

COEN 241: HW 1

System vs OS Virtualization

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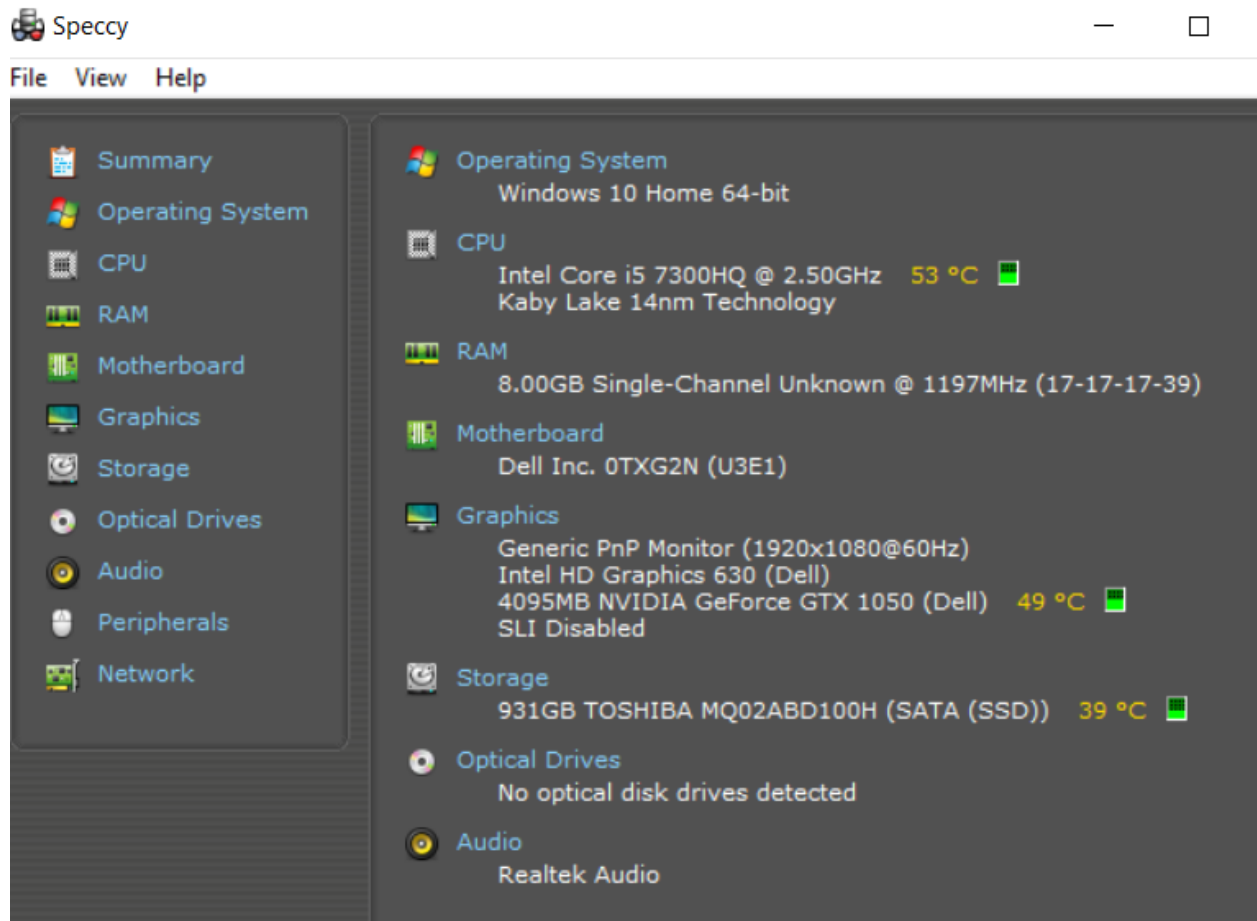
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1. System Configurations:

1.1) Personal Computer(Base) Setup:

1. **OS:** Windows 10 Home 64-bit
2. **CPU:** Intel Core i5 7300HQ @ 2.50GHz(Kaby Lake 14nm Technology)
3. **RAM:** 8.00GB@ 1197MHz
4. **MOTHERBOARD:** Dell Inc. 0TXG2N (U3E1)
5. **STORAGE:** 931GB TOSHIBA MQ02ABD100H (SATA (SSD))
6. **CORES:** 4
7. **THREADS:** 4
8. **VIRTUALIZATION:** Supported

We can either check the system specs by executing “dxdiag.exe” from windows run or execute “systeminfo” in CMD prompt. Also, to get extensive information, the speccy tool can be used as shown below.



1.2) QEMU: UBUNTU Virtual OS:

1. **OS:** Ubuntu 16.04 xenial
2. **KERNEL:** x86_64 Linux 4.4.0-186-generic
3. **Shell:** bash 4.3.48
4. **CPU:** QEMU Virtual CPU version 2.5+ @ 2.496GHZ
5. **RAM:** 72MiB/1998MiB

```
surya@ubuntusurya:~$ screenfetch
      ./+0+-
      yyyyyy- -yyyyyy+
      ://+////////-yyyyyyo
      .++ ://++++++/-+.sss/`
      .:++0: /+++++++/:-:-:/-
      o:+0:+++. .` .` .-/oo+++++/
      .:0+:0o/. .` .` .+sss0o+/
      .++/+0:++0+0: .` .` /sss000.
      /++++//+:`oo+0 .` .` /:-:-:.
      \+/+0+++`o+0 .` .` .+////////.
      .++o+0++0o+:` .` .` /dddhhh.
      .+.o+0o: .` .` .` oddhhhh+
      \+.++0+0`-` .` .` .:ohdhhhhh+
      :o+++`ohhhhhhhhhhyo++os:
      .o: .syhhhhhhhh/.oo++o`
      /osyyyyyyo++000+++/.
      +00+++o\:.
      `oo+++.

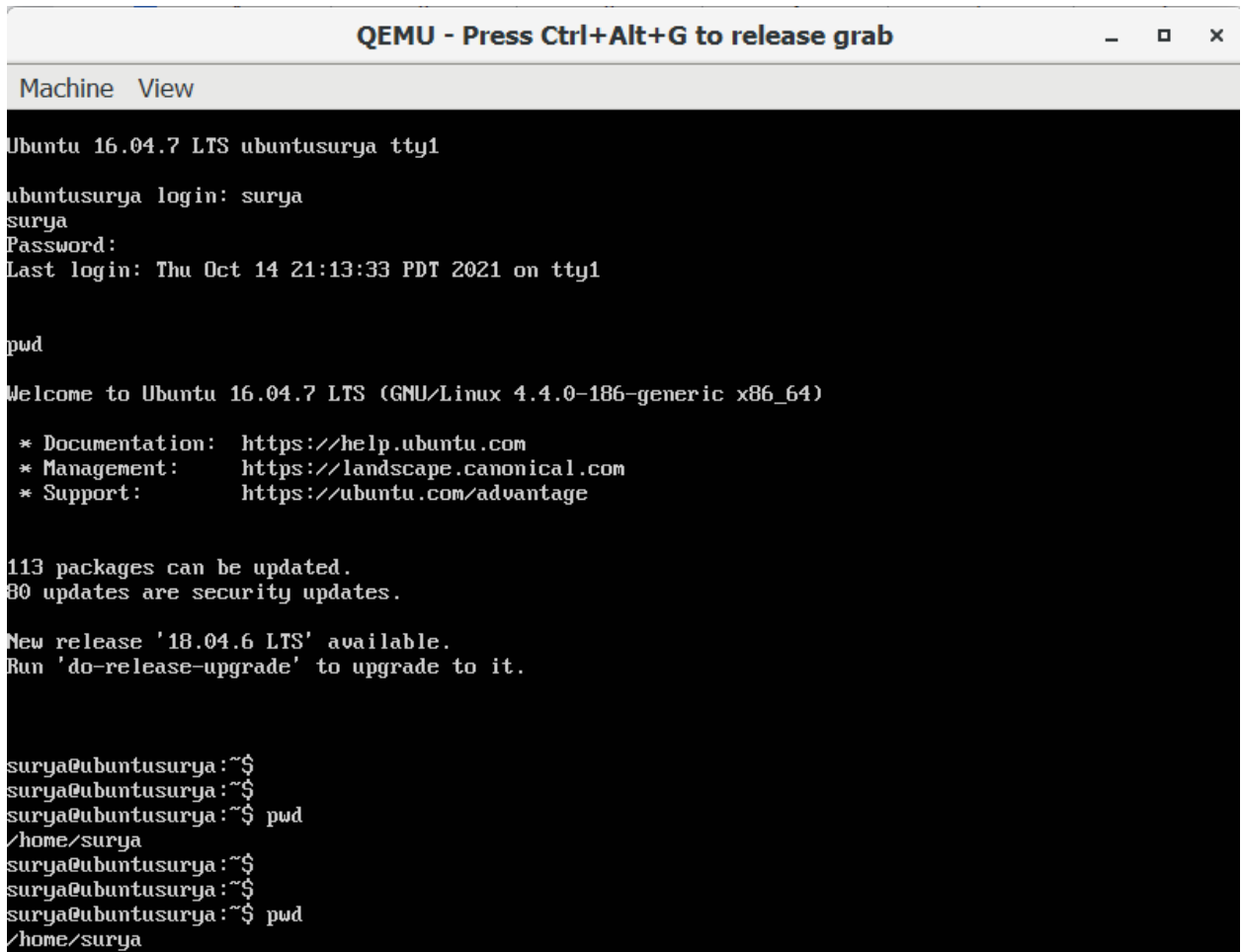
surya@ubuntusurya:~$

surya@ubuntusurya
OS: Ubuntu 16.04 xenial
Kernel: x86_64 Linux 4.4.0-186-generic
Uptime: 24m
Packages: 451
Shell: bash 4.3.48
CPU: QEMU Virtual CPU version 2.5+ @ 2.496GHz
RAM: 72MiB / 1998MiB
```

2) Steps to enable a QEMU VM:

1. First, we will **download Ubuntu 16.04 server**(AMD64 version) and need to **install qemu binaries for windows** system from their official webpage.
2. Now, place the installed qemu binaries path in the environment variables.
3. Create a qemu image for the Ubuntu guest virtual machine. It can be done by executing the following in Powershell, navigate to the virtual machine iso folder and execute: **"qemu-img.exe create ubuntu.img 10G -f qcow2"**.
4. Once image is created, execute the installation command:
"qemu-system-x86_64.exe -L "C:\Program Files\qemu" -hda .\ubuntu.img -boot d -cdrom .\ubuntu-16.04.7-server-amd64.iso -m 2046 -boot strict=on"

5. After installation is complete, you can now boot from the image created, execute **"qemu-system-x86_64.exe -hda .\ubuntu.img -boot d -m 2046 -boot strict=on"**.
6. You will be able to see ubuntu booted through qemu as shown below:



The screenshot shows a QEMU terminal window titled "QEMU - Press Ctrl+Alt+G to release grab". The terminal displays the following text:

```
Machine View
Ubuntu 16.04.7 LTS ubuntu@surya tty1
ubuntu@surya login: surya
surya
Password:
Last login: Thu Oct 14 21:13:33 PDT 2021 on tty1

pwd

Welcome to Ubuntu 16.04.7 LTS (GNU/Linux 4.4.0-186-generic x86_64)

 * Documentation:  https://help.ubuntu.com
 * Management:    https://landscape.canonical.com
 * Support:       https://ubuntu.com/advantage

113 packages can be updated.
80 updates are security updates.

New release '18.04.6 LTS' available.
Run 'do-release-upgrade' to upgrade to it.

surya@ubuntu@surya:~$
surya@ubuntu@surya:~$
surya@ubuntu@surya:~$ pwd
/home/surya
surya@ubuntu@surya:~$
surya@ubuntu@surya:~$
surya@ubuntu@surya:~$ pwd
/home/surya
```

QEMU-Ubuntu VM Configurations:

1. Host : ubuntu@surya
2. Kernel: 4.4.0-186-generic x86_64(64 bit) Console :tty 1
3. Qemu-harddisk: 10.7GB
4. Cache: 512KB
5. Distro: Ubuntu 16.04 xenial

We can get the system information either by `$screenfetch` or `$inxi -F`.

```

surya@ubuntusurya:~$ inxi -F
System:   Host: ubuntusurya Kernel: 4.4.0-186-generic x86_64 (64 bit) Console: tty 1
          Distro: Ubuntu 16.04 xenial
Machine:  System: QEMU product: Standard PC (i440FX + PIIX 1996) v: pc-i440fx-5.2
          Mobo: N/A model: N/A
          Bios: Sea v: rel-1.14.0-0-g155821a1990b-prebuilt.qemu.org date: 04/01/2014
CPU:      Single core QEMU Virtual version 2.5+ (-UP-) cache: 512 KB speed: 2491 MHz (max)
Graphics: Card: Device 1234:1111
          Display Server: N/A driver: N/A tty size: 100x37 Advanced Data: N/A out of X
Network:  Card: Intel 82540EM Gigabit Ethernet Controller driver: e1000
          IF: ens3 state: up speed: 1000 Mbps duplex: full mac: 52:54:00:12:34:56
Drives:   HDD Total Size: 10.7GB (26.0% used) ID-1: /dev/sda model: QEMU_HARDDISK size: 10.7GB
Partition: ID-1: / size: 8.1G used: 1.7G (22%) fs: ext4 dev: /dev/dm-0
          ID-2: /boot size: 720M used: 59M (9%) fs: ext2 dev: /dev/sda1
          ID-3: swap-1 size: 1.03GB used: 0.00GB (0%) fs: swap dev: /dev/dm-1
RAID:     No RAID devices: /proc/mdstat, md_mod kernel module present
Sensors:  None detected - is lm-sensors installed and configured?
Info:     Processes: 102 Uptime: 26 min Memory: 84.7/1998.0MB Init: systemd runlevel: 5
          Client: Shell (bash) inxi: 2.2.35
surya@ubuntusurya:~$ _

```

3) Enabling Docker Container.

1. We will be downloading and installing Docker Desktop (for Windows).
2. Once installation is complete, open the CMD prompt and check the docker version to verify the installation as shown below: “docker --version”.

```

C:\Users\usury>docker --version
Docker version 20.10.8, build 3967b7d

```

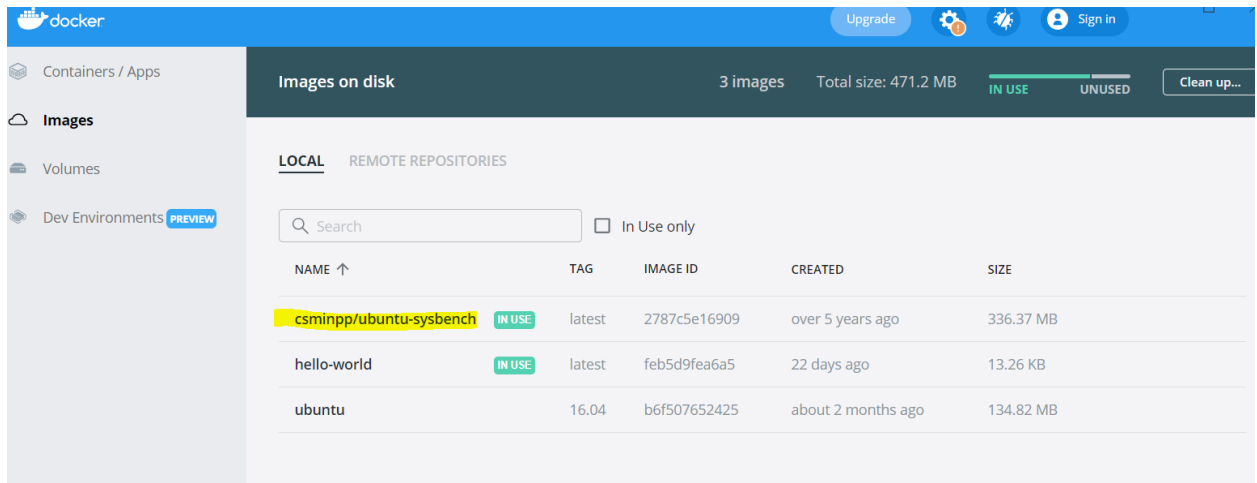
3. After Docker desktop installation is successful, we will install a image **csmnpp/ubuntu-sysbench**, which has testbench preinstalled.
4. Execute the command “**docker pull csmnpp/ubuntu-sysbench**” in cmd.

```

C:\Users\usury>docker pull csmnpp/ubuntu-sysbench
Using default tag: latest
latest: Pulling from csmnpp/ubuntu-sysbench
Image docker.io/csmnpp/ubuntu-sysbench:latest uses outdated schema1 manifest format. Please upgrade to a schema2 image
for better future compatibility. More information at https://docs.docker.com/registry/spec/deprecated-schema-v1/
d89e1bee20d9: Already exists
9e0bc8a71bde: Already exists
27aa681c95e5: Already exists
a3ed95caeb02: Already exists
55734f896640: Already exists
Digest: sha256:90fd06985472eec3aa99b665618c23f074deb326fcc87a5fb59d2be1f9d97435
Status: Image is up to date for csmnpp/ubuntu-sysbench:latest
docker.io/csmnpp/ubuntu-sysbench:latest

```

5. Verify the image installation in docker desktop:
Shown as highlighted below:



Or in CMD: **docker images**

```
C:\Users\usury>docker images
REPOSITORY          TAG          IMAGE ID       CREATED        SIZE
hello-world         latest       feb5d9fea6a5   3 weeks ago   13.3kB
ubuntu              16.04       b6f507652425   6 weeks ago   135MB
csmnpp/ubuntu-sysbench latest       2787c5e16909   5 years ago   336MB
```

6. Check the currently running processes:(Empty as we arent running anything).

```
C:\Users\usury>docker ps
CONTAINER ID   IMAGE     COMMAND   CREATED   STATUS    PORTS   NAMES
```

7. Check the dangling docker images:**docker volume ls -f dangling=true**

```
C:\Users\usury>docker volume ls -f dangling=true
DRIVER      VOLUME NAME
```

8. Examine the docker containers:**docker container ls -a**

```
C:\Users\usury>docker container ls -a
CONTAINER ID   IMAGE                COMMAND          CREATED   STATUS    PORTS   NAMES
a55fe867d3df   hello-world         "/hello"        3 days ago Exited (0) 3 days ago   romantic_blackwell
c763ce787526   csmnpp/ubuntu-sysbench "/bin/bash"     3 days ago Exited (255) 50 minutes ago pedantic_hodgkin
48ea6efd7cc    csmnpp/ubuntu-sysbench:latest "/bin/bash"     3 days ago Exited (255) 50 minutes ago Sysbench
c3b07efe484b   hello-world         "/hello"        4 days ago Exited (0) 4 days ago   wizardly_jones
ca0bfcc452b7   csmnpp/ubuntu-sysbench:latest "/bin/bash"     4 days ago Exited (255) 50 minutes ago surya
```

9. Inspecting a particular container configuration:
docker container inspect surya

```
C:\Users\usury>docker container ls -a
CONTAINER ID   IMAGE      COMMAND                  CREATED        STATUS        PORTS        NAMES
a55fe867d3df   hello-world "/hello"               3 days ago    Exited (0) 3 days ago           romantic_blackwell
c763ace78752e   csmnpp/ubuntu-sysbench "/bin/bash"          3 days ago    Exited (255) 50 minutes ago      pedantic_hodgkin
48eae6fd97cc   csmnpp/ubuntu-sysbench:latest "/bin/bash"          3 days ago    Exited (255) 50 minutes ago      Sysbench
c3b07efe484b   hello-world "/hello"               4 days ago    Exited (0) 4 days ago           wizardly_jones
ca0bfcc452b7   csmnpp/ubuntu-sysbench:latest "/bin/bash"          4 days ago    Exited (255) 50 minutes ago      surya

C:\Users\usury>docker container inspect surya
[
  {
    "Id": "ca0bfcc452b767b1aac45e1352f59ebcd9b49bf35bf9b5042887c71c1ef5e712",
    "Created": "2021-10-11T18:55:02.1832302Z",
    "Path": "/bin/bash",
    "Args": [],
    "State": {
      "Status": "exited",
      "Running": false,
      "Paused": false,
      "Restarting": false,
      "OOMKilled": false,
      "Dead": false,
      "Pid": 0,
      "Exitcode": 255,
      "Error": "",
      "StartedAt": "2021-10-11T18:55:05.4297131Z",
      "FinishedAt": "2021-10-11T19:18:39.0574771Z",
    },
    "Image": "sha256:2787c5e169096c2187f94a4ab58071d0876de08722c32dbd9c6e9f400a01f6",
    "ResolvConfPath": "/var/lib/docker/containers/ca0bfcc452b767b1aac45e1352f59ebcd9b49bf35bf9b5042887c71c1ef5e712/resolv.conf",
    "HostnamePath": "/var/lib/docker/containers/ca0bfcc452b767b1aac45e1352f59ebcd9b49bf35bf9b5042887c71c1ef5e712/hostname",
    "HostsPath": "/var/lib/docker/containers/ca0bfcc452b767b1aac45e1352f59ebcd9b49bf35bf9b5042887c71c1ef5e712/hosts",
    "LogPath": "/var/lib/docker/containers/ca0bfcc452b767b1aac45e1352f59ebcd9b49bf35bf9b5042887c71c1ef5e712/ca0bfcc452b767b1aac45e1352f59ebcd9b49bf35bf9b5042887c71c1ef5e712-json.log",
    "Name": "/surya",
    "RestartCount": 0,
    "Driver": "overlay2",
    "Platform": "linux",
    "MountLabel": "",
    "ProcessLabel": "",
    "AppArmorProfile": "",
    "ExecIDs": null,
  }
]
```

10. Finally, we will run the docker image in an interactive mode:
docker container run -it csmnpp/ubuntu-sysbench

```
C:\Users\usury>docker run -it csmnpp/ubuntu-sysbench
root@1042ef9f1fde:/#
```

Since our image is running: **docker ps** will show the running container.

```
C:\Users\usury>docker ps
CONTAINER ID   IMAGE      COMMAND                  CREATED        STATUS        PORTS        NAMES
1042ef9f1fde   csmnpp/ubuntu-sysbench "/bin/bash"          2 minutes ago    Up 2 minutes           pedantic_sutherland
```

docker container run -it "csmnpp/ubuntu-sysbench" /bin/bash

```
C:\Users\usury>docker ps
CONTAINER ID   IMAGE      COMMAND                  CREATED        STATUS        PORTS        NAMES
199f03aacda9   csmnpp/ubuntu-sysbench "/bin/bash"          13 seconds ago    Up 11 seconds           affectionate_allen

C:\Users\usury>docker container run -it "csmnpp/ubuntu-sysbench" /bin/bash
root@444b136c36b0:/#
```

11. Now, we can stop the running container by executing: **docker stop container_name** (The interactive run will be exited).

```
C:\Users\usury>docker ps
CONTAINER ID   IMAGE                  COMMAND                  CREATED        STATUS        PORTS        NAMES
1042ef9f1fde   csmhpp/ubuntu-sysbench "/bin/bash"             6 minutes ago   Up 6 minutes   pedantic_sutherland

C:\Users\usury>docker stop pedantic_sutherland
pedantic_sutherland

C:\Users\usury>docker ps
CONTAINER ID   IMAGE                  COMMAND                  CREATED        STATUS        PORTS        NAMES
```

4) Proof of Experiments:

1. Testing different arguments of qemu: Booting with -smp(specifying number of cores) and -m(amount of memory):**qemu-system-x86_64.exe -L "C:/Program Files/qemu" -smp 3 -hda .\ubuntu.img -boot d -m 2046 -boot strict=on**

```
PS C:\Users\usury\Downloads> qemu-system-x86_64.exe -L "C:/Program Files/qemu" -smp 3 -hda .\ubuntu.img -boot d -m 2046 -boot strict=on
WARNING: Image format was not specified for '.\ubuntu.img' and probing guessed raw.
Automatically detecting the format is dangerous for raw images, write operations on block 0 will be restricted.
Specify the 'raw' format explicitly to remove the restrictions.
```

We can see the number of cores in CPU is 3 as highlighted below:

```
surya@ubuntusurya:~$ screenfetch
      ./+0+-
    yyyyy- -yyyyyy+
  ://+////////-yyyyyyo
    .++ .:/++++++/- .+sss/
  .:+++: /+++++++:--:/-
o: +0:++ . ' . ' . -/00+++++
  .: +0: +0/ . ' +sss00+/
.++/+ : +00+0 ' /sss000 .
/+++//+: 00+0 /::--: .
\+/+0+++`0+0 ++////.
  .++ .0++ +00+: ` /dddhhh.
  .+.0+00: . ' odddhhhh+
\+. +0+0 ' - ' . :ohdhhhh+
  :o+++ ohhhhhhhhyo++os:
  .o: `syhhhhhhh/.00++o`
    /osyyyyyyo++000+++/
      +00+++o\ :
      `00++ .

surya@ubuntusurya:~$
```

```
surya@ubuntusurya
OS: Ubuntu 16.04 xenial
Kernel: x86_64 Linux 4.4.0-186-generic
Uptime: 1m
Packages: 504
Shell: bash 4.3.48
CPU: 3x QEMU Virtual CPU version 2.5+ @ 2.496GHz
RAM: 69MiB / 1997MiB
```


The number of **cores** helped in improving the startup time of the virtual machine as shown below: **systemd-analyze(with 3 cores)**.

```
surya@ubuntusurya:~$ systemd-analyze
Startup finished in 16.360s (kernel) + 26.086s (userspace) = 42.446s
```

The number of cores helped in improving the startup of the virtual machine as shown below: **systemd-analyze(with 1 cores)**.

```
surya@ubuntusurya:~$ systemd-analyze
Startup finished in 17.983s (kernel) + 1min 6.072s (userspace) = 1min 24.055s
```

2. Sysbench version in Docker container: **sysbench --version**


```
C:\Users\usury>docker container run -it "csminpp/ubuntu-sysbench" /bin/bash
root@444b136c36b0:/# sysbench --version
sysbench 0.4.12
root@444b136c36b0:/#
```

3. Sysbench version in Ubuntu VM:

```
surya@ubuntusurya:~$ sysbench --version
sysbench 0.4.12
surya@ubuntusurya:~$
```


4.1) sysbench --test=cpu --cpu-max-prime=20000 Experiment:

- Check for any current processes by executing “top -i” and make sure no other tasks are running in qemu and container.
- Execute the bash script created to get the results.
- Check the memory during each execution for user-level and kernel-level usage.

Results:  COEN241:HW1:TEST1


4.2) sysbench --test=cpu --cpu-max-prime=30000 Experiment:

- Check for any current processes by executing “top -i” and make sure no other tasks are running in qemu and container.
- Execute the bash script created to get the results.
- Check the memory during each execution for user-level and kernel-level usage.

Results:  COEN241:HW1:TEST2

4.3) sysbench --test=cpu --cpu-max-prime=35000 Experiment:

- Check for any current processes by executing “top -i” and make sure no other tasks are running in qemu and container.
- Execute the bash script created to get the results.
- Check the memory during each execution for user-level and kernel-level usage.


Results:  COEN241:HW1:TEST3

4.4) FILE IO Test -1:

- Check for any current processes by executing “top -i” and make sure no other tasks are running in qemu and container.
- Execute the bash script created to get the results.
- Check the memory during each execution for disk IO, Latency and disk utilization.

If you want to see results at each stage execute :


```
sysbench --num-threads=16 --test=fileio --file-total-size=3G
--file-test-mode=rndrw prepare
sysbench --num-threads=16 --test=fileio --file-total-size=3G
--file-test-mode=rndrw run
sysbench --num-threads=16 --test=fileio --file-total-size=3G
--file-test-mode=rndrw cleanup
```

Results:  COEN241:HW1:FILE TEST1

4.5) FILE IO Test -2:

- Check for any current processes by executing “top -i” and make sure no other tasks are running in qemu and container.
- Execute the bash script created to get the results.
- Check the memory during each execution for disk IO, Latency and disk utilization.

```
sysbench --num-threads=32--test=fileio --file-total-size=3G
--file-test-mode=seqwr prepare
sysbench --num-threads=32 --test=fileio --file-total-size=3G
--file-test-mode=seqwr run
sysbench --num-threads=32 --test=fileio --file-total-size=3G
--file-test-mode=seqwr cleanup
```

Result:  COEN241:HW1:FILE TEST2

4.6) FILE IO Test -3:

- Check for any current processes by executing “top -i” and make sure no other tasks are running in qemu and container.
- Execute the bash script created to get the results.
- Check the memory during each execution for disk IO, Latency and disk utilization.

```
sysbench      --num-threads=16--test=fileio      --file-total-size=4G
--file-test-mode=rndrw prepare
```

```
sysbench      --num-threads=16      --test=fileio      --file-total-size=4G
--file-test-mode=rndrw run
```

```
sysbench      --num-threads=16--test=fileio      --file-total-size=4G
--file-test-mode=rndrw cleanup
```

Result:  COEN241:HW1:FILE TEST3

Dropping cache for the docker container after each run :

```
C:\Users\usury>docker run -ti --rm -v /proc:/writable_proc csmnpp/ubuntu-sysbench bash
root@5587d7fbd4c:/# echo 3 > /writable_proc/sys/vm/drop_caches
root@5587d7fbd4c:/#
```

4.7) Shell Scripts for the experiments:

The shell scripts are as attached, to run the script make sure to follow the instructions above and execute using “./script_name.sh”.

<https://github.com/skiranu/COEN241-HW1.git>

4.8) Analysis of the experiments:

Thorough analyses for each of the experiments are present in the attached excel file. It was seen that the docker containers were always faster than the qemu VM overall. The impact of the native system was highest on Qemu VM as compared to the container image, the recover of container image after a halt/ freeze scenario was much quicker than Qemu VM.

5) Git repository information:

Repository name:COEN241-HW1

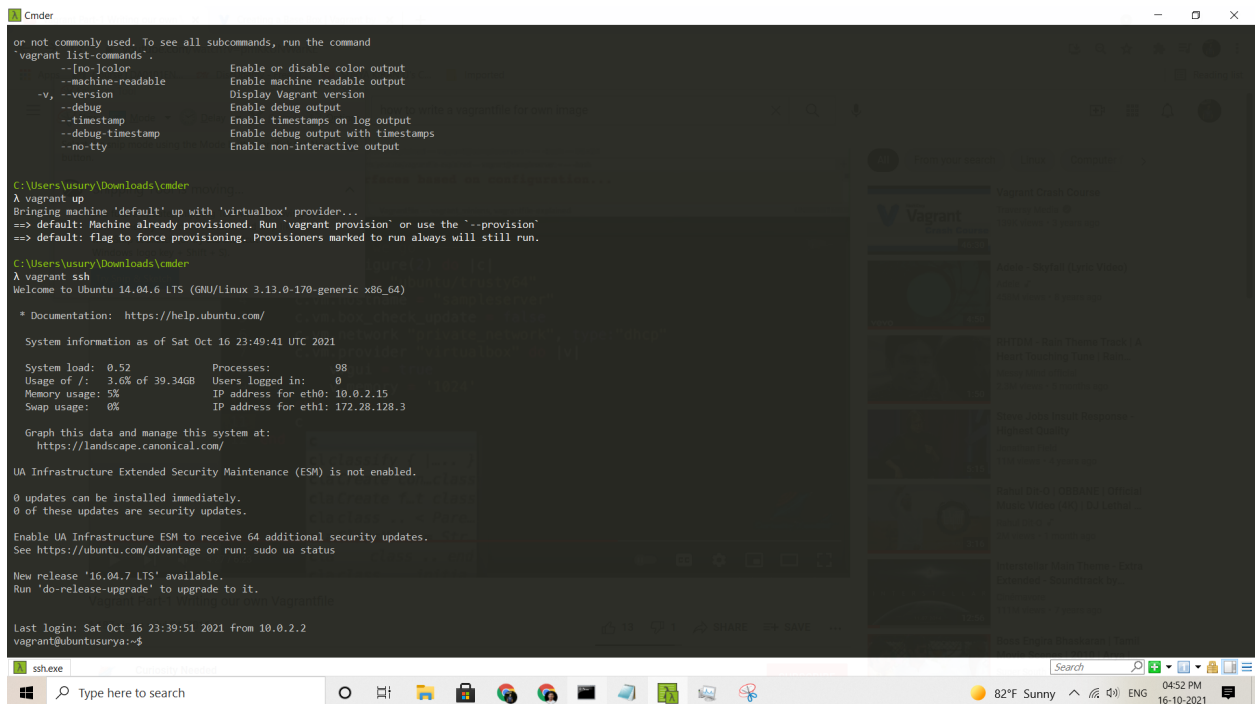
URL:<https://github.com/skiranu/COEN241-HW1.git>

Since it is a private repository, I have sent the invite to the instructor.

6)Vagrant file:

I had fun writing ruby code, the vagrant script was tested multiple times with different parameters for IP/DHCP. After multiple failed attempts to use the virtual box, I disabled all the anti-virus software and finally was able to boot into GUI mode through VirtualBox.

Booting of ubuntu through “vagrant ssh”



```
C:\Users\usury\Downloads\cmdr
or not commonly used. To see all subcommands, run the command
'vagrant list-commands'.
--[no]-color          Enable or disable color output
--machine-readable    Enable machine readable output
-v, --version         Display Vagrant version
--debug              Enable debug output
--timestamp           Enable timestamps on log output
--debug-timestamp     Enable debug output with timestamps
--no-tty              Enable non-interactive output

C:\Users\usury\Downloads\cmdr
A vagrant up
Bringing machine 'default' up with 'virtualbox' provider...
=> default: Machine already provisioned. Run 'vagrant provision' or use the '--provision'
=> default: flag to force provisioning. Provisioners marked to run always will still run.

C:\Users\usury\Downloads\cmdr
A vagrant ssh
Welcome to Ubuntu 14.04.6 LTS (GNU/Linux 3.13.0-170-generic x86_64)

 * Documentation:  https://help.ubuntu.com/

System information as of Sat Oct 16 23:49:41 UTC 2021

System load:  0.52               Processes:    98
Usage of /:   3.6% of 39.34GB    Users logged in:  0
Memory usage: 5%                IP address for eth0: 10.0.2.15
Swap usage:   0%                IP address for eth1: 172.28.128.3

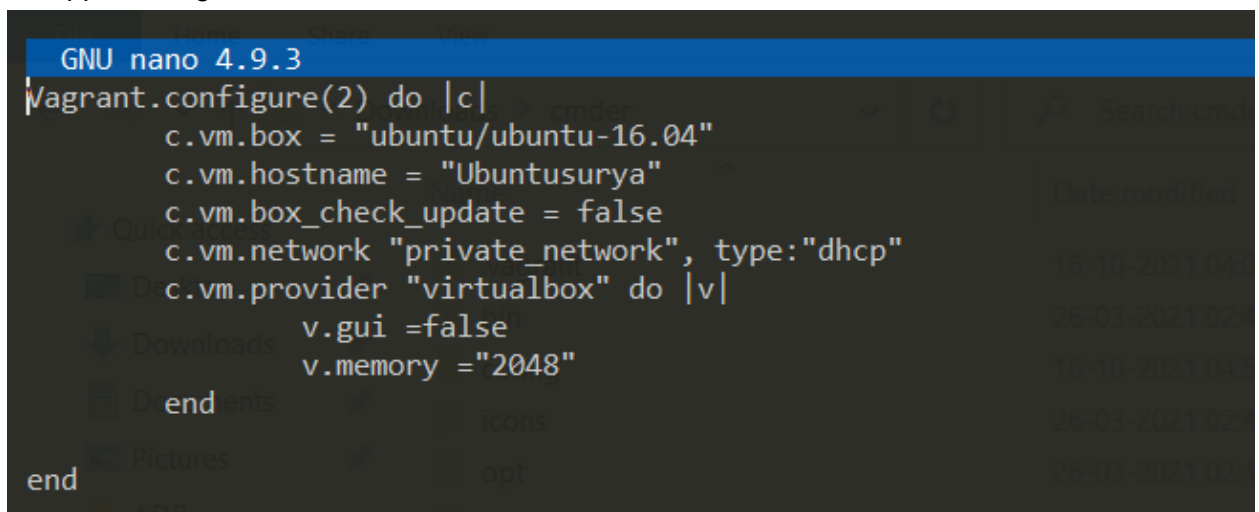
Graph this data and manage this system at:
https://landscape.canonical.com/

UA Infrastructure Extended Security Maintenance (ESM) is not enabled.
0 updates can be installed immediately.
0 of these updates are security updates.
Enable UA Infrastructure ESM to receive 64 additional security updates.
See https://ubuntu.com/advantage or run: sudo ua status

New release '16.04.7 LTS' available.
Run 'do-release-upgrade' to upgrade to it.

Last login: Sat Oct 16 23:39:51 2021 from 10.0.2.2
vagrant@ubuntusurya:~$
```

A snippet of vagrant file:

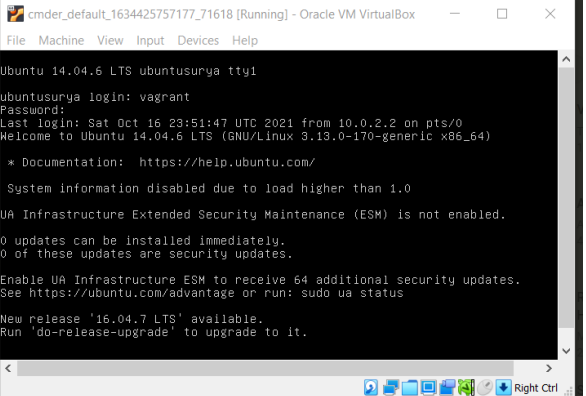


```
GNU nano 4.9.3
Vagrant.configure(2) do |c|
  c.vm.box = "ubuntu/ubuntu-16.04"
  c.vm.hostname = "Ubuntusurya"
  c.vm.box_check_update = false
  c.vm.network "private_network", type:"dhcp"
  c.vm.provider "virtualbox" do |v|
    v.gui = false
    v.memory = "2048"
  end
end
```

Ubuntu logged in through GUI(Virtual Box):**vagrant reload**

```
C:\Users\usury\Downloads\cmdr
λ vagrant reload
==> default: Attempting graceful shutdown of VM...
==> default: Clearing any previously set forwarded ports...
==> default: Clearing any previously set network interfaces...
==> default: Preparing network interfaces based on configuration...
    default: Adapter 1: nat
    default: Adapter 2: hostonly
==> default: Forwarding ports...
    default: 22 (guest) => 2222 (host) (adapter 1)
==> default: Running 'pre-boot' VM customizations...
==> default: Booting VM...
==> default: Waiting for machine to boot. This may take a few minutes...
    default: SSH address: 127.0.0.1:2222
    default: SSH username: vagrant
    default: SSH auth method: private key
==> default: Machine booted and ready!
==> default: Checking for guest additions in VM...
    default: The guest additions on this VM do not match the installed version of
    default: VirtualBox! In most cases this is fine, but in rare cases it can
    default: prevent things such as shared folders from working properly. If you see
    default: shared folder errors, please make sure the guest additions within the
    default: virtual machine match the version of VirtualBox you have installed on
    default: your host and reload your VM.
    default: Guest Additions Version: 4.3.40
    default: VirtualBox Version: 6.1
==> default: Setting hostname...
==> default: Configuring and enabling network interfaces...
==> default: Mounting shared folders...
    default: /vagrant => C:\Users\usury\Downloads\cmdr
==> default: Machine already provisioned. Run 'vagrant provision' or use the '--provision'
    default: flag to force provisioning. Provisioners marked to run always will still run.

C:\Users\usury\Downloads\cmdr
λ
```



Steps to execute vagrant file:

- 1) nano/touch vagrantfile.
- 2) Execute **vagrant up**.
- 3) Execute **vagrant ssh** for ssh connectivity.
- 4) Execute **vagrant reload** after making changes to vagrant file to boot using Virtual box.