Boot Sequence & Kernel Compilation

Boot Terminology:

1. Loader: program that moves bits from disk (usually) to memory and transfers CPU control to the newly “loaded”bits (executable).
2. Bootloader/bootstrap: program that loads the “first program” (the kernel)
3. Boot PROM/PROM monitor/BIOS: persistent code that is “already loaded” on power-up
4. Boot manager: program that lets you choose “first program” load.

Boot basic:

1. BIOS (Basic input output system executes MBR): system checkup before jump to OS
2. MBR (Master Boot Record executes GRUB): first 512 bytes on disk as a first program after BIOS
3. GRUB (Grand unified bootloader executes Kernel): program (eventually as a menu for selecting the kernel)
4. Kernel (Kernel executes /sbin/init): program to activate hardwares, scheduling, memory, etc.
5. Init (Executes runlevel program): first level user application in OS.
6. Runlevel (Executes from /etc/rc.d/rc*.d: boot script (lots of shell script executed in sequence)

Booting

1. Lewat disk yang ditaroh di laptop kita
2. Lewat network

Use startup script to:

1. Set frequencies in kernel
2. Set voltage in kernel
3. Set ondemages scheduler parameter]
4. Start daemonsl like cron, apache, ets
5. Lpad additional kernel modules
6. Turn on additional swapping partitions.
7. Mount additional partitions

UEFI:

1. Penggantinya BIOS
2. Stands for Unified Extensible Firmware Interface
3. BIOS Limitation: force 16-bit, can only boot from HDD < 2 T, 1 MB address space
4. UEFI:9.4 zettabytes boot, secure boot, remote (configuration), GUI, prommable.

GPT

1. Replacing MBR, strongly tied with UEFI
2. GUID (Globally Unique Identifiers) partition table :a standard layout of partition table on disk

3. MBR: 2TB max, 4 primary partitions max
4. GPT: store partition+boot data in several copies, backward compatible with BIOS, checksum.

Systemd

1. Bagian init pada UNIX baru
2. Keuntungan:
   - Parallelization
   - Simpler unix syntax
   - Automatic dependent resolver,
3. Kerugian:
   - Monolithic sciprt, not POSOC compliant.

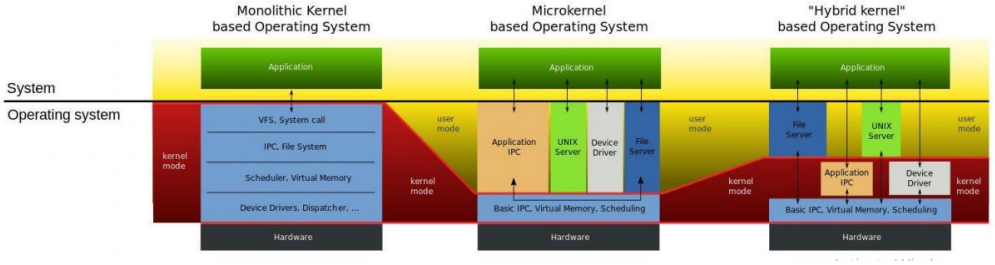
init vs systemd

- The developers claimed many benefits compared to systemV init : see previous link
- Some differences, though :

	SystemV init	systemd
Key point path	/etc/inittab	/etc/systemd/system/, /etc/systemd/system
Number of Files	75	900 files + glib + DBus
Portable to non x86	Yes	No (yet, besides ARM)
Implementation in distros	Init is slowly replaced by systemd	

- Why we need to compile kernel?
  - Make system match your hardware
  - Kita harus tahu bahwa kernel yang ada di komputer kita dibuat oleh orang lain dengan hardware mereka masing-masing.
  - Boot faster in embedded system

- Monolithic
- Micro-kernel
- Hybrid



- Monolithic:
  - Hampir semua pekerjaan dikerjakan di kernel mode (controlled by Kernel)
  - Biasanya untuk embedded system, tidak butuh compile driver ulang.
  - Komputernya biasanya hanya memiliki satu tujuan (single purpose computer)
  - Misal: wireless router, access point, modem.
- Micro-kernel:
  User mode:
  - Application IPC
  - UNIX Server
  - Device Driver
  - File Server

  Kernel mode:

  - Basic IPC, virtual memory, scheduling

  ■ Device driver bisa di compile lagi.

  Example: windows nt, Symbian, blackberry 10.

- Hybrid
  Kernel mode:
  - Application IPC
  - Device Driver

  User mode:
  - UNIX Server
  - File Server

  Kernel tidak perlu di redefined, karena compile dilakukan di user level.

  Example: Windows NT, BSD Based Kernel, XNU Kernel (core of Darwin, used in OS X)

Kernel Compilation

1. Persiapan untuk pengguna *windows*: apabila terdapat WSL/Hyper-V/Docker Dekstop pada laptop kita, maka fitur-fitur tersebut bisa di *unsintall* atau *disable* terlebih dahulu, karena hal ini akan menyebabkan beberapa *failure* ketika melakukan kompilasi nantinya.
   Gunakan command: **bcdedit /set hypervisorlaunchtype off** pada command prompt sebagai Administrator.
   Apabila ingin suatu saat ingin mengaktifkannya lagi, buka command prompt sebagai Administrator kemudian ketikkan **bcdedit /set hypervisorlaunchtype auto**
2. Download source linux dengan versi 4.15.1
   wget http://kambing.ui.ac.id/linux/v4.x/linux-4.15.1.tar.xz

```
user@sysprog-ova:~$ wget http://kambing.ui.ac.id/linux/v4.x/linux-4.15.1.tar.xz
--2020-12-22 11:47:38--  http://kambing.ui.ac.id/linux/v4.x/linux-4.15.1.tar.xz
Resolving kambing.ui.ac.id (kambing.ui.ac.id)... 152.118.24.30, 2403:da00:1:3::1
e
Connecting to kambing.ui.ac.id (kambing.ui.ac.id)|152.118.24.30|:80... connected
.
HTTP request sent, awaiting response... 200 OK
Length: 102176316 (97M) [application/octet-stream]
Saving to: 'linux-4.15.1.tar.xz.1'

linux-4.15.1.tar.xz   9%[>                    ]   9.04M   875KB/s    eta 96s
```

3. Extract hasil *download* pada poin 1
   tar –xvJf linux-4.15.1.tar.xz

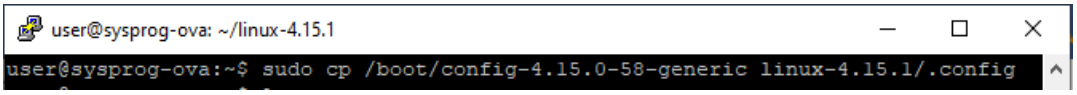
```
user@sysprog-ova:~$ tar -xvJf linux-4.15.1.tar.xz
linux-4.15.1/
linux-4.15.1/.cocciconfig
linux-4.15.1/.get_maintainer.ignore
linux-4.15.1/.gitattributes
linux-4.15.1/.gitignore
linux-4.15.1/.mailmap
linux-4.15.1/COPYING
linux-4.15.1/CREDITS
linux-4.15.1/Documentation/
linux-4.15.1/Documentation/.gitignore
linux-4.15.1/Documentation/00-INDEX
linux-4.15.1/Documentation/ABI/
linux-4.15.1/Documentation/ABI/README
linux-4.15.1/Documentation/ABI/obsolete/
linux-4.15.1/Documentation/ABI/obsolete/sysfs-bus-usb
linux-4.15.1/Documentation/ABI/obsolete/sysfs-driver-hid-roccat-arvo
linux-4.15.1/Documentation/ABI/obsolete/sysfs-driver-hid-roccat-isku
linux-4.15.1/Documentation/ABI/obsolete/sysfs-driver-hid-roccat-koneplus
linux-4.15.1/Documentation/ABI/obsolete/sysfs-driver-hid-roccat-konepure
linux-4.15.1/Documentation/ABI/obsolete/sysfs-driver-hid-roccat-kovaplus
linux-4.15.1/Documentation/ABI/obsolete/sysfs-driver-hid-roccat-lua
linux-4.15.1/Documentation/ABI/obsolete/sysfs-driver-hid-roccat-pyra
linux-4.15.1/Documentation/ABI/obsolete/sysfs-driver-hid-roccat-ryos
linux-4.15.1/Documentation/ABI/obsolete/sysfs-driver-hid-roccat-savu
linux-4.15.1/Documentation/ABI/obsolete/sysfs-firmware-acpi
linux-4.15.1/Documentation/ABI/obsolete/sysfs-gpio
linux-4.15.1/Documentation/ABI/removed/
linux-4.15.1/Documentation/ABI/removed/devfs
linux-4.15.1/Documentation/ABI/removed/dv1394
linux-4.15.1/Documentation/ABI/removed/ip_queue
linux-4.15.1/Documentation/ABI/removed/net_dma
linux-4.15.1/Documentation/ABI/removed/o2cb
```

Setelah tahapan ini disarankan memakai user *root* atau menggunakan command *sudo*

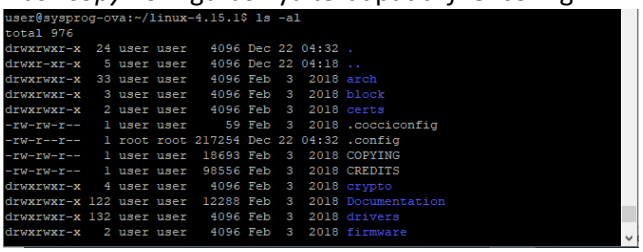
4. Melakukan *copy* konfigurasi kernel yang sudah ada ke *kernel* yang baru kita extract

```
user@sysprog-ova:/$ cd boot
user@sysprog-ova:/boot$ ls
config-4.15.0-58-generic      System.map-4.15.0-58-generic
grub                          vmlinuz-4.15.0-58-generic
```

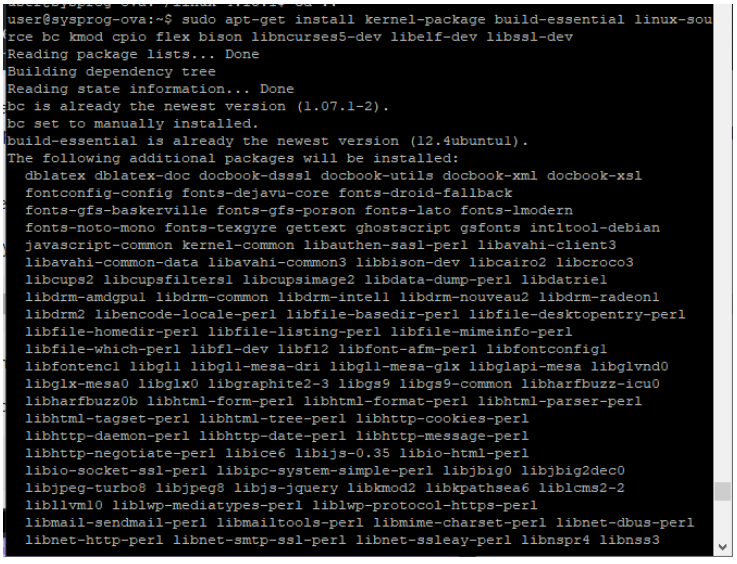
   Terlihat disana, saya sudah memiliki sebuah konfigurasi yaitu *config-4.15.1.0-58-generic*
   sudo cp /boot/config-4.15.0-58-generic linux-4.15.1/.config



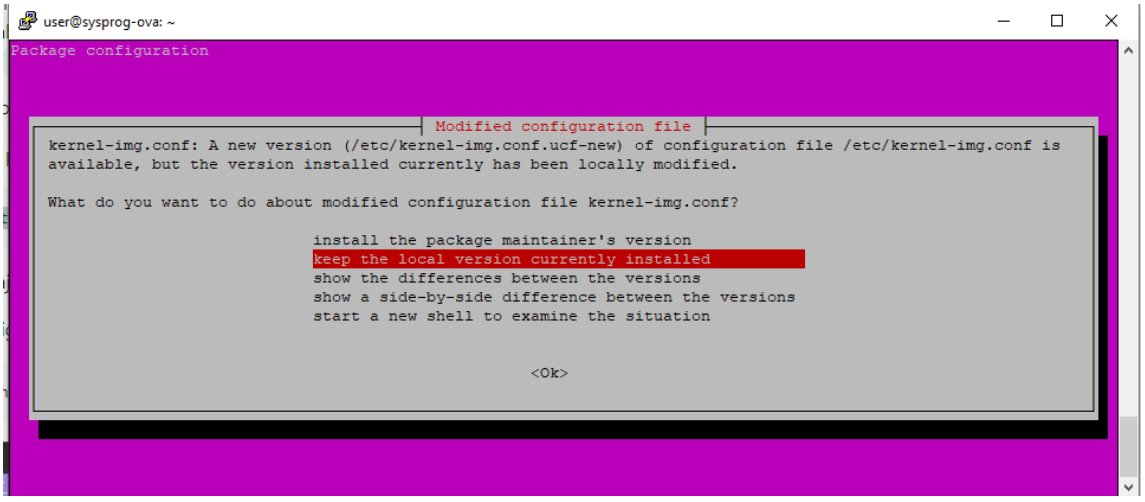
Hasil *copy* konfigurasinya terdapat di *file* .config



5. Sebelum melakukan tahapan selanjutnya, pastikan kita melakukan *update* terlebih dahulu pada linux kita.
   sudo apt-get update
6. Lakukan instalasi *dependencies* yang dibutuhkan dalam proses kompilasi kernel
   sudo apt-get install kernel-package build-essential linux-source bc kmod cpio flex bison libncurses5-dev libelf-dev libssl-dev

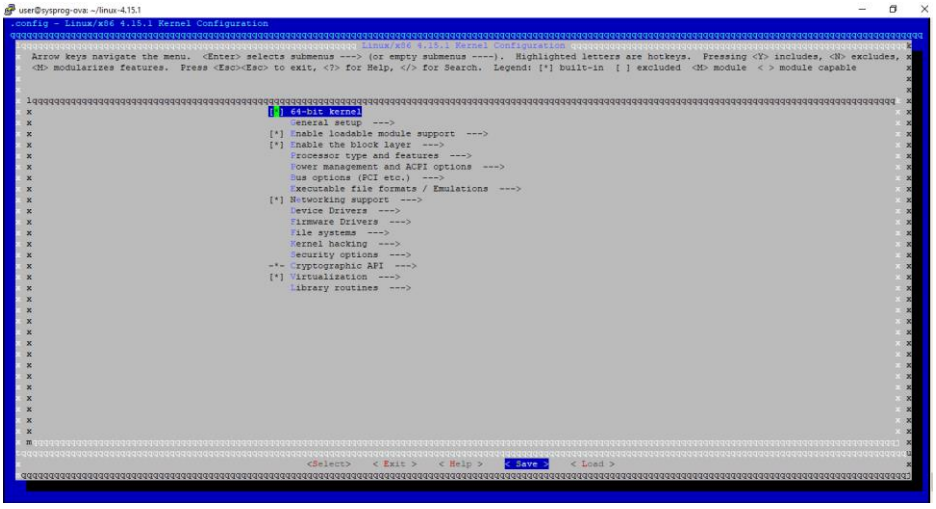


Ketika melakukan instalasi diatas, akan muncuk sebuah pop-up window seperti ini:



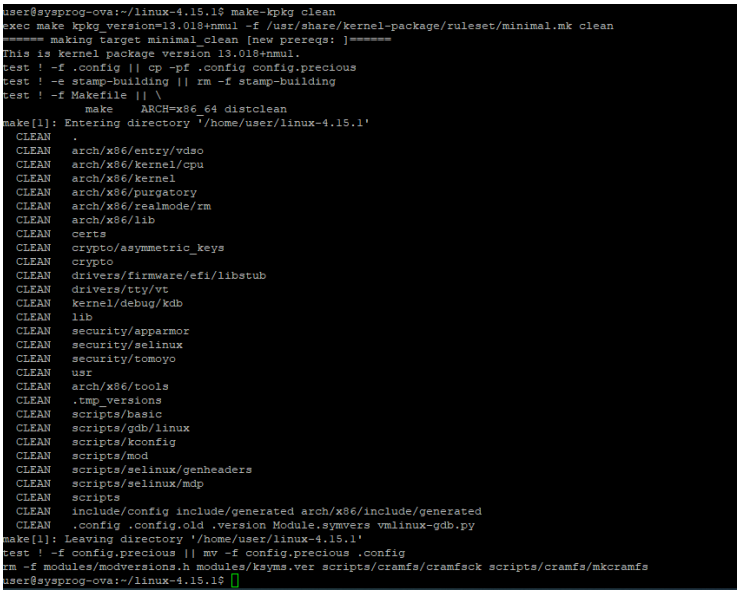
penulis memilih opsi pertama.

7. Memilih *module* yang ingin diinstall
   sudo make menuconfig



Langsung save kemudian arahkan arrow pada keyboard ke exit.

8. Lakukan *cleaning* sebelum melakukan kompilasi
   sudo make-kpkg clean



9. Bagian kompilasi: bagian yang paling krusial. Pada bagian ini, penulis mengalami beberapa masalah mulai dari *storage* dan kondisi laptop yang tiba-tiba *ngelag* ditengah kompilasi sehingga harus mengulang dari awal dan memakan waktu beberapa hari. Kemudian, karena penulis menggunakan windows maka ada masalah di virtualisasi, solusinya terdapat pada tahap 1.
   Akhirnya setelah melewati perjuangan panjang, kernel penulis berhasil di kompilasi.

   - Merubah *custom* nama untuk instalasi kernel pada file /include/linux/uts.h
     Penulis lupa me-*screenshot* bagian ini. Intinya langsung kita tambahkan setelah **#define UTS_SYSNAME** (yang kedua) dengan *custom name* kita misalnya “Linux Compiled by SF”

   Kemudian, lakukan instalasi dengan *command* seperti berikut

   sudo make-kpkg -j 2 --initrd --append-to-version=deb-sf-version kernel_image kernel_headers

   keterangan:

   - **-j 2** berfungsi untuk membagi job ke 2 CPU yang tersedia.
   - **--initrd** mendefinisikan *image* yang sesuai dengan initrd
   - **--append-to-version=deb-sf-version** untuk nama subversion dari kernel yang ingin kita custom
   - **kernel_image** untuk mendefinisikan bahwa output dari command tersebut terdapat kernel image nya
   - **kernel_headers** untuk mendefinisikan bahwa output dari command tersebut terdapat kernel header nya

Berikut waktu yang komputer penulis butuhkan untuk melakukan kompilasi:

```
chown -R root:root                  /home/user/linux-4.15.1/debian/linux-headers-4.15.1deb-sf-version
chmod -R og=rX                      /home/user/linux-4.15.1/debian/linux-headers-4.15.1deb-sf-version
dpkg --build                        /home/user/linux-4.15.1/debian/linux-headers-4.15.1deb-sf-version ..
dpkg-deb: building package 'linux-headers-4.15.1deb-sf-version' in '../linux-headers-4.15.1deb-sf-version_4.15.1deb-sf-
cp -pf debian/control.dist          debian/control
make[2]: Leaving directory '/home/user/linux-4.15.1'
make[1]: Leaving directory '/home/user/linux-4.15.1'

real    349m10.960s
user    194m4.324s
sys     24m20.081s
```

10. Hasil kompilasi berupa kernel image dan header

```
user@sysprog-ova:~/linux-4.15.1$ cd /home/user/
user@sysprog-ova:~$ ls -al
total 160436
drwxr-xr-x  5 user user      4096 Dec 28 21:58 .
drwxr-xr-x  3 root root      4096 Sep  1  2019 ..
-rw-------  1 user user       357 Sep  1  2019 .bash_history
-rw-r--r--  1 user user       220 Apr  4  2018 .bash_logout
-rw-r--r--  1 user user      3771 Apr  4  2018 .bashrc
drwx------  2 user user      4096 Sep  1  2019 .cache
drwx------  3 user user      4096 Sep  1  2019 .gnupg
drwxrwxr-x 26 user user      4096 Dec 28 21:57 linux-4.15.1
-rw-rw-r--  1 user user 102176316 Feb  3  2018 linux-4.15.1.tar.xz
-rw-r--r--  1 root root   9162672 Dec 28 21:58 linux-headers-4.15.1deb-sf-version_4.15.1deb-sf-version-10.00.Custom_amd64.deb
-rw-r--r--  1 root root  52896952 Dec 28 21:56 linux-image-4.15.1deb-sf-version_4.15.1deb-sf-version-10.00.Custom_amd64.deb
-rw-r--r--  1 user user       807 Apr  4  2018 .profile
-rw-r--r--  1 user user         0 Sep  1  2019 .sudo_as_admin_successful
```

11. Instalasi kernel

- Instalasi kernel image
  sudo dpkg -i linux-headers-4.15.1deb-sf-version_4.15.1deb-sf-version-10.00.Custom_amd64.deb
- Instalsi kernel header
  dpkg -i linux-image-4.15.1deb-sf-version_4.15.1deb-sf-version-10.00.Custom_amd64.deb

```
user@sysprog-ova:~$ sudo dpkg -i linux-headers-4.15.1deb-sf-version_4.15.1deb-sf-version-10.00.Custom_amd64.deb
[sudo] password for user:
Selecting previously unselected package linux-headers-4.15.1deb-sf-version.
(Reading database ... 114736 files and directories currently installed.)
Preparing to unpack linux-headers-4.15.1deb-sf-version_4.15.1deb-sf-version-10.00.Custom_amd64.deb ...
Unpacking linux-headers-4.15.1deb-sf-version (4.15.1deb-sf-version-10.00.Custom) ...
Setting up linux-headers-4.15.1deb-sf-version (4.15.1deb-sf-version-10.00.Custom) ...
Examining /etc/kernel/header_postinst.d.
Selecting previously unselected package linux-headers-4.15.1deb-sf-version.
(Reading database ... 114736 files and directories currently installed.)
Preparing to unpack linux-headers-4.15.1deb-sf-version_4.15.1deb-sf-version-10.00.Custom_amd64.deb ...
Unpacking linux-headers-4.15.1deb-sf-version (4.15.1deb-sf-version-10.00.Custom) ...
Setting up linux-headers-4.15.1deb-sf-version (4.15.1deb-sf-version-10.00.Custom) ...
Examining /etc/kernel/header_postinst.d.
user@sysprog-ova:~$ sudo dpkg -i linux-image-4.15.1deb-sf-version_4.15.1deb-sf-version-10.00.Custom_amd64.deb
[sudo] password for user:
Selecting previously unselected package linux-image-4.15.1deb-sf-version.
(Reading database ... 138332 files and directories currently installed.)
Preparing to unpack linux-image-4.15.1deb-sf-version_4.15.1deb-sf-version-10.00.Custom_amd64.deb ...
Examining /etc/kernel/preinst.d/
run-parts: executing /etc/kernel/preinst.d/intel-microcode 4.15.1deb-sf-version /boot/vmlinuz-4.15.1deb-sf-version
Done.
Unpacking linux-image-4.15.1deb-sf-version (4.15.1deb-sf-version-10.00.Custom) ...
Setting up linux-image-4.15.1deb-sf-version (4.15.1deb-sf-version-10.00.Custom) ...
Running depmod.
Examining /etc/kernel/postinst.d.
run-parts: executing /etc/kernel/postinst.d/apt-auto-removal 4.15.1deb-sf-version /boot/vmlinuz-4.15.1deb-sf-version
run-parts: executing /etc/kernel/postinst.d/initramfs-tools 4.15.1deb-sf-version /boot/vmlinuz-4.15.1deb-sf-version
update-initramfs: Generating /boot/initrd.img-4.15.1deb-sf-version
run-parts: executing /etc/kernel/postinst.d/unattended-upgrades 4.15.1deb-sf-version /boot/vmlinuz-4.15.1deb-sf-version
run-parts: executing /etc/kernel/postinst.d/update-notifier 4.15.1deb-sf-version /boot/vmlinuz-4.15.1deb-sf-version
run-parts: executing /etc/kernel/postinst.d/x-grub-legacy-ec2 4.15.1deb-sf-version /boot/vmlinuz-4.15.1deb-sf-version
Searching for GRUB installation directory ... found: /boot/grub
Searching for default file ... found: /boot/grub/default
Testing for an existing GRUB menu.lst file ... found: /boot/grub/menu.lst
Searching for splash image ... none found, skipping ...
Found kernel: /boot/vmlinuz-4.15.0-58-generic
Found kernel: /boot/vmlinuz-4.15.1deb-sf-version
Found kernel: /boot/vmlinuz-4.15.0-58-generic
Replacing config file /run/grub/menu.lst with new version
Updating /boot/grub/menu.lst ... done

run-parts: executing /etc/kernel/postinst.d/zz-update-grub 4.15.1deb-sf-version /boot/vmlinuz-4.15.1deb-sf-version
Sourcing file `/etc/default/grub'
Generating grub configuration file ...
Found linux image: /boot/vmlinuz-4.15.1deb-sf-version
Found initrd image: /boot/initrd.img-4.15.1deb-sf-version
Found linux image: /boot/vmlinuz-4.15.0-58-generic
Found initrd image: /boot/initrd.img-4.15.0-58-generic
done
```

12. Instalasi *modules*
    sudo make modules_install

    hasilnya dapat ditemukan di folder /boot

13. Update initframs

    sudo update-initramfs -c -k vmlinuz-4.15.1deb-sf-version

```
user@sysprog-ova:/boot$ sudo update-initramfs -c -k vmlinuz-4.15.1deb-sf-version
update-initramfs: Generating /boot/initrd.img-vmlinuz-4.15.1deb-sf-version
WARNING: missing /lib/modules/vmlinuz-4.15.1deb-sf-version
Ensure all necessary drivers are built into the linux image!
depmod: ERROR: Bad version passed vmlinuz-4.15.1deb-sf-version
dpkg: warning: version 'vmlinuz-4.15.1deb-sf-version' has bad syntax: version number does not start with digit
dpkg: warning: version 'vmlinuz-4.15.1deb-sf-version' has bad syntax: version number does not start with digit
dpkg: warning: version 'vmlinuz-4.15.1deb-sf-version' has bad syntax: version number does not start with digit
dpkg: warning: version 'vmlinuz-4.15.1deb-sf-version' has bad syntax: version number does not start with digit
depmod: ERROR: Bad version passed vmlinuz-4.15.1deb-sf-version
```

14. Update grub
    cd /boot
    sudo update-grub

```
user@sysprog-ova:/boot$ sudo update-grub
Sourcing file `/etc/default/grub'
Generating grub configuration file ...
Found linux image: /boot/vmlinuz-4.15.1deb-sf-version
Found initrd image: /boot/initrd.img-4.15.1deb-sf-version
Found linux image: /boot/vmlinuz-4.15.0-58-generic
Found initrd image: /boot/initrd.img-4.15.0-58-generic
done
```

=== SELESAI ===

Lakukan *reboot* dengan mematikan virtual box kemudian menyalakannya kembali. Ketika kita membuka virtual box kita akan terdapat pilihan Ubuntu for Advance options dan terdapat pilihan kernel yang sudah kita install tadi

Kita bisa mengecek hasil custom name kita dengan perintah **uname –a** dan menghasilkan

```
user@sysprog-ova:~$ uname -a
Linux Compiled by Selvy sysprog-ova 4.15.1deb-sf-version #1 SMP Mon Dec 28 16:10
:03 UTC 2020 x86_64 x86_64 x86_64 GNU/Linux
```