EEL6871 Autonomic Computing Fall 2013 **Homework 2**
Assigned: Thursday, Sep-5-2013
Due: Tuesday, Sep-17-2013 5pm

Create Your Own Hadoop Cluster on FutureGrid

This homework requires that you learn how to create a Hadoop cluster using Nimbus on FutureGrid. FutureGrid is a large cloud test-bed that allows researchers to conduct experiments such as virtualization, scheduling, middleware, cybersecurity and so on. It includes a geographically distributed set of heterogeneous computing systems, a data management system that holds both metadata and a growing library of software images, and a dedicated network allowing isolatable, secure experiments. The Hadoop cluster you create will be used as the basic experimental environment for your course project.

Hadoop is one open source implementation of MapReduce framework.. MapReduce is a programming model and an associated implementation for processing and generating large data sets. Users specify a map function that processes a key/value pair to generate a set of intermediate key/value pairs, and a reduce function that merges all intermediate values associated with the same intermediate key.[1] MapReduce is inspired from functional programming.

There are four tasks in this homework: creating your account on the FutureGrid portal, getting familiar with using Nimbus on FutureGrid, starting a Hadoop cluster, running an application on Hadoop.

1 Tasks

1. **Create Your FutureGrid Account**

   Follow this link to create your user account on FutureGrid. Make sure to use your *ufl.edu* email address during application to speed up the verification process. **Do this task as soon as possible because it will take a couple of days for your account to be approved.**

   FutureGrid resources can be accessed via SSH. Follow the steps in this tutorial to generate a ssh key pair and upload that to the FutureGrid Portal. It is stongly recommended that you test your ssh key as explained in the above link before heading to the next task.

2. **Using Nimbus on FutureGrid**

   Nimbus is an open source service package that allows users to run virtual machines on FutureGrid hardware. You can easily upload your own VM image or customize an image provided by Nimbus. When you boot a VM, it is assigned a public IP address (and/or an optional private address); you are authorized to log in as root via SSH. You can then run services, perform computations, and configure the system as desired.

After using and configuring the VM, you can save the modified VM image back to the Nimbus image repository.

This tutorial walks you through the steps of starting a new virtual machine and a new cluster on FutureGrid using Nimbus. Like other cloud services (e.g. Amazon EC2) you interact with cloud services endpoint through a cloud client. The client we use in the above tutorial is called Nimbus Cloud Client. There is a quick start guide on how to use this client to access Nimbus cloud.

Nimbus uses contextualization mechanism to provision one-click clusters. Contextualization is a process where each instance in a cluster is configured at launch time based on what it is supposed to do. Contextualization causes last minute changes inside an instance to adapt to a cluster environment. Many automated cloud services are enabled by contextualization. For example in one-click Hadoop clusters, contextualization basically amounts to generating and distributing ssh key pairs among instances, telling an instance where the master node is and what other slave nodes it should be aware of, etc. If you want to know more about contextualization and what happened behind the scene, check this advanced tutorial here.

3. **Start a Hadoop Cluster** We assume that you are familiar with Nimbus commands when you reach this task , we will go ahead to introduce a wrapper of Nimbus cloud client that will allow you to start a Hadoop cluster in One-click. Being able to launch one-click Hadoop cluster allow researchers and developers analysis data in an easily and time-effectively manner. The steps are as follows.

   (a) Get the source files from Github.

   ```
   git clone https://github.com/kyrameng/OneClickHadoopClusterOnNimbus.git
   ```

   (b) Copy the commands to bin directory and the cluster definition files to sample directory under your nimbus cloud client.

   ```
   cd OneClickHadoopClusterOnNimubs
   cp launch-hadoop-cluster.sh your_nimbus_client/bin/
   cp expand-hadoop-cluster.sh your_nimbus_client/bin/
   cp hadoop-cluster-template.xml your_nimbus_client/samples/
   cp hadoop-add-nodes.xml your_nimbus_client/samples/
   ```

   (c) Launch a cluster using the following command.

   ```
   bin/launch-hadoop-cluster.sh --cluster samples/hadoop-cluster-template.xml --
       nodes 1 --conf conf/hotel.conf --hours 1
   ```

      i. –nodes specifies how many slave nodes you want to have in your cluster. This command will launch a stand-alone master node separately.

      ii. –hours tells Nimbus how long this cluster will run. The cluster will be automatically terminated after reaching the specified hours.

      iii. –cluster specifies which cluster definition file to use. Usually you **should not** change the contents of hadoop-cluster-template.xml.

iv. –conf specifies the site where the cluster will be launched and some configuration about the VMs launched at that site.

Output of the above command.

```
SSH known_hosts contained tilde:
  - '~/.ssh/known_hosts' --> '/home/meng/.ssh/known_hosts'

Requesting cluster.
  - master-node: image 'hadoop-50GB-scheduler.gz', 1 instance
  - slave-nodes: image 'hadoop-50GB-scheduler.gz', 1 instance

Context Broker:
    https://svc.uc.futuregrid.org:8443/wsrf/services/NimbusContextBroker

Created new context with broker.

Workspace Factory Service:
    https://svc.uc.futuregrid.org:8443/wsrf/services/WorkspaceFactoryService

Creating workspace "master-node"... done.
  - 149.165.148.157 [ vm-148-157.uc.futuregrid.org ]

Creating workspace "slave-nodes"... done.
  - 149.165.148.158 [ vm-148-158.uc.futuregrid.org ]

Launching cluster-042... done.

Waiting for launch updates.
  - cluster-042: all members are Running
  - wrote reports to '/home/meng/futuregrid/history/cluster-042/reports-vm'

Waiting for context broker updates.
  - cluster-042: contextualized
  - wrote ctx summary to '/home/meng/futuregrid/history/cluster-042/reports-ctx
      /CTX-OK.txt'
  - wrote reports to '/home/meng/futuregrid/history/cluster-042/reports-ctx'

SSH trusts new key for vm-148-157.uc.futuregrid.org [[ master-node ]]

SSH trusts new key for vm-148-158.uc.futuregrid.org [[ slave-nodes ]]
cluster-042
Hadoop-Cluster-Handle cluster99
```

Go to Hadoop Web UI to check your cluster status, e.g. http://149.165.148.157:50030

In order to start a Hadoop cluster, you must use the customized Hadoop images called hadoop.gz. We provide two flavors of Hadoop images. The first one resides on Alamo. It's light weighted and can accommodate only 2G data per node. The other one resides on Hotel and Foxtrot. It can accommodate 50GB data per node. You should specify hadoop.gz in your cluster definition file for both master node and slave nodes. The cluster definition template you obtained from GitHub use these images by default. A couple of notes about this image:

- If you want to perform large data analysis, start your cluster on Hotel or Foxtrot. Otherwise use Alamo. Given the approximate size of your data and the capacity for each node, you should be able to estimate how many nodes you need in your cluster.
- The hadoop.gz image itself is large (approximately 1G), so it will take longer time to deploy VMs compared to using other small images.
- The hadoop cluster you start using hadoop.gz on Hotel or Foxtrot will have a fair scheduler plugged in for you. Find more about Hadoop fair scheduler at here. Your can check the scheduler status at http://master-ip:50030/scheduler
- Hadoop is installed at */usr/local/hadoop*.
- Most of Hadoop configuration parameters can be at */usr/local/hadoop/conf*.
- Each account on FutureGrid can have maximum 12 VMs running at the same time. However in order to avoid congestion towards the due date of homework, I recommend you to start your homework earlier instead of at last minute.
- If you use hadoop.gz on Hotel or Foxtrot, try to limit your cluster size to 7. Terminate your clusters if you are not using them.

4. Monitoring your Hadoop Clusters

   Hadoop offers a couple of web interfaces for you to check its running status.

   (a) NameNode - http://master-ip:50070/

   (b) JobTracker - http://master-ip:50030/

   (c) TaskTracker - http://slave-ip:50060/

   (d) Scheduler - http://master-ip:50030/scheduler

2 Deliverables

1. Start a hadoop cluster on FutureGrid. Give a snapshot of its JobTracker webpage at http://master-ip:50030 like the following:

hadoopmaster Hadoop Map/Reduce Administration

State: RUNNING
Started: Wed Sep 04 15:04:30 HST 2013
Version: 1.0.3, r1335192
Compiled: Tue May 8 20:31:25 UTC 2012 by hortonfo
Identifier: 201309041504

Cluster Summary (Heap Size is 15.5 MB/966.69 MB)

Running Map Tasks	Running Reduce Tasks	Total Submissions	Nodes	Occupied Map Slots	Occupied Reduce Slots	Reserved Map Slots	Reserved Reduce Slots
0	0	0	2	0	0	0	0

Scheduling Information

Queue Name	State	Scheduling Information
default	running	N/A

Filter (Jobid, Priority, User, Name)
Example: 'user:smith 3200' will filter by 'smith' only in the user field and '3200' in all fields

Running Jobs

none

2. There are many example/testing application shipped with the Hadoop distribution (*hadoop-examples-1.0.3.jar*,*hadoop-test-1.0.3.jar*). Choose one of the examples or testing programs and run it on your Hadoop cluster. Give a snapshot of the program running result. For example the following is the snapshot of running TestDFSIO.

```
root@hadoopmaster:/usr/local/hadoop# bin/hadoop jar hadoop-test-1.0.3.jar TestDFSIO
 -write -nrFiles 10 -fileSize 100
TestDFSIO.0.0.4
13/09/04 15:32:39 INFO fs.TestDFSIO: nrFiles = 10
13/09/04 15:32:39 INFO fs.TestDFSIO: fileSize (MB) = 100
13/09/04 15:32:39 INFO fs.TestDFSIO: bufferSize = 1000000
13/09/04 15:32:40 INFO fs.TestDFSIO: creating control file: 100 mega bytes, 10 file
s
13/09/04 15:32:41 INFO fs.TestDFSIO: created control files for: 10 files
13/09/04 15:32:41 INFO mapred.FileInputFormat: Total input paths to process : 10
13/09/04 15:32:41 INFO mapred.JobClient: Running job: job_201309041504_0001
13/09/04 15:32:42 INFO mapred.JobClient:  map 0% reduce 0%
13/09/04 15:33:00 INFO mapred.JobClient:  map 10% reduce 0%
13/09/04 15:33:09 INFO mapred.JobClient:  map 20% reduce 0%
13/09/04 15:33:15 INFO mapred.JobClient:  map 30% reduce 0%
13/09/04 15:33:18 INFO mapred.JobClient:  map 30% reduce 6%
13/09/04 15:33:24 INFO mapred.JobClient:  map 40% reduce 6%
13/09/04 15:33:27 INFO mapred.JobClient:  map 40% reduce 10%
13/09/04 15:33:30 INFO mapred.JobClient:  map 50% reduce 10%
13/09/04 15:33:33 INFO mapred.JobClient:  map 50% reduce 13%
13/09/04 15:33:36 INFO mapred.JobClient:  map 60% reduce 13%
13/09/04 15:33:42 INFO mapred.JobClient:  map 70% reduce 16%
13/09/04 15:33:48 INFO mapred.JobClient:  map 70% reduce 20%
13/09/04 15:33:51 INFO mapred.JobClient:  map 80% reduce 20%
13/09/04 15:33:54 INFO mapred.JobClient:  map 80% reduce 23%
13/09/04 15:34:00 INFO mapred.JobClient:  map 90% reduce 23%
13/09/04 15:34:03 INFO mapred.JobClient:  map 90% reduce 26%
13/09/04 15:34:06 INFO mapred.JobClient:  map 100% reduce 26%
13/09/04 15:34:09 INFO mapred.JobClient:  map 100% reduce 30%
13/09/04 15:34:18 INFO mapred.JobClient:  map 100% reduce 100%
13/09/04 15:34:23 INFO mapred.JobClient: Job complete: job_201309041504_0001
13/09/04 15:34:23 INFO mapred.JobClient: Counters: 30
13/09/04 15:34:23 INFO mapred.JobClient:   Job Counters
13/09/04 15:34:23 INFO mapred.JobClient:     Launched reduce tasks=1
13/09/04 15:34:23 INFO mapred.JobClient:     SLOTS_MILLIS_MAPS=60592
13/09/04 15:34:23 INFO mapred.JobClient:     Total time spent by all reduces waitin
g after reserving slots (ms)=0
```

3. Explain your understanding of the application you choose, specifically what does the program do ? What does the map and reduce function do the input data? If possible

list the input/output key-value pairs for the map and reduce functions. You **should not** choose a program that is too easy to interpret its map and reduce functionality such as word count or sleep.

4. Include all the above answers in a PDF file named as *your_name*_hw2.pdf.

3 Helpful Links

1. Google MapReduce paper
2. FutureGrid Tutorials: https://portal.futuregrid.org/tutorials
3. Nimbus Documentation: http://www.nimbusproject.org/doc/nimbus/
4. Hadoop Tutorial: http://developer.yahoo.com/hadoop/tutorial/
5. Hadoop word count example : http://hadoop.apache.org/docs/stable/mapred_tutorial.html