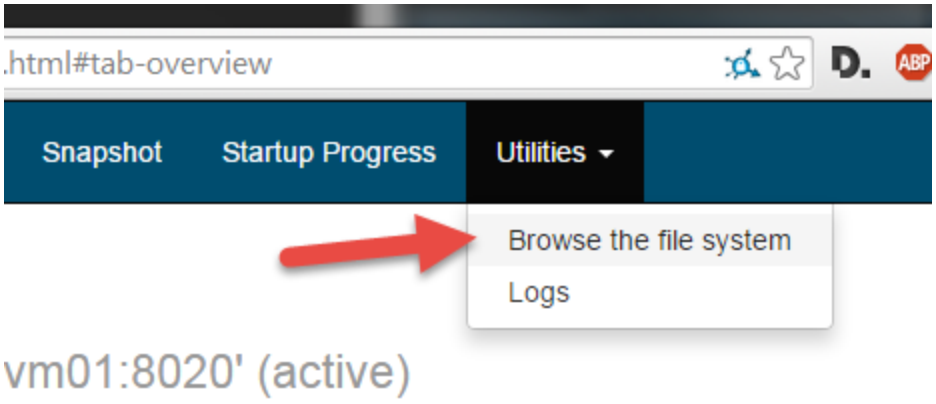
190 files and directories, 15 blocks = 205 total filesystem object(s).

Heap Memory used 28.39 MB of 278.44 MB Heap Memory. Max Heap Memory is 278.44 MB.

Non Heap Memory used 41.5 MB of 41.94 MB Commited Non Heap Memory. Max Non Heap Memory is 130 MB.

Configured Capacity:	35.43 GB
DFS Used:	100.07 MB
Non DFS Used:	5.73 GB

Take a few minutes to browse around the page and explore the various links.



Browse Directory

/ Go!

Permission	Owner	Group	Size	Replication	Block Size	Name
drwxrwxrwt	hdfs	supergroup	0 B	0	0 B	tmp
drwxr-xr-x	hdfs	supergroup	0 B	0	0 B	user

Try navigating to the Project Gutenberg files on your own:

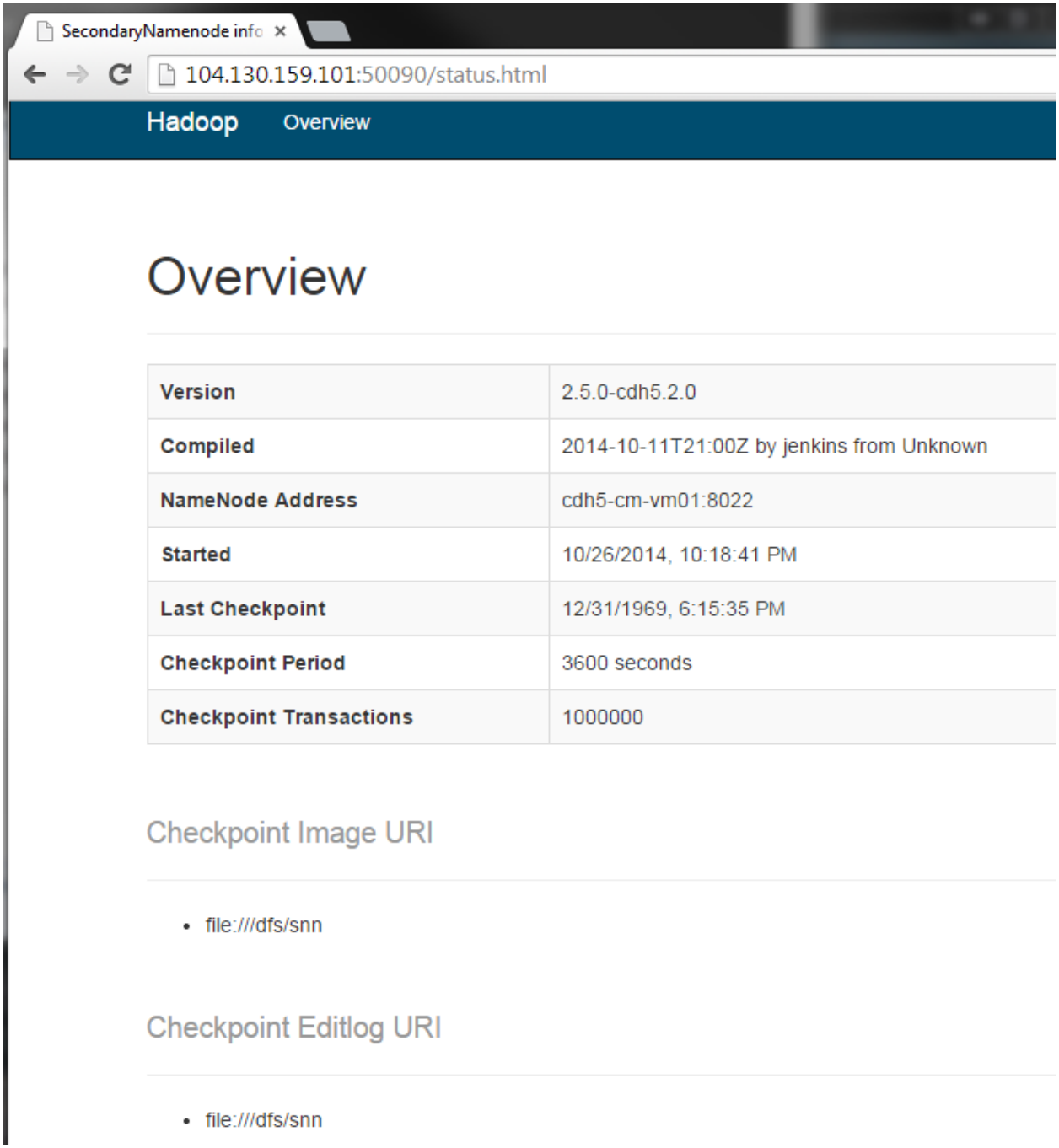
Browse Directory

/user/ec2-user/gutenberg_input Go!

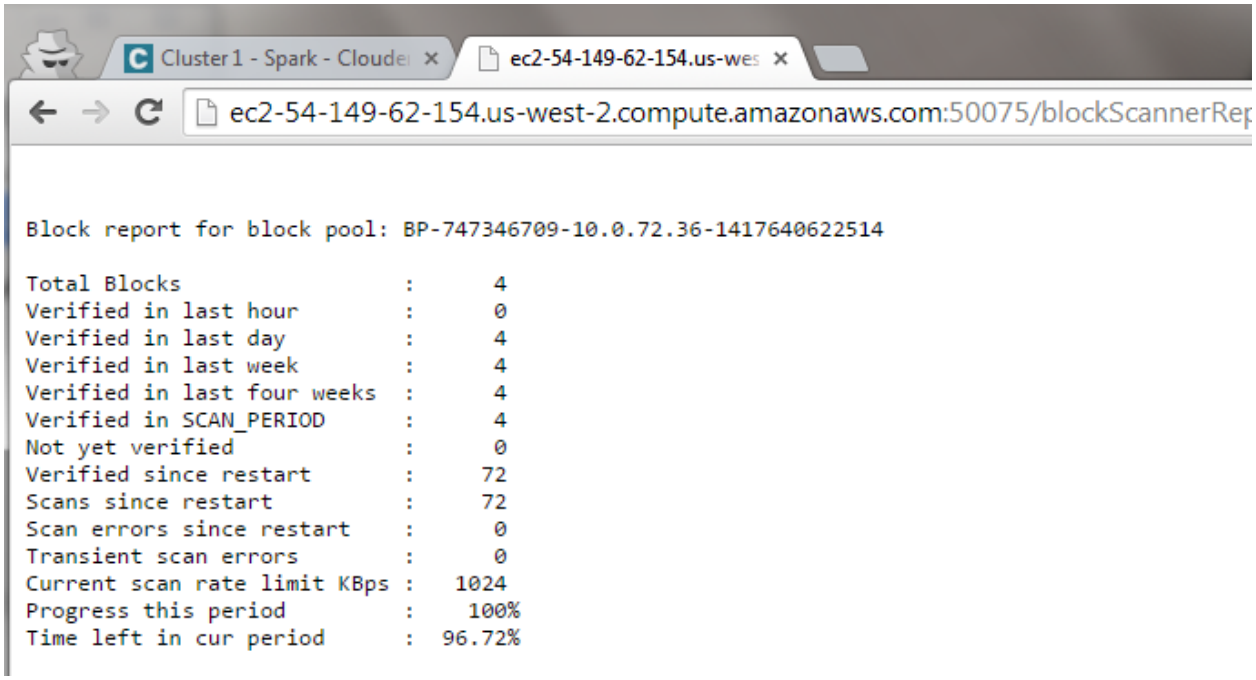
Permission	Owner	Group	Size	Replication	Block Size	Name
-rw-r--r--	ec2-user	supergroup	5.33 MB	1	128 MB	shakespeare.txt
-rw-r--r--	ec2-user	supergroup	406.39 KB	1	128 MB	tom_sawyer.txt
-rw-r--r--	ec2-user	supergroup	2.17 MB	1	128 MB	wealth_of_nations.txt

You can see the Secondary NameNode status and last checkpoint taken time with the following URL:

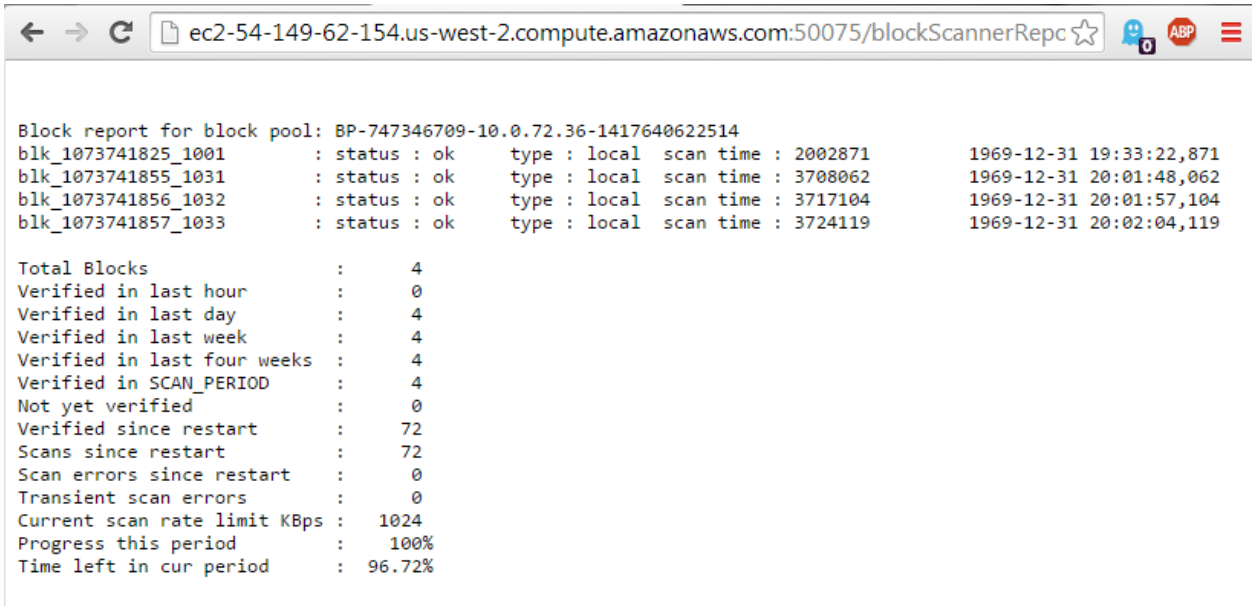
`http://<ip address>:50090`



You can see the Block Scanner Report with the following URL:
`http://<ip address>:50075/blockScannerReport`



Finally you can see all of the blocks in the HDFS file system with:
`http://<ip address>:50075/blockScannerReport?listblocks`



The columns in the first four lines are: Block ID / status / scan type / scan time.

Great! You have successfully completed the HDFS cmd-line lab.

To continue learning about HDFS on your own time, I recommend the following links:

Read Chapter 8 of “The Architecture of Open Source Applications” for a great high-level overview of how HDFS works:
http://www.aosabook.org/en/hdfs.html

Brad Hedlund of Dell has an excellent blog post with diagrams explaining HDFS:
http://bradhedlund.com/2011/09/10/understanding-hadoop-clusters-and-the-network/

I have a 30 min YouTube video with a high-level overview of HDFS:
https://www.youtube.com/watch?v=ziqx2hJY8Hg

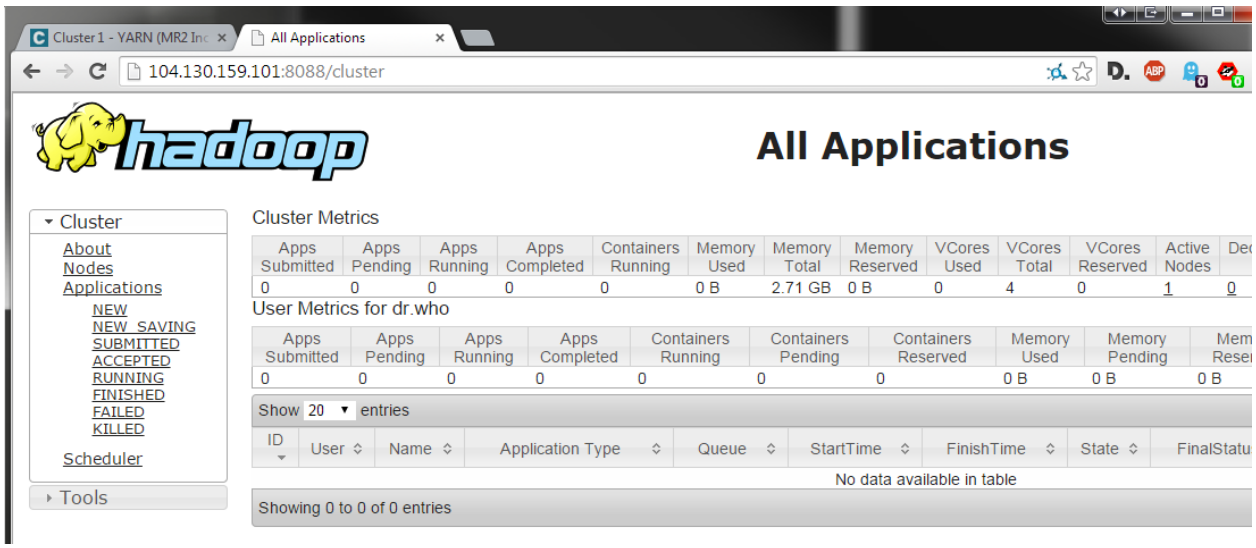
Here is a page with all of the HDFS settings in the respective XML file:
https://hadoop.apache.org/docs/current/hadoop-project-dist/hadoop-hdfs/hdfs-default.xml

And here is the official Apache Hadoop docs website:
https://hadoop.apache.org/docs/current/

Spark and YARN

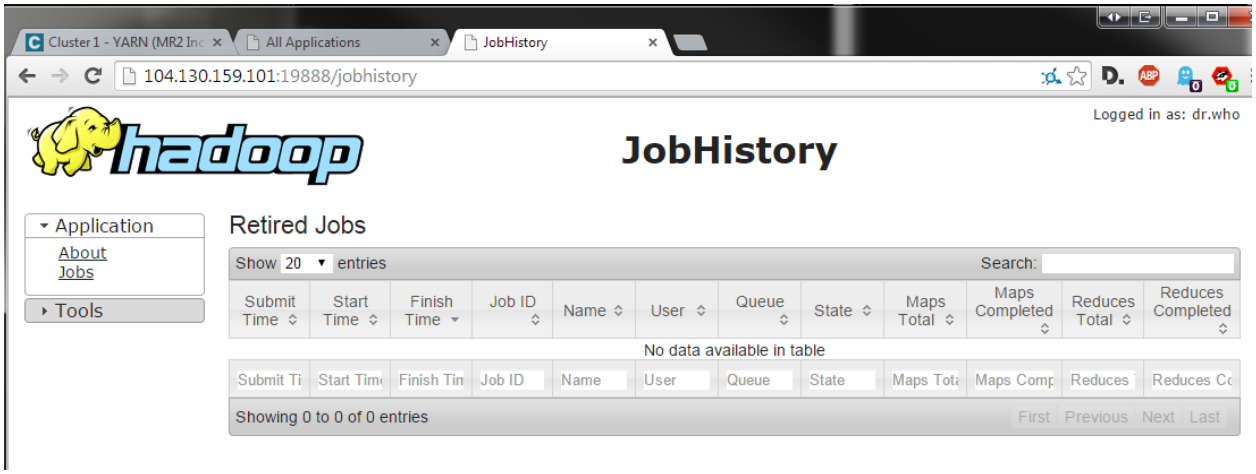
Let's explore YARN at a high level first.

Take a look at the YARN resource manager UI:
`http://<ip address>:8088`



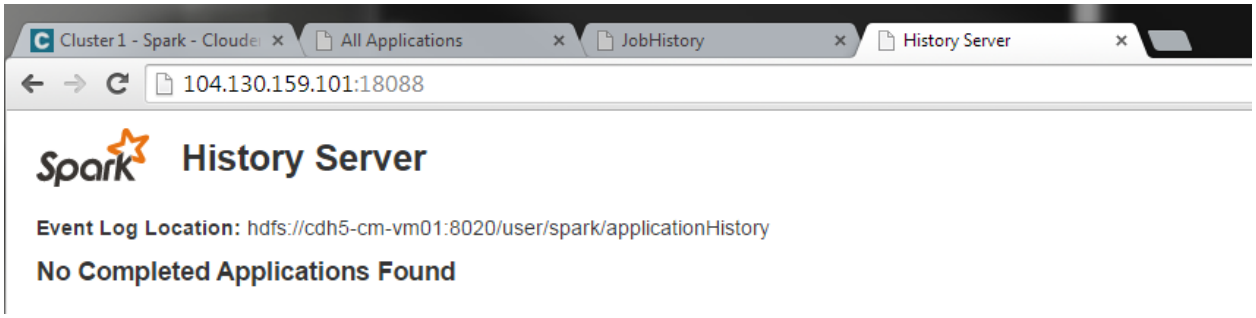
There should be no applications showing up as we have not submitted or started the Spark application within YARN yet.

Take a look at the YARN history manager UI:
`http://<ip address>:19888`



Okay, nothing there either.

Don't confuse the YARN history server with the Spark history server, which has it's own UI on a different port:
`http://<ip address>:18088`



Next, let's take a look at some Spark configuration files:

```
[ec2-user@ip-10-0-72-36 ~]$ cat
/etc/spark/conf.cloudera.spark_on_yarn/spark-defaults.conf
spark.eventLog.dir=hdfs://ip-10-0-72-36.us-west-2.compute.internal:8020/user/
spark/applicationHistory
spark.eventLog.enabled=true
spark.yarn.historyServer.address=http://ip-10-0-72-36.us-west-2.compute.inter
nal:18088
```

The above file is where you *can* add additional settings such as (*however, do not add this line at this time*)**:**

```
spark.executor.memory     2g
```

Here are the rest of the Spark configuration files:

```
[ec2-user@ip-10-0-72-36 ~]$ ls /etc/spark/conf.cloudera.spark_on_yarn/
log4j.properties  spark-defaults.conf  spark-env.sh

[ec2-user@ip-10-0-72-36 ~]$ cat
/etc/spark/conf.cloudera.spark_on_yarn/spark-env.sh
#!/usr/bin/env bash
##
# Generated by Cloudera Manager and should not be modified directly
##

export SPARK_HOME=/opt/cloudera/parcels/CDH-5.2.1-1.cdh5.2.1.p0.12/lib/spark
export
DEFAULT_HADOOP_HOME=/opt/cloudera/parcels/CDH-5.2.1-1.cdh5.2.1.p0.12/lib/hado
op

### Path of Spark assembly jar in HDFS
export
SPARK_JAR_HDFS_PATH=${SPARK_JAR_HDFS_PATH:-/user/spark/share/lib/spark-assemb
ly.jar}

### Let's run everything with JVM runtime, instead of Scala
export SPARK_LAUNCH_WITH_SCALA=0
export SPARK_LIBRARY_PATH=${SPARK_HOME}/lib
export SCALA_LIBRARY_PATH=${SPARK_HOME}/lib

export HADOOP_HOME=${HADOOP_HOME:-$DEFAULT_HADOOP_HOME}

if [ -n "$HADOOP_HOME" ]; then
```

```
  export SPARK_LIBRARY_PATH=$SPARK_LIBRARY_PATH:${HADOOP_HOME}/lib/native
fi

export HADOOP_CONF_DIR=${HADOOP_CONF_DIR:-/etc/hadoop/conf}
```

We should now make a change in the log4j file to reduce the level of logging for Spark, or else we will be overwhelmed by too many INFO messages. You may use VI or NANO to do this.

```
[ec2-user@ip-10-0-72-36 ~]$ sudo vi
/etc/spark/conf.cloudera.spark_on_yarn/log4j.properties
```

Then change line #2 from INFO to ERROR:

```
# Set everything to be logged to the console
log4j.rootCategory=ERROR, console
log4j.appender.console=org.apache.log4j.ConsoleAppender
log4j.appender.console.target=System.err
log4j.appender.console.layout=org.apache.log4j.PatternLayout
log4j.appender.console.layout.ConversionPattern=%d{yy/MM/dd HH:mm:ss} %p
%c{1}: %m%n

# Settings to quiet third party logs that are too verbose
log4j.logger.org.eclipse.jetty=WARN
log4j.logger.org.apache.spark.repl.SparkIMain$exprTyper=INFO
log4j.logger.org.apache.spark.repl.SparkILoop$SparkILoopInterpreter=INFO
```

Save & Quit out of the file.

This is the Spark user's directory in HDFS:

```
[ec2-user@ip-10-0-72-36 ~]$ sudo -u hdfs hadoop fs -ls /user/spark
Found 2 items
drwxrwxrwt   - spark spark          0 2014-10-27 04:21
/user/spark/applicationHistory
drwxr-xr-x   - spark spark          0 2014-10-27 04:21 /user/spark/share
```

Local machine logs for Spark are here:

```
[ec2-user@ip-10-0-72-36 ~]$ cd /var/log/spark/

[ec2-user@ip-10-0-72-36 spark]# ls
```

```
spark-history-server-ip-10-0-72-36.us-west-2.compute.internal.log

[ec2-user@ip-10-0-72-36 spark]# tail -3
spark-history-server-ip-10-0-72-36.us-west-2.compute.internal.log
2014-10-27 05:21:50,298 INFO org.eclipse.jetty.server.AbstractConnector:
Started SelectChannelConnector@0.0.0.0:18088
2014-10-27 05:21:50,303 INFO org.apache.spark.util.Utils: Successfully
started service on port 18088.
2014-10-27 05:21:50,313 INFO org.apache.spark.deploy.history.HistoryServer:
Started HistoryServer at http://cdh5-cm-vm01:18088
```

Finally, let's actually do something interesting with Spark. How about a WordCount job?

Go to the linux tmp dir and download animals.txt:

```
[ec2-user@ip-10-0-72-36 spark]# cd /tmp

[ec2-user@ip-10-0-72-36 tmp]# wget http://blueplastic.com/hadoop/animals.txt
--2014-10-27 06:37:46--  http://blueplastic.com/hadoop/animals.txt
Resolving blueplastic.com... 74.220.207.68
Connecting to blueplastic.com|74.220.207.68|:80... connected.
HTTP request sent, awaiting response... 200 OK
Length: 44 [text/plain]
Saving to: "animals.txt"

100%[======================================================================>] 44
--.-K/s   in 0s

2014-10-27 06:37:46 (3.87 MB/s) - "animals.txt" saved [44/44]

[ec2-user@ip-10-0-72-36 tmp]$ cat animals.txt
cat cat
dog dog
fish fish fish fish fish
fly
```

Copy the file to the Spark users' folder in HDFS:

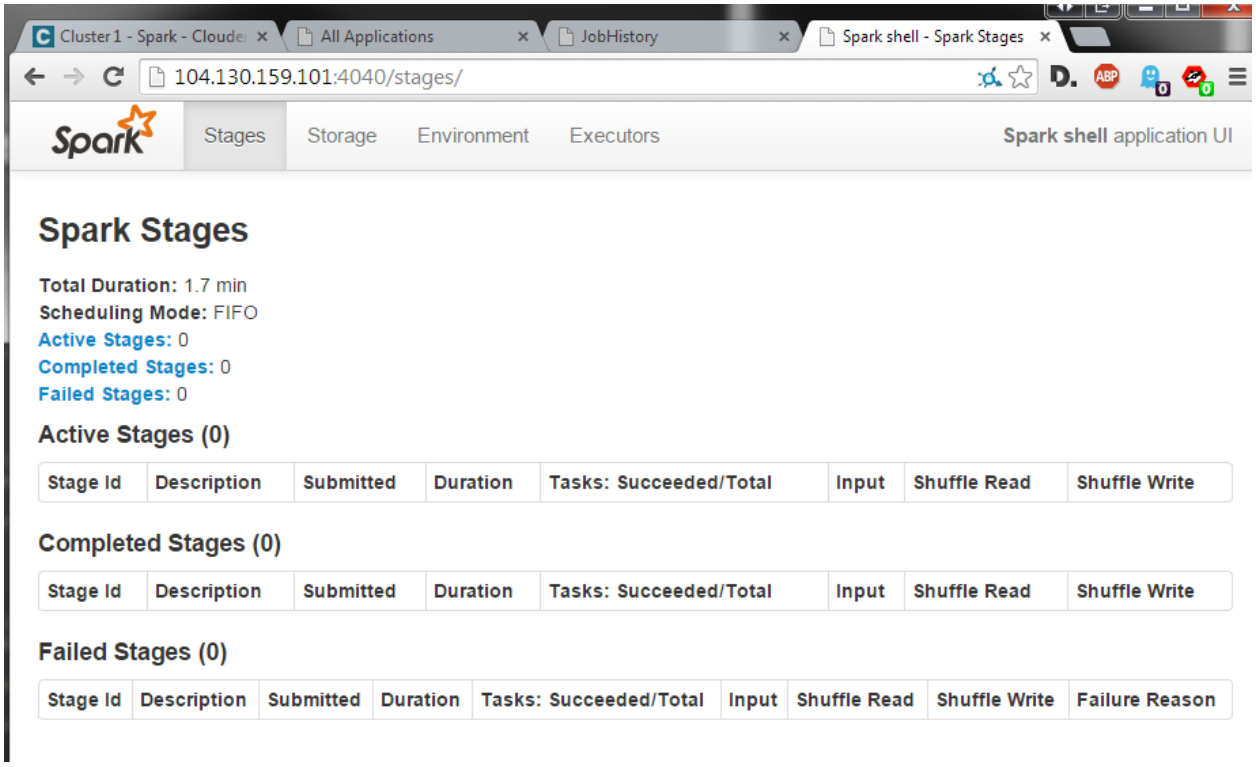
```
[ec2-user@ip-10-0-72-36 tmp]$ sudo -u spark hadoop fs -copyFromLocal
animals.txt /user/spark/
```

```
[ec2-user@ip-10-0-72-36 tmp]$ sudo -u hdfs hadoop fs -ls /user/spark
Found 3 items
-rw-r--r--   1 spark spark         44 2014-10-27 06:41
/user/spark/animals.txt
drwxrwxrwt   - spark spark          0 2014-10-27 04:21
/user/spark/applicationHistory
drwxr-xr-x   - spark spark          0 2014-10-27 04:21 /user/spark/share
```

Start the Spark scala shell:

```
[ec2-user@ip-10-0-72-36 tmp]$ spark-shell
SLF4J: Class path contains multiple SLF4J bindings.
SLF4J: Found binding in
[jar:file:/opt/cloudera/parcels/CDH-5.2.0-1.cdh5.2.0.p0.36/jars/spark-assembl
y-1.1.0-cdh5.2.0-hadoop2.5.0-cdh5.2.0.jar!/org/slf4j/impl/StaticLoggerBinder.
class]
SLF4J: Found binding in
[jar:file:/opt/cloudera/parcels/CDH-5.2.0-1.cdh5.2.0.p0.36/jars/slf4j-log4j12
-1.7.5.jar!/org/slf4j/impl/StaticLoggerBinder.class]
SLF4J: See http://www.slf4j.org/codes.html#multiple_bindings for an
explanation.
SLF4J: Actual binding is of type [org.slf4j.impl.Log4jLoggerFactory]
Welcome to
      ____              __
     / __/__  ___ _____/ /__
    _\ \/ _ \/ _ `/ __/  '_/
   /___/ .__/\_,_/_/ /_/\_\   version 1.1.0
      /_/

Using Scala version 2.10.4 (Java HotSpot(TM) 64-Bit Server VM, Java 1.7.0_67)
Type in expressions to have them evaluated.
Type :help for more information.
Spark context available as sc.

scala>
```

Ignore the binding messages at the beginning.
At port 4040, you will now see the Spark Stages UI for this shell application that is currently running in the cmd prompt:
`http://<ip address>:4040`



Notice that no stages have been submitted yet.

Let's run through some Scala commands. Most of the commands we're running should be self-explanatory.

```
scala> sc
res0: org.apache.spark.SparkContext = org.apache.spark.SparkContext@287a3e19
```

At a high level, every Spark application consists of a driver program that launches various parallel operations on a cluster. The driver program contains your application's main function and defines distributed datasets on the cluster, then applies operations to them. In the example above, the driver program was the Spark shell itself, and you could just
type in the operations you wanted to run.

Driver programs access Spark through a SparkContext object, which represents a connection to a computing cluster. In the shell, a SparkContext is automatically created for you, as the variable called sc .

The help command shows common commands:

```
scala> :help
All commands can be abbreviated, e.g. :he instead of :help.
Those marked with a * have more detailed help, e.g. :help imports.

:cp <path>                  add a jar or directory to the classpath
:help [command]             print this summary or command-specific help
:history [num]              show the history (optional num is commands to
show)
:h? <string>                search the history
:imports [name name ...]    show import history, identifying sources of names
:implicits [-v]             show the implicits in scope
:javap <path|class>         disassemble a file or class name
:load <path>                load and interpret a Scala file
:paste                      enter paste mode: all input up to ctrl-D compiled
together
:quit                       exit the repl
:replay                     reset execution and replay all previous commands
:reset                      reset the repl to its initial state, forgetting
all session entries
:sh <command line>          run a shell command (result is implicitly =>
List[String])
:silent                     disable/enable automatic printing of results
:fallback
disable/enable advanced repl changes, these fix some issues but may introduce
others.
This mode will be removed once these fixes stablize
:type [-v] <expr>           display the type of an expression without
evaluating it
:warnings                   show the suppressed warnings from the most recent
line which had any
```

Try to create a base RDD from an incorrect animals file and count the # of lines in it:

```
scala> val fileBaseRDD = sc.textFile("/user/spark/animals-fake.txt")
fileBaseRDD: org.apache.spark.rdd.RDD[String] = /user/spark/animals.txt
MappedRDD[1] at textFile at <console>:12

scala> fileBaseRDD.count()
```

```
org.apache.hadoop.mapred.InvalidInputException: Input path does not exist:
hdfs://ip-10-0-72-36.us-west-2.compute.internal:8020/user/spark/animals-fake.
txt
        at
org.apache.hadoop.mapred.FileInputFormat.singleThreadedListStatus(FileInputFo
rmat.java:285)
        at
org.apache.hadoop.mapred.FileInputFormat.listStatus(FileInputFormat.java:228)
        at
org.apache.hadoop.mapred.FileInputFormat.getSplits(FileInputFormat.java:313)
        at org.apache.spark.rdd.HadoopRDD.getPartitions(HadoopRDD.scala:180)
```

Woah, we got an error! Notice that this is basically a file not found error. More specifically, HDFS was not found at localhost. Notice that we did not get a file missing error until we called an ACTION on the base RDD.

Let's fix this by giving the full path for HDFS:

```
scala> val fileBaseRDD = sc.textFile("hdfs://<YOUR PUBLIC
hostname>:8020/user/spark/animals.txt")
fileBaseRDD: org.apache.spark.rdd.RDD[String] =
hdfs://ec2-54-149-62-154.us-west-2.compute.amazonaws.com:8020/user/spark/anim
als.txt MappedRDD[5] at textFile at <console>:12

scala> fileBaseRDD.count()
res2: Long = 4

scala> fileBaseRDD.collect()
res4: Array[String] = Array(cat cat, dog dog, fish fish fish fish fish, fly)

scala> fileBaseRDD.partitions.length
res5: Int = 2

scala> val counts = fileBaseRDD.flatMap(line => line.split(" ")).map(word =>
(word,1)).reduceByKey(_ + _)
counts: org.apache.spark.rdd.RDD[(String, Int)] = ShuffledRDD[6] at
reduceByKey at <console>:14

scala> counts.collect()
res6: Array[(String, Int)] = Array((fish,5), (dog,2), (cat,2), (fly,1))
```

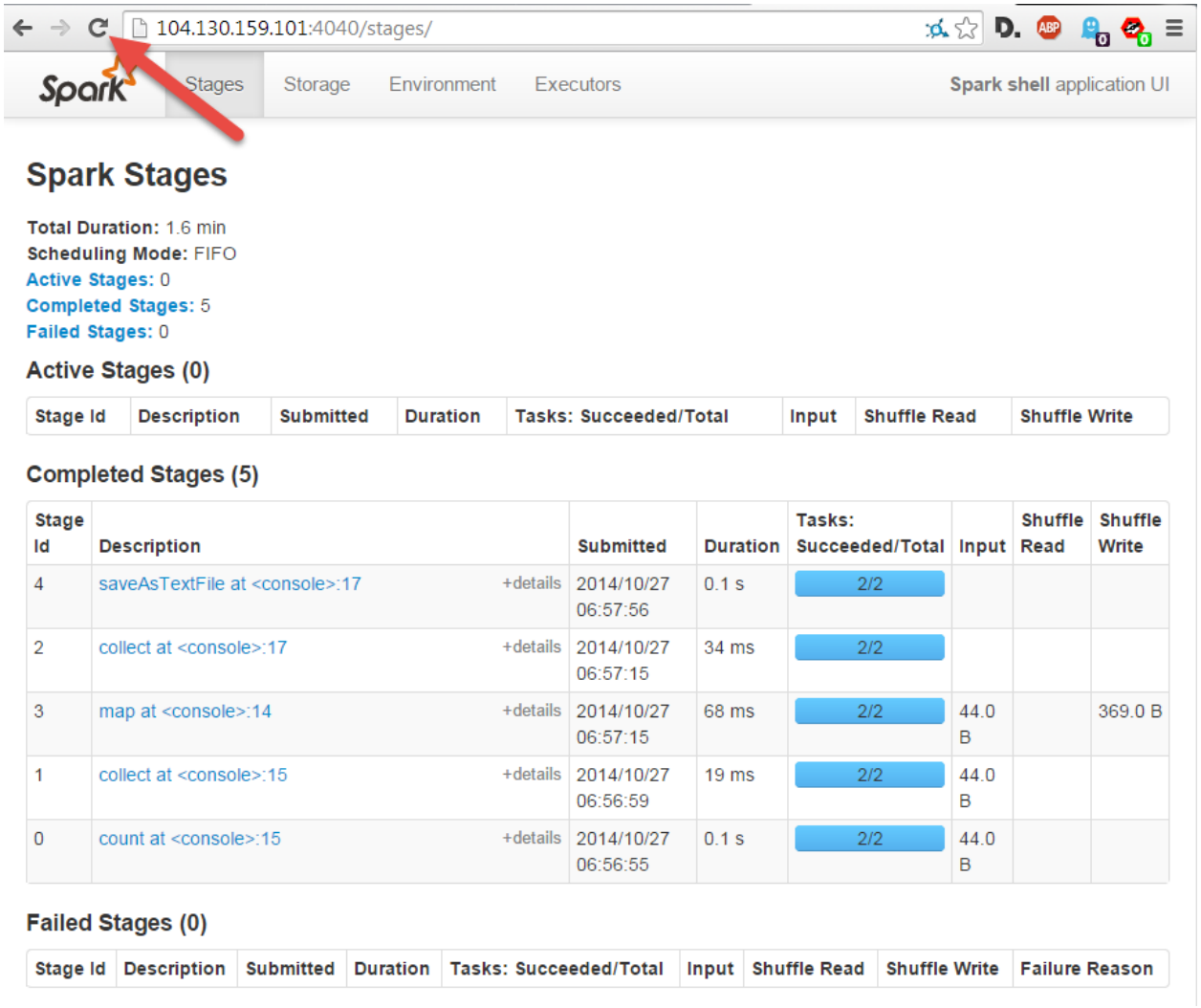
```
scala> counts.saveAsTextFile("hdfs://<YOUR PUBLIC
hostname>:8020/user/spark/wc-results.txt")
org.apache.hadoop.security.AccessControlException: Permission denied:
user=root, access=WRITE, inode="/user/spark":spark:spark:drwxr-x--x
        at
org.apache.hadoop.hdfs.server.namenode.DefaultAuthorizationProvider.checkFsPe
rmission(DefaultAuthorizationProvider.java:255)
        at
org.apache.hadoop.hdfs.server.namenode.DefaultAuthorizationProvider.check(Def
aultAuthorizationProvider.java:236)
```

Hmm, another error. It seems we have started the Spark shell as the *ec2-user*, but are trying to write to HDFS into the Spark users' dir, which gives us an error.

Try writing the results to the ec2-users' dir:

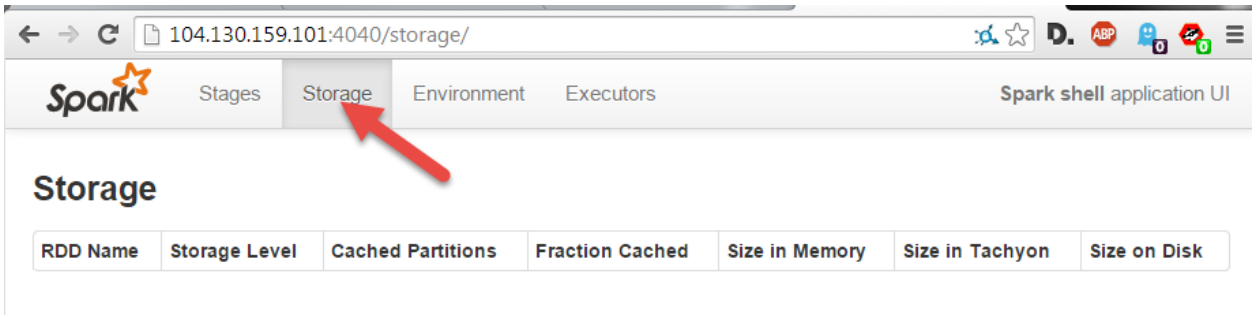
```
scala> counts.saveAsTextFile("hdfs://<YOUR PUBLIC
hostname>:8020/user/ec2-user/wc-results.txt")
```

Switch to the browser and reload or refresh the Spark stages UI at port 4040:

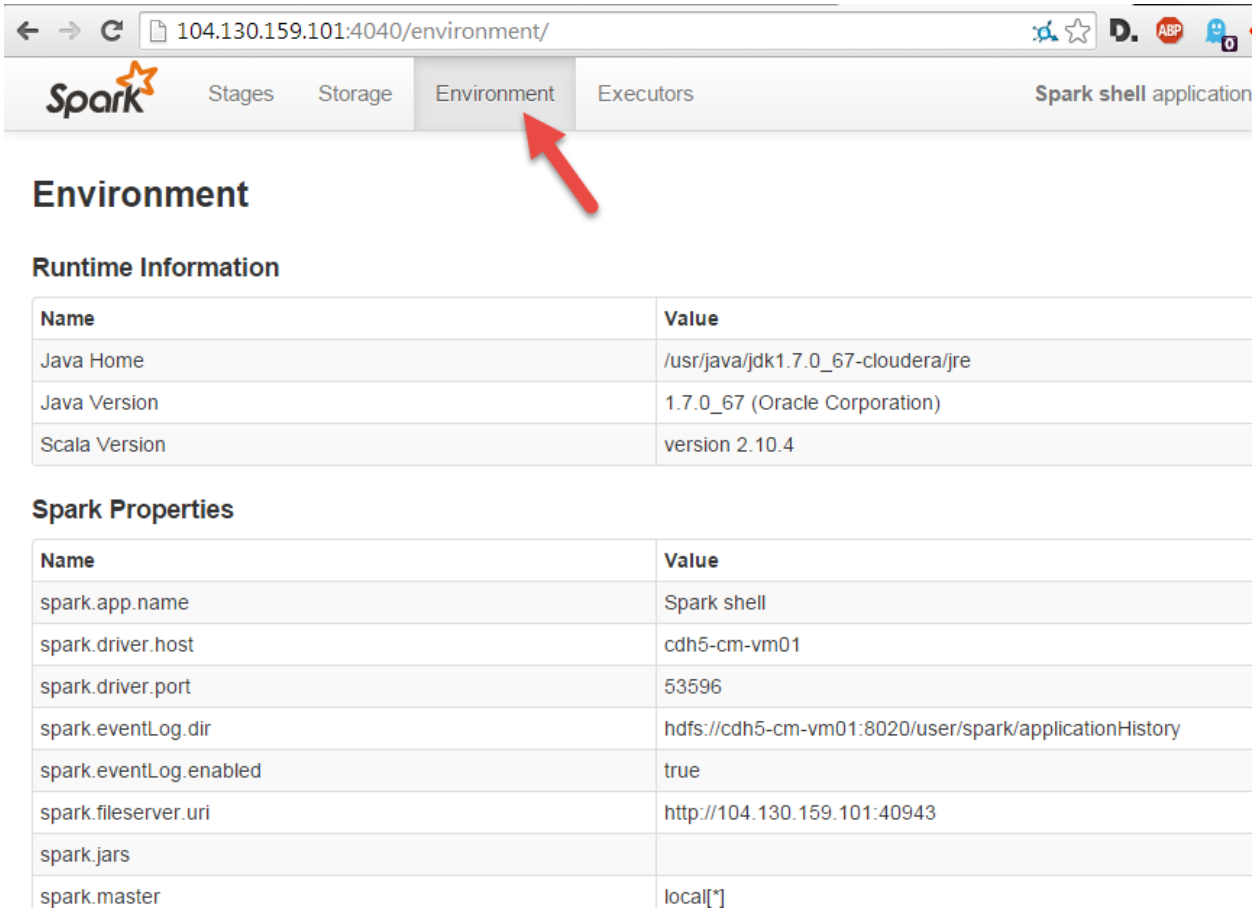


Notice all of the completed stages!

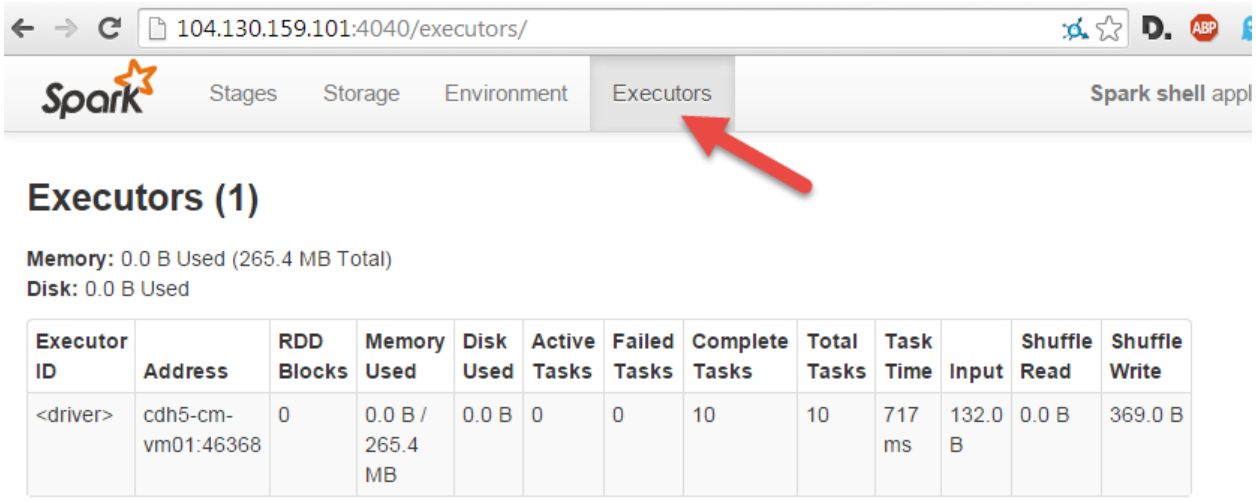
If you click on the Storage tab, you will not see anything since we have not persisted anything to memory yet:



Check out the Environment tab:



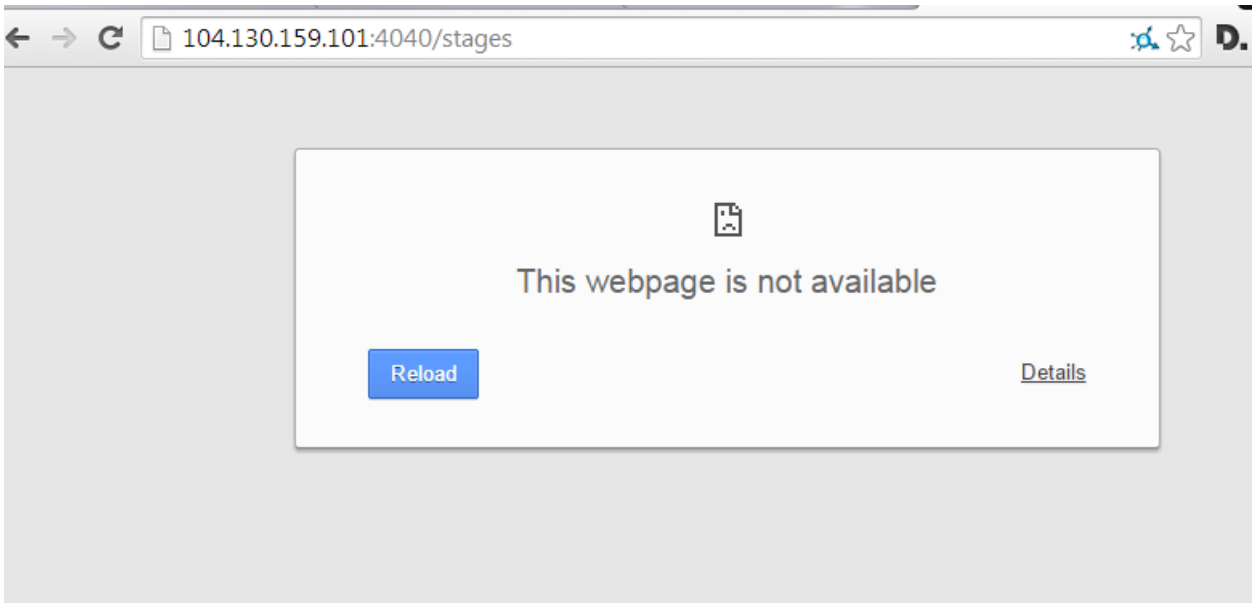
And the Executors' tab:



Next, go ahead and quit out of the Scala spark shell:

```
scala> :q
Stopping spark context.
```

The Stages UI will not stop loading as we have terminated the Spark application (which was the scala shell in this case):



If you are interested, you can explore more of the Scala transformations and actions by reading this page:
https://spark.apache.org/docs/1.1.0/programming-guide.html#transformations

Let's take a look at the results in HDFS:

```
[ec2-user@ip-10-0-72-36 tmp]$ hadoop fs -ls /user/ec2-user/
Found 3 items
drwx------   - ec2-user supergroup          0 2014-12-03 16:39
/user/ec2-user/.Trash
drwxr-xr-x   - ec2-user supergroup          0 2014-12-03 16:36
/user/ec2-user/gutenberg_input
drwxr-xr-x   - ec2-user supergroup          0 2014-12-04 09:19
/user/ec2-user/wc-results.txt
```

Notice that wc-results.txt is actually a directory! So in the future, keep in mind that when you save some RDD results to HDFS, you are actually giving a dir location, not a final output file name!

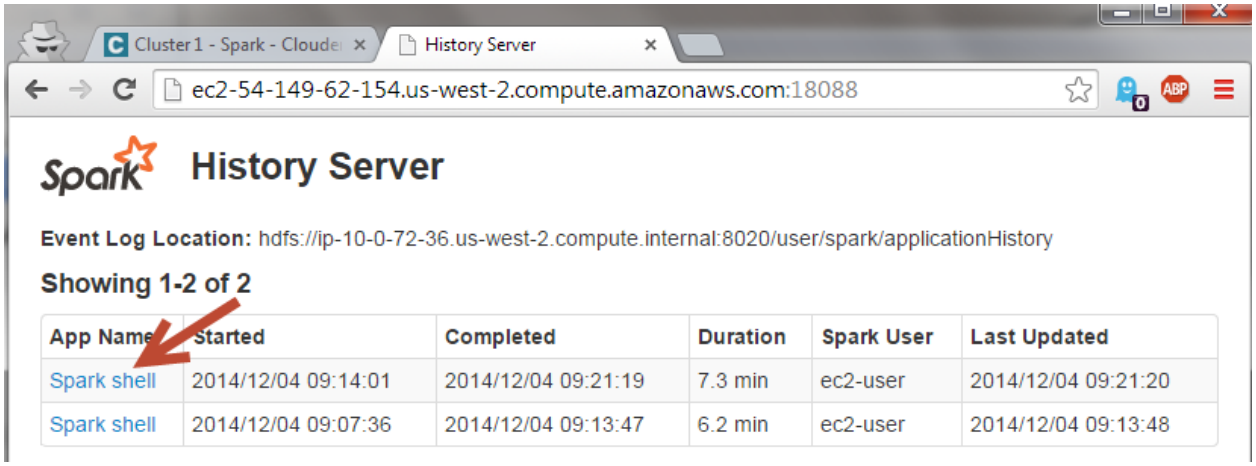
```
[ec2-user@ip-10-0-72-36 tmp]$ hadoop fs -ls /user/root/wc-results.txt/
Found 3 items
-rw-r--r--   1 ec2-user supergroup          0 2014-12-04 09:19
/user/ec2-user/wc-results.txt/_SUCCESS
-rw-r--r--   1 ec2-user supergroup         25 2014-12-04 09:19
/user/ec2-user/wc-results.txt/part-00000
-rw-r--r--   1 ec2-user supergroup          8 2014-12-04 09:19
/user/ec2-user/wc-results.txt/part-00001
```

Since we had to partitions in our RDD, we will have 2 results files:

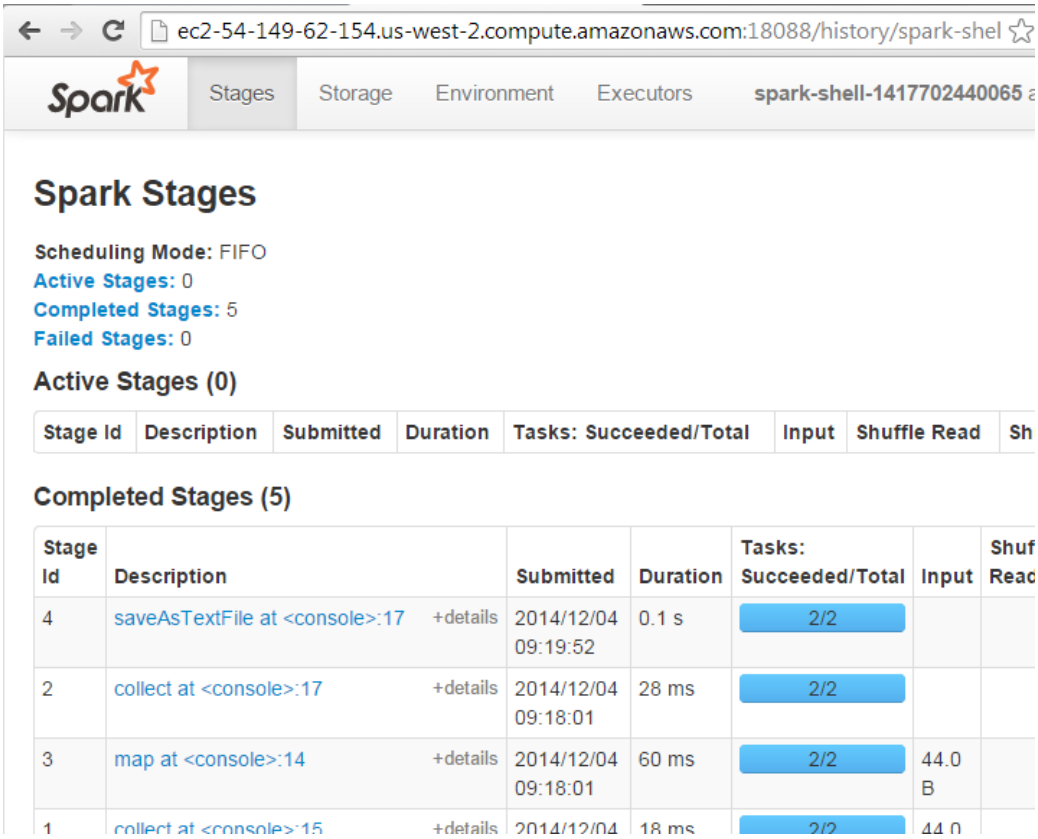
```
[ec2-user@ip-10-0-72-36 tmp]$ hadoop fs -cat
/user/ec2-user/wc-results.txt/part-00000
(fish,5)
(dog,2)
(cat,2)
```

```
[ec2-user@ip-10-0-72-36 tmp]$ hadoop fs -cat
/user/ec2-user/wc-results.txt/part-00001
(fly,1)
```

Try refreshing the Spark history server UI on port 18088 to see the now terminated Scala Spark shell application *(note you will only see one old app, instead of two in the screenshot below!*)



Try clicking on one of the "Spark shell" links in the screenshot above to see the stages of execution of that specific application.



Let's try to do something a bit more complicated. How about using the Python Spark shell and submitting Spark SQL commands from python code?

First, let's download some data to play with. We will download the MovieLens database that the University of Minnesota has made available for free. MovieLens is a structured data set which is available in three sizes: 100,000 reviews, 1 million reviews and 10 million review. For this lab, we'll use the 1 million ratings and first move that data set to HDFS. You can browse the MovieLens webpage here:
http://grouplens.org/datasets/movielens/

You should be in the /tmp directory:

```
[ec2-user@ip-10-0-72-36 tmp]$ pwd
/tmp

[ec2-user@ip-10-0-72-36 tmp]$ wget http://blueplastic.com/hadoop/movies.dat
--2014-10-27 07:17:14--  http://blueplastic.com/hadoop/movies.dat
Resolving blueplastic.com... 74.220.207.68
Connecting to blueplastic.com|74.220.207.68|:80... connected.
HTTP request sent, awaiting response... 200 OK
```

```
Length: 163512 (160K) [text/plain]
Saving to: “movies.dat”

100%[======================================================================>] 163,512
385K/s   in 0.4s

2014-10-27 07:17:15 (385 KB/s) - “movies.dat” saved [163512/163512]

[ec2-user@ip-10-0-72-36 tmp]$ wget http://blueplastic.com/hadoop/ratings.dat
--2014-10-27 07:17:20--  http://blueplastic.com/hadoop/ratings.dat
Resolving blueplastic.com... 74.220.207.68
Connecting to blueplastic.com|74.220.207.68|:80... connected.
HTTP request sent, awaiting response... 200 OK
Length: 21593504 (21M) [text/plain]
Saving to: “ratings.dat”

83% [=================================================>           ]
18,005,776  4.62M/s  eta 2s
w100%[=============================================================>]
21,593,504  5.40M/s   in 5.1s

2014-10-27 07:17:26 (4.01 MB/s) - “ratings.dat” saved [21593504/21593504]

[ec2-user@ip-10-0-72-36 tmp]$ wget http://blueplastic.com/hadoop/users.dat
--2014-10-27 07:17:27--  http://blueplastic.com/hadoop/users.dat
Resolving blueplastic.com... 74.220.207.68
Connecting to blueplastic.com|74.220.207.68|:80... connected.
HTTP request sent, awaiting response... 200 OK
Length: 110208 (108K) [text/plain]
Saving to: “users.dat”

100%[======================================================================>] 110,208
341K/s   in 0.3s

2014-10-27 07:17:28 (341 KB/s) - “users.dat” saved [110208/110208]
```

Take a look at the contents of each of the 3 .dat files and do a line count on each:

```
[ec2-user@ip-10-0-72-36 tmp]$ head -5 movies.dat
1#Toy Story (1995)#Animation|Children's|Comedy
2#Jumanji (1995)#Adventure|Children's|Fantasy
3#Grumpier Old Men (1995)#Comedy|Romance
```

```
4#Waiting to Exhale (1995)#Comedy|Drama
5#Father of the Bride Part II (1995)#Comedy

[ec2-user@ip-10-0-72-36 tmp]$ wc -l movies.dat
3883 movies.dat

[ec2-user@ip-10-0-72-36 tmp]$ head -5 ratings.dat
1#1193#5#978300760
1#661#3#978302109
1#914#3#978301968
1#3408#4#978300275
1#2355#5#978824291

[ec2-user@ip-10-0-72-36 tmp]$ wc -l ratings.dat
1000209 ratings.dat

[ec2-user@ip-10-0-72-36 tmp]$ head -5 users.dat
1#F#1#10#48067
2#M#56#16#70072
3#M#25#15#55117
4#M#45#7#02460
5#M#25#20#55455

[ec2-user@ip-10-0-72-36 tmp]$ wc -l users.dat
6040 users.dat
```

The structure of each file is as follows:

movies.dat: `<movieID>#<Title>#<Genres>`

ratings.dat: `<UserID>#<MovieID>#<Rating>#<Timestamp>`

users.dat: `<UserID>#<Gender>#<Age>#<Occupation>#<ZipCode>`

The movie rating is on a 5-star scale. Timestamp refers to when the rating was recorded.

Copy the 3 files into the Spark user's dir in HDFS:

```
[ec2-user@ip-10-0-72-36 tmp]$ sudo -u spark hadoop fs -copyFromLocal
movies.dat /user/spark/
```

```
[ec2-user@ip-10-0-72-36 tmp]$ sudo -u spark hadoop fs -copyFromLocal
users.dat /user/spark/

[ec2-user@ip-10-0-72-36 tmp]$ sudo -u spark hadoop fs -copyFromLocal
ratings.dat /user/spark/

[ec2-user@ip-10-0-72-36 tmp]$ sudo -u hdfs hadoop fs -ls /user/spark
Found 6 items
-rw-r--r--   1 spark spark         44 2014-10-27 06:41
/user/spark/animals.txt
drwxrwxrwt   - spark spark          0 2014-10-27 07:13
/user/spark/applicationHistory
-rw-r--r--   1 spark spark     163512 2014-10-27 07:22 /user/spark/movies.dat
-rw-r--r--   1 spark spark   21593504 2014-10-27 07:22
/user/spark/ratings.dat
drwxr-xr-x   - spark spark          0 2014-10-27 04:21 /user/spark/share
-rw-r--r--   1 spark spark     110208 2014-10-27 07:22 /user/spark/users.dat
```

Start the Spark Python shell as the spark user:

```
[ec2-user@ip-10-0-72-36 tmp]$ sudo -u spark pyspark
Python 2.6.6 (r266:84292, Jan 22 2014, 09:42:36)
[GCC 4.4.7 20120313 (Red Hat 4.4.7-4)] on linux2
Type "help", "copyright", "credits" or "license" for more information.
SLF4J: Class path contains multiple SLF4J bindings.
SLF4J: Found binding in
[jar:file:/opt/cloudera/parcels/CDH-5.2.0-1.cdh5.2.0.p0.36/jars/spark-assembl
y-1.1.0-cdh5.2.0-hadoop2.5.0-cdh5.2.0.jar!/org/slf4j/impl/StaticLoggerBinder.
class]
SLF4J: Found binding in
[jar:file:/opt/cloudera/parcels/CDH-5.2.0-1.cdh5.2.0.p0.36/jars/slf4j-log4j12
-1.7.5.jar!/org/slf4j/impl/StaticLoggerBinder.class]
SLF4J: See http://www.slf4j.org/codes.html#multiple_bindings for an
explanation.
SLF4J: Actual binding is of type [org.slf4j.impl.Log4jLoggerFactory]
Welcome to
      ____              __
     / __/__  ___ _____/ /__
    _\ \/ _ \/ _ `/ __/  '_/
   /__ / .__/\_,_/_/ /_/\_\   version 1.1.0
      /_/
```

```
Using Python version 2.6.6 (r266:84292, Jan 22 2014 09:42:36)
SparkContext available as sc.
>>>
```

Let's get right to work and play around with some Python and Spark SQL commands. See if you can figure out what each command is doing… it's pretty simple!

```
>>> moviesBaseRDD = sc.textFile("hdfs://<your public
IP>:8020/user/spark/movies.dat")

>>> moviesBaseRDD.count()
3883

>>> moviesBaseRDD.take(5)
[u"1#Toy Story (1995)#Animation|Children's|Comedy", u"2#Jumanji
(1995)#Adventure|Children's|Fantasy", u'3#Grumpier Old Men
(1995)#Comedy|Romance', u'4#Waiting to Exhale (1995)#Comedy|Drama',
u'5#Father of the Bride Part II (1995)#Comedy']


>>> type(moviesBaseRDD.take(5))
<type 'list'>

>>> moviesPartsRDD = moviesBaseRDD.map(lambda l: l.split("#"))
```

Now we have a list of lists (with each nested list having 3 items):

```
>>> moviesPartsRDD.take(5)
[[u'1', u'Toy Story (1995)', u"Animation|Children's|Comedy"], [u'2',
u'Jumanji (1995)', u"Adventure|Children's|Fantasy"], [u'3', u'Grumpier Old
Men (1995)', u'Comedy|Romance'], [u'4', u'Waiting to Exhale (1995)',
u'Comedy|Drama'], [u'5', u'Father of the Bride Part II (1995)', u'Comedy']]
```

Let's see if we can clean up the 2nd element in the list, which has both the title and the year of the movie. It would be nice to be able to separate them.

Now, take the 2nd element in each sub-list and split on " (" and then remove the trailing):

This takes out just the 2nd item:

```
>>> tRDD = moviesPartsRDD.map(lambda l: l[1])
>>> tRDD.take(2)
[u'Toy Story (1995)', u'Jumanji (1995)']
```

```
>>> import string
```

Define a custom function in Python:

```
>>> def custFunc(item):
...   item[2:2] = [item[2]]
...   item[2] = (item[1].rstrip(')'))[-4:]
...   item[1] = string.split(item[1], ' (')[0]
...   return item
...

>>> moviesPartsRDD2 = moviesPartsRDD.map(lambda l: custFunc(l))

>>> moviesPartsRDD2.take(4)
[[u'1', u'Toy Story', u'1995', u"Animation|Children's|Comedy"], [u'2',
u'Jumanji', u'1995', u"Adventure|Children's|Fantasy"], [u'3', u'Grumpier Old
Men', u'1995', u'Comedy|Romance'], [u'4', u'Waiting to Exhale', u'1995',
u'Comedy|Drama']]
```

Interesting. Did you see how we can define a custom function in Python to separate the title from the year of the movie and apply it to the data set?

Let's do some Spark SQL integration now…

```
>>> moviesRDD = moviesPartsRDD2.map(lambda m: {"movieid": m[0], "title":
m[1], "year": int(m[2]), "genres": m[3]})

>>> from pyspark.sql import SQLContext, Row

>>> sqlContext = SQLContext(sc)

>>> moviesTable = sqlContext.inferSchema(moviesRDD)
/opt/cloudera/parcels/CDH-5.2.0-1.cdh5.2.0.p0.36/lib/spark/python/pyspark/sql
.py:1039: UserWarning: Using RDD of dict to inferSchema is deprecated,please
use pyspark.Row instead
  warnings.warn("Using RDD of dict to inferSchema is deprecated,"
```

Ignore the warning and continue...

```
>>> moviesTable.registerTempTable("movies")
```

```
>>> newFilmsRDD = sqlContext.sql("SELECT title, year FROM movies WHERE year > 1995")

>>> newFilmsRDD.take(2)
[Row(title=u'Eye for an Eye', year=1996), Row(title=u"Don't Be a Menace to South Central While Drinkin  Your Juice in the Hood", year=1996)]

>>> newFilmsRDD.count()
1436L
```

Now set up the ratings table…

```
>>> ratingsBaseRDD = sc.textFile("hdfs://<Your Public IP>:8020/user/spark/ratings.dat")

>>> ratingsBaseRDD.take(5)
[u'1#1193#5#978300760', u'1#661#3#978302109', u'1#914#3#978301968', u'1#3408#4#978300275', u'1#2355#5#978824291']

>>> ratingsPartsRDD = ratingsBaseRDD.map(lambda l: l.split("#"))

>>> ratingsPartsRDD.take(5)
[[u'1', u'1193', u'5', u'978300760'], [u'1', u'661', u'3', u'978302109'], [u'1', u'914', u'3', u'978301968'], [u'1', u'3408', u'4', u'978300275'], [u'1', u'2355', u'5', u'978824291']]

>>> ratingsRDD = ratingsPartsRDD.map(lambda m: {"userid": int(m[0]), "movieid": int(m[1]), "rating": int(m[2]), "tstamp": m[3]})

>>> ratingsTable = sqlContext.inferSchema(ratingsRDD)

>>> ratingsTable.registerTempTable("ratings")
```

```
>>> myRDD = sqlContext.sql("SELECT movieid, rating FROM ratings WHERE rating
> 2")

>>> myRDD.take(3)
[Row(movieid=1193, rating=5), Row(movieid=661, rating=3), Row(movieid=914,
rating=3)]
```

Can you figure out what the next few commands do? Hint, we are focusing on just the Toy Story movie, which is ID = 1.

```
>>> complexRDD = sqlContext.sql("SELECT ratings.rating, COUNT(ratings.rating)
FROM ratings WHERE movieid=1 GROUP BY ratings.rating")

>>> complexRDD.count()
5L

>>> complexRDD.collect()
[Row(rating=1, c1=16), Row(rating=2, c1=61), Row(rating=3, c1=345),
Row(rating=4, c1=835), Row(rating=5, c1=820)]
```

To get a list of movie ratings with movie titles, we will need to join the ratings and movies tables:

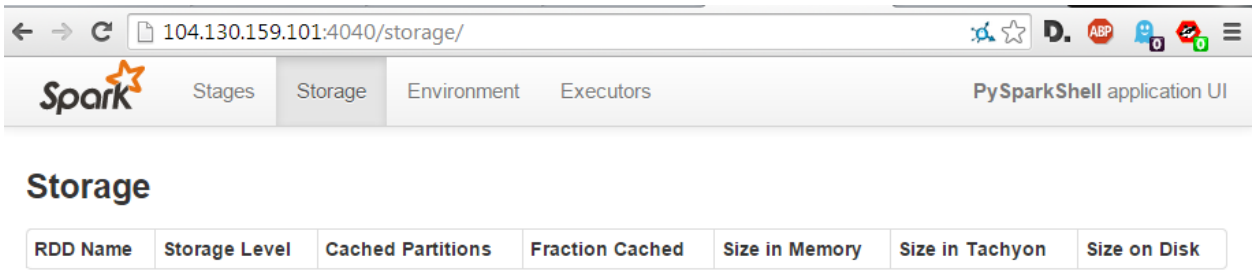
```
>>> joinRDD = sqlContext.sql("SELECT ratings.userid, ratings.rating,
movies.title FROM ratings JOIN movies ON (ratings.movieid = movies.movieid)
LIMIT 5")

>>> joinRDD.count()
5L

>>> joinRDD.collect()
[Row(userid=2, rating=3, title=u"Soldier's Story, A"), Row(userid=2,
rating=5, title=u'Amadeus'), Row(userid=2, rating=2, title=u'Thin Red Line,
The'), Row(userid=2, rating=1, title=u'Get Shorty'), Row(userid=3, rating=5,
title=u'Caddyshack')]
```

Next, let's see how we can cache an RDD to memory, so we can operate on it at memory speed in the future:

```
>>> joinRDD.cache()
MapPartitionsRDD[92] at mapPartitions at SchemaRDD.scala:413
```

Actually, the RDD is not cached to memory until we call an action on it. For example, visit the Spark Storage UI and you won't see any RDD's listed:

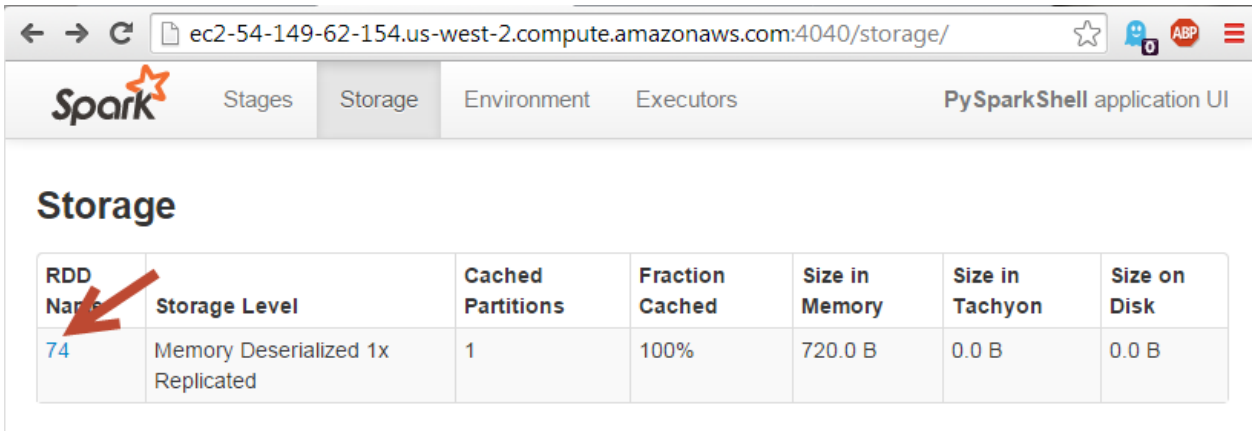
http://<Your public hostname>:4040/storage/



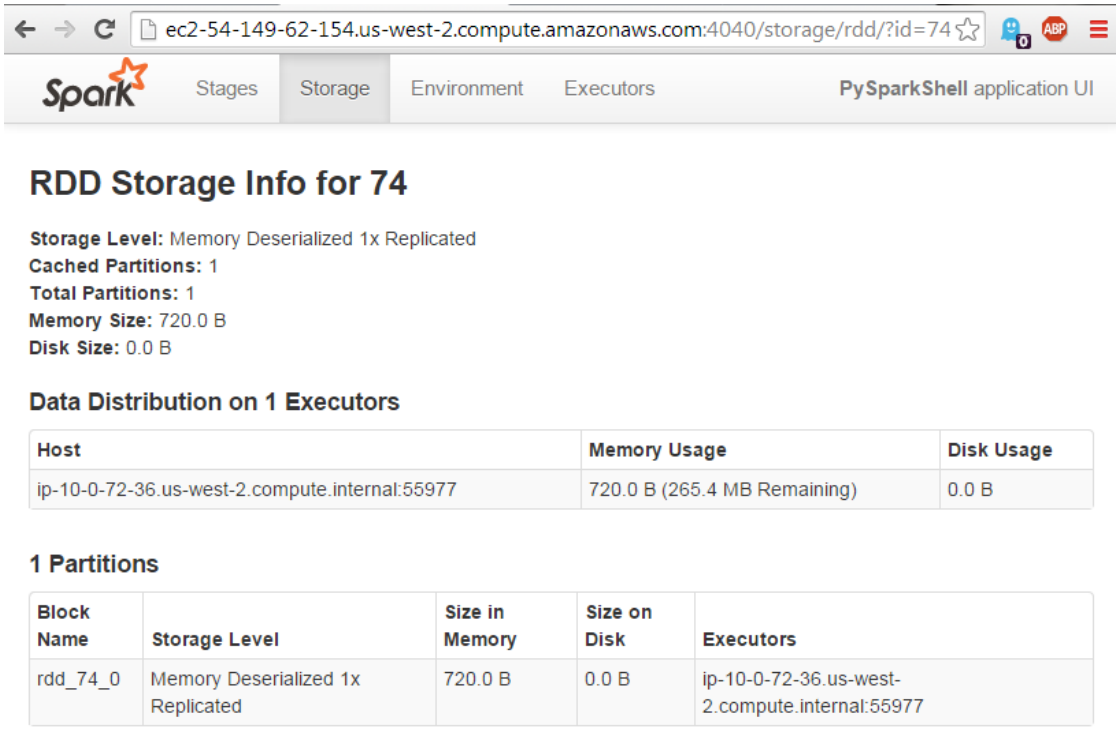
Call an action on the joinRDD:

```
>>> joinRDD.collect()
[Row(userid=2, rating=3, title=u"Soldier's Story, A"), Row(userid=2,
rating=5, title=u'Amadeus'), Row(userid=2, rating=2, title=u'Thin Red Line,
The'), Row(userid=2, rating=1, title=u'Get Shorty'), Row(userid=3, rating=5,
title=u'Caddyshack')]
```

Now the RDD is cached:



Try clicking on the RDD name in the left-most column to see more details about the RDD:



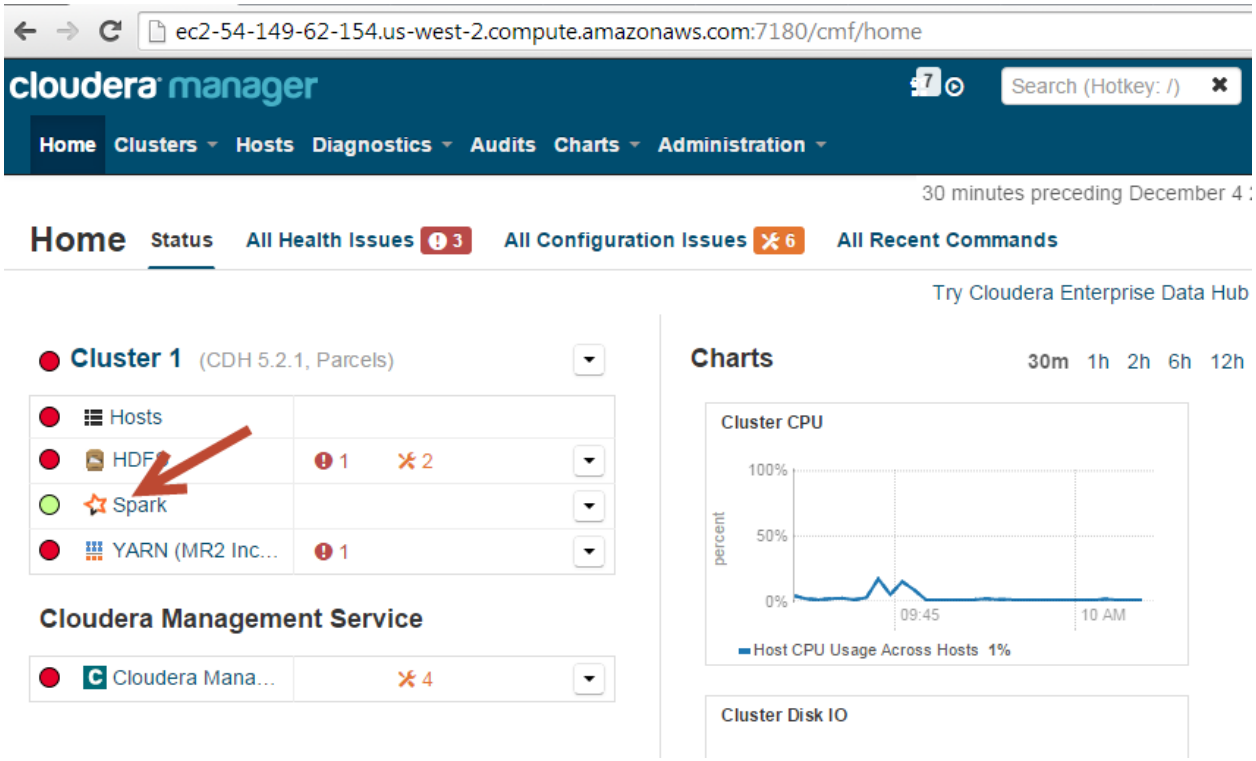
Notice that the RDD is made of 1 partition and the size it is taking up in the Executor's JVM memory on-heap is 720 Bytes.

Move back to the Spark python shell and exit it:

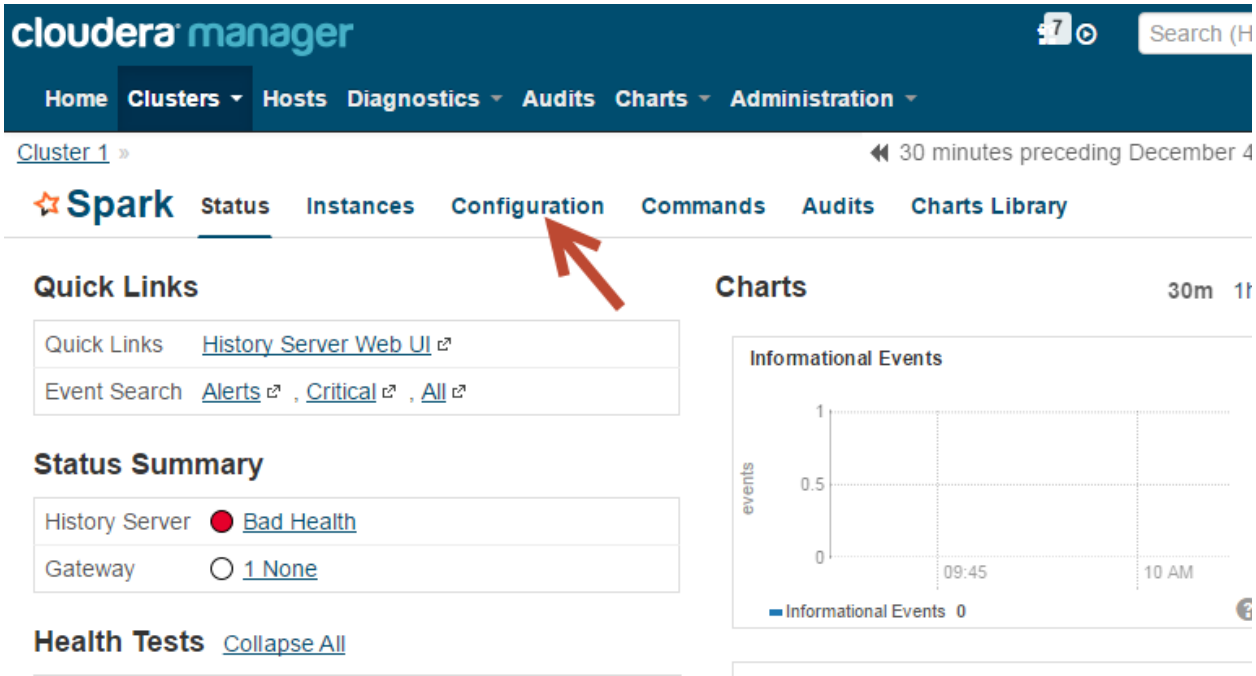
```
>>> quit()
[ec2-user@ip-10-0-72-36 tmp]$
```

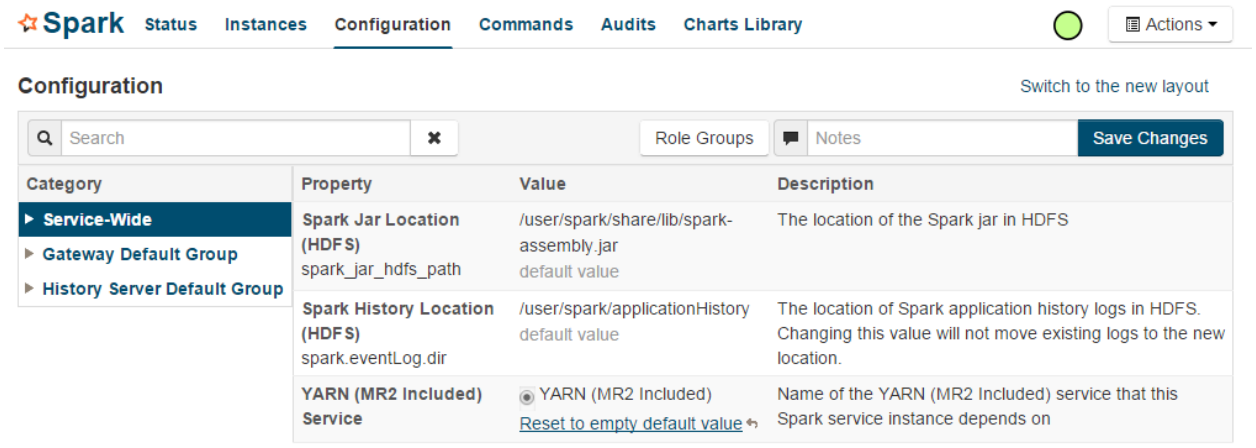
Currently Spark is running in YARN mode in CDH 5.2.1.

Let's take a look at the Spark configuration settings. Go to the Cloudera Manager UI and click on Spark:

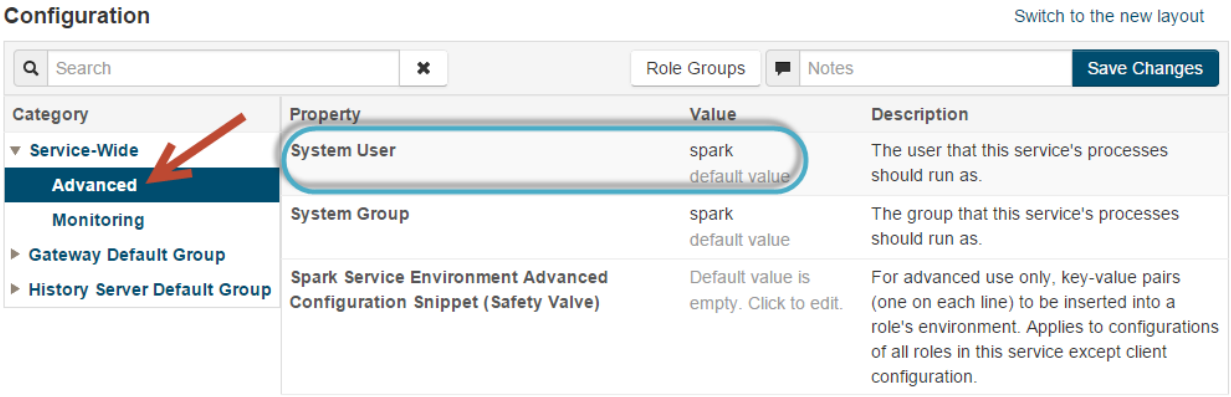


From the Spark service page, click on Configuration:

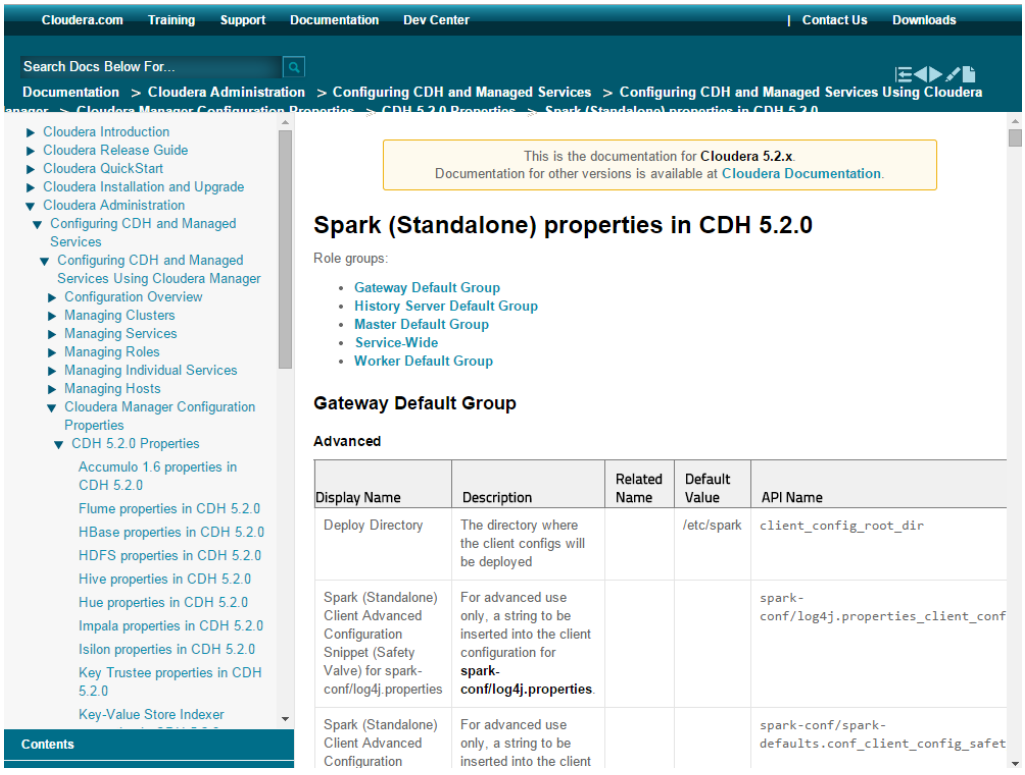

cloudera manager
Search (H
Home
Clusters
Hosts
Diagnostics
Audits
Charts
Administration
Cluster 1
30 minutes preceding December 4
Spark
Status
Instances
Configuration
Commands
Audits
Charts Library
Quick Links
Quick Links
History Server Web UI
Event Search
Alerts
Critical
All
Status Summary
History Server
Bad Health
Gateway
1 None
Health Tests
Collapse All
Charts
30m
Informational Events
events
1
0.5
0
09:45
10 AM
Informational Events 0


Spark
Status
Instances
Configuration
Commands
Audits
Charts Library
Actions
Configuration
Switch to the new layout
Search
Role Groups
Notes
Save Changes
Category
Service-Wide
Gateway Default Group
History Server Default Group
Property
Value
Description
Spark Jar Location (HDFS)
spark_jar_hdfs_path
/user/spark/share/lib/spark-assembly.jar
default value
The location of the Spark jar in HDFS
Spark History Location (HDFS)
spark.eventLog.dir
/user/spark/applicationHistory
default value
The location of Spark application history logs in HDFS. Changing this value will not move existing logs to the new location.
YARN (MR2 Included) Service
YARN (MR2 Included)
Reset to empty default value
Name of the YARN (MR2 Included) service that this Spark service instance depends on

You can expand "Service-Wide" on the left and click on "Advanced" to see what user the Spark service runs as:



To understand what the properties here mean, check out the CDH 5.2 Spark Standalone properties page:
http://www.cloudera.com/content/cloudera/en/documentation/core/latest/topics/cm_props_cdh520_spark_standalone_.html



Submitting Spark apps in YARN client and cluster mode

Next, we will use the information from the following page to submit a SparkPi application in YARN Client Mode and then YARN Cluster Mode:

http://www.cloudera.com/content/cloudera/en/documentation/core/latest/topics/cdh_ig_running_spark_apps.html

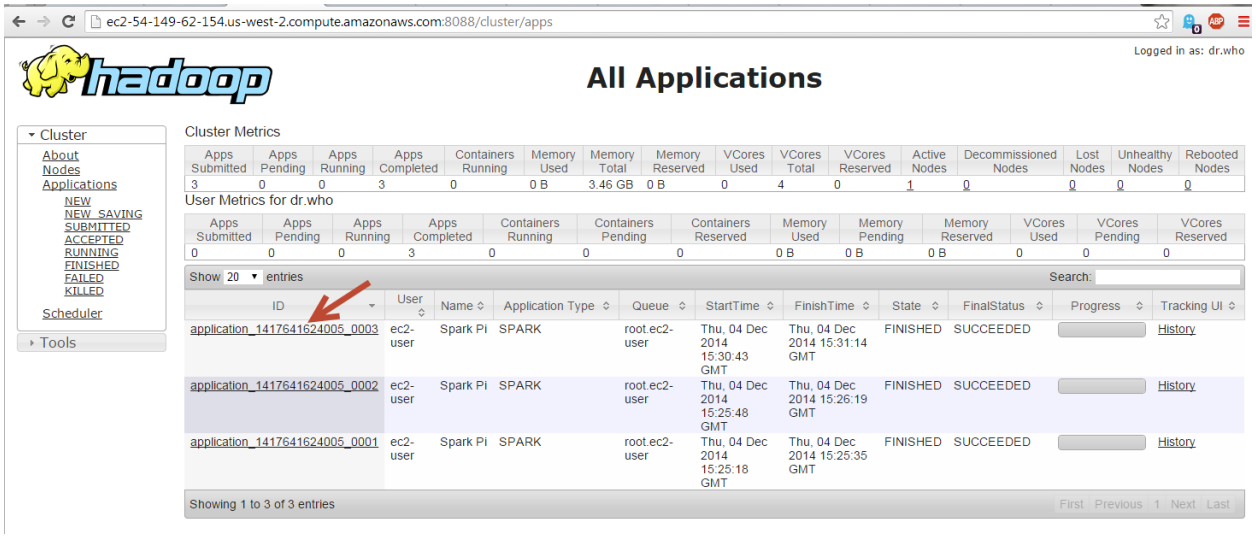
The code for SparkPi is available here:
https://github.com/apache/spark/blob/master/examples/src/main/scala/org/apache/spark/examples/SparkPi.scala

```
[ec2-user@ip-10-0-72-36 /]$ cd ~

[ec2-user@ip-10-0-72-36 ~]$ spark-submit --class
org.apache.spark.examples.SparkPi --deploy-mode client --master yarn
/opt/cloudera/parcels/CDH-5.2.1-1.cdh5.2.1.p0.12/jars/spark-examples-1.1.0-cd
h5.2.1-hadoop2.5.0-cdh5.2.1.jar 10
SLF4J: Class path contains multiple SLF4J bindings.
SLF4J: Found binding in
[jar:file:/opt/cloudera/parcels/CDH-5.2.1-1.cdh5.2.1.p0.12/jars/spark-assembl
y-1.1.0-cdh5.2.1-hadoop2.5.0-cdh5.2.1.jar!/org/slf4j/impl/StaticLoggerBinder.
class]
SLF4J: Found binding in
[jar:file:/opt/cloudera/parcels/CDH-5.2.1-1.cdh5.2.1.p0.12/jars/slf4j-log4j12
-1.7.5.jar!/org/slf4j/impl/StaticLoggerBinder.class]
SLF4J: See http://www.slf4j.org/codes.html#multiple_bindings for an
explanation.
SLF4J: Actual binding is of type [org.slf4j.impl.Log4jLoggerFactory]
--args is deprecated. Use --arg instead.
Pi is roughly 3.144032
```

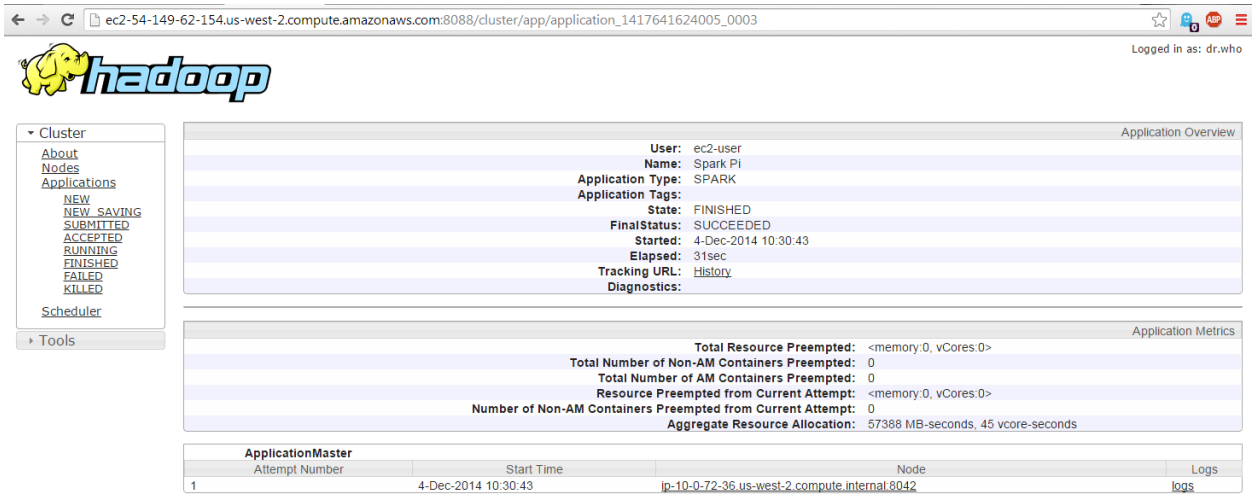
Note that in client mode, the output from the Spark app is sent directly back to the cmd-line.

At this point, you can go to the YARN applications page to see the SparkPi application launched. *(Note, the screenshot below shows 3 apps, but you should only see one)*

Visit the URL:
`http://<your public hostname>:8088/cluster/apps`



Click on a specific application from the web page above and you will see details of the app:

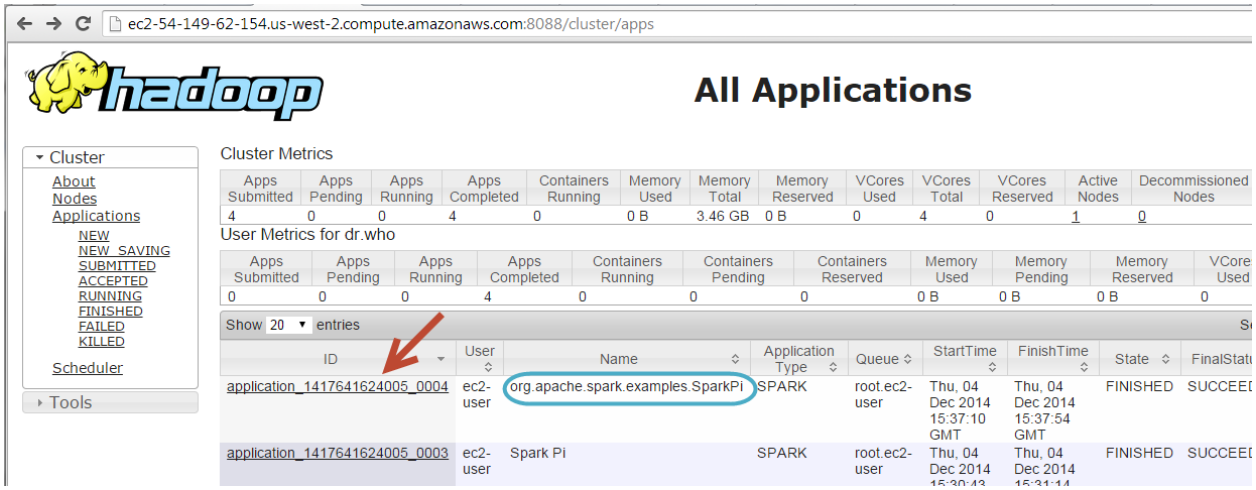


Run the following command to run the same SparkPi app in cluster mode:

```
[ec2-user@ip-10-0-72-36 ~]$ spark-submit --class
org.apache.spark.examples.SparkPi --deploy-mode cluster --master yarn
/opt/cloudera/parcels/CDH-5.2.1-1.cdh5.2.1.p0.12/jars/spark-examples-1.1.0-cd
h5.2.1-hadoop2.5.0-cdh5.2.1.jar 10
SLF4J: Class path contains multiple SLF4J bindings.
SLF4J: Found binding in
[jar:file:/opt/cloudera/parcels/CDH-5.2.1-1.cdh5.2.1.p0.12/jars/spark-assembl
y-1.1.0-cdh5.2.1-hadoop2.5.0-cdh5.2.1.jar!/org/slf4j/impl/StaticLoggerBinder.
class]
SLF4J: Found binding in
[jar:file:/opt/cloudera/parcels/CDH-5.2.1-1.cdh5.2.1.p0.12/jars/slf4j-log4j12
-1.7.5.jar!/org/slf4j/impl/StaticLoggerBinder.class]
SLF4J: See http://www.slf4j.org/codes.html#multiple_bindings for an
explanation.
SLF4J: Actual binding is of type [org.slf4j.impl.Log4jLoggerFactory]
```

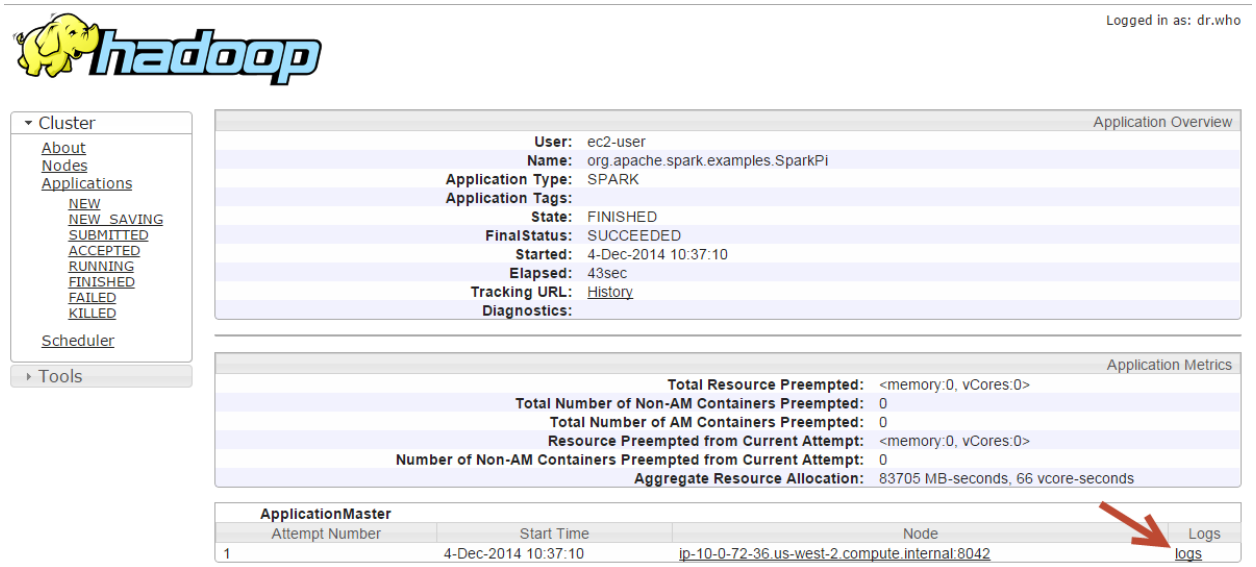
Notice that this time, the output is not shown on the cmd line. The output will be printed to the stdout log file for the application. We'll find that now...

Visit the URL:
http://<your public hostname>:8088/cluster/apps

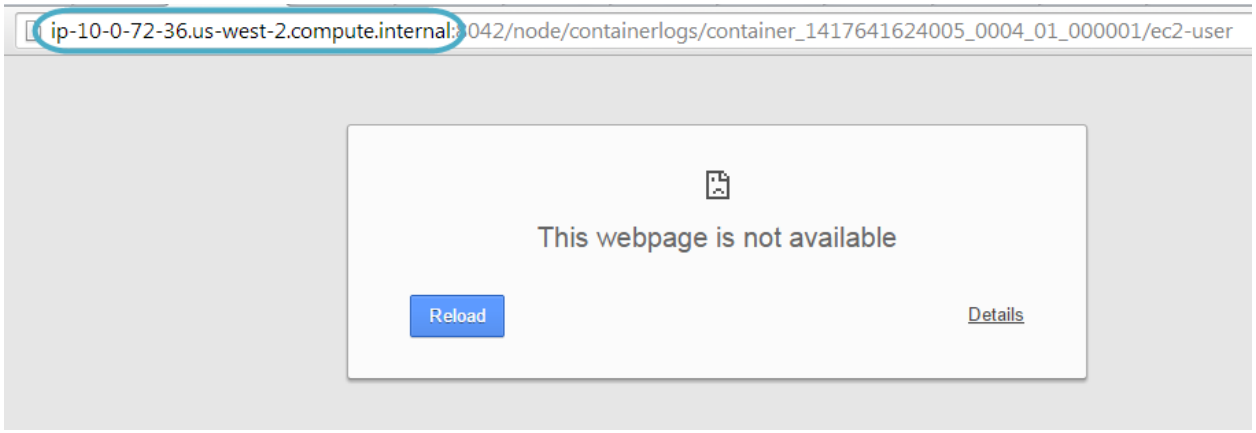


Notice above that the name of the SparkPi app now appears with the full class path. Click on the latest Spark Application ID as seen in the screenshot above.

The next page will show an ApplicationMaster's logs at the bottom right corner. Click on 'logs':



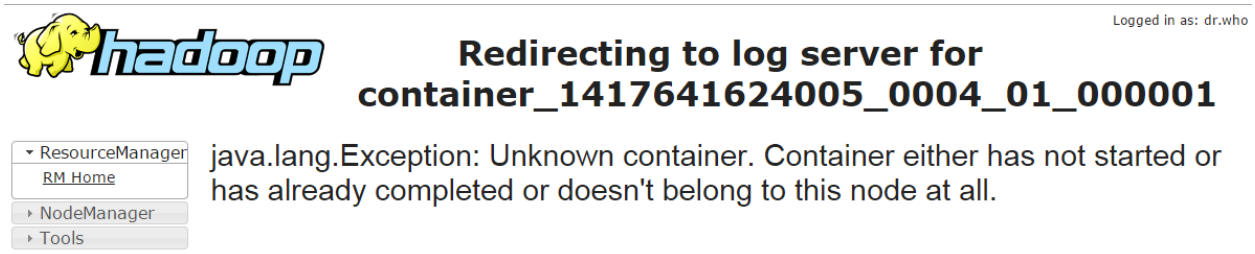
At the point, you'll see a 404 page. Simply replace the internal hostname of the EC2 instance with the public hostname:



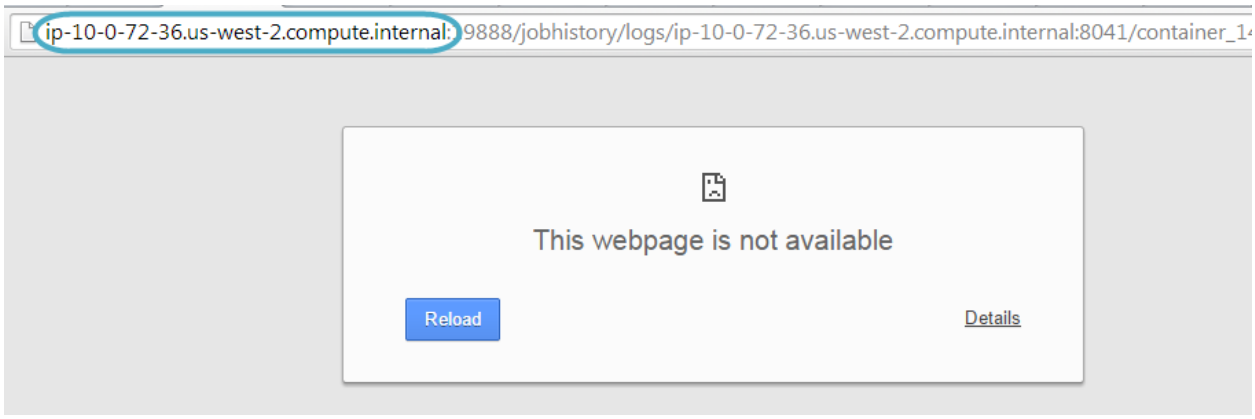
So, replace this:
http://ip-10-0-72-36.us-west-2.compute.internal:8042/node/containerlogs/container_1417641624005_0004_01_000001/ec2-user

with something like this:
http://**<your public hostname>**:8042/node/containerlogs/container_1417641624005_0004_01_000001/ec2-user

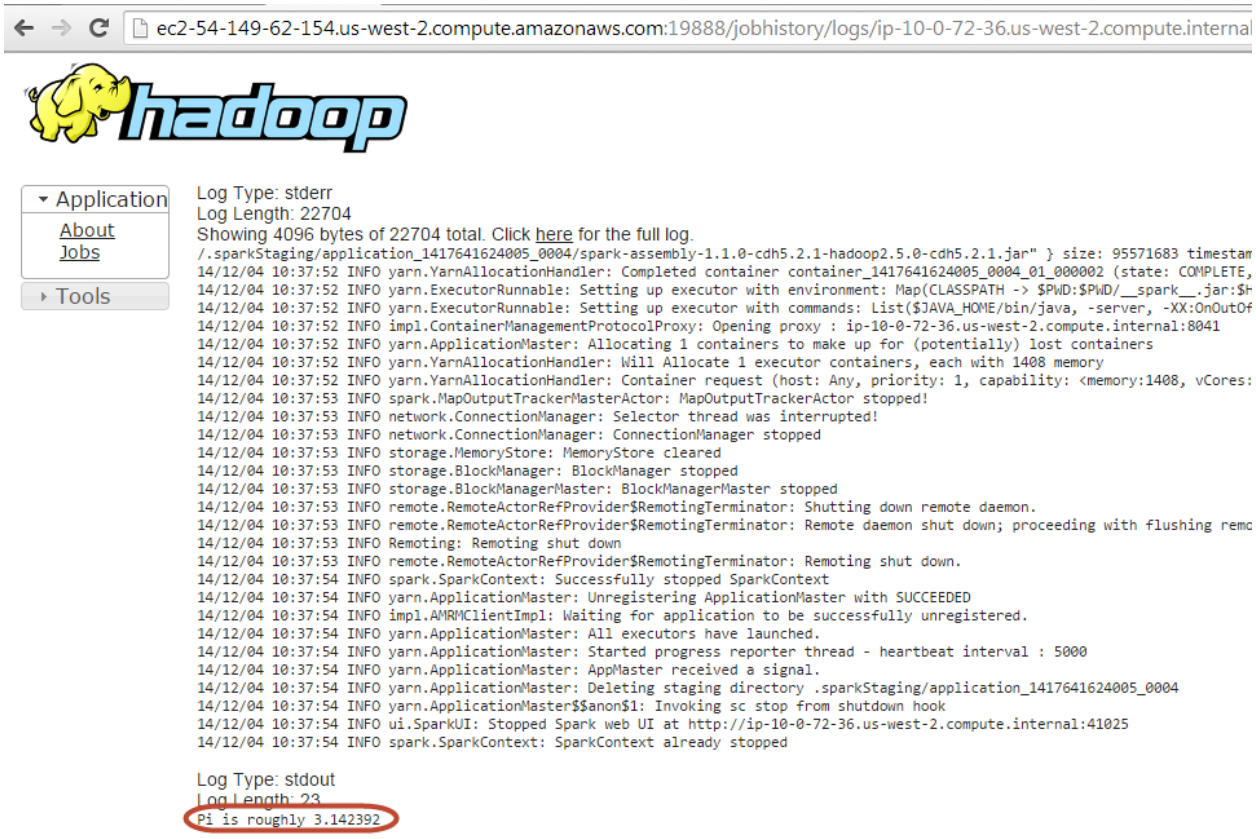
When you hit enter on the fixed URL, you will see this page for about 1-2 seconds:



But then you'll get another 404 page:



Once again, replace the internal hostname in the beginning of the URL with the public hostname and finally, you'll see:



Also, in the screenshot above, the 3rd log line in stderr will show the JVM size of the Executor memory:

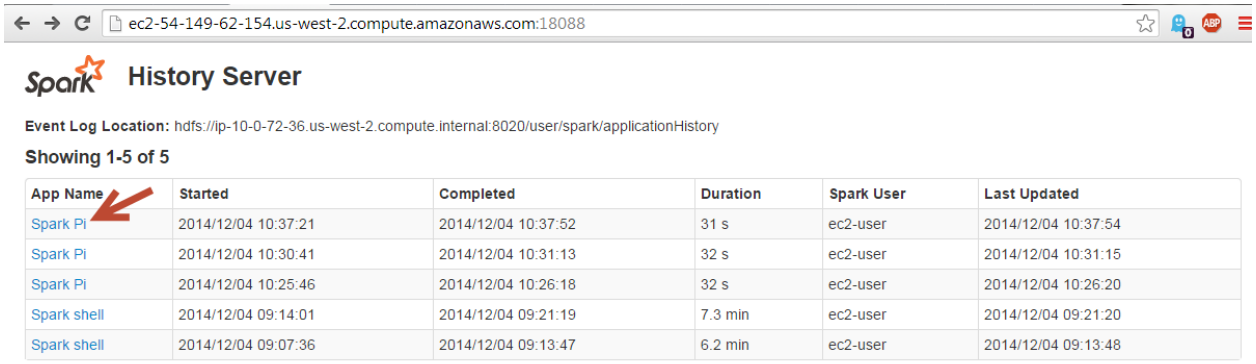
```
14/12/04 10:37:52 INFO yarn.ExecutorRunnable: Setting up executor with
commands: List($JAVA_HOME/bin/java, -server, -XX:OnOutOfMemoryError='kill
%p', -Xms1024m -Xmx1024m <rest of line truncated>
```

And the second to last line shows that there was a Spark web UI available while the Spark app was running (but it will no longer be available):

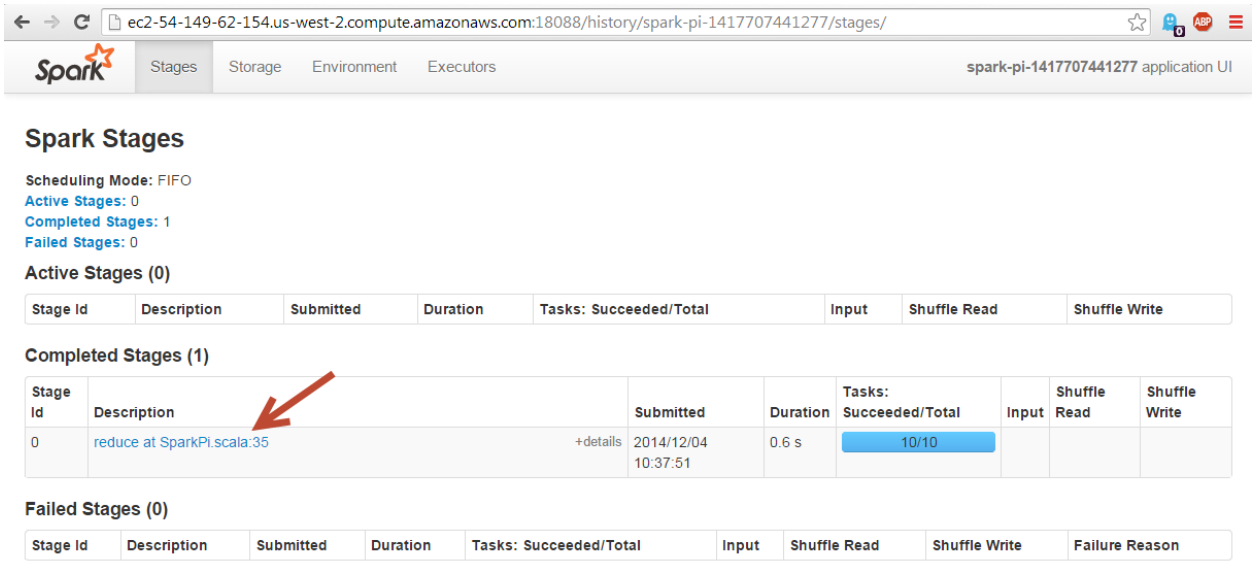
```
14/12/04 10:37:54 INFO ui.SparkUI: Stopped Spark web UI at
http://ip-10-0-72-36.us-west-2.compute.internal:41025
```

Now that we've run several Spark Apps (via the Scala shell, Pyhon Shell and YARN client/cluster modes), we can visit the Spark History server to see the details of each of the jobs that was run:

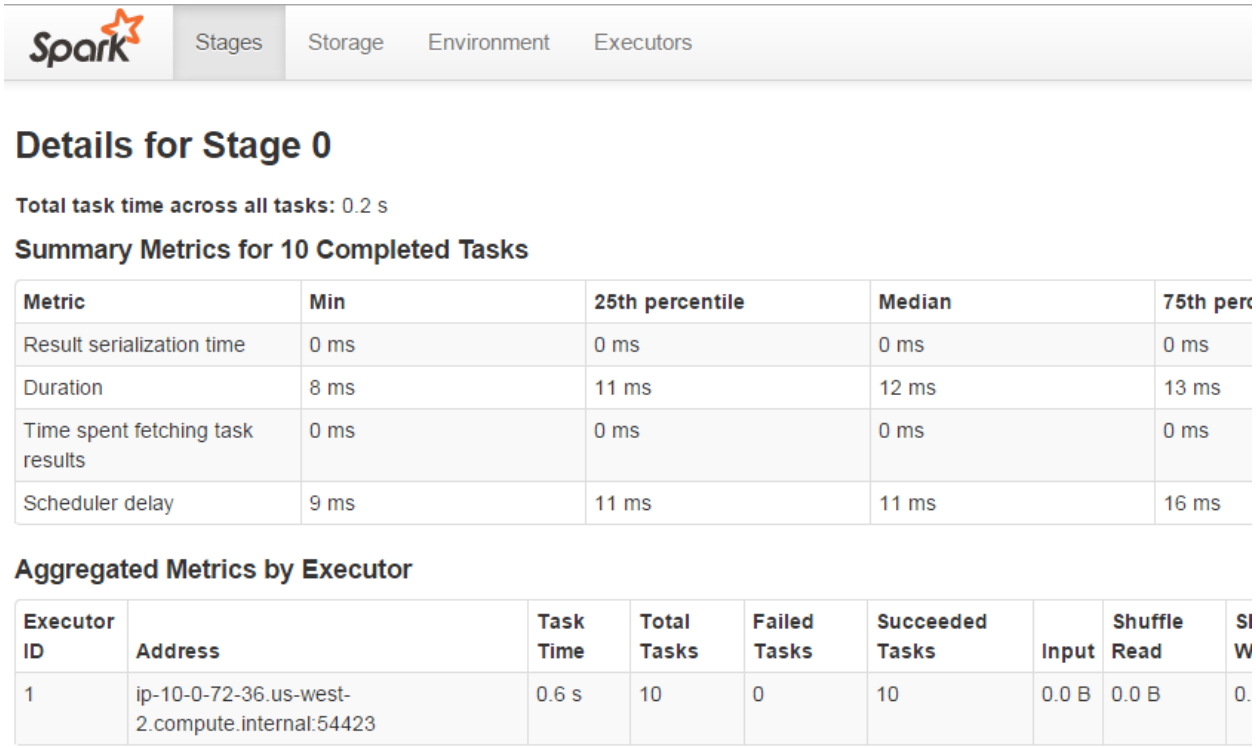
`http://<your public hostname>:18088/`



Try clicking on one of the App Names above to see the details of that app:



Here you will see many details of the Spark application:



Spark | Stages | Storage | Environment | Executors

Details for Stage 0

Total task time across all tasks: 0.2 s

Summary Metrics for 10 Completed Tasks

Metric	Min	25th percentile	Median	75th perc
Result serialization time	0 ms	0 ms	0 ms	0 ms
Duration	8 ms	11 ms	12 ms	13 ms
Time spent fetching task results	0 ms	0 ms	0 ms	0 ms
Scheduler delay	9 ms	11 ms	11 ms	16 ms

Aggregated Metrics by Executor

Executor ID	Address	Task Time	Total Tasks	Failed Tasks	Succeeded Tasks	Input	Shuffle Read	Sl W
1	ip-10-0-72-36.us-west-2.compute.internal:54423	0.6 s	10	0	10	0.0 B	0.0 B	0.

At the end of the page, you will see 10 tasks which corresponds to the fact that you passed in the #10 when running the SparkPi application:

Tasks

Index	ID	Attempt	Status	Locality Level	Executor	Launch Time	Duration	GC Time	Accumulators	Errors
0	0	0	SUCCESS	PROCESS_LOCAL	ip-10-0-72-36.us-west-2.compute.internal	2014/12/04 10:37:51	0.1 s			
1	1	0	SUCCESS	PROCESS_LOCAL	ip-10-0-72-36.us-west-2.compute.internal	2014/12/04 10:37:52	13 ms			
2	2	0	SUCCESS	PROCESS_LOCAL	ip-10-0-72-36.us-west-2.compute.internal	2014/12/04 10:37:52	11 ms			
3	3	0	SUCCESS	PROCESS_LOCAL	ip-10-0-72-36.us-west-2.compute.internal	2014/12/04 10:37:52	11 ms			
4	4	0	SUCCESS	PROCESS_LOCAL	ip-10-0-72-36.us-west-2.compute.internal	2014/12/04 10:37:52	13 ms			
5	5	0	SUCCESS	PROCESS_LOCAL	ip-10-0-72-36.us-west-2.compute.internal	2014/12/04 10:37:52	11 ms			
6	6	0	SUCCESS	PROCESS_LOCAL	ip-10-0-72-36.us-west-2.compute.internal	2014/12/04 10:37:52	14 ms			
7	7	0	SUCCESS	PROCESS_LOCAL	ip-10-0-72-36.us-west-2.compute.internal	2014/12/04 10:37:52	8 ms			
8	8	0	SUCCESS	PROCESS_LOCAL	ip-10-0-72-36.us-west-2.compute.internal	2014/12/04 10:37:52	12 ms			
9	9	0	SUCCESS	PROCESS_LOCAL	ip-10-0-72-36.us-west-2.compute.internal	2014/12/04 10:37:52	12 ms			

Before moving on, note that you can also pass in the # of executors and the amount of memory to assign to each executor like this. This command is just FYI - *do not run it!*

```
[ec2-user@ip-10-0-72-36 ~]$ spark-submit --class
org.apache.spark.examples.SparkPi --deploy-mode client --master yarn --name
“My Pi App” --num-executors 3 --executor-memory 2g
/opt/cloudera/parcels/CDH-5.2.1-1.cdh5.2.1.p0.12/jars/spark-examples-1.1.0-cd
h5.2.1-hadoop2.5.0-cdh5.2.1.jar 10
```

You can learn more details about running Spark on YARN here:
http://spark.apache.org/docs/latest/running-on-yarn.html