

PRACTICAL JOURNAL IN

BIG DATA ANALYTICS

MODERN NETWORKING

EMBEDDED SYSTEMS

SUBMITTED BY

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SCIENCE IN INFORMATION TECHNOLOGY PART – I
SEMESTER II**

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**B.N. BANDODKAR COLLEGE OF SCIENCE (AUTONOMOUS)
(AFFILIATED TO UNIVERSITY OF MUMBAI)**

THANE (W) - 400601, MAHARASHTRA

YEAR: 2023-2024

Vidya Prasarak Mandal's
**B. N. BANDODKAR COLLEGE OF SCIENCE
(AUTONOMOUS), THANE.**

(Affiliated to University of Mumbai)

NAAC REACCREDITED 'A' GRADE
Best College Award, University of Mumbai

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CERTIFICATE

This is to certify that

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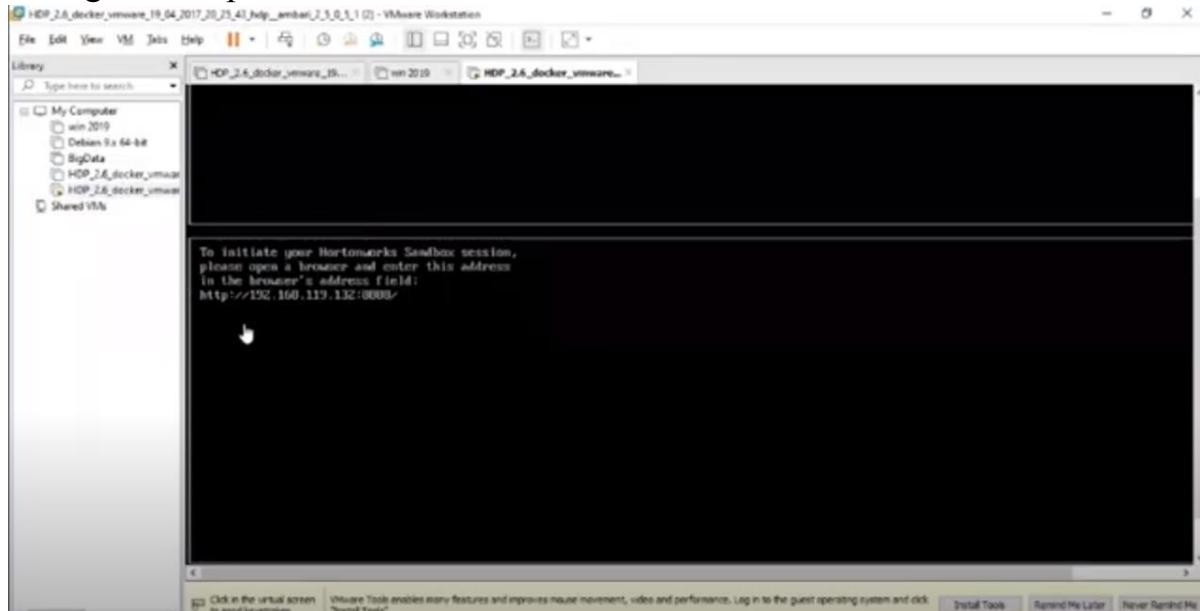
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4	Implement the program using Pig.
5	Implement the application in Hive.
6	Implement an application that stores big data in Hbase/ Python
7	Implement Decision tree classification techniques
8	Implement SVM classification techniques

Practical 1

Install, configure and run Hadoop and HDFS ad explore HDFS.

Download Virtual machine setup ie VMware setup (in which Hadoop is configured). Step 1: Load the server on VM ware workstation



Step 2: To enable admin login open shell and reset root

login. Open Terminal 192.168.119.132:4200

In Sandbox login enter root

And Password is Hadoop

And reset the password

```
root@sandbox.hortonworks.com's password:  
You are required to change your password immediately (root enforced)  
Last login: Wed Jun 30 14:50:19 2021 from 172.17  
.0.2  
Changing password for root.  
(current) UNIX password:  
New password:  
Retype new password:  
[root@sandbox ~]# █
```

Windows linux system and Hadoop system are different

When we type **ls** command it is executed in local system

```
(current) UNIX password:  
New password:  
Retype new password:  
[root@sandbox ~]# ls  
anaconda-ks.cfg  install.log.syslog  
blueprint.json    sandbox.info  
build.out        start_ambari.sh  
hdp              start_hbase.sh  
install.log :  
[root@sandbox ~]# █
```

When we type **hdfs dfs -ls** it will execute in Hadoop system directory

```
New password:  
Retype new password:  
[root@sandbox ~]# ls  
anaconda-ks.cfg  install.log.syslog  
blueprint.json   sandbox.info  
build.out        start_ambari.sh  
hdp             start_hbase.sh  
install.log  
[root@sandbox ~]# hdfs dfs -ls /  
[
```

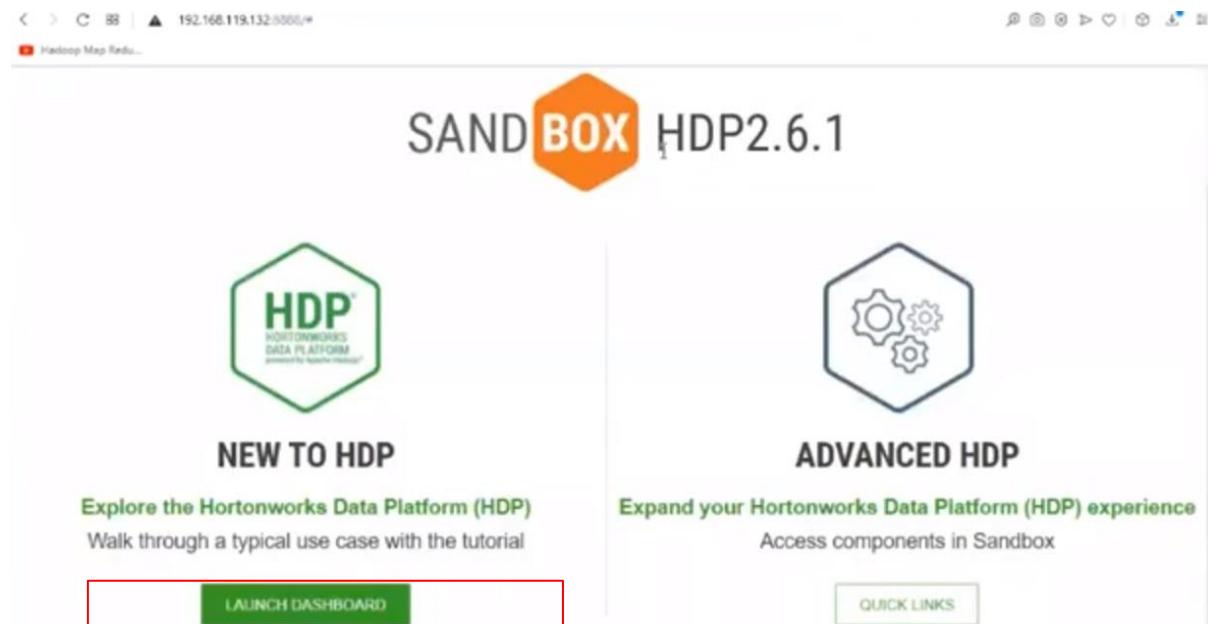
Step 3: Reset Admin account Password

```
[root@sandbox ~]# ambari-admin-password-reset  
Please set the password for admin:  
Please retype the password for admin:  
  
The admin password has been set.  
Restarting ambari-server to make the password change effective...  
  
Using python /usr/bin/python  
Restarting ambari-server  
Waiting for server stop...  
Ambari Server stopped  
Ambari Server running with administrator privileges.  
Organizing resource files at /var/lib/ambari-server/resources...  
Ambari database consistency check started...  
Server PID at: /var/run/ambari-server/ambari-server.pid  
Server out at: /var/log/ambari-server/ambari-server.out  
Server log at: /var/log/ambari-server/ambari-server.log  
Waiting for server start....[
```

Server listening on 8080 and shell login is complete.

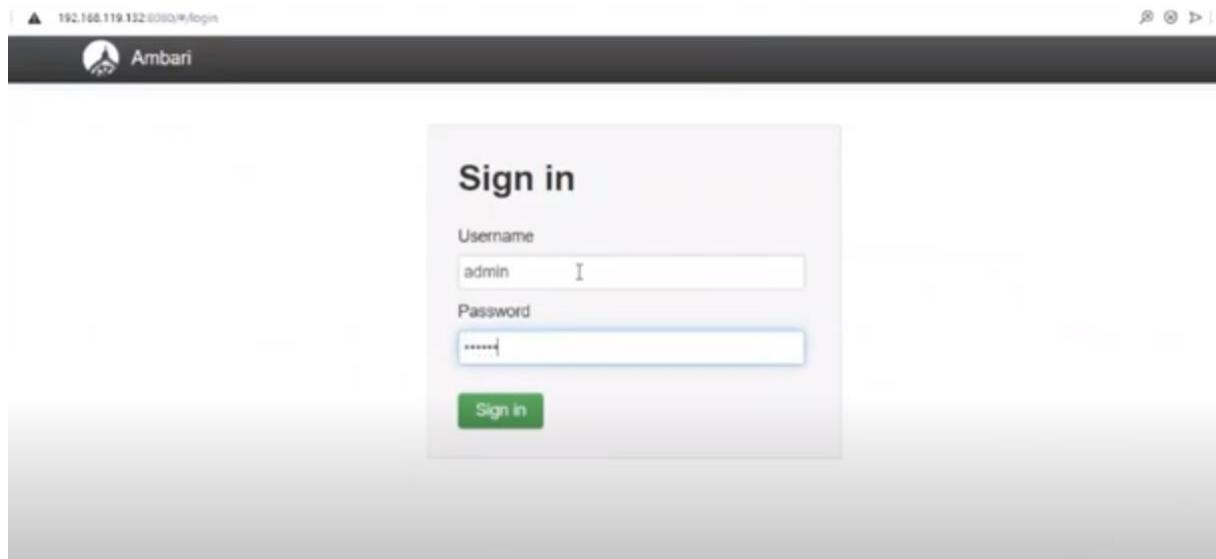
```
The admin password has been set.  
Restarting ambari-server to make the password change effective...  
  
Using python /usr/bin/python  
Restarting ambari-server  
Waiting for server stop...  
Ambari Server stopped  
Ambari Server running with administrator privileges.  
Organizing resource files at /var/lib/ambari-server/resources...  
Ambari database consistency check started...  
Server PID at: /var/run/ambari-server/ambari-server.pid  
Server out at: /var/log/ambari-server/ambari-server.out  
Server log at: /var/log/ambari-server/ambari-server.log  
Waiting for server start.....  
Server started listening on 8080  
  
DB configs consistency check: no errors and warnings were found.  
[root@sandbox ~]#
```

To use graphical user interface login to 192.168.119.132:4200



Click on Launch Dashboard Enter the username and password for admin login.

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Below is the Hadoop server.

A screenshot of the Ambari Metrics Dashboard. The URL in the address bar is 192.168.119.132:8080/#/main/dashboard/metrics. The dashboard shows various metrics for HDFS, YARN, and other services. The left sidebar lists services: HDFS, YARN (selected), MapReduce2, Tez, Hive, HBase, Pig, Sqoop, Oozie, ZooKeeper, Falcon, Storm, Flume, Ambari Infra, and Ambari. The main area displays metrics like HDFS Disk Usage (n/a), DataNodes Live (n/a), HDFS Links (NameNode, Secondary NameNode, 1 DataNodes), Memory Usage (No Data Available), Network Usage (No Data Available), CPU Usage (No Data Available), Cluster Load (No Data Available), NameNode Heap (n/a), NameNode RPC (n/a), NameNode CPU WIO (n/a), and HBase Master Uptime (192.168.119.132:8080/#/main/services/VarHandleSummary).

To view file in HDFS click on HDFS and click on File view.

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The screenshot shows the Ambari UI interface for the HDFS service. The left sidebar lists various services: YARN, MapReduce2, Tez, Hive, HBase, Pig, Sqoop, Oozie, ZooKeeper, Falcon, Storm, Flume, Ambari Infra, and Ambari. The 'HDFS' service is highlighted with a red box. The main content area has tabs for 'Summary', 'Heatmaps', 'Configs', and 'Quick Links'. A 'Summary' card displays metrics for NameNodes, DataNodes, and NFSGateways. A 'Metrics' card shows five metrics: NameNode GC count, NameNode GC time, NN Connection Load, NameNode Heap, and NameNode Host Load. On the right, a 'YARN Queue Manager' dropdown menu is open, showing options like 'File View' (which is highlighted with a red box) and 'Hive View'. Other options include 'Hive View 2.0', 'Pig View', 'Storm View', 'Tez View', and 'Workflow Manager'.

Commands:

- 1) To view root folder file from terminal use command hdfs dfs -ls /user and press enter.

It will display all the files in the root user that we see in UI(Screenshot 2).
ls: This command is used to list all the files

```
DB configs consistency check: no errors and warnings were found.  
[root@sandbox ~]# hdfs dfs -ls /user  
Found 13 items  
drwxr-xr-x  - admin      hdfs          0 2017-04-19 19:09 /user/admin  
drwxrwx---  - ambari-qa  hdfs          0 2017-04-19 18:48 /user/ambari-qa  
drwxr-xr-x  - amy_ds    hdfs          0 2017-04-19 19:04 /user/amy_ds  
drwxr-xr-x  - hbase     hdfs          0 2017-04-19 18:48 /user/hbase  
drwxr-xr-x  - hcat      hdfs          0 2017-04-19 18:51 /user/hcat  
drwxr-xr-x  - hive      hdfs          0 2017-04-19 19:08 /user/hive  
drwxr-xr-x  - holger_gov hdfs          0 2017-04-19 19:05 /user/holger_gov  
drwxrwxr-x  - livy      hdfs          0 2017-04-19 18:49 /user/livy  
drwxr-xr-x  - maria_dev hdfs          0 2017-04-19 18:58 /user/maria_dev  
drwxrwxr-x  - oozie     hdfs          0 2017-04-19 18:52 /user/oozie  
drwxr-xr-x  - raj_ops   hdfs          0 2017-04-19 19:06 /user/raj_ops  
drwxrwxr-x  - spark     hdfs          0 2017-04-19 18:49 /user/spark  
drwxr-xr-x  - zeppelin  hdfs          0 2017-04-19 18:49 /user/zeppelin  
[root@sandbox ~]#
```

The screenshot shows a file browser interface for HDFS. At the top, there are icons for refresh, search, and refresh. The path is shown as '/ > user'. A yellow box in the top right corner displays 'Total: 13 files or folders'. Below this is a table with the following columns: Name, Size, Last Modified, and Owner. The table lists three entries:

Name	Size	Last Modified	Owner
admin	--	2017-04-20 00:39	admin
ambari-qa	--	2017-04-20 00:18	ambari-qa
amy_ds	--	2017-04-20 00:34	amy_ds

2)

mkdir: To create a directory.

Create a folder in Hadoop directory. Type command hdfs dfs -mkdir /bigdatastest and enter. After it execute the command, we will see whether it is created folder in UI.

The terminal window shows the command being run:

```
[root@sandbox bigdata]# hdfs dfs -mkdir /bigdatastest
[root@sandbox bigdata]#
```

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Name >	Size >	Last Modified >	Owner >
app-logs	--	2017-04-20 00:38	yarn
apps	--	2017-04-20 00:25	hdfs
ats	--	2017-04-20 00:18	yarn
bigdatatest	--	2021-06-30 20:31	root
demo	--	2017-04-20 00:33	hdfs
hdp	--	2017-04-20 00:18	hdfs

- 3) Create a file in local directory

Cat: Create a file.

Cat>>

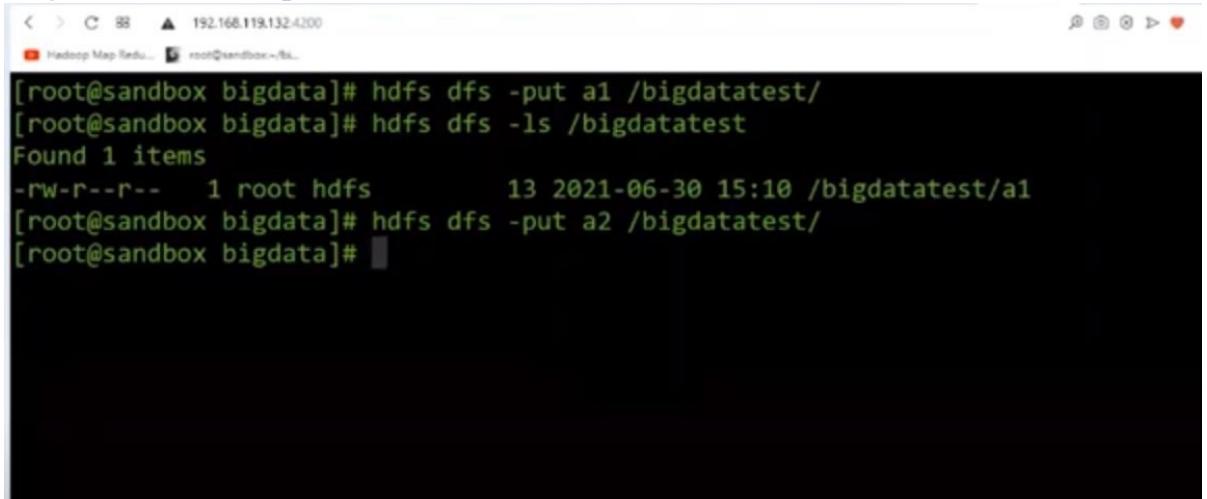
To terminate press ctrl+d

```
< > C ⌂ ▲ 192.168.119.132:4200
Hadoop Map Redu...
[-text [-ignoreCrc] <src> ...]
[-touchz <path> ...]
[-truncate [-w] <length> <path> ...]
[root@sandbox bigdata]# hdfs dfs -cat >>/bigdatatest/a1
-bash: /bigdatatest/a1: No such file or directory
[root@sandbox bigdata]# cat >>a1
hello world
[root@sandbox bigdata]# cat >>a2
ffffjhsf

gdsgdsghsd
gs
gs
hf
hf
h
f
[root@sandbox bigdata]# ls
a1 a2
[root@sandbox bigdata]# cat a1
```

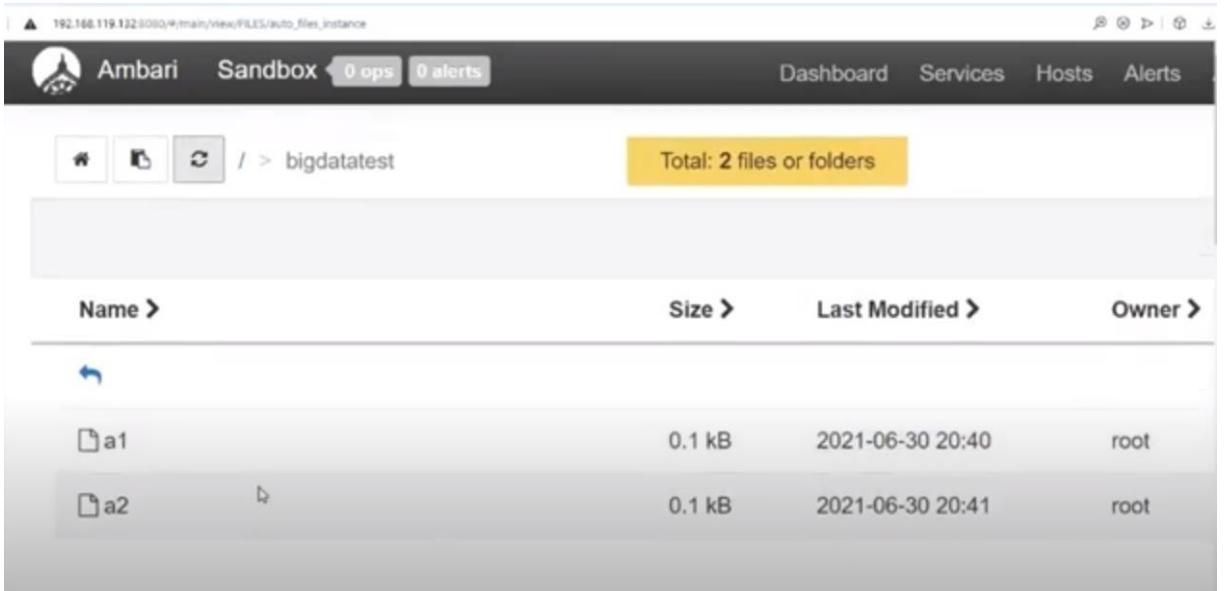
- 4) To upload files/directory to from local to HDFS

Put: to move a local file or directories into the distributed file system
Command: hdfs dfs -put a1 /bigdatatest/ and hdfs dfs -put a2 /bigdatatest/ will upload both the files.



```
< > C BB 192.168.119.132:4200
[root@sandbox bigdata]# hdfs dfs -put a1 /bigdatatest/
[root@sandbox bigdata]# hdfs dfs -ls /bigdatatest
Found 1 items
-rw-r--r-- 1 root hdfs 13 2021-06-30 15:10 /bigdatatest/a1
[root@sandbox bigdata]# hdfs dfs -put a2 /bigdatatest/
[root@sandbox bigdata]#
```

Refresh the user interface we can see both the files.



The screenshot shows the Ambari UI with the "Sandbox" cluster selected. In the top navigation bar, there are tabs for Dashboard, Services, Hosts, and Alerts. Below the navigation bar, there is a breadcrumb trail showing the path: / > bigdatatest. A yellow callout box indicates "Total: 2 files or folders". The main content area displays a table of files and folders in the "/bigdatatest" directory. The table has columns for Name, Size, Last Modified, and Owner. There are two entries: "a1" and "a2". Both files are owned by "root" and have a size of 0.1 kB, with last modified dates of 2021-06-30 20:40 and 2021-06-30 20:41 respectively.

Name	Size	Last Modified	Owner
a1	0.1 kB	2021-06-30 20:40	root
a2	0.1 kB	2021-06-30 20:41	root

To download files/directories from hdfs to local
Get: To copy files/folders from hdfs store to local file system.
Command: hdfs dfs -get

/bigdatatest/a1 and hdfs dfs -get /bigdatatest/ a2 will upload both the files.

```
< > C 192.168.119.132:4200
Hadoop Map Redu... root@sandbox:~/bl...
Found 1 items
-rw-r--r-- 1 root hdfs 13 2021-06-30 15:10 /bigdatatest/a1
[root@sandbox bigdata]# hdfs dfs -put a2 /bigdatatest/
[root@sandbox bigdata]# hdfs dfs -get /bigdatatest/a1
get: `a1': File exists
[root@sandbox bigdata]# ls
a1 a2
[root@sandbox bigdata]# rm a2
rm: remove regular file `a2'? y
[root@sandbox bigdata]# rm a1
rm: remove regular file `a1'? y
[root@sandbox bigdata]# ls
[root@sandbox bigdata]# hdfs dfs -get /bigdatatest/a1
[root@sandbox bigdata]# ls
a1
[root@sandbox bigdata]# cat a1
hello world
[root@sandbox bigdata]#
```

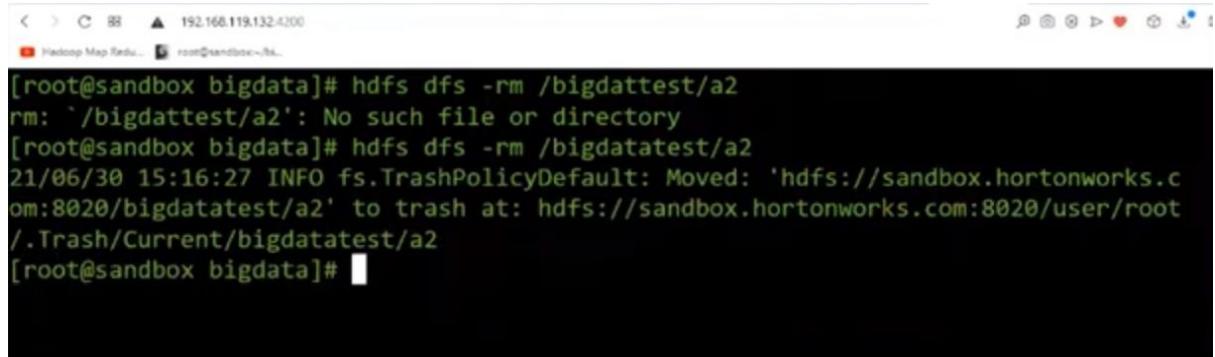
5) To remove file from local use rm command

```
< > C 192.168.119.132:4200
Hadoop Map Redu... root@sandbox:~/bl...
[root@sandbox bigdata]# hdfs dfs -put a1 /bigdatatest/
[root@sandbox bigdata]# hdfs dfs -ls /bigdatatest
Found 1 items
-rw-r--r-- 1 root hdfs 13 2021-06-30 15:10 /bigdatatest/a1
[root@sandbox bigdata]# hdfs dfs -put a2 /bigdatatest/
[root@sandbox bigdata]# hdfs dfs -get /bigdatatest/a1
get: `a1': File exists
[root@sandbox bigdata]# ls
a1 a2
[root@sandbox bigdata]# rm a2 I
rm: remove regular file `a2'? y
[root@sandbox bigdata]# rm a1
rm: remove regular file `a1'? 
```

6) To remove file from Hadoop directory

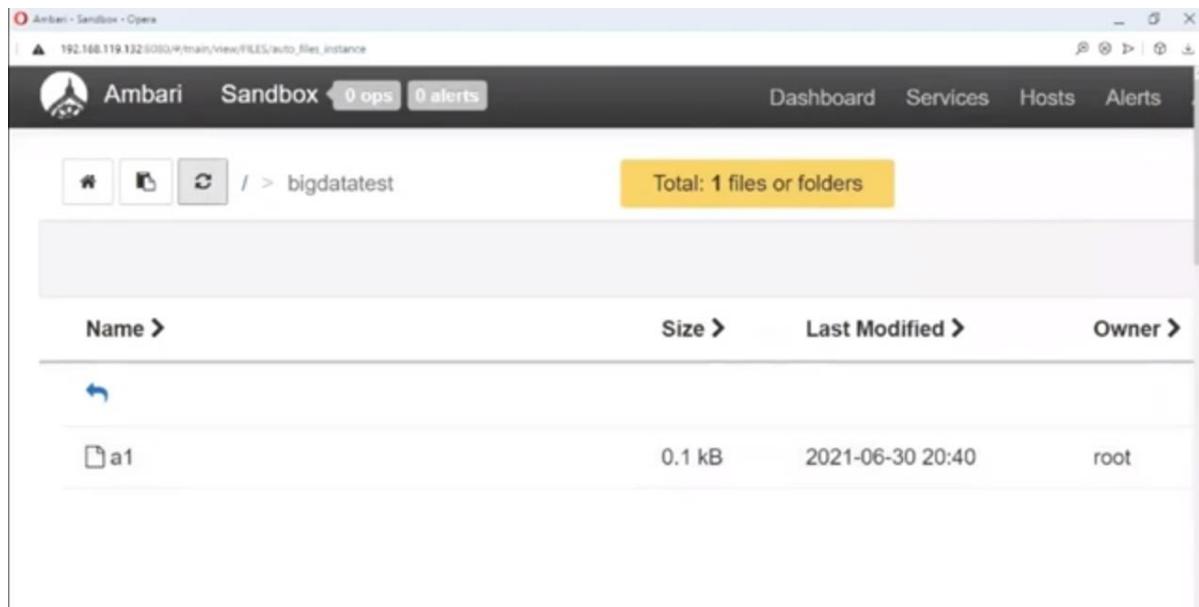
Command: hdfs dfs -rm a2 /gibdatatest/a2

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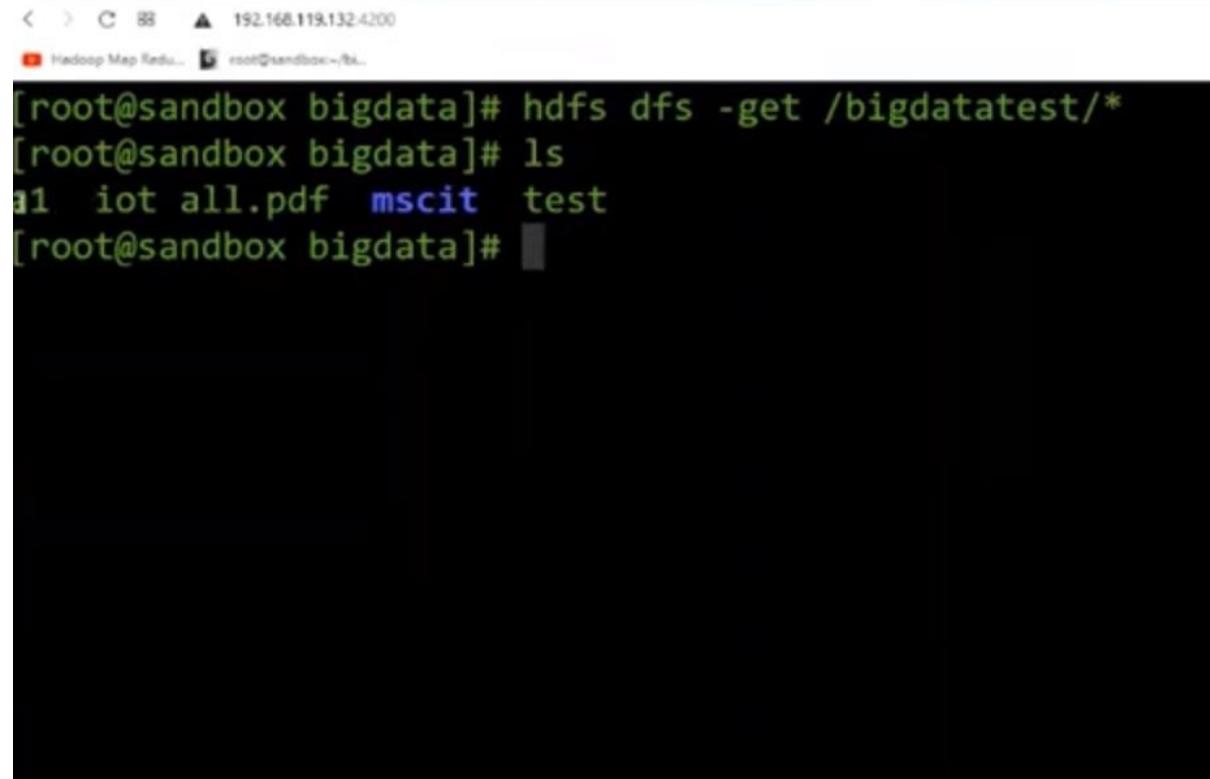
```
< > C ⌂ 192.168.119.132:4200
[root@sandbox bigdata]# hdfs dfs -rm /bigdattest/a2
rm: '/bigdattest/a2': No such file or directory
[root@sandbox bigdata]# hdfs dfs -rm /bigdattest/a2
21/06/30 15:16:27 INFO fs.TrashPolicyDefault: Moved: 'hdfs://sandbox.hortonworks.com:8020/bigdattest/a2' to trash at: hdfs://sandbox.hortonworks.com:8020/user/root/.Trash/Current/bigdattest/a2
[root@sandbox bigdata]#
```

Now refresh the UI and the file will be deleted.



The screenshot shows the Ambari Sandbox HDFS file browser. The URL in the address bar is 192.168.119.132:8080/train/View/FILES/auto_files_instance. The main interface displays a list of files under the path /bigdattest. There is one item listed: 'a1' with a size of 0.1 kB, last modified on 2021-06-30 20:40, and owned by root. The interface includes standard file operations like 'Create', 'Delete', and 'Edit' buttons, and a search bar.

- 7) To download all the files from hdfs to local Command: hdfs dfs -get /bigdattest/*



The screenshot shows a terminal window with the following session:

```
< > C 88 ▲ 192.168.119.132:4200
[Hadoop Map Redu... root@sandbox:~/bigdata]# hdfs dfs -get /bigdatatest/*
[root@sandbox bigdata]# ls
a1 iot all.pdf mscit test
[root@sandbox bigdata]#
```

- 8) Change user and directory and change user
only Command: su – hdfs (Change user and directory)
Su hdfs (change user only)

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```
< > C B8 | ▲ 192.168.119.132:4200
Hadoop Map Redu... root@sandbox:~/bl...
[root@sandbox bigdata]# hdfs dfs -get /bigdatatest/
[root@sandbox bigdata]# hdfs dfs -get /bigdatatest/*
[root@sandbox bigdata]# ls
a1 iot all.pdf mscit test
[root@sandbox bigdata]# hdfs dfs -put * /bigdatatest/x
put: unexpected URISyntaxException
put: `/bigdatatest/x': No such file or directory
[root@sandbox bigdata]# pwd
/root/bigdata
[root@sandbox bigdata]# su hdfs
[hdfs@sandbox bigdata]$ pwd
/root/bigdata
[hdfs@sandbox bigdata]$ exit
exit
[root@sandbox bigdata]# su -Ihdfs
[hdfs@sandbox ~]$ pwd
/home/hdfs
[hdfs@sandbox ~]$ 
```

Practical 2

Implement word count / frequency programs using MapReduce

Map Reduce as two component Map and Reduce.

Java program:

```
write program save as WordCount.java///////////
import java.io.IOException;
import java.util.StringTokenizer;
import org.apache.hadoop.conf.Configuration;
import org.apache.hadoop.fs.Path;
import org.apache.hadoop.io.IntWritable;
import org.apache.hadoop.io.Text;
import org.apache.hadoop.mapreduce.Job;
import org.apache.hadoop.mapreduce.Mapper;
import
org.apache.hadoop.mapreduce.Reducer;
import org.apache.hadoop.mapreduce.lib.input.FileInputFormat;
import org.apache.hadoop.mapreduce.lib.output.FileOutputFormat;
public class WordCount { public static class TokenizerMapper
extends Mapper<Object, Text, Text, IntWritable>{
private final static IntWritable one = new IntWritable(1);
private Text word = new Text();
public void map(Object key, Text value, Context context
) throws IOException, InterruptedException
{ StringTokenizer itr = new
StringTokenizer(value.toString()); while
(itr.hasMoreTokens()) ///"This is the output is the"
word.set(itr.nextToken());
context.write(word, one);
}
}
}
}
public static class IntSumReducer extends
Reducer<Text,IntWritable,Text,IntWritable> {
private IntWritable result = new IntWritable();
public void reduce(Text key, Iterable<IntWritable> values, Context context)
throws IOException,
InterruptedException
{//is,3
int sum = 0;
for (IntWritable val : values)
{ sum += val.get();}
```

```
}

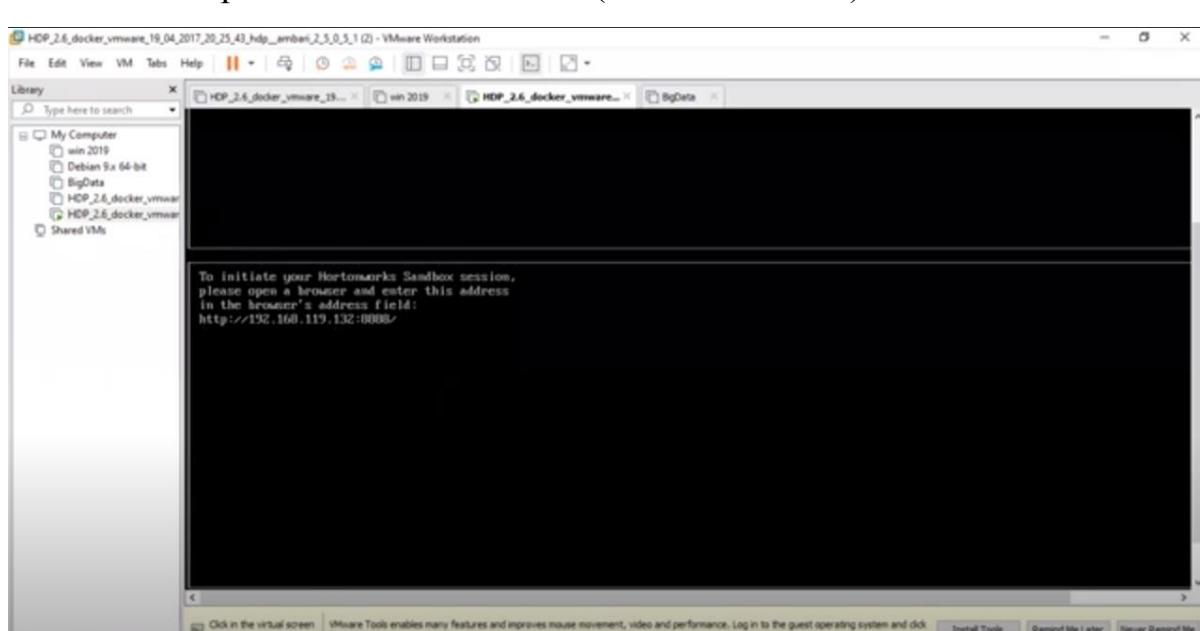
result.set(sum);
context.write(key, result);
}

}public static void main(String[] args) throws Exception
{ Configuration conf = new Configuration();
Job job = Job.getInstance(conf, "word count");
job.setJarByClass(WordCount.class);
job.setMapperClass(TokenizerMapper.class);
job.setCombinerClass(IntSumReducer.class);
job.setReducerClass(IntSumReducer.class);
job.setOutputKeyClass(Text.class);
job.setOutputValueClass(IntWritable.class);
FileInputFormat.addInputPath(job, new Path(args[0]));
FileOutputFormat.setOutputPath(job, new Path(args[1]));
System.exit(job.waitForCompletion(true)?0:1);
}
}

//////////Text File:
```

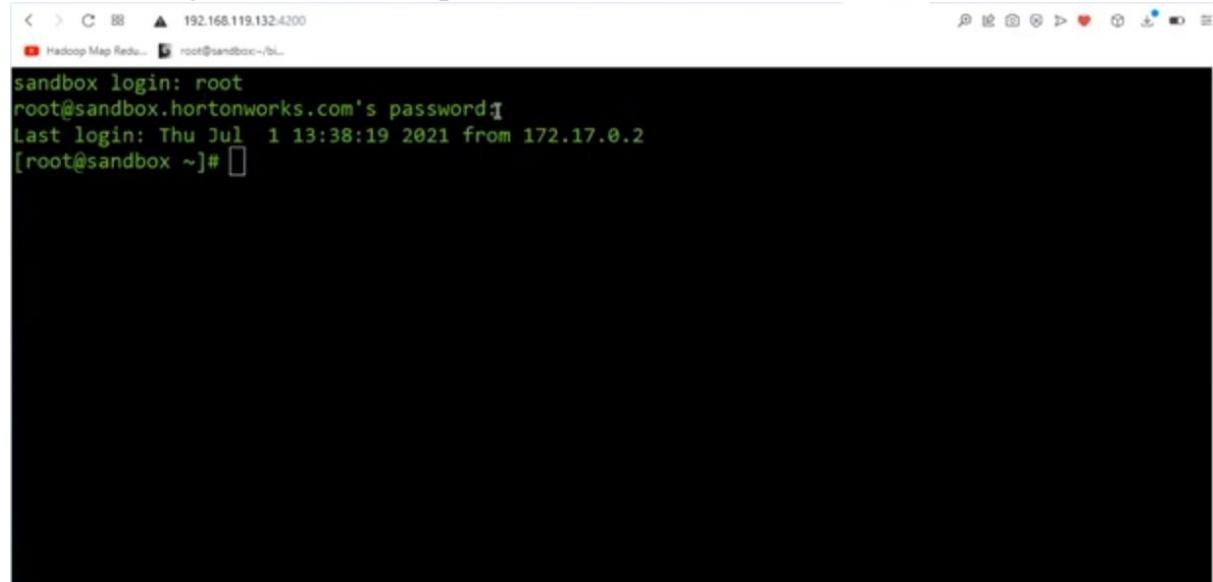
Hello World

This is the output is theStart the server (Horton Sandbox)



Open the terminal with 192.168.119.132/4200

Enter the login: root and the password and enter



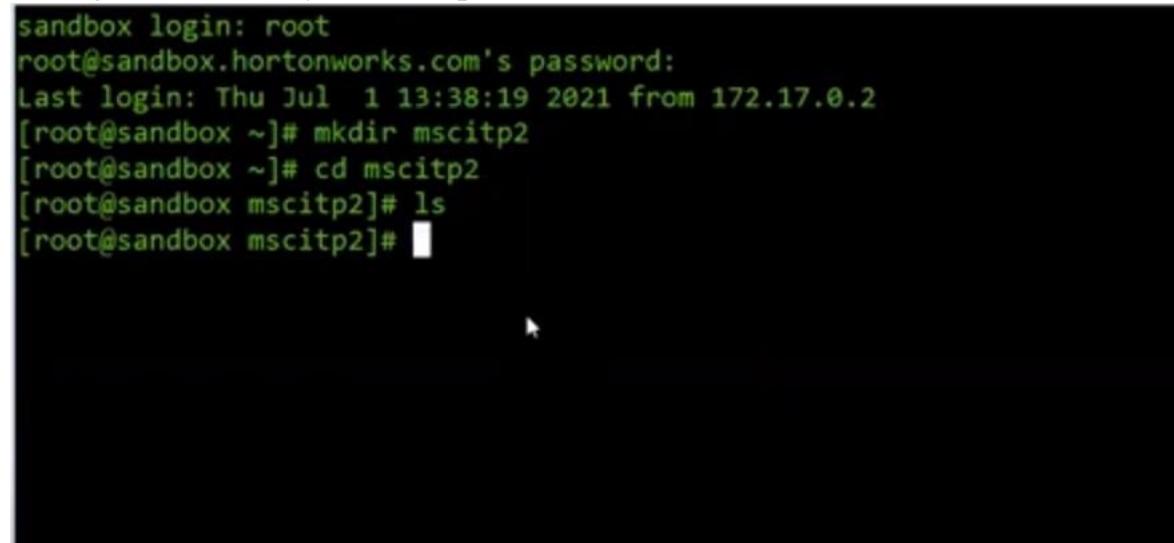
A screenshot of a terminal window titled "Hadoop Map Redu...". The window shows a root login session. The text in the terminal is:

```
192.168.119.132:4200
root@sandbox.hortonworks.com's password:
Last login: Thu Jul  1 13:38:19 2021 from 172.17.0.2
[root@sandbox ~]#
```

Create a folder in local directory.

Command: mkdir mscitp2

Change the directory cd mscitp2



A screenshot of a terminal window showing the creation of a folder and changing directory. The text in the terminal is:

```
sandbox login: root
root@sandbox.hortonworks.com's password:
Last login: Thu Jul  1 13:38:19 2021 from 172.17.0.2
[root@sandbox ~]# mkdir mscitp2
[root@sandbox ~]# cd mscitp2
[root@sandbox mscitp2]# ls
[root@sandbox mscitp2]#
```

Now create input file

Command: cat >> wordin.txt

Paste the text by right clicking on terminal

Hello World

This is the output is the

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A screenshot of a terminal window titled "192.168.119.132:4200". The terminal shows a root shell on a sandbox host. A context menu is open over the command line, with the "Paste from browser" option highlighted. A small modal dialog box is overlaid on the terminal, containing the text "192.168.119.132:4200 says" and a text input field with the placeholder "Hello World\n>This is the output is the".

```
sandbox login: root
root@sandbox.hortonworks.com's password:
Last login: Thu Jul  1 13:38:19 2021 from 172.17.0.2
[root@sandbox ~]# mkdir mscitp2
[root@sandbox ~]# cd mscitp2
[root@sandbox mscitp2]# ls
[root@sandbox mscitp2]# cat >>wordin.txt
```

Copy
Paste
Paste from browser
Reset
✓ Unicode
Visual Bell
Onscreen Keyboard
Disable Alt Key
✓ Blinking Cursor
About...

A screenshot of a terminal window titled "192.168.119.132:4200". The terminal shows a root shell on a sandbox host. The command "cat >>wordin.txt" has been run, and the output "Hello World" is visible. Below the command line, the text "This is the output is the" is pasted into the terminal, with the cursor positioned after "the".

```
sandbox login: root
root@sandbox.hortonworks.com's password:
Last login: Thu Jul  1 13:38:19 2021 from 172.17.0.2
[root@sandbox ~]# mkdir mscitp2
[root@sandbox ~]# cd mscitp2
[root@sandbox mscitp2]# ls
[root@sandbox mscitp2]# cat >>wordin.txt
Hello World
This is the output is the
```

To remove the extra space type command

vi wordin.txt

After removing the extra space check the content of the file

cat wordin.txt

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```
< > C 88 ▲ 192.168.119.132:4200
Hadoop Map Redu... root@ sandbox:~/bl...
sandbox login: root
root@sandbox.hortonworks.com's password:
Last login: Thu Jul  1 13:38:19 2021 from 172.17.0.2
[root@sandbox ~]# mkdir mscitp2
[root@sandbox ~]# cd mscitp2
[root@sandbox mscitp2]# ls
[root@sandbox mscitp2]# cat >>wordin.txt
Hello World

This is the output is the
[root@sandbox mscitp2]# vi wordin.txt
[root@sandbox mscitp2]# cat wordin.txt
Hello World
This is the output is the
[root@sandbox mscitp2]#
```

Create another file wordcount.java

```
This is the output is the
[root@sandbox mscitp2]# vi wordin.txt
[root@sandbox mscitp2]# cat wordin.txt
Hello World
This is the output is the
[root@sandbox mscitp2]# cat >>WordCount.java
```

Paste the java code.

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A screenshot of a terminal window titled '192.168.119.132:4200'. The terminal shows a Java code execution process. A context menu is open over the terminal window, with the 'Paste from browser' option highlighted. A tooltip window titled '192.168.119.132:4200 says' contains the Java code: 'new Path(args[1]).~> System.exit(job.waitForCompletion(true)?0:1);~>}'. Buttons for 'OK' and 'Cancel' are visible at the bottom of the tooltip.

```
sandbox login: root
root@sandbox.hortonworks.com's password:
Last login: Thu Jul  1 13:38:19 2018
[root@sandbox ~]# mkdir mscitp2
[root@sandbox ~]# cd mscitp2
[root@sandbox mscitp2]# ls
[root@sandbox mscitp2]# cat >>wordin.txt
Hello World
This is the output i
[root@sandbox mscitp2]# t.java
[root@sandbox mscitp2]#
```

Press control d to save the file

Check both the files create with command ls

A screenshot of a terminal window titled '192.168.119.132:4200'. The terminal shows the result of the 'ls' command, which lists two files: 'WordCount.java' and 'wordin.txt'. The terminal prompt '[root@sandbox mscitp2]#' is visible at the end.

```
[root@sandbox mscitp2]# ls
WordCount.java wordin.txt
[root@sandbox mscitp2]#
```

Now, to compile the java file

```
export HADOOP_CLASSPATH=$(hadoop classpath)
mkdir classes (To keep the compile files)
```

```
javac -classpath ${HADOOP_CLASSPATH} -d classes WordCount.java
```

```
[root@sandbox mscitp2]# ls  
WordCount.java wordin.txt  
[root@sandbox mscitp2]# export HADOOP_CLASSPATH=$(hadoop classpath)  
[root@sandbox mscitp2]# ls  
WordCount.java wordin.txt  
[root@sandbox mscitp2]# mkdir classes  
[root@sandbox mscitp2]# javac -classpath ${HADOOP_CLASSPATH} -d classes WordCount.java  
[root@sandbox mscitp2]#
```

Check class files are created with command ls classes

```
WordCount.java wordin.txt  
[root@sandbox mscitp2]# mkdir classes  
[root@sandbox mscitp2]# javac -classpath ${HADOOP_CLASSPATH} -d classes WordCount.java  
[root@sandbox mscitp2]# ls classes  
WordCount.class WordCount$IntSumReducer.class WordCount$TokenizerMapper.class  
[root@sandbox mscitp2]#
```

Now we have to bind all the class into single jar file with below command

```
jar -cvf WordCount.jar -C classes/ .
```

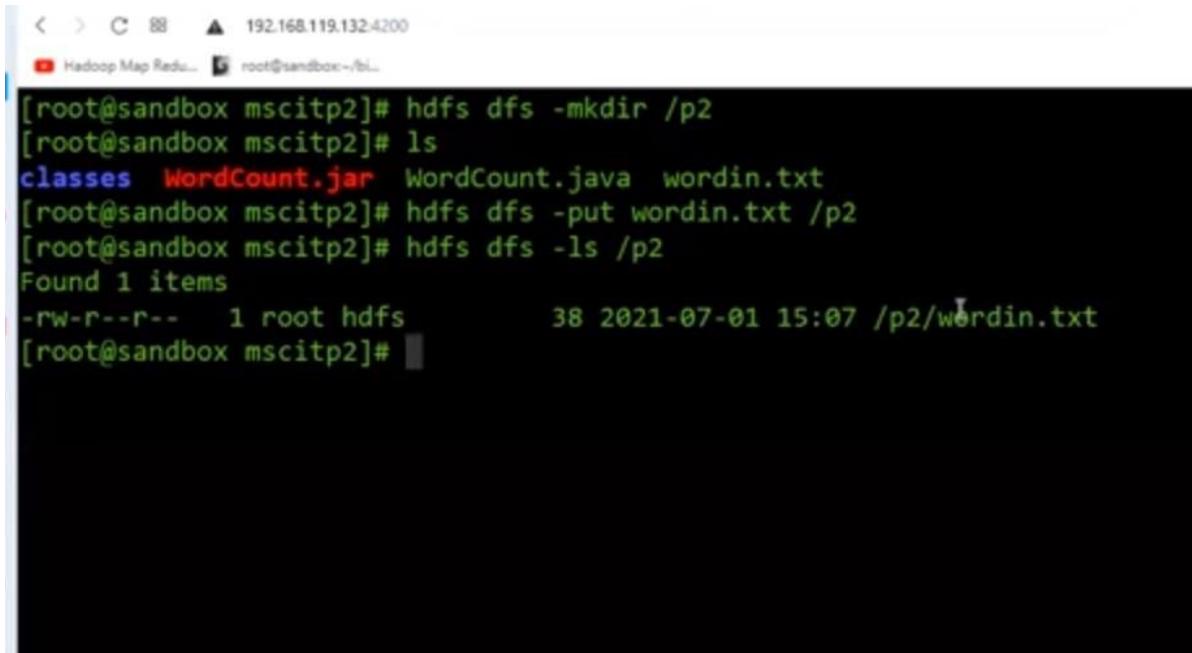
```
[root@sandbox mscitp2]# ls  
WordCount.java wordin.txt  
[root@sandbox mscitp2]# export HADOOP_CLASSPATH=$(hadoop classpath)  
[root@sandbox mscitp2]# ls  
WordCount.java wordin.txt  
[root@sandbox mscitp2]# mkdir classes  
[root@sandbox mscitp2]# javac -classpath ${HADOOP_CLASSPATH} -d classes WordCount.java  
[root@sandbox mscitp2]# ls classes  
WordCount.class WordCount$IntSumReducer.class WordCount$TokenizerMapper.class  
[root@sandbox mscitp2]# ls  
classes WordCount.java wordin.txt  
[root@sandbox mscitp2]# jar -cvf WordCount.jar -C classes/ .  
added manifest  
adding: WordCount$IntSumReducer.class(in = 1739) (out= 742)(deflated 57%)  
adding: WordCount$TokenizerMapper.class(in = 1736) (out= 756)(deflated 56%)  
adding: WordCount.class(in = 1491) (out= 813)(deflated 45%)  
[root@sandbox mscitp2]#
```

Run ls command we can see jar file is created.

```
[root@sandbox mscitp2]# ls  
classes WordCount.jar WordCount.java wordin.txt  
[root@sandbox mscitp2]#
```

wordin.txt should be present in word directory of hdfs. So we need to upload wordin.txt file.

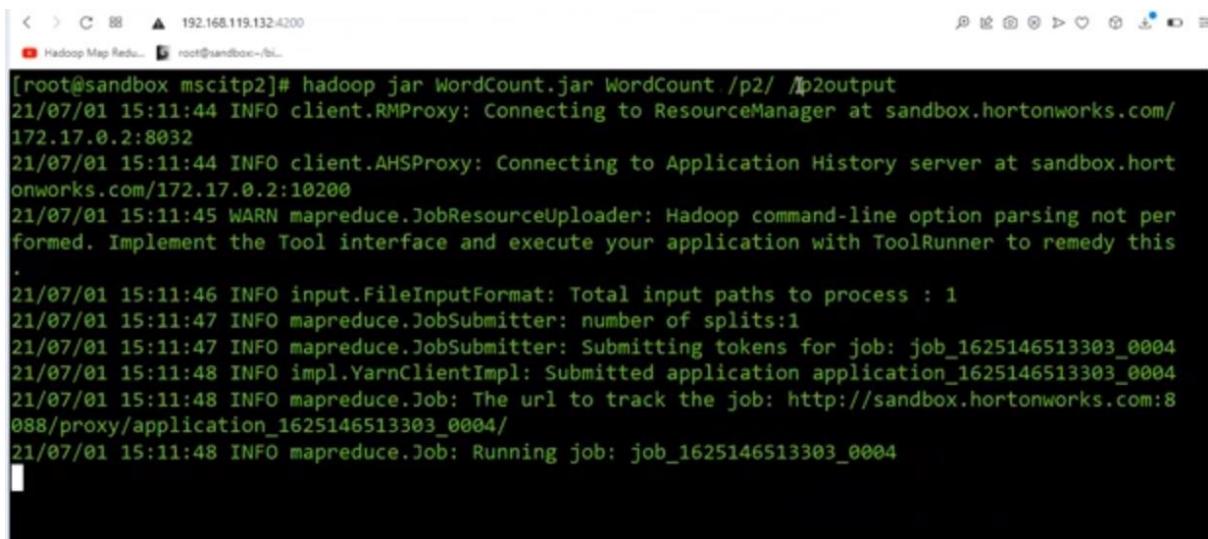
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```
< > C 192.168.119.132:4200
Hadoop Map Redu... root@sandbox:~/bl...
[root@sandbox mscitp2]# hdfs dfs -mkdir /p2
[root@sandbox mscitp2]# ls
classes WordCount.jar WordCount.java wordin.txt
[root@sandbox mscitp2]# hdfs dfs -put wordin.txt /p2
[root@sandbox mscitp2]# hdfs dfs -ls /p2
Found 1 items
-rw-r--r-- 1 root hdfs          38 2021-07-01 15:07 /p2/wordin.txt
[root@sandbox mscitp2]#
```

We need to put the final output p2output.

hadoop jar WordCount.jar WordCount /p2/ /p2output

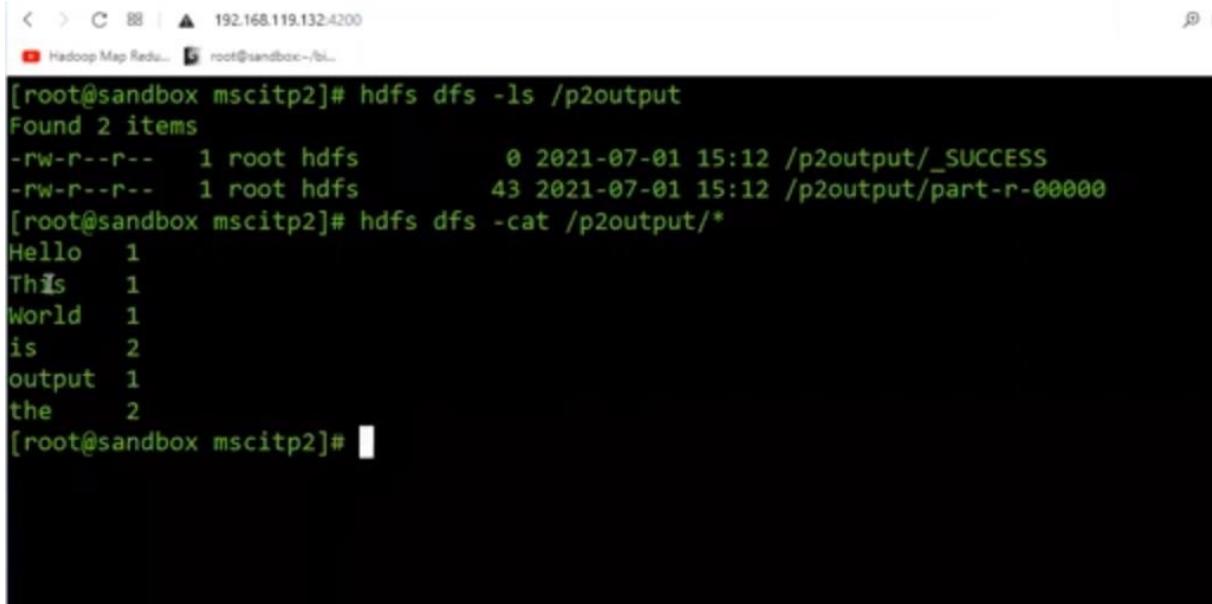


```
< > C 192.168.119.132:4200
Hadoop Map Redu... root@sandbox:~/bl...
[root@sandbox mscitp2]# hadoop jar WordCount.jar WordCount /p2/ /p2output
21/07/01 15:11:44 INFO client.RMProxy: Connecting to ResourceManager at sandbox.hortonworks.com/172.17.0.2:8032
21/07/01 15:11:44 INFO client.AHSProxy: Connecting to Application History server at sandbox.hortonworks.com/172.17.0.2:10200
21/07/01 15:11:45 WARN mapreduce.JobResourceUploader: Hadoop command-line option parsing not performed. Implement the Tool interface and execute your application with ToolRunner to remedy this.
.
21/07/01 15:11:46 INFO input.FileInputFormat: Total input paths to process : 1
21/07/01 15:11:47 INFO mapreduce.JobSubmitter: number of splits:1
21/07/01 15:11:47 INFO mapreduce.JobSubmitter: Submitting tokens for job: job_1625146513303_0004
21/07/01 15:11:48 INFO impl.YarnClientImpl: Submitted application application_1625146513303_0004
21/07/01 15:11:48 INFO mapreduce.Job: The url to track the job: http://sandbox.hortonworks.com:8088/proxy/application_1625146513303_0004/
21/07/01 15:11:48 INFO mapreduce.Job: Running job: job_1625146513303_0004
```

Print the content of the output file

Command: hdfs dfs -cat /p2output/*

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The screenshot shows a terminal window with the following session:

```
[root@sandbox mscitp2]# hdfs dfs -ls /p2output
Found 2 items
-rw-r--r-- 1 root hdfs          0 2021-07-01 15:12 /p2output/_SUCCESS
-rw-r--r-- 1 root hdfs        43 2021-07-01 15:12 /p2output/part-r-00000
[root@sandbox mscitp2]# hdfs dfs -cat /p2output/*
Hello    1
This    1
World    1
is        2
output   1
the      2
[root@sandbox mscitp2]#
```

Ctrl + l to clear the screen.

vi filename.txt= this command will create/ open filename.txt

two modes of vi editor

- 1) Insert mode – i (press i key)
- 2) Command mode – esc key

:wq is to save and exit

Practical 3

Implement an MapReduce program that processes a weather dataset.

Java program:

```
MyMaxMin.java
///////////////
// importing Libraries
import java.io.IOException;
import java.util.Iterator;
import org.apache.hadoop.fs.Path;
import org.apache.hadoop.io.LongWritable;
import org.apache.hadoop.io.Text;
import org.apache.hadoop.mapreduce.lib.input.FileInputFormat;
import org.apache.hadoop.mapreduce.lib.output.FileOutputFormat;
import
org.apache.hadoop.mapreduce.lib.output.TextOutputFormat;
import org.apache.hadoop.mapreduce.lib.input.TextInputFormat;
import org.apache.hadoop.mapreduce.Job;
import org.apache.hadoop.mapreduce.Mapper;
import
org.apache.hadoop.mapreduce.Reducer;
import org.apache.hadoop.conf.Configuration;public class MyMaxMin {
    // Mapper

    /*MaxTemperatureMapper class is static
     * and extends Mapper abstract class
     * having four Hadoop generics type
     * LongWritable, Text, Text, Text.
    */
}
```

```
public static class MaxTemperatureMapper extends  
    Mapper<LongWritable, Text, Text, Text> {  
    public static final int MISSING = 9999;  
  
    @Override  
    public void map(LongWritable arg0, Text Value, Context context)  
        throws IOException, InterruptedException {  
  
        String line = Value.toString();  
  
        // Check for the empty line  
        if (!(line.length() == 0)) {  
  
            // from character 6 to 14 we have  
            // the date in our dataset  
            String date = line.substring(6, 14);  
            // similarly we have taken the maximum  
            // temperature from 39 to 45 characters  
            float temp_Max = Float.parseFloat(line.substring(39,  
45).trim());  
  
            // similarly we have taken the minimum  
            // temperature from 47 to 53 characters  
            float temp_Min = Float.parseFloat(line.substring(47,  
53).trim());  
            // if maximum temperature is  
            // greater than 30, it is a hot day  
        }  
    }  
}
```

```
if (temp_Max > 30.0) {  
  
    // Hot day  
    context.write(new Text("The Day is Hot Day :"  
+ date),  
                new  
Text(String.valueOf(temp_Max)));  
}  
// if the minimum  
temperature is  
  
// less than 15, it is a cold day  
if (temp_Min < 15) {  
  
    // Cold day  
    context.write(new Text("The Day is Cold Day  
:" + date),  
                new  
Text(String.valueOf(temp_Min)));  
}  
}  
}  
}  
} // Reducer  
  
/*MaxTemperatureReducer class is  
static and extends Reducer abstract class  
having four Hadoop generics type  
Text, Text, Text, Text.  
*/  
//The Day is Cold Day :20150101 ,-21.8  
  
public static class MaxTemperatureReducer extends
```

```
Reducer<Text, Text, Text, Text> {          /**
 * @method reduce
 * This method takes the input as key and
 * list of values pair from the mapper,
 * it does aggregation based on keys and
 * produces the final context.
 */
}

public void reduce(Text Key, Iterator<Text> Values, Context
context) throws IOException, InterruptedException {
    // putting all the values in
    // temperature variable of type String
    String temperature = Values.next().toString();
    context.write(Key, new Text(temperature));
} } /**

* @method main
* This method is used for setting
* all the configuration properties.
* It acts as a driver for map-reduce
* code.
*/
}

public static void main(String[] args) throws Exception {      // reads
the default configuration of the
    // cluster from the configuration XML files
    Configuration conf = new Configuration();
```

```
// Initializing the job with the
// default configuration of the cluster
Job job = new Job(conf, "weather example");

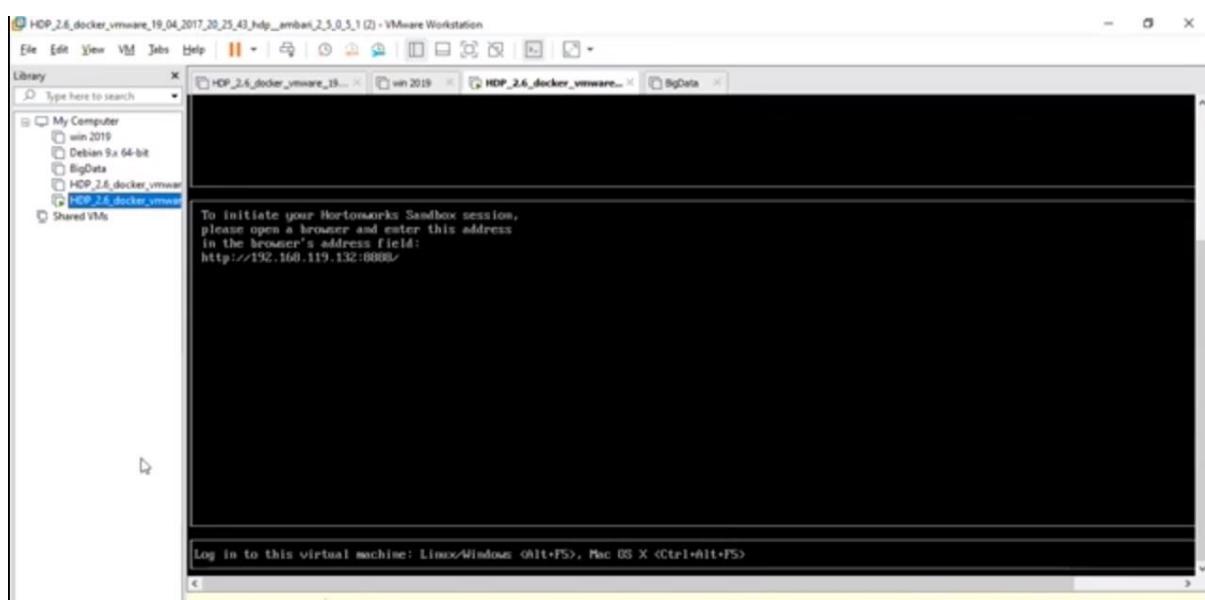
// Assigning the driver class name
job.setJarByClass(MyMaxMin.class);           // Key type coming
out of mapper
job.setMapOutputKeyClass(Text.class);

// value type coming out of mapper
job.setMapOutputValueClass(Text.class);        // Defining the
mapper class name
job.setMapperClass(MaxTemperatureMapper.class);

// Defining the reducer class name
job.setReducerClass(MaxTemperatureReducer.class); // Defining input Format class which is
                                                     // responsible to parse the dataset
                                                     // into a key value pair
job.setInputFormatClass(TextInputFormat.class);

// Defining output Format class which is
// responsible to parse the dataset
// into a key value pair
job.setOutputFormatClass(TextOutputFormat.class); // setting the second argument
                                                 // as a path in a path variable
Path outputPath = new Path(args[1]);           // Configuring the
input path
```

```
// from the filesystem into the job  
FileInputFormat.addInputPath(job, new Path(args[0])); //  
Configuring the output path from  
// the filesystem into the job  
FileOutputFormat.setOutputPath(job, new Path(args[1])); //  
deleting the context path automatically  
// from hdfs so that we don't have  
// to delete it explicitly  
OutputPath.getFileSystem(conf).delete(OutputPath);  
// flag value becomes false  
System.exit(job.waitForCompletion(true) ? 0 : 1); }  
}  
///////////Start the server
```



Open the terminal with 192.168.119.132/4200

Enter the login: root and the password and enter

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A screenshot of a terminal window titled "192.168.119.132:4200". The title bar also shows "Hadoop Map Redu..." and "root@sandbox:~\$". The terminal prompt is "root@sandbox ~]#". The session starts with "sandbox login: root", followed by a password prompt "root@sandbox.hortonworks.com's password:", and ends with "Last login: Thu Jul 1 13:38:19 2021 from 172.17.0.2". The command history shows "[root@sandbox ~]#".

Create a folder in local directory.

Command: mkdir mscitp3

Change the directory cd mscitp3

A screenshot of a terminal window titled "192.168.119.132:4200". The title bar also shows "Hadoop Map Redu..." and "root@sandbox:~\$ Bulk Image Resize". The terminal prompt is "root@sandbox ~]#". The session starts with "sandbox login: root", followed by a password prompt "root@sandbox.hortonworks.com's password:", and ends with "Last login: Thu Jul 1 14:53:58 2021 from 172.17.0.2". The command history shows "[root@sandbox ~]# ls", "[root@sandbox ~]# mkdir mscitp3", and "[root@sandbox ~]# cd mscitp3".

Now create input file

Command: cat >> weatherin2.txt

Paste the weather dataset by right clicking on terminal

Ctrl d will save the file

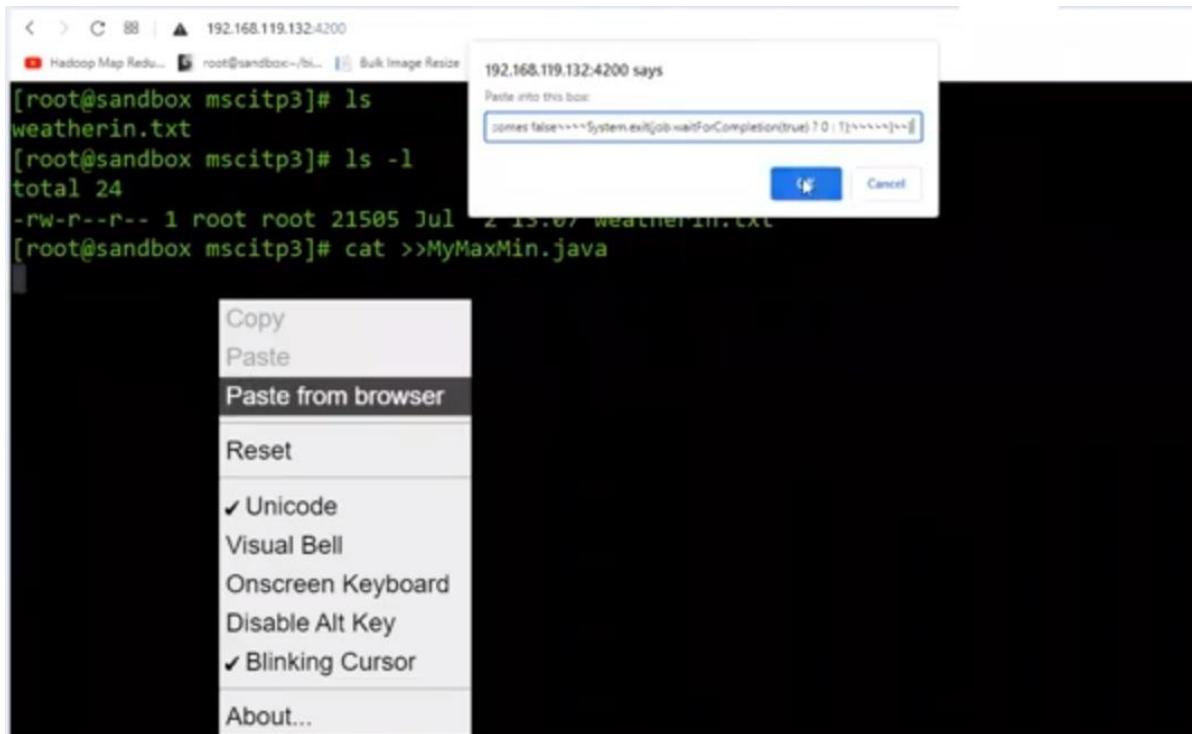
Run command ls to see the file.

Create java file

Command: cat >>MyMaxMin.java

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Paste the java code and ctrl d to save the file



A screenshot of a terminal window on a Linux system. The terminal shows the command [root@sandbox mscitp3]# ls followed by weatherin.txt. Then [root@sandbox mscitp3]# ls -l which shows a total of 24 files, including weatherin.txt. Finally, [root@sandbox mscitp3]# cat >>MyMaxMin.java. A context menu is open over the terminal window, with the 'Paste from browser' option highlighted. A clipboard dialog box is overlaid on the terminal, containing the text 'comes false\n***System.exit(job.waitForCompletion(true)) TO : T[*****]\n'. There are 'OK' and 'Cancel' buttons at the bottom of the clipboard dialog.

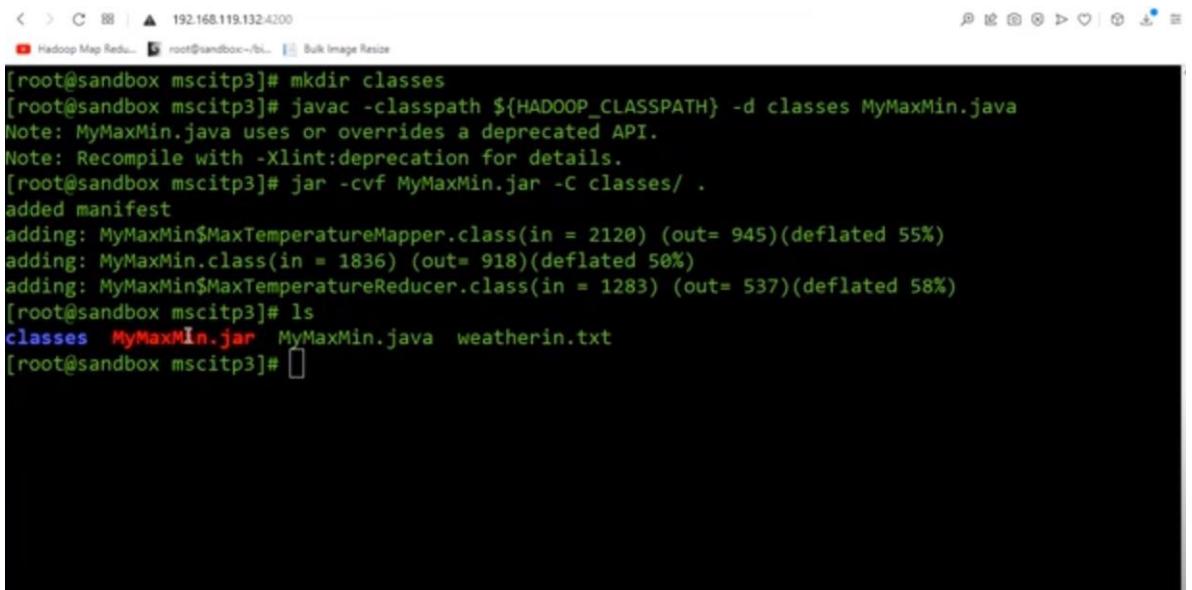
export HADOOP_CLASSPATH=\$(hadoop classpath) //compile and to create jar file

mkdir classes

javac -classpath \${HADOOP_CLASSPATH} -d classes MyMaxMin.java

After compile need to create a jar file

jar -cvf MyMaxMin.jar -C classes/ .



A screenshot of a terminal window on a Linux system. The terminal shows the commands [root@sandbox mscitp3]# mkdir classes, [root@sandbox mscitp3]# javac -classpath \${HADOOP_CLASSPATH} -d classes MyMaxMin.java, and [root@sandbox mscitp3]# jar -cvf MyMaxMin.jar -C classes/. The output of the javac command includes notes about deprecated APIs and recompilation. The final output shows the creation of the MyMaxMin.jar file. The terminal also shows the contents of the classes directory, which includes MyMaxMin.jar, MyMaxMin.java, and weatherin.txt.

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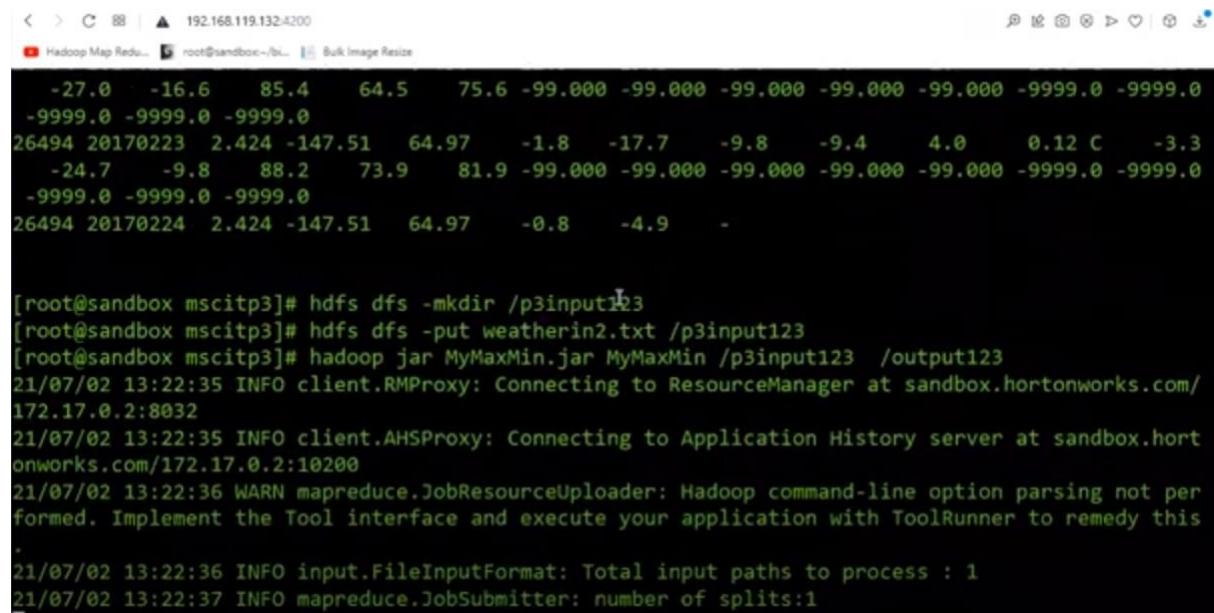
Now, put weatherin.txt in hdfs

Before that create a folder

Command: hdfs dfs -mkdir /p3input123

Then run command: hdfs dfs -put weatherin2.txt /p3input123

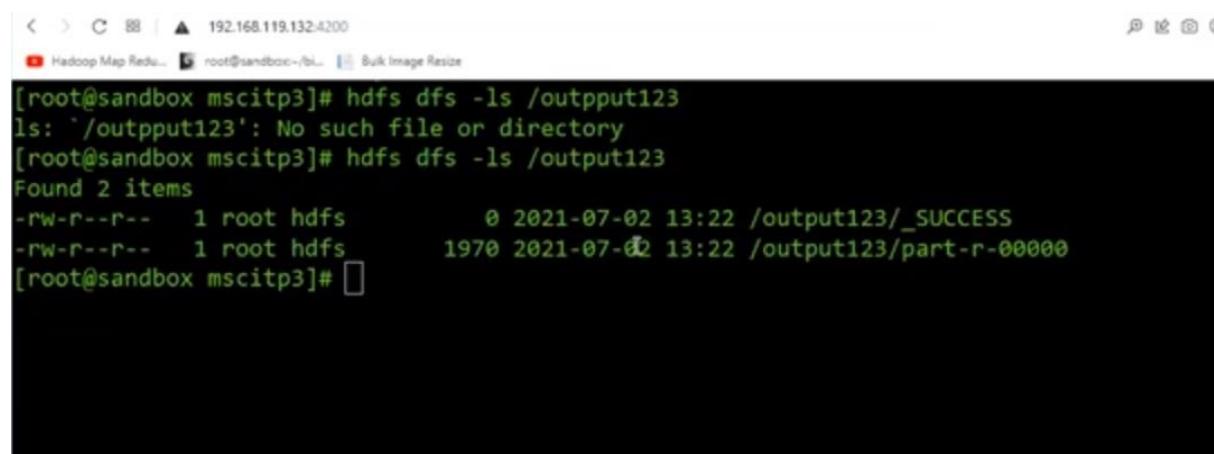
hadoop jar MyMaxMin.jar MyMaxMin /p3inputw /output123



```
< > C 88 | ▲ 192.168.119.132:4200
[Hadoop Map Redu... root@sandbox:~/bi... Bulk Image Resize
-27.0 -16.6 85.4 64.5 75.6 -99.000 -99.000 -99.000 -99.000 -99.000 -9999.0 -9999.0
-9999.0 -9999.0 -9999.0
26494 20170223 2.424 -147.51 64.97 -1.8 -17.7 -9.8 -9.4 4.0 0.12 C -3.3
-24.7 -9.8 88.2 73.9 81.9 -99.000 -99.000 -99.000 -99.000 -99.000 -9999.0 -9999.0
-9999.0 -9999.0 -9999.0
26494 20170224 2.424 -147.51 64.97 -0.8 -4.9 -
[root@sandbox mscitp3]# hdfs dfs -mkdir /p3input123
[root@sandbox mscitp3]# hdfs dfs -put weatherin2.txt /p3input123
[root@sandbox mscitp3]# hadoop jar MyMaxMin.jar MyMaxMin /p3input123 /output123
21/07/02 13:22:35 INFO client.RMProxy: Connecting to ResourceManager at sandbox.hortonworks.com/172.17.0.2:8032
21/07/02 13:22:35 INFO client.AHSProxy: Connecting to Application History server at sandbox.hortonworks.com/172.17.0.2:10200
21/07/02 13:22:36 WARN mapreduce.JobResourceUploader: Hadoop command-line option parsing not performed. Implement the Tool interface and execute your application with ToolRunner to remedy this
.
21/07/02 13:22:36 INFO input.FileInputFormat: Total input paths to process : 1
21/07/02 13:22:37 INFO mapreduce.JobSubmitter: number of splits:1
```

Check outfile is created

Command: hdfs dfs -ls /output123



```
< > C 88 | ▲ 192.168.119.132:4200
[Hadoop Map Redu... root@sandbox:~/bi... Bulk Image Resize
[root@sandbox mscitp3]# hdfs dfs -ls /outpput123
ls: '/outpput123': No such file or directory
[root@sandbox mscitp3]# hdfs dfs -ls /output123
Found 2 items
-rw-r--r-- 1 root hdfs 0 2021-07-02 13:22 /output123/_SUCCESS
-rw-r--r-- 1 root hdfs 1970 2021-07-02 13:22 /output123/part-r-00000
[root@sandbox mscitp3]#
```

hdfs dfs -cat /output123/*

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```
< > C ☰ ▲ 192.168.119.132:4200
Hadoop Map Redu... root@sandbox:~/bl... Bulk Image Resize

      Reduce output records=55
[root@sandbox mscitp3]# hdfs dfs -ls /outpput123
ls: '/outpput123': No such file or directory
[root@sandbox mscitp3]# hdfs dfs -ls /output123
Found 2 items
-rw-r--r-- 1 root hdfs          0 2021-07-02 13:22 /output123/_SUCCESS
-rw-r--r-- 1 root hdfs 1970 2021-07-02 13:22 /output123/part-r-00000
[root@sandbox mscitp3]# hdfs dfs -cat /output123/*
The Day is Cold Day :20170101 -8.7
The Day is Cold Day :20170102 -9.2
The Day is Cold Day :20170103 -10.7
The Day is Cold Day :20170104 -10.1
The Day is Cold Day :20170105 -20.0
The Day is Cold Day :20170106 -23.7
The Day is Cold Day :20170107 -22.1
The Day is Cold Day :20170108 -21.2
The Day is Cold Day :20170109 -17.7
The Day is Cold Day :20170110 -21.0
The Day is Cold Day :20170111 -22.7
The Day is Cold Day :20170112 -20.2
The Day is Cold Day :20170113 -19.0
The Day is Cold Day :20170114 -25.5
```

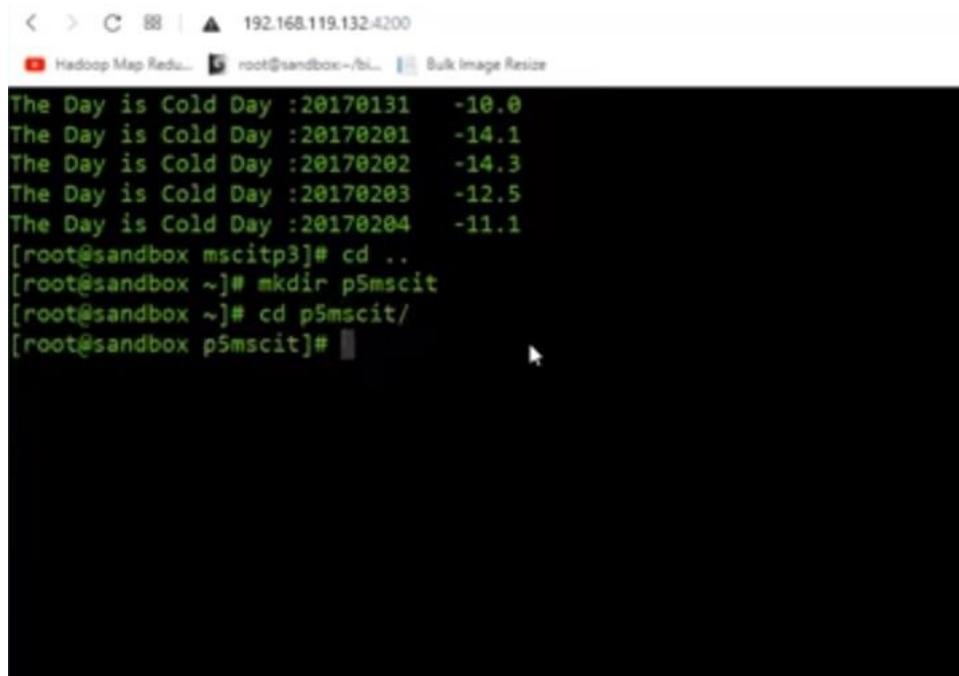
Practical 4

Implement the program using Pig.

Dataset:

```
001,Rajiv,Reddy,21,9848022337,Hyderabad  
002,siddarth,Battacharya,22,9848022338,Kolkata  
003,Rajesh,Khanna,22,9848022339,Delhi  
004,Preethi,Agarwal,21,9848022330,Pune  
005,Trupthi,Mohanthy,23,9848022336,Bhuwaneshwar  
006,Archana,Mishra,23,9848022335,Chennai  
007,Komal,Nayak,24,9848022334,trivendram  
008,Bharathi,Nambiayar,24,9848022333,Chennai  
#student.txtcreate a directory and get into that directory
```

Command: mkdir p5mscit



The screenshot shows a terminal window with the IP address 192.168.119.132:4200 at the top. The window title is "Hadoop Map Redu...". The terminal displays the following text:

```
The Day is Cold Day :20170131 -10.0  
The Day is Cold Day :20170201 -14.1  
The Day is Cold Day :20170202 -14.3  
The Day is Cold Day :20170203 -12.5  
The Day is Cold Day :20170204 -11.1  
[root@sandbox mscitp3]# cd ..  
[root@sandbox ~]# mkdir p5mscit  
[root@sandbox ~]# cd p5mscit/  
[root@sandbox p5mscit]#
```

Create a file

Command: cat >>student.txt

Right click and paste the text

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The screenshot shows a terminal window with the IP address 192.168.119.132:4200. A context menu is open over a list of student records. The menu includes options like Copy, Paste, Paste from browser, Reset, Unicode (checked), Visual Bell, Onscreen Keyboard, and Disable Alt Key.

```
The Day is Cold Day :20170131 -10.0
The Day is Cold Day :20170201 -14.1
The Day is Cold Day :20170202 -14.3
The Day is Cold Day :20170203 -12.5
The Day is Cold Day :20170204 -11.1
[root@sandbox mscitp3]# cd ..
[root@sandbox ~]# mkdir p5mscit
[root@sandbox ~]# cd p5mscit/
[root@sandbox p5mscit]# cat student.txt
cat: student.txt: No such file or directory
[root@sandbox p5mscit]# cat >>student.txt
```

```
The Day is Cold Day :20170201 -14.1
The Day is Cold Day :20170202 -14.3
The Day is Cold Day :20170203 -12.5
The Day is Cold Day :20170204 -11.1
[root@sandbox mscitp3]# cd ..
[root@sandbox ~]# mkdir p5mscit
[root@sandbox ~]# cd p5mscit/
[root@sandbox p5mscit]# cat student.txt
cat: student.txt: No such file or directory
[root@sandbox p5mscit]# cat >>student.txt
001,Rajiv,Reddy,21,9848022337,Hyderabad
002,siddarth,Battacharya,22,9848022338,Kolkata
003,Rajesh,Khanna,22,9848022339,Delhi
004,Preethi,Agarwal,21,9848022330,Pune
005,Trupthi,Mohanthy,23,9848022336,Bhuwaneshwar
006,Archana,Mishra,23,9848022335,Chennai
007,Komal,Nayak,24,9848022334,trivendram
008,Bharathi,Nambiayar,24,9848022333,Chennai
```

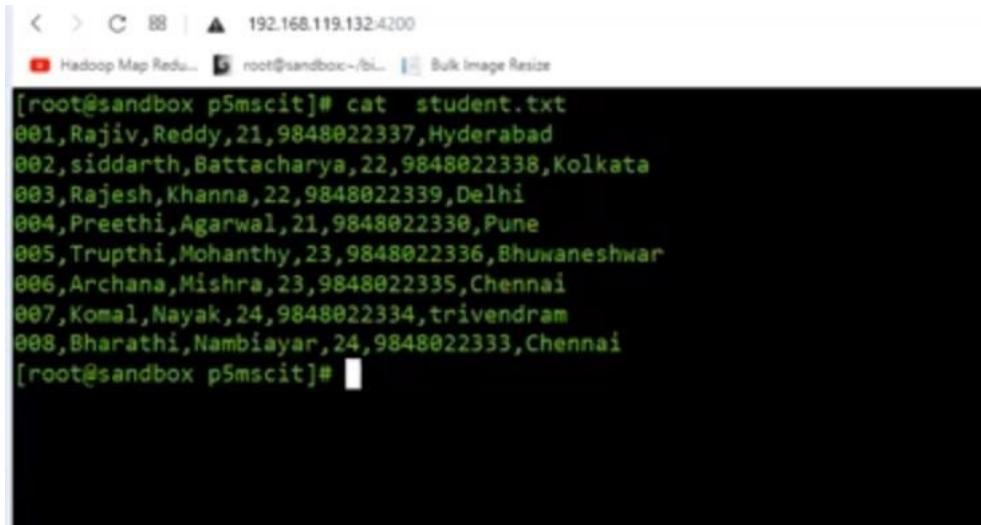
Remove the space with vi editor

Command: vi student.txt and press i for insert mode

After editing: wq and enter

Print the content and see the text

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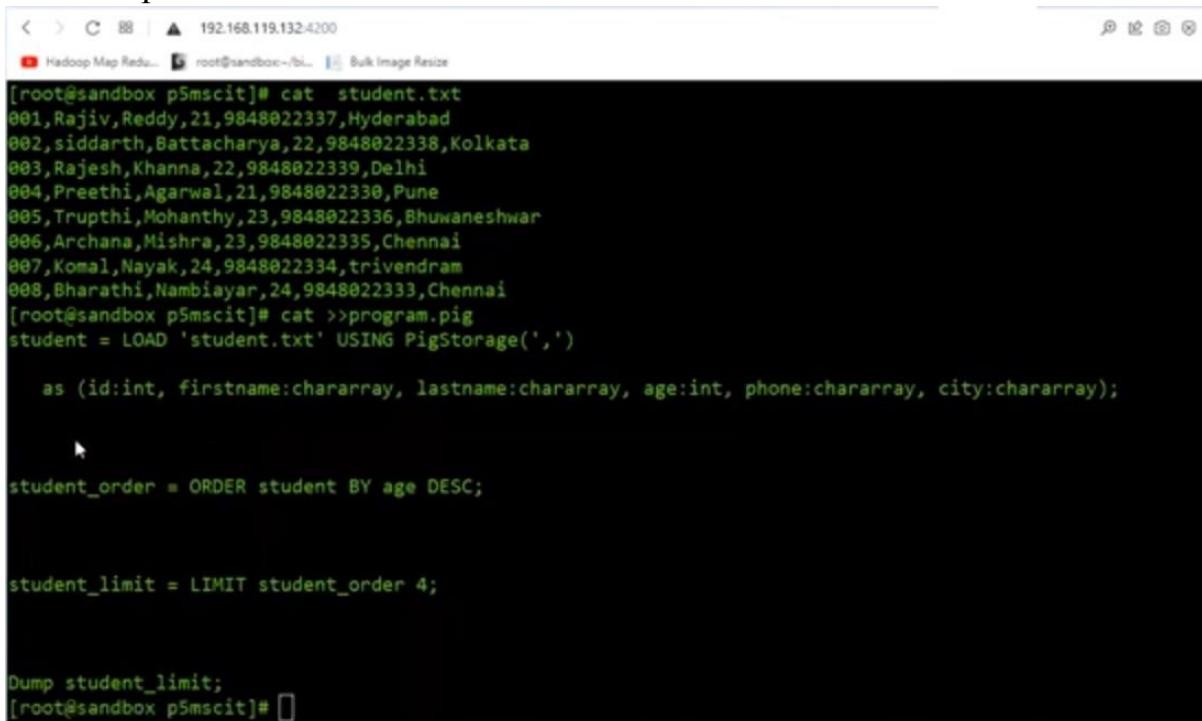


```
< > C 88 | ▲ 192.168.119.132:4200
Hadoop Map Redu... root@sandbox:~/bi... Bulk Image Resize
[root@sandbox p5mscit]# cat student.txt
001,Rajiv,Reddy,21,9848022337,Hyderabad
002,siddarth,Battacharya,22,9848022338,Kolkata
003,Rajesh,Khanna,22,9848022339,Delhi
004,Preethi,Agarwal,21,9848022330,Pune
005,Trupthi,Mohanthy,23,9848022336,Bhuwaneshwar
006,Archana,Mishra,23,9848022335,Chennai
007,Komal,Nayak,24,9848022334,trivendram
008,Bharathi,Nambiyar,24,9848022333,Chennai
[root@sandbox p5mscit]#
```

Create a program file

```
//////////script start
student = LOAD 'student.txt' USING PigStorage(',')
    as (id:int, firstname:chararray, lastname:chararray, age:int, phone:chararray,
city:chararray);

student_order = ORDER student BY age DESC;student_limit = LIMIT
student_order 4;Dump student_limit;
/////////script end
```



```
< > C 88 | ▲ 192.168.119.132:4200
Hadoop Map Redu... root@sandbox:~/bi... Bulk Image Resize
[root@sandbox p5mscit]# cat student.txt
001,Rajiv,Reddy,21,9848022337,Hyderabad
002,siddarth,Battacharya,22,9848022338,Kolkata
003,Rajesh,Khanna,22,9848022339,Delhi
004,Preethi,Agarwal,21,9848022330,Pune
005,Trupthi,Mohanthy,23,9848022336,Bhuwaneshwar
006,Archana,Mishra,23,9848022335,Chennai
007,Komal,Nayak,24,9848022334,trivendram
008,Bharathi,Nambiyar,24,9848022333,Chennai
[root@sandbox p5mscit]# cat >>program.pig
student = LOAD 'student.txt' USING PigStorage(',')
    as (id:int, firstname:chararray, lastname:chararray, age:int, phone:chararray, city:chararray);

student_order = ORDER student BY age DESC;

student_limit = LIMIT student_order 4;

Dump student_limit;
[root@sandbox p5mscit]#
```

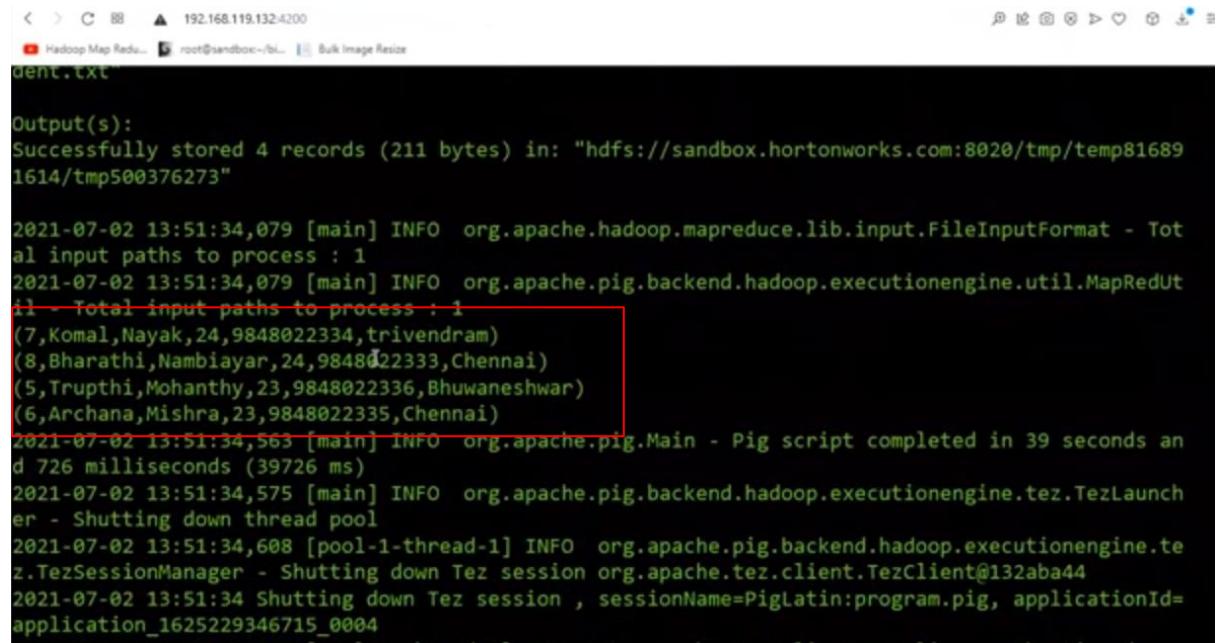
Upload student on hdfs

Command: hdfs dfs -put student.txt /user/root/

Run the pig program

```
[root@sandbox p5mscit]# hdfs dfs -put student.txt /user/root/
[root@sandbox p5mscit]# pig program.pig
```

Output:



```
< > C 192.168.119.132:4200
Hadoop Map Redu... root@sandbox:/bl... Bulk Image Resize
student.txt

Output(s):
Successfully stored 4 records (211 bytes) in: "hdfs://sandbox.hortonworks.com:8020/tmp/temp816891614/tmp500376273"

2021-07-02 13:51:34,079 [main] INFO org.apache.hadoop.mapreduce.lib.input.FileInputFormat - Total input paths to process : 1
2021-07-02 13:51:34,079 [main] INFO org.apache.pig.backend.hadoop.executionengine.util.MapReduceUtil - Total input paths to process : 1
(7,Komal,Nayak,24,9848022334,trivendram)
(8,Bharathi,Nambiayar,24,9848022333,Chennai)
(5,Trupthi,Mohanthy,23,9848022336,Bhuwaneshwar)
(6,Archana,Mishra,23,9848022335,Chennai)
2021-07-02 13:51:34,563 [main] INFO org.apache.pig.Main - Pig script completed in 39 seconds and 726 milliseconds (39726 ms)
2021-07-02 13:51:34,575 [main] INFO org.apache.pig.backend.hadoop.executionengine.tez.TezLauncher - Shutting down thread pool
2021-07-02 13:51:34,608 [pool-1-thread-1] INFO org.apache.pig.backend.hadoop.executionengine.tez.TezSessionManager - Shutting down Tez session org.apache.tez.client.TezClient@132aba44
2021-07-02 13:51:34 Shutting down Tez session , sessionName=PigLatin:program.pig, applicationId=application_1625229346715_0004
```

Practical 5

Implement the application in Hive.

Dataset:

```
001,Rajiv,Reddy,21,9848022337,Hyderabad  
002,siddarth,Battacharya,22,9848022338,Kolkata  
003,Rajesh,Khanna,22,9848022339,Delhi  
004,Preethi,Agarwal,21,9848022330,Pune  
005,Trupthi,Mohanthy,23,9848022336,Bhuwaneshwar  
006,Archana,Mishra,23,9848022335,Chennai  
007,Komal,Nayak,24,9848022334,trivendram  
008,Bharathi,Nambiayar,24,9848022333,Chennai  
#student.txtcreate a directory and get into that directory
```

Command: mkdir p6mscit

Create a file

Command: cat >>data.txt

Right click and paste the text

```
< > C 88 ▲ 192.168.119.132:4200  
Hadoop Map Redu... root@sandbox:~/bl... Bulk Image Resize  
[root@sandbox ~]# mkdir p5mscit  
mkdir: cannot create directory `p5mscit': File exists  
[root@sandbox ~]# mkdir p6mscit  
[root@sandbox ~]# cd p6mscit/  
[root@sandbox p6mscit]# cat >>data.txt  
001,Rajiv,Reddy,21,9848022337,Hyderabad  
  
002,siddarth,Battacharya,22,9848022338,Kolkata  
  
003,Rajesh,Khanna,22,9848022339,Delhi  
004,Preethi,Agarwal,21,9848022330,Pune  
  
005,Trupthi,Mohanthy,23,9848022336,Bhuwaneshwar  
  
006,Archana,Mishra,23,9848022335,Chennai  
  
007,Komal,Nayak,24,9848022334,trivendram  
  
008,Bharathi,Nambiayar,24,9848022333,Chennai
```

Remove the space with vi editor

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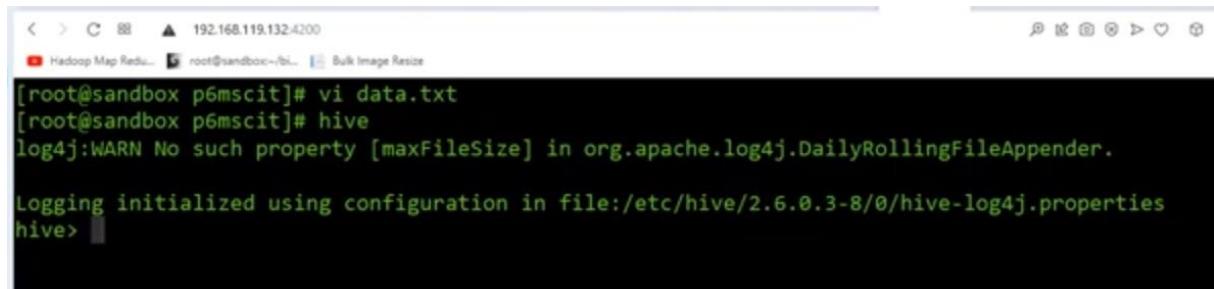
Command: vi student.txt and press i for insert mode

After editing: wq and enter

Print the content and see the text

Now start the hive terminal

Command: hive



```
< > C 192.168.119.132:4200
[root@sandbox p6mscit]# vi data.txt
[root@sandbox p6mscit]# hive
log4j:WARN No such property [maxFileSize] in org.apache.log4j.DailyRollingFileAppender.

Logging initialized using configuration in file:/etc/hive/2.6.0.3-8/0/hive-log4j.properties
hive>
```

Copy paste below command on hive and enter

CREATE TABLE IF NOT EXISTS employee (eid int, fname String,

lname String, age int, contact String, city String)

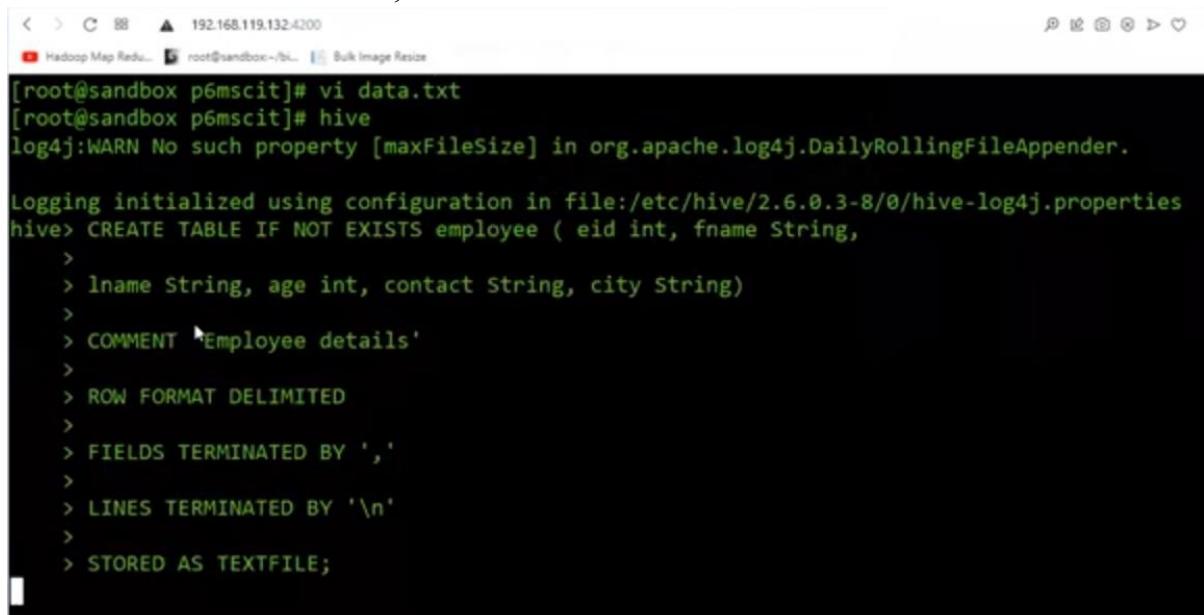
COMMENT 'Employee details'

ROW FORMAT DELIMITED

FIELDS TERMINATED BY ','

INES TERMINATED BY '\n'

STORED AS TEXTFILE;



```
< > C 192.168.119.132:4200
[root@sandbox p6mscit]# vi data.txt
[root@sandbox p6mscit]# hive
log4j:WARN No such property [maxFileSize] in org.apache.log4j.DailyRollingFileAppender.

Logging initialized using configuration in file:/etc/hive/2.6.0.3-8/0/hive-log4j.properties
hive> CREATE TABLE IF NOT EXISTS employee ( eid int, fname String,
> lname String, age int, contact String, city String)
> COMMENT 'Employee details'
> ROW FORMAT DELIMITED
> FIELDS TERMINATED BY ','
> LINES TERMINATED BY '\n'
> STORED AS TEXTFILE;
```

Run command: LOAD DATA LOCAL INPATH 'data.txt' OVERWRITE INTO

TABLE employee;

```
hive> LOAD DATA LOCAL INPATH 'data.txt' OVERWRITE INTO TABLE employee;
Loading data to table default.employee
Table default.employee stats: [numFiles=1, numRows=0, totalSize=339, rawDataSize=0]
OK
Time taken: 1.296 seconds
hive> ;
```

Run the command like select * from employee;

```
< > C 192.168.119.132:4200
Hadoop Map Redu... root@sandbox:/bl... Bulk Image Resize
Loading data to table default.employee
Table default.employee stats: [numFiles=1, numRows=0, totalSize=339, rawDataSize=0]
OK
Time taken: 1.296 seconds
hive> select * from employee;
OK
1      Rajiv    Reddy   21      9848022337      Hyderabad
2      siddarth Battacharya 22      9848022338      Kolkata
3      Rajesh    Khanna   22      9848022339      Delhi
4      Preethi   Agarwal  21      9848022330      Pune
5      Trupthi   Mohanthy 23      9848022336      Bhuvaneshwar
6      Archana   Mishra   23      9848022335      Chennai
7      Komal     Nayak    24      9848022334      trivendram
8      Bharathi Nambiayar 24      9848022333      Chennai
Time taken: 0.188 seconds, Fetched: 8 row(s)
hive> select * from employee where age > 23;
OK
7      Komal     Nayak    24      9848022334      trivendram
8      Bharathi Nambiayar 24      9848022333      Chennai
Time taken: 0.551 seconds, Fetched: 2 row(s)
hive> ;
```

Practical 6

Implement an application that stores big data in Hbase/

Python What is HBase?

HBase is a distributed column-oriented database built on top of the Hadoop file system. It is an open-source project and is horizontally scalable. It is a part of the Hadoop ecosystem that provides random real-time read/write access to data in the Hadoop File System. Go to GUI page and start the hbase service.

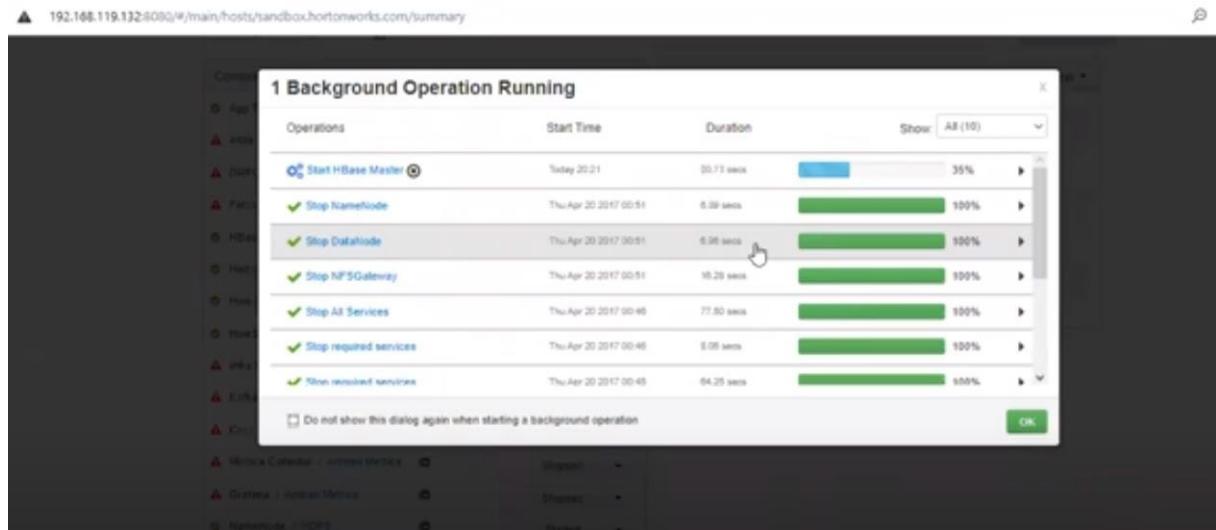
The screenshot shows the 'Components' section of the HDP 2.6.3 Summary UI. It lists several services with their current status:

Service	Status
App Timeline Server / YARN	Started
Atlas Metadata S... / Atlas	Stopped
DRPC Server / Storm	Stopped
Falcon Server / Falcon	Stopped
HBase Master / HBase	Stopped
History Server / MapReduce2	Started

A large 'Start' button is prominently displayed below the service list, indicating that the HBase service is currently inactive.

Click on OK to start the service.

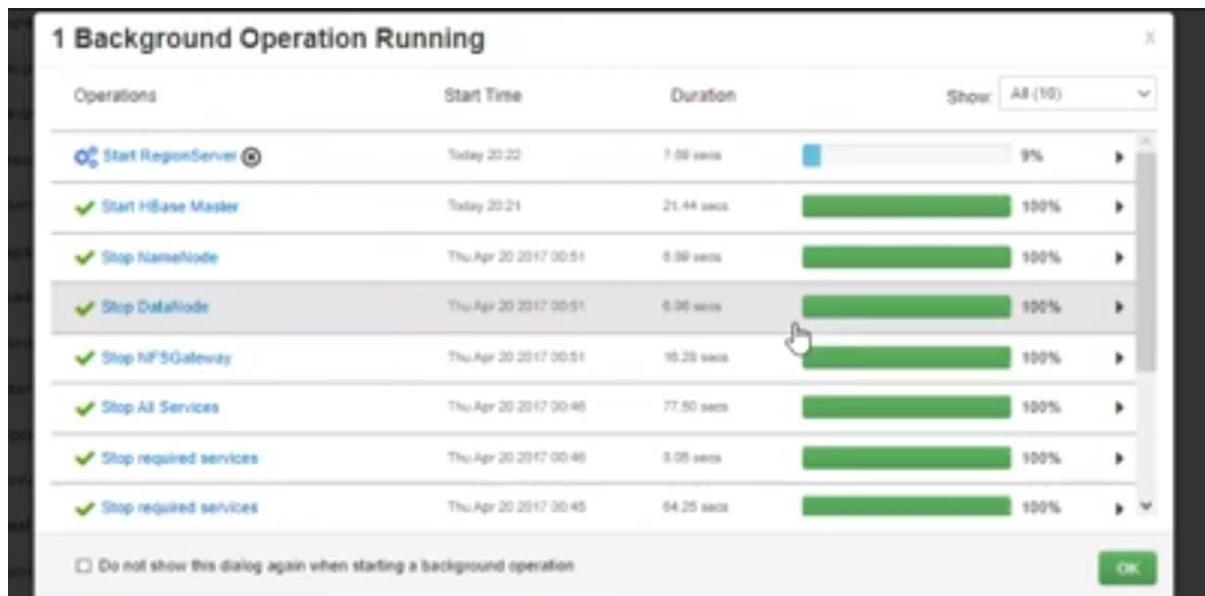
A confirmation dialog box titled 'Confirmation' is displayed. The message inside the box reads: 'Are you sure?'. There are two buttons at the bottom: 'Cancel' (grey) and 'OK' (green).



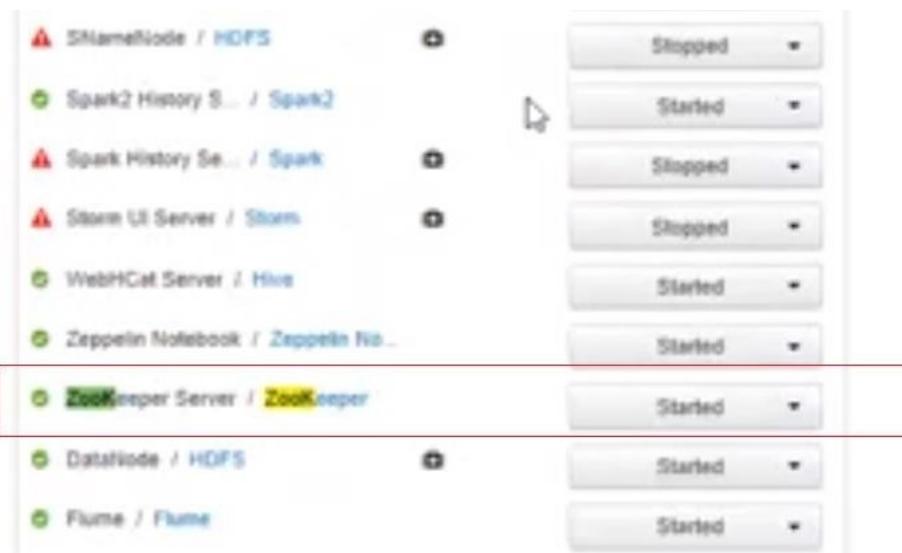
Now we must start region server.

The screenshot shows the Ambari Service Status page. The "RegionServer / HBase" service is highlighted with a red border and has a dropdown menu open over its status button. The menu options are: Start, Turn Off Maintenance Mode, and Go to... . The status button currently displays "Stopped".

Service	Status
ResourceManager / YARN	Started
NameNode / HDFS	Stopped
Spark2 History Server / Spark2	Started
Spark History Server / Spark	Stopped
Storm UI Server / Storm	Stopped
WebHCat Server / Hive	Started
Zeppelin Notebook / Zeppelin Notebooks	Started
ZooKeeper Server / ZooKeeper	Started
DataNode / HDFS	Started
Flume / Flume	Started
RegionServer / HBase	Stopped
Livy for Spark2 / Spark2	Started
Livy Server / Spark	Stopped
Metrics Monitor / Ambari Metrics	Stopped
NFSGateway / HDFS	Started



Check zookeeper server is started.



Check hbase and region server are started.

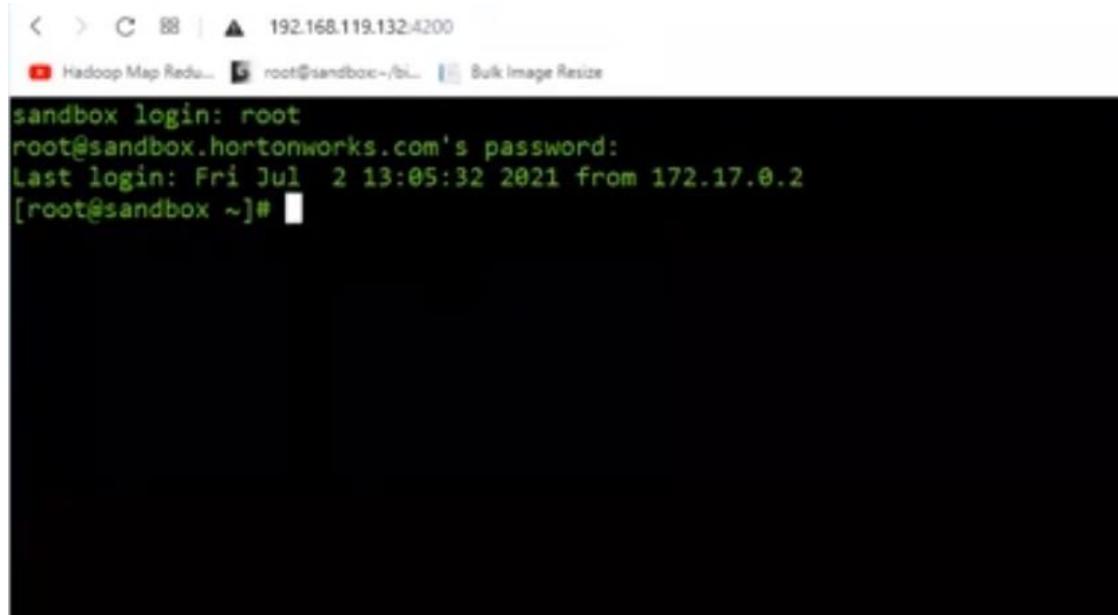
The screenshot shows the 'Components' section of the Hortonworks Data Platform UI. It lists various services along with their application names and current status. The services listed are:

Component	Application Name	Status
App Timeline Server / YARN		Started
Atlas Metadata S... / Atlas		Stopped
DRPC Server / Storm		Stopped
Falcon Server / Falcon		Stopped
HBase / HBase		Started
History Server / MapReduce2		Started
Hive Metastore / Hive		Started
WebHCat Server / Hive		Started
Zeppelin Notebook / Zeppelin No...		Started
ZooKeeper Server / ZooKeeper		Started
DataNode / HDFS		Started
Flume / Flume		Started
RegionServer / HBase		Started
Livy for Spark2 ... / Spark2		Started
Livy Server / Spark		Stopped

Command: **whichapplication-name** gives directory in which application-name is installed.

Open the shell

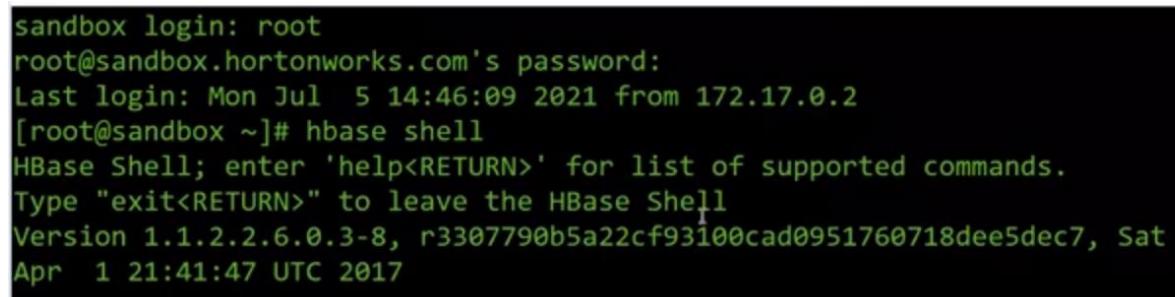
192.168.119.132:4200



The screenshot shows a terminal window with a black background and white text. At the top, there are several small icons: a left arrow, a right arrow, a circle, a square, a triangle pointing up, and a triangle pointing down. To the right of these icons, the IP address '192.168.119.132:4200' is displayed. Below the icons, there is a red status bar with the text 'Hadoop Map Redu...' and 'root@sandbox:/bi... Bulk Image Resize'. The main area of the terminal shows the following text:
sandbox login: root
root@ sandbox.hortonworks.com's password:
Last login: Fri Jul 2 13:05:32 2021 from 172.17.0.2
[root@sandbox ~]#

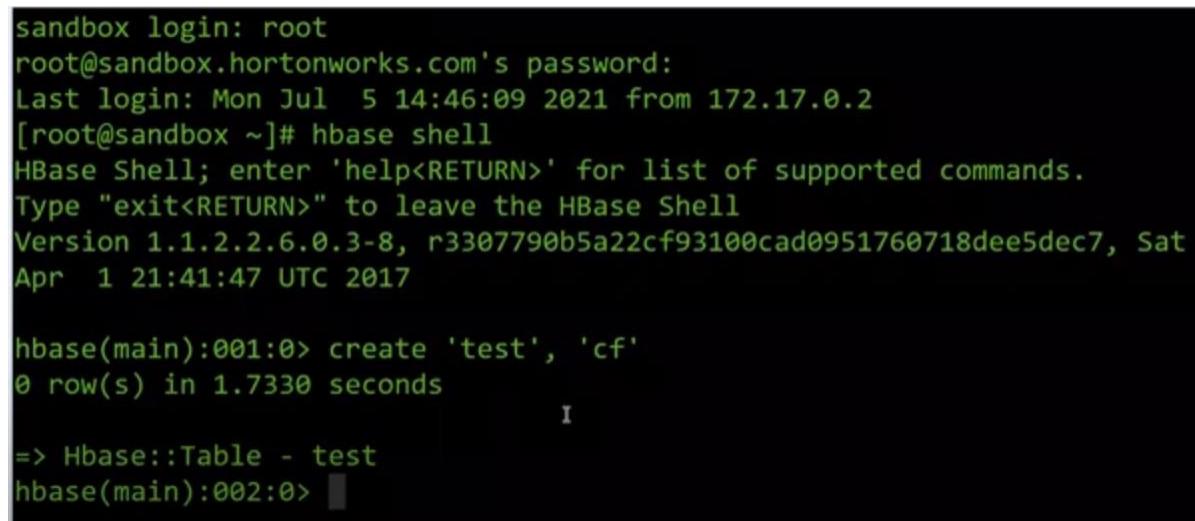
Command: hbase shell

It will start the server



The screenshot shows a terminal window with a black background and white text. The text is identical to the previous command line, followed by:
HBase Shell; enter 'help<RETURN>' for list of supported commands.
Type "exit<RETURN>" to leave the HBase Shell
Version 1.1.2.2.6.0.3-8, r3307790b5a22cf93100cad0951760718dee5dec7, Sat Apr 1 21:41:47 UTC 2017

Enter the command create 'test', 'cf' and it will create the table



The screenshot shows a terminal window with a black background and white text. The text is identical to the previous command line, followed by:
hbase(main):001:0> create 'test', 'cf'
0 row(s) in 1.7330 seconds
=> Hbase::Table - test
hbase(main):002:0>

Check the table is created with

command List- It will list all the tables created.

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```
< > C 192.168.119.132:4200
Hadoop Map Redu... root@sandbox:~/bl... Bulk Image Resize
Apr 1 21:41:47 UTC 2017

hbase(main):001:0> create 'test', 'cf'
0 row(s) in 1.7330 seconds

=> Hbase::Table - test
hbase(main):002:0> list
TABLE           I
ATLAS_ENTITY_AUDIT_EVENTS
atlas_titan
iemployee
test
4 row(s) in 0.0740 seconds

=> ["ATLAS_ENTITY_AUDIT_EVENTS", "atlas_titan", "iemployee", "test"]
hbase(main):003:0>
```

If we want to see column description of a table.

Command- describe tablename

```
hbase(main):003:0> describe 'test'
Table test is ENABLED
test
COLUMN FAMILIES DESCRIPTION
{NAME => 'cf', BLOOMFILTER => 'ROW', VERSIONS => '1', IN_MEMORY => 'false',
KEEP_DELETED_CELLS => 'FALSE', DATA_BLOCK_ENCODING => 'NONE', TTL => 'FOREVER',
COMPRESSION => 'NONE', MIN_VERSIONS => '0', BLOCKCACHE => 'true',
BLOCKSIZE => '65536', REPLICATION_SCOPE => '0'}
1 row(s) in 0.1950 seconds

hbase(main):004:0>
```

Now, we have to put the values in table

Values:

put 'test', 'row1', 'cf:a', 'value1'

put 'test', 'row2', 'cf:b', 'value2'

put 'test', 'row3', 'cf:c', 'value3'

copy paste the data in shell.

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```
< > C 88 | ▲ 192.168.119.132:4200
Hadoop Map Redu... root@sandbox:~/bl... Bulk Image Resize

'FOREVER', COMPRESSION => 'NONE', MIN VERSIONS => '0', BLO
rue', BLOCKSIZE => '65536', REPLICATION_SCOPE => '0'}
1 row(s) in 0.1950 seconds

hbase(main):004:0> put 'test', 'row1', 'cf:a', 'value1'
0 row(s) in 0.1930 seconds

hbase(main):005:0>
hbase(main):006:0* put 'test', 'row2', 'cf:b', 'value2'
0 row(s) in 0.0140 seconds

hbase(main):007:0>
hbase(main):008:0* put 'test', 'row3', 'cf:c', 'value3'
0 row(s) in 0.0340 seconds
```

We to display the records of table

Command: scan ‘test’

```
hbase(main):009:0> scan 'test'
ROW COLUMN+CELL
row1 column=cf:a, timestamp=1625496989589, value=value1
row2 column=cf:b, timestamp=1625496989697, value=value2
row3 column=cf:c, timestamp=1625496993087, value=value3
3 row(s) in 0.0620 seconds
```

Python: storage/retrieval

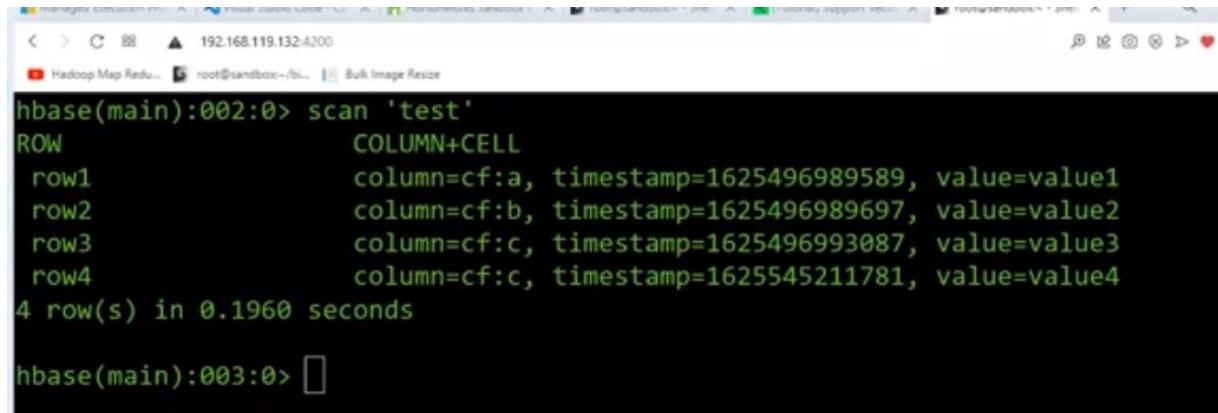
Start the service with command

Hbase thrift start -p 9090 –inforport 9095

```
< > C 88 | ▲ 192.168.119.132:4200
Hadoop Map Redu... root@sandbox:~/bl... Bulk Image Resize

sandbox login: root
root@ sandbox.hortonworks.com's password:
Last login: Tue Jul  6 13:22:05 2021 from 172.17.0.2
[root@sandbox ~]# hbase thrift start -p 9090 --infoport 9095
2021-07-06 14:52:38,870 INFO  [main] util.VersionInfo: HBase 1.1.2.2.6.0
.3-8
2021-07-06 14:52:38,873 INFO  [main] util.VersionInfo: Source code repos
itory git://c66-slave-ff632c10-5/grid/0/jenkins/workspace/HDP-parallel-c
entos6/SOURCES/hbase revision=3307790b5a22cf93100cad0951760718dee5dec7
2021-07-06 14:52:38,873 INFO  [main] util.VersionInfo: Compiled by jenki
ns on Sat Apr  1 21:41:47 UTC 2017
2021-07-06 14:52:38,873 INFO  [main] util.VersionInfo: From source with
checksum e816bb65a763f766331d511df40814e0
```

Create the table the way we did it in hbase and see the records using scan command



A screenshot of a terminal window titled "hbase(main):002:0>". The window shows the command "scan 'test'" being run. The output displays four rows (row1, row2, row3, row4) with their corresponding column values (cf:a, cf:b, cf:c) and timestamps. The timestamp for row1 is 1625496989589, for row2 is 1625496989697, for row3 is 1625496993087, and for row4 is 1625545211781. The value for each row is labeled as "value1", "value2", "value3", and "value4" respectively. The total execution time is 0.1960 seconds.

```
hbase(main):002:0> scan 'test'
ROW                                COLUMN+CELL
row1                               column=cf:a, timestamp=1625496989589, value=value1
row2                               column=cf:b, timestamp=1625496989697, value=value2
row3                               column=cf:c, timestamp=1625496993087, value=value3
row4                               column=cf:c, timestamp=1625545211781, value=value4
4 row(s) in 0.1960 seconds

hbase(main):003:0>
```

Create a program file

Import happybase as hb

```
conn=hb.connection('192.168.119.132', 9090)
```

```
print(conn.table('test').row('row1'))
```

```
print(conn.table('test').row('row2'))
```

```
print(conn.table('test').row('row3'))
```

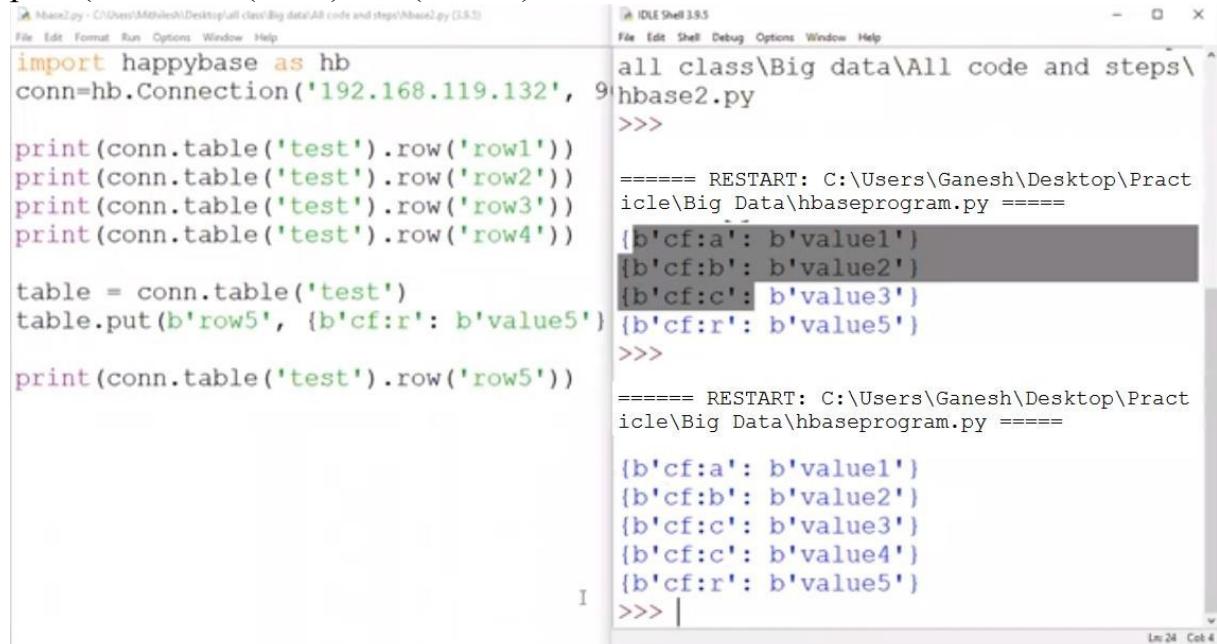
```
print(conn.table('test').row('row4'))
```

```
table = conn.table('test')
```

```
table.put(b'row5', {b'cf:r': b'value5'})
```

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```
print(conn.table('test').row('row5'))
```



```
import happybase as hb
conn=hb.Connection('192.168.119.132', 9)

print(conn.table('test').row('row1'))
print(conn.table('test').row('row2'))
print(conn.table('test').row('row3'))
print(conn.table('test').row('row4'))

table = conn.table('test')
table.put(b'row5', {b'cf:r': b'value5'})

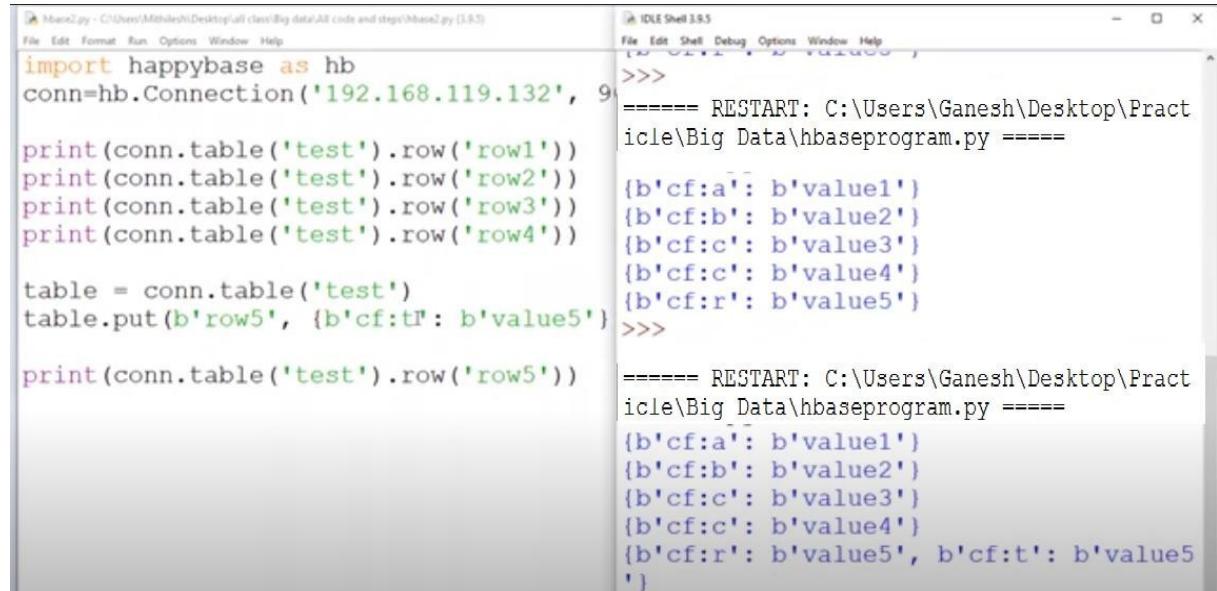
print(conn.table('test').row('row5'))
```

```
IDLE Shell 3.9.5
File Edit Shell Debug Options Window Help
all class\Big data\All code and steps\hbase2.py
>>>
=====
RESTART: C:\Users\Ganesh\Desktop\Practice\Big Data\hbaseprogram.py =====
[b'cf:a': b'value1']
[b'cf:b': b'value2']
[b'cf:c': b'value3']
[b'cf:r': b'value5']
>>>
=====
RESTART: C:\Users\Ganesh\Desktop\Practice\Big Data\hbaseprogram.py =====
[b'cf:a': b'value1']
[b'cf:b': b'value2']
[b'cf:c': b'value3']
[b'cf:c': b'value4']
[b'cf:r': b'value5']
>>> |
```

Run a scan command on shell to display the values

```
hbase(main):004:0> scan 'test'
ROW           COLUMN+CELL
row1          column=cf:a, timestamp=1625496989589, value=value1
row2          column=cf:b, timestamp=1625496989697, value=value2
row3          column=cf:c, timestamp=1625496993087, value=value3
row4          column=cf:c, timestamp=1625545211781, value=value4
row5          column=cf:r, timestamp=1625583481042, value=value5
5 row(s) in 0.0320 seconds
```

Now, try with duplicate value at row 5 say value t



```
import happybase as hb
conn=hb.Connection('192.168.119.132', 9)

print(conn.table('test').row('row1'))
print(conn.table('test').row('row2'))
print(conn.table('test').row('row3'))
print(conn.table('test').row('row4'))

table = conn.table('test')
table.put(b'row5', {b'cf:t': b'value5'})

print(conn.table('test').row('row5'))
```

```
IDLE Shell 3.9.5
File Edit Shell Debug Options Window Help
>>>
=====
RESTART: C:\Users\Ganesh\Desktop\Practice\Big Data\hbaseprogram.py =====
[b'cf:a': b'value1']
[b'cf:b': b'value2']
[b'cf:c': b'value3']
[b'cf:c': b'value4']
[b'cf:r': b'value5']
>>>
=====
RESTART: C:\Users\Ganesh\Desktop\Practice\Big Data\hbaseprogram.py =====
[b'cf:a': b'value1']
[b'cf:b': b'value2']
[b'cf:c': b'value3']
[b'cf:c': b'value4']
[b'cf:r': b'value5', b'cf:t': b'value5']
```

Run a scan command on shell to display the values

When there is unique value, it will create a record. If duplicate value it will not create a record

```
hbase(main):005:0> scan 'test'
ROW                                COLUMN+CELL
row1                               column=cf:a, timestamp=1625496989589, value=value1
row2                               column=cf:b, timestamp=1625496989697, value=value2
row3                               column=cf:c, timestamp=1625496993087, value=value3
row4                               column=cf:c, timestamp=1625545211781, value=value4
row5                               column=cf:r, timestamp=1625583481042, value=value5
row5                               column=cf:t, timestamp=1625583505297, value=value5
5 row(s) in 0.1320 seconds
```

Practical 7

Implement Decision tree classification techniques **Decision Trees (DTs)** are a non-parametric supervised learning method used for classification and regression. The goal is to create a model that predicts the value of a target variable by learning simple decision rules inferred from the data features. A tree can be seen as a piecewise constant approximation. Using the Iris dataset, we can construct a tree as follows:

+ Code + Text

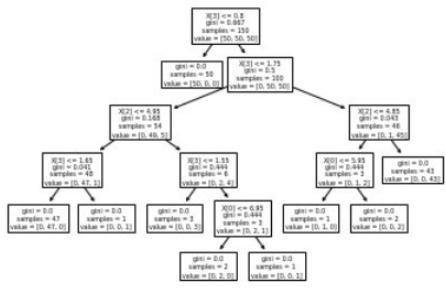


```
from sklearn.datasets import load_iris
from sklearn import tree
iris = load_iris()
X, y = iris.data, iris.target
clf = tree.DecisionTreeClassifier()
clf = clf.fit(X, y)
```

Once trained, we can plot the tree with the **plot_tree** function:

[4] tree.plot_tree(clf)

```
[Text(167.4, 199.32, 'X[3] <= 0.8\n gini = 0.667\n samples = 150\nvalue = [50, 50, 50]'),
Text(141.15384615385, 163.0799999999998, 'gini = 0.0\nsamples = 50\nvalue = [50, 0, 0]'),
Text(193.15384615384616, 163.0799999999998, 'X[3] <= 1.75\n gini = 0.5\nsamples = 100\nvalue = [0, 50, 50]'),
Text(103.01538461538462, 126.83999999999999, 'X[2] <= 4.95\n gini = 0.168\nsamples = 54\nvalue = [0, 49, 5]'),
Text(51.50769230769231, 90.6, 'X[3] <= 1.65\n gini = 0.041\nsamples = 48\nvalue = [0, 47, 1]'),
Text(25.753846153846155, 54.35999999999985, 'gini = 0.0\nsamples = 47\nvalue = [0, 47, 0]'),
Text(77.26153846153846, 54.35999999999985, 'gini = 0.0\nsamples = 1\nvalue = [0, 0, 1]'),
Text(154.52307692307693, 90.6, 'X[3] <= 1.55\n gini = 0.444\nsamples = 6\nvalue = [0, 2, 4]'),
Text(128.76923076923077, 54.35999999999985, 'gini = 0.0\nsamples = 3\nvalue = [0, 0, 3]'),
Text(180.27692307692308, 54.35999999999985, 'X[0] <= 6.95\n gini = 0.444\nsamples = 3\nvalue = [0, 2, 1]'),
Text(154.52307692307693, 18.11999999999976, 'gini = 0.0\nsamples = 2\nvalue = [0, 2, 0]'),
Text(206.03076923076924, 18.11999999999976, 'gini = 0.0\nsamples = 1\nvalue = [0, 0, 1]'),
Text(283.2923076923077, 126.83999999999999, 'X[2] <= 4.85\n gini = 0.043\nsamples = 46\nvalue = [0, 1, 45]'),
Text(257.53846153846155, 90.6, 'X[0] <= 5.95\n gini = 0.444\nsamples = 3\nvalue = [0, 1, 2]'),
Text(231.7846153846154, 54.35999999999985, 'gini = 0.0\nsamples = 1\nvalue = [0, 1, 0]'),
Text(283.2923076923077, 54.35999999999985, 'gini = 0.0\nsamples = 2\nvalue = [0, 0, 2]'),
Text(309.04615384615386, 90.6, 'gini = 0.0\nsamples = 43\nvalue = [0, 0, 43]')]
```



Practical 8

Implement SVM classification techniques

Support Vector Machines

Generally, Support Vector Machines is considered to be a classification approach, it but can be employed in both types of classification and regression problems. It can easily handle multiple continuous and categorical variables. SVM constructs a hyperplane in multidimensional space to separate different classes. SVM generates optimal hyperplane in an iterative manner, which is used to minimize an error. The core idea of SVM is to find a maximum marginal hyperplane (MMH) that best divides the dataset into classes.

Loading data:

```
[1] #Import scikit-learn dataset library
    from sklearn import datasets

    #Load dataset
    cancer = datasets.load_breast_cancer()
```

Exploring data:

```
▶ # print the names of the 13 features
print("Features: ", cancer.feature_names)

# print the label type of cancer('malignant' 'benign')
print("Labels: ", cancer.target_names)

⇒ Features: ['mean radius' 'mean texture' 'mean perimeter' 'mean area'
'mean smoothness' 'mean compactness' 'mean concavity'
'mean concave points' 'mean symmetry' 'mean fractal dimension'
'radius error' 'texture error' 'perimeter error' 'area error'
'smoothness error' 'compactness error' 'concavity error'
'concave points error' 'symmetry error' 'fractal dimension error'
'worst radius' 'worst texture' 'worst perimeter' 'worst area'
'worst smoothness' 'worst compactness' 'worst concavity'
'worst concave points' 'worst symmetry' 'worst fractal dimension']
Labels: ['malignant' 'benign']
```

Check the shape of the dataset using shape.

```
▶ # print data(feature)shape
cancer.data.shape

⇒ (569, 30)
```

Check top 5 records of the feature set.

```
[4] # print the cancer data features (top 5 records)
print(cancer.data[0:5])

[[1.799e+01 1.038e+01 1.228e+02 1.001e+03 1.184e-01 2.776e-01 3.001e-01
 1.471e-01 2.419e-01 7.871e-02 1.095e+00 9.053e-01 8.589e+00 1.534e+02
 6.399e-03 4.904e-02 5.373e-02 1.587e-02 3.003e-02 6.193e-03 2.538e+01
 1.733e+01 1.846e+02 2.019e+03 1.622e-01 6.656e-01 7.119e-01 2.654e-01
 4.601e-01 1.189e-01]
[2.057e+01 1.777e+01 1.329e+02 1.326e+03 8.474e-02 7.864e-02 8.690e-02
 7.017e-02 1.812e-01 5.667e-02 5.435e-01 7.339e-01 3.398e+00 7.408e+01
 5.225e-03 1.308e-02 1.860e-02 1.340e-02 1.389e-02 3.532e-03 2.499e+01
 2.341e+01 1.588e+02 1.956e+03 1.238e-01 1.866e-01 2.416e-01 1.860e-01
 2.750e-01 8.902e-02]
[1.969e+01 2.125e+01 1.300e+02 1.203e+03 1.096e-01 1.599e-01 1.974e-01
 1.279e-01 2.069e-01 5.999e-02 7.456e-01 7.869e-01 4.585e+00 9.403e+01
 6.150e-03 4.006e-02 3.832e-02 2.058e-02 2.250e-02 4.571e-03 2.357e+01
 2.553e+01 1.525e+02 1.709e+03 1.444e-01 4.245e-01 4.504e-01 2.430e-01
 3.613e-01 8.758e-02]
[1.142e+01 2.038e+01 7.758e+01 3.861e+02 1.425e-01 2.839e-01 2.414e-01
 1.052e-01 2.597e-01 9.744e-02 4.956e-01 1.156e+00 3.445e+00 2.723e+01
 9.110e-03 7.458e-02 5.661e-02 1.867e-02 5.963e-02 9.208e-03 1.491e+01
 2.650e+01 9.887e+01 5.677e+02 2.098e-01 8.663e-01 6.869e-01 2.575e-01
 6.638e-01 1.730e-01]
[2.029e+01 1.434e+01 1.351e+02 1.297e+03 1.003e-01 1.328e-01 1.980e-01
 1.043e-01 1.809e-01 5.883e-02 7.572e-01 7.813e-01 5.438e+00 9.444e+01
 1.149e-02 2.461e-02 5.688e-02 1.885e-02 1.756e-02 5.115e-03 2.254e+01
 1.667e+01 1.522e+02 1.575e+03 1.374e-01 2.050e-01 4.000e-01 1.625e-01
 2.364e-01 7.678e-02]]
```

Target set:

Splitting Data:

To understand model performance, dividing the dataset into a training set and a test set is a good strategy.

Split the dataset by using the function `train_test_split()`. you need to pass 3 parameters features, target, and test_set size. Additionally, you can use `random_state` to select records randomly.

```
[7] # Import train_test_split function
from sklearn.model_selection import train_test_split

# Split dataset into training set and test set
X_train, X_test, y_train, y_test = train_test_split(cancer.data, cancer.target, test_size=0.3, random_state=109) # 70% training and 30% test
```

Generate Model:

Let's build support vector machine model. First, import the SVM module and create support vector classifier object by passing argument kernel as the linear kernel in SVC() function.

Then, fit your model on train set using fit() and perform prediction on the test set using predict().

```
[8] #Import svm model
from sklearn import svm

#Create a svm Classifier
clf = svm.SVC(kernel='linear') # Linear Kernel

#Train the model using the training sets
clf.fit(X_train, y_train)

#Predict the response for test dataset
y_pred = clf.predict(X_test)
```

Evaluating

the Model:

Let's estimate how accurately the classifier or model can predict the breast cancer of patients. Accuracy can be computed by comparing actual test set values and predicted values.



```
#Import scikit-learn metrics module for accuracy calculation
from sklearn import metrics

# Model Accuracy: how often is the classifier correct?
print("Accuracy:",metrics.accuracy_score(y_test, y_pred))
```

Accuracy: 0.9649122807017544

Vidya Prasarak Mandal's
**B. N. BANDODKAR COLLEGE OF SCIENCE
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दूरध्वनी क. २५३३ ६५०७



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CERTIFICATE

This is to certify that

Shri / Kum. _____

of M. Sc. (Information Technology) Part I Semester - II has completed the required number of experiments (Total =) signed herein, in this laboratory during the year 2023 – 2024.

Seal

Incharge
Department of Information
Technology

Principal
B. N. Bandodkar College of Science,
Thane

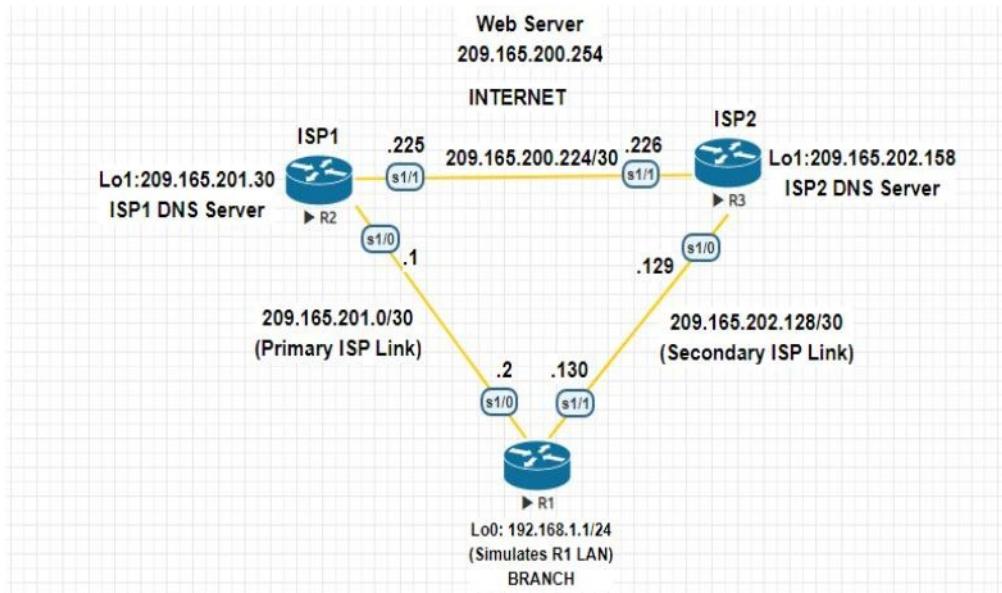
External Examiner

INDEX

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4	Secure the Management Plane
5	Configure and Verify Path Control Using PBR
6	IP Service Level Agreements and Remote SPAN in a Campus Environment
7	Inter-VLAN Routing
8	Simulating MPLS environment
9	Simulating VRF

Practical 1

NETWORK TOPOLOGY



R1

```
Router>enable
Router# conf t R
outer(config)#hostname R1
R1(config)#interface Loopback 0
R1(config-if)#ip address 192.168.1.1 255.255.255.0
R1(config-if)#exit
R1(config)#interface s1/0
R1(config-if)#ip address 209.165.201.2 255.255.255.252
R1(config-if)#no shutdown
R1(config-if)#exit
R1(config)#interface s1/1
R1(config-if)#ip address 209.165.202.130 255.255.255.252
R1(config-if)#no shutdown
R1(config-if)#exit
R1(config)#ip route 0.0.0.0 0.0.0.0 209.165.201.1
R1(config)#ip sla 12
R1(config-ip-sla)#icmp-echo 209.165.201.30
R1(config-ip-sla-echo)#frequency 11
R1(config-ip-sla-echo)#exit
R1(config)#ip sla schedule 12 life forever start-time now R
1#sh ip sla configuration 12
IP SLAs Infrastructure Engine-III
Entry number: 12
Owner:
```

Tag:
Operation timeout (milliseconds): 5000
Type of operation to perform: icmp-echo
Target address/Source address: 209.165.201.30/0.0.0.0
Type Of Service parameter: 0x0
Request size (ARR data portion): 28
Verify data: No
Vrf Name:
Schedule:
Operation frequency (seconds): 11 (not considered if randomly scheduled)
Next Scheduled Start Tim
e: Start Time already passed
Group Scheduled : FALSE Randomly Scheduled : FALSE
Life (seconds): Forever
Entry Ageout (seconds): never
Recurring (Starting Everyday):
FALSE
Status of entry (SNMP RowStatus): Active
Threshold (milliseconds): 5000
Distribution Statistics:
Number of statistic hours kept: 2
Number of statistic distribution buckets kept: 1
Statistic distribution interval (milliseconds): 20
Enhanced History:
History Statistics:
Number of history Lives kept: 0
Number of history Buckets kept: 15
History Filter Type: None R1#sh ip sla statistics
IPSLAs Latest Operation Statistics
IPSLA operation id: 12
Latest RTT: 11 milliseconds
Latest operation start time: 18:21:25 EET Thu Apr 9 2020
Latest operation return code: OK
Number of successes: 22
Number of failures: 0
Operation time to live: Forever
R1(config)#ip sla 24
R1(config-ip-sla)#icmp-echo 209.165.202.158
R1(config-ip-sla-echo)#frequency 10
R1(config-ip-sla-echo)#exit
R1(config)#ip sla schedule 24 life forever start-time now
R1#sh ip sla configuration 24
IP SLAs Infrastructure Engine-III
Entry number: 24
Owner:
Tag:
Operation timeout (milliseconds): 5000
Type of operation to perform: icmp-echo

Target address/Source address: 209.165.202.158/0.0.0.0
Type Of Service parameter: 0x0
Request size (A
RR data portion): 28
Verify data: No Vrf Name:
Schedule:
Operation frequency (seconds): 10 (not considered if randomly scheduled)
Next Scheduled Start Time: Start Time already passed
Group Scheduled : FALSE
Randomly Scheduled : FALSE
Life (seconds): Forever
Entry Ageout (seconds): never
Recurring (Starting Everyday):
FALSE
Status of entry (SNMP RowStatus): Active
Threshold (milliseconds): 5000
Distribution Statistics:
Number of statistic hours kept: 2
Number of statistic distribution buckets kept:
1 Statistic distribution interval (milliseconds):
20 Enhanced History:
History Statistics:
Number of history Lives kept: 0
Number of history Buckets kept: 15
History Filter Type: None
R1#sh ip sla statistics 24
IPSLAs Latest Operation Statistics
IPSLA operation id: 24 Latest RTT: 20 milliseconds
Latest operation start time: 18:33:25 EET Thu Apr 9 2020
Latest operation return code: OK
Number of successes: 16
Number of failures: 0
Operation time to live: Forever
R1(config)#no ip route 0.0.0.0 0.0.0.0 209.165.201.1
R1(config)#ip route 0.0.0.0 0.0.0.0 209.165.201.1 5
R1#sh ip route
Codes: L - local, C - connected, S - static, R - RIP, M - mobile, B - BGP D - EIGRP, EX - EIGRP
external, O - OSPF, IA - OSPF inter area N1 - OSPF NSSA external type 1, N2 - OSPF NSSA
external type 2 E1 - OSPF external type 1, E2 - OSPF external type 2 i - IS-IS, su - IS-IS
summary, L1 - IS-IS level-1, L2 - IS-IS level-2 ia - IS-IS inter area, * - candidate default, U -
per- user static route o - ODR, P - periodic downloaded static route, H - NHRP, l - LISP a -
application route + - replicated route, % - next hop override
Gateway of last resort is 209.165.201.1 to network 0.0.0.0
S* 0.0.0.0/0 [5/0] via 209.165.201.1 192.168.1.0/24 is variably subnetted, 2 subnets, 2
masks
C 192.168.1.0/24 is directly connected, Loopback0
L 192.168.1.1/32 is directly connected, Loopback0 209.165.201.0/24 is variably subnetted,
2 subnets, 2 masks

C 209.165.201.0/30 is directly connected, Serial1/0
L 209.165.201.2/32 is directly connected, Serial1/0 209.165.202.0/24 is variably subnetted, 2 subnets, 2 masks
C 209.165.202.128/30 is directly connected,
Serial1/1 L 209.165.202.130/32 is directly connected, Serial1/1 R1(config)#track 1 ip sla 12
reachability
R1(config-track)#delay down 10 up 1
R1(config-track)#exit
R1(config)#ip route 0.0.0.0 0.0.0.0 209.165.201.1 2 track 1
R1(config)#track 2 ip sla 12 reachability
R1(config-track)#delay down 10 up 1
R1(config-track)#exit
R1(config)#ip route 0.0.0.0 0.0.0.0 209.165.201.1 3 track 2
R1#sh ip route
Codes: L - local, C - connected, S - static, R - RIP, M - mobile, B - BGP D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2 E1 - OSPF external type 1, E2 - OSPF external type 2 i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2 ia - IS-IS inter area, * - candidate default, U - per-user static route o - ODR, P - periodic downloaded static route, H - NHRP, l - LISP a - application route + - replicated route, % - next hop override
Gateway of last resort is 209.165.201.1 to network 0.0.0.0
S* 0.0.0.0/0 [3/0] via 209.165.201.1 192.168.1.0/24 is variably subnetted, 2 subnets, 2 masks
C 192.168.1.0/24 is directly connected, Loopback0
L 192.168.1.1/32 is directly connected, Loopback0 209.165.201.0/24 is variably subnetted, 2 subnets, 2 masks
C 209.165.201.0/30 is directly connected, Serial1/0
L 209.165.201.2/32 is directly connected, Serial1/0 209.165.202.0/24 is variably subnetted, 2 subnets, 2 masks
C 209.165.202.128/30 is directly connected,
Serial1/1 L 209.165.202.130/32 is directly connected, Serial1/1 R1#sh ip route
Codes: L - local, C - connected, S - static, R - RIP, M - mobile, B - BGP D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2 E1 - OSPF external type 1, E2 - OSPF external type 2 i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2 ia - IS-IS inter area, * - candidate default, U - per-user static route o - ODR, P - periodic downloaded static route, H - NHRP, l - LISP a - application route + - replicated route, % - next hop override
Gateway of last resort is 209.165.201.1 to network 0.0.0.0
S* 0.0.0.0/0 [5/0] via 209.165.201.1 192.168.1.0/24 is variably subnetted, 2 subnets, 2 masks
C 192.168.1.0/24 is directly connected, Loopback0
L 192.168.1.1/32 is directly connected, Loopback0 209.165.201.0/24 is variably subnetted, 2 subnets, 2 masks
C 209.165.201.0/30 is directly connected, Serial1/0
L 209.165.201.2/32 is directly connected, Serial1/0 209.165.202.0/24 is variably subnetted, 2 subnets, 2 masks

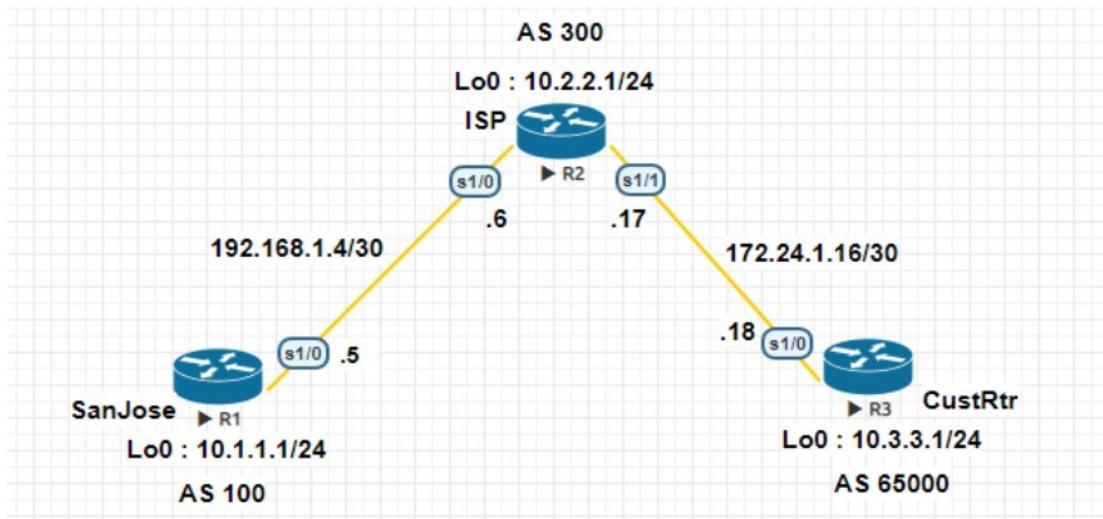
C 209.165.202.128/30 is directly connected,
Serial1/1 L 209.165.202.130/32 is directly
connected, Serial1/1 R1#sh ip sla statistics
IPSLAs Latest Operation Statistics
IPSLA operation id: 12
Latest RTT: NoConnection/Busy/Timeout
Latest operation start time: 19:02:29 EET Thu Apr 9 2020
Latest operation return code: Timeout
Number of successes: 227
Number of failures: 19
Operation time to live: Forever
IPSLA operation id: 24
Latest RTT: 20 milliseconds
Latest operation start time: 19:02:35 EET Thu Apr 9 2020
Latest operation return code: OK
Number of successes: 190
Number of failures: 1
Operation time to live: Forever
R1#trace 209.165.200.254 source 192.168.1.1
Type escape sequence to abort.
Tracing the route to 209.165.200.254
VRF info: (vrf in name/id, vrf out name/id)
1 209.165.201.1 10 msec 14 msec *
R1#sh ip sla statistics
IPSLAs Latest Operation
Statistics IPSLA operation id:
12
Latest RTT: 10 milliseconds
Latest operation start time: 19:07:04 EET Thu Apr 9 2020
Latest operation return code: OK
Number of successes: 236
Number of failures: 35
Operation time to live: Forever
IPSLA operation id: 24 Latest RTT: 21 milliseconds
Latest operation start time: 19:07:05 EET Thu Apr 9 2020
Latest operation return code: OK
Number of successes: 217
Number of failures: 1
Operation time to live: Forever
R1#sh ip route
Codes: L - local, C - connected, S - static, R - RIP, M - mobile, B - BGP D - EIGRP, EX - EIGRP
external, O - OSPF, IA - OSPF inter area N1 - OSPF NSSA external type 1, N2 - OSPF NSSA
external type 2 E1 - OSPF external type 1, E2 - OSPF external type 2 i - IS-IS, su - IS-IS
summary, L1 - IS-IS level-1, L2 - IS-IS level-2 ia - IS-IS inter area, * - candidate default, U -
per- user static route o - ODR, P - periodic downloaded static route, H - NHRP, l - LISP a -
application route + - replicated route, % - next hop override
Gateway of last resort is 209.165.201.1 to network 0.0.0.0

```
S* 0.0.0.0/0 [3/0] via 209.165.201.1 192.168.1.0/24 is variably subnetted, 2 subnets, 2
masks
C 192.168.1.0/24 is directly connected, Loopback0
L 192.168.1.1/32 is directly connected, Loopback0 209.165.201.0/24 is variably
subnetted, 2 subnets, 2 masks
C 209.165.201.0/30 is directly connected, Serial1/0
L 209.165.201.2/32 is directly connected, Serial1/0 209.165.202.0/24 is variably
subnetted, 2 subnets, 2 masks
C 209.165.202.128/30 is directly connected,
Serial1/1 L 209.165.202.130/32 is directly
connected, Serial1/1 ISP1 (R2)
Router>enable
Router#conf
t
Router(config)#hostname ISP1
ISP1(config)#interface Loopback0
ISP1(config-if)#description Simulated Internet Web Server
ISP1(config-if)#ip address 209.165.200.254 255.255.255.255
ISP1(config-if)#exit
ISP1(config)#interface Loopback1
ISP1(config-if)#ip address 209.165.201.30 255.255.255.255
ISP1(config-if)#exit
ISP1(config)#interface s1/0
ISP1(config-if)#ip address 209.165.201.1 255.255.255.252
ISP1(config-if)#no shutdown
ISP1(config-if)#exit
ISP1(config)#interface s1/1
ISP1(config-if)#ip address 209.165.200.225 255.255.255.252
ISP1(config-if)#no shutdown
ISP1(config-if)#exit
ISP1(config)#router eigrp 200
ISP1(config-router)#network 209.165.200.224
ISP1(config-router)#network 209.165.201.0
ISP1(config-router)#no auto-summary
ISP1(config-router)#exit
ISP1(config)#ip route 192.168.1.0 255.255.255.0 209.165.201.2
ISP1(config)#interface loopback 1
ISP1(config-if)#shut
ISP1(config)#interface loopback 1
ISP1(config-if)#no shutdown
ISP2 (R3)
Router>enable
Router#conf t
Router(config)#hostname ISP2
ISP2(config)#interface Loopback0
ISP2(config-if)#description Simulated Internet Web Server
ISP2(config-if)#ip address 209.165.200.254 255.255.255.255
ISP2(config-if)#exit
```

```
ISP2(config)#interface Loopback1
ISP2(config-if)#ip address 209.165.202.158 255.255.255.255
ISP2(config-if)#exit
ISP2(config)#interface s1/1
ISP2(config-if)#ip address 209.165.200.226 255.255.255.252
ISP2(config-if)#no shutdown
ISP2(config-if)#exit ISP2(config)#interface s1/0
ISP2(config-if)#ip address 20
9.165.202.129 255.255.255.252
ISP2(config-if)#no shutdown
ISP2(config-if)#exit
ISP2(config)#router eigrp 200
ISP2(config-router)#network 209.165.200.224
ISP2(config-router)#network 209.165.202.128
ISP2(config-router)#no auto-summary
ISP2(config-router)#exit
ISP2(config)#ip route 192.168.1.0 255.255.255.0 209.165.202.130
```

Practical 2

NETWORK TOPOLOGY



SanJose

Router>enable

Router#conf
t

```
Router(config)#hostname SanJose
SanJose(config)#interface Loopback0
SanJose(config-if)#ip address 10.1.1.1
255.255.255.0 SanJose(config-if)#exit
SanJose(config)#interface Serial1/0
SanJose(config-if)#ip address 192.168.1.5 255.255.255.252
SanJose(config-if)#no shutdown
SanJose(config-if)#end
```

```
SanJose(config)#router bgp 100
SanJose(config-router)#network 10.1.1.0 mask 255.255.255.0
SanJose(config-router)#neighbor 192.168.1.6 remote-as 300
SanJose(config-router)#exit
```

SanJose#sh ip route

Codes: L - local, C - connected, S - static, R - RIP, M - mobile, B - BGP D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2 E1 - OSPF external type 1, E2 - OSPF external type 2 i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2 ia - IS-IS inter area, * - candidate default, U - per-user static route o - ODR, P - periodic downloaded static route, H - NHRP, l - LISP a - application route + - replicated route, % - next hop override

Gateway of last resort is not set

10.0.0.0/8 is variably subnetted, 4 subnets, 2 masks

C 10.1.1.0/24 is directly connected, Loopback0

L 10.1.1.1/32 is directly connected, Loopback0

```

B 10.2.2.0/24 [20/0] via 192.168.1.6, 00:05:47
B 10.3.3.0/24 [20/0] via 192.168.1.6, 00:02:13 192.168.1.0/24 is variably subnetted,
2 subnets, 2 masks
C 192.168.1.4/30 is directly connected,
Serial1/0 L 192.168.1.5/32 is directly connected,
Serial1/0 SanJose#sh ip bgp
BGP table version is 4, local router ID is 10.1.1.1
Status codes: s suppressed, d damped, h history, * valid, > best, i - internal, r RIB-failure, S
Stale, m multipath, b backup-path, f RT-Filter, x best-external, a additional-path, c RIB-
compressed, Origin codes: i - IGP, e - EGP, ? - incomplete RPKI validation codes: V valid, I
invalid, N Not found


| Network        | Next Hop    | Metric | LocPrf | Weight | Path    |
|----------------|-------------|--------|--------|--------|---------|
| *> 10.1.1.0/24 | 0.0.0.0     | 0      | 32768  | i      |         |
| *> 10.2.2.0/24 | 192.168.1.6 | 0      | 0      | 300    | i       |
| *> 10.3.3.0/24 | 192.168.1.6 |        | 0      | 300    | 65000 i |


SanJose#sh ip bgp
BGP table version is 5, local router ID is 10.1.1.1
Status codes: s suppressed, d damped, h history, * valid, > best, i - internal, r RIB-failure, S
Stale, m multipath, b backup-path, f RT-Filter, x best-external, a additional-path, c RIB-
compressed, Origin codes: i - IGP, e - EGP, ? - incomplete RPKI validation codes: V valid, I
invalid, N Not found


| Network        | Next Hop    | Metric | LocPrf | Weight |
|----------------|-------------|--------|--------|--------|
| *> 10.1.1.0/24 | 0.0.0.0     | 0      | 32768  | i      |
| *> 10.2.2.0/24 | 192.168.1.6 | 0      | 0      | 300 i  |
| *> 10.3.3.0/24 | 192.168.1.6 |        | 0      | 300 i  |


ISP Router>enable
Router#conf t
Router(config)#hostname ISP
ISP(config)#interface Loopback0
ISP(config-if)#ip address 10.2.2.1 255.255.255.0
ISP(config-if)#exit ISP(config)#interface Serial1/0
ISP(config-if)#ip address 192.168.1.6 255.255.255.252 I
ISP(config-if)#no shutdown
ISP(config-if)#exit
ISP(config)#interface Serial1/1
ISP(config-if)#ip address 172.24.1.17 255.255.255.252
ISP(config-if)#no shutdown
ISP(config-if)#end
ISP(config)#router bgp 300
ISP(config-router)#network 10.2.2.0 mask 255.255.255.0
ISP(config-router)#neighbor 192.168.1.5 remote-as 100
ISP(config-router)#neighbor 172.24.1.18 remote-as 65000
ISP(config)#router bgp 300
ISP(config-router)#neighbor 192.168.1.5 remove-private-as
ISP(config-router)#end
ISP#clear ip bgp * soft

```

```

ISP(config)#ip as-path access-list 1 deny ^100$ ISP(config)#ip as-path access-list 1 permit .*
ISP(config)#router bgp 300
ISP(config-router)#neighbor 172.24.1.18 filter-list 1
out ISP(config-router)#end
ISP#sh ip route
Codes: L - local, C - connected, S - static, R - RIP, M - mobile, B - BGP D - EIGRP, EX - EIGRP
external, O - OSPF, IA - OSPF inter area N1 - OSPF NSSA external type 1, N2 - OSPF NSSA
external type 2 E1 - OSPF external type 1, E2 - OSPF external type 2 i - IS-IS, su - IS-IS
summary, L1 - IS-IS level-1, L2 - IS-IS level-2 ia - IS-IS inter area, * - candidate default, U -
per- user static route o - ODR, P - periodic downloaded static route, H - NHRP, l - LISP a -
application route + - replicated route, % - next hop override
Gateway of last resort is not set
  10.0.0.0/8 is variably subnetted, 4 subnets, 2 masks
    B 10.1.1.0/24 [20/0] via 192.168.1.5, 00:46:41
    C 10.2.2.0/24 is directly connected, Loopback0
    L 10.2.2.1/32 is directly connected, Loopback0
    B 10.3.3.0/24 [20/0] via 172.24.1.18, 00:43:07 172.24.0.0/16 is variably subnetted,
  2 subnets, 2 masks
    C 172.24.1.16/30 is directly connected, Serial1/1
    L 172.24.1.17/32 is directly connected, Serial1/1 192.168.1.0/24 is variably subnetted, 2
  subnets, 2 masks
    C 192.168.1.4/30 is directly connected, Serial1/0
    L 192.168.1.6/32 is directly connected, Serial1/0
ISP#show ip bgp regexp ^100$
BGP table version is 4, local router ID is 10.2.2.1
Status codes: s suppressed, d damped, h history, * valid, > best, i - internal, r RIB-failure, S
Stale, m multipath, b backup-path, f RT-Filter, x best-external, a additional-path, c RIB-
compressed,
Origin codes: i - IGP, e - EGP, ? - incomplete
RPKI validation codes: V valid, I invalid, N Not found


| Network              | Next Hop    | Metric | LocPrf | Weight |
|----------------------|-------------|--------|--------|--------|
| Pat h *> 10.1.1.0/24 | 192.168.1.5 | 0      | 0      | 100 i  |


CustRtr
Router>enable
Router#conf
t
Router(config)#hostname CustRtr
CustRtr(config)#interface Loopback0
CustRtr(config-if)#ip address 10.3.3.1
255.255.255.0 CustRtr(config-if)#exit
CustRtr(config)#interface Serial1/0
CustRtr(config-if)#ip address 172.24.1.18 255.255.255.252
CustRtr(config-if)#no shutdown
CustRtr(config-if)#end
CustRtr(config)#router bgp 65000
CustRtr(config-router)#network 10.3.3.0 mask 255.255.255.0
CustRtr(config-router)#neighbor 172.24.1.17 remote-as 30
0 CustRtr(config-router)#end

```

```
CustRtr#sh ip route
```

Codes: L - local, C - connected, S - static, R - RIP, M - mobile, B - BGP D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2 E1 - OSPF external type 1, E2 - OSPF external type 2 i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2 ia - IS-IS inter area, * - candidate default, U - per-user static route o - ODR, P - periodic downloaded static route, H - NHRP, l - LISP a - application route + - replicated route, % - next hop override

Gateway of last resort is not set

10.0.0.0/8 is variably subnetted, 3 subnets, 2 masks

B 10.2.2.0/24 [20/0] via 172.24.1.17, 00:45:59

C 10.3.3.0/24 is directly connected, Loopback0

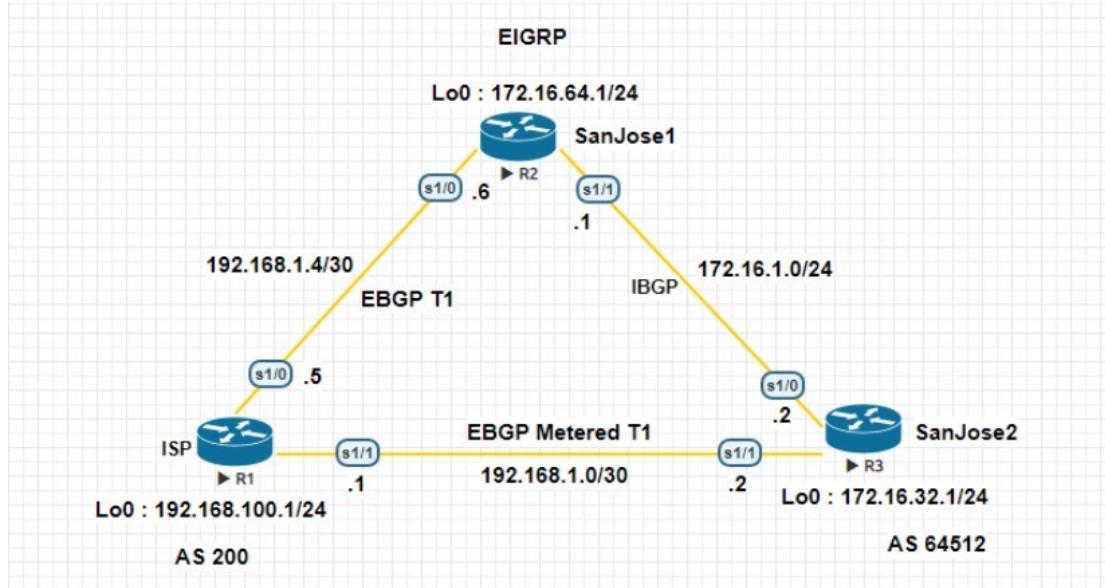
L 10.3.3.1/32 is directly connected, Loopback0 172.24.0.0/16 is variably subnetted, 2 subnets, 2 mask

s C 172.24.1.16/30 is directly connected, Serial1/0

L 172.24.1.18/32 is directly connected, Serial1/0

Practical 3

NETWORK TOPOLOGY



R1(ISP)

```
Router>enable
Router#conf
t
Router(config)#hostname ISP
ISP(config)#interface Loopback0
ISP(config-if)#ip address 192.168.100.1 255.255.255.0
ISP(config-if)#exit
ISP(config)#interface Serial1/0
ISP(config-if)#ip address 192.168.1.5 255.255.255.252
ISP(config-if)#no shutdown
ISP(config-if)#exit
ISP(config)#interface Serial1/1
ISP(config-if)#ip address 192.168.1.1 255.255.255.252
ISP(config-if)#no shutdown
ISP(config-if)#exit
ISP(config)#router bgp 200
ISP(config-router)#network 192.168.100.0
ISP(config-router)#neighbor 192.168.1.6 remote-as 64512
ISP(config-router)#neighbor 192.168.1.2 remote-as 64512
ISP(config-router)#exit
ISP#sh ip bgp
BGP table version is 3, local router ID is 192.168.100.1
Status codes: s suppressed, d damped, h history, * valid, > best, i - internal, r RIB-failure, S
Stale, m multipath, b backup-path, f RT-Filter, x best-external, a additional-path, c RIB-
compressed,
Origin codes: i - IGP, e - EGP, ? - incomplete
```

RPKI validation codes: V valid, I invalid, N Not found

Network Path	Next Hop	Metric	LocPrf	Weight
* 172.16.0.0	192.168.1.2	0	0	64512 i
*> 192.168.1.6	0	0	64512 i	
*> 192.168.100.0	0.0.0.0	0	32768 i	

ISP#ping 172.16.1.1 source 192.168.100.1

Type escape sequence to abort.

Sending 5, 100-byte ICMP Echos to 172.16.1.1, timeout is 2 seconds:

Packet sent with a source address of 192.168.100.1 !!!!

Success rate is 100 percent (5/5), round-trip min/avg/max = 10/10/11 ms

ISP#ping 172.16.32.1 source 192.168.100.1

Type escape sequence to abort.

Sending 5, 100-byte ICMP Echos to 172.16.32.1, timeout is 2 seconds:

Packet sent with a source address of 192.168.100.1 !!!!

Success rate is 100 percent (5/5), round-trip min/avg/max = 15/15/16 ms

ISP#ping 172.16.1.2 source 192.

168.100.1

Type escape sequence to abort.

Sending 5, 100-byte ICMP Echos to 172.16.1.2, timeout is 2 seconds:

Packet sent with a source address of 192.168.100.1 !!!!

Success rate is 100 percent (5/5), round-trip min/avg/max = 15/17/25 ms

ISP(config)#router bgp 200

ISP(config-router)#network 192.168.1.0 mask 255.255.255.252

ISP(config-router)#network 192.168.1.4 mask 255.255.255.252

ISP(config-router)#exit

ISP#sh ip bgp

BGP table version is 5, local router ID is 192.168.100.1

Status codes: s suppressed, d damped, h history, * valid, > best, i - internal, r RIB-failure, S

Stale, m multipath, b backup-path, f RT-Filter, x best-external, a additional-path, c RIB-compressed,

Origin codes: i - IGP, e - EGP, ? - incomplete

RPKI validation codes: V valid, I invalid, N Not found

Network Weight Path	Next Hop	Metric	LocPrf
* 172.16.0.0	192.168.1.6	0	
0 64512 i			
*> 192.168.1.2	0	0	64512
i *> 192.168.1.0/30	0.0.0.0	0	32768 i
*> 192.168.1.4/30	0.0.0.0	0	32768 i
*> 192.168.100.0	0.0.0.0	0	32768

i

ISP#sh ip bgp

BGP table version is 6, local router ID is 192.168.100.1

Status codes: s suppressed, d damped, h history, * valid, > best, i - internal, r RIB-failure, S

Stale, m multipath, b backup-path, f RT-Filter, x best-external, a additional-path, c RIB-compressed,

Origin codes: i - IGP, e - EGP, ? - incomplete

RPKI validation codes: V valid, I invalid, N Not found

Network	Next Hop	Metric	LocPrf
Weight Path *-> 172.16.0.0	192.168.1.6		50
0 64512 i			
* 192.168.1.2	75	0	
64512 i			
*-> 192.168.1.0/30	0.0.0.0	0	
32768 i			
*-> 192.168.1.4/30	0.0.0.0		
32768 i			
*-> 192.168.100.0	0.0.0.0		
32768 i			
ISP#ping 172.16.1.1			

Type escape sequence to abort.

Sending 5, 100-byte ICMP Echos to 172.16.1.1, timeout is 2 seconds: !!!!

Success rate is 100 percent (5/5), round-trip min/avg/max = 9/10/11 ms

ISP#ping 172.16.1.2

Type escape sequence to abort.

Sending 5, 100-byte ICMP Echos to 172.16.1.2, timeout is 2 seconds: !!!!

Success rate is 100 percent (5/5), round-trip min/avg/max = 20/21/25 ms

ISP#traceroute 172.16.1.1

Type escape sequence to abort.

Tracing the route to 172.16.1.1

VRF info: (vrf in name/id, vrf out name/id)

1 192.168.1.6 10 msec 10 msec *

ISP#traceroute 172.16.1.2

Type escape sequence to abort.

Tracing the route to 172.16.1.2

VRF info: (vrf in name/id, vrf out name/id)

1 192.168.1.6 10 msec 10 msec 13 msec

2 172.16.1.2 [AS 64512] 20 msec 19 msec

* R2 (SanJose1)

Router>enable Router#conf t

Router(config)#hostname SanJose1

SanJose1(config)#interface Loopback0

SanJose1(config-if)#ip address 172.16.64.1 255.255.255.0

SanJose1(config-if)#ip address 172.16.64.1 255.255.255.0

SanJose1(config-if)#exit

SanJose1(config)#interface Serial1/0

SanJose1(config-if)#ip address 192.168.1.6 255.255.255.252

SanJose1(config-if)#no shutdown

SanJose1(config-if)#exit

SanJose1(config)#interface Serial1/1

SanJose1(config-if)#ip address 172.16.1.1 255.255.255.0

SanJose1(config-if)#no shutdown

SanJose1(config-if)#exit

SanJose1(config)#router eigrp 64512

```

SanJose1(config-router)#network 172.16.0.0
SanJose1(config-router)#no auto-summary
SanJose1(config-router)#exit
SanJose1(config)#router bgp 64512
SanJose1(config-router)#neighbor 172.16.32.1 remote-as 64512
SanJose1(config-router)#neighbor 172.16.32.1 update-source loopback0
SanJose1(config-router)#exit
SanJose1(config)#ip route 172.16.0.0 255.255.0.0 null 0
SanJose1(config)#router bgp 64512
SanJose1(config-router)#network 172.16.0.0
SanJose1(config-router)#neighbor 192.168.1.5 remote-as 200 S
SanJose1(config-router)#exit
SanJose1(config)#router bgp 64512
SanJose1(config-router)#neig
hbor 172.16.32.1 next-hop-self
SanJose1(config-router)#exit
SanJose1#sh ip bgp
BGP table version is 5, local router ID is 172.16.64.1
Status codes: s suppressed, d damped, h history, * valid, > best, i - internal, r RIB-failure, S
Stale, m multipath, b backup-path, f RT-Filter, x best-external, a additional-path, c RIB-
compressed, Origin codes: i - IGP, e - EGP, ? - incomplete
RPKI validation codes: V valid, I invalid, N Not found


| Network                       | Next Hop           | Metric              | LocPrf  |
|-------------------------------|--------------------|---------------------|---------|
| Weight Path * i 172.16.0.0    | 172.16.32.1        | 0                   |         |
| 100 0 i                       |                    |                     |         |
| *> 0.0.0.0                    | 0                  | 32768 i             |         |
| * i 192.168.1.0/30            | 172.16.32.1        | 100                 | 0 200 i |
| *> 192.168.1.5 0 0 200 i      | r i 192.168.1.4/30 | 172.16.32.1 0 100 0 | 200 i   |
| r> 192.168.1.5 0 0 200 i      |                    |                     |         |
| * i 192.168.100.0 172.16.32.1 | 0                  | 100                 | 0 200 i |
| *> 192.168.1.5                | 0                  | 0                   | 200 i   |


SanJose1(config)#route-map PRIMARY_T1_IN permit 10
SanJose1(config-route-map)#set local-preference 160
SanJose1(config-route-map)#exit
SanJose1(config)#router bgp 64512
SanJose1(config-router)#neighbor 192.168.1.5 route-map PRIMARY_T1_IN in
SanJose1(config-router)#exit
SanJose1#clear ip bgp * soft
SanJose1#sh ip bgp
BGP table version is 8, local router ID is 172.16.64.1
Status codes: s suppressed, d damped, h history, * valid, > best, i - internal, r RIB-failure, S
Stale, m multipath, b backup-path, f RT-Filter, x best-external, a additional-path, c RIB-
compressed, Origin codes: i - IGP, e - EGP, ? - incomplete
RPKI validation codes: V valid, I invalid, N Not found


| Network                    | Next Hop    | Metric | LocPrf |
|----------------------------|-------------|--------|--------|
| Weight Path * i 172.16.0.0 | 172.16.32.1 | 0      |        |
| 100 0 i                    |             |        |        |


```

*> 0.0.0.0	0		32768
i *> 192.168.1.0/30	192.168.1.5	0	160 0
200 i			
r> 192.168.1.4/30	192.168.1.5	0	160
200 i			
*> 192.168.100.0	192.168.1.5	0	160 0
200 i			

```

SanJose1(config)#route-map PRIMARY_T1_MED_OUT permit 10
SanJose1(config-route-map)#set Metric 50
SanJose1(config-route-map)#exit
SanJose1(config)#router bgp 64512
SanJose1(config-router)#neighbor 192.168.1.5 route-map PRIMARY_T1_MED_OUT out
SanJose1(config-router)#exit
SanJose1(config)#exit
SanJose1#clear ip bgp * soft
SanJose1#sh ip bgp
BGP table version is 8, local router ID is 172.16.64.1
Status codes: s suppressed, d damped, h history, * valid, > best, i - internal, r RIB-failure, S
Stale, m multipath, b backup-path, f RT-Filter, x best-external, a additional-path, c RIB-
compressed, Origin codes: i - IGP, e - EGP, ? - incomplete
RPKI validation codes: V valid, I invalid, N Not found

```

Network	Next Hop	Metric	LocPrf
Weight Path * i 172.16.0.0	172.16.32.1	0	
100 0 i			
*> 0.0.0.0	0		
32768 i			
*> 192.168.1.0/30	192.168.1.5	0	160
0 200 i			
r> 192.168.1.4/30	192.168.1.5	0	160
0 200 i			
*> 192.168.100.0	192.168.1.5	0	
160 0 200 i			

SanJose1#sh ip route
Codes: L - local, C - connected, S - static, R - RIP, M - mobile, B - BGP D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2 E1 - OSPF external type 1, E2 - OSPF external type 2 i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2 ia - IS-IS inter area, * - candidate default, U - per-user static route o - ODR, P - periodic downloaded static route, H - NHRP, l - LISP a - application route + - replicated route, % - next hop override

Gateway of last resort is not set

172.16.0.0/16 is variably subnetted, 6 subnets, 3
masks S 172.16. 0.0/16 is directly connected, Null0
C 172.16. 1.0/24 is directly connected, Serial1/1
L 172.16. 1.1/32 is directly connected, Serial1/1
D 172.16.32.0/24 [90/2297856] via 172.16. 1.2, 01:28:25, Serial1/1
C 172.16. 64.0/24 is directly connected, Loopback0

L 172.16.64.1/32 is directly connected, Loopback0 192.168.1.0/24 is variably subnetted, 3 subnets, 2 masks

B 192.168.1.0/30 [20/0] via 192.168.1.5, 00:45:28

C 192.168.1.4/30 is directly connected, Serial1/0

L 192.168.1.6/32 is directly connected, Serial1/0

B 192.168.100.0/24 [20/0] via 192.168.1.5, 00:45:28

After issuing ip default-network

SanJose1(config)#ip default-network 192.168.100.0

SanJose1(config)#end SanJose1#sh ip route

Codes: L - local, C - connected, S - static, R - RIP, M - mobile, B - BGP D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2 E1 - OSPF external type 1, E2 - OSPF external type 2 i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2 ia - IS-IS inter area, * - candidate default, U - per-user static route o - ODR, P - periodic downloaded static route, H - NHRP, l - LISP a - application route + - replicated route, % - next hop override

Gateway of last resort is 192.168.1.5 to network 192.168.100.0

S* 0.0.0.0/0 [20/0] via 192.168.1.5 172.16.0.0/16 is variably subnetted, 6 subnets, 3

masks S 172.16.0.0/16 is directly connected, Null0

C 172.16.1.0/24 is directly connected, Serial1/1

L 172.16.1.1/32 is directly connected, Serial1/1

D 172.16.32.0/24 [90/2297856] via 172.16.1.2, 01:33:38, Serial1/1

C 172.16.64.0/24 is directly connected, Loopback0

L 172.16.64.1/32 is directly connected, Loopback0 192.168.1.0/24 is variably subnetted, 3 subnets, 2 masks

B 192.168.1.0/30 [20/0] via 192.168.1.5, 00:50:41

C 192.168.1.4/30 is directly connected,

Serial1/0 L 192.168.1.6/32 is directly connected,

Serial1/0

B* 192.168.100.0/24 [20/0] via 192.168.1.5, 00:50:41

SanJose1#ping 192.168.1.2

Type escape sequence to abort.

Sending 5, 100-byte ICMP Echos to 192.168.1.2, timeout is 2 seconds: !!!!!

Success rate is 100 percent (5/5), round-trip min/avg/max = 14/15/16 ms

SanJose1#traceroute 192.168.1.2

Type escape sequence to abort.

Tracing the route to 192.168.1.2

VRF info: (vrf in name/id, vrf out name/id) 1 192.168.1.5 [AS 200] 10 msec 10 msec 10 msec

2 192.168.1.2 [AS 200] 15 msec 15 msec *

SanJose1#ping 192.168.1.1

Type escape sequence to abort.

Sending 5, 100-byte ICMP Echos to 192.168.1.1, timeout is 2 seconds: !!!!!

Success rate is 100 percent (5/5), round-trip min/avg/max = 9/9/11 ms

SanJose1#traceroute 192.168.1.1

Type escape sequence to abort.

Tracing the route to 192.168.1.1

VRF info: (vrf in name/id, vrf out

name/id 1 192.168.1.5 [AS 200] 10 msec

11 msec *

R3 (SanJose2)

```
Router>en
Router#conf t
Router(config)#hostname SanJose2
SanJose2(config)#interface Loopback0
SanJose2(config-if)#ip address 172.16.32.1 255.255.255.0
SanJose2(config-if)#exit
SanJose2(config)#interface Serial1/1
SanJose2(config-if)#ip address 192.168.1.2 255.255.255.252
SanJose2(config-if)#no shutdown
SanJose2(config-if)#exit
SanJose2(config)#interface Serial1/0
SanJose2(config-if)#ip address 172.16.1.2 255.255.255.0
SanJose2(config-if)#no shutdown
SanJose2(config-if)#exit
SanJose2(config)#router eigrp 64512
SanJose2(config-router)#network 172.16.0.0
SanJose2(config-router)#no auto-summary
SanJose2(config-router)#exit
SanJose2(config)#router bgp 64512
SanJose2(config-router)#neighbor 172.16.64.1 remote-as 64512
SanJose2(config-router)#neighbor 172.16.64.1 update-source loopback0
SanJose2(config-router)#exit
SanJose2(config)#ip route 172.16.0.0 255.255.0.0 null 0
SanJose2(config)#router bgp 64512
SanJose2(config-router)#network 172.16.0.0
SanJose2(config-router)#neighbor 192.168.1.1 remote-as 200
SanJose2(config-router)#exit
SanJose2#sh ip bgp summary
BGP router identifier 172.16.32.1, local AS number 64512
BGP table version is 4, main routing table version 4
2 network entries using 280 bytes of memory
4 path entries using 320 bytes of memory 4/2 BGP path/bestpath attribute entries using
576 bytes of memory
1 BGP AS-PATH entries using 24 bytes of memory
0 BGP route-map cache entries using 0 bytes of memory 0
BGP filter-list cache entries using 0 bytes of memory
BGP using 1200 total bytes of memory
BGP activity 2/0 prefixes, 4/0 paths, scan interval 60 secs Neighbor V AS MsgRcvd MsgSent
TblVer InQ OutQ Up/Down State/PfxRcd 172.16.64.1 4 64512 31 32 4 0 0 00:24:41 2
192.168.1.1 4 200 8 6 4 0 0 00:01:22 1
SanJose2#sh ip route
Codes: L - local, C - connected, S - static, R - RIP, M - mobile, B - BGP D - EIGRP, EX - EIGRP
external, O - OSPF, IA - OSPF inter area N1 - OSPF NSSA external type 1, N2 - OSPF NSSA
external type 2 E1 - OSPF external type 1, E2 - OSPF external type 2 i - IS-IS, su - IS-IS
summary, L1 - IS-IS level-1, L2 - IS-IS level-2 ia - IS-IS inter area, * - candidate default, U -
per- user static route o - ODR, P - periodic downloaded static route, H - NHRP, l - LISP a -
application route + - replicated route, % - next hop override
```

Gateway of last resort is not set
 172.16.0.0/16 is variably subnetted, 6 subnets, 3
 masks S 172.16.0.0/16 is directly connected, Null0
 C 172.16.1.0/24 is directly connected, Serial1/0 L 172.16.1.2/32 is directly connected,
 Serial1/0 C 172.16.32.0/24 is directly connected, Loopback0
 L 172.16.32.1/32 is directly connected, Loopback0
 D 172.16.64.0/24 [90/2297856] via 172.16.1.1, 00:08:46, Serial1/0 192.168.1.0/24 is
 variably subnetted, 3 subnets, 2 mask
 s C 192.168.1.0/30 is directly connected, Serial1/1
 L 192.168.1.2/32 is directly connected, Serial1/1
 B 192.168.1.4/30 [20/0] via 192.168.1.1, 00:02:19
 B 192.168.100.0/24 [20/0] via 192.168.1.1, 00:07:40
 SanJose2#sh ip bgp
 BGP table version is 5, local router ID is 172.16.32.1
 Status codes: s suppressed, d damped, h history, * valid, > best, i - internal, r RIB-failure, S
 Stale, m multipath, b backup-path, f RT-Filter, x best-external, a additional-path, c RIB-
 compressed, Origin codes: i - IGP, e - EGP, ? - incomplete
 RPKI validation codes: V valid, I invalid, N Not found

Network	Next Hop	Metric	LocPrf
Weight Path * i 172.16.0.0	172.16.64.1	0	
100 0 i			
*> 0.0.0.0 32768 i r i 192.168.1.0/30	192.168.1.5	0	100 0
200 i			
r> 192.168.1.1 0 0 200 i			
* i 192.168.1.4/30	192.168.1.5	0	100 0
200 i			
*> 192.168.1.1	0	0	
200 i			
* i 192.168.100.0 192.168.1.5	0	100	
0 200 i			
*> 192.168.1.1	0	0	
200 i			
SanJose2(config)#router bgp 64512			
SanJose2(config-router)#neighbor 172.16.64.1 next-hop-self			
SanJose2(config-router)#exi			
t			
SanJose2#sh ip bgp			
BGP table version is 5, local router ID is 172.16.32.1			
Status codes: s suppressed, d damped, h history, * valid, > best, i - internal, r RIB-failure, S Stale, m multipath, b backup-path, f RT-Filter, x best-external, a additional-path, c RIB- compressed, Origin codes: i - IGP, e - EGP, ? - incomplete			
RPKI validation codes: V valid, I invalid, N Not found			
Network	Next Hop	Metric	LocPrf
Weight Path * i 172.16.0.0 172.16.64.1 0 100 0 i *> 0.0.0.0 32768 i r i 192.168 1.0/30			
172.16.64.1 0 100 0 200 i r> 192.168.1.1 0 0 200 i * i 192.168. 1.4/30 172.16.64.1 0 100 0			
200 i *> 192.168.1.1 0 0 200 i * i 192.168.100.0 172.16 64.1 0 100 0 200 i *> 192.168.1.1 0 0			
200 i			
SanJose2(config)#route-map SECONDARY_T1_IN permit 10			
SanJose2(config-route-map)#set local-preference 125			
SanJose2(config-route-map)#exi			

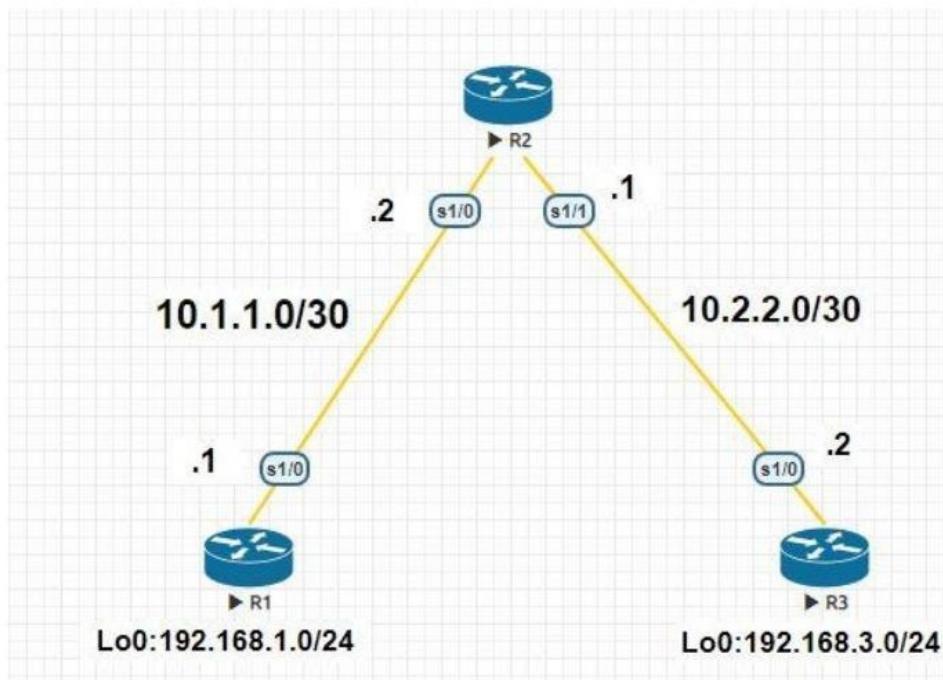
```

t SanJose2(config)#router bgp 64512
SanJose2(config-router)#neighbor 192.168.1.1 route-map SECONDARY_T1_IN in
SanJose2(config-router)#exit
SanJose2#clear ip bgp * soft
SanJose2#sh ip bgp
BGP table version is 8, local router ID is 172.16.32.1 Status codes: s suppressed, d damped,
h history, * valid, > best, i - internal, r RIB-failure, S Stale, m multipath, b backup-path, f
RT- Filter, x best-external, a additional-path, c RIB-compressed, Origin codes: i - IGP, e -
EGP, ? - incomplete
RPKI validation codes: V valid, I invalid, N Not found Network Next Hop Metric LocPrf
Weight Path * i 172.16.0.0 172.16.64.1 0 100 0 i *> 0.0.0.0 0 32768 i r>i 192.168.1.0/30
172.16.64.1 0 160 0 200 i r 192.168.1.1 0 125 0 200 i *>i 192.168.1.4/30 172.16.64.1 0 160 0
200 i * 192.168.1.1 0 125 0 200 i *>i 192.168.100.0 172.16.64.1 0 160 0 200 i * 192.168.1.1 0
125 0 200 i
SanJose2(config)#route-map SECONDARY_T1_MED_OUT permit 10
SanJose2(config-route-map)#set Metric 75
SanJose2(config-route-map)#exit
SanJose2(config)#router bgp 64512
SanJose2(config-router)#$2.168.1.1 route-map SECONDARY_T1_MED_OUT out
SanJose2(config-router)#end
SanJose2#clear ip bgp * soft
SanJose2#sh ip bgp
BGP table version is 8, local router ID is 172.16.32.1 Status codes: s suppressed, d damped,
h history, * valid, > best, i - internal, r RIB-failure, S Stale, m multipath, b backup-path, f
RT- Filter, x best-external, a additional-path, c RIB-compressed, Origin codes: i - IGP, e -
EGP, ? - incomplete
RPKI validation codes: V valid, I invalid, N Not found
Network Next Hop Metric LocPrf
Weight Path * i 172.16.0.0 172.16.64.1 0
100 0 i
*> 0.0.0.0 0 32768
i
r>i 192.168.1.0/30 172.16.64.1 0 160 0
200 i
r 192.168.1.1 0 125 0 200
i
*>i 192.168.1.4/30 172.16.64.1 0 160 0
200 i
* 192.168.1.1 0 125 0
200 i
*>i 192.168.100.0 172.16.64.1 0 160
200 i
* 192.168.1.1 0 125 0
200 i

```

Practical 4

NETWORK TOPOLOGY



```
R1 Router>en
Router#conf t
Enter configuration commands, one per line. End with CNTL/Z.
Router(config)#hostname R1
R1(config)#interface Loopback 0
*Dec 19 07:53:42.473: %LINEPROTO-5-UPDOWN: Line protocol on Interface Loopback0,
changed state to up
R1(config-if)#ip address 192.168.1.1 255.255.255.0
R1(config-if)#exit
R1(config)#interface s1/0
R1(config-if)#ip address 10.1.1.1 255.255.255.252
R1(config-if)#no shutdown
*Dec 19 07:57:21.998: %LINK-3-UPDOWN: Interface Serial1/0, changed state to up
*Dec 19 07:57:22.999: %LINEPROTO-5-UPDOWN: Line protocol on Interface Serial1/0,
changed state to up
R1(config-if)#exit

R1(config)#exit Configure static routes a.
On R1, configure a default static route to ISP.
R1(config)# ip route 0.0.0.0 0.0.0.0 10.1.1.2
```

```
R1#show ip route
Codes: L - local, C - connected, S - static, R - RIP, M - mobile, B - BGP D - EIGRP, EX -
EIGRP external, O - OSPF, IA - OSPF inter area N1 - OSPF NSSA external type 1, N2 - OSPF
NSSA external type 2 E1 - OSPF external type 1, E2 - OSPF external type 2 i - IS-IS, su - IS-IS
summary, L1 - IS-IS level-1, L2 - IS-IS level-2 ia - IS-IS inter area, * - candidate default,U -
per- user static route o - ODR, P - periodic downloaded static route,H - NHRP,l - LISP a -
application route + - replicated route, % - next hop override
Gateway of last resort is 10.1.1.2 to network 0.0.0.0
S* 0.0.0.0/0 [1/0] via 10.1.1.2 10.0.0.0/8 is variably subnetted, 2 subnets, 2
masks C 10.1.1.0/30 is directly connected, Serial1/0
L 10.1.1.1/32 is directly connected, Serial1/0 192.168.1.0/24 is variably subnetted, 2
subnets, 2 masks
C 192.168.1.0/24 is directly connected, Loopback0
L 192.168.1.1/32 is directly connected, Loopback0 Secure management access
R1(config)#security passwords min-length 10
R1(config)#enable secret class12345
R1(config)#line console 0
R1(config-line)#password ciscocompass
R1(config-line)#exec-timeout 5 0
R1(config-line)#login
R1(config-line)#logging synchronous
R1(config-line)#exit
R1(config)#line vty 0 4
R1(config-line)#password ciscovtypass
R1(config-line)#exec-timeout 5 0
R1(config-line)#login
R1(config-line)#exit
R1(config)#line aux 0
R1(config-line)#no exec

R1(config-line)#end
R1(config)#service password-encryption
R1(config)#banner motd $Unauthorized access strictly prohibited!$"
R1(config)#exit Configure enhanced username password security
R1(config)#username JR-ADMIN secret class12345
R1(config)#username ADMIN secret class54321
R1(config)#line console 0
R1(config-line)#login local
R1(config-line)#end
R1(config)#line vty 0 4

R1(config-line)#login local
R1(config-line)#end Enabling AAA RADIUS Authentication with Local User for Backup
R1(config)# aaa new-model
R1(config)# radius server RADIUS-1
R1(config-radius-server)# address ipv4 192.168.1.101
R1(config-radius-server)# key RADIUS-1-pa55w0rd
```

```
R1(config-radius-server)# exit
R1(config)# radius server RADIUS-2
R1(config-radius-server)# address ipv4 192.168.1.102
R1(config-radius-server)# key RADIUS-2-pa55w0rd
R1(config-radius-server)# exit
R1(config)# aaa group server radius RADIUS-GROUP
R1(config-sg-radius)# server name RADIUS-1
R1(config-sg-radius)# server name RADIUS-2
R1(config-sg-radius)# exit
R1(config)# aaa authentication login default group RADIUS-GROUP local
R1(config)# aaa authentication login TELNET-LOGIN group RADIUS-GROUP localcase
R1(config)# line vty 0 4
R1(config-line)# login authentication TELNET-LOGIN
R1(config-line)# exit
R2 Router>enable
Router#conf t Enter configuration commands, one per line. End with CNTL/Z.
Router(config)#hostname R2
R2(config)#interface s1/0
R2(config-if)#ip address 10.1.1.2 255.255.255.252
R2(config-if)#no shutdown
*Dec 19 08:01:10.279: %LINK-3-UPDOWN: Interface Serial1/0, changed state to up *Dec 19
08:01:11.279: %LINEPROTO-5-UPDOWN: Line protocol on Interface Serial1/0, changed state
to up R2(config-if)#exit
R2(config)#interface s1/1
R2(config-if)#ip address 10.2.2.1 255.255.255.252
R2(config-if)#no shutdown
*Dec 19 08:02:33.002: %LINK-3-UPDOWN: Interface Serial1/1, changed state to up
*Dec 19 08:02:34.009: %LINEPROTO-5-UPDOWN: Line protocol on Interface Serial1/1,
changed state to up
R2(config-if)#exit
R2(config)#exit Configure static routes a. On R2, configure two static routes.
R2(config)# ip route 192.168.1.0 255.255.255.0 10.1.1.1
R2(config)# ip route 192.168.3.0 255.255.255.0 10.2.2.2
R2#show ip route Codes: L - local, C - connected, S - static, R - RIP, M - mobile, B - BGP D -
EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area N1 - OSPF NSSA external type 1,
N2
- OSPF NSSA external type 2 E1 - OSPF external type 1, E2 - OSPF external type 2 i - IS-IS, su
- IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2 ia - IS-IS inter area, * - candidate
default, U - per-user static route o - ODR, P - periodic downloaded static route, H - NHRP, l
- LISP a - application route + - replicated route, % - next hop override
Gateway of last resort is not set 10.0.0.0/8 is variably subnetted, 4 subnets, 2 mask
s C 10.1.1.0/30 is directly connected, Serial1/0 L 10.1.1.2/32 is directly connected, Serial1/0
C 10.2.2.0/30 is directly connected, Serial1/1
L 10.2.2.1/32 is directly connected, Serial1/1
S 192.168.1.0/24 [1/0] via 10.1.1.1
S 192.168.3.0/24 [1/0] via 10.2.2.2 Secure management access
R2(config)#security passwords min-length 10
R2(config)#enable secret class12345
```

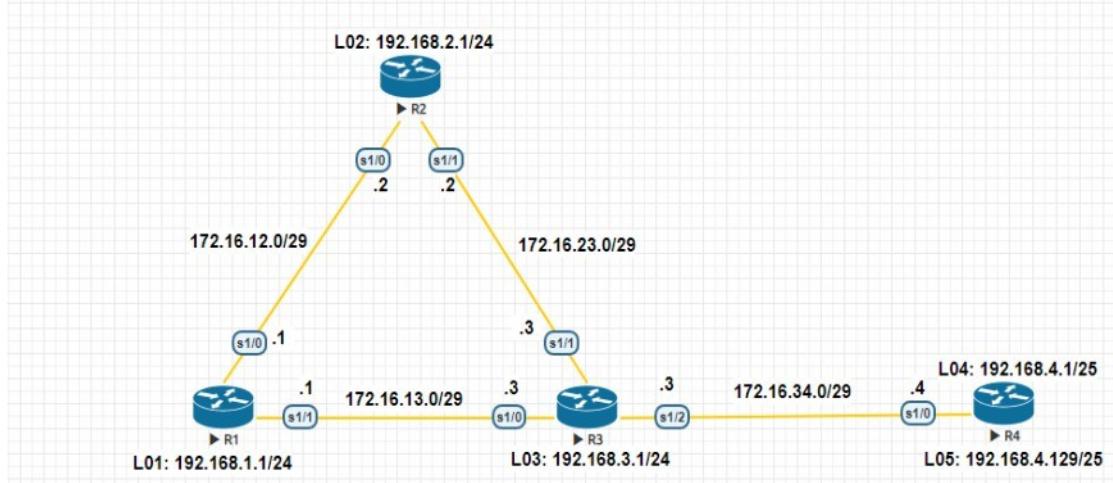
```
R2(config)#line console 0 R2(config-line)#password ciscocompass
R2(config-line)#exec-timeout 5 0
R2(config-line)#login
R2(config-line)#logging synchronous
R2(config-line)#exit
R2(config)#line vty 0 4
R2(config-line)#password ciscovtypass
R2(config-line)#exec-timeout 5 0
R2(config-line)#login
R2(config-line)#exit
R2(config)#line aux 0
R2(config-line)#no exec
R2(config-line)#end
R2(config)#service password-encryption
R2(config)#banner motd $Unauthorized access strictly prohibited!$Configure enhanced username password security
R2(config)#username JR-ADMIN secret class12345
R2(config)#username ADMIN secret class54321
R2(config)#line console 0
R2(config-line)#login local
R2(config-line)#end
R2(config)#line vty 0 4
R2(config-line)#login local
R2(config-line)#end Enabling AAA RADIUS Authentication with Local User for Backup
R2(config)# aaa new-model
R2(config)# radius server RADIUS-1
R2(config-radius-server)# address ipv4 192.168.1.101
R2(config-radius-server)# key RADIUS-1-pa55w0rd
R2(config-radius-server)# exit
R2(config)# radius server RADIUS-2
R2(config-radius-server)# address ipv4 192.168.1.102
R2(config-radius-server)# key RADIUS-2-pa55w0rd
R2(config-radius-server)# exit R2(config)# aaa group server radius RADIUS-GROUP
R2(config-sg-radius)# server name RADIUS-1
R2(config-sg-radius)# server name RADIUS-2
R2(config-sg-radius)# exit
R2(config)# aaa authentication login default group RADIUS-GROUP local
R2(config)# aaa authentication login TELNET-LOGIN group RADIUS-GROUP localcase
R2(config)# line vty 0 4
R2(config-line)# login authentication TELNET-LOGIN
R2(config-line)# exit
R3 Router>enable
Router#conf t Enter configuration commands, one per line. End with CNTL/Z.
Router(config)#hostname R3
R3(config)#interface loopback 0
*Dec 19 08:07:50.079: %LINEPROTO-5-UPDOWN: Line protocol on Interface Loopback0, changed state to up
```

```
R3(config-if)#ip address 192.168.3.1 255.255.255.0
R3(config-if)#exit
R3(config)#interface s1/0
R3(config-if)#ip address 10.2.2.2 255.255.255.252
R3(config-if)#no shutdown
R3(config-if)#exit
*Dec 19 08:09:26.986: %LINK-3-UPDOWN: Interface Serial1/0, changed state to up
*Dec 19 08:09:27.996: %LINEPROTO-5-UPDOWN: Line protocol on Interface Serial1/0,
changed state to up
R3(config)#end Configure static routes a. On R3, configure a default static route to ISP.
R3(config)# ip route 0.0.0.0 0.0.0.0 10.2.2.1
R3#show ip route Codes: L - local, C - connected, S - static, R - RIP, M - mobile, B - BGP D -
EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area N1 - OSPF NSSA external type 1,
N2
- OSPF NSSA external type 2 E1 - OSPF external type 1, E2 - OSPF external type 2 i - IS-IS, su
- IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2 ia - IS-IS inter area, * - candidate
default, U - per-user static route o - ODR, P - periodic downloaded static route, H - NHRP, l
- LISP a - application route + - replicated route, % - next hop override
Gateway of last resort is 10.2.2.1 to network 0.0.0.0
S* 0.0.0.0/0 [1/0] via 10.2.2.1 10.0.0.0/8 is variably subnetted, 2 subnets, 2
masks C 10.2.2.0/30 is directly connected, Serial1/0
L 10.2.2.2/32 is directly connected, Serial1/0 192.168.3.0/24 is variably subnetted, 2
subnets, 2 masks
C 192.168.3.0/24 is directly connected, Loopback0
L 192.168.3.1/32 is directly connected, Loopback0 Secure management access
R3(config)#security passwords min-length 10
R3(config)#enable secret class12345
R3(config)#line console 0
R3(config-line)#password ciscoconpass
R3(config-line)#exec-timeout 5 0
R3(config-line)#login
R3(config-line)#logging synchronous
R3(config-line)#exit
R3(config)#line vty 0 4
R3(config-line)#password ciscovtypass
R3(config-line)#exec-timeout 5 0
R3(config-line)#login R3(config-line)#exit
R3(config)#line aux 0
R3(config-line)#no exec
R3(config-line)#end
R3(config)#service password-encryption
R3(config)#banner motd $Unauthorized access strictly prohibited!$ Configure enhanced
username password security
R3(config)#username JR-ADMIN secret class12345
R3(config)#username ADMIN secret class54321
R3(config)#line console 0
R3(config-line)#login local
R3(config-line)#exit
```

```
R3(config)#line vty 0 4
R3(config-line)#login local
R3(config-line)#exit
Enabling AAA RADIUS Authentication with Local User for Backup
R3(config)# aaa new-model
R3(config)# radius server RADIUS-1
R3(config-radius-server)# address ipv4 192.168.1.101
R3(config-radius-server)# key RADIUS-1-pa55w0rd
R3(config-radius-server)# exit
R3(config)# radius server RADIUS-2
R3(config-radius-server)# address ipv4 192.168.1.102
R3(config-radius-server)# key RADIUS-2-pa55w0rd
R3(config-radius-server)# exit
R3(config)# aaa group server radius RADIUS-GROUP
R3(config-sg-radius)# server name RADIUS-1
R3(config-sg-radius)# server name RADIUS-2 R3(config-sg-radius)# exit
R3(config)# aaa authentication login default group RADIUS-GROUP loca
l R3(config)# aaa authentication login TELNET-LOGIN group RADIUS-GROUP localcase
R3(config)# line vty 0 4
R3(config-line)# login authentication TELNET-LOGIN
R3(config-line)# exit
```

Practical 5

NETWORK TOPOLOGY



R1 Router>enable

Router#conf t Enter configuration commands, one per line. End with CNTL/Z.

Router(config)#hostname R1

R1(config)#interface Lo1

R1(config-if)#ip address 192.168.1.1 255.255.255.0

R1(config-if)#exit

R1(config)#interface s1/0

R1(config-if)#ip address 172.16.12.1 255.255.255.248

R1(config-if)#no shutdown

R1(config-if)#exit R1(config)#interface s1/1

R1(config-if)#ip address 172.16.13.1 255.255.255.248 R1(config-if)#no shutdown

R1(config-if)#exit

R1(config)#router eigrp 100

R1(config-router)#network 192.168.1.0

R1(config-router)#network 172.16.12.0

R1(config-router)#network 172.16.13.0

R1(config-router)#no auto-summary

R1(config-router)#exit

R1#sh ip eigrp neighbors

EIGRP-IPv4 Neighbors for AS(100) H Address Interface Hold Uptime SRTT RTT Q Seq (sec)

(ms) Cnt Num 1 172.16.13.3 Se1/1 14 00:04:43 11 100 0 10 0 172.16.12.2 Se1/0 12 00:07:05

19 114 0 8

R1#sh ip route

Codes: L - local, C - connected, S - static, R - RIP, M - mobile, B - BGP D - EIGRP, EX -

EIGRP external, O - OSPF, IA - OSPF inter area N1 - OSPF NSSA external type 1, N2 - OSPF

NSSA external type 2 E1 - OSPF external type 1, E2 - OSPF external type 2 i - IS-IS, su - IS-

IS

summary, L1 - IS-IS level-1, L2 - IS-IS level-2 ia - IS-IS inter area, * - candidate default, U - per-user static route o - ODR, P - periodic downloaded static route, H - NHRP, l - LISP a - application route + - replicated route, % - next hop override

Gateway of last resort is not set

172.16.0.0/16 is variably subnetted, 6 subnets, 2 masks

C 172.16.12.0/29 is directly connected, Serial1/0

L 172.16.12.1/32 is directly connected, Serial1/0

C 172.16.13.0/29 is directly connected, Serial1/1

L 172.16.13.1/32 is directly connected, Serial1/1

D 172.16.23.0/29 [90/2681856] via 172.16.13.3, 00:08:31, Serial1/1 [90/2681856] via 172.16.12.2, 00:08:31, Serial1/0

D 172.16.34.0/29 [90/2681856] via 172.16.13.3, 00:08:31, Serial1/1 192.168.1.0/24 is variably subnetted, 2 subnets, 2 masks

C 192.168.1.0/24 is directly connected, Loopback1

L 192.168.1.1/32 is directly connected, Loopback1

D 192.168.2.0/24 [90/2297856] via 172.16.12.2, 00:08:31, Serial1/0

D 192.168.3.0/24 [90/2297856] via 172.16.13.3, 00:08:31, Serial1/1 192.168.4.0/25 is subnetted, 2 subnets

D 192.168.4.0 [90/2809856] via 172.16.13.3, 00:05:15, Serial1/1

D 192.168.4.128 [90/2809856] via 172.16.13.3, 00:05:15, Serial1/1

R2 Router>enable

Router#conf t

Router(config)#hostname R2

R2(config)#interface Lo2

R2(config-if)#ip address 192.168.2.1 255.255.255.0

R2(config-if)#exit

R2(config)#interface s1/0

R2(config-if)#ip address 172.16.12.2 255.255.255.248

R2(config-if)#no shutdown

R2(config-if)#exit

R2(config)#interface s1/1

R2(config-if)#ip address 172.16.23.2 255.255.255.248

R2(config-if)#no shutdown R2(config-if)#exit

R2(config)#router eigrp 100

R2(config-router)#network 192.168.2.0

R2(config-router)#network 172.16.12.0

R2(config-router)#network 172.16.23.0

R2(config-router)#no auto-summary

R2#sh ip eigrp neighbors EIGRP-IPv4

Neighbors for AS(100) H Address Interface Hold Uptime SRTT RTO Q Seq (sec) (ms) Cnt Num

1 172.16.23.3 Se1/1 12 00:05:23 12 100 0 11 0 172.16.12.1 Se1/0 12 00:07:45 22 132 0 8 R3

Router>enable

Router#conf

t

Router(config)#hostname R3

R3(config)#interface Lo3

R3(config-if)#ip address 192.168.3.1 255.255.255.0

R3(config-if)#exit

```

R3(config)#interface s1/0
R3(config-if)#ip address 172.16.13.3 255.255.255.248
R3(config-if)#no shutdown
R3(config-if)#exit
R3(config)#interface s1/1
R3(config-if)#ip address 172.16.23.3 255.255.255.248
R3(config-if)#no shutdown
R3(config-if)#exit
R3(config)#interface s1/2
R3(config-if)#ip address 172.16.34.3 255.255.255.248
R3(config-if)#no shutdown
R3(config-if)#exit
R3(config)#router eigrp 100
R3(config-router)#network 192.168.3.0
R3(config-router)#network 172.16.13.0
R3(config-router)#network 172.16.23.0
R3(config-router)#network 172.16.34.0
R3(config-router)#no auto-summary
R3#sh ip eigrp neighbors EIGRP-IPv4 Neighbors for AS(100) H Address Interface Hold
Uptime SRTT RTO Q Seq (sec) (ms) Cnt Num 2 172.16.34.4 Se1/2 14 00:03:09 15 100 0 3 1
172.16.13.1 Se1/0 14 00:06:25 21 126 0 9 0 172.16.23.2 Se1/1 13 00:06:25 20 120 0 9
R3#sh ip route
Codes: L - local, C - connected, S - static, R - RIP, M - mobile, B - BGP D - EIGRP, EX - EIGRP
external, O - OSPF, IA - OSPF inter area N1 - OSPF NSSA external type 1, N2 - OSPF NSSA
external type 2 E1 - OSPF external type 1, E2 - OSPF external type 2 i - IS-IS, su - IS-IS
summary, L1 - IS-IS level-1, L2 - IS-IS level-2 ia - IS-IS inter area, * - candidate default, U -
per- user static route o - ODR, P - periodic downloaded static route, H - NHRP, l - LISP a -
application route + - replicated route, % - next hop override
Gateway of last resort is not set
172.16.0.0/16 is variably subnetted, 7 subnets, 2 masks
D 172.16.12.0/29 [90/2681856] via 172.16.23.2, 00:16:48, Serial1/1 [90/2681856] via
172.16.13.1, 00:16:48, Serial1/0
C 172.16.13.0/29 is directly connected, Serial1/0
L 172.16.13.3/32 is directly connected, Serial1/0
C 172.16.23.0/29 is directly connected,
Serial1/1 L 172.16.23.3/32 is directly connected,
Serial1/1 C 172.16.34.0/29 is directly
connected, Serial1/2 L 172.16.34.3/32 is directly
connected, Serial1/2
D 192.168.1.0/24 [90/2297856] via 172.16.13.1, 00:16:48, Serial1/0
D 192.168.2.0/24 [90/2297856] via 172.16.23.2, 00:16:48, Serial1/1 192.168.3.0/24 is
variably subnetted, 2 subnets, 2 masks
C 192.168.3.0/24 is directly connected, Loopback3
L 192.168.3.1/32 is directly connected, Loopback3 192.168.4.0/25 is subnetted, 2 subnets
D 192.168.4.0 [90/2297856] via 172.16.34.4, 00:13:32, Serial1/2
D 192.168.4.128 [90/2297856] via 172.16.34.4, 00:13:32, Serial1/2
R3(config)#ip access-list standard PBR-ACL
R3(config std-nacl)#remark ACL matches

```

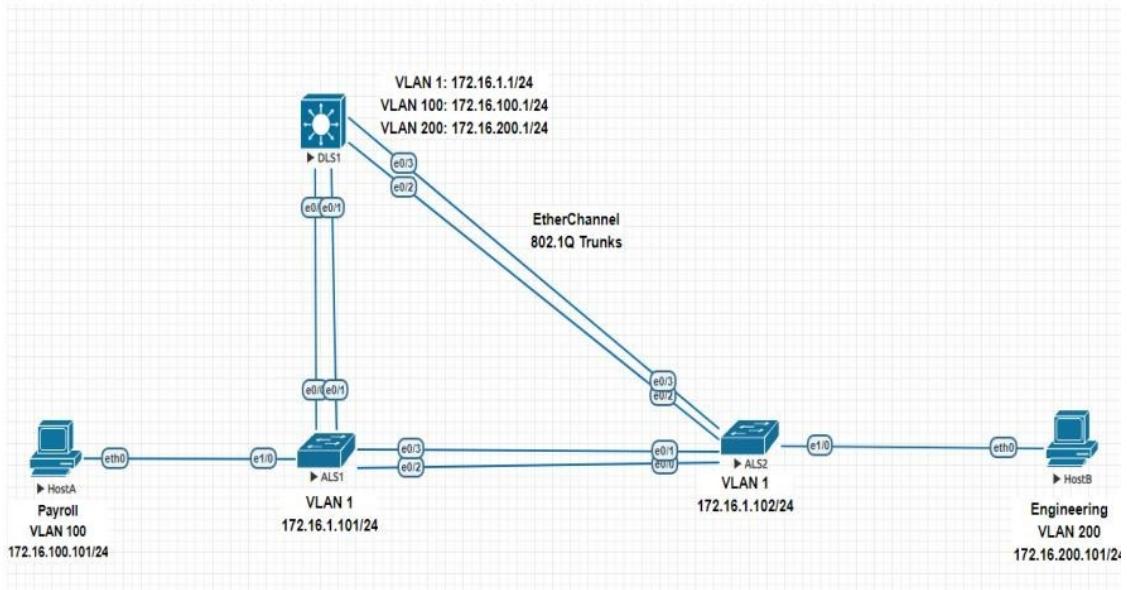
```
R4 LAN B traffic
R3(config-std-nacl)#permit 192.168.4.128 0.0.0.127
R3(config-std-nacl)#exit
R3(config)#route-map R3-to-R1 permit
R3(config-route-map)#match ip address PBR-ACL
R3(config-route-map)#set ip next-hop 172.16.13.1
R3(config-route-map)#end
R3(config)#int s1/2
R3(config-if)#ip policy route-map R3-to-R1
R3(config-if)#exit
R3#sh route-map route-map R3-to-R1, permit, sequence 10 Match clauses: ip address
(access-lists): PBR-ACL Set clauses: ip next-hop 172.16.13.1 Policy routing matches: 0
packets, 0 bytes R3(config)#access-list 1 permit 192.168.4.0 0.0.0.255

R4
Router>enable
Router#conf
t
Router(config)#hostname R4
R4(config)#interface lo4
R4(config-if)#ip address 192.168.4.1 255.255.255.128
R4(config-if)#exit
R4(config)#interface lo5
R4(config-if)#ip address 192.168.4.129 255.255.255.128
R4(config-if)#exit
R4(config)#interface s1/0
R4(config-if)#ip address 172.16.34.4 255.255.255.248
R4(config-if)#no shutdown
R4(config-if)#exit
R4(config)#router eigrp 100
R4(config-router)#network 192.168.4.0
R4(config-router)#network 172.16.34.0
R4(config-router)#no auto-summary
R4#sh ip eigrp neighbors EIGRP-IPv4 Neighbors for AS(100) H Address Interface Hold Uptime
SRTT RTO Q Seq (sec) (ms) Cnt Num 0 172.16.34.3 Se1/0 14 00:04:07 25 150 0 9 Before
Route Maps R4#traceroute 192.168.1.1 source 192.168.4.1
Type escape sequence to abort.
Tracing the route to 192.168.1.1
VRF info: (vrf in name/id, vrf out name/id) 1 172.16.34.3 13 msec 11 msec 10 msec 2
172.16.13.1 20 msec 17 msec *
R4#traceroute 192.168.1.1 source 192.168.4.129
Type escape sequence to abort.
Tracing the route to 192.168.1.1
VRF info: (vrf in name/id, vrf out name/id) 1 172.16.34.3 15 msec 10 msec 10 msec 2
172.16.13.1 19 msec 24 msec *
After Route Maps R4#traceroute 192.168.1.1 source 192.168.4.1
Type escape sequence to abort. Tracing the route to 192.168.1.1
VRF info: (vrf in name/id, vrf out name/id) 1 172.16.34.3 11 msec 10 msec 10 msec 2
172.16.13.1 21 msec 22 msec *
```

```
R4#traceroute 192.168.1.1 source 192.168.4.129
Type escape sequence to abort.
Tracing the route to 192.168.1.1
VRF info: (vrf in name/id, vrf out name/id) 1 172.16.34.3 10 msec 10 msec 10 msec 2
172.16.13.1 18 msec 18 msec
```

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```
DLS1 Switch>en
Switch#conf t
Switch(config)#hostname DLS1
DLS1(config)#interface vlan 1
DLS1(config-if)#ip address 172.16.1.1 255.255.255.0
DLS1(config-if)#no shutdown
DLS1(config-if)#exit Configure the trunks and EtherChannel from DLS1 to ALS1.
DLS1(config)#interface range e0/0/1
DLS1(config-if-range)#switchport trunk encapsulation dot1q
DLS1(config-if-range)#switchport mode trunk
```

```
DLS1(config-if-range)#channel-group 1 mode desirable Creating a port-channel interface
Port-channel 1
DLS1(config-if-range)#exit Configure the trunks and EtherChannel from DLS1 to ALS2.
DLS1(config)#interface range e0/2-3
DLS1(config-if-range)#switchport trunk encapsulation dot1q
DLS1(config-if-range)#switchport mode trunk
DLS1(config-if-range)#channel-group 2 mode desirable Creating a port-channel interface
Port-channel 2
DLS1(config-if-range)#exit Configure VTP on DLS1 and create VLANs 100 and 200 for the
domain DLS1(config)#vtp domain SWPOD Changing VTP domain name from NULL to SWPOD
DLS1(config)#vtp version 2
DLS1(config)#vlan 100
DLS1(config-vlan)#name Payroll
DLS1(config-vlan)#exit
DLS1(config)#vlan 200
DLS1(config-vlan)#name Engineering
DLS1(config-vlan)#exit On DLS1, create the SVIs for VLANs 100 and 200.
Note that the corresponding Layer 2 VLANs must be configured for the Layer 3 SVIs to
activate DLS1(config)#interface vlan 100
DLS1(config-if)#ip address 172.16.100.1 255.255.255.0
DLS1(config-if)#no shutdown
DLS1(config-if)#exit
DLS1(config)#interface vlan 200
DLS1(config-if)#ip address 172.16.200.1 255.255.255.0
DLS1(config-if)#no shutdown
DLS1(config-if)#exit The ip routing command is also needed to allow the
DLS1 switch to act as a Layer 3 device to route between these VLANs. Because the VLANs
are all considered directly connected, a routing protocol is not needed at this time. The
default configuration on 3560 switches is no ip routing.
DLS1(config)#ip routing
DLS1#sh ip route Codes: L - local, C - connected, S - static, R - RIP, M - mobile, B - BGP D -
EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area N1 - OSPF NSSA external type 1,
N2
- OSPF NSSA external type 2 E1 - OSPF external type 1, E2 - OSPF external type 2 i - IS-IS, su
- IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2 ia - IS-IS inter area, * - candidate
default, U - per-user static route o - ODR, P - periodic downloaded static route, H - NHRP, l
- LISP a - application route + - replicated route, % - next hop override
Gateway of last resort is not set
172.16.0.0/16 is variably subnetted, 6 subnets, 2 masks
C 172.16.1.0/24 is directly connected, Vlan1
L 172.16.1.1/32 is directly connected, Vlan1
C 172.16.100.0/24 is directly connected, Vlan100
L 172.16.100.1/32 is directly connected, Vlan100
C 172.16.200.0/24 is directly connected, Vlan200
L 172.16.200.1/32 is directly connected, Vlan200
Configure the Cisco IOS IP SLA source to measure network performance
DLS1(config)#ip sla 1
DLS1(config-ip-sla)#icmp-echo 172.16.100.101
```

```
DLS1(config-ip-sla-echo)#exit
DLS1(config)#ip sla 2
DLS1(config-ip-sla)#icmp-echo 172.16.200.101
DLS1(config-ip-sla-echo)#exit
DLS1(config)#ip sla 3
DLS1(config-ip-sla)#udp-jitter 172.16.1.101 5000
DLS1(config-ip-sla-jitter)#exit
DLS1(config)#ip sla 4
DLS1(config-ip-sla)#udp-jitter 172.16.1.102 5000
DLS1(config-ip-sla-jitter)#exit
DLS1(config)#ip sla schedule 1 life forever start-time now
DLS1(config)#ip sla schedule 2 life forever start-time now
DLS1(config)#ip sla schedule 3 life forever start-time now
DLS1(config)#ip sla schedule 4 life forever start-time now Monitor IP SLAs operations
DLS1#show ip sla configuration 1
IP SLAs Infrastructure Engine-III Entry number: 1 Owner: Tag: Operation timeout
(milliseconds): 5000 Type of operation to perform: icmp-echo Target address/Source
address: 172.16.100.101/0.0.0.0 Type Of Service parameter: 0x0 Request size (ARR data
portion): 28 Data pattern: 0xABCDABCD Verify data: No Vrf Name: Schedule: Operation
frequency (seconds): 60 (not considered if randomly scheduled)
Next Scheduled Start Time: Start Time already passed Group Scheduled : FALSE Randomly
Scheduled : FALSE Life (seconds): Forever Entry Ageout (seconds): never
Recurring (Starting Everyday): FALSE Status of entry (SNMP RowStatus): Active Threshold
(milliseconds): 5000
Distribution Statistics:
Number of statistic hours kept: 2
Number of statistic distribution buckets kept: 1
Statistic distribution interval (milliseconds): 20 E
nhanced History: History Statistics:
Number of history Lives kept: 0
Number of history Buckets kept: 15
History Filter Type: None
DLS1#show ip sla configuration 3 IP SLAs Infrastructure Engine-III
Entry number: 3
Owner: Tag: Operation timeout (milliseconds): 5000
Type of operation to perform: udp-jitter
Target address/Source address: 172.16.1.101/0.0.0.0 Target port/Source port: 5000/0
Type Of Service parameter: 0x0
Request size (ARR data portion): 32
Packet Interval (milliseconds)/Number of packets: 20/10 Verify data:
No Vrf Name: Control Packets: enabled Schedule:
Operation frequency (seconds): 60 (not considered if randomly scheduled)
Next Scheduled Start Time: Start Time already passed Group Scheduled : FALSE Randomly
Scheduled : FALSE Life (seconds): Forever Entry Ageout (seconds): never
Recurring (Starting Everyday): FALSE Status of entry (SNMP RowStatus): Active Threshold
(milliseconds): 5000 Distribution Statistics:
Number of statistic hours kept: 2
```

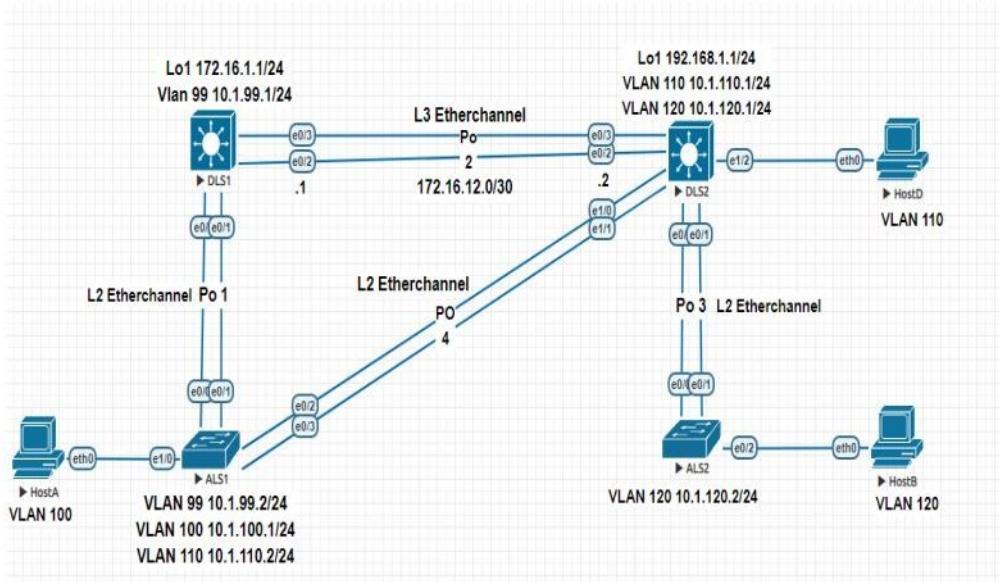
Number of statistic distribution buckets kept: 1 Statistic distribution interval (milliseconds): 20 Enhanced History: Percentile:
DLS1#show ip sla application IP Service Level Agreements Version: Round Trip Time MIB
2.2.0, Infrastructure Engine-III
Supported Operation Types: icmpEcho, path-echo, path-jitter, udpEcho, tcpConnect, http
dns, udpJitter, dhcp, ftp, lsp Group, lspPing, lspTrace pseudowirePing, udpApp, wspApp,
mcast, generic Supported Features: IPSLAs Event Publisher IP SLAs low memory water mark:
225778552 Estimated system max number of entries: 165365
Estimated number of configurable operations: 165241 Number of Entries configured : 4
Number of active Entries : 4
Number of pending Entries : 0
Number of inactive Entries : 0 Time of last change in whole IP SLAs: *14:08:46.139 EET Sat
Apr 11 2020 DLS1#show ip sla statistics 1 IPSLAs
Latest Operation Statistics IPSLA operation id: 1 Latest RTT: 1 milliseconds Latest operation
start time: 14:34:23 EET Sat Apr 11 2020
Latest operation return code: OK
Number of successes: 26
Number of failures: 1 Operation time to live: Forever
DLS1#show ip sla statistics 3 IPSLAs Latest Operation Statistics IPSLA operation id: 3 Type of
operation: udp-jitter Latest RTT: 1 milliseconds Latest operation start time: 14:34:36 EET Sat
Apr 11 2020 Latest operation return code: OK RTT Values: Number Of RTT: 10 RTT
Min/Avg/Max: 1/1/2 milliseconds Latency one-way time
: Number of Latency one-way Samples: 6
Source to Destination Latency one way Min/Avg/Max: 0/0/1 milliseconds Destination to
Source Latency one way Min/Avg/Max: 0/0/1 milliseconds Jitter Time:
Number of SD Jitter Samples: 9
Number of DS Jitter Samples: 9
Source to Destination Jitter Min/Avg/Max: 0/1/1 milliseconds
Destination to Source Jitter Min/Avg/Max: 0/1/1 milliseconds Over Threshold: Number Of
RTT Over Threshold: 0 (0%) Packet Loss Values: Loss Source to Destination: 0
Source to Destination Loss Periods Number: 0 Source to Destination Loss Period Length
Min/Max: 0/0 Source to Destination Inter Loss Period Length Min/Max: 0/0 Loss Destination
to Source: 0 Destination to Source Loss Periods Number: 0
Destination to Source Loss Period Length Min/Max: 0/0
Destination to Source Inter Loss Period Length Min/Max: 0/0 Out Of Sequence: 0 Tail Drop:
0 Packet Late Arrival: 0 Packet Skipped: 0 Voice Score Values: Calculated Planning
Impairment Factor (ICPIF): 0 Mean Opinion Score (MOS): 0 Number of successes: 27
Number of failures: 0 Operation time to live: Forever Configure Remote Span
DLS1(config)#vlan 100 DLS1(config-vlan)#remote-span
DLS1(config-vlan)#exit
t DLS1(config)#monitor session 1 source interface e0/0 both
DLS1(config)# monitor session 1 destination remote vlan 100 ALS1
Switch>en Switch#conf t
Switch(config)#hostname ALS1
ALS1(config)#interface vlan 1
ALS1(config-if)#ip address 172.16.1.101 255.255.255.0
ALS1(config-if)#no shutdown

```
ALS1(config-if)#exit
ALS1(config)#ip default-gateway 172.16.1.1
Configure the trunks and EtherChannel between ALS1 and DLS1
ALS1(config)#interface range e0/0-1
ALS1(config-if-range)# switchport trunk encapsulation dot1q
ALS1(config-if-range)#switchport mode trunk
ALS1(config-if-range)#channel-group 1 mode desirable Creating a port-channel interface
Port-channel 1
ALS1(config-if-range)#exit
Configure the trunks and EtherChannel between ALS1 and ALS2
ALS1(config)#interface range e0/2-3
ALS1(config-if-range)#switchport trunk encapsulation dot1q
ALS1(config-if-range)#switchport mode trunk
ALS1(config-if-range)#channel-group 2 mode desirable Creating a port-channel interface
Port-channel 2 Configure VTP on ALS1
ALS1(config)#vtp mode client Setting device to VTP Client mode for VLANS.
ALS1(config)#int e1/0
ALS1(config-if)#switchport mode access
ALS1(config-if)#switchport access vlan 100
ALS1(config-if)#exit Configure Cisco IOS IP SLA responders.
ALS1(config)#ip sla responder
ALS1(config)#ip sla responder udp-echo ipaddress 172.16.1.1 port 5000
ALS1#show ip sla responder General IP SLA Responder on Control port 1967
General IP SLA Responder on Control V2 port 1167 General IP SLA Responder is: Enabled
Number of control message received: 16
Number of errors: 0 Recent sources: 172.16.1.1 [14:23:36.259 EET Sat Apr 11 2020]
172.16.1.1 [14:22:36.257 EET Sat Apr 11 2020] 172.16.1.1 [14:21:36.255 EET Sat Apr 11
2020] 172.16.1.1 [14:20:36.256 EET Sat Apr 11 2020] 172.16.1.1 [14:19:36.258 EET Sat Apr
11 2020] Recent error sources:
Number of control v2 message received: 0
Number of errors: 0
Recent sources: Recent error sources:
Permanent Port IP SLA Responder Permanent Port IP SLA Responder is: Enabled udpEcho
Responder: IP Address Port 172.16.1.1 5000
ALS2 Switch>en Switch#conf t Enter configuration commands, one per line. End with
CRTL/Z. Switch(config)#hostname ALS2
ALS2(config)#interface vlan 1
ALS2(config-if)#ip address 172.16.1.102 255.255.255.0
ALS2(config-if)#no shutdown
ALS2(config-if)#exit
ALS2(config)#ip default-gateway 172.16.1.1 Configure the trunks and EtherChannel between
ALS2 and ALS1
ALS2(config)#interface range e0/0-1
ALS2(config-if-range)#switchport trunk encapsulation dot1q
ALS2(config-if-range)#switchport mode trunk
ALS2(config-if-range)#channel-group 2 mode desirable Creating a port-channel interface
Port-channel 2
```

```
ALS2(config-if-range)#exit Configure the trunks and EtherChannel between ALS2 and DLS1
ALS2(config)#interface range e0/2-3
ALS2(config-if-range)#switchport trunk encapsulation dot1q
ALS2(config-if-range)#switchport mode trunk
ALS2(config-if-range)#channel-group 1 mode desirable Creating a port-channel interface
Port-channel 1
ALS2(config-if-range)#exit Configure VTP on ALS2
ALS2(config)#vtp mode
client Setting device to VTP Client mode for VLANS
ALS2(config)#int e1/0 ALS2(config-if)#switchport mode access
ALS2(config-if)#switchport access vlan 200
ALS2(config-if)#exit Configure Cisco IOS IP SLA responders.
ALS2(config)#ip sla responder
ALS2(config)#ip sla responder udp-echo ipaddress 172.16.1.1 port 5000
```

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```

DLS1 Switch>enable
Switch#conf t
Switch(config)#hostname DLS1
DLS1(config)#interface loopback 1
DLS1(config-if)#ip address 172.16.1.1 255.255.255.0
DLS1(config-if)#exit
DLS1(config)#interface vlan 99
DLS1(config-if)#ip address 10.1.99.1 255.255.255.0
DLS1(config-if)#no shutdown
Implement a Layer 3
EtherChannel DLS1(config)#int
range e0/2-3 DLS1(config-if-
range)#no switchport DLS1(config-
if-range)#no ip address
DLS1(config-if-range)#channel-group 2 mode on Creating a port-channel interface Port-
channel 2 DLS1(config-if-range)#exit
DLS1(config)#interface port-channel 2
DLS1(config-if)#ip address 172.16.12.1 255.255.255.252
DLS1(config-if)#end
DLS1(config)#int range e0/0-1
DLS1(config-if-range)#switchport trunk encapsulation dot1q
DLS1(config-if-range)#switchport mode trunk

```

```
DLS1(config-if-range)#channel-group 1 mode desirable Creating a port-channel interface
Port-channel 1
DLS1(config-if-range)#end
DLS1#sh interfaces trunk Port Mode Encapsulation Status Native vlan Po1 on 802.1q
trunking 1 Port Vlans allowed on trunk Po1 1-4094 Port Vlans allowed and active in
management domain Po1 1,99 Port Vlans in spanning tree forwarding state and not pruned
Po1 1,99 Implement Static Routing DLS1(config)#ip routing
DLS1(config)#ip route 192.168.1.0 255.255.255.252 172.16.12.2
DLS1(config)# ip route 192.168.1.0 255.255.255.0 10.1.120.1
DLS1(config)# ip route 192.168.1.0 255.255.255.0 10.1.110.1
DLS1#sh ip route Codes: L - local, C - connected, S - static, R - RIP, M - mobile, B - BGP D -
EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area N1 - OSPF NSSA external type 1,
N2
- OSPF NSSA external type 2 E1 - OSPF external type 1, E2 - OSPF external type 2 i - IS-IS, su
- IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2 ia - IS-IS inter area, * - candidate
default, U - per-user static route o - ODR, P - periodic downloaded static route, H - NHRP, l
- LISP a - application route + - replicated route, % - next hop override
Gateway of last resort is not set 10.0.0.0/8 is variably subnetted, 2 subnets, 2
masks C 10.1.99.0/24 is directly connected, Vlan99
L 10.1.99.1/32 is directly connected, Vlan99 172.16.0.0/16 is variably subnetted, 4
subnets, 3 masks C 172.16.1.0/24 is directly connected, Loopback1
L 172.16.1.1/32 is directly connected, Loopback1
C 172.16.12.0/30 is directly connected, Port-channel2
L 172.16.12.1/32 is directly connected, Port-channel2 192.168.1.0/30 is subnetted, 1
subnets S 192.168.1.0 [1/0] via 172.16.12.2
DLS2 Switch>en Switch#conf t
Switch(config)#hostname DLS2
DLS2(config)#interface loopback 1
DLS2(config-if)#ip address 192.168.1.1 255.255.255.0
DLS2(config-if)#exit
DLS2(config)#interface vlan 110
DLS2(config-if)#ip address 10.1.110.1 255.255.255.0
DLS2(config-if)#no shutdown
DLS2(config-if)#exi
t DLS2(config)#interface vlan 120
DLS2(config-if)#ip address 10.1.120.1 255.255.255.0
DLS2(config-if)#no shutdown
DLS2(config-if)#exit Implement a Layer 3 EtherChannel
DLS2(config)#interface range e0/2-3
DLS2(config-if-range)#no switchport
DLS2(config-if-range)#no ip
DLS2(config-if-range)#no ip address
DLS2(config-if-range)#channel-group 2 mode on Creating a port-channel interface Port-
channel 2 DLS2(config-if-range)#exit
DLS2(config)#interface port-channel 2
DLS2(config-if)#ip address 172.16.12.2 255.255.255.252
DLS2(config-if)#end DLS2(config)#interface range e0/0-1
DLS2(config-if-range)#switchport trunk encapsulation dot1q
```

```

DLS2(config-if-range)#switchport mode trunk
DLS2(config-if-range)#channel-group 3 mode desirable Creating a port-channel interface
Port-channel 3
DLS2(config-if-range)#exit
DLS2(config)#interface range e1/0-1
DLS2(config-if-range)#switchport trunk encapsulation dot1q
DLS2(config-if-range)#switchport mode trunk
DLS2(config-if-range)#channel-group 4 mode desirable Creating a port-channel interface
Port-channel 4
DLS2(config-if-range)#end
DLS2#sh interfaces trunk Port Mode Encapsulation Status Native vlan Po3 on 802.1q
trunking 1 Po4 on 802.1q trunking 1 Port Vlans allowed on trunk Po3 1-4094 Po4 1-4094
Port Vlans allowed and active in management domain Po3 1,110,120 Po4 1,110,120 Port
Vlans in spanning tree forwarding state and not pruned Po3 1,110,120 Po4 1,110,120
Implement Static Routing DLS2(config)#ip routing DLS2(config)#ip route 172.16.1.0
255.255.255.252 172.16.12.1
DLS2(config)# ip route 172.16.1.0 255.255.255.0 10.1.99.1 Configure the host ports for the
appropriate VLANs according to the diagram
DLS2(config)#interface e1/2
DLS2(config-if)#switchport mode access
DLS2(config-if)#switchport access vlan 110
DLS2#sh ip route
Codes: L - local, C - connected, S - static, R - RIP, M - mobile, B - BGP D - EIGRP, EX - EIGRP
external, O - OSPF, IA - OSPF inter area N1 - OSPF NSSA external type 1, N2 - OSPF NSSA
external type 2 E1 - OSPF external type 1, E2 - OSPF external type 2 i - IS-IS, su - IS-IS
summary, L1 - IS-IS level-1, L2 - IS-IS level-2 ia - IS-IS inter area, * - candidate default, U -
per- user static route o - ODR, P - periodic downloaded static route, H - NHRP, l - LISP a -
application route + - replicated route, % - next hop override
Gateway of last resort is not set 10.0.0.0/8 is variably subnetted, 4 subnets, 2
masks C 10.1.110.0/24 is directly connected, Vlan110
L 10.1.110.1/32 is directly connected, Vlan110
C 10.1.120.0/24 is directly connected, Vlan120
L 10.1.120.1/32 is directly connected, Vlan120 172.16.0.0/16 is variably subnetted, 3
subnets, 2 masks S 172.16.1.0/30 [1/0] via 172.16.12.1
C 172.16.12.0/30 is directly connected, Port-channel2
L 172.16.12.2/32 is directly connected, Port-channel2 192.168.1.0/24 is variably
subnetted, 2 subnets, 2 masks
C 192.168.1.0/24 is directly connected, Loopback1
L 192.168.1.1/32 is directly connected, Loopback1 ALS1
Switch>en Switch#conf t S
witch(config)#hostname ALS1
ALS1(config)#ip default-gateway 10.1.99.1
ALS1(config)#ip default-gateway 10.1.110.1
ALS1(config)#ip default-gateway 10.1.100.2 Implement a Layer 3 EtherChannel
ALS1(config)#int range e0/0-1
ALS1(config-if-range)#switchport trunk encapsulation dot1q
ALS1(config-if-range)#switchport mode trunk

```

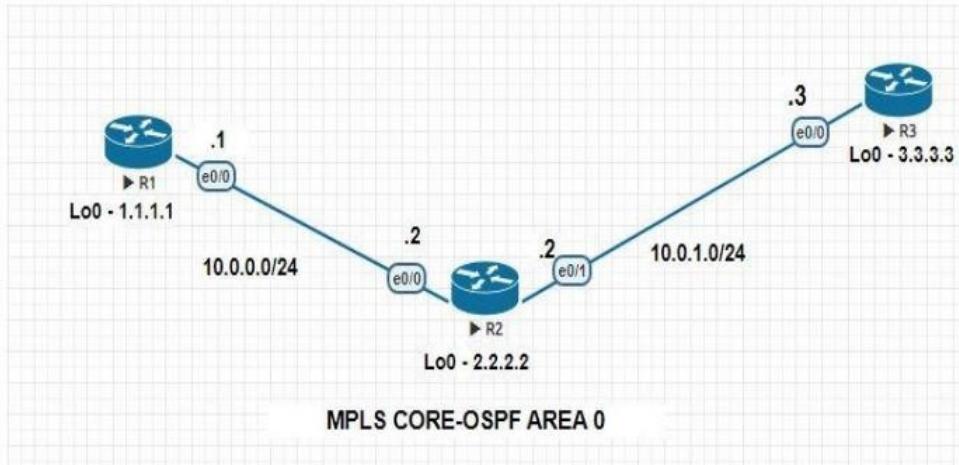
```

ALS1(config-if-range)#channel-group 1 mode desirable Creating a port-channel interface
Port-channel 1
ALS1(config-if-range)#exit
ALS1(config)#int range e0/2-3
ALS1(config-if-range)#switchport trunk encapsulation dot1q
ALS1(config-if-range)#switchport mode trunk
ALS1(config-if-range)#channel-group 4 mode desirable Creating a port-channel interface
Port-channel 4
ALS1(config-if-range)#end
ALS1#sh etherchannel summary
Flags: D - down P - bundled in port-channel I - stand-alone s - suspended H - Hot-standby
(LACP only) R - Layer3 S - Layer2 U - in use N - not in use, no aggregation f - failed to
allocate aggregator M - not in use, minimum links not met m - not in use, port not
aggregated due to minimum links not met u - unsuitable for bundling w - waiting to be
aggregated d - default port A - formed by Auto LAG Number of channel-groups in use: 2
Number of aggregators: 2
Group Port-channel Protocol Ports -----+-----+-----+
-----1 Po1(SU) PAgP Et0/0(P) Et0/1(P) 4 Po4(SU) PAgP Et0/2(P) Et0/3(P)
Configure the host ports for the appropriate VLANs according to the diagram
ALS1(config)#interface e1/0
ALS1(config-if)#switchport mode access
ALS1(config-if)#switchport access vlan 100 ALS2
Switch>en Switch#conf t
Switch(config)#hostname ALS2
ALS2(config)#ip default-gateway 10.1.120.1 Implement a Layer 3 EtherChannel
ALS2(config)#int range e0/0-1
ALS2(config-if-range)#switchport trunk encapsulation dot1q
ALS2(config-if-range)#switchport mode trunk
ALS2(config-if-range)#channel-group 3 mode desirable Creating a port-channel interface
Port-channel 3
ALS2(config-if-range)#end
ALS2#sh etherchannel summary
Flags: D - down P - bundled in port-channel I - stand-alone s - suspended H - Hot-standby
(LACP only) R - Layer3 S - Layer2 U - in use N - not in use, no aggregation f - failed to
allocate aggregator M - not in use, minimum links not met m - not in use, port not
aggregated due to minimum links not met u - unsuitable for bundling w - waiting to be
aggregated d - default port A - formed by Auto LAG Number of channel-groups in use: 1
Number of aggregators: 1
Group Port-channel Protocol Ports -----+-----+-----+
-----3 Po3(SU) PAgP Et0/0(P) Et0/1(P) Configure the host ports for the appropriate VLANs
according to the diagram
ALS2(config)#interface e0/2
ALS2(config-if)#switchport mode access
ALS2(config-if)#switchport access vlan 120 HOST A VPCS> ip 10.1.100.1 255.255.255.0
10.1.100.2 HOST B
VPCS> ip 10.1.120.2 255.255.255.0 10.1.120.1 HOST D
VPCS> ip 10.1.110.2 255.255.255.0 10.1.110.1

```

Practical 8

NETWORK TOPOLOGY



```
R1 Router>enable
Router#conf t
Router(config)#hostname R1
R1(config)# interface loopback 0
R1(config-if)#ip address 1.1.1.1 255.255.255.255
R1(config-if)#exit R1(config)#int e0/0
R1(config-if)#ip address 10.0.0.1
255.255.255.0 R1(config-if)#no shut
R1(config)#router ospf 1
R1(config-router)#network 1.1.1.0 0.0.0.255 area 0
R1(config-router)#network 10.0.0.0 0.0.0.255 area
0 R1(config-router)#exit R
1#show ip route ospf
Codes: L - local, C - connected, S - static, R - RIP, M - mobile, B - BGP D - EIGRP, EX - EIGRP
external, O - OSPF, IA - OSPF inter area N1 - OSPF NSSA external type 1, N2 - OSPF NSSA
external type 2 E1 - OSPF external type 1, E2 - OSPF external type 2 i - IS-IS, su - IS-IS
summary, L1 - IS-IS level-1, L2 - IS-IS level-2 ia - IS-IS inter area, * - candidate default, U -
per- user static route o - ODR, P - periodic downloaded static route, H - NHRP, l - LISP a -
application route + - replicated route, % - next hop override
Gateway of last resort is not set
2.0.0.0/32 is subnetted, 1 subnets O 2.2.2.2 [110/11] via 10.0.0.2, 00:15:40, Ethernet0/0
3.0.0.0/32 is subnetted, 1 subnets
O 3.3.3.3 [110/21] via 10.0.0.2, 00:04:01, Ethernet0/0 10.0.0.0/8 is variably subnetted, 3
subnets, 2 masks
O 10.0.1.0/24 [110/20] via 10.0.0.2, 00:09:25, Ethernet0/0
R1#sh ip cef Prefix Next Hop Interface 0.0.0.0/0 no route 0.0.0.0/8 drop 0.0.0.0/32
```

```
receive 1.1.1.1/32 receive Loopback0 2.2.2.2/32 10.0.0.2
Ethernet0/0 3.3.3.3/32 10.0.0.2 Ethernet0/0 10.0.0.0/24 attached Ethernet0/0 10.0.0.0/32
receive Ethernet0/0 10.0.0.1/32 receive Ethernet0/0 10.0.0.2/32 attached Ethernet0/0
10.0.0.255/32 receive Ethernet0/0 10.0.1.0/24 10.0.0.2
Ethernet0/0 127.0.0.0/8 drop 224.0.0.0/4 drop 224.0.0.0/24 receive 240.0.0.0/4
drop 255.255.255.255/32 receive
R1#sh ip route 2.2.2.2
Routing entry for 2.2.2.2/32 Known via "ospf 1", distance 110, metric 11, type intra area
Last update from 10.0.0.2 on Ethernet0/0, 00:30:34 ago Routing Descriptor Blocks: *
10.0.0.2, from 2.2.2.2, 00:30:34 ago, via Ethernet0/0 Route metric is 11, traffic share count
is 1 R1#sh ip route 3.3.3.3 Routing entry for 3.3.3.3/32 Known via "ospf 1", distance 110,
metric 21, type intra area Last update from 10.0.0.2 on Ethernet0/0, 00:11:43 ago Routing
Descriptor Blocks: * 10.0.0.2, from 3.3.3.3, 00:11:43 ago, via Ethernet0/0 Route metric is
21, traffic share count is 1 R1#sh ip cef 2.2.2.2 2.2.2.2/32 nexthop 10.0.0.2 Ethernet0/0
R1#sh ip cef 3.3.3.3 3.3.3.3/32 nexthop 10.0.0.2 Ethernet0/0
R1(config)#mpls label range 100 199
R1(config)#mpls label protocol ldp
R1(config)#mpls ldp router-id loopback 0
R1(config)#int e0/0
R1(config-if)#mpls ip
R1#sh mpls interfaces Interface IP Tunnel BGP Static Operational Ethernet0/0 Yes (ldp) No
No No Yes
R1#sh mpls ldp neighbor Peer LDP Ident: 2.2.2.2:0; Local LDP Ident 1.1.1.1:0 TCP connection:
2.2.2.2.27963 - 1.1.1.1.646 State: Oper; Msgs sent/rcvd: 13/14; Downstream Up time:
00:05:21 LDP discovery sources: Ethernet0/0, Src IP addr: 10.0.0.2 Addresses bound to peer
LDP Ident: 10.0.0.2 10.0.1.2 2.2.2.2
R1#sh ip cef 3.3.3.3 3.3.3.3/32 nexthop 10.0.0.2 Ethernet0/0 label
201 R1#sh ip cef 2.2.2.2 2.2.2.2/32 nexthop 10.0.0.2 Ethernet0/0
R1#sh mpls forwarding-table
Local Outgoing Prefix Bytes Label Outgoing Next Hop Label Label or Tunnel Id Switched
interface 100 Pop Label 2.2.2.2/32 0 Et0/0 10.0.0.2 101 201 3.3.3.3/32 0 Et0/0 10.0.0.2
102
Pop Label 10.0.1.0/24 0 Et0/0 10.0.0.2
R1#sh mpls ldp bindings lib entry: 1.1.1.1/32, rev 2
local binding: label: imp-null
remote binding: lsr: 2.2.2.2:0, label: 200
lib entry: 2.2.2.2/32, rev 4 local binding: label: 100 remote binding: lsr: 2.2.2.2:0, label: imp-
null
lib entry: 3.3.3.3/32, rev 6 local binding: label: 101 remote binding: lsr: 2.2.2.2:0, label:
201 lib entry: 10.0.0.0/24, rev 8 local binding: label: imp-null remote binding: lsr: 2.2.2.2:0,
label: imp-null lib entry: 10.0.1.0/24, rev 10 local binding: label: 102 remote binding: lsr:
2.2.2.2:0, label: imp-null
R1#ping 3.3.3.3 source 10.0.0.1
Type escape sequence to abort. Sending 5, 100-byte
ICMP Echos to 3.3.3.3, timeout is 2 seconds:
Packet sent with a source address of 10.0.0.1 !!!! Success rate is 100 percent (5/5), round-
trip min/avg/max = 1/1/2 ms
R1#traceroute 3.3.3.3 source 10.0.0.1 Type escape sequence to abort.
```

Tracing the route to 3.3.3.3 VRF info: (vrf in name/id, vrf out name/id) 1 10.0.0.2 [MPLS:
Label 201 Exp 0] 1 msec 1 msec 0 msec 2 10.0.1.3 1 msec 2 msec
* R1#ping 2.2.2.2 source 10.0.0.1 Type escape sequence to abort. Sending 5, 100-byte ICMP
Echos to 2.2.2.2, timeout is 2 seconds:
Packet sent with a source address of 10.0.0.1 !!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 5/5/6 ms R1#traceroute
2.2.2.2 source 10.0.0.1 Type escape sequence to abort.
Tracing the route to 2.2.2.2 VRF info: (vrf in name/id, vrf out name/id) 1 10.0.0.2 2 msec 1
msec
* R2
Router>enable
Router#conf t
Router(config)#hostname R2
R2(config)# interface loopback 0
R2(config-if)#ip address 2.2.2.2 255.255.255.255
R2(config-if)# exit
R2(config)#int e0/0
R2(config-if)#ip address 10.0.0.2 255.255.255.0 R2(config-if)#no shut
R2(config)#int e0/1
R2(config-if)#ip address 10.0.1.2
255.255.255.0 R2(config-if)#no shut
R2(config)#router ospf 1
R2(config-router)#network 2.2.2.0 0.0.0.255 area 0
R2(config-router)#network 10.0.0.0 0.0.0.255 area 0 R2(config-router)#network 10.0.1.0
0.0.0.255 area 0
R2(config-router)#exit
R2#show ip route
ospf Codes: L - local, C - connected, S - static, R - RIP, M - mobile, B - BGP D - EIGRP, EX -
EIGRP external, O - OSPF, IA - OSPF inter area N1 - OSPF NSSA external type 1, N2 - OSPF
NSSA external type 2 E1 - OSPF external type 1, E2 - OSPF external type 2 i - IS-IS, su - IS-IS
summary, L1 - IS-IS level-1, L2 - IS-IS level-2 ia - IS-IS inter area, * - candidate default, U -
per- user static route o - ODR, P - periodic downloaded static route, H - NHRP, l - LISP a -
application route + - replicated route, % - next hop override
Gateway of last resort is not set
1.0.0.0/32 is subnetted, 1 subnets 0 1.1.1.1 [110/11] via 10.0.0.1, 00:15:32, Ethernet0/0
3.0.0.0/32 is subnetted, 1 subnets 0 3.3.3.3 [110/11] via 10.0.1.3, 00:03:58, Ethernet0/1
R2#sh ip cef Prefix Next Hop Interface 0.0.0.0/0 no route 0.0.0.0/8 drop 0.0.0.0/32
receive 1.1.1.1/32 10.0.0.1 Ethernet0/0 2.2.2.2/32
receive Loopback0 3.3.3.3/32 10.0.1.3 Ethernet0/1 10.0.0.0/24 attached Ethernet0/0
10.0.0.0/32
receive Ethernet0/0 10.0.0.1/32 attached Ethernet0/0 10.0.0.2/32
receive Ethernet0/0 10.0.0.255/32
receive Ethernet0/0 10.0.1.0/24 attached Ethernet0/1 10.0.1.0/32
receive Ethernet0/1 10.0.1.2/32
receive Ethernet0/1 10.0.1.3/32 attached Ethernet0/1 10.0.1.255/32 r
eceive Ethernet0/1 127.0.0.0/8 drop 224.0.0.0/4 drop 224.0.0.0/24
receive 240.0.0.0/4 drop 255.255.255.255/32 receive

```
R2#sh ip route 1.1.1.1
Routing entry for 1.1.1.1/32 Known via "ospf 1", distance 110, metric 11, type intra area
Last update from 10.0.0.1 on Ethernet0/0, 00:33:11 ago
Routing Descriptor Blocks: * 10.0.0.1, from 1.1.1.1, 00:33:11 ago, via Ethernet0/0 Route
metric is 11, traffic share count is 1
R2#sh ip route 3.3.3.3
Routing entry for 3.3.3.3/32 Known via "ospf 1", distance 110, metric 11, type intra area
Last update from 10.0.1.3 on Ethernet0/1, 00:21:49 ago R
outing Descriptor Blocks: * 10.0.1.3, from 3.3.3.3, 00:21:49 ago, via Ethernet0/1 Route
metric is 11, traffic share count is 1
R2#sh ip cef 1.1.1.1 1.1.1.1/32 nexthop 10.0.0.1 Ethernet0/0 R2#sh ip cef 3.3.3.3 3.3.3.3/32
nexthop 10.0.1.3 Ethernet0/1
R2(config)#mpls label range 200 299
R2(config)#mpls label protocol ldp
R2(config)#mpls ldp router-id loopback 0
R2(config)#int e0/0
R2(config-if)#mpls
ip R2(config-if)#int
e0/1 R2(config-
if)#mpls ip R2#sh
mpls interfaces
Interface IP Tunnel BGP Static Operational Ethernet0/0 Yes (ldp) No No No Yes Ethernet0/1
Yes (ldp) No No No Yes
R2#sh mpls forwarding-table
Local Outgoing Prefix Bytes Label Outgoing Next Hop Label Label or Tunnel Id Switched
interface 200 Pop Label 1.1.1.1/32 0 Et0/0 10.0.0.1 201 Pop Label 3.3.3.3/32 1266 Et0/1
10.0.1.3
R2#sh mpls ldp neighbor
Peer LDP Ident: 1.1.1.1:0; Local LDP Ident 2.2.2.2:0 TCP connection: 1.1.1.1.646 -
2.2.2.2.27963 State: Oper; Msgs sent/rcvd: 41/42; Downstream Up time: 00:29:24 LDP
discovery sources: Ethernet0/0, Src IP addr: 10.0.0.1 Addresses bound to peer LDP Ident:
10.0.0.1 1.1.1.1 Peer LDP Ident: 3.3.3.3:0; Local LDP Ident 2.2.2.2:0 TCP connection:
3.3.3.3.44196 - 2.2.2.2.646 State: Oper; Msgs sent/rcvd: 38/38; Downstream Up time:
00:27:24 LDP discovery sources: Ethernet0/1, Src IP addr: 10.0.1.3 Addresses bound to peer
LDP Ident: 10.0.1.3 3.3.3.3
R2#sh mpls ldp bindings
lib entry: 1.1.1.1/32, rev 2 local binding: label: 200 remote binding: lsr: 1.1.1.1:0, label: imp-
null remote binding: lsr: 3.3.3.3:0, label: 300
lib entry: 2.2.2.2/32, rev 4 local binding: label: imp-null remote binding: lsr: 1.1.1.1:0, label:
100 remote binding: lsr: 3.3.3.3:0, label: 301
lib entry: 3.3.3.3/32, rev 6 local binding: label: 201 remote binding: lsr: 1.1.1.1:0, label: 101
remote binding: lsr: 3.3.3.3:0, label: imp-null
lib entry: 10.0.0.0/24, rev 8 local binding: label: imp-null remote binding: lsr: 1.1.1.1:0, label:
imp-null remote binding: lsr: 3.3.3.3:0, label: 302
lib entry: 10.0.1.0/24, rev 10 local binding: label: imp-null remote binding: lsr: 1.1.1.1:0,
label: 102 remote binding: lsr: 3.3.3.3:0, label: imp-null
R2#ping 1.1.1.1 source 10.0.0.2
```

Type escape sequence to abort. Sending 5, 100-byte ICMP Echos to 1.1.1.1, timeout is 2 seconds:

Packet sent with a source address of 10.0.0.2 !!!!

Success rate is 100 percent (5/5), round-trip min/avg/max = 1/1/1 ms

R2#traceroute 1.1.1.1 source 10.0.0.2 Type escape sequence to abort. Tracing the route to 1.1.1.1

VRF info: (vrf in name/id, vrf out name/id) 1 10.0.0.1 2 msec 1 msec *

R2#ping 3.3.3.3 source 10.0.1.2 Type escape sequence to abort. Sending 5, 100-byte ICMP Echos to 3.3.3.3, timeout is 2 seconds:

Packet sent with a source address of 10.0.1.2 !!!! Success rate is 100 percent (5/5), round-trip min/avg/max = 1/1/1 ms

R2#traceroute 3.3.3.3 source 10.0.1.2 Type escape sequence to abort. Tracing the route to 3.3.3.3 VRF info: (vrf in name/id, vrf out name/id) 1 10.0.1.3 0 msec 1 msec *

R3

Router>enable Router#conf t

Router(config)#hostname R

3 R3(config)#interface loopback 0

R3(config-if)#ip address 3.3.3.3 255.255.255.255

R3(config-if)#exit

R3(config)#int e0/0

R3(config-if)#ip address 10.0.1.3

255.255.255.0 R3(config-if)#no shu

t R3(config-if)#exit

R3(config)#router ospf 1

R3(config-router)#network 3.3.3.0 0.0.0.255 area 0

R3(config-router)#network 10.0.1.0 0.0.0.255 area

0 R3(config-router)#exit

R3#sh ip route osp

f Codes: L - local, C - connected, S - static, R - RIP, M - mobile, B - BGP D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2 E1 - OSPF external type 1, E2 - OSPF external type 2 i - IS-IS, su - IS-IS summary,

L1 - IS-IS level-1, L2 - IS-IS level-2 ia - IS-IS inter area, * - candidate default, U - per-user static route o - ODR, P - periodic downloaded static route, H - NHRP, l - LISP a - application route +

- replicated route, % - next hop override

Gateway of last resort is not set

1.0.0.0/32 is subnetted, 1 subnets O 1.1.1.1 [110/21] via 10.0.1.2, 00:03:45,

Ethernet0/0 2.0.0.0/32 is subnetted, 1 subnets O 2.2.2.2 [110/11] via 10.0.1.2, 00:03:45,

Ethernet0/0 10.0.0.0/8 is variably subnetted, 3 subnets, 2 masks O 10.0.0.0/24 [110/20] via 10.0.1.2, 00:03:45,

Ethernet0/0

R3#sh ip cef

Prefix

Next Hop Interface 0.0.0.0/0 no route 0.0.0.0/8 drop 0.0.0.0/32 receive 1.1.1.1/32 10.0.1.2

Ethernet0/0 2.2.2.2/32 10.0.1.2 Ethernet0/0 3.3.3.3/32 receive Loopback0 10.0.0.0/24

10.0.1.2 Ethernet0/0 10.0.1.0/24 attached

Ethernet0/0 10.0.1.0/32 receive Ethernet0/0 10.0.1.2/32 attached Ethernet0/0 10.0.1.3/32 receive Ethernet0/0 10.0.1.255/32 receive

Ethernet0/0 127.0.0.0/8 drop 224.0.0.0/4 drop 224.0.0.0/24 receive 240.0.0.0/4 drop
255.255.255.255/32 receive

R3#sh ip route 1.1.1.1

Routing entry for 1.1.1.1/32 Known via "ospf 1", distance 110, metric 21, type intra area
Last update from 10.0.1.2 on Ethernet0/0, 00:23:51 ago Routing Descriptor Blocks: *
10.0.1.2, from 1.1.1.1, 00:23:51 ago, via Ethernet0/0 Route metric is 21, traffic share
count is 1

R3#sh ip route 2.2.2.2 Routing entry for 2.2.2.2/32 Known via "ospf 1", distance 110, metric
11, type intra area Last update from 10.0.1.2 on Ethernet0/0, 00:23:58 ago Routing
Descriptor Blocks: * 10.0.1.2, from 2.2.2.2, 00:23:58 ago, via Ethernet0/0 Route metric is
11, traffic share count is 1

R3#sh ip cef 1.1.1.1 1.1.1.1/32 nexthop 10.0.1.2 Ethernet0/0

R3#sh ip cef 2.2.2.2 2.2.2.2/32 nexthop 10.0.1.2 Ethernet0/0

R3(config)#mpls label range 300 399

R3(config)#mpls lab

el protocol ldp

R3(config)#mpls ldp router-id loopback 0

R3(config)#int e0/0

R3(config-if)#mpls ip R3#sh mpls interfaces Interface IP Tunnel BGP Static Operational

Ethernet0/0 Yes (ldp) No No No Yes R3#sh mpls ldp binding

lib entry: 1.1.1.1/32, rev 2 local binding: label: 300 remote
binding: lsr: 2.2.2.2:0, label: 200 lib entry: 2.2.2.2/32, rev 4 local
binding: label: 301 remote binding: lsr: 2.2.2.2:0, label: imp-null lib entry: 3.3.3.3/32,
rev 6 local binding: label: imp-null remote binding: lsr: 2.2.2.2:0, label: 201 lib
entry: 10.0.0.0/24,
rev 8 local binding: label: 302 remote binding: lsr: 2.2.2.2:0, label: imp-null lib entry:
10.0.1.0/24,
rev 10 local binding: label: imp-null remote binding: lsr: 2.2.2.2:0, label: imp-null

R3#sh mpls ldp neighbor Peer LDP Ident: 2.2.2.2:0; Local LDP Ident 3.3.3.3:0
TCP connection: 2.2.2.2.646 - 3.3.3.3.44196 State: Oper; Msgs sent/rcvd: 51/51;
Downstream Up time: 00:38:15
LDP discovery sources:
Ethernet0/0, Src IP addr: 10.0.1.2 Addresses bound to peer LDP Ident: 10.0.0.2 10.0.1.2
2.2.2.2

R3#sh mpls forwarding-table

Local Outgoing Prefix

Bytes

Label Outgoing Next Hop Label Label or Tunnel Id Switched interface 300 200 1.1.1.1/32 0
Et0/0 10.0.1.2 301 Pop Label 2.2.2.2/32 0 Et0/0 10.0.1.2 302 Pop Label 10.0.0.0/24 0 Et0/0
10.0.1.2

R3#sh ip cef 1.1.1.1 1.1.1.1/32 nexthop 10.0.1.2 Ethernet0/0 label
200 R3#sh ip cef 2.2.2.2 2.2.2.2/32 nexthop 10.0.1.2 Ethernet0/0

R3#ping 1.1.1.1 source 10.0.1.3 Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 1.1.1.1, timeout is 2 seconds: Packet sent with a source
address of 10.0.1.3 !!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 1/1/3 ms R3#traceroute
1.1.1.1 source 10.0.1.3
Type escape sequence to abort.

Tracing the route to 1.1.1.1

VRF info:

(vrf in name/id, vrf out name/id) 1 10.0.1.2 [MPLS: Label 200 Exp 0] 1 msec 2 msec 1 msec 2
10.0.0.1 2 msec 2 msec *

R3#ping 2.2.2.2 source 10.0.1.3 Type escape sequence to abort.

Sending 5, 100-byte ICMP Echos to 2.2.2.2, timeout is 2 seconds:

Packet sent with a source address of 10.0.1.3 !!!!

Success rate is 100 percent (5/5), round-trip min/avg/max = 1/1/1 ms

R3#traceroute 2.2.2.2

source 10.0.1.3

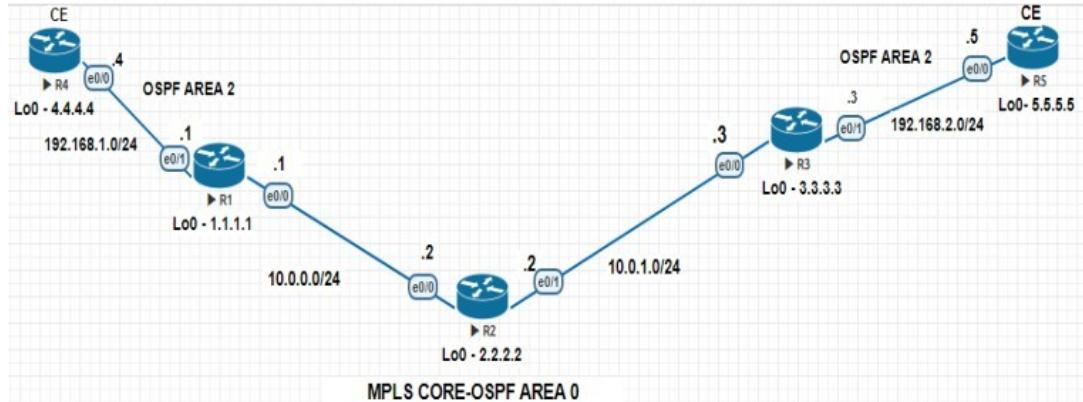
Type escape sequence to abort. Tracing the route to 2.2.2.2

VRF info:

(vrf in name/id, vrf out name/id) 1 10.0.1.2 2 msec 2 msec *

Practical 9

NETWORK TOPOLOGY



R1

```

Router>enable
Router#conf t
Router(config)#hostname R1
R1(config)# interface loopback 0
R1(config-if)#ip address 1.1.1.1 255.255.255.255
R1(config-if)#exit
R1(config)#int e0/0
R1(config-if)#ip address 10.0.0.1
255.255.255.0 R1(config-if)#no shut
R1(config)#int e0/1
R1(config-if)#ip address 192.168.1.1 255.255.255.0
R1(config-if)#no shut
R1(config)#router ospf 1
R1(config-router)#network 1.1.1.0 0.0.0.255 area 0
R1(config-router)#network 10.0.0.0 0.0.0.255 area 0 R1(config-router)#exit
R1(config)#mpls label range 100 199
R1(config)#mpls label protocol ldp
R1(config)#mpls ldp router-id loopback 0
R1(config)#int e0/0
R1(config-if)#mpls ip
R1(config)#ip vrf A-1
R1(config-vrf)#rd 500:1
R1(config-vrf)#route-target import 500:1
R1(config-vrf)#route-target export 500:1
R1(config-vrf)#exit
R1(config)#exit
R1#sh ip vrf Name Default RD Interfaces A-1 500:1 R1#sh ip vrf detail VRF A-1 (VRF Id = 1);
default RD 500:1;

```

default VPNID Old CLI format, supports IPv4 only Flags: 0xC No interfaces Address family
ipv4 unicast (Table ID = 0x1): Flags: 0x0 Export VPN route-target communities RT:500:1
Import VPN route-target communities RT:500:1 No import route-map No global export
route-map No export route-map VRF label distribution protocol: not configured VRF label
allocation mode: per-prefix

```
R1(config)#int e0/1
R1(config-if)#ip vrf forwarding A-1 % Interface Ethernet0/1 IPv4 disabled and address(es)
removed due to enabling VRF A-1 R1(config-if)#ip address 192.168.1.1 255.255.255.0
R1(config-if)#end
R1#sh ip route vrf A-1
Routing Table: A-1 Codes: L - local, C - connected, S - static, R - RIP, M - mobile, B - BGP D -
EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area N1 - OSPF NSSA external type 1,
N2
- OSPF NSSA external type 2 E1 - OSPF external type 1, E2 - OSPF external type 2 i - IS-IS, su
- IS-IS
summary,
L1 - IS-IS level-1, L2 - IS-IS level-2 ia - IS-IS inter area, * - candidate default, U - per-user
static route o - ODR, P - periodic downloaded static route, H - NHRP, l - LISP a - application
route +
- replicated route, % - next hop
override Gateway of last resort is not
set
192.168.1.0/24 is variably subnetted, 2 subnets, 2 masks
C 192.168.1.0/24 is directly connected, Ethernet0/1
L 192.168.1.1/32 is directly connected, Ethernet0/1
R1#sh ip vrf Name Default RD Interfaces A-1 500:1 Et0/1
R1(config)#router ospf 10 vrf A-1
R1(config-router)#network 192.168.1.0 0.0.0.255 area 10
R1(config-router)#end
R1#sh ip ospf neighbor Neighbor ID Pri State Dead Time Address In
terface 2.2.2.2 1 FULL/DR 00:00:39 10.0.0.2 Ethernet0/0 4.4.4.4 1 FULL/DR 00:00:38
192.168.1.4 Ethernet0/1 R1#sh ip ospf 10 neighbor Neighbor ID Pri State Dead Time Address
Interface 4.4.4.4 1 FULL/DR 00:00:38 192.168.1.4 Ethernet0/1
R1#sh ip route vrf A-1 ospf
Routing Table: A-1 Codes: L - local, C - connected, S - static, R - RIP, M - mobile, B - BGP D -
EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area N1 - OSPF NSSA external type 1,
N2
- OSPF NSSA external type 2 E1 - OSPF external type 1, E2 - OSPF external type 2 i - IS-IS, su
- IS-IS
summary,
L1 - IS-IS level-1,
L2 - IS-IS level-2 ia - IS-IS inter area,
* - candidate default,
U - per-user static route o - ODR
, P - periodic downloaded static route, H -
NHRP, l - LISP a - application route +
- replicated route,
% - next hop override Gateway of last resort is not set 4.0.0.0/32 is subnetted, 1 subnets O
4.4.4.4 [110/11] via 192.168.1.4, 00:03:58, Ethernet0/1 R1(config)#router bgp
500 R1(config-router)#no bgp default ipv4-unicast
R1(config-router)#neighbor 3.3.3.3 remote-as 500
```

```
R1(config-router)#neighbor 3.3.3.3 update-source loopback 0
```

```

R1(config-router)#address-family vpng4 unicast
R1(config-router-af)#neighbor 3.3.3.3 activate R1(config-router-af)#neighbor 3.3.3.3 send-
community extended R1(config-router-af)#neighbor 3.3.3.3 next-hop-self R1(config-router-
af)#end
R1#sh ip bgp vpng4 all summary
BGP router identifier 1.1.1.1, local AS number 500 BGP table version is 1, main routing
table version 1 Neighbor V AS MsgRcvd MsgSent TblVer InQ OutQ Up/Down State/PfxRcd
3.3.3.3 4 500 6 7 1 0 0 00:03:19 0
R1(config)#router bgp 500
R1(config-router)#address-family ipv4 vrf A-1
R1(config-router-af)#redistribute ospf 10 vrf A-1 match internal external 1 external
2 R1(config-router-af)#exit R1(config-router)#exit
R1(config)#router ospf 10 vrf A-1
R1(config-router)#redistribute bgp 500 subnets
R1(config-router)#end R1#sh ip bgp vpng4 all BGP table version is 7, local router ID is
1.1.1.1 Status codes: s suppressed, d damped, h history, * valid, > best, i - internal, r RIB-
failure, S Stale, m multipath, b backup-path, f RT-Filter, x best-external, a additional-path,
c RIB- compressed, Origin codes: i - IGP, e - EGP, ? - incomplete RPKI validation codes: V
valid, I invalid, N Not found
Network      Next Hop Metric LocPrf Weight Path Route Distinguisher: 500:1 (default for
vrf A-1)
*> 4.4.4.4/32 192.168.1.4 11          32768 ?
*>i 5.5.5.5/32 3.3.3.3 11   100        0 ?
*> 192.168.1. 0 0.0.0.0    0          32768 ?
*>i 192.168.2.0 3.3.3.3    0          100 0 ?
R1#sh ip route vrf A-1
Routing Table: A-1 Codes: L - local, C - connected, S - static, R - RIP, M - mobile, B - BGP D -
EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area N1 - OSPF NSSA external type 1,
N2
- OSPF NSSA external type 2 E1 - OSPF external type 1, E2 - OSPF external type 2 i - IS-IS, su
- IS-IS
summary,
L1 - IS-IS level-1, L2 - IS-IS level-2 ia - IS-IS inter area, * - candidate default, U - per-user
static route o - ODR, P - periodic downloaded static route, H - NHRP, l - LISP a - application
route +
- replicated route, % - next hop
override Gateway of last resort is
not set
4.0.0.0/32 is subnetted, 1 subnets O 4.4.4.4 [110/11] via 192.168.1.4, 07:36:09, Ethernet0/1
5.0.0.0/32 is subnetted, 1 subnets B 5.5.5.5 [200/11] via 3.3.3.3, 00:06:15 192.168.1.0/24 is
variably subnetted, 2 subnets, 2 masks
C 192.168.1.0/24 is directly connected, Ethernet0/1 L 192.168.1.1/32 is directly connected,
Ethernet0/1 B 192.168.2.0/24 [200/0] via 3.3.3.3, 00:06:15
R1#sh ip route vrf A-1 bgp
Routing Table: A-1 Codes: L - local, C - connected, S - static, R - RIP, M - mobile, B - BGP D -
EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area N1 - OSPF NSSA external type 1,
N2
- OSPF NSSA external type 2 E1 - OSPF external type 1, E2 - OSPF external type 2 i - IS-IS, su
- IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2 ia - IS-IS inter area, * - candidate
default, U - per-user static route o - ODR, P - periodic downloaded static route, H - NHRP, l
- LISP a - application route + - replicated route, % - next hop override

```

```
Gateway of last resort is not set 5.0.0.0/32 is subnetted, 1 subnets B 5.5.5.5 [200/11] via
3.3.3.3, 00:07:31 B 192.168.2.0/24 [200/0] via 3.3.3.3, 00:07:31
R1#ping vrf A-1 4.4.4.4
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 4.4.4.4, timeout is 2 seconds: !!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 1/2/6 ms
R2
Router>enable
Router#conf
t
Router(config)#hostname R2
R2(config)# interface loopback 0
R2(config-if)#ip address 2.2.2.2 255.255.255.255
R2(config-if)# exit
R2(config)#int e0/0
R2(config-if)#ip address 10.0.0.2
255.255.255.0 R2(config-if)#no shut
R2(config)#int e0/1
R2(config-if)#ip address 10.0.1.2
255.255.255.0 R2(config-if)#no shut
R2(config)#router ospf 1
R2(config-router)#network 2.2.2.0 0.0.0.255 area 0
R2(config-router)#network 10.0.0.0 0.0.0.255 area 0
R2(config-router)#network 10.0.1.0 0.0.0.255 area
0 R2(config-router)#exit
R2(config)#mpls label range 200 299 R2(config)#mpls label protocol ldp
R2(config)#mpls ldp router-id loopback 0
R2(config)#int e0/0 R2(config-if)#mpls
ip R2(config-if)#int e0/1
R2(config-if)#mpls ip
R3
Router>enable
Router#conf t
Router(config)#hostname
R3
R3(config)#interface loopback 0
R3(config-if)#ip address 3.3.3.3 255.255.255.255
R3(config-if)#exit
R3(config)#int e0/0
R3(config-if)#ip address 10.0.1.3 255.255.255.0
R3(config-if)#no shut
R3(config-if)#exit
R3(config)#interface e0/1
R3(config-if)#ip address 192.168.2.3 255.255.255.0
R3(config-if)#no shut
R3(config-if)#exit
R3(config)#router ospf 1
R3(config-router)#network 3.3.3.0 0.0.0.255 area 0
```

```

R3(config-router)#network 10.0.1.0 0.0.0.255 area 0
R3(config-router)#exit
R3(config)#mpls label range 300 399
R3(config)#mpls label protocol ldp
R3(config)#mpls ldp router-id loopback 0
R3(config)#int e0/0
R3(config-if)#mpls ip
R3(config)#ip vrf A-2
R3(config-vrf)#rd 500:1
R3(config-vrf)#route-target import 500:1
R3(config-vrf)#route-target export 500:1
R3#sh ip vrf Name Default RD Interfaces A-2 500:1
R3#sh ip vrf detail
VRF A-2 (VRF Id = 1);
default RD 500:1; default VPNID Old CLI format, supports IPv4 only Flags: 0xC No interfaces
Address family ipv4 unicast (Table ID = 0x1): Flags: 0x0 Export VPN route-target
communities RT:500:1 Import VPN route-target communities RT:500:1 No import route-map
No global export route-map No export route-map VRF label distribution protocol: not
configured VRF label allocation mode: per-prefix R3(config)#int e0/1 R3(config-if)#ip vrf
forwarding A-2 % Interface Ethernet0/1 IPv4 disabled and address(es) removed due to
enabling VRF A-2 R3(config-if)#ip address 192.168.2.3 255.255.255.0
R3(config-if)#end
R3#sh ip route vrf A-2 Routing Table: A-2
Codes: L - local, C - connected, S - static, R - RIP, M - mobile, B - BGP D - EIGRP, EX - EIGRP
external, O - OSPF, IA - OSPF inter area N1 - OSPF NSSA external type 1, N2 - OSPF NSSA
external type 2 E1 - OSPF external type 1, E2 - OSPF external type 2 i - IS-IS, su - IS-IS
summary, L1 - IS-IS level-1, L2 - IS-IS level-2 ia - IS-IS inter area, * - candidate default, U -
per- user static route o - ODR, P - periodic downloaded static route, H - NHRP, l - LISP a -
application route + - replicated route, % - next hop override
Gateway of last resort is not set
192.168.2.0/24 is variably subnetted, 2 subnets, 2 masks C 192.168.2.0/24 is directly
connected,
Ethernet0/1 L 192.168.2.3/32 is directly connected,
Ethernet0/1
R3#sh ip vrf Name Default RD Interfaces A-2 500:1 Et0/1
R3(config)#router ospf 10 vrf A-2
R3(config-router)#network 192.168.2.0 0.0.0.255 area 0 R3(config-router)#end R3#sh ip
ospf 10 neighbor Neighbor ID Pri State Dead Time Address Interface 5.5.5.5 1 FULL/DR
00:00:33 192.168.2.5 Ethernet0/1
R3#sh ip route vrf A-2 ospf
Routing Table: A-2
Codes: L - local, C - connected, S - static, R - RIP, M - mobile, B - BGP D - EIGRP, EX - EIGRP
external, O - OSPF, IA - OSPF inter area N1 - OSPF NSSA external type 1, N2 - OSPF NSSA
external type 2 E1 - OSPF external type 1, E2 - OSPF external type 2 i - IS-IS, su - IS-IS
summary, L1 - IS-IS level-1, L2 - IS-IS level-2 ia - IS-IS inter area, * - candidate default, U -
per- user static route o - ODR, P - periodic downloaded static route, H - NHRP, l - LISP a -
application route + - replicated route, % - next hop override

```

Gateway of last resort is not set
 5.0.0.0/32 is subnetted, 1 subnets O 5.5.5.5 [110/11] via 192.168.2.5, 00:06:37,
 Ethernet0/1
 R3(config)#router bgp 500
 R3(config-router)#no bgp default ipv4-unicast R3(config-router)#neighbor 1.1.1.1 remote-as
 500
 R3(config-router)#neighbor 1.1.1.1 update-source loopback 0 R3(config-router)#address-
 family vpng4 unicast
 R3(config-router-af)#neighbor 1.1.1.1 activate
 R3(config-router-af)#neighbor 1.1.1.1 send-community extended
 R3(config-router-af)#neighbor 1.1.1.1 next-hop-self
 R3#sh ip bgp vpng4 all
 summary
 BGP router identifier 3.3.3.3, local AS number 500 BGP table version is 1, main routing
 table version 1 Neighbor V AS MsgRcvd MsgSent TblVer InQ OutQ Up/Down State/PfxRcd
 1.1.1.1 4 500 7 6 1 0 0 00:03:01
 R3(config)#router bgp 500
 R3(config-router)#address-family ipv4 vrf A-2
 R3(config-router-af)#redistribute ospf 10 vrf A-2 match internal external 1 external
 2 R3(config-router-af)#exit R
 3(config-router)#exit
 R3(config)#router ospf 10 vrf A-2
 R3(config-router)#redistribute bgp 500 subnets
 R3(config-router)#end
 R3#sh ip bgp vpng4 all
 BGP table version is 7, local router ID is 3.3.3.3
 Status codes: s suppressed, d damped, h history, * valid, > best, i - internal, r RIB-failure, S
 Stale, m multipath, b backup-path, f RT-Filter, x best-external, a additional-path, c RIB-
 compressed, Origin codes: i - IGP, e - EGP, ? - incomplete RPKI validation codes: V valid, l
 invalid, N Not found
 Network Next Hop Metric LocPrf Weight Path Route Distinguisher: 500:1 (default
 for vrf A-2)
 *>i 4.4.4.4/32 1.1.1.1 11 100 0 ?
 *> 5.5.5.5/32 192.168.2.5 11 32768 ?
 *>i 192.168.1.0 1.1.1.1 0 100 0 ?
 *> 192.168.2.0 0.0.0.0 0 32768 ?
 R3#sh ip route vrf A-2
 Routing Table: A-2
 Codes: L - local, C - connected, S - static, R - RIP, M - mobile, B - BGP D - EIGRP, EX - EIGRP
 external, O - OSPF, IA - OSPF inter area N1 - OSPF NSSA external type 1, N2 - OSPF NSSA
 external type 2 E1 - OSPF external type 1, E2 - OSPF external type 2 i - IS-IS, su - IS-IS
 summary, L1 - IS-IS level-1, L2 - IS-IS level-2 ia - IS-IS inter area, * - candidate default, U -
 per- user static route o - ODR, P - periodic downloaded static route, H - NHRP, l - LISP a -
 application route + - replicated route, % - next hop override
 Gateway of last resort is not set
 4.0.0.0/32 is subnetted, 1 subnets B 4.4.4.4 [200/11] via 1.1.1.1, 00:55:23 5.0.0.0/32 is
 subnetted, 1 subnets O 5.5.5.5 [110/11] via 192.168.2.5, 01:50:21,

Ethernet0/1 B 192.168.1.0/24 [200/0] via 1.1.1.1, 00:55:23 192.168.2.0/24 is variably subnetted, 2 subnets, 2 masks C 192.168.2.0/24 is directly connected, Ethernet0/1 L 192.168.2.3/32 is directly connected, Ethernet0/1 R3#ping vrf A-2 5.5.5.5 T
ype escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 5.5.5.5, timeout is 2 seconds: !!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 1/1/1 ms

R4 Router>enable
Router#conf t
Router(config)#hostname R4
R4(config)#int loopback 0
R4(config-if)#ip address 4.4.4.4 255.255.255.255
R4(config-if)#exit
R4(config)#int e0/0
R4(config-if)#ip address 192.168.1.4 255.255.255.0
R4(config-if)#no shutdown
R4(config-if)#exit
R4(config)#router ospf 1
R4(config-router)#network 4.4.4.0 0.0.0.255 area 10
R4(config-router)#network 192.168.1.0 0.0.0.255 area 10
R4(config-router)#exit
R4#sh ip route ospf
Codes: L - local, C - connected, S - static, R - RIP, M - mobile, B - BGP D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2 E1 - OSPF external type 1, E2 - OSPF external type 2 i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2 ia - IS-IS inter area, * - candidate default, U - per-user static route o - ODR, P - periodic downloaded static route, H - NHRP, l - LISP a - application route + - replicated route, % - next hop override
Gateway of last resort is not set
5.0.0.0/32 is subnetted, 1 subnets O IA 5.5.5.5 [110/21] via 192.168.1.1, 00:23:41,
Ethernet0/0 O IA 192.168.2.0/24 [110/11] via 192.168.1.1, 00:23:41,
Ethernet0/0 R4#ping 5.5.5.5 source lo 0
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 5.5.5.5, timeout is 2 seconds:
Packet sent with a source address of 4.4.4.4 !!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 1/1/2 ms R5

Router>enable
Router#conf t
Router(config)#hostname R5
R5(config)#int loopback 0
R5(config-if)#ip address 5.5.5.5 255.255.255.255
R5(config-if)#exit
R5(config)#int e0/0
R5(config-if)#ip address 192.168.2.5 255.255.255.255.
R5(config-if)#no shutdown
R5(config-if)#exit
R5(config)#router ospf 1
R5(config-router)#network 5.5.5.0 0.0.0.255 area 0

```
R5(config-router)#network 192.168.2.0 0.0.0.255 area 0 R5(config-router)#exit
R5#sh ip route ospf Codes: L - local, C - connected, S - static, R - RIP, M - mobile, B - BGP D -
EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area N1 - OSPF NSSA external type 1, N2
- OSPF NSSA external type 2 E1 - OSPF external type 1, E2 - OSPF external type 2 i - IS-IS, su
- IS-IS
summary, L1 - IS-IS level-1, L2 - IS-IS level-2 ia - IS-IS inter area, * - candidate default, U -
per- user static route o - ODR, P - periodic downloaded static route, H - NHRP, l - LISP a -
application route + - replicated route, % - next hop override
Gateway of last resort is not set 4.0.0.0/32 is subnetted, 1 subnets O IA 4.4.4.4 [110/21]
via 192.168.2.3, 00:23:51, Ethernet0/0 O IA 192.168.1.0/24 [110/11] via 192.168.2.3,
00:23:51,
Ethernet0/0
R5#ping 4.4.4.4 source lo 0
Type escape sequence to abort. Sending 5, 100-byte ICMP Echos to 4.4.4.4, timeout is 2
seconds: Packet sent with a source address of 5.5.5.5 !!!!
```

Vidya Prasarak Mandal's
**B. N. BANDODKAR COLLEGE OF SCIENCE
(AUTONOMOUS), THANE.**

(Affiliated to University of Mumbai)

NAAC REACCREDITED 'A' GRADE
Best College Award, University of Mumbai

माहिती व तंत्रज्ञान विभाग

दूरध्वनी क. २५३३ ६५०७



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CERTIFICATE

This is to certify that

Shri / Kum. _____

of M. Sc. (Information Technology) Part I Semester - II has completed the required number of experiments (Total =) signed herein, in this laboratory during the year 2023 – 2024.

Seal

Incharge
Department of Information
Technology

Principal
B. N. Bandodkar College of Science,
Thane

External Examiner

INDEX

Sr. No.	Title	Page No.	Sign
1	Study of hardware components (8051 Microcontroller, Resistors (color code, types), Capacitors, ADC, DAC, Operational Amplifiers, Transistors, Diode, Crystal Oscillator, Types of Relays, Sensors, Actuator, Types of connectors).		
2	Write a program to convert ADC to DAC.		
3	Write a program to blink an LED.		
4	Write a program to serial data binterface.		
5	Write a program for the keypad and LCD interface.		

Practical No. 1

8051 Microcontroller :

The 8051 microcontroller was invented in 1980's by Intel. Its foundation is based on Harvard architecture and this microcontroller was developed principally for bringing it to be used in **Embedded Systems**.

At first it was created by using NMOS technology but the use of NMOS consumed more power to work therefore Intel re-launch the microcontroller 8051 using CMOS technology and new edition came up with edition of letter 'C' in the title name, therefore the new modified version of microcontroller is called by name 80C51.

The 8051 microcontroller programming is performed in **embedded C language** using Keil software.

Resistors (color code, types):

The measure of opposition offered by the substance in the flow electric current is known as Resistance of the substance and the element that possess the resistance is called a Resistor.

Types of Resistors:

The resistor are broadly classified into two types –

Fixed Resistors:

The fixed resistor is defined as the resistor whose resistance value does not change with the any change in temperature or voltage. These resistors are available in different shapes and sizes. The main function of an ideal fixed resistance gives a stable resistance in all situations.

Variable Resistors:

The values of resistors are determined by color band marked on the resistor body. The

color code marking system has been adopted by the Electronics Industries Association (EIA) and the United States Armed Forces and recognized throughout the world.

Capacitors:

A capacitor is a two-terminal electrical device that can store energy in the form of an electric charge. It consists of two electrical conductors that are separated by a distance. The space between the conductors may be filled by vacuum or with an insulating material known as a dielectric. The ability of the capacitor to store charges is known as capacitance.

Capacitors store energy by holding apart pairs of opposite charges. The simplest design for a capacitor is a parallel plate, which consists of two metal plates with a gap between them. But, different types of capacitors are manufactured in many forms, styles, lengths, girths, and materials.

ADC:

Analog-to-digital conversion (ADC) is an electronic process in which a continuously variable, or analog, signal is changed into a multilevel [digital](#) signal without altering its essential content.

An *analog-to-digital converter* changes an analog signal that's continuous in terms of both time and amplitude to a digital signal that's discrete in terms of both time and amplitude. The analog input to a *converter* consists of a voltage that varies among a theoretically infinite number of values. Examples are sine waves, the waveforms representing human speech and the signals from a conventional television camera.

DAC (Digital-to-Analog Converter):

A DAC converts digital signals into analog signals. It accepts digital input data and generates a continuous analog output voltage or current proportional to the digital input. DACs are used in audio systems, waveform generators, motor control, and communication systems. DACs vary in resolution, accuracy, settling time, and output voltage range, depending on the application requirements.

Operational Amplifiers (Op-Amps):

Op-amps are versatile electronic devices with high gain and differential input. They are used in a wide range of analog circuits for amplification, filtering, signal conditioning, and mathematical operations. Op-amps have two input terminals (inverting and non-inverting), an output terminal, and a power supply connection. Op-amp configurations include inverting amplifier, non-inverting amplifier, summing amplifier, difference amplifier, integrator, differentiator, and voltage follower.

Transistors:

Transistors are semiconductor devices used for amplification, switching, and signal modulation. Bipolar junction transistors (BJTs) are current-controlled devices with three terminals: emitter, base, and collector. Field-effect transistors (FETs) are voltage-controlled devices with three terminals: source, gate, and drain. Transistors are classified as NPN or PNP (for BJTs) and N-channel or P-channel (for FETs), depending on the doping of the semiconductor material.

Diode:

Diodes are semiconductor devices that allow current to flow in one direction only. They consist of a p-n junction that conducts when forward-biased and blocks when reverse-biased. Diodes are used in rectification, voltage regulation, signal demodulation, switching, and protection circuits. Common types of diodes include rectifier diodes, zener diodes, Schottky diodes, light-emitting diodes (LEDs), and photodiodes.

Crystal Oscillator:

A crystal oscillator is an electronic circuit that generates stable and precise frequencies using the mechanical resonance of a vibrating crystal. Crystal oscillators are used as timing references in microcontrollers, microprocessors, clocks, and communication systems. They offer high frequency stability, low phase noise, and excellent temperature stability compared to other oscillator circuits.

Types of Relays:

Relays are electromechanical switches used to control high-power circuits with low-power signals. Electromagnetic relays use an electromagnet to mechanically operate a switch. Solid-state relays use semiconductor devices for switching without moving parts. Reed relays use a reed switch enclosed in a glass envelope for switching. Thermal relays protect circuits from overcurrent by detecting temperature rise.

Sensors:

Sensors are devices that detect and measure physical quantities such as temperature, pressure, light, motion, and proximity.

Types of sensors include temperature sensors, pressure sensors, proximity sensors, motion sensors, humidity sensors, and gas sensors.

Sensors are used in various applications such as industrial automation, automotive systems, environmental monitoring, and medical devices.

Actuator:

Actuators are devices that convert electrical signals into physical motion or action. Examples include motors (DC motors, stepper motors, servo motors), solenoids, relays, hydraulic actuators, and pneumatic actuators. Actuators are used in robotics, industrial automation, automotive systems, HVAC systems, and aerospace applications.

Types of Connectors:

Connectors are physical interfaces used to connect electrical or electronic components together. Types of connectors include USB (Universal Serial Bus), HDMI (High-Definition Multimedia Interface), Ethernet, D-sub (D-subminiature), RCA (Radio Corporation of America), audio jack, terminal blocks, and header pins. Connectors vary in form factor, pin configuration, mating cycle, and environmental sealing, depending on the application requirements.

Practical No. 2

Code :

```
ORG 0          ; reset vector
    JMP main      ; jump to the main program

ORG 3          ; external 0 interrupt vector
    JMP ext0ISR   ; jump to the external 0 ISR

ORG 0BH        ; timer 0 interrupt vector
    JMP timer0ISR ; jump to timer 0 ISR

ORG 30H        ; main program starts here
main:
    SETB IT0      ; set external 0 interrupt as edge-activated
    SETB EX0      ; enable external 0 interrupt
    CLR P0.7      ; enable DAC WR line
    MOV TMOD, #2  ; set timer 0 as 8-bit auto-reload interval timer

    MOV TH0, #-20  ; | put -20 into timer 0 high-byte - this reload value,
    ; | with system clock of 12 MHz, will result in a timer 0 overflow every 20 us

    MOV TL0, #-20  ; | put the same value in the low byte to ensure the timer starts counting from
    ; | 236 (256 - 20) rather than 0

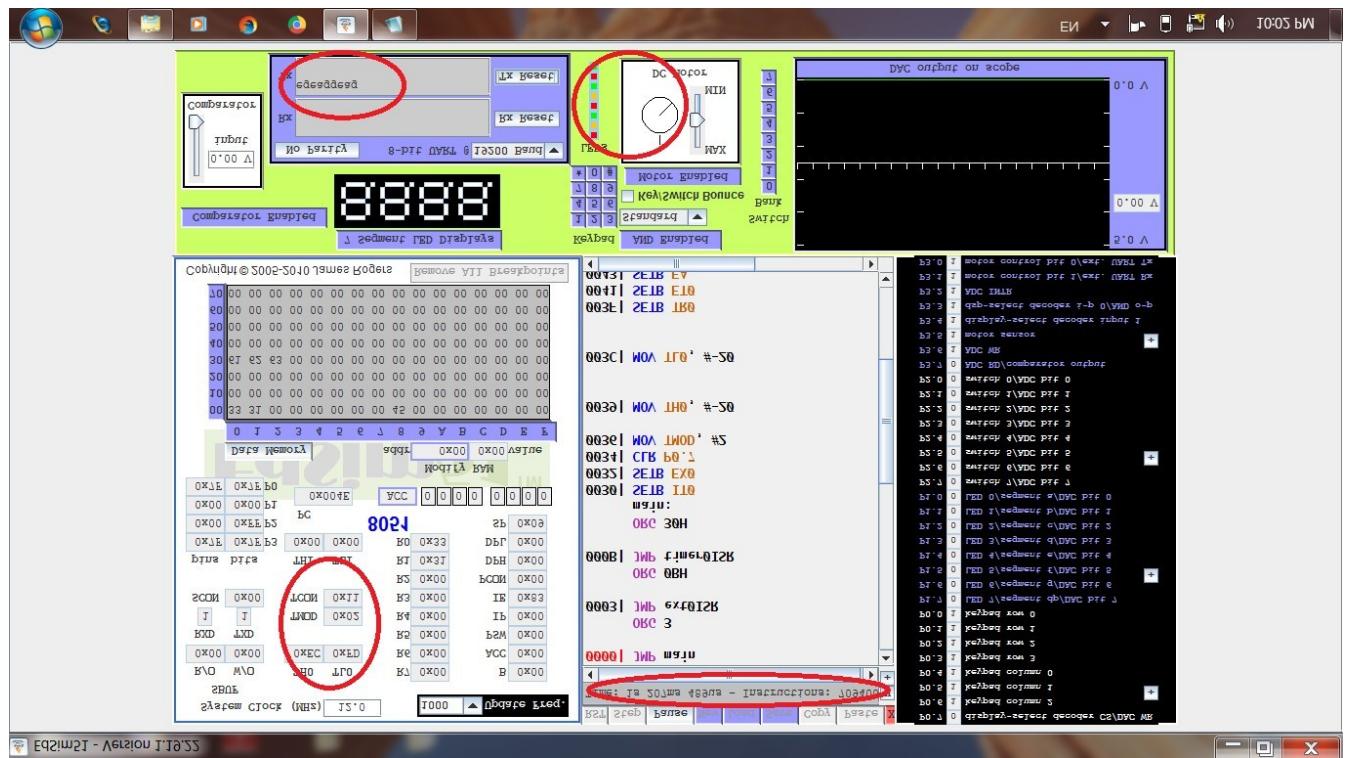
    SETB TR0      ; start timer 0
    SETB ET0      ; enable timer 0 interrupt
    SETB EA       ; set the global interrupt enable bit
    JMP $         ; jump back to the same line (ie; do nothing)

; end of main program

; timer 0 ISR - simply starts an ADC conversion
timer0ISR:
    CLR P3.6      ; clear ADC WR line
    SETB P3.6      ; then set it - this results in the required positive edge to start a conversion
    RETI           ; return from interrupt

; external 0 ISR - responds to the ADC conversion complete interrupt
ext0ISR:
    CLR P3.7      ; clear the ADC RD line - this enables the data lines
    MOV P1, P2      ; take the data from the ADC on P2 and send it to the DAC data lines on P1
    SETB P3.7      ; disable the ADC data lines by setting RD
    RETI           ; return from interrupt
```

Output :



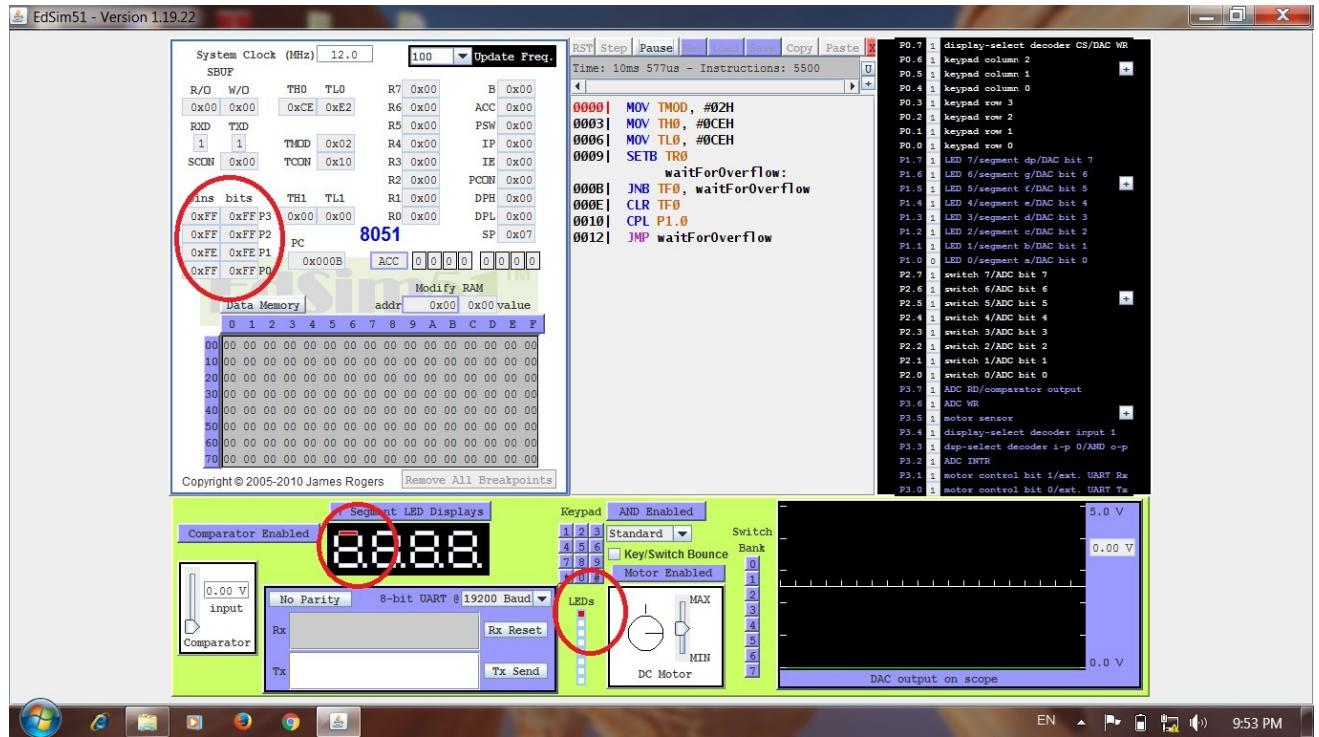
Practical No. 3

Code :

```
MOV TMOD, #02H ;initialize timer 0 as 8-bit auto-reload timer  
MOV TH0, #0CEH ;set timer 0 high byte to produce 50us delay (assuming system clock frequency of 12MHz)  
MOV TL0, #0CEH ; ensure that, first time, the timer begins counting from the reload value  
SETB TR0 ;start timer 0
```

```
waitForOverflow:  
JNB TF0, waitForOverflow ;if timer 0 overflow bit is not set, repeat this instruction  
CLR TF0 ;reset timer 0 overflow bit  
CPL P1.0 ;invert (complement) port 1 pin 0  
JMP waitForOverflow
```

Output :



Practical No. 4

Code :

```
CLR SM0          ;|
SETB SM1          ;| put serial port in 8-bit UART mode

MOV A, PCON      ;|
SETB ACC.7      ;|
MOV PCON, A      ;| set SMOD in PCON to double baud rate

MOV TMOD, #20H    ; put timer 1 in 8-bit auto-reload interval timing mode
MOV TH1, #243     ; put -13 in timer 1 high byte (timer will overflow every 13 us)
MOV TL1, #243     ; put same value in low byte so when timer is first started it will overflow

after 1 us
SETB TR1          ; start timer 1

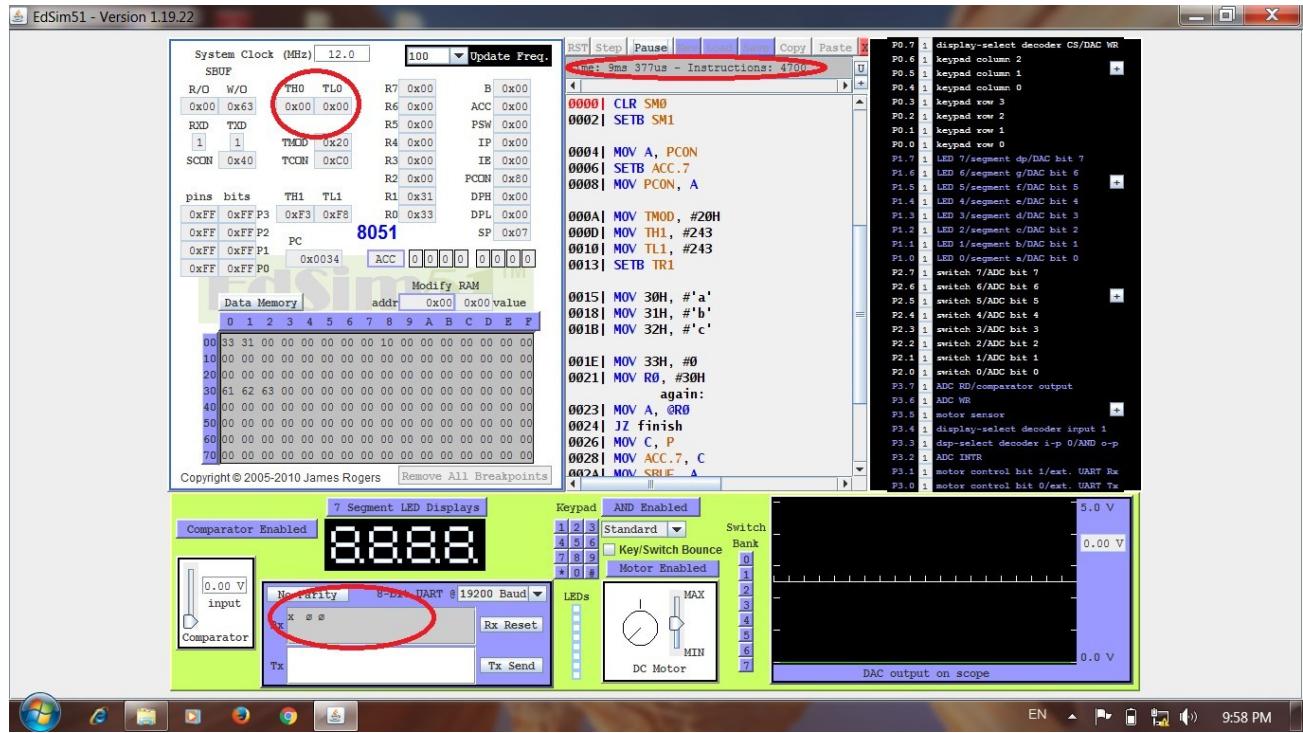
MOV 30H, #'a'    ;|
MOV 31H, #'b'    ;|
MOV 32H, #'c'    ;| put data to be sent in RAM, start address 30H

MOV 33H, #0        ; null-terminate the data (when the accumulator contains 0, no more data to
be sent)
MOV R0, #30H       ; put data start address in R0

again:
MOV A, @R0          ; move from location pointed to by R0 to the accumulator
JZ finish           ; if the accumulator contains 0, no more data to be sent, jump to finish
MOV C, P            ; otherwise, move parity bit to the carry
MOV ACC.7, C         ; and move the carry to the accumulator MSB
MOV SBUF, A          ; move data to be sent to the serial port
INC R0              ; increment R0 to point at next byte of data to be sent
JNB TI, $            ; wait for TI to be set, indicating serial port has finished sending byte
CLR TI              ; clear TI
JMP again            ; send next byte

finish:
JMP $                ; do nothing
```

Output :



Practical No. 5

Code :

start:

```
MOV R0, #0           ; clear R0 - the first key is key0

; scan row0
SETB P0.3           ; set row3
CLR P0.0             ; clear row0
CALL colScan          ; call column-scan subroutine
JB F0, finish         ; | if F0 is set, jump to end of program
                           ; | (because the pressed key was found and its number is in R0)

; scan row1
SETB P0.0           ; set row0
CLR P0.1             ; clear row1
CALL colScan          ; call column-scan subroutine
JB F0, finish         ; | if F0 is set, jump to end of program
                           ; | (because the pressed key was found and its number is in R0)

; scan row2
SETB P0.1           ; set row1
CLR P0.2             ; clear row2
CALL colScan          ; call column-scan subroutine
JB F0, finish         ; | if F0 is set, jump to end of program
                           ; | (because the pressed key was found and its number is in R0)

; scan row3
SETB P0.2           ; set row2
CLR P0.3             ; clear row3
CALL colScan          ; call column-scan subroutine
JB F0, finish         ; | if F0 is set, jump to end of program
                           ; | (because the pressed key was found and its number is in R0)
```

JMP start ; | go back to scan row 0
 ; | (this is why row3 is set at the start of the program
 ; | - when the program jumps back to start, row3 has just been

scanned)

finish:

```
JMP $                ; program execution arrives here when key is found - do nothing
```

; column-scan subroutine
colScan:

```
JNB P0.4, gotKey    ; if col0 is cleared - key found
INC R0               ; otherwise move to next key
```

```

JNB P0.5, getKey      ; if col1 is cleared - key found
INC R0                  ; otherwise move to next key
JNB P0.6, getKey      ; if col2 is cleared - key found
INC R0                  ; otherwise move to next key
RET                   ; return from subroutine - key not found

getKey:
SETB F0                ; key found - set F0
RET                   ; and return from subroutine

```

Output :

