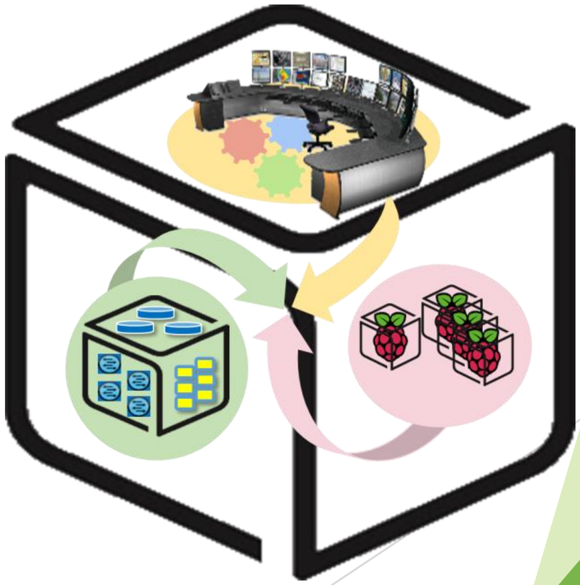
SmartX Labs for Computer Systems

Cluster Lab

(2016, Spring)

NetCS Lab



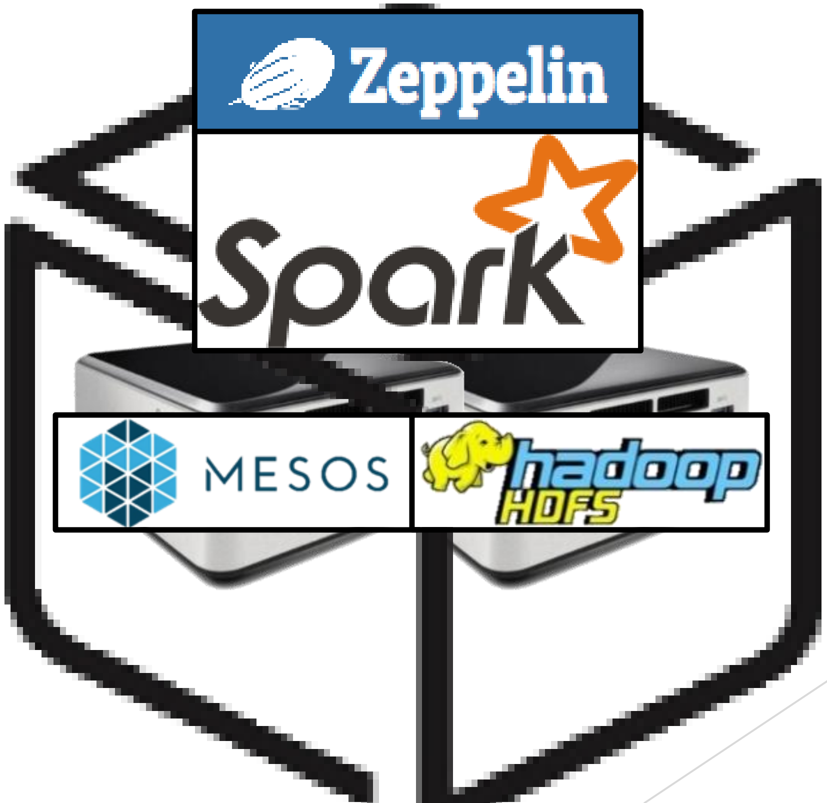
History and Contributor of Cluster Lab (2016. 06. 30.)

Version	Updated Date	Updated Contents	Contributor
-	2015/10	(구) Analytics Lab 작성	송지원
v1	2016/04	Cluster Lab 초안 작성	김승룡
v2	2016/05	Cluster Lab 수정	송지원
v3r3	2016/05/28	Cluster Lab 2차 수정 (내용 수정 및 추가)	송지원
v4r1	2016/05/30	Cluster Lab 3차 수정 (피드백 반영)	송지원
v5	2016/06/01	HDFS를 옵션으로 변경, 기타 문제 수정	송지원
v6r1	2016/06/03	실습자 검수 후 수정	송지원, 윤희범, 남택호
v6r2	2016/06/29	HDFS 설치 과정 등 수정	송지원
v6r3	2016/06/30	Zeppelin 독립 실행 모드 설명 추가	송지원
0.6.4	2016/07/04	Zeppelin 설치 방법 누락된 부분 추가	송지원

CSLab: Cluster LAB - Goal

SETUP to run data processing and visualization

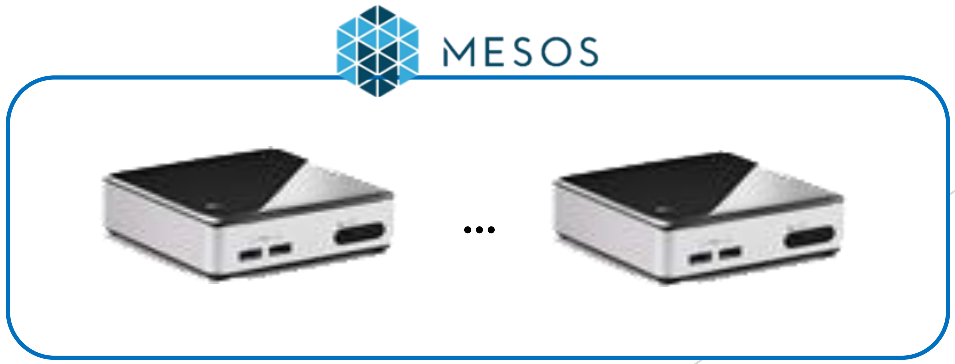
- Install Mesos, HDFS, Spark, Zeppelin on NUC



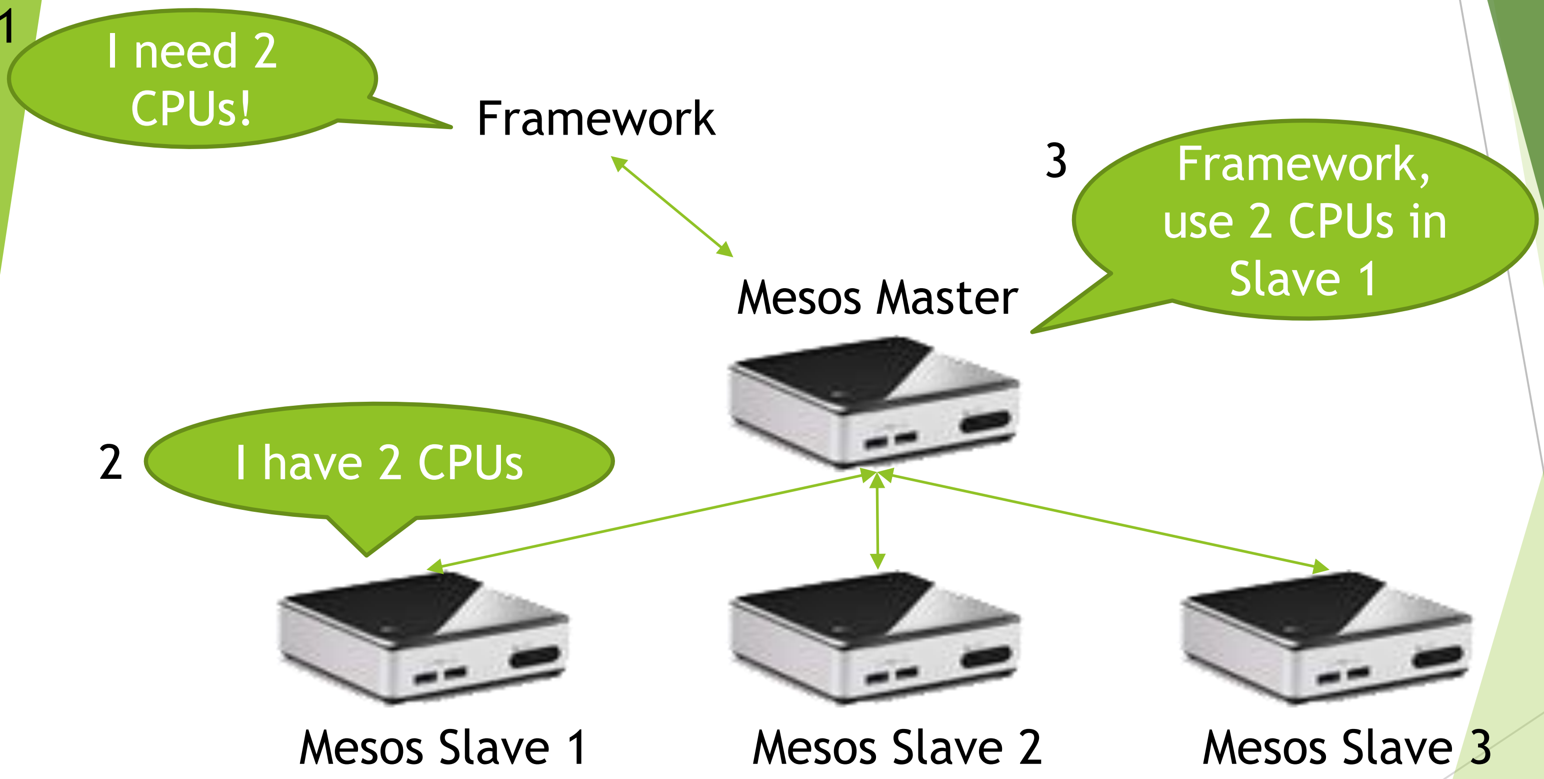
Apache Mesos - Concept

What is Mesos?
A distributed systems kernel
Mesos is built using the same principles as the Linux kernel, only at a different level of abstraction. The Mesos kernel runs on every machine and provides applications (e.g., Hadoop, Spark, Kafka, Elastic Search) with API's for resource management and scheduling across entire datacenter and cloud environments.

- Cloud as a single computer
- Share resources across the machines



Apache Mesos
- Architecture



HDFS - Concept

Hadoop Distributed FileSystem

- A distributed file system that provides high-throughput access to application data.

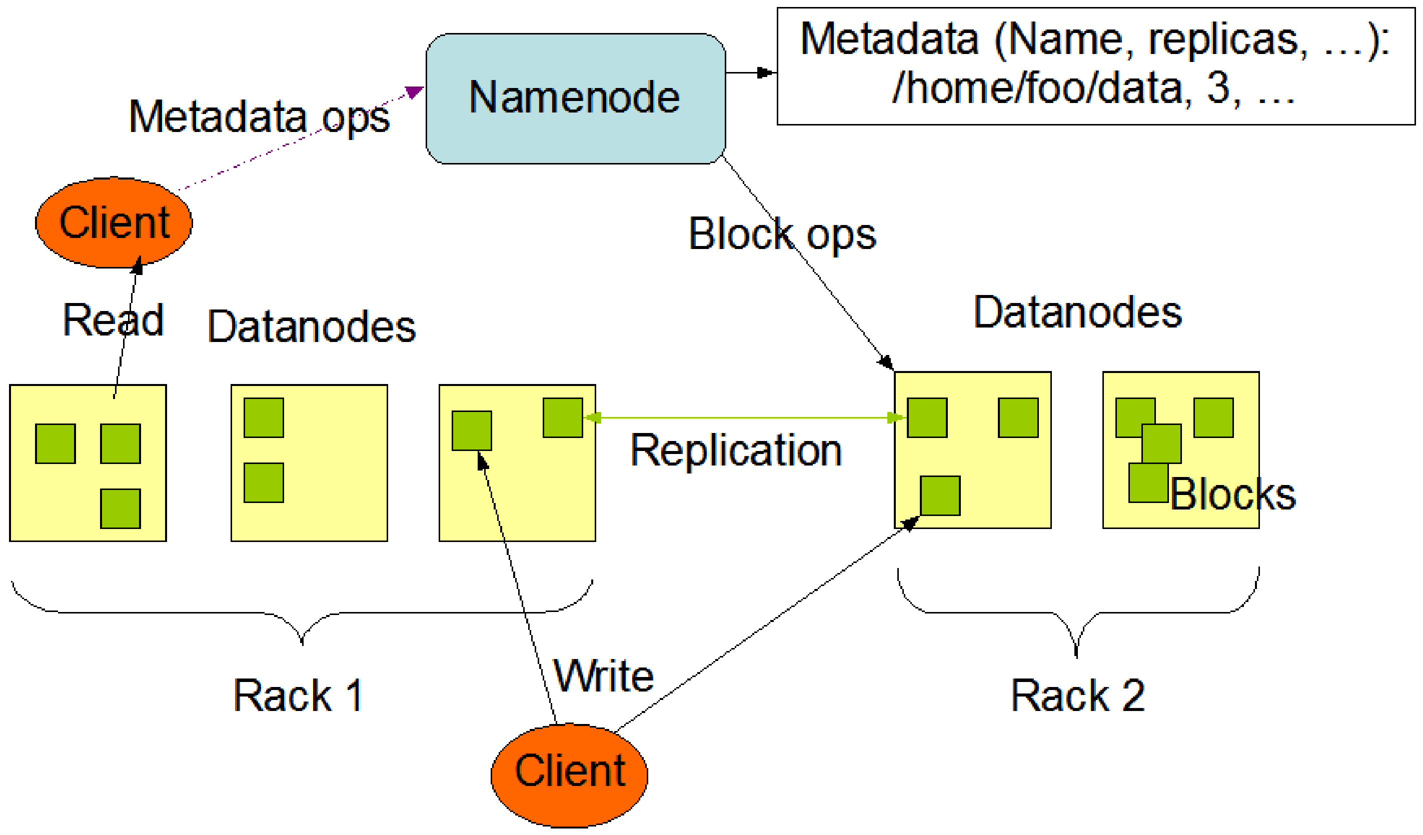
Features

- Fault tolerance by detecting faults and applying quick, automatic recovery
- Portability across heterogeneous commodity hardware and operating systems
- Scalability to reliably store and process large amounts of data
- Economy by distributing data and processing across clusters of commodity personal computers
- Efficiency by distributing data and logic to process it in parallel on nodes where data is located
- Reliability by automatically maintaining multiple copies of data and automatically redeploying processing logic in the event of failures

HDFS
- Architecture

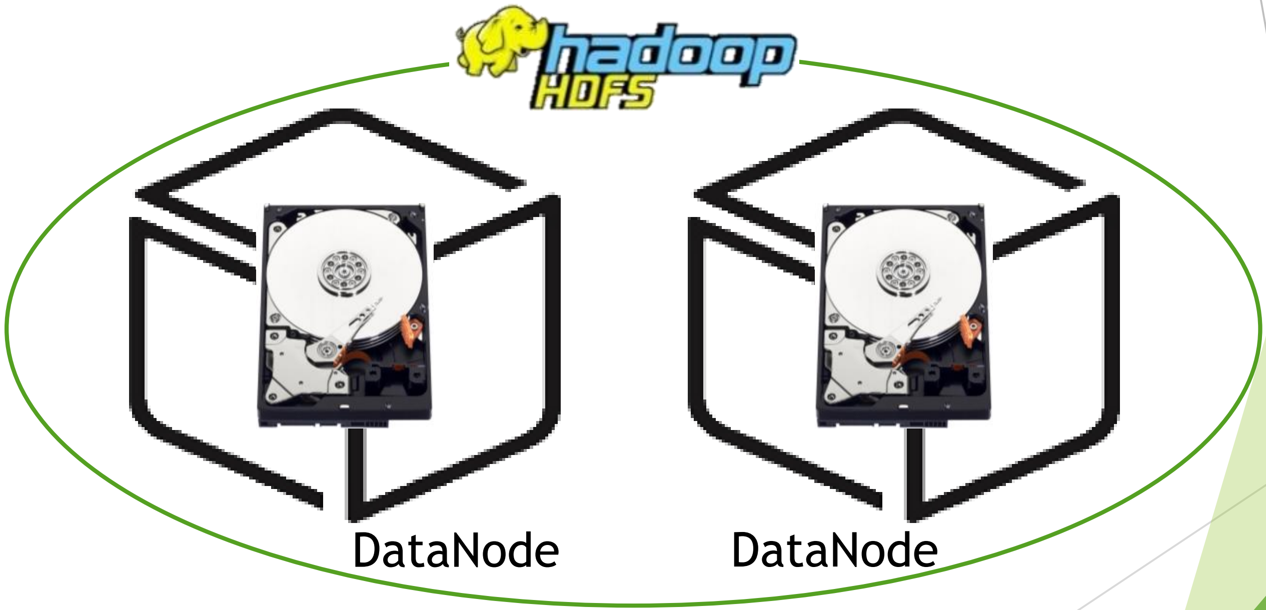
<Master/Slave architecture>

- NameNode: A single node which manages the file system namespace and regulates access to files by clients.
- DataNode: DataNodes manage storage attached to the nodes that they run on.



HDFS
- Architecture

HDFS makes storages of separate machines in cluster into a single storage.

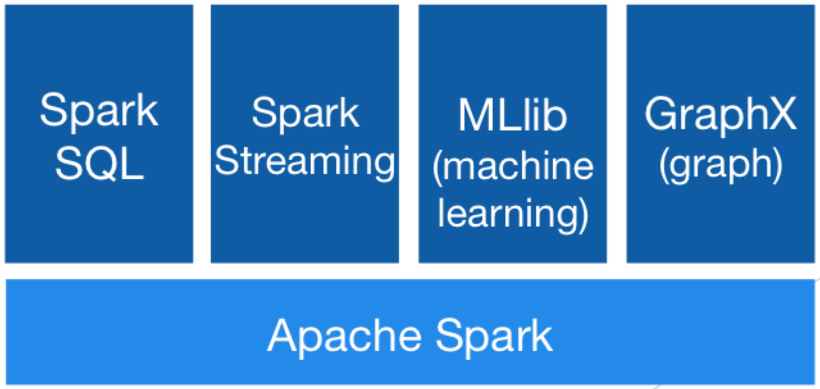


Apache Spark
- Concept

Apache Spark™ is a fast and general engine for large-scale data processing.

- In-memory data processing framework: Fast!
- Easy to use, community fastly growing
- Libraries: SQL and DataFrame, Streaming, MLlib, GraphX
- Run on standalone or Mesos, Yarn, etc

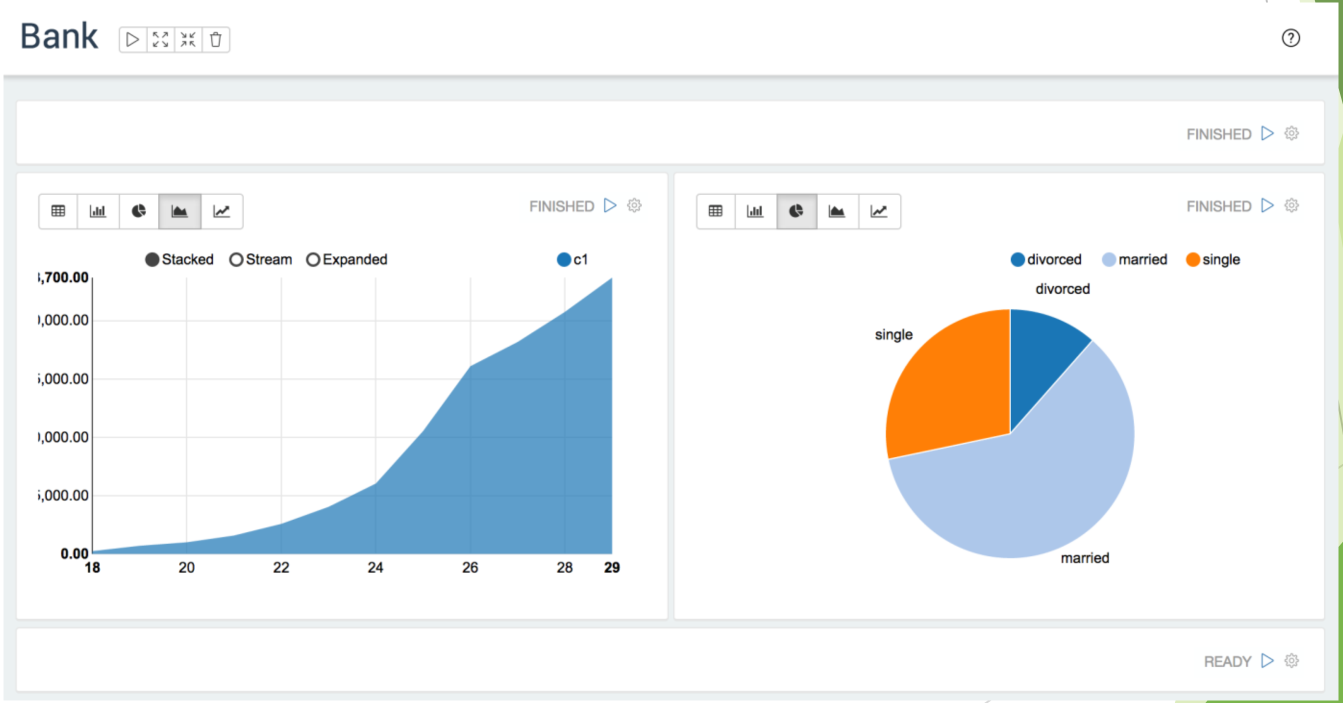
- Scala, Java, Python



Apache Zeppelin
-Concept

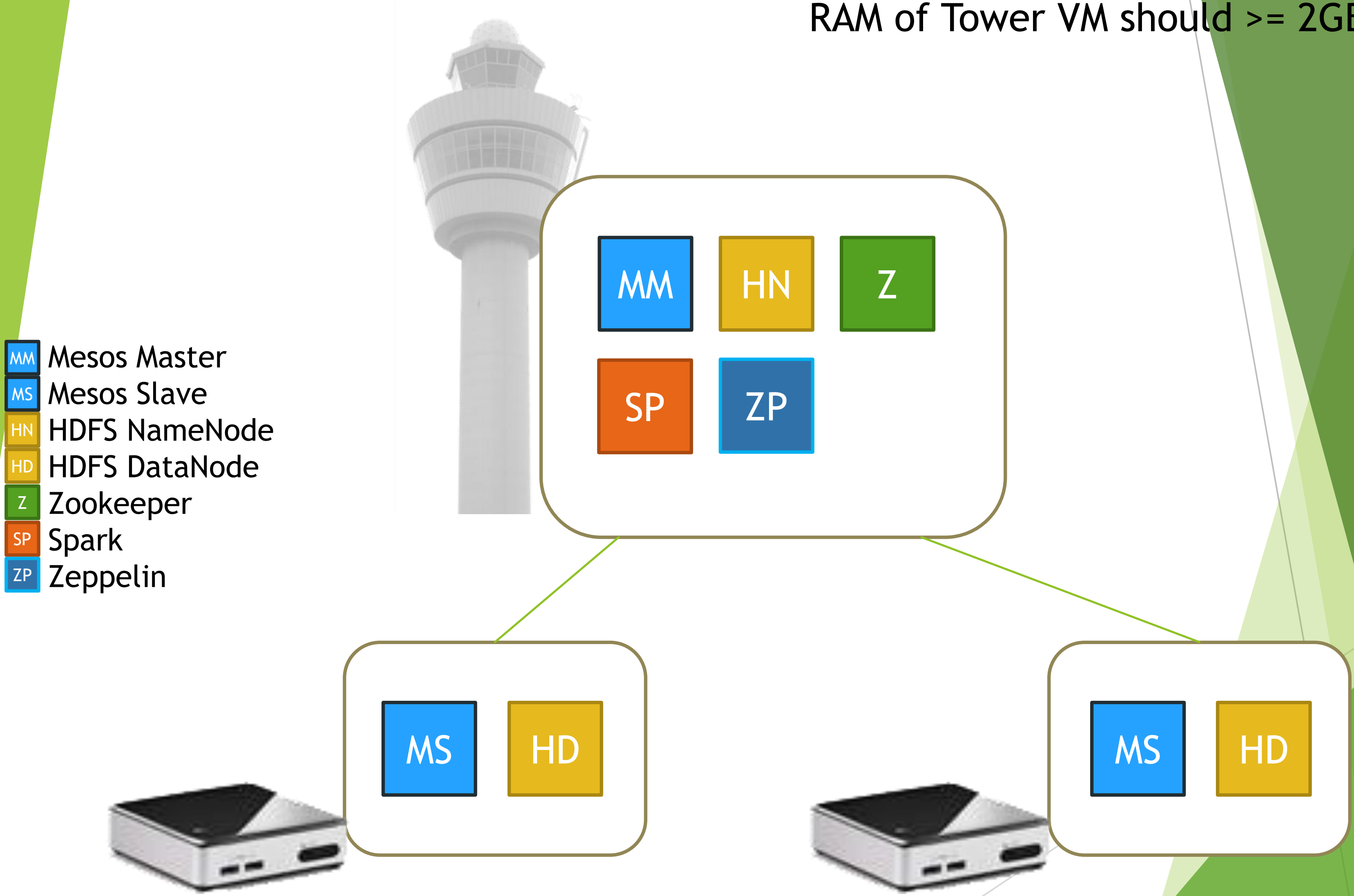
A web-based notebook that enables interactive data analytics.

Support Spark



0. Cluster Overview

Prerequisite: Ubuntu 14.04 - 64bit.
(To install Java, see AppServer Lab.)
RAM of Tower VM should >= 2GB.



0. Preparation
- Install Java

Install JAVA JDK 8

```
$ sudo add-apt-repository ppa:webupd8team/java
$ sudo apt-get update
$ sudo apt-get install oracle-java8-installer
```

If fail to install JAVA like

```
        error: sudo add-apt-repository: command not found
        Follow command
                $ sudo apt-get install software-properties-common python-software-properties
                $ sudo apt-get update
```

Do this for all tower and NUCs.

If you already installed Java 8 in previous labs, you can skip it.

0. Preparation
- Configure accounts

Do this for all tower and NUCs.

1. Set root password

```
•  sudo passwd
```

2. Create Hadoop account and login

```
•  sudo -s
•  adduser hadoop
•  adduser hadoop sudo

•  su hadoop    #login as ‘hadoop’
```

This procedure is required when you install HDFS.

0. Preparation
- Configure hostnames

Do this for all tower and NUCs.

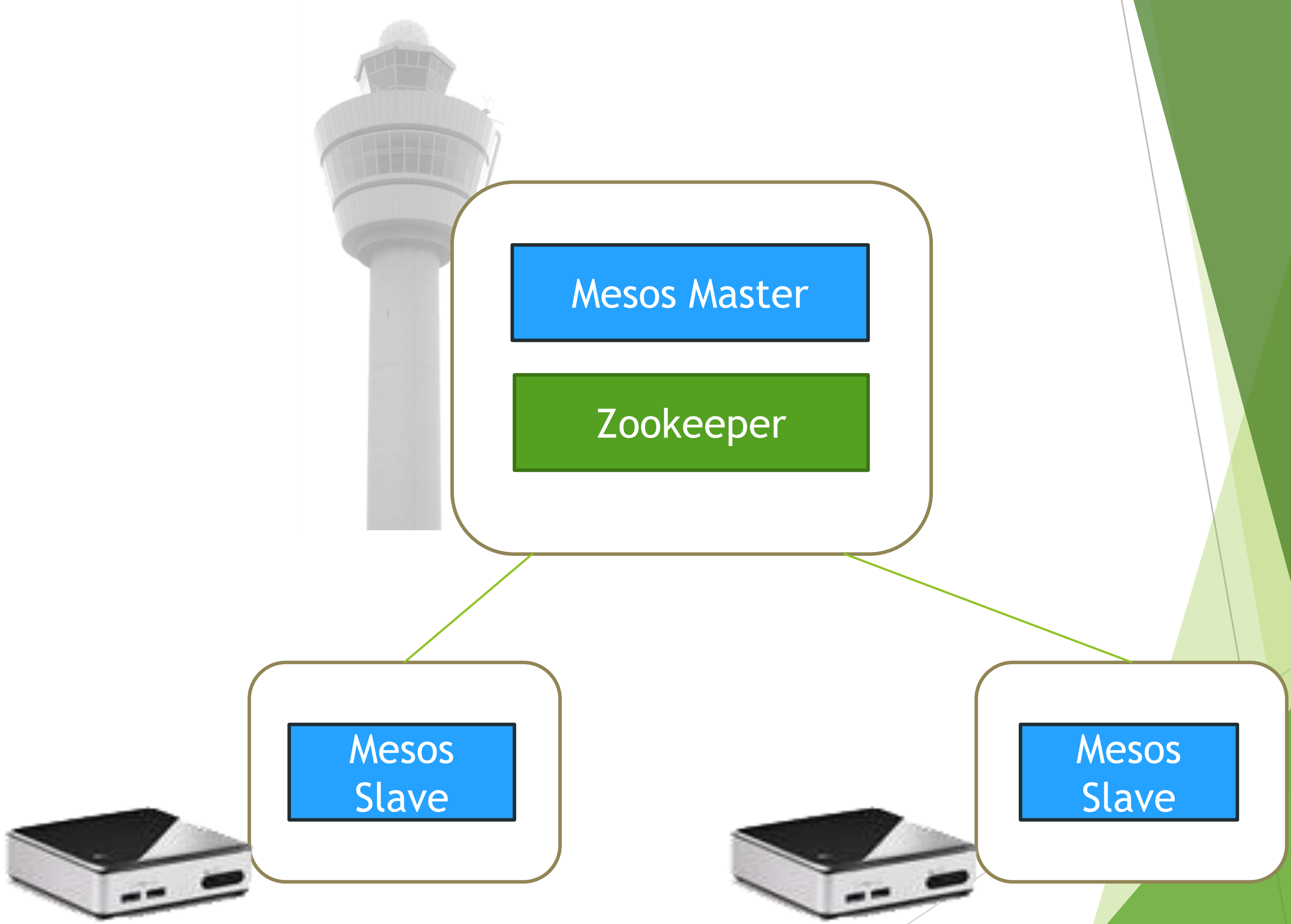
1. Edit /etc/hosts

```
•  sudo vi /etc/hosts
```

Edit:

```
EX)  127.0.0.1      localhost
     192.168.0.1    tower
     192.168.0.2    nuc01
     192.168.0.3    nuc02
```

1. Apache Mesos
- Install



1. Apache Mesos
- Installation Procedure

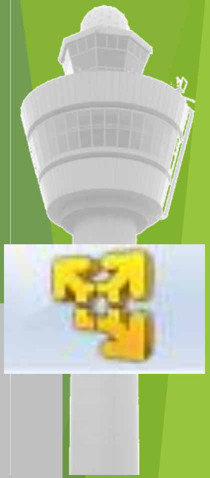
1. Add Mesosphere repository
2. Install Mesos Master
3. Install Mesos Slave
4. Check on the Web UI

1. Apache Mesos
- Install: Add Mesosphere repository

Add the repository to Tower and NUCs.

```
sudo apt-key adv --keyserver keyserver.ubuntu.com --recv E56151BF

DISTRO=$(lsb_release -is | tr '[:upper:]' '[:lower:]')
CODENAME=$(lsb_release -cs)

        To check you correctly input, use echo command.
        echo $DISTRO $CODENAME
        ubuntu trusty

echo "deb http://repos.mesosphere.io/${DISTRO} ${CODENAME} main" | sudo
tee /etc/apt/sources.list.d/mesosphere.list

sudo apt-get -y update
```

1. Apache Mesos
- Install: Mesos Master



```
sudo apt-get -y install mesos
sudo reboot

sudo service mesos-slave stop

echo manual | sudo tee /etc/init/mesos-slave.override
echo <TOWER_IP_ADDR> | sudo tee /etc/mesos-master/ip
echo <TOWER_HOSTNAME> | sudo tee /etc/mesos-master/hostname
echo zk://<TOWER_IP_ADDR>:2181/mesos | sudo tee /etc/mesos/zk
echo <NAME> | sudo tee /etc/mesos-master/cluster

sudo service zookeeper restart
sudo service mesos-master restart

echo 1 | sudo tee /etc/zookeeper/conf/myid
```

NAME: anything you want

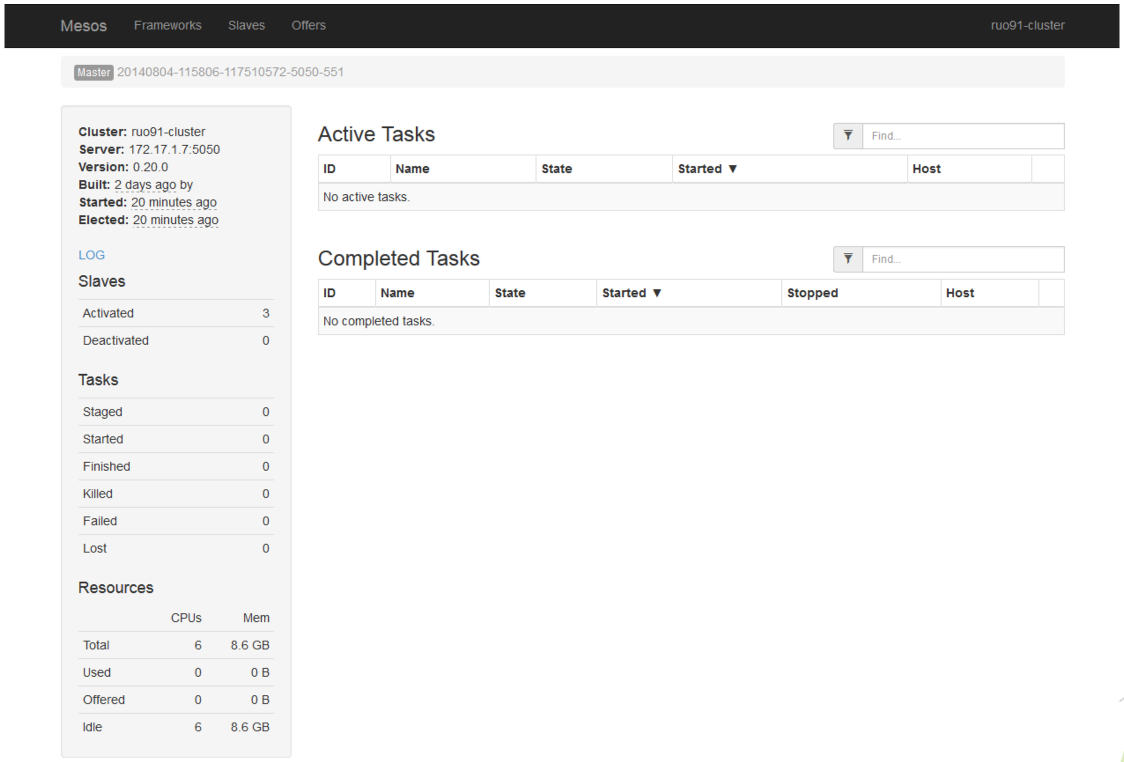
1. Apache Mesos
- Install: Mesos Slave

```
• sudo apt-get -y install mesos
• sudo reboot

• sudo service mesos-master stop
• echo manual | sudo tee /etc/init/mesos-master.override
• sudo service zookeeper stop
• echo manual | sudo tee /etc/init/zookeeper.override
• sudo apt-get -y remove --purge zookeeper

• echo <NUC_IP_ADDR> | sudo tee /etc/mesos-slave/ip
• echo <NUC_HOSTNAME> | sudo tee /etc/mesos-slave/hostname
• echo zk://<TOWER_IP_ADDR>:2181/mesos | sudo tee /etc/mesos/zk
• echo HADOOP_HOME=/usr/local/hadoop | sudo tee –a
  /etc/default/mesos-slave

• sudo reboot
```

HADOOP_HOME will be needed later if you want to use Spark with HDFS.

1. Apache Mesos
- Check on the Web UI

In your web browser, go to
`http://<MASTER-IP-ADDR>:5050`



Master 20140804-115806-117510572-5050-551

Cluster: ruo91-cluster
Server: 172.17.1.7:5050
Version: 0.20.0
Built: 2 days ago by
Started: 20 minutes ago
Elected: 20 minutes ago

LOG

Slaves

Activated	3
Deactivated	0

Tasks

Staged	0
Started	0
Finished	0
Killed	0
Failed	0
Lost	0

Resources

	CPUs	Mem
Total	6	8.6 GB
Used	0	0 B
Offered	0	0 B
Idle	6	8.6 GB

Active Tasks

ID	Name	State	Started ▼	Host
No active tasks.				

Completed Tasks

ID	Name	State	Started ▼	Stopped	Host
No completed tasks.					

Check the activated slaves and resources.

2. Apache Spark
- Install

1. Download and unarchive Spark binary for all Tower and NUCs.

```
•  cd ~
•  wget http://mirror.apache-kr.org/spark/spark-1.6.2/spark-1.6.2-bin-
   hadoop2.6.tgz
•  tar xzf spark-1.6.2-bin-hadoop2.6.tgz
```

2. On Tower, configure `spark-env.sh` file.

```
•  cd spark-1.6.2-bin-hadoop2.6/conf
•  cp spark-env.sh.template spark-env.sh
•  vi spark-env.sh
```

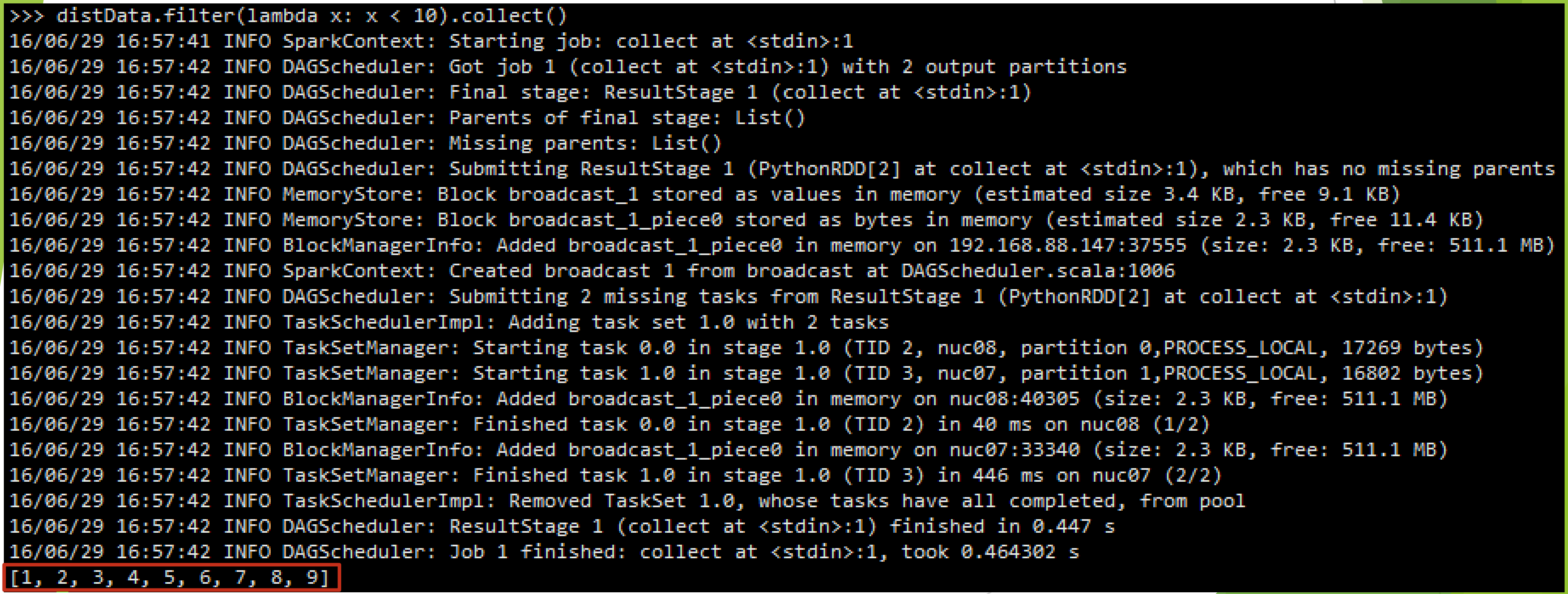
Edit:
```
export MESOS_NATIVE_JAVA_LIBRARY=/usr/local/lib/libmesos.so
export MASTER=mesos://<TOWER_IP>:5050
```

2. Apache Spark
## - Test

# Test Spark: In Tower

```
• cd ..
• bin/pyspark

>>> data = range(1, 10001)
>>> distData = sc.parallelize(data)
>>> distData.filter(lambda x: x < 10).collect()
```

Go to Mesos web UI and see Spark framework running.



```
>>> distData.filter(lambda x: x < 10).collect()
16/06/29 16:57:41 INFO SparkContext: Starting job: collect at <stdin>:1
16/06/29 16:57:42 INFO DAGScheduler: Got job 1 (collect at <stdin>:1) with 2 output partitions
16/06/29 16:57:42 INFO DAGScheduler: Final stage: ResultStage 1 (collect at <stdin>:1)
16/06/29 16:57:42 INFO DAGScheduler: Parents of final stage: List()
16/06/29 16:57:42 INFO DAGScheduler: Missing parents: List()
16/06/29 16:57:42 INFO DAGScheduler: Submitting ResultStage 1 (PythonRDD[2] at collect at <stdin>:1), which has no missing parents
16/06/29 16:57:42 INFO MemoryStore: Block broadcast_1 stored as values in memory (estimated size 3.4 KB, free 9.1 KB)
16/06/29 16:57:42 INFO MemoryStore: Block broadcast_1_piece0 stored as bytes in memory (estimated size 2.3 KB, free 11.4 KB)
16/06/29 16:57:42 INFO BlockManagerInfo: Added broadcast_1_piece0 in memory on 192.168.88.147:37555 (size: 2.3 KB, free: 511.1 MB)
16/06/29 16:57:42 INFO SparkContext: Created broadcast 1 from broadcast at DAGScheduler.scala:1006
16/06/29 16:57:42 INFO DAGScheduler: Submitting 2 missing tasks from ResultStage 1 (PythonRDD[2] at collect at <stdin>:1)
16/06/29 16:57:42 INFO TaskSchedulerImpl: Adding task set 1.0 with 2 tasks
16/06/29 16:57:42 INFO TaskSetManager: Starting task 0.0 in stage 1.0 (TID 2, nuc08, partition 0,PROCESS_LOCAL, 17269 bytes)
16/06/29 16:57:42 INFO TaskSetManager: Starting task 1.0 in stage 1.0 (TID 3, nuc07, partition 1,PROCESS_LOCAL, 16802 bytes)
16/06/29 16:57:42 INFO BlockManagerInfo: Added broadcast_1_piece0 in memory on nuc08:40305 (size: 2.3 KB, free: 511.1 MB)
16/06/29 16:57:42 INFO TaskSetManager: Finished task 0.0 in stage 1.0 (TID 2) in 40 ms on nuc08 (1/2)
16/06/29 16:57:42 INFO BlockManagerInfo: Added broadcast_1_piece0 in memory on nuc07:33340 (size: 2.3 KB, free: 511.1 MB)
16/06/29 16:57:42 INFO TaskSetManager: Finished task 1.0 in stage 1.0 (TID 3) in 446 ms on nuc07 (2/2)
16/06/29 16:57:42 INFO TaskSchedulerImpl: Removed TaskSet 1.0, whose tasks have all completed, from pool
16/06/29 16:57:42 INFO DAGScheduler: ResultStage 1 (collect at <stdin>:1) finished in 0.447 s
16/06/29 16:57:42 INFO DAGScheduler: Job 1 finished: collect at <stdin>:1, took 0.464302 s
[1, 2, 3, 4, 5, 6, 7, 8, 9]
```

3. Apache Zeppelin
- Install (on Mesos)

```
# Work in home directory.
•  wget http://mirror.apache-
   kr.org/incubator/zeppelin/0.5.6-incubating/zeppelin-
   0.5.6-incubating-bin-all.tgz

•  tar xzf zeppelin-0.5.6-incubating-bin-all.tgz

•  cd zeppelin-0.5.6-incubating-bin-all/conf
•  cp zeppelin-env.sh.template zeppelin-env.sh
•  vi zeppelin-env.sh
```

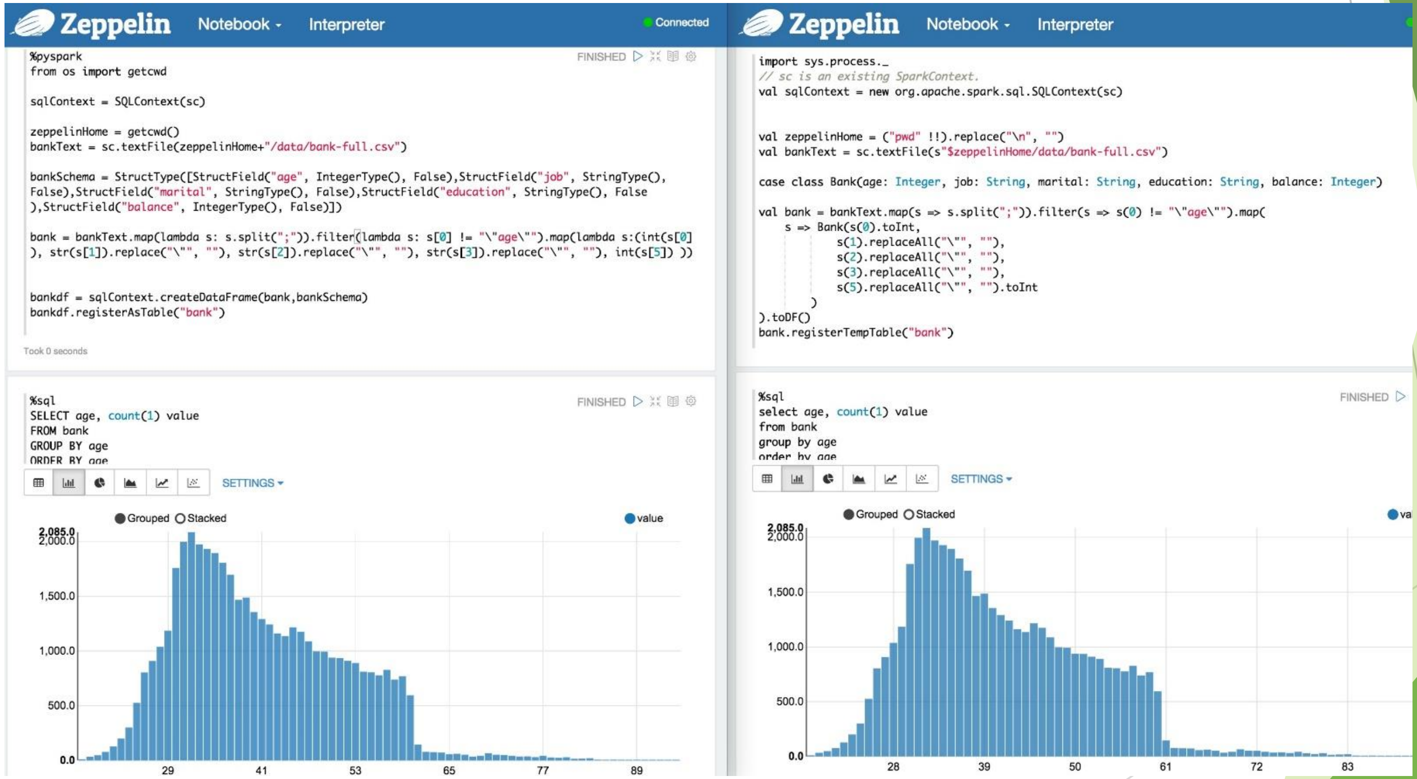
Edit:
```
export MESOS_NATIVE_JAVA_LIBRARY=/usr/local/lib/libmesos.so
export MASTER=mesos://<MASTER_IP_ADDR>:5050
export SPARK_HOME=/home/<user>/spark-1.6.1-bin-hadoop2.6
```

Start Zeppelin daemon.
```
cd ..
bin/zeppelin-daemon.sh start
```

http://<Tower IP-ADDR>:8080

3. Apache Zeppelin
- Run Example

In Zeppelin tutorial, Press ‘Run’ button to test.



```
%pyspark
from os import getcwd

sqlContext = SQLContext(sc)

zeppelinHome = getcwd()
bankText = sc.textFile(zeppelinHome+"/data/bank-full.csv")

bankSchema = StructType([StructField("age", IntegerType(), False),StructField("job", StringType(),
False),StructField("marital", StringType(), False),StructField("education", StringType(), False
),StructField("balance", IntegerType(), False)])

bank = bankText.map(lambda s: s.split(";")).filter(lambda s: s[0] != "\"age\"").map(lambda s:(int(s[0]
), str(s[1]).replace("\"", ""), str(s[2]).replace("\"", ""), str(s[3]).replace("\"", ""), int(s[5]) ))


bankdf = sqlContext.createDataFrame(bank,bankSchema)
bankdf.registerAsTable("bank")
```

Took 0 seconds

```
%sql
SELECT age, count(1) value
FROM bank
GROUP BY age
ORDER BY age
```

```
import sys.process._
// sc is an existing SparkContext.
val sqlContext = new org.apache.spark.sql.SQLContext(sc)


val zeppelinHome = ("pwd" !!).replace("\n", "")
val bankText = sc.textFile(s"$zeppelinHome/data/bank-full.csv")

case class Bank(age: Integer, job: String, marital: String, education: String, balance: Integer)

val bank = bankText.map(s => s.split(";")).filter(s => s(0) != "\"age\"").map(
    s => Bank(s(0).toInt,
            s(1).replaceAll("\"", ""),
            s(2).replaceAll("\"", ""),
            s(3).replaceAll("\"", ""),
            s(5).replaceAll("\"", "").toInt
        )
).toDF()
bank.registerTempTable("bank")
```

```
%sql
select age, count(1) value
from bank
group by age
order by age
```

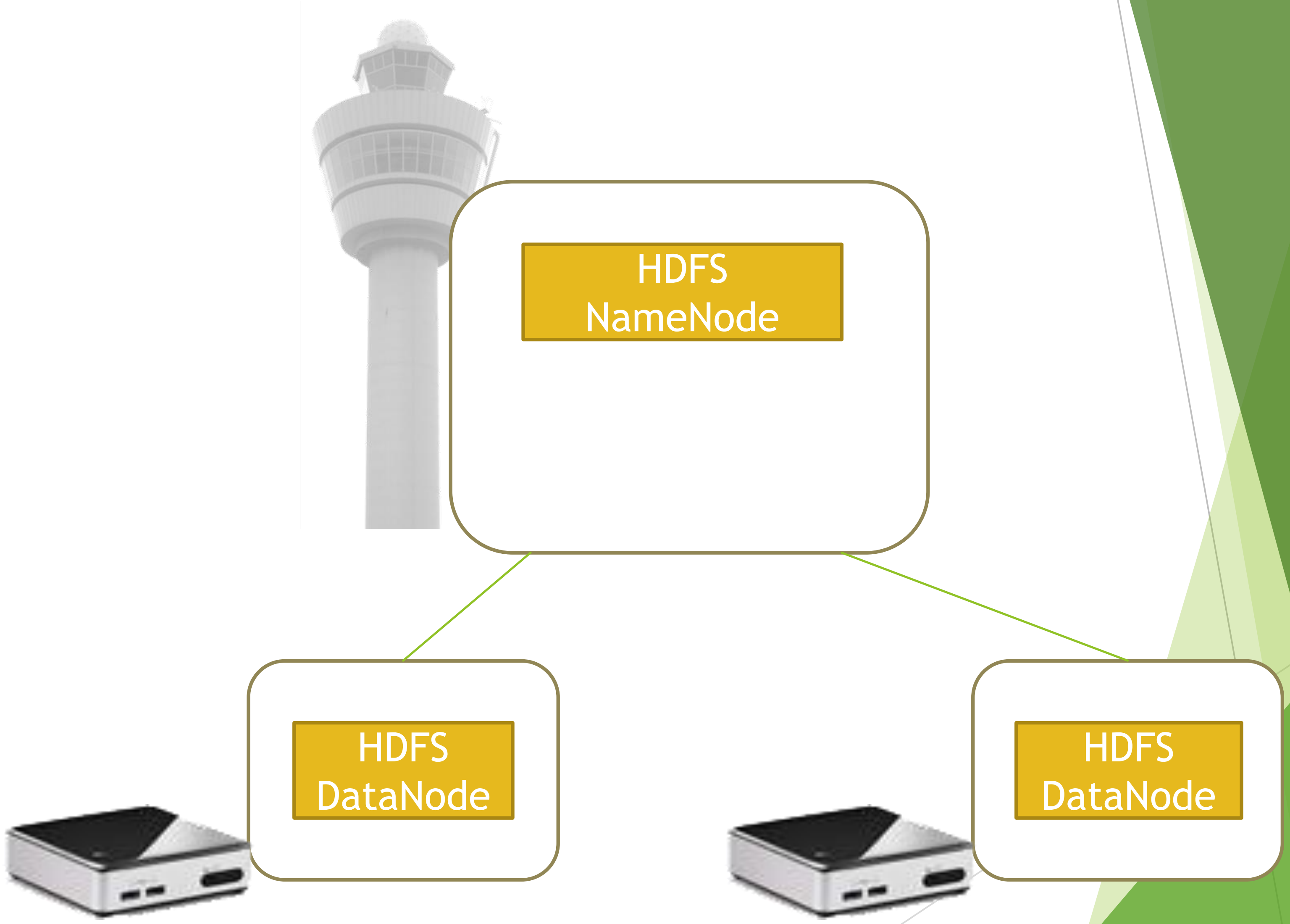
3. Apache Zeppelin
- Tip: Zeppelin Standalone mode

If you have trouble running Zeppelin on Mesos, or have only one machine, then you can run Zeppelin in standalone mode.

```
If you already made configuration file, remove it first.
•  rm conf/zeppelin-env.sh

Without any configuration, just start Zeppelin daemon.
•  bin/zeppelin-daemon.sh start
```

#(or if daemon is already running, use ‘`restart`’ instead of ‘`start`.’)

4. HDFS (Optional)
- Install



4. HDFS (Optional)
- Installation Procedure

1. Set hostnames
2. Configure accounts and SSH settings
3. Download and Unzip Hadoop
4. Configure HDFS
5. Start and test

4-1. HDFS
- Configure accounts and SSH settings

1. Log in to user ‘hadoop’.
   ```
   • su hadoop
   ```

2. Generate key (just press enter x 3) in tower and NUCs
   ```
   • ssh-keygen -t rsa
   • cp /home/hadoop/.ssh/id_rsa.pub
     /home/hadoop/.ssh/authorized_keys
   ```

3. Modify key permission
   ```
   • cd .ssh
   • chmod 644 authorized_keys
   ```

4. Copy key from Tower to all NUCs
   ```
   • scp authorized_keys hadoop@<NUC_IP>:~/.ssh/
   ```

5. Try to login via SSH to check if you can login to NUC without password.

4-1. HDFS
- Download and Unzip Hadoop

1. Download and Unzip in all Tower and NUCs.

```
• cd
• wget http://mirror.apache-kr.org/hadoop/common/hadoop-
  2.7.2/hadoop-2.7.2.tar.gz
• tar -xvzf hadoop-2.7.2.tar.gz
• sudo mv hadoop-2.7.2 /usr/local/hadoop
```

2. Go to the directory which contains configuration files.

```
• cd /usr/local/hadoop/etc/hadoop
```

- We will edit these files:
  hadoop-env.sh, core-site.xml, hdfs-site.xml, slaves

4-1. HDFS
- Configuration

Edit these files.

1. <hadoop-env.sh> file

Edit:
```
export JAVA_HOME=/usr/lib/jvm/java-8-oracle
```

2. <core-site.xml> file

Edit:
```
<configuration>
        <property>
                <name>fs.defaultFS</name>
                <value>hdfs://tower_hostname:9000/</value>
        </property>
</configuration>
```

This option must be a hostname, not IP address.

4-1. HDFS
- Configuration

4. <hdfs-site.xml> file

Edit:
```
<configuration>
    <property>
        <name>dfs.replication</name>
        <value>2</value>
    </property>
    <property>
        <name>dfs.namenode.name.dir</name>
        <value>file:///usr/local/hadoop/namenode</value>
    </property>
    <property>
        <name>dfs.datanode.data.dir</name>
        <value>file:///usr/local/hadoop/datanode</value>
    </property>
</configuration>
```

5. <slaves> file: Add hostname or IP address of all NUCs, one per line.

Ex)
```
nuc1
nuc2
```

4-1. HDFS
- Configuration

6. Deploy configuration files from Tower to all slaves.

```
•  cd ..
•  scp -r hadoop hadoop@<NUC_IP>:/usr/local/hadoop/etc/
```

7. In NUCs, make DataNode directory.

```
•  mkdir /usr/local/hadoop/datanode
```

8. In all Tower and NUCs, edit /etc/environment file.

```
•  vi /etc/environment
```

Add this line at the end of the paths, and close with ”.

```
:/usr/local/hadoop/bin

Ex) PATH=“/usr/local/sbin:/usr/local/bin:
… :/sbin:/bin:/usr/local/hadoop/bin”
```

9. Reboot.

4-1. HDFS
- Start and Test

1. Login to user 'hadoop'.

```
•   su hadoop
```

2. Format NameNode.

```
•   hdfs namenode -format
```

3. Start HDFS.

```
•   hadoop/sbin/start-dfs.sh
```

4. Make a directory and upload a file to HDFS to check if it is working.

```
•   hadoop fs -mkdir /user
•   hadoop fs -put ~/hadoop-2.7.2.tar.gz /user/
•   hadoop fs -ls hdfs://<TOWER_IP>:9000/user/
```

# Try the last command on both tower and slaves.

You can also see on the web:
http://<TOWER_IP>:50070

4-2. Apache Spark with HDFS
- Configuration

```
In home directory where Spark directory is located
•  hadoop fs –put spark-1.6.2-bin-hadoop2.6.tgz /user/

•  cd spark-1.6.2-bin-hadoop2.6/conf
•  vi spark-env.sh
```

Edit:

```
export MESOS_NATIVE_JAVA_LIBRARY=/usr/local/lib/libmesos.so
export MASTER=mesos://<TOWER_IP>:5050
export SPARK_EXECUTOR_URI=hdfs://<TOWER_IP>:9000/user/spark-1.6.2-
bin-hadoop2.6.tgz
```

# Test Spark

```
•  cd ..
•  bin/pyspark

>>> data = range(1, 10001)
>>> distData = sc.parallelize(data)
>>> distData.filter(lambda x: x < 10).collect()
```

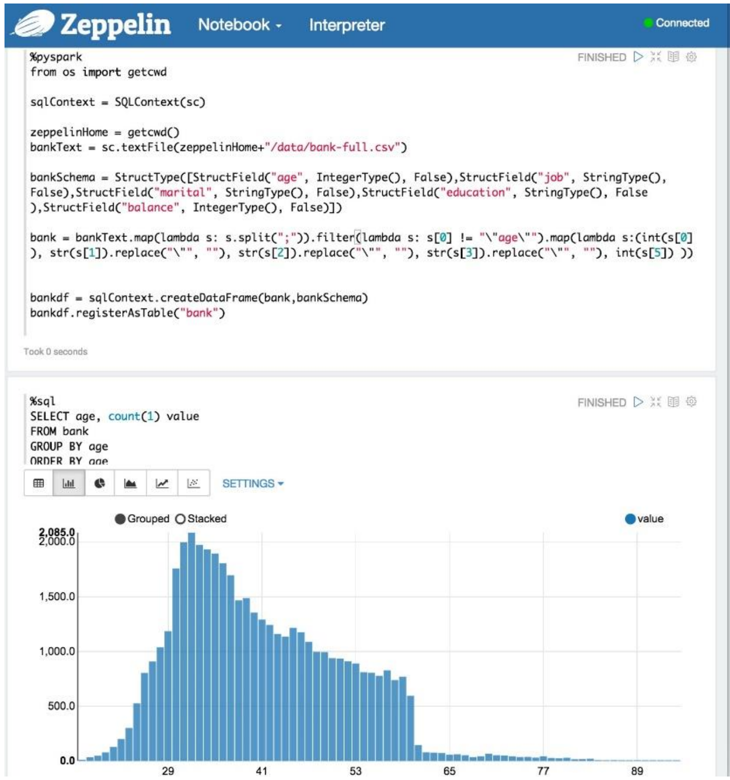
Go to Mesos web UI and see Spark framework running.

3. Apache Zeppelin
- Run Example

In Zeppelin directory,

```
• bin/zeppelin-daemon.sh restart
```

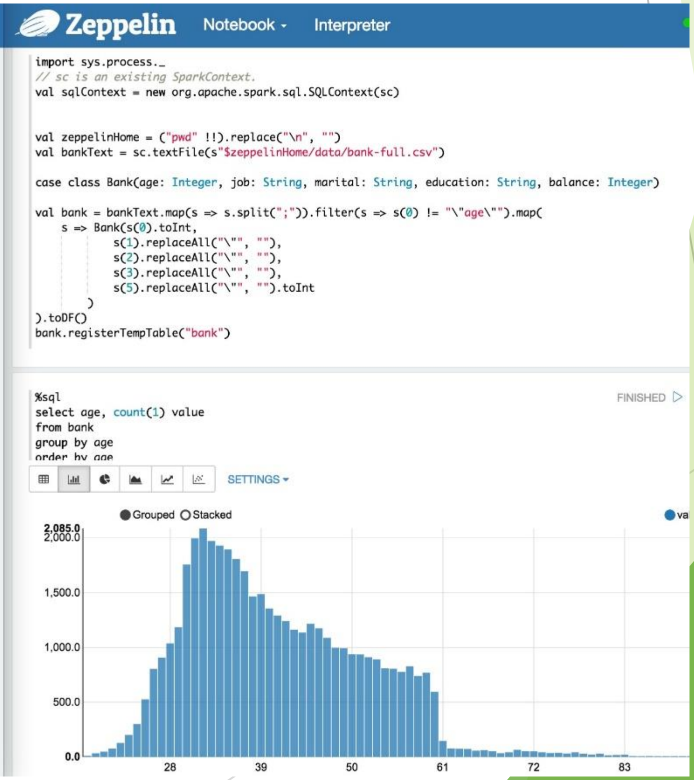
In Zeppelin tutorial, Press ‘Run’ button to test changed configurations.



```
%pyspark
from os import getcwd

sqlContext = SQLContext(sc)

zeppelinHome = getcwd()
bankText = sc.textFile(zeppelinHome+"/data/bank-full.csv")

bankSchema = StructType([StructField("age", IntegerType(), False),StructField("job", StringType(),
False),StructField("marital", StringType(), False),StructField("education", StringType(), False
),StructField("balance", IntegerType(), False)])

bank = bankText.map(lambda s: s.split(";")).filter(lambda s: s[0] != "\"age\"").map(lambda s:(int(s[0]
), str(s[1]).replace("\"", ""), str(s[2]).replace("\"", ""), str(s[3]).replace("\"", ""), int(s[5]) ))


bankdf = sqlContext.createDataFrame(bank,bankSchema)
bankdf.registerAsTable("bank")
```

Took 0 seconds

```
%sql
SELECT age, count(1) value
FROM bank
GROUP BY age
ORDER BY age
```



```
import sys.process._
// sc is an existing SparkContext.
val sqlContext = new org.apache.spark.sql.SQLContext(sc)


val zeppelinHome = ("pwd" !!).replace("\n", "")
val bankText = sc.textFile(s"$zeppelinHome/data/bank-full.csv")

case class Bank(age: Integer, job: String, marital: String, education: String, balance: Integer)

val bank = bankText.map(s => s.split(";")).filter(s => s(0) != "\"age\"").map(
    s => Bank(s(0).toInt,
            s(1).replaceAll("\"", ""),
            s(2).replaceAll("\"", ""),
            s(3).replaceAll("\"", ""),
            s(5).replaceAll("\"", "").toInt
        )
).toDF()
bank.registerTempTable("bank")
```

```
%sql
select age, count(1) value
from bank
group by age
order by age
```

Thank You for Your Attention
Any Questions?