

CS5250 – Advanced Operating Systems

AY2018/2019 Semester 2

Assignment 1

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Part A : Linux Kernel Installation

1. Install Virtualbox on laptop

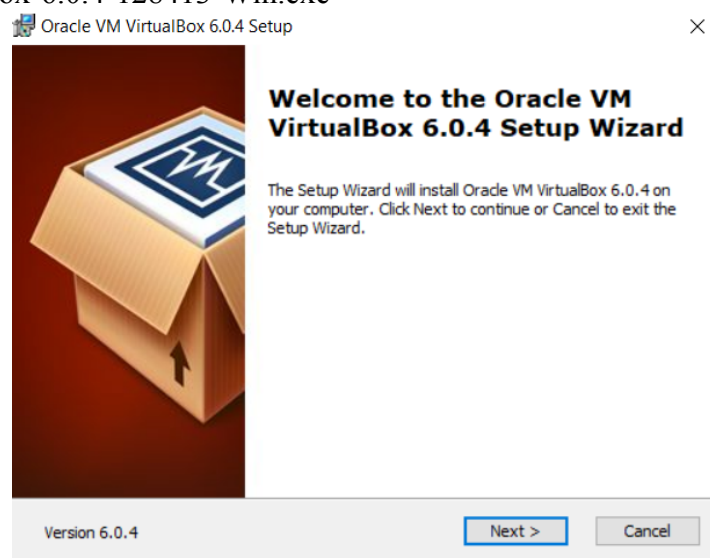
1.1 download Virtualbox

download Virtualbox 6.0.4 (Windows hosts) from the below link

<https://www.virtualbox.org/wiki/Downloads>

1.2 install Virtualbox 6.0.4

run the file "VirtualBox-6.0.4-128413-Win.exe"



and click next as the setup wizard instruction till final step to click finish.

2. Install Ubuntu 18.04

2.1 download Ubuntu

download Ubuntu 18.04 ("ubuntu-18.04.1-desktop-amd64.iso") from the following link

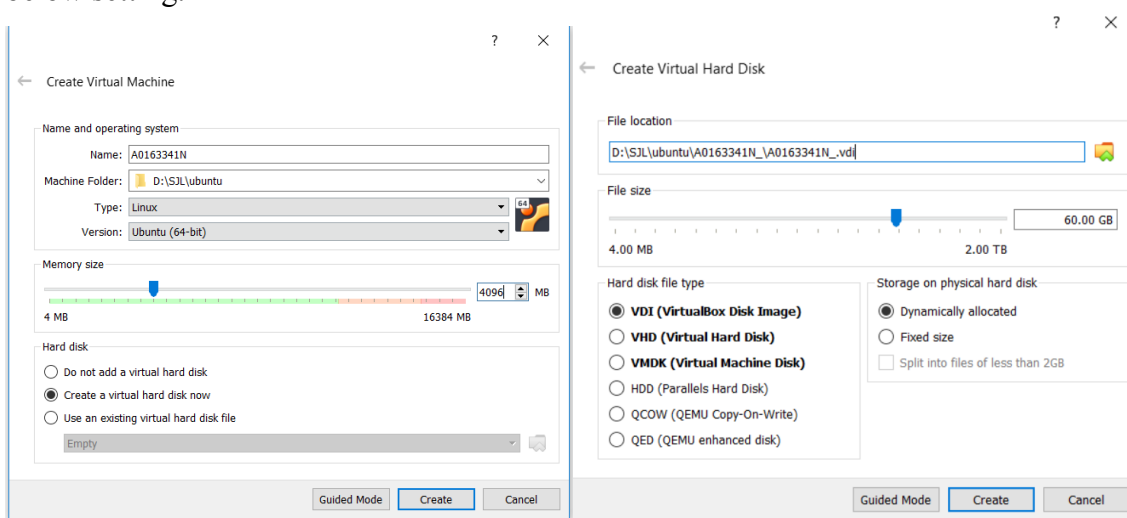
<http://mirror.nus.edu.sg/ubuntu-ISO/18.04>

Index of /ubuntu-ISO/18.04/

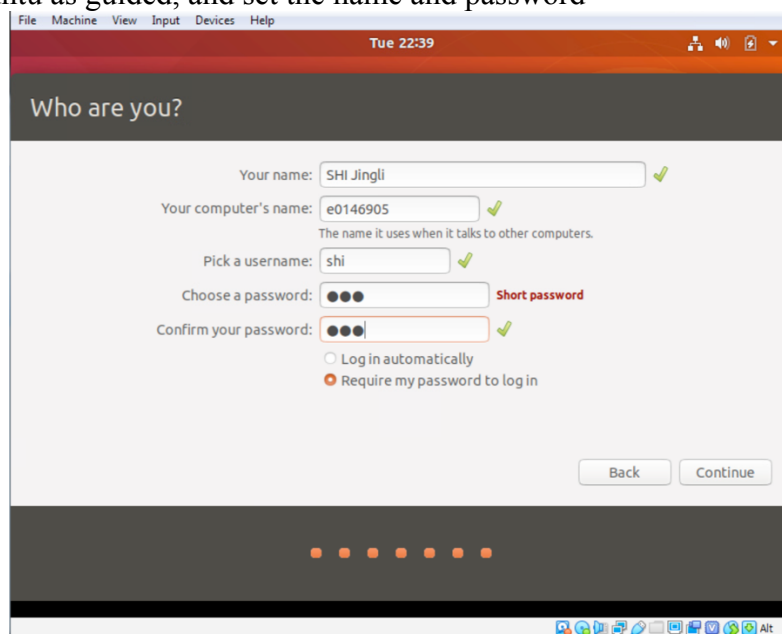
| | | |
|---|-------------------|------|
| ../ | 30-Nov-2018 08:02 | 810 |
| FOOTER.html | 30-Nov-2018 08:03 | 4241 |
| HEADER.html | 30-Nov-2018 07:27 | 140 |
| MD5SUMS | 30-Nov-2018 07:27 | 150 |
| MD5SUMS-metalink | 30-Nov-2018 07:27 | 916 |
| MD5SUMS-metalink.gpg | 30-Nov-2018 07:27 | 916 |
| MD5SUMS.gpg | 30-Nov-2018 07:27 | 156 |
| SHA1SUMS | 30-Nov-2018 07:27 | 916 |
| SHA1SUMS.gpg | 30-Nov-2018 07:27 | 204 |
| SHA256SUMS | 30-Nov-2018 07:27 | 916 |
| SHA256SUMS.gpg | 25-Jul-2018 11:22 | 26 |
| ubuntu-18.04.1-desktop-amd64.iso | 27-Jul-2018 00:55 | 73K |
| ubuntu-18.04.1-desktop-amd64.iso.torrent | 27-Jul-2018 00:55 | 4M |
| ubuntu-18.04.1-desktop-amd64.iso.zsync | 25-Jul-2018 11:22 | 7897 |
| ubuntu-18.04.1-desktop-amd64.list | 25-Jul-2018 11:19 | 55K |
| ubuntu-18.04.1-desktop-amd64.manifest | 30-Nov-2018 07:27 | 51K |
| ubuntu-18.04.1-desktop-amd64.manifest.gpg | 30-Nov-2018 06:30 | 812M |
| ubuntu-18.04.1-live-server-amd64.iso | 30-Nov-2018 06:30 | 812M |
| ubuntu-18.04.1.0-live-server-amd64.iso | 30-Nov-2018 07:27 | 32K |
| ubuntu-18.04.1.0-live-server-amd64.iso.torrent | 30-Nov-2018 07:27 | 2M |
| ubuntu-18.04.1.0-live-server-amd64.iso.zsync | 30-Nov-2018 07:27 | 8002 |
| ubuntu-18.04.1.0-live-server-amd64.list | 30-Nov-2018 07:27 | 14K |
| ubuntu-18.04.1.0-live-server-amd64.manifest | 30-Nov-2018 07:27 | 53K |
| ubuntu-18.04.1.0-live-server-amd64.manifest.gpg | | |

2.2 Set up new virtual machine

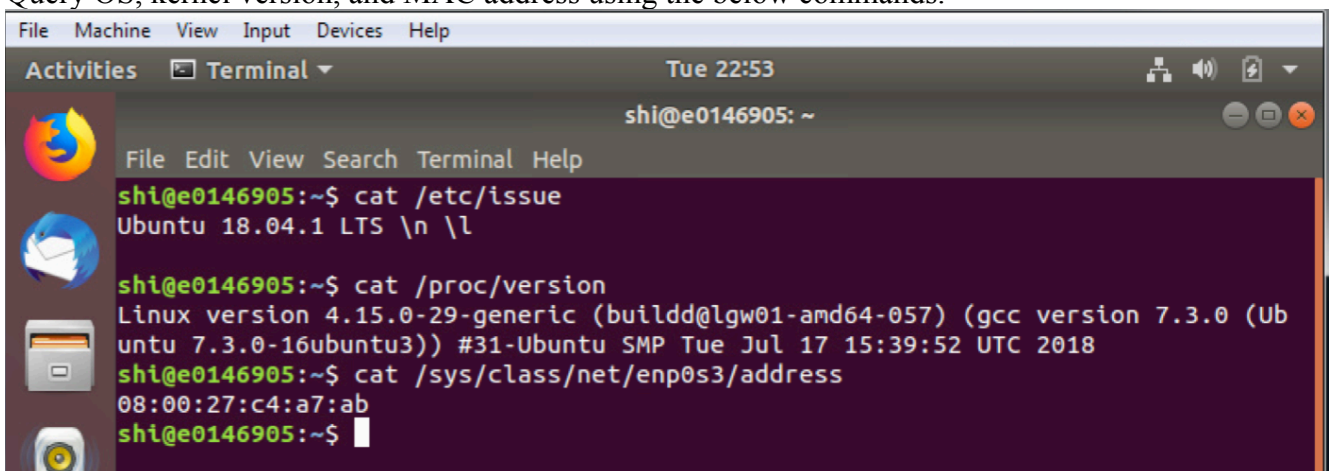
Run Oracle VM VirtualBox and create one new virtual machine using downloaded ISO file with the below setting.



Start to install Ubuntu as guided, and set the name and password



Query OS, kernel version, and MAC address using the below commands.



3 Build Linux Kernel 4.20.4

3.1 install Linux kernel

download Linux 4.20.4 from <https://cdn.kernel.org/pub/linux/kernel/v4.x/>.

Some errors appear before kernel 4.20.4 is built.

Error 1: 'make' not found.

Solution 1: sudo apt install make make-guile

Error2: gcc: not found.

Solution 2: sudo apt install gcc

Error3: Unable to find the ncurses package.

Solution 3: sudo apt install libncurses-dev.

Error4: bison: not found.

Solution 4: sudo apt install bison

Error5: flex: not found.

Solution 5: sudo apt install flex

run the following commands to install Linux kernel version 4.20.4.

1) make menuconfig

in order to reduce compiled kernel size, some driver options are excluded(e.g. sound, network, hardware driver).

(i) what do they means?

[*] built-in : the feature is built with the kernel.

[] excluded: the feature is not built with the kernel.

<M> module : the feature is built as module format, which is loaded dynamically after kernel is running up.

(ii) which are the one that will appears in the kernel image?

[*] built-in items are built directly into kernel image itself, whereas <M> modules are stored externally on the filesystem.

```
.config - Linux/x86 4.20.4 Kernel Configuration
+ Device Drivers

                                Device Drivers
Arrow keys navigate the menu. <Enter> selects submenus ---> (or empty
submenus ----). Highlighted letters are hotkeys. Pressing <Y>
includes, <N> excludes, <M> modularizes features. Press <Esc><Esc> to
exit, <?> for Help, </> for Search. Legend: [*] built-in [ ]

    Generic Driver Options  --->
    Bus devices  ----
    < > Connector - unified userspace <-> kernelspace linker  ----
    < > GNSS receiver support  ----
    < > Memory Technology Device (MTD) support  ----
    [ ] Device Tree and Open Firmware support  ----
    < > Parallel port support  ----
    *- Plug and Play support  --->
    [ ] Block devices  ----
        NVME Support  --->
        Misc devices  --->
+ (+)

<Select>  < Exit >  < Help >  < Save >  < Load >
```

2) make -j 2

2 core are assigned to the virtual Ubuntu OS, all of which are used to build the kernel.

3) sudo make INSTALL_MOD_STRIP=1 modules_install -j 2

Setting INSTALL_MOD_STRIP as 1 to strip off unnecessary debug information from the

compiled images.

4) `sudo make install -j 2`

3.3 Setup boot loader

(1) original kernel (4.15.0-29)

the original kernel boot entry is shown as below.

```
sh@e0146905: ~  
File Edit View Search Terminal Help  
sh@e0146905:~$ uname -a  
Linux e0146905 4.15.0-29-generic #31-Ubuntu SMP Tue Jul 17 15:39:52 UTC 2018 x86_64 x86_64 x86_64 GNU/Linux  
sh@e0146905:~$  
  
sh@e0146905:~$ grep "menuentry" /boot/grub/grub.cfg  
if [ x"${feature_menuentry_id}" = xy ]; then  
    menuentry_id_option="--id"  
    menuentry_id_option=""  
export menuentry_id_option  
menuentry 'Ubuntu' --class ubuntu --class gnu-linux --class gnu --class os $menuentry_id_option 'gnulinux-simple-9a0c21f6-a4fc-49e2-8585-cc7ce15f7c13' {  
    submenu 'Advanced options for Ubuntu' $menuentry_id_option 'gnulinux-advanced-9a0c21f6-a4fc-49e2-8585-cc7ce15f7c13' {  
        menuentry 'Ubuntu, with Linux 4.15.0-29-generic' --class ubuntu --class gnu-linux --class gnu --class os $menuentry_id_option 'gnulinux-4.15.0-29-generic-advanced-9a0c21f6-a4fc-49e2-8585-cc7ce15f7c13' {  
            menuentry 'Ubuntu, with Linux 4.15.0-29-generic (recovery mode)' --class ubuntu --class gnu-linux --class gnu --class os $menuentry_id_option 'gnulinux-4.15.0-29-generic-recovery-9a0c21f6-a4fc-49e2-8585-cc7ce15f7c13' {  
                menuentry 'Memory test (memtest86+)' {  
                    menuentry 'Memory test (memtest86+, serial console 115200)' {  
sh@e0146905:~$
```

(2) new kernel (4.20.4)

```
sh@e0146905: ~  
File Edit View Search Terminal Help  
sh@e0146905:~$ uname -a  
Linux e0146905 4.20.4 #10 SMP Wed Feb 13 15:45:43 +08 2019 x86_64 x86_64 x86_64 GNU/Linux  
sh@e0146905:~$
```

after install new kernel, run the below commands to update boot order.

1) `sudo update-initramfs -c -k 4.20.4`

2) `sudo update-grub`

after running the above commands, /boot/grub/grub.cfg is updated automatically.

```

shi@e0146905:~$ grep "menuentry" /boot/grub/grub.cfg
if [ x"${feature_menuentry_id}" = xy ]; then
    menuentry_id_option="--id"
    menuentry_id_option=""
export menuentry_id_option
menuentry 'Ubuntu' --class ubuntu --class gnu-linux --class gnu --class os $menuentry_id_option 'gnulinux-simple-9a0c21f6-a4fc-49e2-8585-cc7ce15f7c13' {
    submenu 'Advanced options for Ubuntu' $menuentry_id_option 'gnulinux-advanced-9a0c21f6-a4fc-49e2-8585-cc7ce15f7c13' {
        menuentry 'Ubuntu, with Linux 4.20.4' --class ubuntu --class gnu-linux --class gnu --class os $menuentry_id_option 'gnulinux-4.20.4-advanced-9a0c21f6-a4fc-49e2-8585-cc7ce15f7c13' {
            menuentry 'Ubuntu, with Linux 4.20.4 (recovery mode)' --class ubuntu --class gnu-linux --class gnu --class os $menuentry_id_option 'gnulinux-4.20.4-recovery-9a0c21f6-a4fc-49e2-8585-cc7ce15f7c13' {
            menuentry 'Ubuntu, with Linux 4.20.4.old' --class ubuntu --class gnu-linux --class gnu --class os $menuentry_id_option 'gnulinux-4.20.4.old-advanced-9a0c21f6-a4fc-49e2-8585-cc7ce15f7c13' {
            menuentry 'Ubuntu, with Linux 4.20.4.old (recovery mode)' --class ubuntu --class gnu-linux --class gnu --class os $menuentry_id_option 'gnulinux-4.20.4.old-recovery-9a0c21f6-a4fc-49e2-8585-cc7ce15f7c13' {
            menuentry 'Ubuntu, with Linux 4.15.0-45-generic' --class ubuntu --class gnu-linux --class gnu --class os $menuentry_id_option 'gnulinux-4.15.0-45-generic-advanced-9a0c21f6-a4fc-49e2-8585-cc7ce15f7c13' {
            menuentry 'Ubuntu, with Linux 4.15.0-45-generic (recovery mode)' --class ubuntu --class gnu-linux --class gnu --class os $menuentry_id_option 'gnulinux-4.15.0-45-generic-recovery-9a0c21f6-a4fc-49e2-8585-cc7ce15f7c13' {

```

3.4 Reboot to new kernel

The comparison of original and new kernel size is listed below.

(1) Original kernel(4.15.0-29) size

```

shi@e0146905:~$ ls -lha /boot/ | grep 4.15.0-29-generic
-rw-r--r-- 1 root root 1.5M Jul 17 2018 abi-4.15.0-29-generic
-rw-r--r-- 1 root root 212K Jul 17 2018 config-4.15.0-29-generic
-rw-r--r-- 1 root root 53M Feb 12 21:54 initrd.img-4.15.0-29-generic
-rw-r--r-- 1 root root 0 Jul 17 2018 retpoline-4.15.0-29-generic
-rw----- 1 root root 3.9M Jul 17 2018 System.map-4.15.0-29-generic
-rw-r--r-- 1 root root 7.9M Jul 25 2018 vmlinuz-4.15.0-29-generic
shi@e0146905:~$

```

(2) New kernel (4.20.4) size

```

shi@e0146905: ~
File Edit View Search Terminal Help
shi@e0146905:~$ ls -lha /boot | grep 4.20.4
-rw-r--r-- 1 root root 121K Feb 13 18:25 config-4.20.4
-rw-r--r-- 1 root root 121K Feb 13 11:10 config-4.20.4.old
-rw-r--r-- 1 root root 20M Feb 13 18:28 initrd.img-4.20.4
-rw-r--r-- 1 root root 3.8M Feb 13 18:25 System.map-4.20.4
-rw-r--r-- 1 root root 3.8M Feb 13 11:10 System.map-4.20.4.old
-rw-r--r-- 1 root root 4.8M Feb 13 18:25 vmlinuz-4.20.4
-rw-r--r-- 1 root root 4.8M Feb 13 11:10 vmlinuz-4.20.4.old
shi@e0146905:~$

```

Part B Assembly Programming

1. `addl $131, -8(%esi)`

2. `81 C2 0D 00 00 00` (base 16)

3. `48 83 C2 0D` (base 16)

4.

```
void unknow_func(char *s)
{
    int idx = 0;
    while(*s != '\0')
    {
        if( *s != 'e' )
        {
            idx++;
            s++;
        }
        else
            break;
    }

    printf("%d\n", idx);
}
```