



**CLOUD COMPUTING PROJECT  
THOTH LAB  
PROJECT REPORT**

**Team Members**

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## 1. Introduction

### 1.1 ThoTh Lab

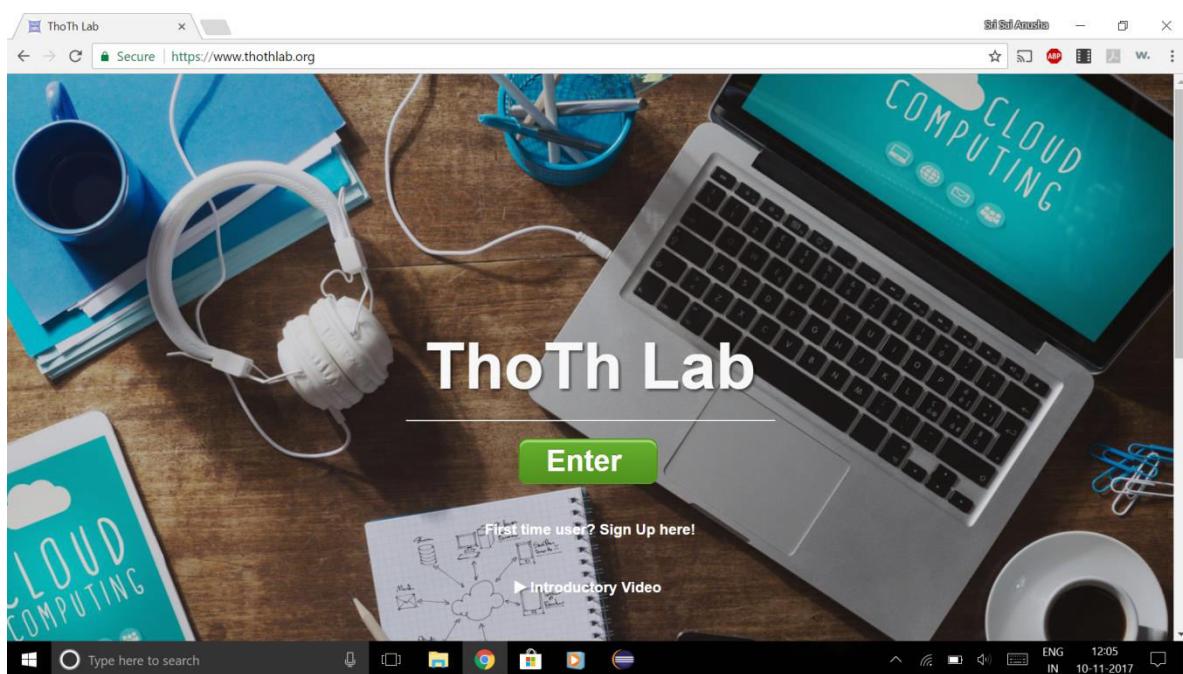
ThoTh Lab is a cloud based virtual lab platform developed by UMKC Alumni and ASU Professor Mr. Dijiang Huang. ThoTh Lab is an educational and research based cloud environment which is primarily developed to provide the lab access for the students of Mr. Huang and to improve hands-on computer science education.

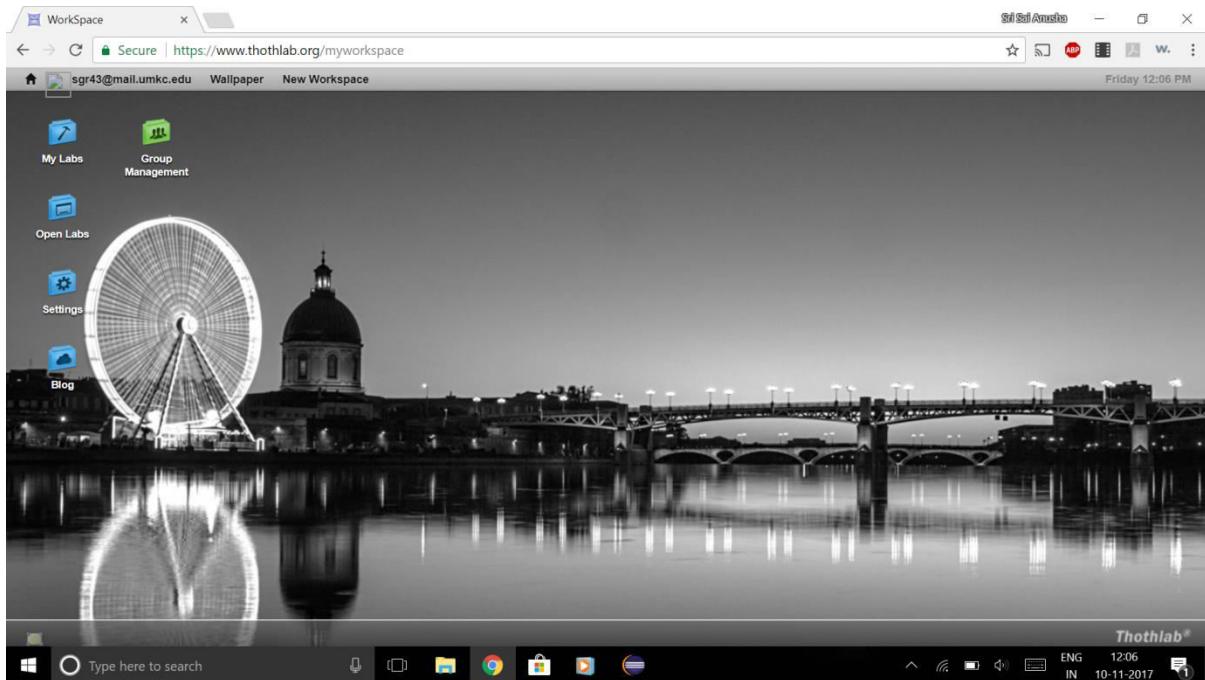
Mr. Huang created a virtual lab where the physical computers and network connections could be emulated on a server to form any computer network configuration. This ThoTh Lab contains a collection of many labs and projects from Network Security to Cloud Computing. With the success of ThoTh Lab with ASU students, Mr. Huang started to think of commercialization of his platform to benefit a wide range of professors and students.

The instructors can also create customized lab configurations for personalized and collaborative learning. The users of ThoTh Lab are spread over universities like Arizona State University, California State University at Fullerton, Penn State University – Altoona and University of Missouri – Kansas City in addition to universities in India, China and the United Arab Emirates.

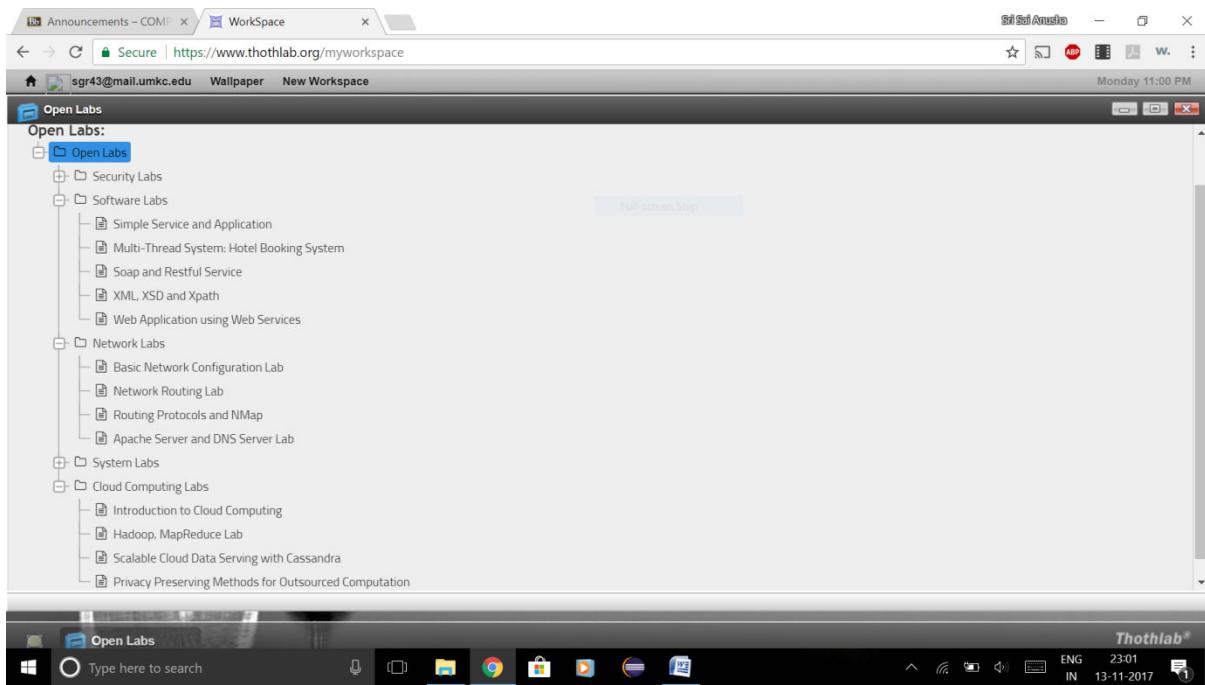
### 1.2 Features

- Flexibility: Allows remote access for users, anywhere and anytime
- Adaptability: No restriction to use any specific platform
- Economic: Frees users from managing and maintaining physical devices
- Manageability: Allows administrators to compose new services and applications
- Expandability: Expandable based on its distributed service-oriented architecture
- High Availability and Redundancy: Hosted by the data centre of ASU





The Open Labs folder contains the list of built-in (previously configured) labs which when provided access to students can be run on the built-in VM (Virtual Machine).



Each section then contains subsections of labs.

## **2. Before The Beginning**

### **2.1 Motivation**

The introduction and development of ThoTh Lab is still in its budding stage. It is still under testing phase where the performance is measured and the bugs are being fixed.

This project helps us in learning new concepts and allows us to face certain challenges where in we can understand the working of the ThoTh Lab and get along.

Thank you Dr. Choi for encouraging and allowing us to work on this project. This is definitely a great learning experience.

### **2.2 Goal**

To work on the built-in labs of ThoTh Lab and execute Cloud Computing Labs and Network Labs.

### **2.3 Team Members' Contribution**

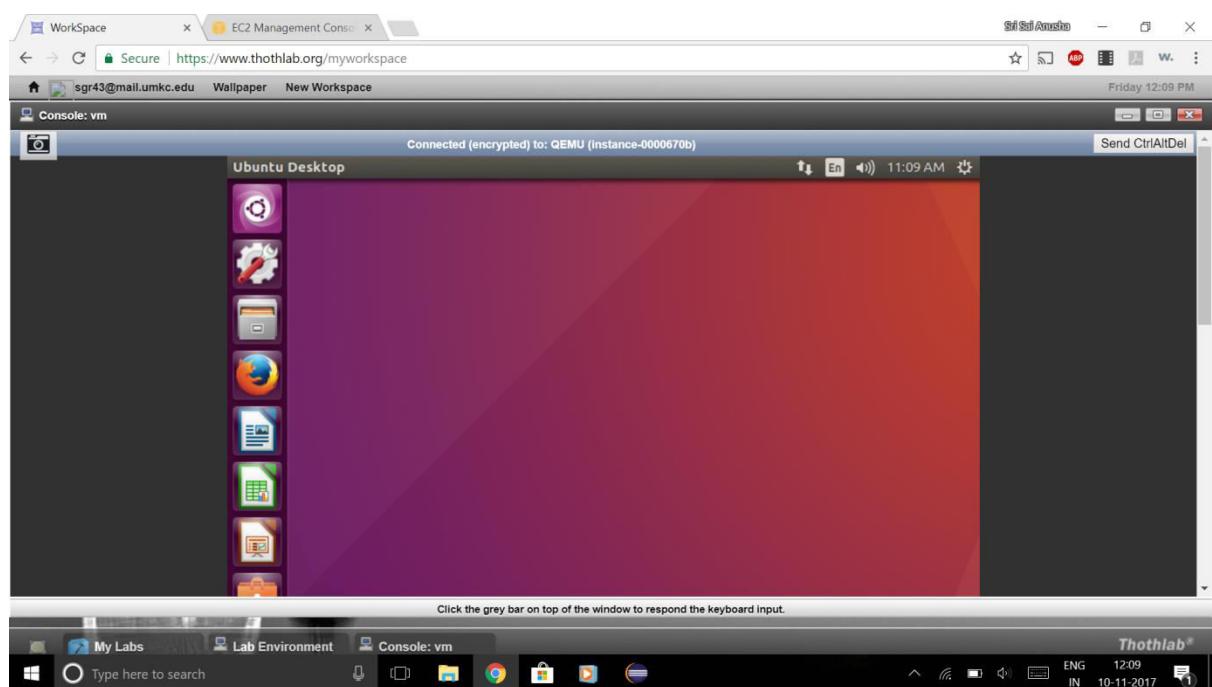
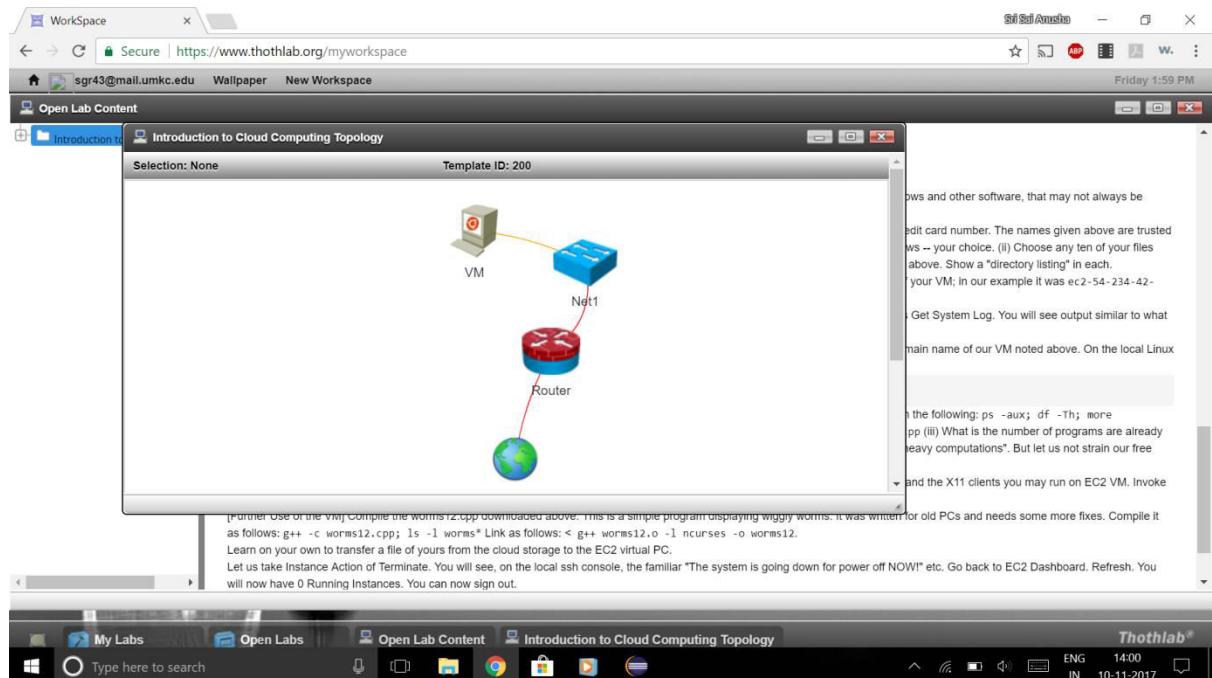
As the work on ThoTh Lab is group oriented, i.e., group access for the project, we have collectively worked on the labs, sorted out the problems we faced and were able to successfully complete three of Cloud Computing Labs and four of Network Labs.

## 3. Cloud Computing Labs

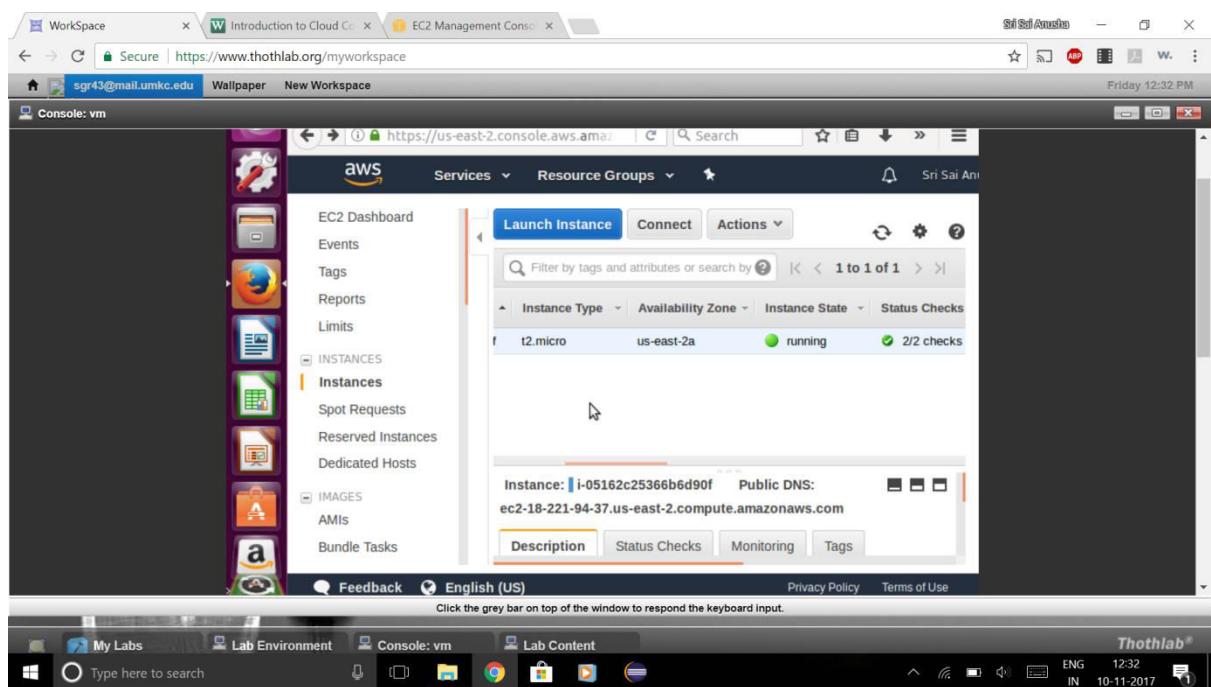
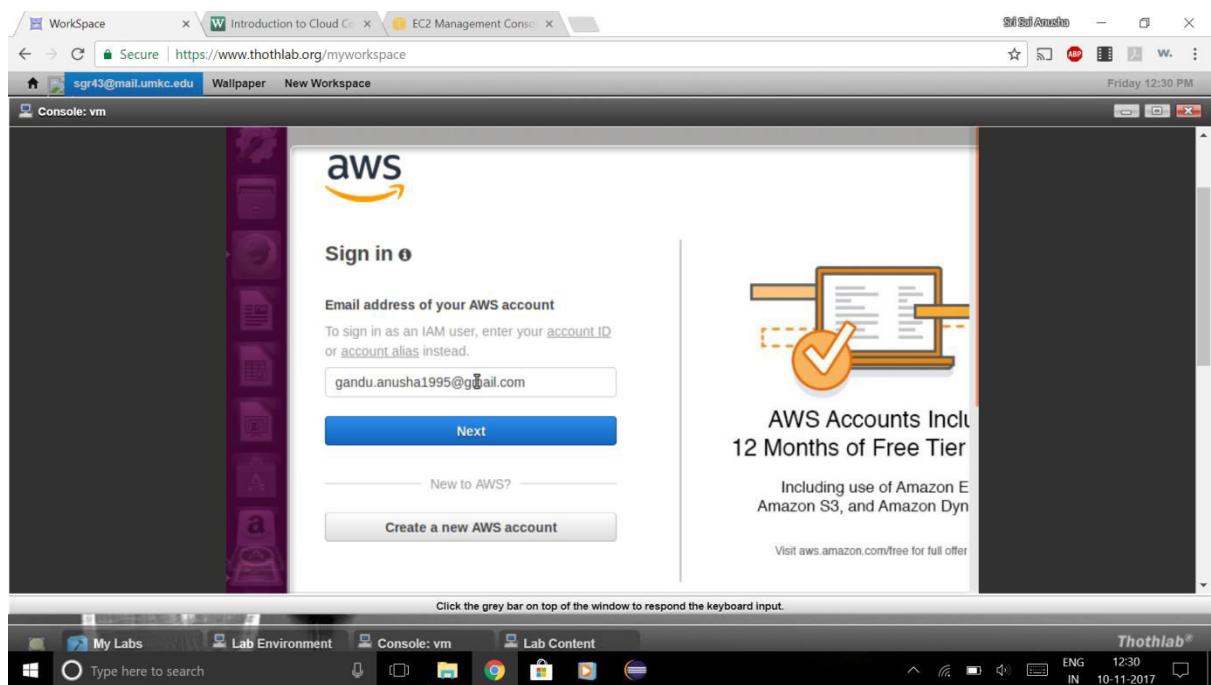
### 3.1 Introduction to Cloud Computing

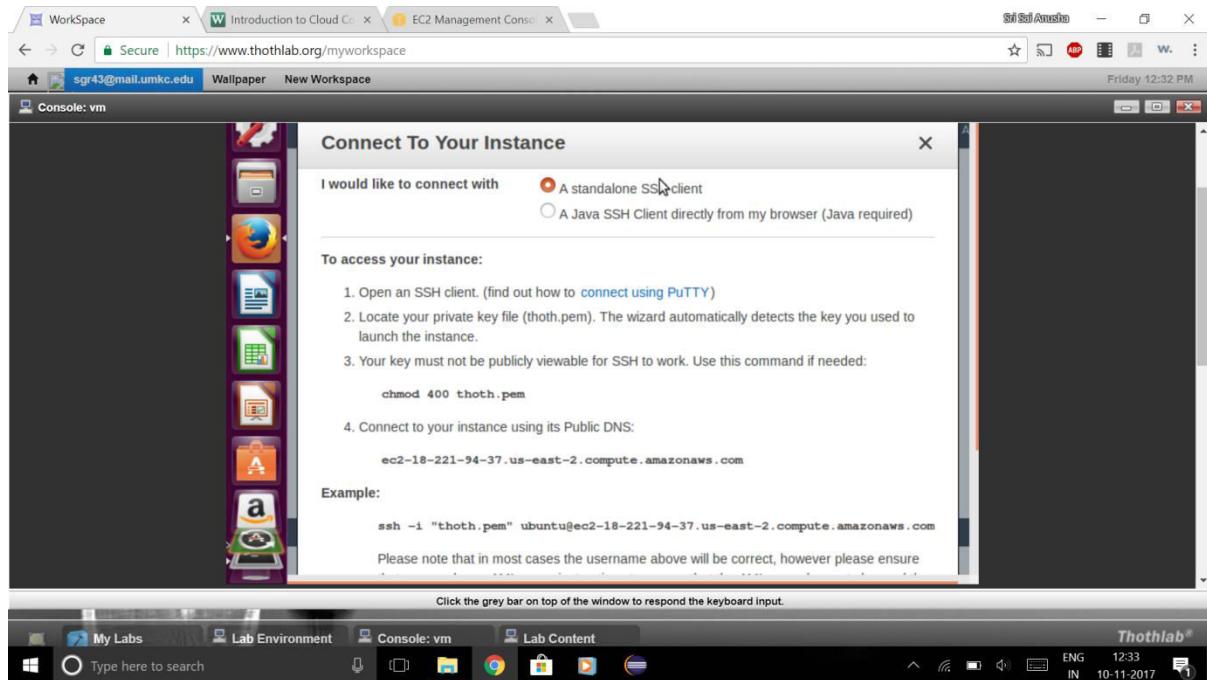
Cloud Computing is all about using many computer systems whose physical address may not be known. We can run computations on remote machines which may not have our files and we need to transport them by using SSH.

In this lab, we use Amazon EC2 Cloud to launch our VM and transfer the files to the remote machine.

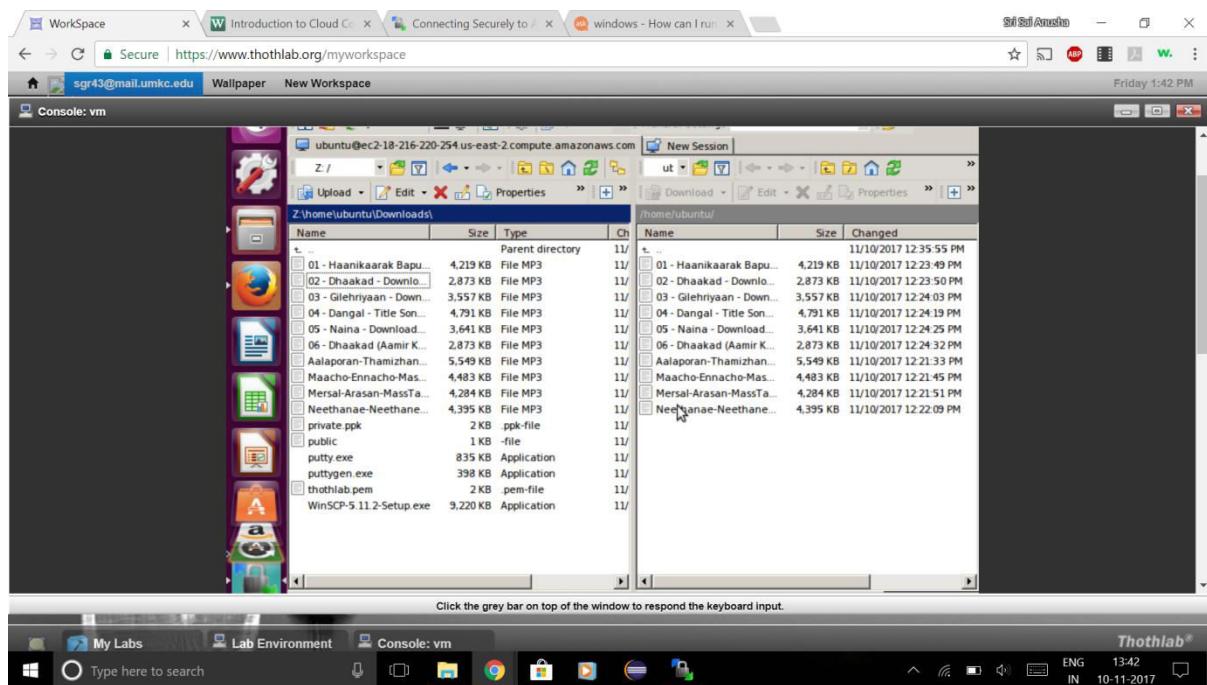


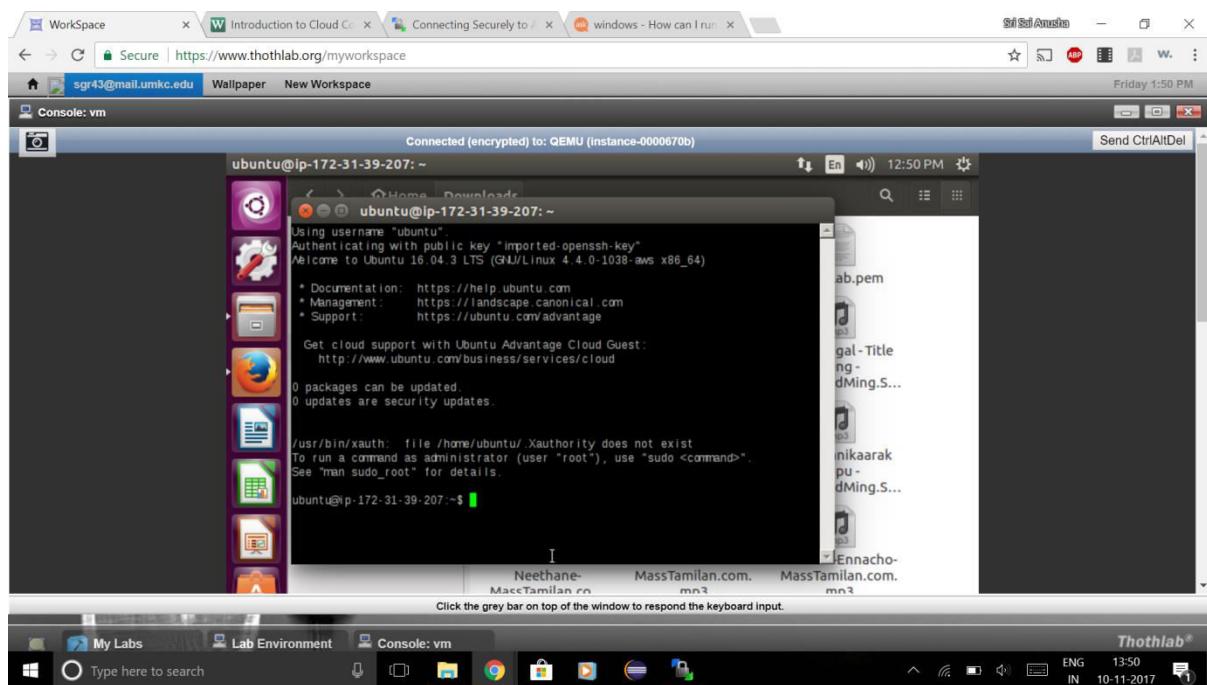
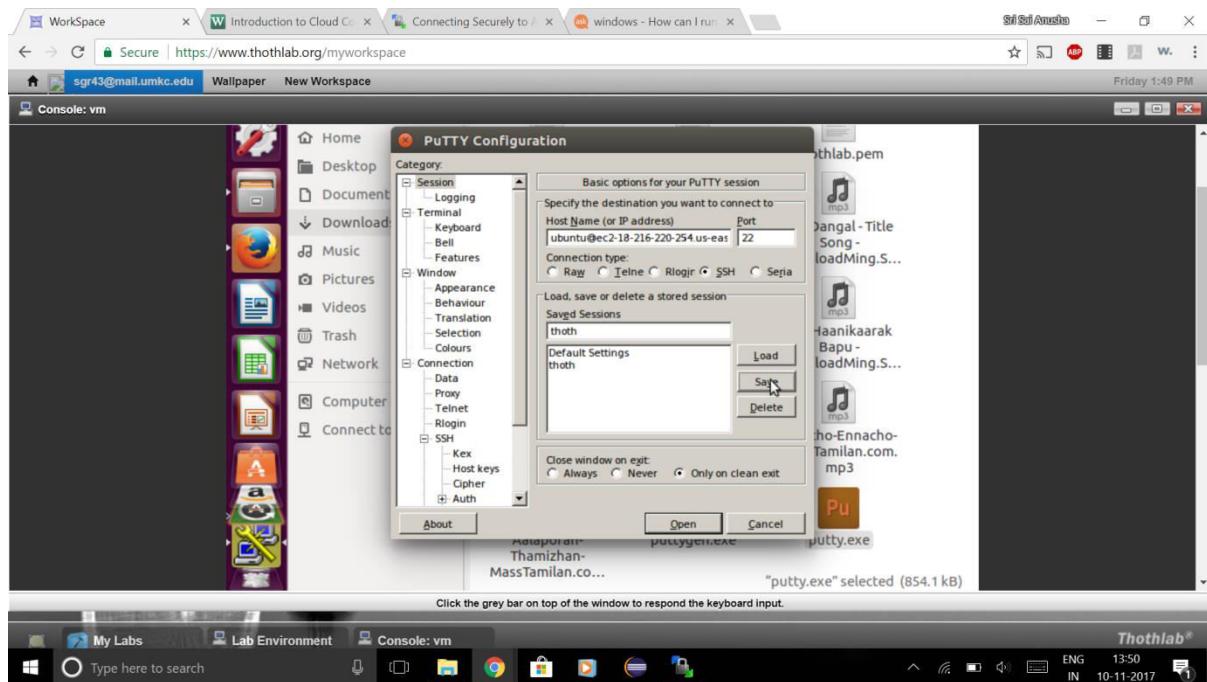
The following are the steps followed to implement the lab.

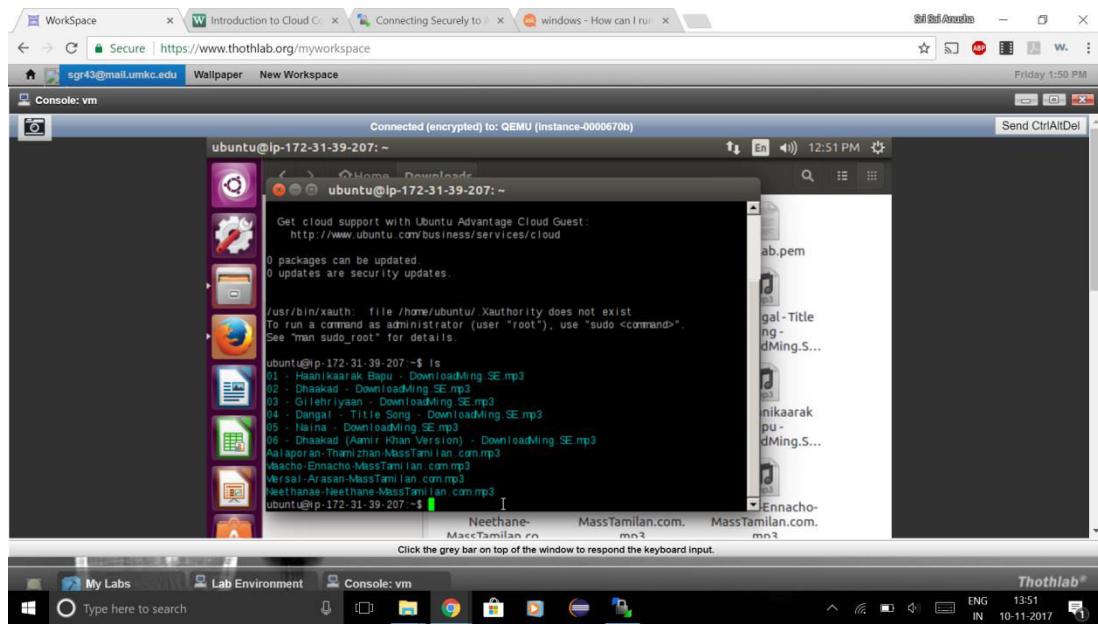




The files are transferred to remote machine (VM) using WinSCP from the local machine.





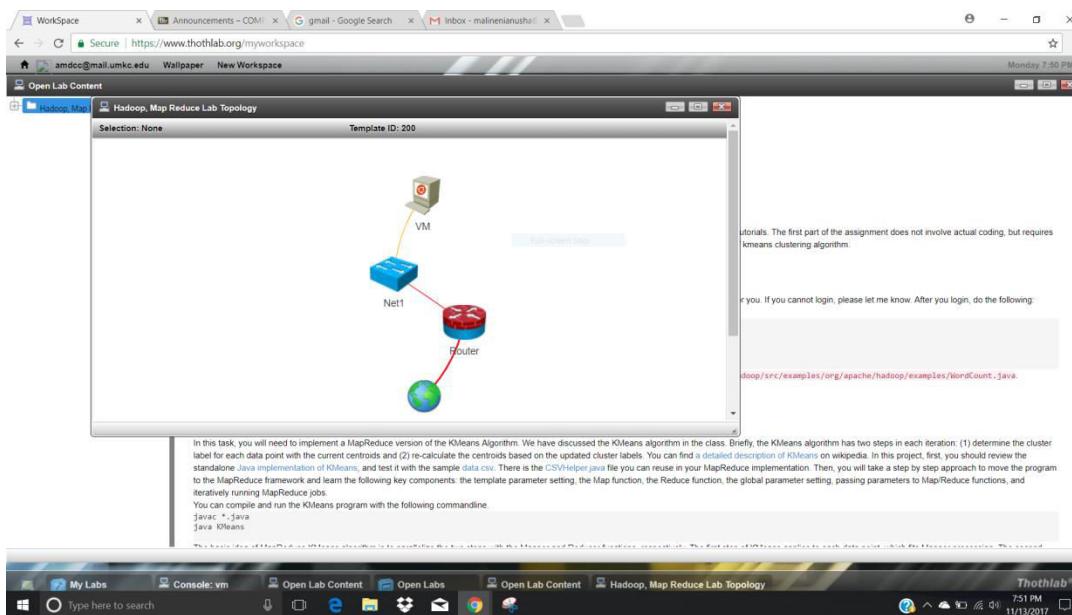


The transfer of the files is complete and the lab is executed.

### 3.2 Hadoop, MapReduce Lab

Hadoop MapReduce is a software framework for easily writing applications which process vast amounts of data in-parallel on large clusters (thousands of nodes) of commodity hardware in a reliable, fault-tolerant manner.

A MapReduce job usually splits the input data-set into independent chunks which are processed by the map tasks in a completely parallel manner. The framework sorts the outputs of the maps, which are then input to the reduce tasks. Typically both the input and the output of the job are stored in a file-system. The framework takes care of scheduling tasks, monitoring them and re-executes the failed tasks.



Typically the compute nodes and the storage nodes are the same, that is, the MapReduce framework and the Hadoop Distributed File System are running on the same set of nodes. This configuration allows the framework to effectively schedule tasks on the nodes where data is already present, resulting in very high aggregate bandwidth across the cluster.

The MapReduce framework consists of a single master JobTracker and one slave TaskTracker per cluster-node. The master is responsible for scheduling the jobs' component tasks on the slaves, monitoring them and re-executing the failed tasks. The slaves execute the tasks as directed by the master.

This lab deals with Hadoop and MapReduce programming. The following are the steps followed to execute the lab.

```

ubuntu@ubuntu-VM:~$ sources.jar
hadoop-2.8.2/share/hadoop/yarn/test/
hadoop-2.8.2/share/hadoop/yarn/test/hadoop-yarn-server-tests-2.8.2-tests.jar
ubuntu@ubuntu-VM:~/Downloads$ sudo mv hadoop-2.8.2 /usr/local/hadoop
ubuntu@ubuntu-VM:~/Downloads$ readlink -f /usr/bin/java | sed "s:bin/java::"
/usr/lib/jvm/java-8-openjdk-amd64/jre
ubuntu@ubuntu-VM:~/Downloads$ ^C
ubuntu@ubuntu-VM:~/Downloads$ sudo nano /usr/local/hadoop/etc/hadoop/hadoop-env.sh
ubuntu@ubuntu-VM:~/Downloads$ cd
ubuntu@ubuntu-VM:~/Downloads$ /usr/local/hadoop/bin/hadoop
Usage: hadoop [-config confdir] [COMMAND | CLASSNAME]
          CLASSNAME           run the class named CLASSNAME
or
          where COMMAND is one of:
          fs                  run a generic filesystem user client
          version             print the version
          jar <jar>            run a jar
          note: please use "yarn jar" to launch
          YARN applications, not this command.
          checknative [-a|-h]  check native hadoop and compression libraries availability
          distcp <srcurl> <desturl> copy file or directories recursively
          archive <archiveName> NAME -p <parent path> <src>* <dest> create a hadoop archive
          classpath            prints the class path needed to get the
                               Hadoop jar and the required libraries
          credential          interact with credential providers
          daemonlog           get/set the log level for each daemon
          trace               view and modify Hadoop tracing settings
Most commands print help when invoked w/o parameters.
ubuntu@ubuntu-VM:~$ 

```

```

ubuntu@ubuntu-VM:~$ rincipal[]*
The file does not exist or is not a normal file: /usr/local/hadoop/share/hadoop/mapreduce/hadoop-mapreduce-examples-2.7.3.jar
ubuntu@ubuntu-VM:~/Downloads$ /usr/local/hadoop/bin/hadoop jar /usr/local/hadoop/share/hadoop/mapreduce/hadoop-mapreduce-examples-2.8.2.jar grep -r /input ->/grep_example 'p
rincipa[...]' 
17/11/11 12:50:50 INFO Configuration.deprecation: session.id is deprecated. Instead, use dfs.metrics.session-id
17/11/11 12:50:50 INFO jvm.JvmMetrics: Initializing JVM Metrics with processName =mapred, user =root
17/11/11 12:50:50 INFO input.FileInputFormat: Total input files to process : 8
17/11/11 12:50:51 INFO mapreduce.JobSubmitter: number of splits:8
17/11/11 12:50:51 INFO mapreduce.JobSubmitter: Submitting tokens for job: job_local344060857_0001
17/11/11 12:50:51 INFO mapreduce.Job: The url to track the job: http://localhost:8080/
17/11/11 12:50:51 INFO mapreduce.Job: Running job: job_local344060857_0001
17/11/11 12:50:51 INFO mapred.LocalJobRunner: OutputCommitter set in config null
17/11/11 12:50:51 INFO output.FileOutputCommitter: File Output Committer Algorithm version is 1
17/11/11 12:50:51 INFO output.FileOutputCommitter: FileOutputCommitter skip cleanup _temporary folders under output directory:false, ignore cleanup failures: false
17/11/11 12:50:51 INFO mapred.LocalJobRunner: OutputCommitter is org.apache.hadoop.mapreduce.lib.output.FileOutputCommitter
17/11/11 12:50:52 INFO mapred.LocalJobRunner: Waiting for map tasks
17/11/11 12:50:52 INFO mapred.LocalJobRunner: Starting task: attempt_local344060857_0001_r_000000_0
17/11/11 12:50:52 INFO output.FileOutputCommitter: File Output Committer Algorithm version is 1
17/11/11 12:50:52 INFO output.FileOutputCommitter: FileOutputCommitter skip cleanup _temporary folders under output directory:false, ignore cleanup failures: false

```

Workspace

Secure | https://www.thothlab.org/myworkspace

amdc@mail.umkc.edu Wallpaper New Workspace

Console: vm

```
Connected (encrypted) to: QEMU (instance-00000670b)
```

```
ubuntu@ubuntu-VM: ~
17/11/11 12:50:57 INFO mapreduce.Job: Job job_local043699851_0002 completed successfully
17/11/11 12:50:57 INFO mapreduce.Job: Counters: 30
   File System Counters
      FILE: Number of bytes read=1273260
      FILE: Number of bytes written=2546624
      FILE: Number of read operations=0
      FILE: Number of large read operations=0
      FILE: Number of write operations=0
   Map-Reduce Framework
      Map input records=2
      Map output records=2
      Map output bytes=37
      Map output materialized bytes=47
      Input split bytes=116
      Combine input records=0
      Combine output records=0
      Reduce input groups=2
      Reduce input records=2
      Reduce input bytes=37
      Reduce input records=2
      Reduce output records=2
      Spilled Records=4
      Shuffled Maps =1
      Failed Shuffles=0
      Merged Map outputs=1
      GC time elapsed (ns)=106
      Total committed heap usage (bytes)=274874368
   Shuffle Errors
      BAD_ID=0
      CONNECTION=0
      IO_ERROR=0
      WRONG_LENGTH=0
      WRONG_MAP=0
      WRONG_REDUCE=0
File Input Format Counters
File Output Format Counters
  Bytes Written=37
ubuntu@ubuntu-VM:~$ cat ~/grep_example/*
6  principal.
1  principal.
ubuntu@ubuntu-VM:~$
```

Click the gray bar on top of the window to respond the keyboard input.

My Labs Open Labs Open Lab Content Lab Environment Console: vm

Thothlab® 1:52 PM 11/11/2017

Workspace

Secure | https://www.thothlab.org/myworkspace

amdc@mail.umkc.edu Wallpaper New Workspace

Console: vm

```
Connected (encrypted) to: QEMU (instance-00000670b)
```

```
ubuntu@ubuntu-VM: ~
Map-Reduce Framework
  Map Input records=2
  Map output records=2
  Map output bytes=37
  Map output materialized bytes=47
  Input split bytes=116
  Combine input records=0
  Combine output records=0
  Reduce input groups=2
  Reduce shuffle bytes=47
  Reduce input records=2
  Reduce output records=2
  Spilled Records=4
  Shuffled Maps =1
  Failed Shuffles=0
  Merged Map outputs=1
  GC time elapsed (ns)=106
  Total committed heap usage (bytes)=274874368
Shuffle Errors
  BAD_ID=0
  CONNECTION=0
  IO_ERROR=0
  WRONG_LENGTH=0
  WRONG_MAP=0
  WRONG_REDUCE=0
File Input Format Counters
File Output Format Counters
  Bytes Written=37
ubuntu@ubuntu-VM:~$ cat ~/grep_example/*
6  principal.
1  principal.
ubuntu@ubuntu-VM:~$
```

Click the gray bar on top of the window to respond the keyboard input.

My Labs Open Labs Open Lab Content Lab Environment Console: vm

Thothlab® 1:54 PM 11/11/2017

Workspace

x \W cecs.wright.edu/~keke.c x \W k-means clustering - Will x \W cecs.wright.edu/~keke.cl x \M Inbox - malinenianusha...

Secure | https://www.thothlab.org/myworkspace

amdc@mail.umkc.edu Wallpaper New Workspace

Console: vm

```
Connected (encrypted) to: QEMU (instance-00000670b)
```

```
ubuntu@ubuntu-VM:~$ cd Desktop
ubuntu@ubuntu-VM:~/Desktop$ javac -Xlint *.java
ubuntu@ubuntu-VM:~/Desktop$ java KMeans
5 2
selected data
Clustering converges at round 2
Label:
1
1
1
0
0
Centroids:
10.5 10.5
1.1866666666666667 1.1866666666666667
ubuntu@ubuntu-VM:~/Desktop$
```

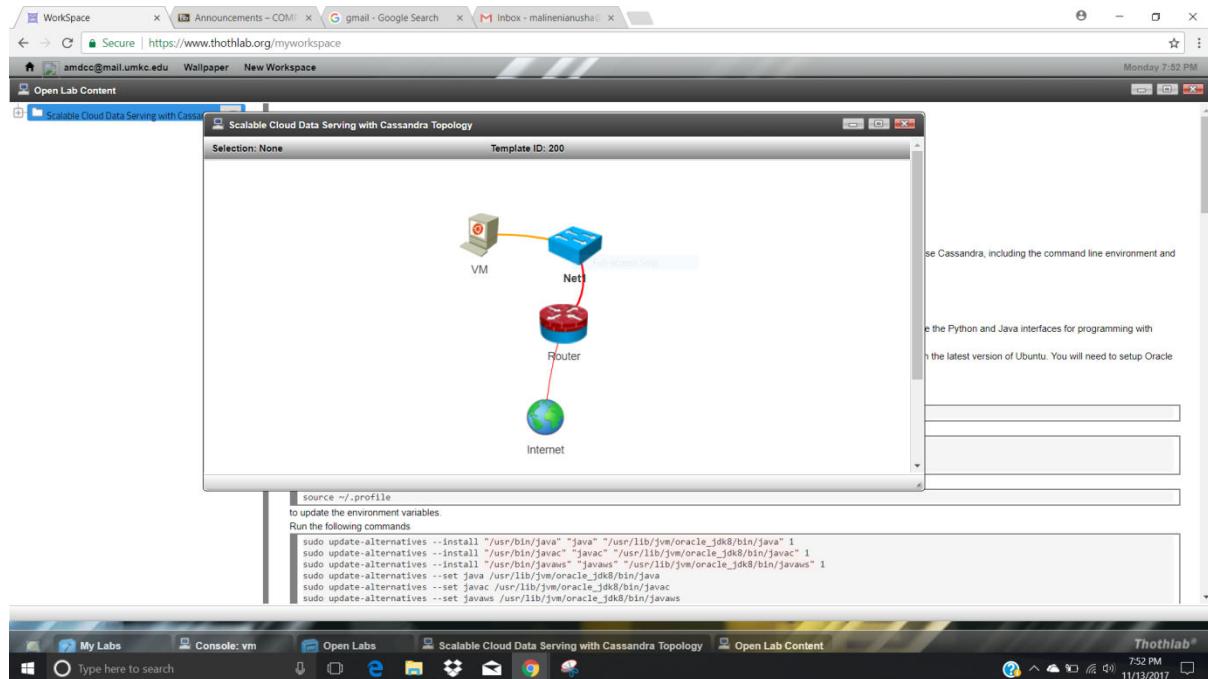
Click the gray bar on top of the window to respond the keyboard input.

My Labs Lab Environment Console: vm Open Labs Open Lab Content

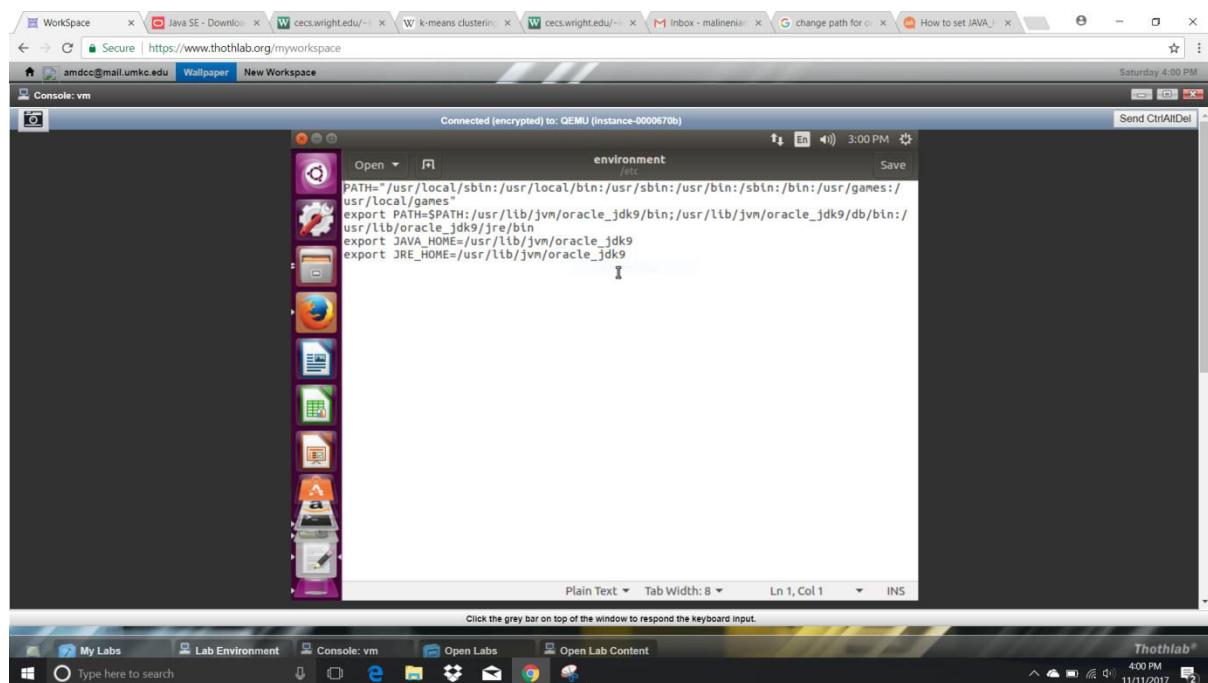
Thothlab® 2:13 PM 11/11/2017

### 3.3 Scalable Cloud Data Serving with Cassandra

Cassandra is a free and open-source distributed NoSQL database management system designed to handle large amounts of data across many commodity servers, providing high availability with no single point of failure. Cassandra offers robust support for clusters spanning multiple data-centers, with asynchronous master-less replication allowing low latency operations for all clients.



There is a limitation in this lab regarding the storage capacity to run nodetool status.



Ubuntu@ubuntu-VM:~

```
[sudo] password for ubuntu:
ubuntu@ubuntu-VM:~$ sudo nano /etc/profile
ubuntu@ubuntu-VM:~$ sudo nano /etc/profile
ubuntu@ubuntu-VM:~$ sudo update-alternatives --install "/usr/bin/java" "java" "/usr/local/java/jdk9.0.1/bin/java" 1
update-alternatives: error: alternative path /usr/local/java/jdk9.0.1/bin/java doesn't exist
ubuntu@ubuntu-VM:~$ sudo update-alternatives --install "/usr/bin/java" "java" "/usr/local/java/jdk9.0.1/bin/java" 1
update-alternatives: using /usr/local/java/jdk9.0.1/bin/java to provide /usr/bin/java (java) in auto mode
ubuntu@ubuntu-VM:~$ sudo update-alternatives --install "/usr/bin/javac" "javac" "/usr/local/java/jdk9.0.1/bin/javac" 1
update-alternatives: using /usr/local/java/jdk9.0.1/bin/javac to provide /usr/bin/javac (javac) in auto mode
ubuntu@ubuntu-VM:~$ sudo update-alternatives --install "/usr/bin/javaws" "javaws" "/usr/local/java/jdk9.0.1/bin/javaws" 1
update-alternatives: using /usr/local/java/jdk9.0.1/bin/javaws to provide /usr/bin/javaws (javaws) in auto mode
ubuntu@ubuntu-VM:~$ sudo nano /etc/profile
ubuntu@ubuntu-VM:~$ sudo update-alternatives --set java /usr/local/java/jdk9.0.1/bin/java
ubuntu@ubuntu-VM:~$ sudo update-alternatives --set javac /usr/local/java/jdk9.0.1/bin/javac
ubuntu@ubuntu-VM:~$ sudo update-alternatives --set javaws /usr/local/java/jdk9.0.1/bin/javaws
ubuntu@ubuntu-VM:~$ source /etc/profile
ubuntu@ubuntu-VM:~$ java -version
java version "9.0.1"
Java(TM) SE Runtime Environment (build 9.0.1+11)
Java HotSpot(TM) 64-Bit Server VM (build 9.0.1+11, mixed mode)
```

Click the grey bar on top of the window to respond the keyboard input.

Ubuntu@ubuntu-VM:~

```
update-alternatives: error: alternative path /usr/local/java/jdk9.0.1/bin/java doesn't exist
ubuntu@ubuntu-VM:~$ sudo update-alternatives --install "/usr/bin/java" "java" "/usr/local/java/jdk9.0.1/bin/java" 1
update-alternatives: using /usr/local/java/jdk9.0.1/bin/java to provide /usr/bin/java (java) in auto mode
ubuntu@ubuntu-VM:~$ sudo update-alternatives --install "/usr/bin/javac" "javac" "/usr/local/java/jdk9.0.1/bin/javac" 1
update-alternatives: using /usr/local/java/jdk9.0.1/bin/javac to provide /usr/bin/javac (javac) in auto mode
ubuntu@ubuntu-VM:~$ sudo update-alternatives --install "/usr/bin/javaws" "javaws" "/usr/local/java/jdk9.0.1/bin/javaws" 1
update-alternatives: using /usr/local/java/jdk9.0.1/bin/javaws to provide /usr/bin/javaws (javaws) in auto mode
ubuntu@ubuntu-VM:~$ sudo nano /etc/profile
ubuntu@ubuntu-VM:~$ sudo update-alternatives --set java /usr/local/java/jdk9.0.1/bin/java
ubuntu@ubuntu-VM:~$ sudo update-alternatives --set javac /usr/local/java/jdk9.0.1/bin/javac
ubuntu@ubuntu-VM:~$ sudo update-alternatives --set javaws /usr/local/java/jdk9.0.1/bin/javaws
ubuntu@ubuntu-VM:~$ source /etc/profile
ubuntu@ubuntu-VM:~$ java -version
Java(TM) SE Runtime Environment (build 9.0.1+11)
Java HotSpot(TM) 64-Bit Server VM (build 9.0.1+11, mixed mode)
ubuntu@ubuntu-VM:~$ cd -/temp
bash: cd: /home/ubuntu/temp: No such file or directory
ubuntu@ubuntu-VM:~$ sudo mkdir /var/lib/cassandra
ubuntu@ubuntu-VM:~$ sudo chown -R $USER:$GROUP /var/lib/cassandra
ubuntu@ubuntu-VM:~$ sudo chown -R $USER:$GROUP /var/log/cassandra
*ubuntu@ubuntu-VM:~*
```

Click the grey bar on top of the window to respond the keyboard input.

Ubuntu@ubuntu-VM:~

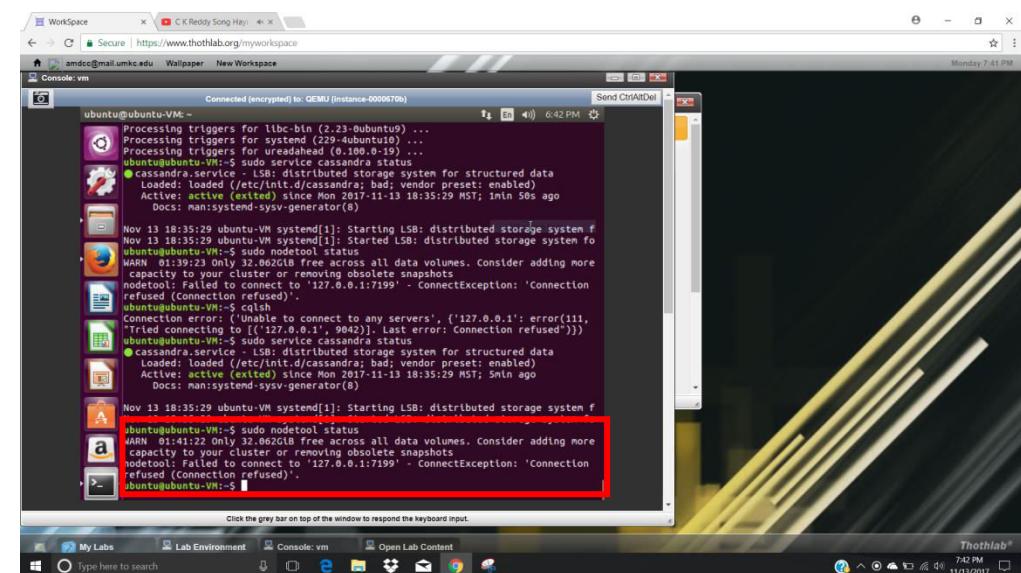
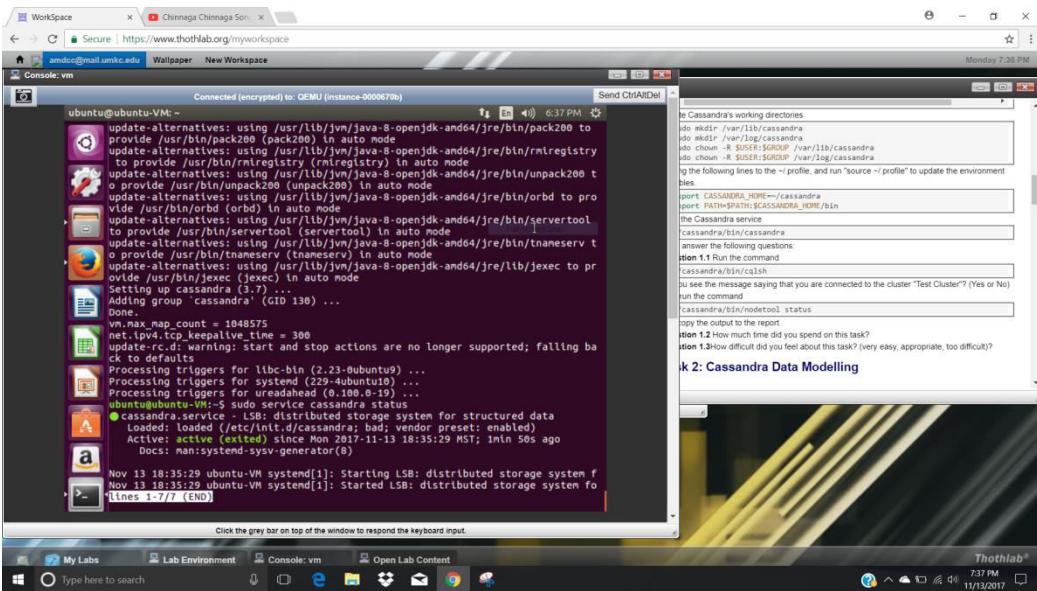
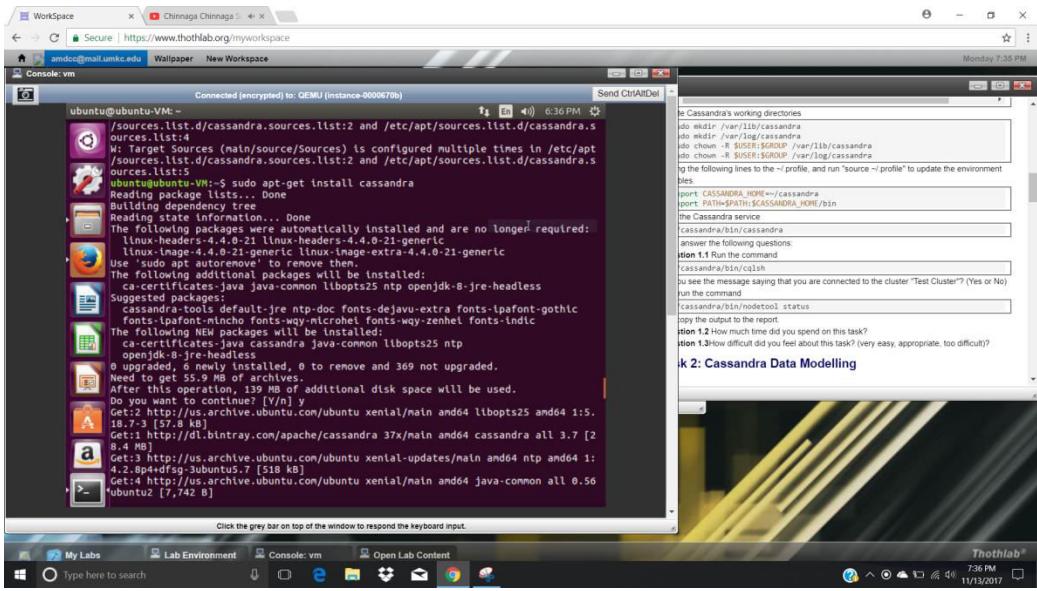
```
deb-src http://www.apache.org/dist/cassandra/debian 37 main
ubuntu@ubuntu-VM:~$ echo "deb-src http://www.apache.org/dist/cassandra/debian 37
x x" > /etc/apt/sources.list.d/cassandra.sources.list
deb-src https://www.apache.org/dist/cassandra/debian 37
ubuntu@ubuntu-VM:~$ gpg --keyserver pgp.mit.edu --recv-keys F758CE318D77295D
gpg: keyring '/home/ubuntu/.gnupg/secring.gpg' created
gpg: keyring '/home/ubuntu/.gnupg/pubring.gpg' created
gpg: keyring '/home/ubuntu/.gnupg/trustdb.gpg' created
gpg: key 8D77295D: public key "Eric Evans <evans@syn-linck.com>" imported
gpg: no ultimately trusted keys found
gpg: Total number processed: 1
gpg:           imported: 1 (RSA: 1)
ubuntu@ubuntu-VM:~$ gpg --keyserver pgp.mit.edu --recv-keys 2B5C1B00
gpg: requesting key 2B5C1B00 from hkp server pgp.mit.edu
gpg: key 2B5C1B00: public key "Sylvain Lebrene (pcmanus) <sylvain@datastax.com>" imported
gpg: Total number processed: 1
gpg:           imported: 1 (RSA: 1)
ubuntu@ubuntu-VM:~$ gpg --export --armor 2B5C1B00 | sudo apt-key add -
OK
ubuntu@ubuntu-VM:~$ gpg --keyserver pgp.mit.edu --recv-keys 0353B12C
gpg: requesting key 0353B12C from hkp server pgp.mit.edu
gpg: key 0353B12C: public key "T Jake Luciani <jake@apache.org>" imported
gpg: no ultimately trusted keys found
gpg: Total number processed: 1
gpg:           imported: 1 (RSA: 1)
ubuntu@ubuntu-VM:~$ gpg --export --armor 0353B12C | sudo apt-key add -
OK
```

Click the grey bar on top of the window to respond the keyboard input.

the Cassandra's working directories  
 do mkdir /var/lib/cassandra  
 do mkdir /var/log/cassandra  
 do chown -R \$USER:\$GROUP /var/lib/cassandra  
 do chown -R \$USER:\$GROUP /var/log/cassandra

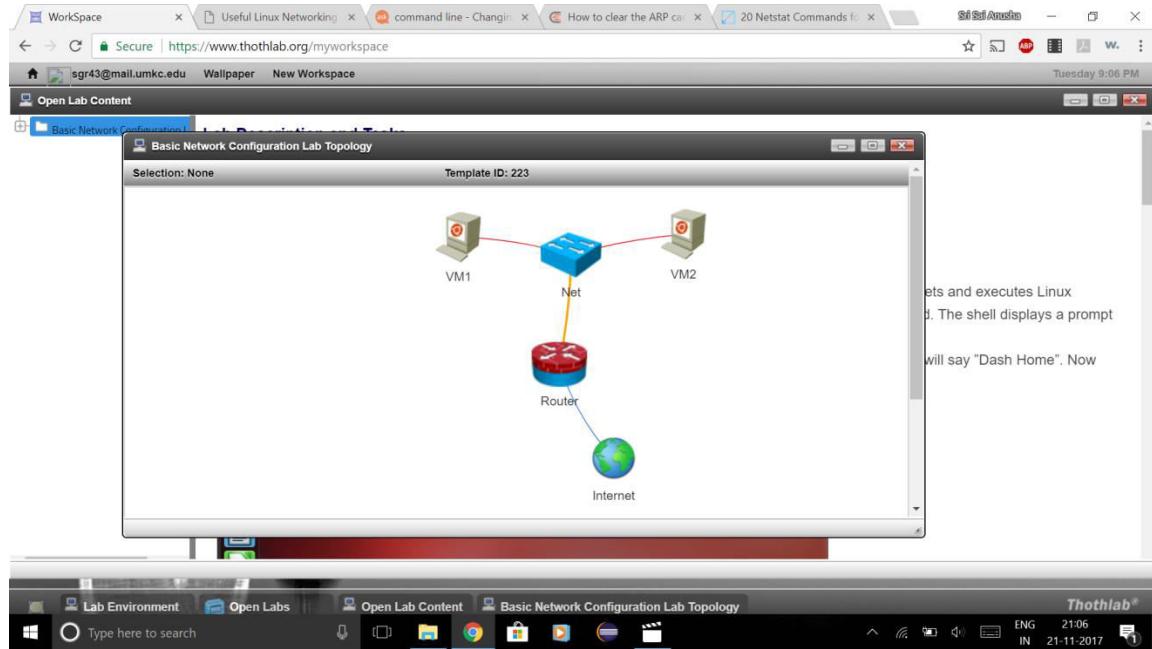
answer the following questions:  
 item 1 Run the command  
 cassandra/bin/cqlsh  
 zu see the message saying that you are connected to the cluster "Test Cluster"? (Yes or No)  
 run the command  
 cassandra/bin/nodetool status  
 copy the output to the clipboard  
 item 12 How much time did you spend on this task?  
 item 13 How difficult did you feel about this task? (very easy, appropriate, too difficult)

**task 2: Cassandra Data Modelling**



## 4. Network Labs

### 4.1 Basic Network Configuration Lab

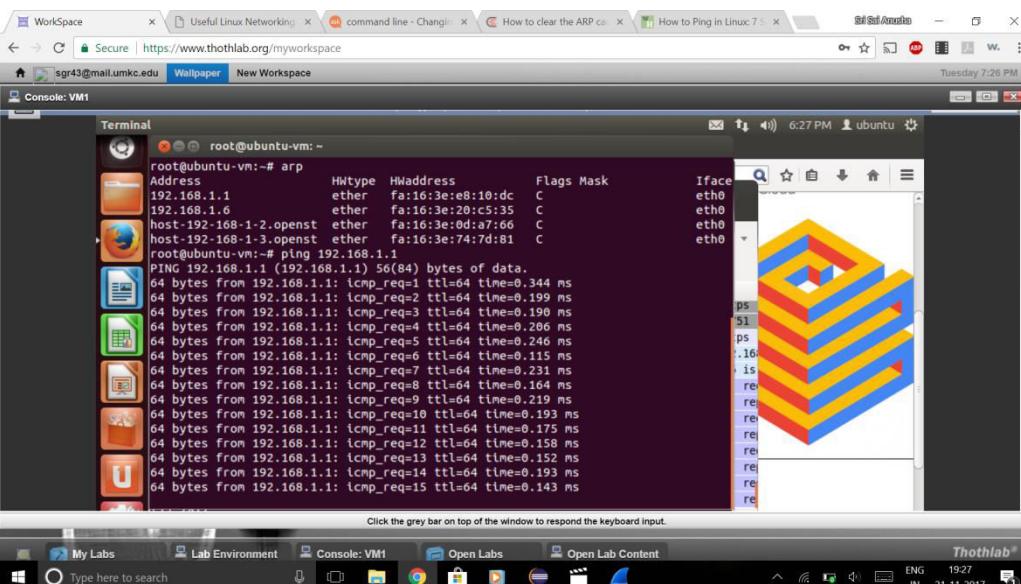
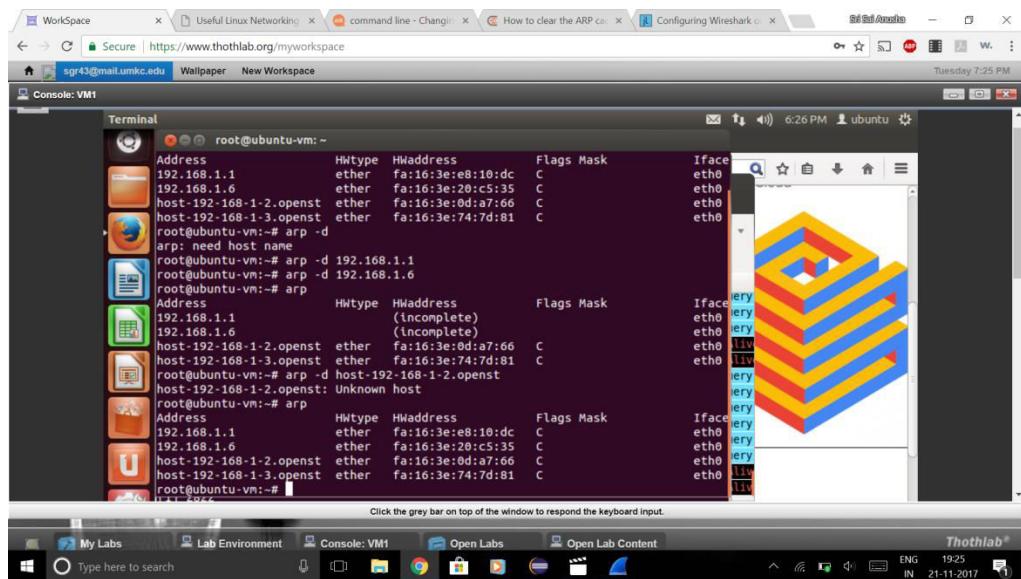
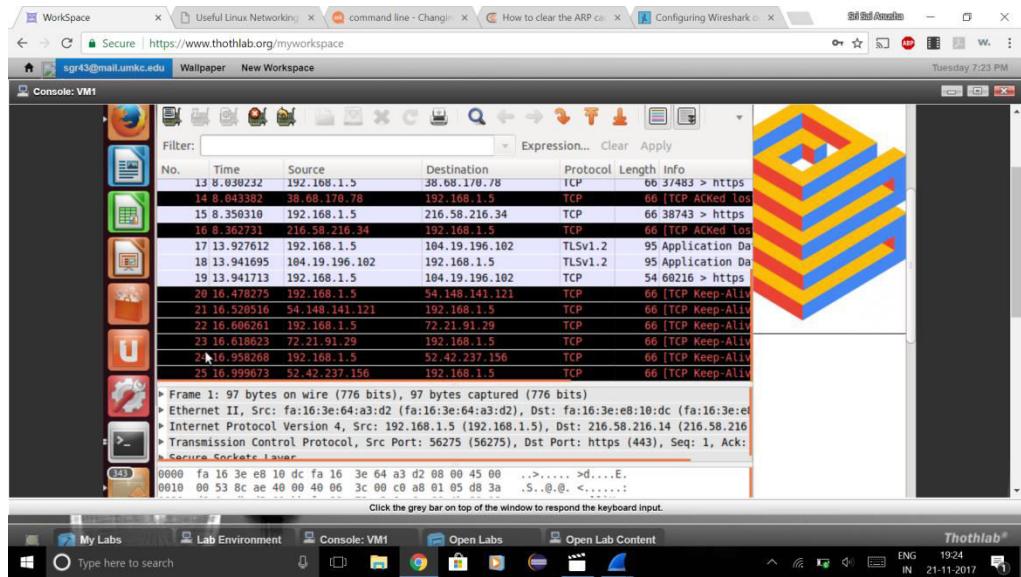


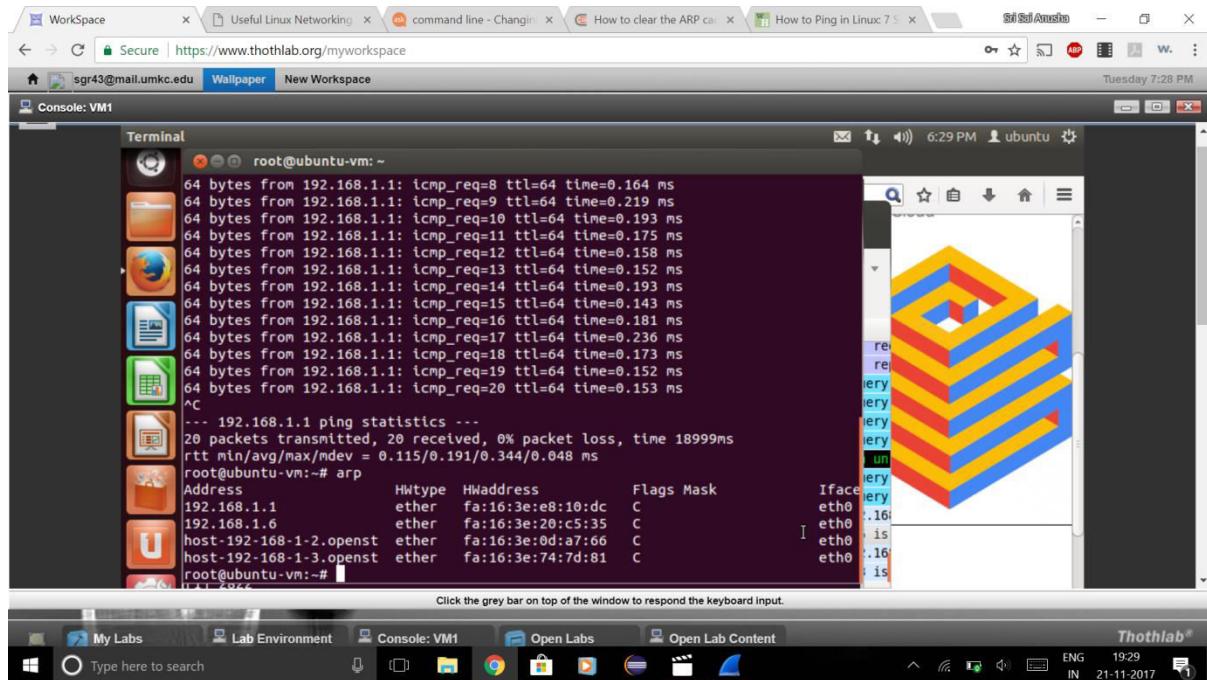
#### Address Resolution Protocol:

The Address Resolution Protocol (ARP) is a communication protocol that is used to discover the link layer address associated with the given IPv4 address. It is used to map a network address to a physical address like a MAC address. It is a request and response protocol whose messages are encapsulated by a link layer protocol.

The screenshot shows a terminal window titled "Console: VM1" connected to QEMU. The terminal displays the following command and its output:

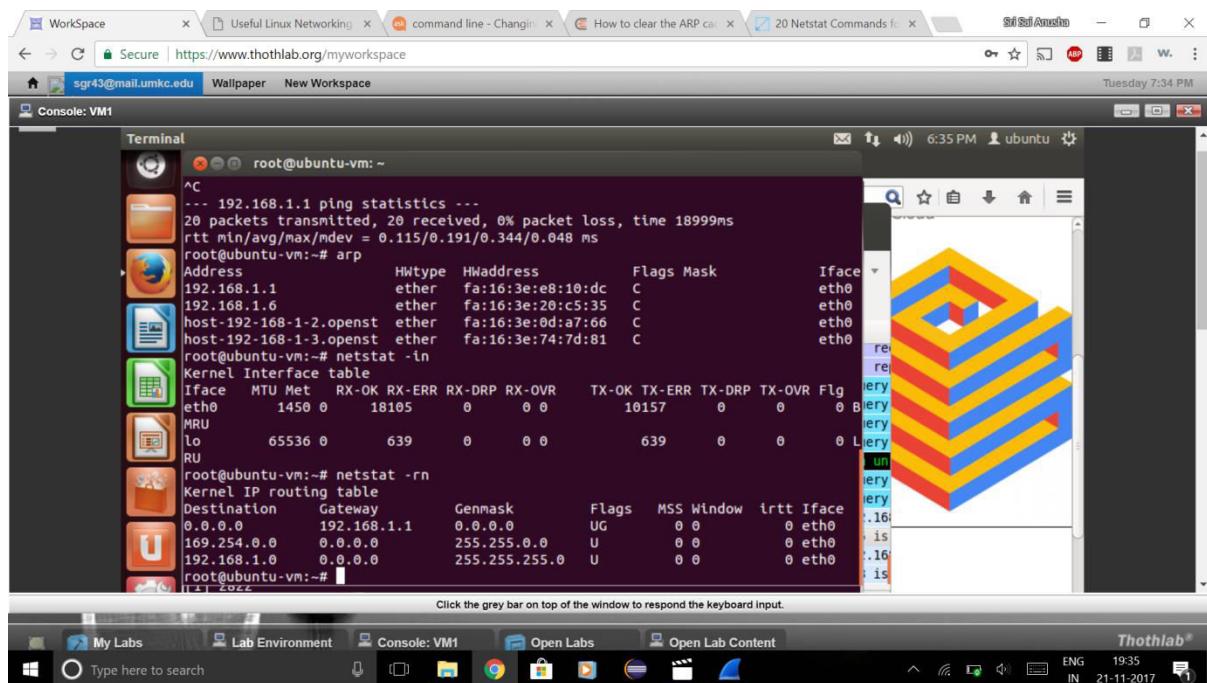
```
ubuntu@ubuntu-vm:~$ sudo -i
[sudo] password for ubuntu:
root@ubuntu-vm:~# arp
Address      HWtype  HWaddress          Flags Mask   Iface
192.168.1.1  ether    fa:16:3e:e8:10:dc C       eth0
192.168.1.6  ether    fa:16:3e:20:c5:35 C       eth0
host-192-168-1-2.openst  ether    fa:16:3e:0d:a7:66 C       eth0
host-192-168-1-3.openst  ether    fa:16:3e:74:7d:81 C       eth0
root@ubuntu-vm:~#
```





### Analyzing Network Statistics (netstat):

In computing, **netstat** is a network utility tool that displays network connections for TCP and network protocol statistics. It is used to find the problems in the network and determine the amount of traffic on the network as a performance measurement.



```

WorkSpace      Useful Linux Networking  command line - Changin...  How to clear the ARP ca...  20 Netstat Commands fo...
Secure | https://www.thothlab.org/myworkspace
sgr43@mail.umkc.edu Wallpaper New Workspace
Console: VM1
root@ubuntu-vm:~# netstat -an | grep 'CONNECTED'
unix 3 [ ] STREAM CONNECTED 11772  /var/run/dbus/system_
unix 3 [ ] STREAM CONNECTED 11580  /var/run/dbus/system_
bus_socket
unix 3 [ ] STREAM CONNECTED 11020  @/tmp/dbus-FHvrfBjzpl
unix 3 [ ] STREAM CONNECTED 11824  @/tmp/dbus-FHvrfBjzpl
unix 3 [ ] STREAM CONNECTED 9776   @/tmp/dbus-FHvrfBjzpl
unix 3 [ ] STREAM CONNECTED 9375   @/tmp/dbus-FHvrfBjzpl
bus_socket
unix 3 [ ] STREAM CONNECTED 11674  @/tmp/dbus-FHvrfBjzpl
unix 3 [ ] STREAM CONNECTED 12187  @/tmp/dbus-FHvrfBjzpl
unix 3 [ ] STREAM CONNECTED 11884  @/tmp/dbus-FHvrfBjzpl
unix 3 [ ] STREAM CONNECTED 11693  @/tmp/dbus-FHvrfBjzpl
bus_socket
unix 3 [ ] STREAM CONNECTED 10205  @/tmp/dbus-FHvrfBjzpl
unix 3 [ ] STREAM CONNECTED 14895  @/tmp/X11-unix/X0
unix 3 [ ] STREAM CONNECTED 9772   @/tmp/dbus-FHvrfBjzpl
unix 3 [ ] STREAM CONNECTED 11823  @/tmp/dbus-FHvrfBjzpl
unix 3 [ ] STREAM CONNECTED 11575  @/tmp/dbus-FHvrfBjzpl
bus_socket
unix 3 [ ] STREAM CONNECTED 13864  @/tmp/dbus-FHvrfBjzpl
unix 3 [ ] STREAM CONNECTED 12287  @/tmp/dbus-FHvrfBjzpl
unix 3 [ ] STREAM CONNECTED 12122  @/tmp/dbus-FHvrfBjzpl
unix 3 [ ] STREAM CONNECTED 11985  @/tmp/dbus-FHvrfBjzpl
unix 3 [ ] STREAM CONNECTED 11734  @/tmp/dbus-FHvrfBjzpl
unix 3 [ ] STREAM CONNECTED 10328  @/tmp/dbus-FHvrfBjzpl
unix 3 [ ] STREAM CONNECTED 11690  @/tmp/dbus-FHvrfBjzpl
root@ubuntu-vm:~#

```

```

WorkSpace      Useful Linux Networking  command line - Changin...  How to clear the ARP ca...  20 Netstat Commands fo...
Secure | https://www.thothlab.org/myworkspace
sgr43@mail.umkc.edu Wallpaper New Workspace
Console: VM1
Tuesday 7:37 PM
root@ubuntu-vm:~# netstat -s
Ip:
    18817 total packets received
        0 forwarded
        0 incoming packets discarded
    18814 incoming packets delivered
    10752 requests sent out
Icmp:
    20 ICMP messages received
        0 input ICMP message failed.
    ICMP input histogram:
        echo replies: 20
    44 ICMP messages sent
        0 ICMP messages failed
    ICMP output histogram:
        destination unreachable: 24
        echo request: 20
IcmpMsg:
    InType0: 20
    OutType3: 24
    OutTypes: 20
Tcp:
    88 active connections openings
    0 passive connection openings
    0 failed connection attempts
    0 connection resets received
    2 connections established
    17650 segments received
    9579 segments send out
    0 segments retransmited
    0 bad segments received.
    44 resets sent
Udp:
    1094 packets received
    24 packets to unknown port received.
    0 packet receive errors
    1144 packets sent
UdpLite:
    58 TCP sockets finished time wait in fast timer
    63 delayed acks sent
    Quick ack mode was activated 4 times
    10107 packet headers predicted
    927 acknowledgments not containing data payload received
    36 predicted acknowledgments
    4 DSACKs sent for old packets
    21 connections reset due to unexpected data
    TCPRcvCoalesce: 14004

```

```

WorkSpace      Useful Linux Networking  command line - Changin...  How to clear the ARP ca...  20 Netstat Commands fo...
Secure | https://www.thothlab.org/myworkspace
sgr43@mail.umkc.edu Wallpaper New Workspace
Console: VM1
Tuesday 7:38 PM
root@ubuntu-vm:~# netstat -s
Ip:
    18817 total packets received
        0 forwarded
        0 incoming packets discarded
    18814 incoming packets delivered
    10752 requests sent out
Icmp:
    20 ICMP messages received
        0 input ICMP message failed.
    ICMP input histogram:
        echo replies: 20
    44 ICMP messages sent
        0 ICMP messages failed
    ICMP output histogram:
        destination unreachable: 24
        echo request: 20
IcmpMsg:
    InType0: 20
    OutType3: 24
    OutTypes: 20
Tcp:
    88 active connections openings
    0 passive connection openings
    0 failed connection attempts
    0 connection resets received
    2 connections established
    17650 segments received
    9579 segments send out
    0 segments retransmited
    0 bad segments received.
    44 resets sent
Udp:
    1094 packets received
    24 packets to unknown port received.
    0 packet receive errors
    1144 packets sent
UdpLite:
    58 TCP sockets finished time wait in fast timer
    63 delayed acks sent
    Quick ack mode was activated 4 times
    10107 packet headers predicted
    927 acknowledgments not containing data payload received
    36 predicted acknowledgments
    4 DSACKs sent for old packets
    21 connections reset due to unexpected data
    TCPRcvCoalesce: 14004

```

```

      1144 packets sent
UdpLite:
TcpExt:
  58 TCP sockets finished time wait in fast timer
  63 delayed acks sent
  Quick ack mode was activated 4 times
  10107 packet headers predicted
  927 acknowledgments not containing data payload received
  36 predicted acknowledgments
  4 DSACKs sent for old packets
  21 connections reset due to unexpected data
TCPRecvCoalesce: 14004
TCPOffQueue: 3577
IpExt:
  InNoRoutes: 3
  InMcastPkts: 63
  OutMcastPkts: 64
  InBcastPkts: 7
  OutBcastPkts: 7
  InOctets: 22487066
  OutOctets: 1003732
  InMcastOctets: 7086
  OutMcastOctets: 6982
  InBcastOctets: 328
  OutBcastOctets: 328
  InNoECTPkts: 18817
root@ubuntu-vm:~#

```

Click the grey bar on top of the window to respond the keyboard input.

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## Configuring IP interfaces in Linux: ifconfig

The **ifconfig** command is a system administration utility used for network interface configuration. It has the feature of configuring, controlling and querying TCP/IP network interface parameters.

```

      InOctets: 22487066
      OutOctets: 1003732
      InMcastOctets: 7086
      OutMcastOctets: 6982
      InBcastOctets: 328
      OutBcastOctets: 328
      InNoECTPkts: 18817
root@ubuntu-vm:~# ifconfig -a
eth0      Link encap:Ethernet HWaddr fa:16:3e:64:a3:d2
          inet addr:192.168.1.5 Bcast:192.168.1.255 Mask:255.255.255.0
            inet6 addr: fe80::f816:3eff:fe64:a3d2/64 Scope:Link
              UP BROADCAST RUNNING MULTICAST MTU:1450 Metric:1
              RX packets:18211 errors:0 dropped:0 overruns:0 frame:0
              TX packets:10278 errors:0 dropped:0 overruns:0 carrier:0
              collisions:0 txqueuelen:1000
              RX bytes:22673976 (22.6 MB) TX bytes:1094657 (1.0 MB)

          Link encap:Local Loopback
          inet addr:127.0.0.1 Mask:255.0.0.0
            inet6 addr: ::1/128 Scope:Host
              UP LOOPBACK RUNNING MTU:65536 Metric:1
              RX packets:689 errors:0 dropped:0 overruns:0 frame:0
              TX packets:689 errors:0 dropped:0 overruns:0 carrier:0
              collisions:0 txqueuelen:0
              RX bytes:66221 (66.2 KB) TX bytes:66221 (66.2 KB)
root@ubuntu-vm:~#

```

Click the grey bar on top of the window to respond the keyboard input.

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```

root@ubuntu-vm:~# ping -n 5 192.168.1.1
connect: Invalid argument
root@ubuntu-vm:~# ping -n 5 -l 2000 192.168.1.1
connect: Invalid argument
root@ubuntu-vm:~# ping -n 5 -l 1450 192.168.1.1
connect: Invalid argument
root@ubuntu-vm:~# ping -n 5 192.168.1.1
PING 192.168.1.1 (192.168.1.1) 56(84) bytes of data.
64 bytes from 192.168.1.1: icmp_req=1 ttl=64 time=0.541 ms
64 bytes from 192.168.1.1: icmp_req=2 ttl=64 time=0.422 ms
64 bytes from 192.168.1.1: icmp_req=3 ttl=64 time=0.154 ms
64 bytes from 192.168.1.1: icmp_req=4 ttl=64 time=0.142 ms
64 bytes from 192.168.1.1: icmp_req=5 ttl=64 time=0.170 ms
64 bytes from 192.168.1.1: icmp_req=6 ttl=64 time=0.204 ms
64 bytes from 192.168.1.1: icmp_req=7 ttl=64 time=0.202 ms
64 bytes from 192.168.1.1: icmp_req=8 ttl=64 time=0.167 ms
^C
-- 192.168.1.1 ping statistics --
8 packets transmitted, 8 received, 0% packet loss, time 6999ms
rtt min/avg/max/mdev = 0.142/0.250/0.541/0.138 ms
root@ubuntu-vm:#

```

Click the grey bar on top of the window to respond the keyboard input.

The network adapter on which the capture was being done is no longer running; the capture has stopped.

No.	Time	Source	Destination	Protocol	Length	Info
51	114.585618	192.168.1.1	192.168.1.5	ICMP	98	Echo (ping) reply id=0xbba6, seq=7/17
52	119.984890	192.168.1.5	192.168.1.2	ICMP	98	Echo (ping) request id=0xbba6, seq=8/20
53	119.984910	192.168.1.5	192.168.1.3	DNS	82	Standard query A videosearch.ubuntu.com
54	119.985706	192.168.1.3	192.168.1.5	DNS	82	Standard query response, No such name
55	119.985717	192.168.1.2	192.168.1.5	DNS	82	Standard query response, No such name
56	119.985853	192.168.1.5	192.168.1.3	DNS	97	Standard query A videosearch.ubuntu.com
57	119.986254	192.168.1.3	192.168.1.5	DNS	97	Standard query response, No such name
58	124.988124	fa:16:3e:74:7d:81	fa:16:3e:64:a3:d2	ARP	42	Who has 192.168.1.5? Tell 192.168.1.3
59	124.988147	fa:16:3e:64:a3:d2	fa:16:3e:74:7d:81	ARP	42	192.168.1.5 is at fa:16:3e:64:a3:d2
60	124.989439	fa:16:3e:64:a3:d2	fa:16:3e:0d:a7:66	ARP	42	Who has 192.168.1.2? Tell 192.168.1.5
61	124.990098	fa:16:3e:0d:a7:66	fa:16:3e:64:a3:d2	ARP	42	192.168.1.2 is at fa:16:3e:0d:a7:66

Frame 1: 82 bytes on wire (656 bits), 82 bytes captured (656 bits)
Ethernet II, Src: fa:16:3e:64:a3:d2 (fa:16:3e:64:a3:d2), Dst: fa:16:3e:0d:a7:66 (fa:16:3e:0d:a7:66)
Internet Protocol Version 4, Src: 192.168.1.5 (192.168.1.5), Dst: 192.168.1.2 (192.168.1.2)
User Datagram Protocol, Src Port: 64784 (64784), Dst Port: domain (53)
Domain Name System (query)

Click the grey bar on top of the window to respond the keyboard input.

No.	Time	Source	Destination	Protocol	Length	Info
4	8.891107	192.168.1.2	192.168.1.5	DNS	82	Standard query response, No such name
5	8.001223	192.168.1.5	192.168.1.3	DNS	97	Standard query A videosearch.ubuntu.com
6	8.001475	192.168.1.3	192.168.1.5	DNS	97	Standard query response, No such name
7	8.577758	fe80::f816:3eff:fe64:ff62::fb		MDNS	101	Standard query PTR '_sane-port._tcp.local'
8	8.577813	192.168.1.5	224.0.0.251	MDNS	81	Standard query PTR '_sane-port._tcp.local'
9	8.579785	192.168.1.5	192.168.1.3	DNS	76	Standard query A daisy.ubuntu.com
10	8.593610	192.168.1.3	192.168.1.5	DNS	108	Standard query response A 162.213.33.133
11	8.593610	192.168.1.3	192.168.1.5	DNS	108	Standard query response A 162.213.33.133
11	8.593610	192.168.1.3	192.168.1.5	DNS	108	Standard query response A 162.213.33.133
11	8.593610	192.168.1.3	192.168.1.5	DNS	108	Standard query response A 162.213.33.133
12	8.593610	192.168.1.3	192.168.1.5	DNS	108	Standard query response A 162.213.33.133
12	8.593610	192.168.1.3	192.168.1.5	DNS	108	Standard query response A 162.213.33.133
13	8.593610	192.168.1.3	192.168.1.5	DNS	108	Standard query response A 162.213.33.133
13	8.593610	192.168.1.3	192.168.1.5	DNS	108	Standard query response A 162.213.33.133
14	8.593610	192.168.1.3	192.168.1.5	DNS	108	Standard query response A 162.213.33.133
14	8.593610	192.168.1.3	192.168.1.5	DNS	108	Standard query response A 162.213.33.133
15	8.593610	192.168.1.3	192.168.1.5	DNS	108	Standard query response A 162.213.33.133
16	8.593610	192.168.1.3	192.168.1.5	DNS	108	Standard query response A 162.213.33.133
16	8.593610	192.168.1.3	192.168.1.5	DNS	108	Standard query response A 162.213.33.133

Frame 16: 76 bytes on wire (608 bits), 76 bytes captured (608 bits)
Ethernet II, Src: fa:16:3e:64:a3:d2 (fa:16:3e:64:a3:d2), Dst: fa:16:3e:74:7d:81 (fa:16:3e:74:7d:81)
Internet Protocol Version 4, Src: 192.168.1.5 (192.168.1.5), Dst: 192.168.1.3 (192.168.1.3)
User Datagram Protocol, Src Port: 36819 (36819), Dst Port: domain (53)
Domain Name System (query)

Click the grey bar on top of the window to respond the keyboard input.

```

collisions:0 txqueuelen:0
RX bytes:66221 (66.2 KB) TX bytes:66221 (66.2 KB)
root@ubuntu-vm:~# ping -n 5 192.168.1.1
connect: Invalid argument
root@ubuntu-vm:~# ping -n 5 -l 2000 192.168.1.1
connect: Invalid argument
root@ubuntu-vm:~# ping -n 5 -l 1450 192.168.1.1
connect: Invalid argument
root@ubuntu-vm:~# ping -n 192.168.1.1
PING 192.168.1.1 (192.168.1.1) 56(84) bytes of data.
64 bytes from 192.168.1.1: icmp_req=1 ttl=64 time=0.541 ms
64 bytes from 192.168.1.1: icmp_req=2 ttl=64 time=0.422 ms
64 bytes from 192.168.1.1: icmp_req=3 ttl=64 time=0.154 ms
64 bytes from 192.168.1.1: icmp_req=4 ttl=64 time=0.142 ms
64 bytes from 192.168.1.1: icmp_req=5 ttl=64 time=0.170 ms
64 bytes from 192.168.1.1: icmp_req=6 ttl=64 time=0.204 ms
64 bytes from 192.168.1.1: icmp_req=7 ttl=64 time=0.202 ms
64 bytes from 192.168.1.1: icmp_req=8 ttl=64 time=0.167 ms
^C
--- 192.168.1.1 ping statistics ---
8 packets transmitted, 8 received, 0% packet loss, time 6999ms
rtt min/avg/max/mdev = 0.142/0.250/0.541/0.138 ms
root@ubuntu-vm:~# ifconfig eth0 down
root@ubuntu-vm:~# ping -n 192.168.1.1
connect: Network is unreachable
root@ubuntu-vm:~#

```

Click the grey bar on top of the window to respond the keyboard input.

```

64 bytes from 192.168.1.1: icmp_req=2 ttl=64 time=0.422 ms
64 bytes from 192.168.1.1: icmp_req=3 ttl=64 time=0.154 ms
64 bytes from 192.168.1.1: icmp_req=4 ttl=64 time=0.142 ms
64 bytes from 192.168.1.1: icmp_req=5 ttl=64 time=0.170 ms
64 bytes from 192.168.1.1: icmp_req=6 ttl=64 time=0.204 ms
64 bytes from 192.168.1.1: icmp_req=7 ttl=64 time=0.202 ms
64 bytes from 192.168.1.1: icmp_req=8 ttl=64 time=0.167 ms
^C
--- 192.168.1.1 ping statistics ---
8 packets transmitted, 8 received, 0% packet loss, time 6999ms
rtt min/avg/max/mdev = 0.142/0.250/0.541/0.138 ms
root@ubuntu-vm:~# ifconfig eth0 down
root@ubuntu-vm:~# ping -n 192.168.1.1
connect: Network is unreachable
root@ubuntu-vm:~# ifconfig eth0 up
root@ubuntu-vm:~# ping -n 192.168.1.1
PING 192.168.1.1 (192.168.1.1) 56(84) bytes of data.
64 bytes from 192.168.1.1: icmp_req=1 ttl=64 time=0.348 ms
64 bytes from 192.168.1.1: icmp_req=2 ttl=64 time=0.184 ms
64 bytes from 192.168.1.1: icmp_req=3 ttl=64 time=0.130 ms
64 bytes from 192.168.1.1: icmp_req=4 ttl=64 time=0.183 ms
64 bytes from 192.168.1.1: icmp_req=5 ttl=64 time=0.173 ms
^C
--- 192.168.1.1 ping statistics ---
5 packets transmitted, 5 received, 0% packet loss, time 3998ms
rtt min/avg/max/mdev = 0.130/0.203/0.348/0.076 ms
root@ubuntu-vm:~#

```

Click the grey bar on top of the window to respond the keyboard input.

## Static Mapping of IP Addresses and Hostnames:

On the Internet, the resolution between IP addresses and hostname is done by **Domain Name System (DNS)**. Before DNS became available, the **/etc/hosts** file was the only method to resolve hostnames in Internet.

```

sudo: /etc/hosts: command not found
root@ubuntu-vm:~# sudo nano /etc/hosts
root@ubuntu-vm:~# ping 192.168.1.1
PING 192.168.1.1 (192.168.1.1) 56(84) bytes of data.
64 bytes from 192.168.1.1: icmp_req=1 ttl=64 time=0.466 ms
64 bytes from 192.168.1.1: icmp_req=2 ttl=64 time=0.183 ms
64 bytes from 192.168.1.1: icmp_req=3 ttl=64 time=0.184 ms
64 bytes from 192.168.1.1: icmp_req=4 ttl=64 time=0.202 ms
64 bytes from 192.168.1.1: icmp_req=5 ttl=64 time=0.176 ms
64 bytes from 192.168.1.1: icmp_req=6 ttl=64 time=0.240 ms
^C
--- 192.168.1.1 ping statistics ---
6 packets transmitted, 6 received, 0% packet loss, time 4998ms
rtt min/avg/max/mdev = 0.176/0.241/0.466/0.104 ms
root@ubuntu-vm:~# ping 192.168.1.6
PING 192.168.1.6 (192.168.1.6) 56(84) bytes of data.
64 bytes from 192.168.1.6: icmp_req=1 ttl=64 time=0.866 ms
64 bytes from 192.168.1.6: icmp_req=2 ttl=64 time=0.456 ms
64 bytes from 192.168.1.6: icmp_req=3 ttl=64 time=0.322 ms
64 bytes from 192.168.1.6: icmp_req=4 ttl=64 time=0.416 ms
64 bytes from 192.168.1.6: icmp_req=5 ttl=64 time=0.576 ms
64 bytes from 192.168.1.6: icmp_req=6 ttl=64 time=0.375 ms
^C
--- 192.168.1.6 ping statistics ---
6 packets transmitted, 6 received, 0% packet loss, time 4997ms
rtt min/avg/max/mdev = 0.322/0.501/0.866/0.183 ms
root@ubuntu-vm:~#

```

Click the grey bar on top of the window to respond the keyboard input.

```

Connected (encrypted) to: QEMU (instance-00006711)
File: /etc/hosts
root@ubuntu-vm:~# nano /etc/hosts
root@ubuntu-vm:~# cat /etc/hosts
127.0.0.1 localhost
127.0.1.1 ubuntu-vm
192.168.1.1 R1
192.168.1.6 R2
# The following lines are desirable for IPv6 capable hosts
::1 ip6-localhost ip6-loopback
fe00::0 ip6-localnet
ff00::0 ip6-mcastprefix
ff02::1 ip6-allnodes
ff02::2 ip6-allrouters
root@ubuntu-vm:~#

```

Click the grey bar on top of the window to respond the keyboard input.

```

root@ubuntu-vm:~#
64 bytes from 192.168.1.6: icmp_req=4 ttl=64 time=0.416 ms
64 bytes from 192.168.1.6: icmp_req=5 ttl=64 time=0.576 ms
64 bytes from 192.168.1.6: icmp_req=6 ttl=64 time=0.375 ms
^C
--- 192.168.1.6 ping statistics ---
6 packets transmitted, 6 received, 0% packet loss, time 4997ms
rtt min/avg/max/mdev = 0.322/0.501/0.866/0.183 ms
root@ubuntu-vm:~# sudo nano /etc/hosts
root@ubuntu-vm:~# ping -c 10 R1
PING R1 (192.168.1.1) 56(84) bytes of data.
64 bytes from R1 (192.168.1.1): icmp_req=1 ttl=64 time=0.335 ms
64 bytes from R1 (192.168.1.1): icmp_req=2 ttl=64 time=0.178 ms
64 bytes from R1 (192.168.1.1): icmp_req=3 ttl=64 time=0.170 ms
64 bytes from R1 (192.168.1.1): icmp_req=4 ttl=64 time=0.165 ms
64 bytes from R1 (192.168.1.1): icmp_req=5 ttl=64 time=0.301 ms
64 bytes from R1 (192.168.1.1): icmp_req=6 ttl=64 time=0.179 ms
64 bytes from R1 (192.168.1.1): icmp_req=7 ttl=64 time=0.185 ms
64 bytes from R1 (192.168.1.1): icmp_req=8 ttl=64 time=0.212 ms
64 bytes from R1 (192.168.1.1): icmp_req=9 ttl=64 time=0.167 ms
64 bytes from R1 (192.168.1.1): icmp_req=10 ttl=64 time=0.231 ms
^C
--- R1 ping statistics ---
10 packets transmitted, 10 received, 0% packet loss, time 9000ms
rtt min/avg/max/mdev = 0.165/0.212/0.335/0.058 ms
root@ubuntu-vm:~# ping -c 10 R2
PING R2 (192.168.1.6) 56(84) bytes of data.

```

Click the grey bar on top of the window to respond the keyboard input.

The screenshot shows a Linux desktop environment with a terminal window titled "Console: VM1". The terminal displays the output of a ping command between two routers, R1 and R2. The output includes statistics for both R1 and R2, showing 10 packets transmitted, 0% packet loss, and round-trip times ranging from 0.185 ms to 0.795 ms.

```

64 bytes from R1 (192.168.1.1): icmp_req=7 ttl=64 time=0.185 ms
64 bytes from R1 (192.168.1.1): icmp_req=8 ttl=64 time=0.212 ms
64 bytes from R1 (192.168.1.1): icmp_req=9 ttl=64 time=0.167 ms
64 bytes from R1 (192.168.1.1): icmp_req=10 ttl=64 time=0.231 ms
...
--- R1 ping statistics ---
10 packets transmitted, 0 received, 0% packet loss, time 9000ms
rtt min/avg/max/mdev = 0.165/0.212/0.335/0.058 ms
root@ubuntu-vm:~# ping -c 10 R2
PING R2 (192.168.1.6) 56(84) bytes of data.
64 bytes from R2 (192.168.1.6): icmp_req=1 ttl=64 time=0.795 ms
64 bytes from R2 (192.168.1.6): icmp_req=2 ttl=64 time=0.294 ms
64 bytes from R2 (192.168.1.6): icmp_req=3 ttl=64 time=0.371 ms
64 bytes from R2 (192.168.1.6): icmp_req=4 ttl=64 time=0.450 ms
64 bytes from R2 (192.168.1.6): icmp_req=5 ttl=64 time=0.536 ms
64 bytes from R2 (192.168.1.6): icmp_req=6 ttl=64 time=0.367 ms
64 bytes from R2 (192.168.1.6): icmp_req=7 ttl=64 time=0.414 ms
64 bytes from R2 (192.168.1.6): icmp_req=8 ttl=64 time=0.446 ms
64 bytes from R2 (192.168.1.6): icmp_req=9 ttl=64 time=0.544 ms
64 bytes from R2 (192.168.1.6): icmp_req=10 ttl=64 time=0.343 ms
...
--- R2 ping statistics ---
10 packets transmitted, 0 received, 0% packet loss, time 9000ms
rtt min/avg/max/mdev = 0.294/0.456/0.795/0.136 ms
root@ubuntu-vm:~#

```

## Basic Shell Scripting:

Scripting is a way by which one can automate the command sequences. This method of scripting makes the computer do all the work.

### Shell Script to display IP address

The screenshot shows a Linux desktop environment with a terminal window titled "Console: VM1". The terminal displays a shell script named "ipaddr" being edited in nano. The script contains a single command: "ifconfig".

```

#!/bin/bash
# Display IP Address
ifconfig

```

```

root@ubuntu-vm:~# netstat -i
eth0      Link encap:Ethernet HWaddr fa:16:3e:64:a3:d2
          inet addr:192.168.1.5  Bcast:192.168.1.255  Mask:255.255.255.0
          inet6 addr: fe80::fa16:3eff:fe64:a3d2/64  Scope:Link
          UP BROADCAST RUNNING MULTICAST  MTU:1540  Metric:1
          RX packets:1032 errors:0 dropped:0 overruns:0 frame:0
          TX packets:1433 errors:0 dropped:0 overruns:0 carrier:0
          collisions:0 txqueuelen:1000
          RX bytes:29122236 (29.1 MB)  TX bytes:2051609 (2.0 MB)

lo        Link encap:Local Loopback
          inet addr:127.0.0.1  Mask:255.0.0.0
          inet6 addr: ::1/128  Scope:Host
          UP LOOPBACK RUNNING  MTU:65536  Metric:1
          RX packets:2091 errors:0 dropped:0 overruns:0 frame:0
          TX packets:2091 errors:0 dropped:0 overruns:0 carrier:0
          collisions:0 txqueuelen:0
          RX bytes:204466 (204.4 KB)  TX bytes:204466 (204.4 KB)

root@ubuntu-vm:~#

```

## Shell Script to ping 10 packets of R1 (192.168.1.1)

```

root@ubuntu-vm:~# nano pingr1
File: pingr1
#!/bin/bash
# Ping R1
ping -c 10 R1

root@ubuntu-vm:~#

```

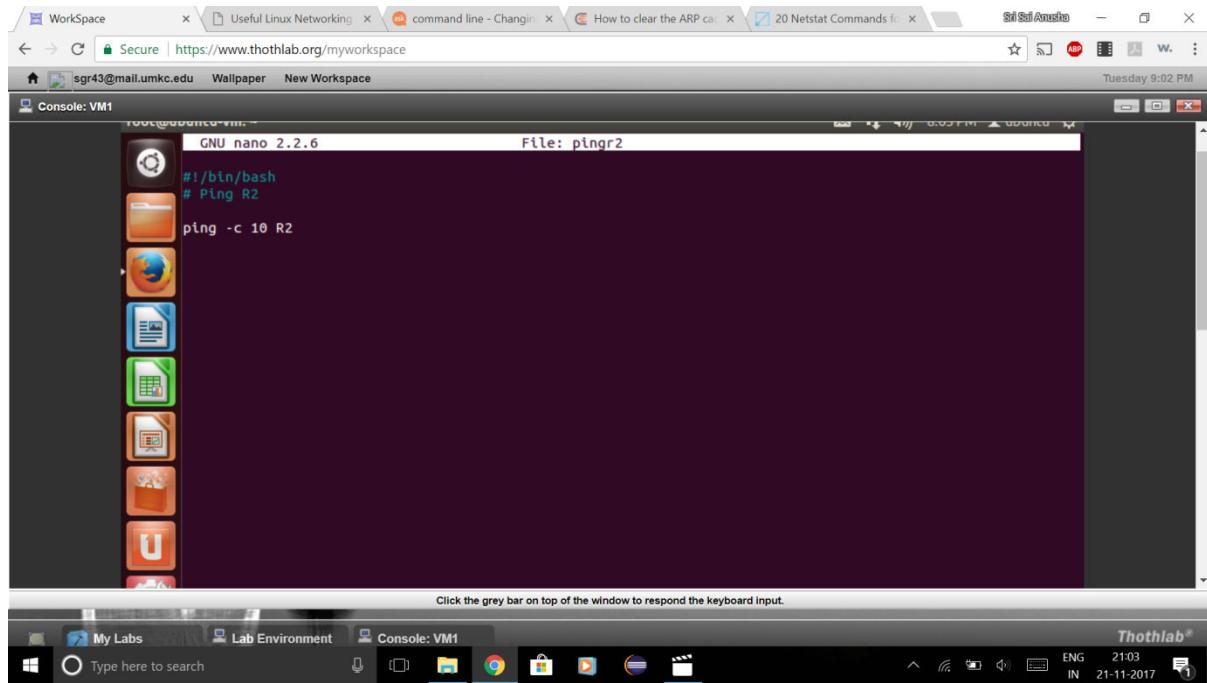
```

root@ubuntu-vm:~# ./pingr1
PING R1 (192.168.1.1) 56(84) bytes of data.
64 bytes from R1 (192.168.1.1): icmp_req=1 ttl=64 time=0.317 ms
64 bytes from R1 (192.168.1.1): icmp_req=2 ttl=64 time=0.400 ms
64 bytes from R1 (192.168.1.1): icmp_req=3 ttl=64 time=0.167 ms
64 bytes from R1 (192.168.1.1): icmp_req=4 ttl=64 time=0.183 ms
64 bytes from R1 (192.168.1.1): icmp_req=5 ttl=64 time=0.241 ms
64 bytes from R1 (192.168.1.1): icmp_req=6 ttl=64 time=0.174 ms
64 bytes from R1 (192.168.1.1): icmp_req=7 ttl=64 time=0.130 ms
64 bytes from R1 (192.168.1.1): icmp_req=8 ttl=64 time=0.187 ms
64 bytes from R1 (192.168.1.1): icmp_req=9 ttl=64 time=0.128 ms
64 bytes from R1 (192.168.1.1): icmp_req=10 ttl=64 time=0.162 ms

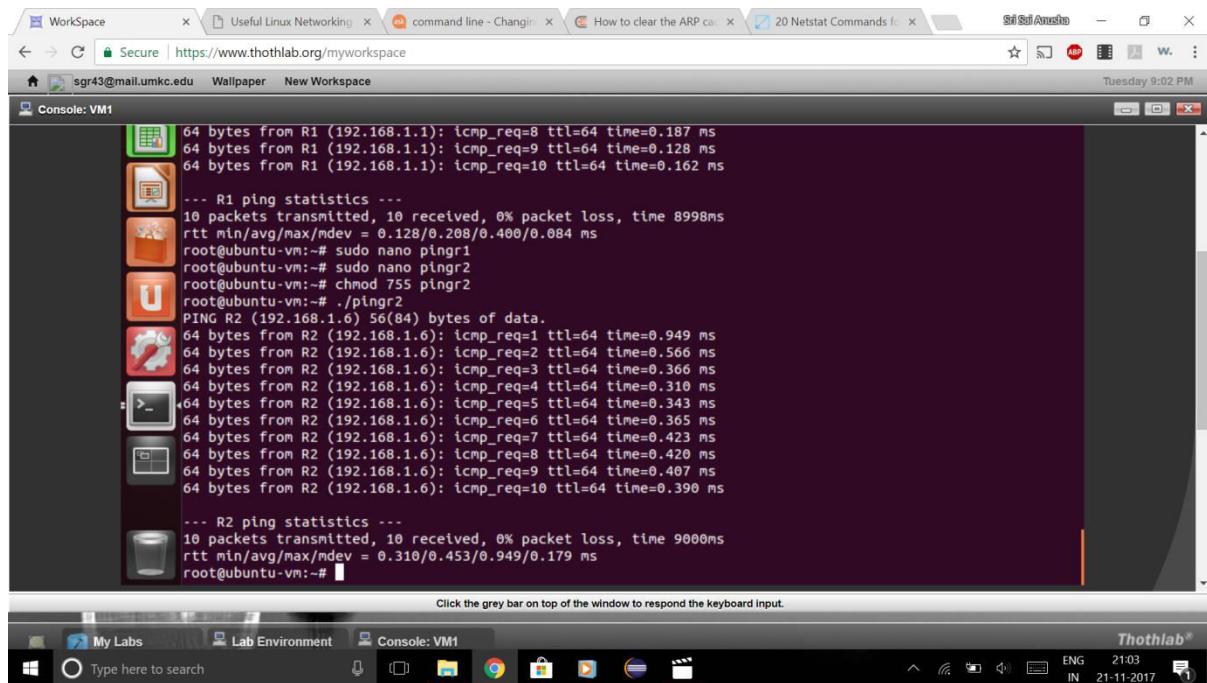
... R1 ping statistics ...
10 packets transmitted, 10 received, 0% packet loss, time 8998ms
rtt min/avg/max/mdev = 0.128/0.268/0.406/0.084 ms
root@ubuntu-vm:~#

```

## Shell Script to ping 10 packets of R2 (192.168.1.6)

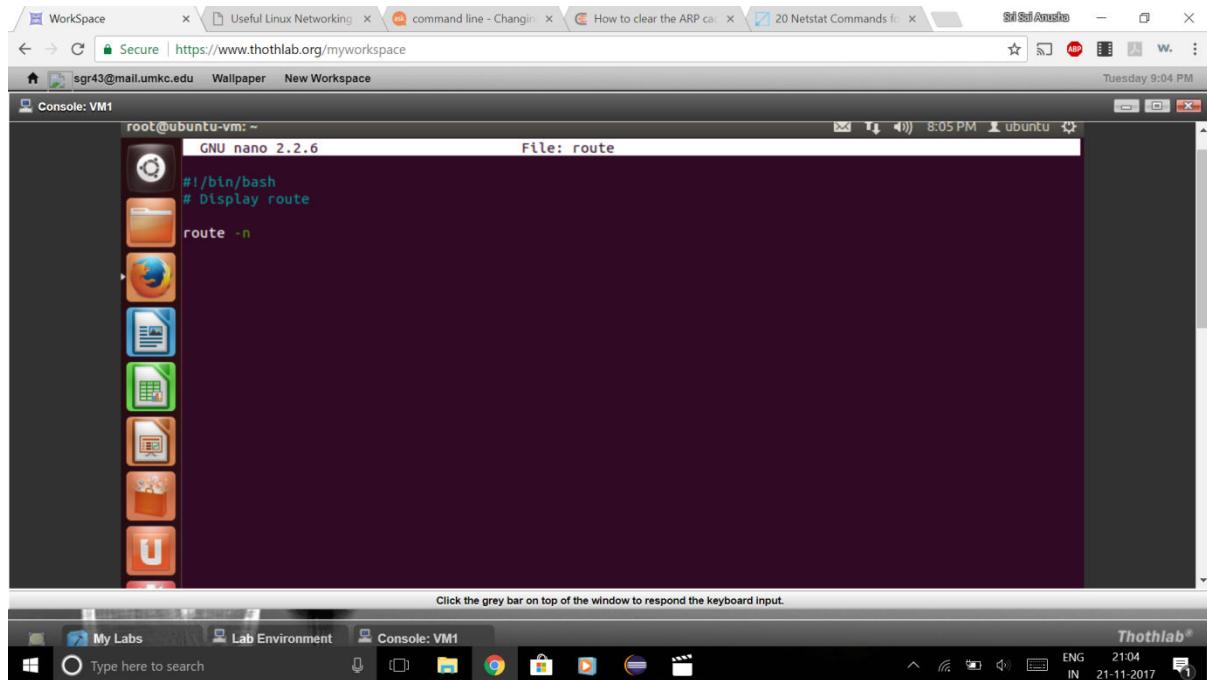


```
root@ubuntu-vm:~# nano pingr2
#!/bin/bash
# Png R2
ping -c 10 R2
```

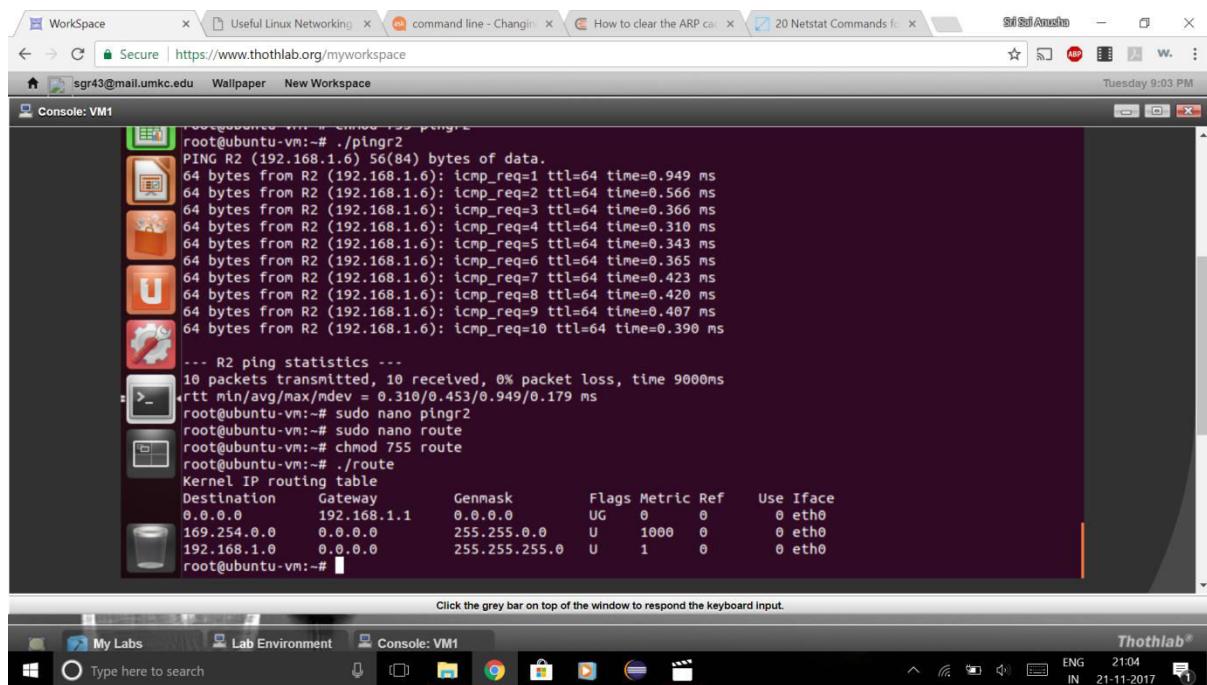


```
64 bytes from R1 (192.168.1.1): icmp_req=8 ttl=64 time=0.187 ms
64 bytes from R1 (192.168.1.1): icmp_req=9 ttl=64 time=0.128 ms
64 bytes from R1 (192.168.1.1): icmp_req=10 ttl=64 time=0.162 ms
--- R1 ping statistics ---
10 packets transmitted, 0 received, 0% packet loss, time 8998ms
rtt min/avg/max/mdev = 0.128/0.208/0.400/0.084 ms
root@ubuntu-vm:~# sudo nano pingr1
root@ubuntu-vm:~# sudo nano pingr2
root@ubuntu-vm:~# chmod 755 pingr2
root@ubuntu-vm:~# ./pingr2
PING R2 (192.168.1.6) 56(84) bytes of data.
64 bytes from R2 (192.168.1.6): icmp_req=1 ttl=64 time=0.949 ms
64 bytes from R2 (192.168.1.6): icmp_req=2 ttl=64 time=0.566 ms
64 bytes from R2 (192.168.1.6): icmp_req=3 ttl=64 time=0.366 ms
64 bytes from R2 (192.168.1.6): icmp_req=4 ttl=64 time=0.310 ms
64 bytes from R2 (192.168.1.6): icmp_req=5 ttl=64 time=0.343 ms
64 bytes from R2 (192.168.1.6): icmp_req=6 ttl=64 time=0.365 ms
64 bytes from R2 (192.168.1.6): icmp_req=7 ttl=64 time=0.423 ms
64 bytes from R2 (192.168.1.6): icmp_req=8 ttl=64 time=0.420 ms
64 bytes from R2 (192.168.1.6): icmp_req=9 ttl=64 time=0.407 ms
64 bytes from R2 (192.168.1.6): icmp_req=10 ttl=64 time=0.390 ms
--- R2 ping statistics ---
10 packets transmitted, 10 received, 0% packet loss, time 9000ms
rtt min/avg/max/mdev = 0.310/0.453/0.949/0.179 ms
root@ubuntu-vm:~#
```

## Shell Script to display route

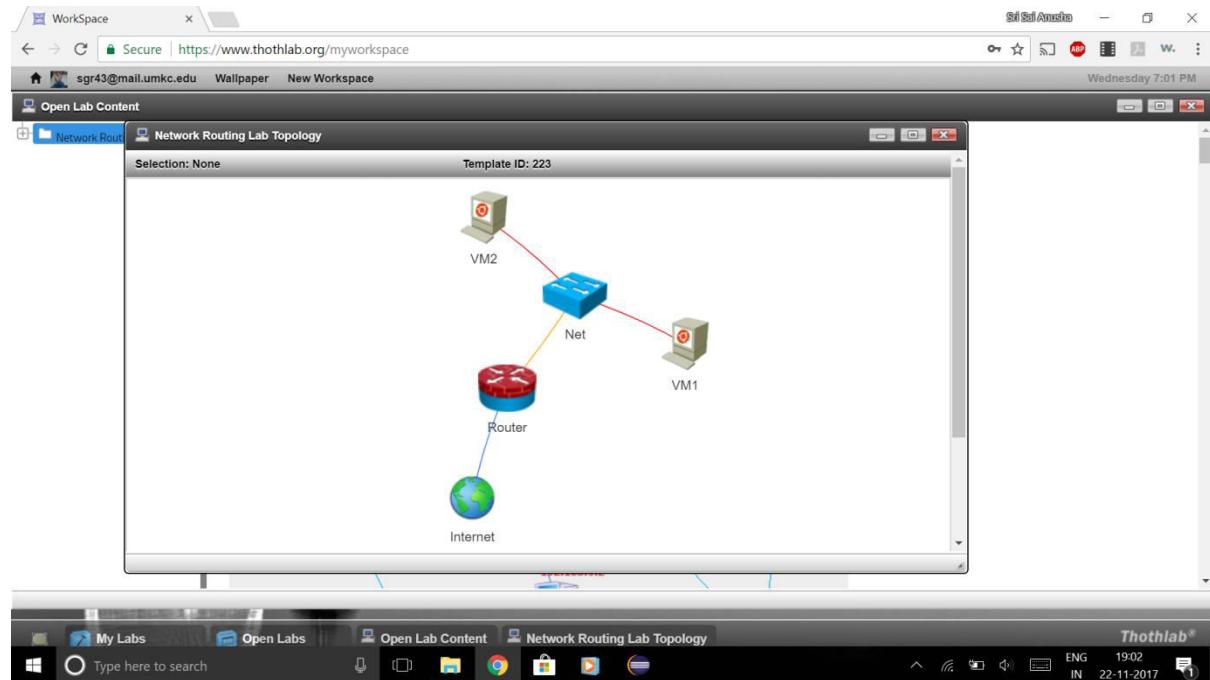


```
root@ubuntu-vm:~# ./route
File: route
GNU nano 2.2.6
#!/bin/bash
# Display route
route -n
```



```
root@ubuntu-vm:~# ./pingr2
PING R2 (192.168.1.6) 56(84) bytes of data.
64 bytes from R2 (192.168.1.6): icmp_req=1 ttl=64 time=0.949 ms
64 bytes from R2 (192.168.1.6): icmp_req=2 ttl=64 time=0.566 ms
64 bytes from R2 (192.168.1.6): icmp_req=3 ttl=64 time=0.366 ms
64 bytes from R2 (192.168.1.6): icmp_req=4 ttl=64 time=0.310 ms
64 bytes from R2 (192.168.1.6): icmp_req=5 ttl=64 time=0.343 ms
64 bytes from R2 (192.168.1.6): icmp_req=6 ttl=64 time=0.365 ms
64 bytes from R2 (192.168.1.6): icmp_req=7 ttl=64 time=0.423 ms
64 bytes from R2 (192.168.1.6): icmp_req=8 ttl=64 time=0.420 ms
64 bytes from R2 (192.168.1.6): icmp_req=9 ttl=64 time=0.407 ms
64 bytes from R2 (192.168.1.6): icmp_req=10 ttl=64 time=0.390 ms
...
R2 ping statistics ...
10 packets transmitted, 10 received, 0% packet loss, time 9000ms
rtt min/avg/max/mdev = 0.310/0.453/0.949/0.179 ms
root@ubuntu-vm:~# sudo nano pingr2
root@ubuntu-vm:~# sudo nano route
root@ubuntu-vm:~# chmod 755 route
root@ubuntu-vm:~# ./route
Kernel IP routing table
Destination     Gateway         Genmask        Flags Metric Ref    Use Iface
0.0.0.0         192.168.1.1   0.0.0.0       UG        0      0        0 eth0
169.254.0.0     0.0.0.0       255.255.0.0   U        1000    0        0 eth0
192.168.1.0     0.0.0.0       255.255.255.0 U        1      0        0 eth0
root@ubuntu-vm:~#
```

## 4.2 Network Routing Lab

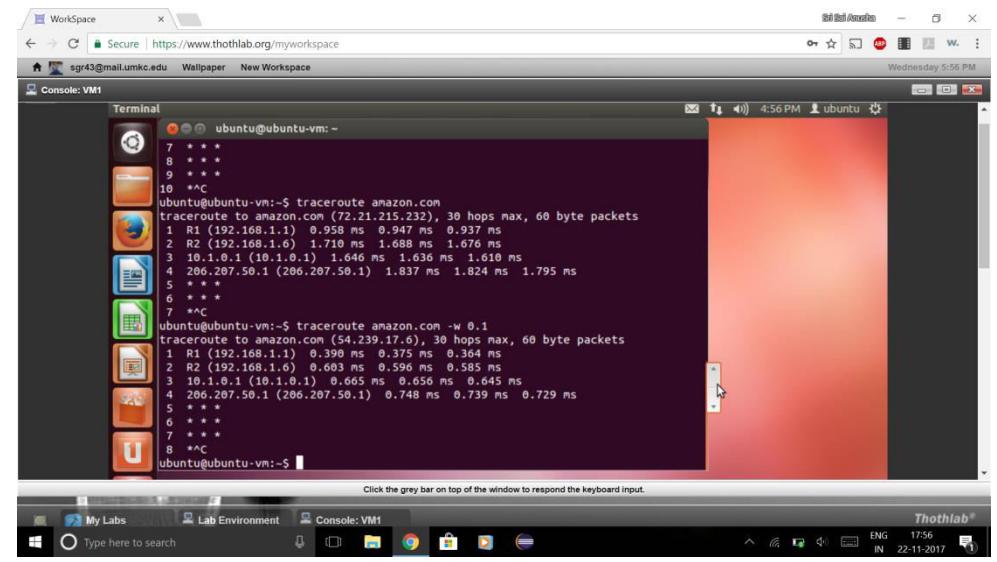
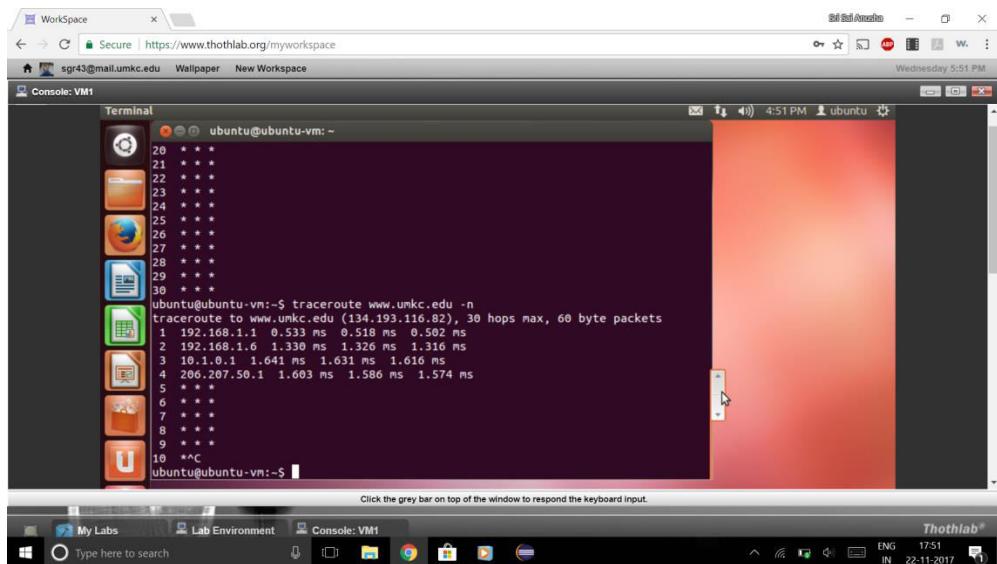
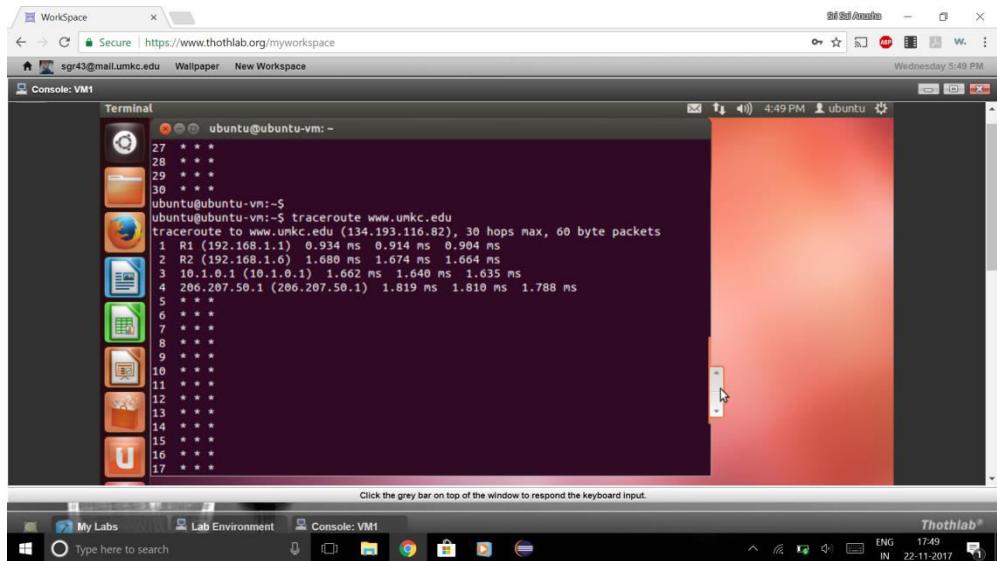


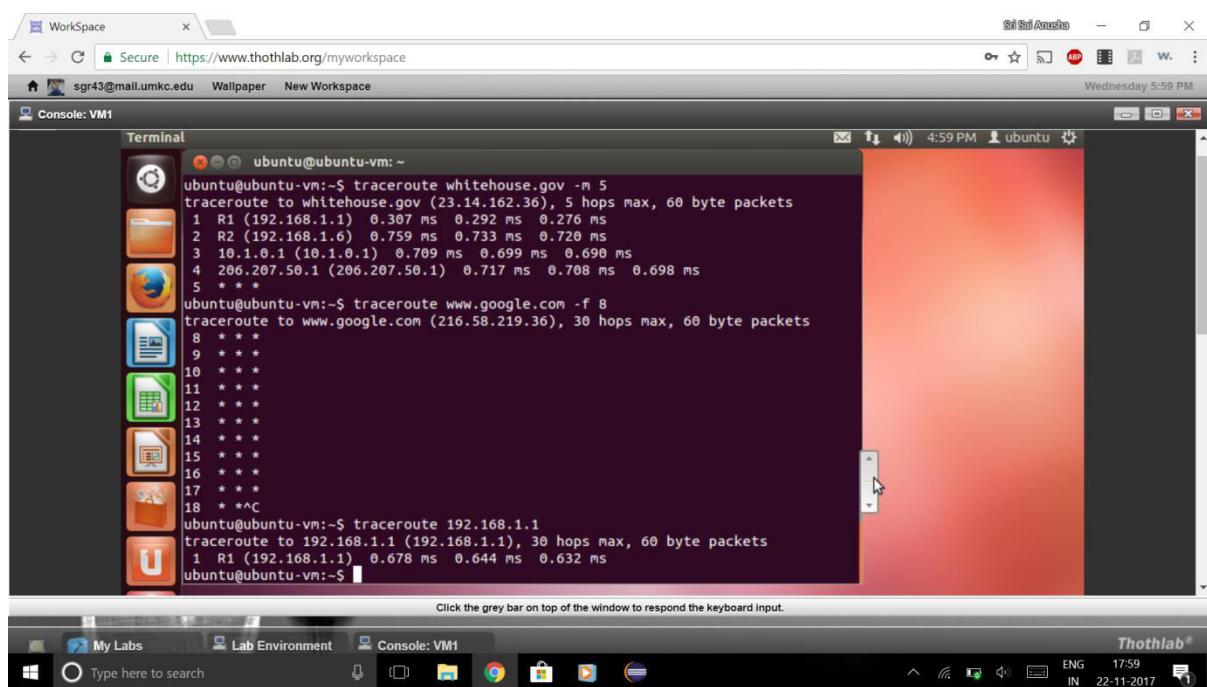
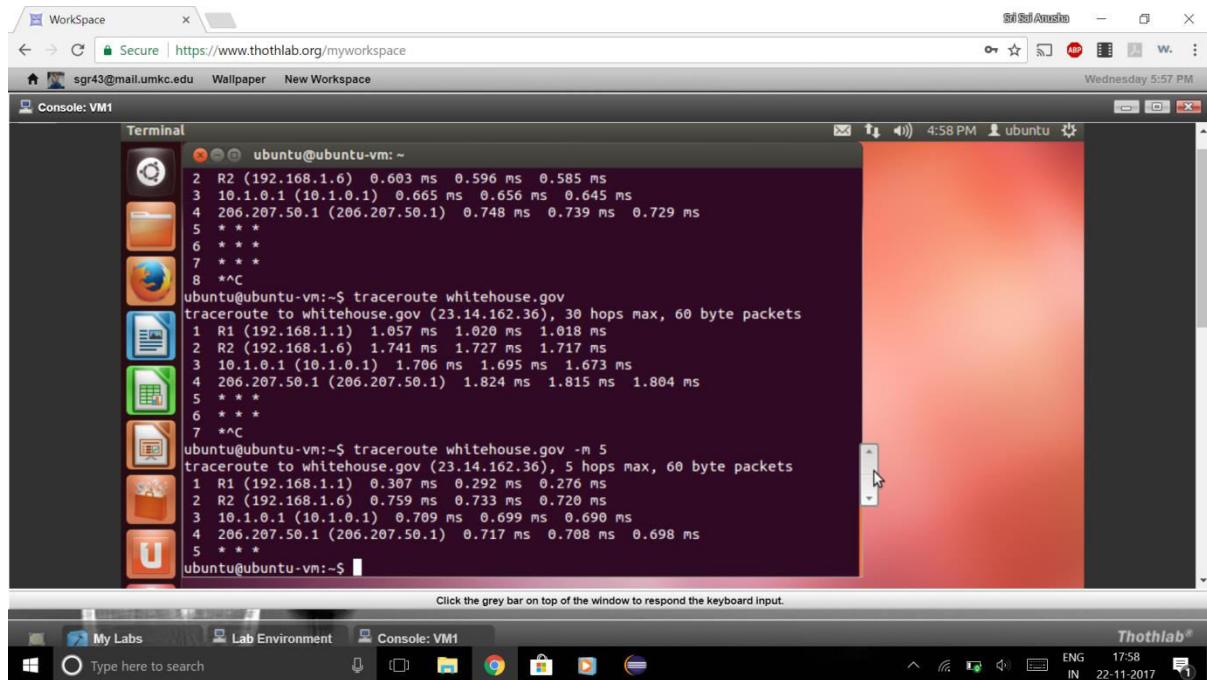
The **traceroute** is a computer network tool to display the route and measure the transit delays of packets (round trip times) across the Internet Protocol (IP) network.

The screenshot shows a terminal window titled "Console: VM1" running on an Ubuntu VM. The terminal prompt is "ubuntu@ubuntu-vm: ~". The user has run the command "traceroute www.google.com". The output shows the path taken by the packets to reach the destination, listing 12 routers along the way. The output is as follows:

```
Setting up traceroute (1:2.0.18-1) ...
update-alternatives: using /usr/bin/traceroute.db to provide /usr/bin/traceroute
(traceroute) in auto mode.
update-alternatives: using /usr/bin/lft.db to provide /usr/bin/lft (lft) in auto
mode.
update-alternatives: using /usr/bin/traceproto.db to provide /usr/bin/traceproto
(traceproto) in auto mode.
update-alternatives: using /usr/sbin/tcptraceroute.db to provide /usr/sbin/tcptr
aceroute (tcptraceroute) in auto mode.
ubuntu@ubuntu-vm:~$ traceroute www.google.com
traceroute to www.google.com (172.217.11.164), 30 hops max, 60 byte packets
 1  R1 (192.168.1.1)  0.603 ms  0.573 ms  0.558 ms
 2  R2 (192.168.1.6)  1.461 ms  1.457 ms  1.444 ms
 3  10.1.0.1 (10.1.0.1)  1.439 ms  1.439 ms  1.411 ms
 4  206.207.50.1 (206.207.50.1)  1.402 ms  1.388 ms  1.392 ms
 5  * * *
 6  * * *
 7  * * *
 8  * * *
 9  * * *
10  * * *
11  * * *
12  * * *
```

The status bar at the bottom right indicates "Thothlab®" and the date/time "22-11-2017 17:44 IN ENG".

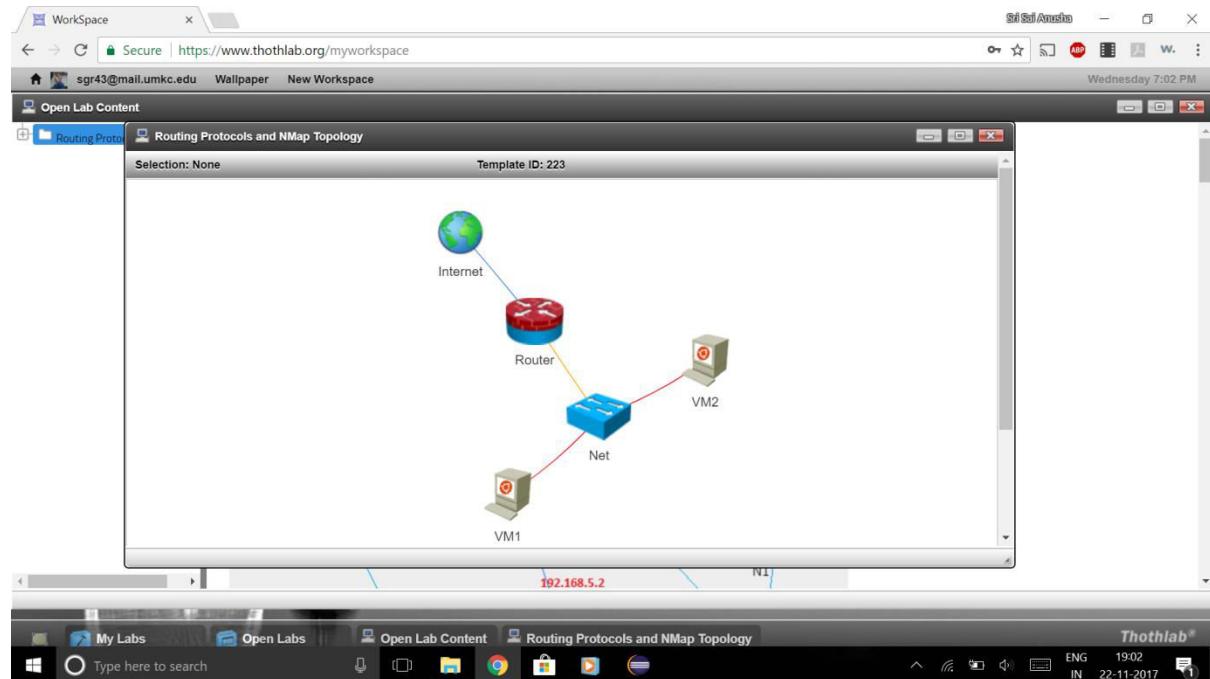




### 4.3 Routing Protocols and NMap

A routing protocol specifies how the routers communicate with each other, distributing information that enables them to select the routes between any two nodes on a computer network.

NMap (Network Mapper) is a security scanner which is used to discover hosts and services on a computer network building a map of the network.



The screenshot shows a terminal window titled "Console: VM1" displaying the following error message:

```
order to install the var-qmail packages.  
Installation aborted.  
dpkg: error processing qmail (--configure):  
    subprocess installed post-installation script returned error exit status 1  
No aptord report written because MaxReports is reached already  
dpkg: dependency problems prevent configuration of qmail-run:  
    qmail-run depends on qmail (>= 1.06-2.1); however:  
      Package qmail is not configured yet.  
dpkg: error processing qmail-run (-configure):  
    dependency problems - leaving unconfigured  
No aptord report written because MaxReports is reached already  
Setting up nmap (5.21-1.1ubuntu1) ...  
Errors were encountered while processing:  
    qmail  
    qmail-run  
E: Sub-process /usr/bin/dpkg returned an error code (1)  
ubuntu@ubuntu-vm:~$ nmap -version  
Nmap version 5.21 ( http://nmap.org )  
ubuntu@ubuntu-vm:~$
```

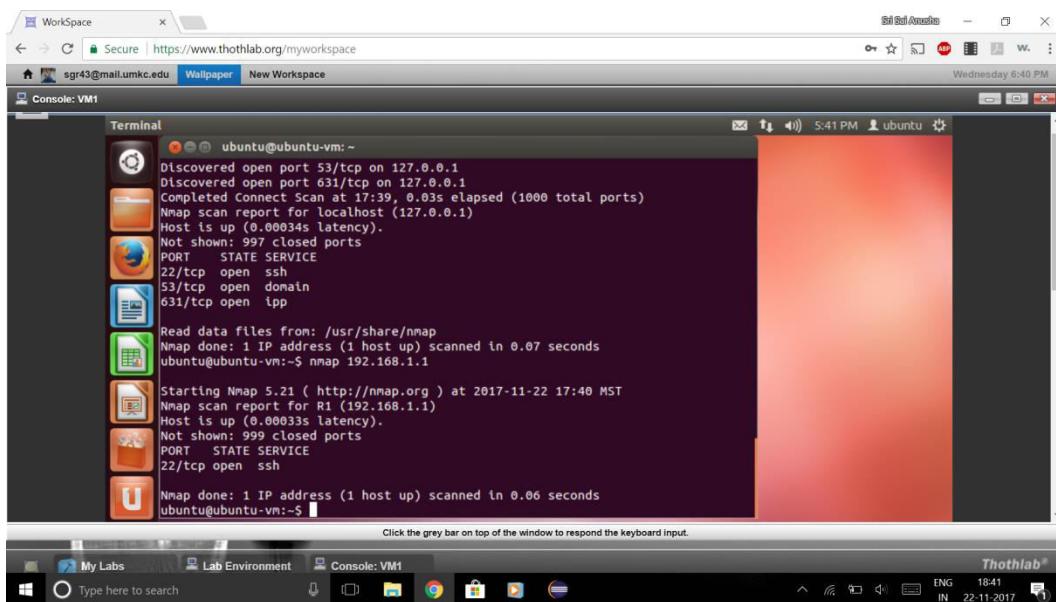
The terminal window has a grey bar at the top with the instruction: "Click the grey bar on top of the window to respond the keyboard input."

Terminal

```
ubuntu@ubuntu-vm:~$ dpkg: error processing qmail-run (--configure):  
dependency problems - leaving unconfigured  
No report written because MaxReports is reached already  
.21-1.ubuntui) ...  
Errors were encountered while processing:  
qmail  
qmail-run  
E: Sub-process /usr/bin/dpkg returned an error code (1)  
ubuntu@ubuntu-vm:~$ nmap -version  
Nmap version 5.21 ( http://nmap.org )  
ubuntu@ubuntu-vm:~$ nmap localhost  
Starting Nmap 5.21 ( http://nmap.org ) at 2017-11-22 17:38 MST  
Nmap scan report for localhost (127.0.0.1)  
Host is up (0.0003zs latency).  
Not shown: 997 closed ports  
PORT      STATE SERVICE  
22/tcp    open  ssh  
53/tcp    open  domain  
631/tcp   open  ipp  
Nmap done: 1 IP address (1 host up) scanned in 0.06 seconds
```

Terminal

```
Nmap done: 1 IP address (1 host up) scanned in 0.06 seconds  
ubuntu@ubuntu-vm:~$ nmap -v localhost  
Starting Nmap 5.21 ( http://nmap.org ) at 2017-11-22 17:39 MST  
Initiating Ping Scan at 17:39  
Scanning localhost (127.0.0.1) [2 ports]  
Completed Ping Scan at 17:39, 0.00s elapsed (1 total hosts)  
Initiating Connect Scan at 17:39  
Scanning localhost (127.0.0.1) [1000 ports]  
Discovered open port 22/tcp on 127.0.0.1  
Discovered open port 53/tcp on 127.0.0.1  
Discovered open port 631/tcp on 127.0.0.1  
Completed Connect Scan at 17:39, 0.03s elapsed (1000 total ports)  
Nmap scan report for localhost (127.0.0.1)  
Host is up (0.00034s latency).  
Not shown: 997 closed ports  
PORT      STATE SERVICE  
22/tcp    open  ssh  
53/tcp    open  domain  
631/tcp   open  ipp  
Read data files from: /usr/share/nmap  
Nmap done: 1 IP address (1 host up) scanned in 0.07 seconds
```



Terminal

```
ubuntu@ubuntu-vm:~$ Discovered open port 53/tcp on 127.0.0.1  
Discovered open port 631/tcp on 127.0.0.1  
Completed Connect Scan at 17:39, 0.03s elapsed (1000 total ports)  
Nmap scan report for localhost (127.0.0.1)  
Host is up (0.00034s latency).  
Not shown: 997 closed ports  
PORT      STATE SERVICE  
22/tcp    open  ssh  
53/tcp    open  domain  
631/tcp   open  ipp  
Read data files from: /usr/share/nmap  
Nmap done: 1 IP address (1 host up) scanned in 0.07 seconds  
ubuntu@ubuntu-vm:~$ nmap 192.168.1.1  
Starting Nmap 5.21 ( http://nmap.org ) at 2017-11-22 17:40 MST  
Nmap scan report for R1 (192.168.1.1)  
Host is up (0.00033s latency).  
Not shown: 999 closed ports  
PORT      STATE SERVICE  
22/tcp    open  ssh  
Nmap done: 1 IP address (1 host up) scanned in 0.06 seconds
```

Workspace

Secure | https://www.thothlab.org/myworkspace

sgr43@mail.umkc.edu Wallpaper New Workspace

Console: VM1

Terminal

```
ubuntu@ubuntu-vm: ~
Not shown: 999 closed ports
PORT STATE SERVICE
22/tcp open ssh

Nmap done: 1 IP address (1 host up) scanned in 0.06 seconds
ubuntu@ubuntu-vm:~$ nmap -v 192.168.1.1

Starting Nmap 5.21 ( http://nmap.org ) at 2017-11-22 17:41 MST
Initiating Ping Scan at 17:41
Scanning 192.168.1.1 [2 ports]
Completed Ping Scan at 17:41, 0.00s elapsed (1 total hosts)
Initiating Connect Scan at 17:41
Scanning R1 (192.168.1.1) [1000 ports]
Discovered open port 22/tcp on 192.168.1.1
Completed Connect Scan at 17:41, 0.03s elapsed (1000 total ports)
Nmap scan report for R1 (192.168.1.1)
Host is up (0.0003zs latency).
Not shown: 999 closed ports
PORT STATE SERVICE
22/tcp open ssh

Read data files from: /usr/share/nmap
Nmap done: 1 IP address (1 host up) scanned in 0.06 seconds
ubuntu@ubuntu-vm:~$
```

Click the grey bar on top of the window to respond the keyboard input.

My Labs Lab Environment Console: VM1

Type here to search ENG 18:41 IN 22-11-2017 Thothlab®

Workspace

Secure | https://www.thothlab.org/myworkspace

sgr43@mail.umkc.edu Wallpaper New Workspace

Console: VM1

Terminal

```
ubuntu@ubuntu-vm: ~
Nmap done: 1 IP address (1 host up) scanned in 0.06 seconds
ubuntu@ubuntu-vm:~$ nmap 192.168.1.1 192.168.1.2 192.168.1.3

Starting Nmap 5.21 ( http://nmap.org ) at 2017-11-22 17:42 MST
Nmap scan report for R1 (192.168.1.1)
Host is up (0.0003zs latency).
Not shown: 999 closed ports
PORT STATE SERVICE
22/tcp open ssh

Nmap scan report for host-192-168-1-2.openstacklocal (192.168.1.2)
Host is up (0.0003zs latency).
Not shown: 999 closed ports
PORT STATE SERVICE
53/tcp open domain

Nmap scan report for host-192-168-1-3.openstacklocal (192.168.1.3)
Host is up (0.00029s latency).
Not shown: 999 closed ports
PORT STATE SERVICE
53/tcp open domain

Nmap done: 3 IP addresses (3 hosts up) scanned in 6.61 seconds
ubuntu@ubuntu-vm:~$
```

Click the grey bar on top of the window to respond the keyboard input.

My Labs Lab Environment Console: VM1

Type here to search ENG 18:43 IN 22-11-2017 Thothlab®

WorkSpace

Secure | https://www.thothlab.org/myworkspace

sgr43@mail.umkc.edu Wallpaper New Workspace

Wednesday 6:44 PM

Console: VM1

```
ubuntu@ubuntu-vm:~$ nmap 192.168.1.1-10
Starting Nmap 5.21 ( http://nmap.org ) at 2017-11-22 17:44 MST
Nmap scan report for R1 (192.168.1.1)
Host is up (0.00049s latency).
Not shown: 999 closed ports
PORT      STATE SERVICE
22/tcp    open  ssh

Nmap scan report for host-192-168-1-2.openstacklocal (192.168.1.2)
Host is up (0.00062s latency).
Not shown: 999 closed ports
PORT      STATE SERVICE
53/tcp    open  domain

Nmap scan report for host-192-168-1-3.openstacklocal (192.168.1.3)
Host is up (0.00060s latency).
Not shown: 999 closed ports
PORT      STATE SERVICE
53/tcp    open  domain

Nmap scan report for host-192-168-1-4.openstacklocal (192.168.1.4)
Host is up (0.00062s latency).
Not shown: 999 closed ports
PORT      STATE SERVICE
22/tcp    open  ssh

Click the grey bar on top of the window to respond the keyboard input.
```

My Labs Lab Environment Console: VM1

Type here to search

ENG 18:44 IN 22-11-2017

Thothlab®

WorkSpace

Secure | https://www.thothlab.org/myworkspace

sgr43@mail.umkc.edu Wallpaper New Workspace

Wednesday 6:44 PM

Console: VM1

```
Nmap scan report for host-192-168-1-3.openstacklocal (192.168.1.3)
Host is up (0.00060s latency).
Not shown: 999 closed ports
PORT      STATE SERVICE
53/tcp    open  domain

Nmap scan report for host-192-168-1-4.openstacklocal (192.168.1.4)
Host is up (0.00062s latency).
Not shown: 999 closed ports
PORT      STATE SERVICE
22/tcp    open  ssh

Nmap scan report for host-192-168-1-5.openstacklocal (192.168.1.5)
Host is up (0.00063s latency).
Not shown: 999 closed ports
PORT      STATE SERVICE
22/tcp    open  ssh

Nmap scan report for R2 (192.168.1.6)
Host is up (0.00053s latency).
All 1000 scanned ports on R2 (192.168.1.6) are closed

Nmap done: 10 IP addresses (6 hosts up) scanned in 7.92 seconds
ubuntu@ubuntu-vm:~$
```

Click the grey bar on top of the window to respond the keyboard input.

My Labs Lab Environment Console: VM1

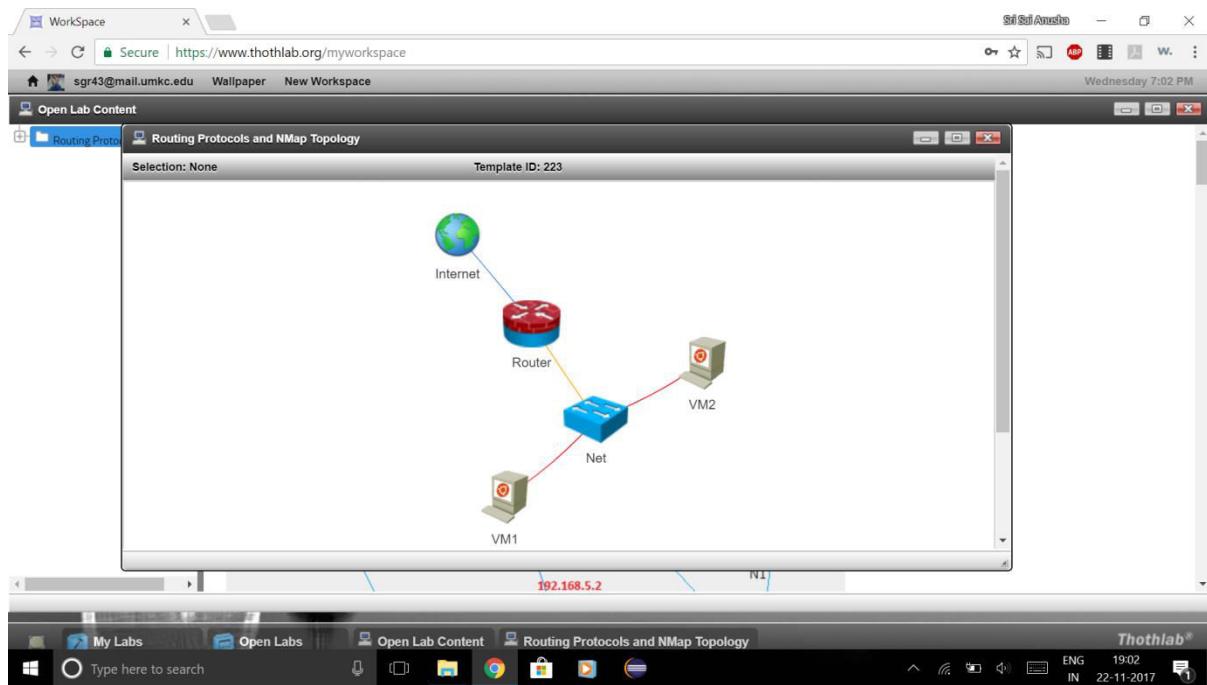
Type here to search

ENG 18:44 IN 22-11-2017

Thothlab®

#### 4.4 Apache Server Lab

Apache Server is an open source http server for hosting web service. In this lab, we display a web page using local host.



The screenshot shows a terminal window titled "Console: VM1". The terminal output displays an error message related to the installation of "var-qmail" packages. The message indicates that the installation was aborted due to errors in processing "qmail" and "qmail-run" packages. It shows dependency problems and a warning about MaxReports being reached. The terminal prompt is "ubuntu@ubuntu-vm:~\$". The window title is "Workspace" and the URL in the address bar is "https://www.thothlab.org/myworkspace". The system tray at the bottom right indicates the date and time as "Wednesday 6:37 PM".

```
order to install the var-qmail packages.

Installation aborted.

dpkg: error processing qmail (--configure):
 subprocess installed post-installation script returned error exit status 1
 No apport report written because MaxReports is reached already
 dpkg: dependency problems prevent configuration of qmail-run:
 qmail-run depends on qmail (>= 1.06-2.1); however:
  Package qmail is not configured yet.
 dpkg: error processing qmail-run (--configure):
 dependency problems - leaving unconfigured
 No apport report written because MaxReports is reached already
Setting up nmap (5.21-1.1ubuntu1) ...
Errors were encountered while processing:
 qmail
 qmail-run
E: Sub-process /usr/bin/dpkg returned an error code (1)
ubuntu@ubuntu-vm:~$ nmap -version
Nmap version 5.21 ( http://nmap.org )
ubuntu@ubuntu-vm:~$
```

```

ubuntu@ubuntu-vm:~$ nmap -v localhost
Starting Nmap 5.21 ( http://nmap.org ) at 2017-11-22 17:39 MST
Initiating Ping Scan at 17:39
Scanning localhost (127.0.0.1) [2 ports]
Completed Ping Scan at 17:39, 0.00s elapsed (1 total hosts)
Initiating Connect Scan at 17:39
Scanning localhost (127.0.0.1) [1000 ports]
Discovered open port 22/tcp on 127.0.0.1
Discovered open port 53/tcp on 127.0.0.1
Discovered open port 631/tcp on 127.0.0.1
Completed Connect Scan at 17:39, 0.03s elapsed (1000 total ports)
Nmap scan report for localhost (127.0.0.1)
Host is up (0.00034s latency).
Not shown: 997 closed ports
PORT      STATE SERVICE
22/tcp    open  ssh
53/tcp    open  domain
631/tcp   open  ipp

Read data files from: /usr/share/nmap
Nmap done: 1 IP address (1 host up) scanned in 0.07 seconds
ubuntu@ubuntu-vm:~$ 

```

```

ubuntu@ubuntu-vm:~$ nmap 192.168.1.1
Discovered open port 53/tcp on 127.0.0.1
Discovered open port 631/tcp on 127.0.0.1
Completed Connect Scan at 17:39, 0.03s elapsed (1000 total ports)
Nmap scan report for localhost (127.0.0.1)
Host is up (0.00034s latency).
Not shown: 997 closed ports
PORT      STATE SERVICE
22/tcp    open  ssh
53/tcp    open  domain
631/tcp   open  ipp

Read data files from: /usr/share/nmap
Nmap done: 1 IP address (1 host up) scanned in 0.07 seconds
ubuntu@ubuntu-vm:~$ 

```

```

ubuntu@ubuntu-vm:~$ nmap -v 192.168.1.1
Not shown: 999 closed ports
PORT      STATE SERVICE
22/tcp    open  ssh

Nmap done: 1 IP address (1 host up) scanned in 0.06 seconds
ubuntu@ubuntu-vm:~$ 

```

```

ubuntu@ubuntu-vm:~$ nmap done: 1 IP address (1 host up) scanned in 0.06 seconds
ubuntu@ubuntu-vm:~$ nmap 192.168.1.1 192.168.1.2 192.168.1.3
Starting Nmap 5.21 ( http://nmap.org ) at 2017-11-22 17:42 MST
Nmap scan report for R1 (192.168.1.1)
Host is up (0.00032s latency).
Not shown: 999 closed ports
PORT      STATE SERVICE
22/tcp    open  ssh

Nmap scan report for host-192-168-1-2.openstacklocal (192.168.1.2)
Host is up (0.00033s latency).
Not shown: 999 closed ports
PORT      STATE SERVICE
53/tcp    open  domain

Nmap scan report for host-192-168-1-3.openstacklocal (192.168.1.3)
Host is up (0.00029s latency).
Not shown: 999 closed ports
PORT      STATE SERVICE
53/tcp    open  domain

Nmap done: 3 IP addresses (3 hosts up) scanned in 6.61 seconds
ubuntu@ubuntu-vm:~$ 

```

```

ubuntu@ubuntu-vm:~$ nmap 192.168.1.1-10
Starting Nmap 5.21 ( http://nmap.org ) at 2017-11-22 17:44 MST
Nmap scan report for R1 (192.168.1.1)
Host is up (0.00049s latency).
Not shown: 999 closed ports
PORT      STATE SERVICE
22/tcp    open  ssh

Nmap scan report for host-192-168-1-2.openstacklocal (192.168.1.2)
Host is up (0.00062s latency).
Not shown: 999 closed ports
PORT      STATE SERVICE
53/tcp    open  domain

Nmap scan report for host-192-168-1-3.openstacklocal (192.168.1.3)
Host is up (0.00060s latency).
Not shown: 999 closed ports
PORT      STATE SERVICE
53/tcp    open  domain

Nmap scan report for host-192-168-1-4.openstacklocal (192.168.1.4)
Host is up (0.00062s latency).
Not shown: 999 closed ports
PORT      STATE SERVICE
22/tcp    open  ssh

ubuntu@ubuntu-vm:~$ 

```

```

ubuntu@ubuntu-vm:~$ nmap open -v
Nmap scan report for host-192-168-1-3.openstacklocal (192.168.1.3)
Host is up (0.00060s latency).
Not shown: 999 closed ports
PORT      STATE SERVICE
53/tcp    open  domain

Nmap scan report for host-192-168-1-4.openstacklocal (192.168.1.4)
Host is up (0.00062s latency).
Not shown: 999 closed ports
PORT      STATE SERVICE
22/tcp    open  ssh

Nmap scan report for host-192-168-1-5.openstacklocal (192.168.1.5)
Host is up (0.00063s latency).
Not shown: 999 closed ports
PORT      STATE SERVICE
22/tcp    open  ssh

Nmap scan report for R2 (192.168.1.6)
Host is up (0.00053s latency).
All 1000 scanned ports on R2 (192.168.1.6) are closed

Nmap done: 10 IP addresses (6 hosts up) scanned in 7.92 seconds
ubuntu@ubuntu-vm:~$ 

```

## 5. Pros

- Availability of multiple labs over the same cloud interface
- No separate installation of any virtual machine
- Need only a browser and Internet connection
- Availability to include new personalized labs
- Can have group access to a common lab

## 6. Cons

- Always require Internet connection to run the cloud
- Poor performance
- High delay
- Long response time
- Need of rebuilding the system once the keypad doesn't respond

## Contributions

As the work on ThoTh Lab is group oriented, i.e., group access for the project, we have collectively worked on the labs, sorted out the problems we faced and were able to successfully complete three of Cloud Computing Labs and four of Network Labs.

## References

- <https://www.thothlab.org/>
- <https://fullcircle.asu.edu/faculty/researcher-entrepreneur-professor-launches-virtual-lab-platform-computing-research-education/>
- <http://www.athenets.com/>
- <https://www.digitalocean.com/community/tutorials/how-to-install-hadoop-in-stand-alone-mode-on-ubuntu-16-04>
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