

Hadoop/Spark

Introduction and Installation

Web Information Retrieval Lab

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Outline

- VirtualBox installation
- Ubuntu introduction
- Linux basic commands
- System configuration
- Hadoop installation
- Spark installation

VirtualBox introduction

- Home page: <https://www.virtualbox.org/>
- Download page: <https://www.virtualbox.org/wiki/Downloads>



VirtualBox

Download VirtualBox

Here you will find links to VirtualBox binaries and its source code.

VirtualBox binaries

By downloading, you agree to the terms and conditions of the respective license.

If you're looking for the latest VirtualBox 6.0 packages, see [VirtualBox 6.0 builds](#). Please also use version 6.0 if you need it.

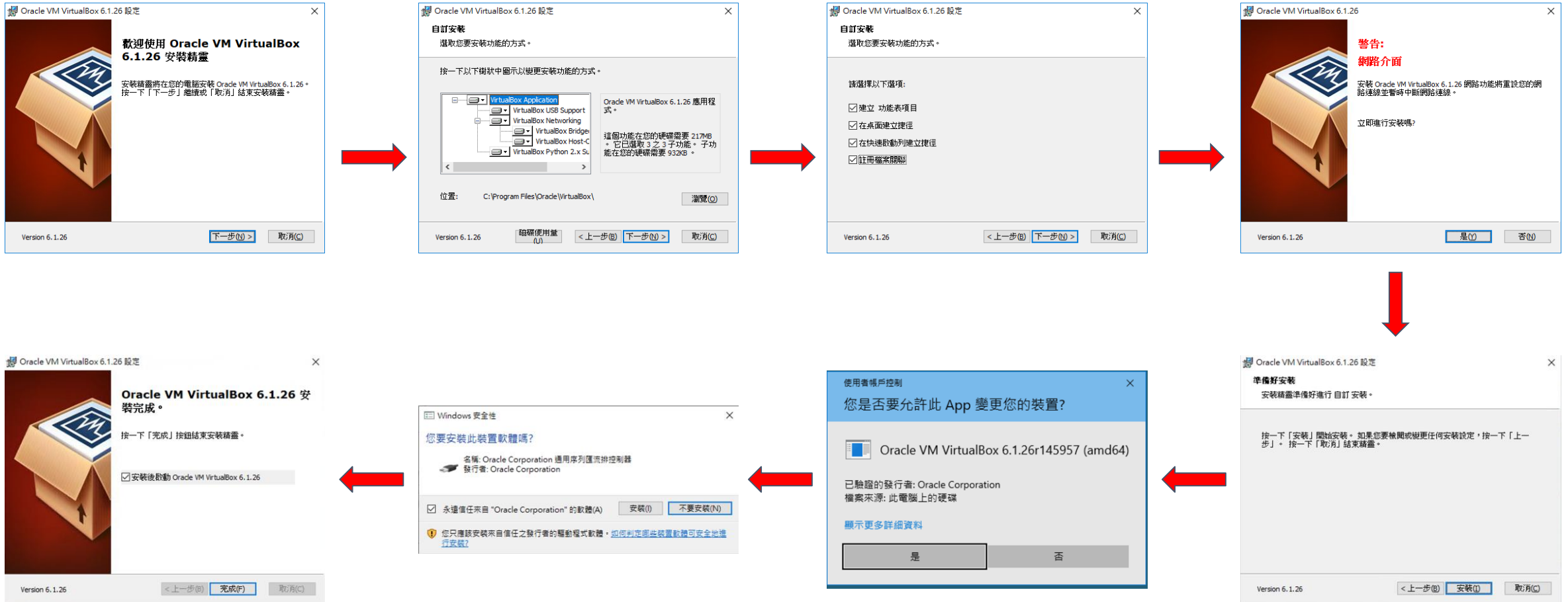
If you're looking for the latest VirtualBox 5.2 packages, see [VirtualBox 5.2 builds](#). Please also use version 5.2 if you still need it.

VirtualBox 6.1.26 platform packages

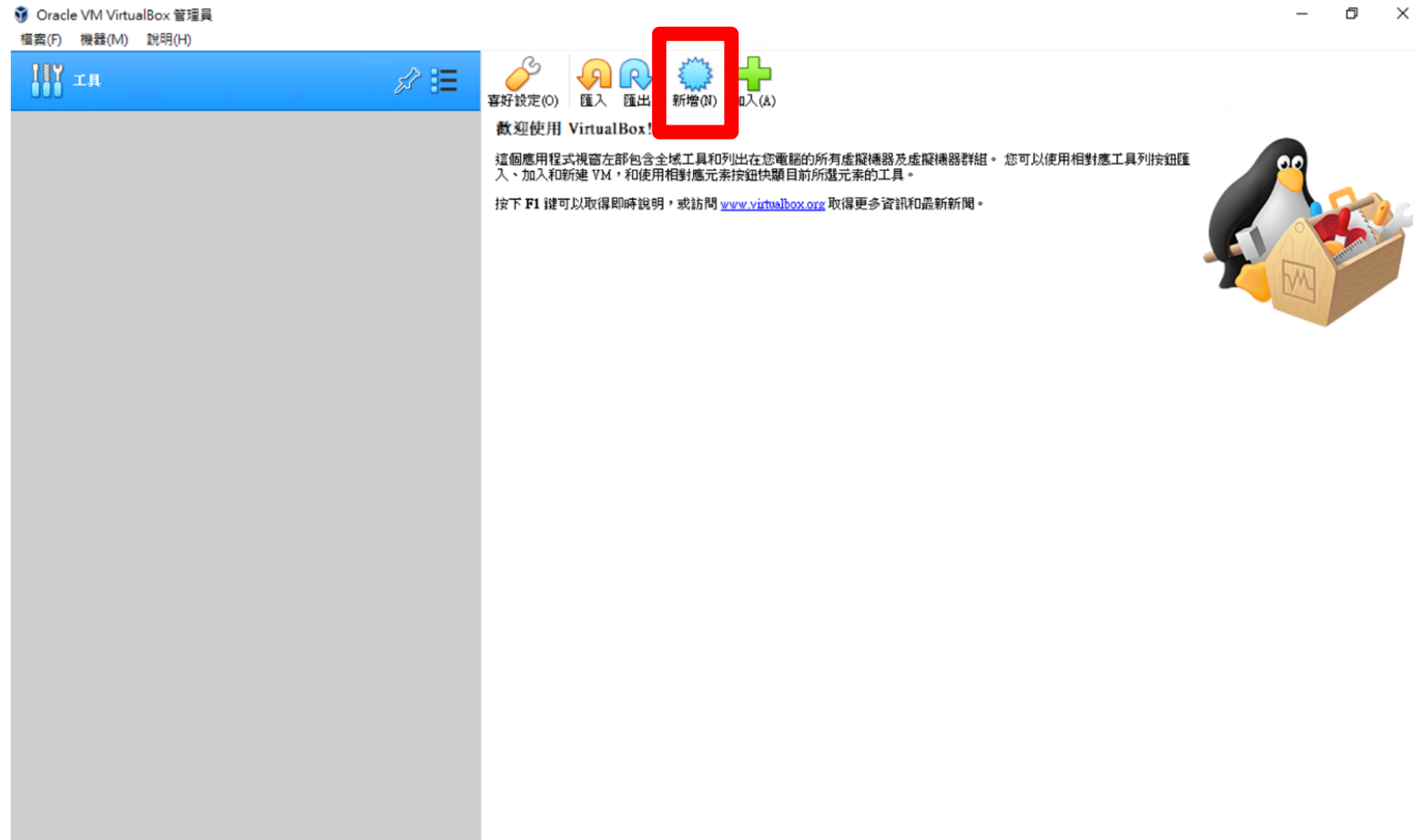
- [Windows hosts](#)
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VirtualBox installation steps



Create new virtual machine



Virtual machine specification

Specification	
OS version	Ubuntu 20.04 LTS Desktop
Amount	3
Memory	4 Gb
Disk	50 Gb
User name	bdm

IP	
spark-1	192.168.88.171
spark-2	192.168.88.172
spark-3	192.168.88.173

Ubuntu introduction

- It's one of LINUX distributions
- Desktop / Server version
- Newest version is 20.10
- Use 20.04 LTS Desktop to homework
- Download: [Click Me](#)

Linux basic commands

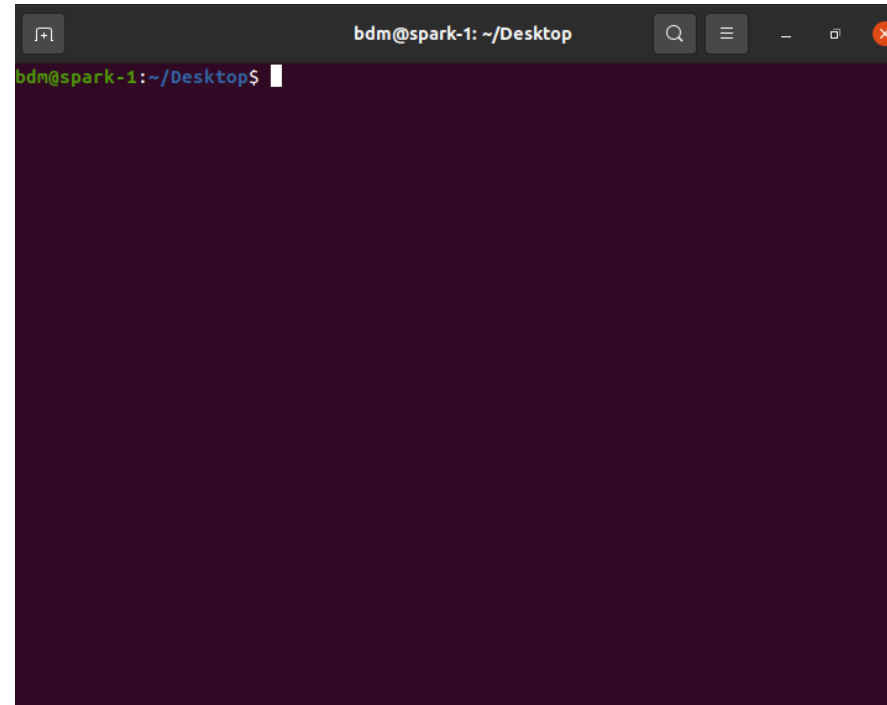
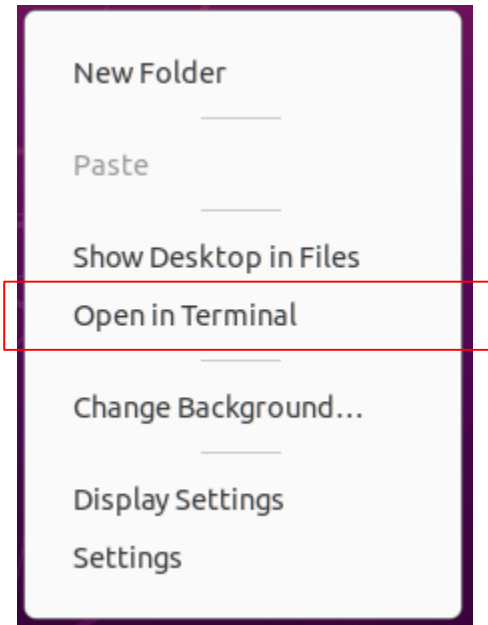
- `cd [path]`: change directory
- `ls [-a -l etc.]`: show directory content
- `rm [-r -f etc.] [path or filename]`: delete directory or file
- `mv [source path] [destination path]` : move directory or file (rename)
- `tar [-zxcvf] [source path] [destination path]` : compress or extract file
- `man [command]` : command's documentation

System configuration

Ubuntu basic environment installation

`sudo apt update`

`sudo apt install -y net-tools openssh-server openjdk-8-jdk vim`



Generate ssh key and copy to remote host

- ssh-keygen
- ls -al ~/.ssh/
- ssh-copy-id 192.168.88.171
- ssh-copy-id 192.168.88.172
- ssh-copy-id 192.168.88.173

- Check IP: ifconfig

```
bdm@spark-1:~$ ssh-keygen
Generating public/private rsa key pair.
Enter file in which to save the key (/home/bdm/.ssh/id_rsa):
Created directory '/home/bdm/.ssh'.
Enter passphrase (empty for no passphrase):
Enter same passphrase again:
Your identification has been saved in /home/bdm/.ssh/id_rsa
Your public key has been saved in /home/bdm/.ssh/id_rsa.pub
The key fingerprint is:
SHA256:EWOR1mk8yAXvQ+byTT4/j7XKCUpE2z2NEPqZBRFUsDg bdm@spark-1
The key's randomart image is:
+---[RSA 3072]---+
|      . * 0 o 0 = .      |
|      . = + 0 +        |
|      . . E + + .       |
|      . * = * 0         |
|      S o + = . + .     |
|      . o = .          |
|      . . . + .         |
|      . . 0 0 0 0 .     |
|      .   + + + .       |
+-----[SHA256]-----+
```

Edit hosts file

`sudo vim /etc/hosts`

```
127.0.0.1      localhost

192.168.88.171 spark-1
192.168.88.172 spark-2
192.168.88.173 spark-3

# The following lines are desirable for IPv6 capable hosts
::1           ip6-localhost ip6-loopback
fe00::0       ip6-localnet
ff00::0       ip6-mcastprefix
ff02::1       ip6-allnodes
ff02::2       ip6-allrouters
```

Edit /etc/profile

- `sudo vim /etc/profile`
- content:
 - `export HADOOP_HOME=/opt/hadoop`
 - `export JAVA_HOME=/usr/lib/jvm/java-1.8.0-openjdk-amd64`
 - `export`
`PATH=$HADOOP_HOME/bin:$HADOOP_HOME/sbin:$JAVA_HOME/bin:$PATH`
 - `export HDFS_NAMENODE_USER=bdm`
 - `export HDFS_DATANODE_USER=bdm`
 - `export HDFS_SECONDARYNAMENODE_USER=bdm`
 - `export YARN_RESOURCEMANAGER_USER=bdm`
 - `export YARN_NODEMANAGER_USER=bdm`

```
fi
if [ -d /etc/profile.d ]; then
  for i in /etc/profile.d/*.sh; do
    if [ -r $i ]; then
      . $i
    fi
  done
  unset i
fi

export HADOOP_HOME=/opt/hadoop
export JAVA_HOME=/usr/lib/jvm/java-1.8.0-openjdk-amd64
export PATH=$HADOOP_HOME/bin:$HADOOP_HOME/sbin:$JAVA_HOME/bin:$PATH
export HDFS_NAMENODE_USER=bdm
export HDFS_DATANODE_USER=bdm
export HDFS_SECONDARYNAMENODE_USER=bdm
export YARN_RESOURCEMANAGER_USER=bdm
export YARN_NODEMANAGER_USER=bdm
~
```

Hadoop installation

Hadoop Installation introduction

- `wget https://dlcdn.apache.org/hadoop/common/hadoop-3.3.1/hadoop-3.3.1.tar.gz`
- `tar -zxvf hadoop-3.3.1.tar.gz`
- `sudo mv hadoop-3.3.1 /opt/hadoop`
- `cd /opt/hadoop`
- Edit files:
 - `etc/hadoop/hadoop-env.sh`
 - `etc/hadoop/core-site.xml`
 - `etc/hadoop/hdfs-site.xml`
 - `etc/hadoop/yarn-site.xml`
 - `etc/hadoop/mapred-site.xml`
 - `etc/hadoop/workers`

Edit etc/hadoop/hadoop-env.sh

export JAVA_HOME=/usr/lib/jvm/java-1.8.0-openjdk-amd64

```
# For privileged registry DNS, user to run as after dropping privileges
# This will replace the hadoop.id.str Java property in secure mode.
# export HADOOP_REGISTRYDNS_SECURE_USER=yarn

# Supplemental options for privileged registry DNS
# By default, Hadoop uses jsvc which needs to know to launch a
# server jvm.
# export HADOOP_REGISTRYDNS_SECURE_EXTRA_OPTS="-jvm server"
export JAVA_HOME=/usr/lib/jvm/java-1.8.0-openjdk-amd64
~
~
~
~
~
```


Edit etc/hadoop/core-site.xml

```
<configuration>
```

```
  <property>
```

```
    <name>fs.defaultFS</name>
```

```
    <value>hdfs://192.168.88.171:9000</value>
```

```
  </property>
```

```
  <property>
```

```
    <name>hadoop.tmp.dir</name>
```

```
    <value>/opt/hadoop/tmp</value>
```

```
  </property>
```

```
</configuration>
```

```
<?xml version="1.0" encoding="UTF-8"?>
<?xml-stylesheet type="text/xsl" href="configuration.xsl"?>
<!--
  Licensed under the Apache License, Version 2.0 (the "License");
  you may not use this file except in compliance with the License.
  You may obtain a copy of the License at

    http://www.apache.org/licenses/LICENSE-2.0

  Unless required by applicable law or agreed to in writing, software
  distributed under the License is distributed on an "AS IS" BASIS,
  WITHOUT WARRANTIES OR CONDITIONS OF ANY KIND, either express or implied.
  See the License for the specific language governing permissions and
  limitations under the License. See accompanying LICENSE file.
-->

<!-- Put site-specific property overrides in this file. -->

<configuration>
  <property>
    <name>fs.defaultFS</name>
    <value>hdfs://192.168.88.171:9000</value>
  </property>
  <property>
    <name>hadoop.tmp.dir</name>
    <value>/opt/hadoop/tmp</value>
  </property>
</configuration>
```

Edit etc/hadoop/hdfs-site.xml

```
<configuration>
  <property>
    <name>dfs.namenode.name.dir</name>
    <value>/opt/hadoop/properties/name</value>
  </property>
  <property>
    <name>dfs.datanode.data.dir</name>
    <value>/opt/hadoop/properties/data</value>
  </property>
  <property>
    <name>dfs.replication</name>
    <value>3</value>
  </property>
  <property>
    <name>dfs.http.address</name>
    <value>192.168.88.171:50070</value>
  </property>
  <property>
    <name>dfs.secondary.http.address</name>
    <value>192.168.88.172:50090</value>
  </property>
</configuration>
```

```
See the LICENSE file for the specific language governing permissions and
limitations under the License. See accompanying LICENSE file.
-->

<!-- Put site-specific property overrides in this file. -->

<configuration>
  <property>
    <name>dfs.namenode.name.dir</name>
    <value>/opt/hadoop/properties/name</value>
  </property>
  <property>
    <name>dfs.datanode.data.dir</name>
    <value>/opt/hadoop/properties/data</value>
  </property>
  <property>
    <name>dfs.replication</name>
    <value>3</value>
  </property>
  <property>
    <name>dfs.http.address</name>
    <value>192.168.88.171:50070</value>
  </property>
  <property>
    <name>dfs.secondary.http.address</name>
    <value>192.168.88.172:50090</value>
  </property>
</configuration>
```

Edit etc/hadoop/yarn-site.xml

```
<configuration>
  <property>
    <name>yarn.nodemanager.aux-services</name>
    <value>mapreduce_shuffle</value>
  </property>
  <property>
    <name>yarn.nodemanager.aux-services.mapreduce_shuffle.class</name>
    <value>org.apache.hadoop.mapred.ShuffleHandler</value>
  </property>
  <property>
    <name>yarn.resourcemanager.resource-tracker.address</name>
    <value>192.168.88.171:8025</value>
  </property>
  <property>
    <name>yarn.resourcemanager.scheduler.address</name>
    <value>192.168.88.171:8030</value>
  </property>
  <property>
    <name>yarn.resourcemanager.address</name>
    <value>192.168.88.171:8050</value>
  </property>
</configuration>
```

```
See the License for the specific language governing permissions and
limitations under the License. See accompanying LICENSE file.
-->
<configuration>
  <property>
    <name>yarn.nodemanager.aux-services</name>
    <value>mapreduce_shuffle</value>
  </property>
  <property>
    <name>yarn.nodemanager.aux-services.mapreduce_shuffle.class</name>
    <value>org.apache.hadoop.mapred.ShuffleHandler</value>
  </property>
  <property>
    <name>yarn.resourcemanager.resource-tracker.address</name>
    <value>192.168.88.171:8025</value>
  </property>
  <property>
    <name>yarn.resourcemanager.scheduler.address</name>
    <value>192.168.88.171:8030</value>
  </property>
  <property>
    <name>yarn.resourcemanager.address</name>
    <value>192.168.88.171:8050</value>
  </property>
</configuration>
```

Edit etc/hadoop/mapred-site.xml

```
<configuration>
  <property>
    <name>mapreduce.framework.name</name>
    <value>yarn</value>
  </property>
  <property>
    <name>yarn.nodemanager.aux-services</name>
    <value>mapreduce_shuffle</value>
  </property>
  <property>
    <name>mapreduce.jobhistory.address</name>
    <value>192.168.88.171:10020</value>
  </property>
  <property>
    <name>mapreduce.jobhistory.webapp.address</name>
    <value>192.168.88.171:19888</value>
  </property>
</configuration>
```

```
<!-- Put site-specific property overrides in this file. -->

<configuration>
  <property>
    <name>mapreduce.framework.name</name>
    <value>yarn</value>
  </property>
  <property>
    <name>yarn.nodemanager.aux-services</name>
    <value>mapreduce_shuffle</value>
  </property>
  <property>
    <name>mapreduce.jobhistory.address</name>
    <value>192.168.88.171:10020</value>
  </property>
  <property>
    <name>mapreduce.jobhistory.webapp.address</name>
    <value>192.168.88.171:19888</value>
  </property>
</configuration>
```

Edit etc/hadoop/workers

spark-1

spark-2

spark-3

```
spark-1  
spark-2  
spark-3
```

```
~
```

```
~
```

```
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~
```

Format hadoop namenode

- `cd /opt/hadoop`
- `bin/hdfs namenode -format`

Result: **INFO common.Storage: Storage directory /opt/hadoop/properties/name has been successfully formatted.**

Running Hadoop

- `sbin/start-all.sh`
- Check hadoop cluster:
 - `http://192.168.88.171:8088/cluster/nodes`
 - `http://192.168.88.171:50070/dfshealth.html#tab-datanode`

Node information of the hadoop cluster

http://192.168.88.171:8088/cluster/nodes



Logged in as: dr.who

Nodes of the cluster

Cluster

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[Nodes](#)
[Node Labels](#)
[Applications](#)
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[NEW SAVING](#)
[SUBMITTED](#)
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[FAILED](#)
[KILLED](#)
[Scheduler](#)

Tools

Cluster Metrics

Apps Submitted	Apps Pending	Apps Running	Apps Completed	Containers Running	Used Resources	Total Resources	Reserved Resources	Physical Mem Used %	Physical VCores Used %
2	0	1	1	3	<memory:5 GB, vCores:3>	<memory:24 GB, vCores:24>	<memory:0 B, vCores:0>	79	0

Cluster Nodes Metrics

Active Nodes	Decommissioning Nodes	Decommissioned Nodes	Lost Nodes	Unhealthy Nodes	Rebooted Nodes	Shutdown Nodes
3	0	0	0	0	0	0

Scheduler Metrics

Scheduler Type	Scheduling Resource Type	Minimum Allocation	Maximum Allocation	Maximum Cluster Application Priority	Scheduler Busy %
Capacity Scheduler	[memory-mb (unit=Mi), vcores]	<memory:1024, vCores:1>	<memory:8192, vCores:4>	0	0

Show 20 entries

Node Labels	Rack	Node State	Node Address	Node HTTP Address	Last health-update	Health-report	Containers	Allocation Tags	Mem Used	Mem Avail	Phys Mem Used %	VCores Used	VCores Avail	Phys VCores Used %	Version
	/default-rack	RUNNING	spark-1:33977	spark-1:8042	Sat Oct 16 12:53:30 -0700 2021		0		0 B	8 GB	85	0	8	0	3.3.1
	/default-rack	RUNNING	spark-3:38243	spark-3:8042	Sat Oct 16 12:53:28 -0700 2021		2		3 GB	5 GB	77	2	6	1	3.3.1
	/default-rack	RUNNING	spark-2:45207	spark-2:8042	Sat Oct 16 12:53:28 -0700 2021		1		2 GB	6 GB	76	1	7	1	3.3.1

Showing 1 to 3 of 3 entries

First Previous 1 Next Last

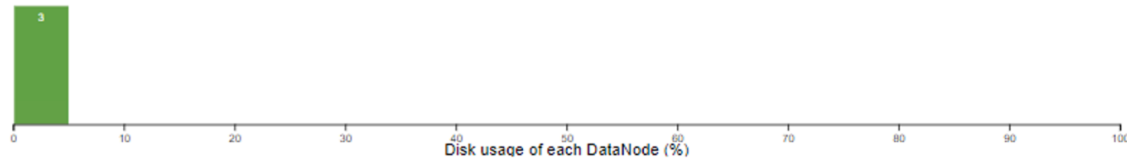
Hadoop HDFS datanode information

<http://192.168.88.171:50070/dfshealth.html#tab-datanode>

Datanode Information

✓ In service ⬇ Down ⬆ Decommissioning ⬇ Decommissioned ⬆ Decommissioned & dead
⬆ Entering Maintenance ⬇ In Maintenance ⬆ In Maintenance & dead

Datanode usage histogram



In operation

DataNode State: All Show 25 entries Search:

Node	Http Address	Last contact	Last Block Report	Used	Non DFS Used	Capacity	Blocks	Block pool used	Version
✓ /default-rack/spark-1-9886 (192.168.88.171:9886)	http://spark-1-9886	2s	154m	220.88 MB	11.34 GB	48.47 GB	5	220.88 MB (0.44%)	3.3.1
✓ /default-rack/spark-3-9886 (192.168.88.173:9886)	http://spark-3-9886	1s	174m	220.88 MB	11.11 GB	48.47 GB	5	220.88 MB (0.44%)	3.3.1
✓ /default-rack/spark-2-9886 (192.168.88.172:9886)	http://spark-2-9886	1s	200m	220.88 MB	11.38 GB	48.47 GB	5	220.88 MB (0.44%)	3.3.1

Showing 1 to 3 of 3 entries

Previous 1 Next

Spark installation

Spark installation introduction

- `wget https://www.apache.org/dyn/closer.lua/spark/spark-3.1.2/spark-3.1.2-bin-hadoop3.2.tgz`
- `tar -zxvf spark-3.1.2-bin-hadoop3.2.tgz`
- `sudo mv spark-3.1.2-bin-hadoop3.2 /opt/spark`
- `cd /opt/spark/conf`
- `cp spark-defaults.conf.template spark-defaults.conf`
- `cp spark-env.sh.template spark-env.sh`
- `cp workers.template workers`
- Edit files:
 - `spark-defaults.conf`
 - `spark-env.sh`
 - `workers`

Edit conf/spark-defaults.conf

- spark.master spark://192.168.88.171:7077
- spark.serializer org.apache.spark.serializer.KryoSerializer
- spark.ui.enabled true

Edit conf/spark-env.sh

- export HADOOP_HOME=/opt/hadoop
- export JAVA_HOME=/usr/lib/jvm/java-1.8.0-openjdk-amd64
- export HADOOP_CONF_DIR=\$HADOOP_HOME/etc/hadoop
- export YARN_CONF_DIR=\$HADOOP_HOME/etc/hadoop
- export PYSPARK_PYTHON=/bin/python3
- export PYSPARK_DRIVER_PYTHON=/bin/python3
- export SPARK_MASTER_IP=192.168.88.171
- SPARK_LOCAL_DIRS=/opt/spark

Edit conf/workers

- spark-1
- spark-2
- spark-3

Running Spark

- `sbin/start-all.sh`
- Check spark cluster:
 - `http://192.168.88.171:8080/`

Spark web UI

http://192.168.88.171:8080/



3.1.2

Spark Master at spark://spark-1:7077

URL: spark://spark-1:7077

Alive Workers: 3

Cores in use: 6 Total, 0 Used

Memory in use: 8.4 GiB Total, 0.0 B Used

Resources in use:

Applications: 0 Running, 0 Completed

Drivers: 0 Running, 0 Completed

Status: ALIVE

Workers (3)

Worker Id	Address	State	Cores	Memory	Resources
worker-20211015072803-192.168.88.173-44201	192.168.88.173:44201	ALIVE	2 (0 Used)	2.8 GiB (0.0 B Used)	
worker-20211015072804-192.168.88.171-39941	192.168.88.171:39941	ALIVE	2 (0 Used)	2.8 GiB (0.0 B Used)	
worker-20211015072804-192.168.88.172-44265	192.168.88.172:44265	ALIVE	2 (0 Used)	2.8 GiB (0.0 B Used)	

Running Applications (0)

Application ID	Name	Cores	Memory per Executor	Resources Per Executor	Submitted Time	User	State	Duration
----------------	------	-------	---------------------	------------------------	----------------	------	-------	----------

Completed Applications (0)

Application ID	Name	Cores	Memory per Executor	Resources Per Executor	Submitted Time	User	State	Duration
----------------	------	-------	---------------------	------------------------	----------------	------	-------	----------

Test spark

```
bin/pyspark --master yarn --deploy-mode client
```

```
bdm@spark-1:/opt/spark$ bin/pyspark --master yarn --deploy-mode client
Python 3.8.10 (default, Sep 28 2021, 16:10:42)
[GCC 9.3.0] on linux
Type "help", "copyright", "credits" or "license" for more information.
2021-10-15 08:07:19,813 WARN util.NativeCodeLoader: Unable to load native-hadoop
p library for your platform... using builtin-java classes where applicable
Setting default log level to "WARN".
To adjust logging level use sc.setLogLevel(newLevel). For SparkR, use setLogLev
el(newLevel).
2021-10-15 08:07:22,586 WARN yarn.Client: Neither spark.yarn.jars nor spark.yar
n.archive is set, falling back to uploading libraries under SPARK_HOME.
Welcome to

      /_/_/_/_/_/_/_/_/_/_/_/_/_/_/_\
     / \ / \ / \ / \ / \ / \ / \ / \
    /___/___/___/___/___/___/___/___\
   /___/___/___/___/___/___/___/___\
  /___/___/___/___/___/___/___/___\
 /___/___/___/___/___/___/___/___\
/_/_/_/_/_/_/_/_/_/_/_/_/_/_/_\

version 3.1.2

Using Python version 3.8.10 (default, Sep 28 2021 16:10:42)
Spark context Web UI available at http://spark-1:4040
Spark context available as 'sc' (master = yarn, app id = application_1634219491
648_0002).
SparkSession available as 'spark'.
>>>
```

Spark application instance on YARN

http://192.168.88.171:8088/cluster/apps



Application application_1634219491648_0002

Logged in as: dr.who

Cluster

About

Nodes

Node Labels

Applications

NEW

NEW SAVING

SUBMITTED

ACCEPTED

RUNNING

FINISHED

FAILED

KILLED

Scheduler

Tools

Kill Application

Application Overview

User: bdm

Name: PySparkShell

Application Type: SPARK

Application Tags:

Application Priority: 0 (Higher Integer value indicates higher priority)

YarnApplicationState: RUNNING: AM has registered with RM and started running.

Queue: default

FinalStatus Reported by AM: Application has not completed yet.

Started: Fri Oct 15 08:07:27 -0700 2021

Launched: Fri Oct 15 08:07:28 -0700 2021

Finished: N/A

Elapsed: 5mins, 44sec

Tracking URL: ApplicationMaster

Log Aggregation Status: DISABLED

Application Timeout (Remaining Time): Unlimited

Diagnostics:

Unmanaged Application: false

Application Node Label expression: <Not set>

AM container Node Label expression: <DEFAULT_PARTITION>

Application Metrics

Total Resource Preempted: <memory:0, vCores:0>

Total Number of Non-AM Containers Preempted: 0

Total Number of AM Containers Preempted: 0

Resource Preempted from Current Attempt: <memory:0, vCores:0>

Number of Non-AM Containers Preempted from Current Attempt: 0

Aggregate Resource Allocation: 1711148 MB-seconds, 1006 vcore-seconds

Aggregate Preempted Resource Allocation: 0 MB-seconds, 0 vcore-seconds

Show 20 entries

Search:

Attempt ID	Started	Node	Logs	Nodes blacklisted by the app	Nodes blacklisted by the system
appattemp_1634219491648_0002_000001	Fri Oct 15 23:07:27 +0800 2021	http://spark-3:8042	Logs	0	0

Showing 1 to 1 of 1 entries

First Previous 1 Next Last