

CS5250 ASSIGNMENT 1

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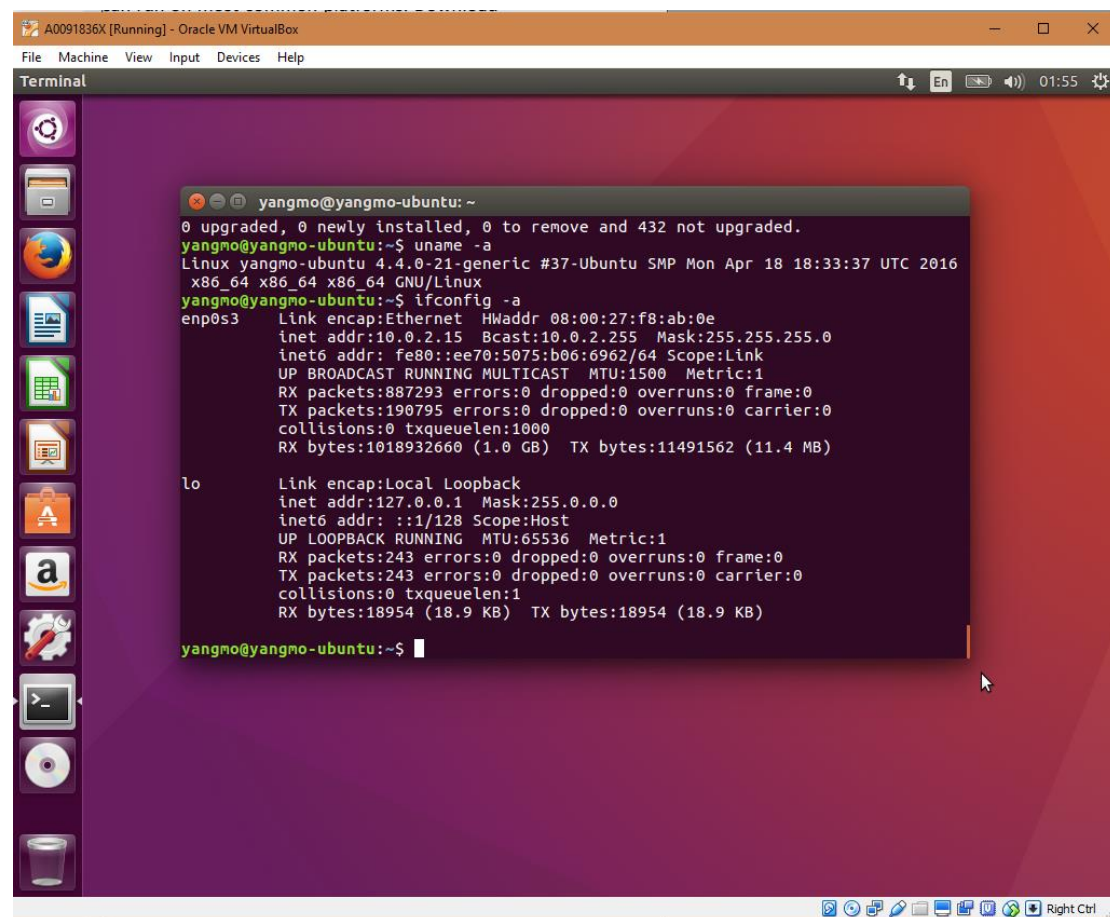
Question 1

1.1 Install a Linux guest machine

Both virtual box and Ubuntu 16.04 are installed successfully.

To output OS and kernel version, use command : **uname -a**

To output MAC address, use command : **ifconfig -a**



```
A0091836X [Running] - Oracle VM VirtualBox
File Machine View Input Devices Help
Terminal
yangmo@yangmo-ubuntu: ~
0 upgraded, 0 newly installed, 0 to remove and 432 not upgraded.
yangmo@yangmo-ubuntu:~$ uname -a
Linux yangmo-ubuntu 4.4.0-21-generic #37-Ubuntu SMP Mon Apr 18 18:33:37 UTC 2016
x86_64 x86_64 x86_64 GNU/Linux
yangmo@yangmo-ubuntu:~$ ifconfig -a
enp0s3    Link encap:Ethernet  HWaddr 08:00:27:f8:ab:0e
          inet addr:10.0.2.15  Bcast:10.0.2.255  Mask:255.255.255.0
          inet6 addr: fe80::ee70:5075:b06:6962/64 Scope:Link
          UP BROADCAST RUNNING MULTICAST  MTU:1500  Metric:1
          RX packets:887293 errors:0 dropped:0 overruns:0 frame:0
          TX packets:190795 errors:0 dropped:0 overruns:0 carrier:0
          collisions:0 txqueuelen:1000
          RX bytes:1018932660 (1.0 GB)  TX bytes:11491562 (11.4 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:243 errors:0 dropped:0 overruns:0 frame:0
          TX packets:243 errors:0 dropped:0 overruns:0 carrier:0
          collisions:0 txqueuelen:1
          RX bytes:18954 (18.9 KB)  TX bytes:18954 (18.9 KB)

yangmo@yangmo-ubuntu:~$
```

As can be seen in the above screenshot,

OS is **GNU/Linux**

Kernel Version is **#37-Ubuntu SMP Mon Apr 18 18:33:37 UTC 2016**

Kernel Release is **4.4.0-21-generic**

MAC Address is **08:00:27:F8:AB:0E**

1.2 Build a specific kernel

Important: After google searching for several online tutorials, I found that in order to use run "make menuconfig", libncurses5 libncurses5-dev libraries are needed. According to the online tutorial: <http://mitchtech.net/compile-linux-kernel-on-ubuntu-12-04-lts-detailed/>

Below are the extra dependencies needed to be installed:

```
git-core libncurses5 libncurses5-dev libelf-dev asciidoc binutils-  
dev linux-source fakeroot build-essential crash kexec-tools  
makedumpfile kernel-wedge kernel-package
```

Besides, when trying to run `make -j5` (since I am giving VM 4 processors, using `make -j5` is faster than `make -j`), some SSL error showed up. It turned out to be due to the missing package: `libssl-dev`

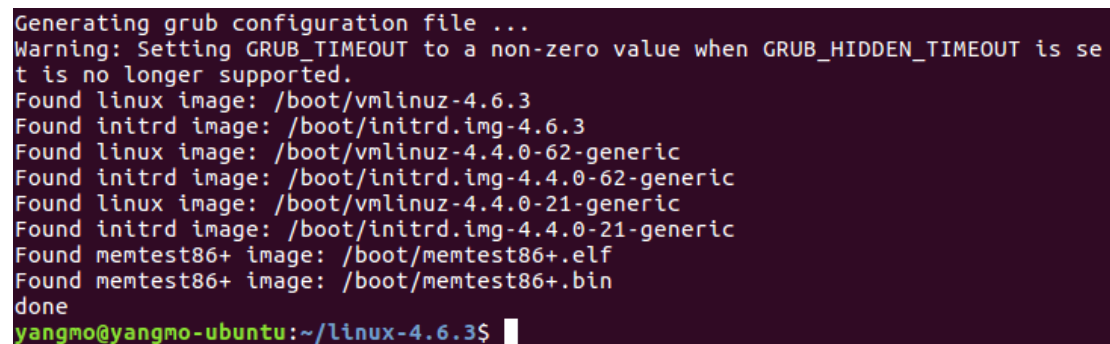
So in conclusion, it is necessary to run the following command before config and compile kernel:

```
sudo apt-get update
```

```
sudo apt-get install git-core libncurses5 libncurses5-dev libelf-dev  
asciidoc binutils-dev linux-source fakeroot build-essential crash  
kexec-tools makedumpfile kernel-wedge kernel-package libssl-dev
```

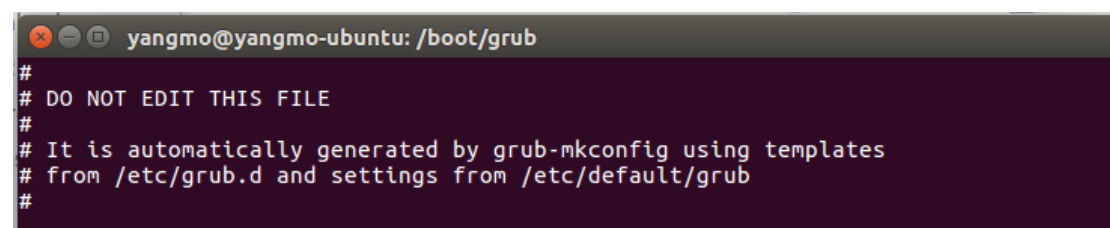
After the final command “`make install`”.

The console print out:

A terminal window with a dark background. The text shows the process of generating a GRUB configuration file. It lists several found images: vmlinuz-4.6.3, initrd.img-4.6.3, vmlinuz-4.4.0-62-generic, initrd.img-4.4.0-62-generic, vmlinuz-4.4.0-21-generic, initrd.img-4.4.0-21-generic, memtest86+.elf, and memtest86+.bin. The process ends with 'done' and a prompt 'yangmo@yangmo-ubuntu:~/linux-4.6.3\$' with a cursor.

```
Generating grub configuration file ...  
Warning: Setting GRUB_TIMEOUT to a non-zero value when GRUB_HIDDEN_TIMEOUT is se  
t is no longer supported.  
Found linux image: /boot/vmlinuz-4.6.3  
Found initrd image: /boot/initrd.img-4.6.3  
Found linux image: /boot/vmlinuz-4.4.0-62-generic  
Found initrd image: /boot/initrd.img-4.4.0-62-generic  
Found linux image: /boot/vmlinuz-4.4.0-21-generic  
Found initrd image: /boot/initrd.img-4.4.0-21-generic  
Found memtest86+ image: /boot/memtest86+.elf  
Found memtest86+ image: /boot/memtest86+.bin  
done  
yangmo@yangmo-ubuntu:~/linux-4.6.3$
```

New linux and initrd image are already found in the correct place. When checking `/boot/grub/grub.cfg` file, new entries are already inserted correctly from the beginning of the menu:

A terminal window titled 'yangmo@yangmo-ubuntu: /boot/grub'. The text shows the beginning of the GRUB menu, including a warning not to edit the file and information about its automatic generation by grub-mkconfig.

```
yangmo@yangmo-ubuntu: /boot/grub  
#  
# DO NOT EDIT THIS FILE  
#  
# It is automatically generated by grub-mkconfig using templates  
# from /etc/grub.d and settings from /etc/default/grub  
#
```

```

yangmo@yangmo-ubuntu: /boot/grub
    set linux_gfx_mode=text
    fi
    else
        set linux_gfx_mode=keep
    fi
else
    set linux_gfx_mode=text
fi
export linux_gfx_mode
menuentry 'Ubuntu' --class ubuntu --class gnu-linux --class gnu --class os $menu
entry_id_option 'gnulinux-simple-42803781-1afd-4af0-8af5-f173f196eccf' {
    recordfail
    load_video
    gfxmode $linux_gfx_mode
    insmod gzio
    if [ x$grub_platform = xxen ]; then insmod xzio; insmod lzopio; fi
    insmod part_msdos
    insmod ext2
    set root='hd0,msdos1'
    if [ x$feature_platform_search_hint = xy ]; then
        search --no-floppy --fs-uuid --set=root --hint-bios=hd0,msdos1 --hint-
efi=hd0,msdos1 --hint-baremetal=ahci0,msdos1 42803781-1afd-4af0-8af5-f173f196ec
cf
    else
        search --no-floppy --fs-uuid --set=root 42803781-1afd-4af0-8af5-f173f1
96eccf
    fi
    linux /boot/vmlinuz-4.6.3 root=UUID=42803781-1afd-4af0-8af5-f173f196ec
cf ro quiet splash crashkernel=384M::128M $vt_handoff
    initrd /boot/initrd.img-4.6.3
}
submenu 'Advanced options for Ubuntu' $menuentry_id_option 'gnulinux-advanced-42
803781-1afd-4af0-8af5-f173f196eccf' {
    menuentry 'Ubuntu, with Linux 4.6.3' --class ubuntu --class gnu-linux --
class gnu --class os $menuentry_id_option 'gnulinux-4.6.3-advanced-42803781-1afd
-4af0-8af5-f173f196eccf' {
        recordfail
        load_video
        gfxmode $linux_gfx_mode
        insmod gzio
        if [ x$grub_platform = xxen ]; then insmod xzio; insmod lzopio;
fi
        insmod part_msdos
        insmod ext2
        set root='hd0,msdos1'
        if [ x$feature_platform_search_hint = xy ]; then
            search --no-floppy --fs-uuid --set=root --hint-bios=hd0,msdos1
--hint-efi=hd0,msdos1 --hint-baremetal=ahci0,msdos1 42803781-1afd-4af0-8af5-f1
73f196eccf
        else
            search --no-floppy --fs-uuid --set=root 42803781-1afd-4af0-8af
5-f173f196eccf
        fi
        echo 'Loading Linux 4.6.3 ...'
        linux /boot/vmlinuz-4.6.3 root=UUID=42803781-1afd-4af0-8af5-f1
:

```

According to the online tutorial: <http://www.howtogeek.com/196655/how-to-configure-the-grub2-boot-loaders-settings/> to change the booting order of kernel, instead of directly changing grub.cfg file, we need to change /etc/default/grub, in which GRUB_DEFAULT value is the index of kernel in the entry menu to boot up. The default value in this file is already 0 which means the first entry:

```
# If you change this file, run 'update-grub' afterwards to update
# /boot/grub/grub.cfg.
# For full documentation of the options in this file, see:
#   info -f grub -n 'Simple configuration'

GRUB_DEFAULT=0
GRUB_HIDDEN_TIMEOUT=0
GRUB_HIDDEN_TIMEOUT_QUIET=true
GRUB_TIMEOUT=10
GRUB_DISTRIBUTOR=`lsb_release -i -s 2> /dev/null || echo Debian`
GRUB_CMDLINE_LINUX_DEFAULT="quiet splash"
GRUB_CMDLINE_LINUX=""

# Uncomment to enable BadRAM filtering, modify to suit your needs
# This works with Linux (no patch required) and with any kernel that obtains
# the memory map information from GRUB (GNU Mach, kernel of FreeBSD ...)
#GRUB_BADRAM="0x01234567,0xfefefefef,0x89abcdef,0xefefefef"

# Uncomment to disable graphical terminal (grub-pc only)
#GRUB_TERMINAL=console

# The resolution used on graphical terminal
# note that you can use only modes which your graphic card supports via VBE
# you can see them in real GRUB with the command `vbeinfo'
#GRUB_GFXMODE=640x480

# Uncomment if you don't want GRUB to pass "root=UUID=xxx" parameter to Linux
#GRUB_DISABLE_LINUX_UUID=true

# Uncomment to disable generation of recovery mode menu entries
#GRUB_DISABLE_RECOVERY="true"

# Uncomment to get a beep at grub start
#GRUB_INIT_TUNE="480 440 1"
/etc/default/grub (END)
```

To make sure newly installed Kernel is to be booted, just run command `sudo update-grub`:

```
yangmo@yangmo-ubuntu:/boot/grub$ sudo update-grub
Generating grub configuration file ...
Warning: Setting GRUB_TIMEOUT to a non-zero value when GRUB_HIDDEN_TIMEOUT is set is no longer supported.
Found linux image: /boot/vmlinuz-4.6.3
Found initrd image: /boot/initrd.img-4.6.3
Found linux image: /boot/vmlinuz-4.4.0-62-generic
Found initrd image: /boot/initrd.img-4.4.0-62-generic
Found linux image: /boot/vmlinuz-4.4.0-21-generic
Found initrd image: /boot/initrd.img-4.4.0-21-generic
Found memtest86+ image: /boot/memtest86+.elf
Found memtest86+ image: /boot/memtest86+.bin
done
```

The bootloader should now be confirmed to load new installed kernel 4.6.3

1.3 Reboot using new kernel

Next simply shutdown and restart the VM to verify the new kernel running:

```
yangmo@yangmo-ubuntu: /boot
yangmo@yangmo-ubuntu:/boot$ ls -lh
total 402M
-rw-r--r-- 1 root root 1.2M Apr 19 2016 abi-4.4.0-21-generic
-rw-r--r-- 1 root root 1.2M Jan 18 23:59 abi-4.4.0-62-generic
-rw-r--r-- 1 root root 185K Apr 19 2016 config-4.4.0-21-generic
-rw-r--r-- 1 root root 186K Jan 18 23:59 config-4.4.0-62-generic
-rw-r--r-- 1 root root 190K Feb 5 14:08 config-4.6.3
drwxr-xr-x 5 root root 4.0K Feb 5 14:19 grub
-rw-r--r-- 1 root root 35M Feb 5 13:07 initrd.img-4.4.0-21-generic
-rw-r--r-- 1 root root 35M Feb 5 13:10 initrd.img-4.4.0-62-generic
-rw-r--r-- 1 root root 298M Feb 5 14:10 initrd.img-4.6.3
-rw-r--r-- 1 root root 179K Jan 28 2016 memtest86+.bin
-rw-r--r-- 1 root root 181K Jan 28 2016 memtest86+.elf
-rw-r--r-- 1 root root 181K Jan 28 2016 memtest86+_multiboot.bin
-rw----- 1 root root 3.7M Apr 19 2016 System.map-4.4.0-21-generic
-rw----- 1 root root 3.7M Jan 18 23:59 System.map-4.4.0-62-generic
-rw-r--r-- 1 root root 3.8M Feb 5 14:08 System.map-4.6.3
-rw-r--r-- 1 root root 6.7M Feb 4 23:54 vmlinuz-4.4.0-21-generic
-rw----- 1 root root 6.8M Jan 18 23:59 vmlinuz-4.4.0-62-generic
-rw-r--r-- 1 root root 6.7M Feb 5 14:08 vmlinuz-4.6.3
yangmo@yangmo-ubuntu:/boot$ uname -a
Linux yangmo-ubuntu 4.6.3 #1 SMP Sun Feb 5 04:41:38 SGT 2017 x86_64 x86_64 x86_64
4 GNU/Linux
yangmo@yangmo-ubuntu:/boot$
```

It can also be seen that new initrd image is too large, we will reduce it and vmlinuz in question 3.

Question 2

Q: During the “make menuconfig” stage, there are three different choices, built-in, excluded and module. (i) What do they mean? (ii) Which are the ones that will appear in the kernel image?

A(i):

built-in: Compile and include this feature inside of the kernel.

excluded: Do not compile the feature

module: Compile this feature as a module, separate from the kernel

A(ii):

Only built-in features will appear in kernel image. Module feature will be in a filesystem hierarchy rooted at /lib/modules/[kernel-release]

Question 3

Upon some research and trials and the help of online resources:

1. <http://unix.stackexchange.com/questions/270390/how-to-reduce-the-size-of-the-initrd-when-compiling-your-kernel/270394>
2. <http://mitchtech.net/compile-linux-kernel-on-ubuntu-12-04-lts-detailed/>
3. <http://www.jinbuguo.com/kernel/longterm-linux-kernel-options.html>

I found the following command and config could effectively reduce both initrd(tremendously) and vmlinuz(around 30% smaller) comparing to the default config and commands used in question 1 while in the **meantime still make the kernel able to run succesfully**.

1. Run “make localmodconfig” to update the configuration to only compile modules that are actually used in the system(according to reference 2 above)

```
yangmo@yangmo-ubuntu:~/linux-4.6.3$ make localmodconfig
using config: '.config'
vboxguest config not found!!
vboxsf config not found!!
vboxvideo config not found!!
*
* Restart config...
*
*
* PCI GPIO expanders
*
AMD 8111 GPIO driver (GPIO_AMD8111) [N/m/y/?] n
BT8XX GPIO abuser (GPIO_BT8XX) [N/m/y/?] (NEW) █
```

2. When “make menuconfig”, I made the following changes to the .config as below:

General setup

- Kernel Compression Mode -> XZ
- Optimize for size -> 'Y'
- Configure standard kernel features(expert users)
 - Include all symbols in kallsyms -> 'N'
- Enable full-sized data structures for core -> 'N'
- Enable SLUB debugging support -> 'N'

Enable loadable module support

- Compress modules on installation
 - Compression algorithm -> 'XZ'

Device Drivers

- Serial ATA and Parallel ATA drivers (libata)
 - Verbose ATA error reporting -> 'N'

Kernel Hacking

- Compile-time checks and compiler options
 - Compile the kernel with debug info -> 'N'
 - Strip assembler-generated symbols during link -> 'Y'
 - Enable unused/obsolete exported symbols -> 'N'
 - Collect scheduler debugging info -> 'N'
 - Collect scheduler statistics -> 'N'
 - Verbose BUG() reporting (adds 70K) -> 'N'
3. For initrd, use `sudo make INSTALL_MOD_STRIP=1 modules_install` instead of `sudo make modules_install`
 4. After above steps, reboot Ubuntu, I finally got an much smaller kernel running successfully:

```
yangmo@yangmo-ubuntu: /boot
yangmo@yangmo-ubuntu:~$ uname -a
Linux yangmo-ubuntu 4.6.3yangmo-minimal-linux #9 SMP Sun Feb 5 23:10:39 SGT 2017
x86_64 x86_64 x86_64 GNU/Linux
yangmo@yangmo-ubuntu:~$ cd ..
yangmo@yangmo-ubuntu:/home$ cd ..
yangmo@yangmo-ubuntu:/$ cd ..
yangmo@yangmo-ubuntu:/boot$ ls -lh
total 429M
-rw-r--r-- 1 root root 1.2M Apr 19 2016 abi-4.4.0-21-generic
-rw-r--r-- 1 root root 1.2M Jan 18 23:59 abi-4.4.0-62-generic
-rw-r--r-- 1 root root 185K Apr 19 2016 config-4.4.0-21-generic
-rw-r--r-- 1 root root 186K Jan 18 23:59 config-4.4.0-62-generic
-rw-r--r-- 1 root root 190K Feb 5 14:08 config-4.6.3
-rw-r--r-- 1 root root 121K Feb 5 23:16 config-4.6.3yangmo-minimal-linux
-rw-r--r-- 1 root root 121K Feb 5 23:11 config-4.6.3yangmo-minimal-linux.old
drwxr-xr-x 5 root root 4.0K Feb 5 23:11 grub
-rw-r--r-- 1 root root 35M Feb 5 13:07 initrd.img-4.4.0-21-generic
-rw-r--r-- 1 root root 35M Feb 5 13:10 initrd.img-4.4.0-62-generic
-rw-r--r-- 1 root root 298M Feb 5 14:10 initrd.img-4.6.3
-rw-r--r-- 1 root root 11M Feb 5 23:16 initrd.img-4.6.3yangmo-minimal-linux
-rw-r--r-- 1 root root 179K Jan 28 2016 memtest86+.bin
-rw-r--r-- 1 root root 181K Jan 28 2016 memtest86+.elf
-rw-r--r-- 1 root root 181K Jan 28 2016 memtest86+_multiboot.bin
-rw-r--r-- 1 root root 3.7M Apr 19 2016 System.map-4.4.0-21-generic
-rw-r--r-- 1 root root 3.7M Jan 18 23:59 System.map-4.4.0-62-generic
-rw-r--r-- 1 root root 3.8M Feb 5 14:08 System.map-4.6.3
-rw-r--r-- 1 root root 3.8M Feb 5 23:16 System.map-4.6.3yangmo-minimal-linux
-rw-r--r-- 1 root root 3.8M Feb 5 23:11 System.map-4.6.3yangmo-minimal-linux.old
-rw-r--r-- 1 root root 6.7M Feb 4 23:54 vmlinuz-4.4.0-21-generic
-rw-r--r-- 1 root root 6.8M Jan 18 23:59 vmlinuz-4.4.0-62-generic
-rw-r--r-- 1 root root 6.7M Feb 5 14:08 vmlinuz-4.6.3
-rw-r--r-- 1 root root 4.2M Feb 5 23:16 vmlinuz-4.6.3yangmo-minimal-linux
-rw-r--r-- 1 root root 4.2M Feb 5 23:11 vmlinuz-4.6.3yangmo-minimal-linux.old
yangmo@yangmo-ubuntu:/boot$
```

- a. As seen from above, kernel release is now 4.6.3yangmo-minimal-linux
- b. Initrd.img-4.6.3yangmo-minimal-linux is just 11M compared to 298M in question 1
- c. Vmlinuz-4.6.3yangmo-minimal-linux is just 4.2M compared to 6.7M in question 1