

PROJECT - NGUYÊN LÝ HỆ ĐIỀU HÀNH

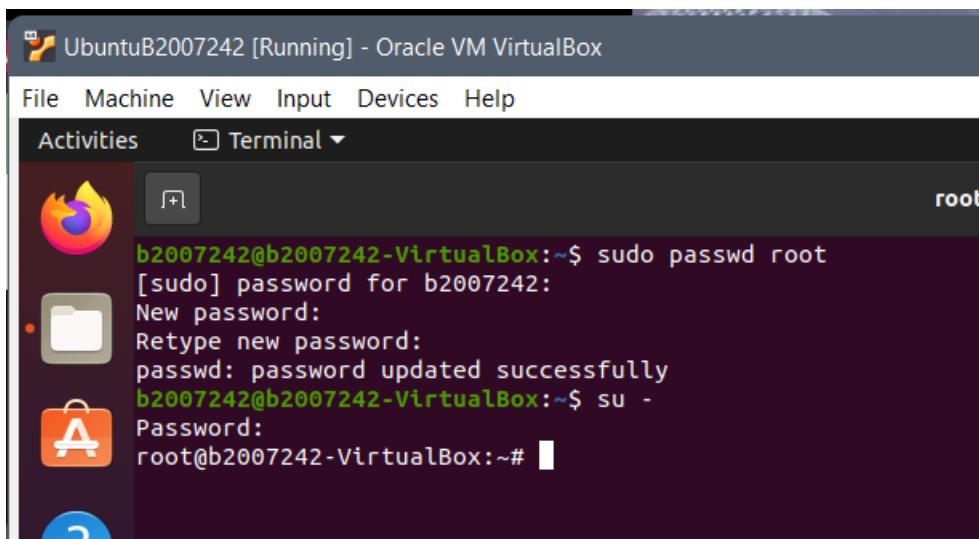
Học kỳ 1 – 2022-2023

HỌ VÀ TÊN: **Đặng Minh Khôi** MSSV: **B2007242**

Tuyên bố: Project này là do chính tôi, **Đặng Minh Khôi** (MSSV: **B2007242**), tự thực hiện, không sao chép của bất kỳ ai. Nếu có bất cứ sao chép nào, tôi hoàn toàn chịu trách nhiệm.

PHẦN 1: XÂY DỰNG LINUX KERNE

**Thực hiện người dùng ở chế độ root:



The screenshot shows a terminal window titled "UbuntuB2007242 [Running] - Oracle VM VirtualBox". The user is in root mode, indicated by the "root" prompt at the top right. The terminal command history shows:

```
b2007242@b2007242-VirtualBox:~$ sudo passwd root
[sudo] password for b2007242:
New password:
Retype new password:
passwd: password updated successfully
b2007242@b2007242-VirtualBox:~$ su -
Password:
root@b2007242-VirtualBox:~#
```

1. Download và cài đặt tool cần thiết vào hệ thống

\$sudo apt-get install -y gcc libncurses5-dev make wget

```

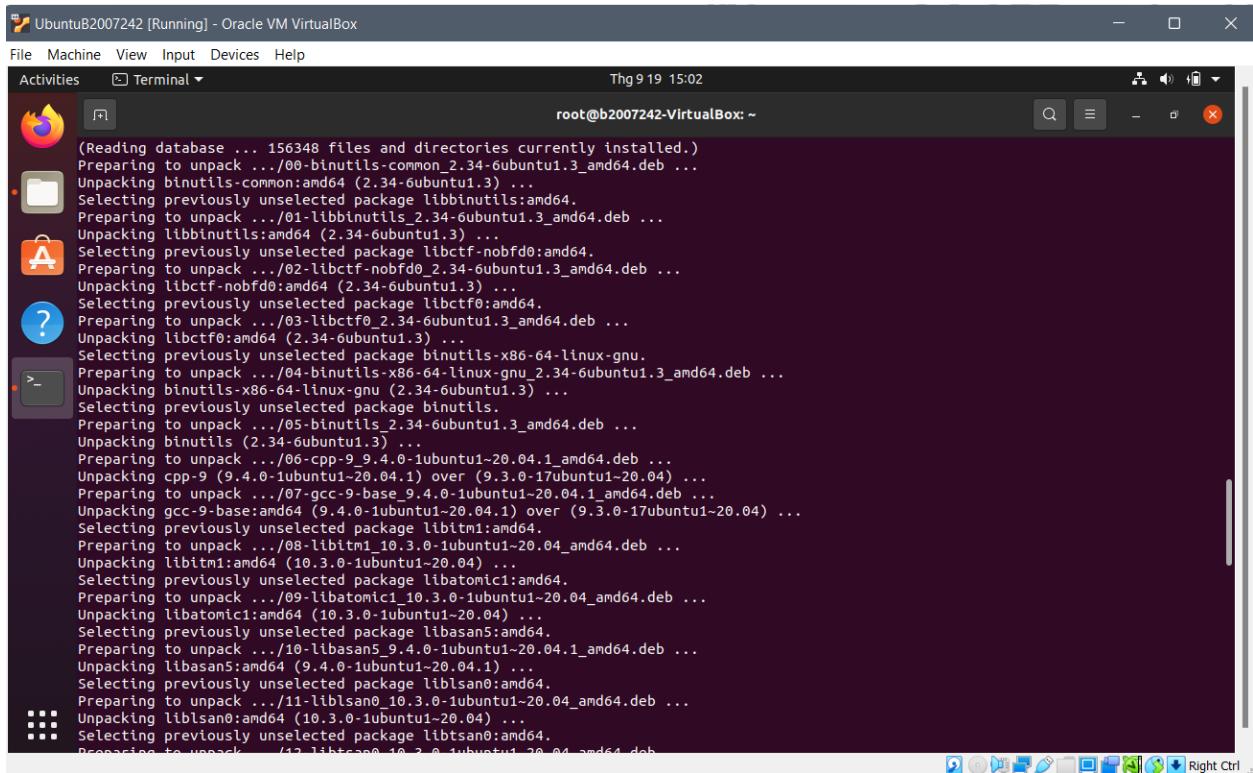
root@b2007242-VirtualBox:~# sudo apt-get install -y gcc libncurses5-dev make wget
Reading package lists... Done
Building dependency tree
Reading state information... Done
wget is already the newest version (1.20.3-1ubuntu2).
wget set to manually installed.
The following additional packages will be installed:
  binutils binutils-common binutils-x86_64-linux-gnu cpp-9 gcc-9-base libasan5 libatomic1 libbinutils libc-dev-bin libc6
  libc6-dbg libcrypt-dev libctf-nobfd0 libctf0 libgcc-9-dev libitm1 liblsan0 libncurses-dev libquadmath0 libtsan0
  libubsan1 linux-libc-dev manpages-dev
Suggested packages:
  binutils-doc gcc-9-locales gcc-multilib autoconf automake libtool flex bison gcc-doc gcc-9-multilib gcc-9-doc glibc-doc
  ncurses-doc make-doc
The following NEW packages will be installed:
  binutils binutils-common binutils-x86_64-linux-gnu gcc gcc-9 libasan5 libatomic1 libbinutils libc-dev-bin libc6-dev libcrypt-dev
  libctf-nobfd0 libctf0 libgcc-9-dev libitm1 liblsan0 libncurses-dev libquadmath0 libtsan0 libubsan1
  linux-libc-dev make manpages-dev
The following packages will be upgraded:
  cpp-9 gcc-9-base libc6 libc6-dbg
4 upgraded, 24 newly installed, 0 to remove and 244 not upgraded.
Need to get 56,4 MB of archives.
After this operation, 76,8 MB of additional disk space will be used.
Get:1 http://vn.archive.ubuntu.com/ubuntu focal-updates/main amd64 libc6-dbg amd64 2.31-0ubuntu9.9 [20,0 kB]
Get:2 http://vn.archive.ubuntu.com/ubuntu focal-updates/main amd64 libtcm amd64 2.31-0ubuntu9.9 [2,722 kB]
Get:3 http://vn.archive.ubuntu.com/ubuntu focal-updates/main amd64 binutils-common amd64 2.34-6ubuntu1.3 [207 kB]
Get:4 http://vn.archive.ubuntu.com/ubuntu focal-updates/main amd64 libbinutils amd64 2.34-6ubuntu1.3 [474 kB]
Get:5 http://vn.archive.ubuntu.com/ubuntu focal-updates/main amd64 libctf-nobfd0 amd64 2.34-6ubuntu1.3 [47,4 kB]
Get:6 http://vn.archive.ubuntu.com/ubuntu focal-updates/main amd64 libctf0 2.34-6ubuntu1.3 [46,0 kB]
Get:7 http://vn.archive.ubuntu.com/ubuntu focal-updates/main amd64 binutils-x86_64-linux-gnu amd64 2.34-6ubuntu1.3 [1.613 kB]
Get:8 http://vn.archive.ubuntu.com/ubuntu focal-updates/main amd64 binutils amd64 2.34-6ubuntu1.3 [3.380 B]
Get:9 http://vn.archive.ubuntu.com/ubuntu focal-updates/main amd64 cpp-9 amd64 9.4.0-1ubuntu1-20.04.1 [7.500 kB]
Get:10 http://vn.archive.ubuntu.com/ubuntu focal-updates/main amd64 gcc-9-base amd64 9.4.0-1ubuntu1-20.04.1 [19,4 kB]
Get:11 http://vn.archive.ubuntu.com/ubuntu focal-updates/main amd64 libitm1 amd64 10.3.0-1ubuntu1-20.04 [26,2 kB]
Get:12 http://vn.archive.ubuntu.com/ubuntu focal-updates/main amd64 libatomic1 amd64 10.3.0-1ubuntu1-20.04 [9.284 kB]
Get:13 http://vn.archive.ubuntu.com/ubuntu focal-updates/main amd64 libasan5 amd64 9.4.0-1ubuntu1-20.04.1 [2.751 kB]
Get:14 http://vn.archive.ubuntu.com/ubuntu focal-updates/main amd64 liblsan0 amd64 10.3.0-1ubuntu1-20.04 [835 kB]
Get:15 http://vn.archive.ubuntu.com/ubuntu focal-updates/main amd64 libtsan0 amd64 10.3.0-1ubuntu1-20.04 [2.009 kB]
Get:16 http://vn.archive.ubuntu.com/ubuntu focal-updates/main amd64 libubsan1 amd64 10.3.0-1ubuntu1-20.04 [784 kB]
Get:17 http://vn.archive.ubuntu.com/ubuntu focal-updates/main amd64 libquadmath0 amd64 10.3.0-1ubuntu1-20.04 [146 kB]
Get:18 http://vn.archive.ubuntu.com/ubuntu focal-updates/main amd64 libgcc-9-dev amd64 9.4.0-1ubuntu1-20.04.1 [2.359 kB]
Get:19 http://vn.archive.ubuntu.com/ubuntu focal-updates/main amd64 gcc-9 amd64 9.4.0-1ubuntu1-20.04.1 [8.274 kB]
Get:20 http://vn.archive.ubuntu.com/ubuntu focal/main amd64 gcc amd64 4:9.3.0-1ubuntu2 [5.208 B]
Get:21 http://vn.archive.ubuntu.com/ubuntu focal-updates/main amd64 libc-dev-bin amd64 2.31-0ubuntu9.9 [71,8 kB]
Get:22 http://vn.archive.ubuntu.com/ubuntu focal-updates/main amd64 linux-libc-dev amd64 5.4.0-125.141 [1.100 kB]
Get:23 http://vn.archive.ubuntu.com/ubuntu focal/main amd64 libcrypt-dev amd64 1:4.16-10ubuntu4 [104 kB]
Get:24 http://vn.archive.ubuntu.com/ubuntu focal-updates/main amd64 libc6-dev amd64 2.31-0ubuntu9.9 [2.519 kB]
Get:25 http://vn.archive.ubuntu.com/ubuntu focal/main amd64 libncurses-dev amd64 6.2-0ubuntu2 [339 kB]
Get:26 http://vn.archive.ubuntu.com/ubuntu focal/main amd64 libncurses5-dev amd64 6.2-0ubuntu2 [976 B]
Get:27 http://vn.archive.ubuntu.com/ubuntu focal/main amd64 make amd64 4.2.1-1.2 [162 kB]
Get:28 http://vn.archive.ubuntu.com/ubuntu focal/main amd64 manpages-dev all 5.05-1 [2.266 kB]
Fetched 56,4 MB in 18s (3.211 kB/s)
Preconfiguring packages ...
(Reading database ... 156191 files and directories currently installed.)
Preparing to unpack .../libc6-dbg_2.31-0ubuntu9.9_amd64.deb ...
Unpacking libc6-dbg:amd64 (2.31-0ubuntu9.9) over (2.31-0ubuntu9.2) ...
Preparing to unpack .../libc6_2.31-0ubuntu9.9_amd64.deb ...
Unpacking libc6:amd64 (2.31-0ubuntu9.9) over (2.31-0ubuntu9.2) ...
Setting up libc6:amd64 (2.31-0ubuntu9.9) ...
Selecting previously unselected package binutils-common:amd64.
(Reading database ... 156348 files and directories currently installed.)
Preparing to unpack .../0-binutils-common_2.34-6ubuntu1.3_amd64.deb ...
Unpacking binutils-common:amd64 (2.34-6ubuntu1.3) ...
Selecting previously unselected package libbinutils:amd64.

```

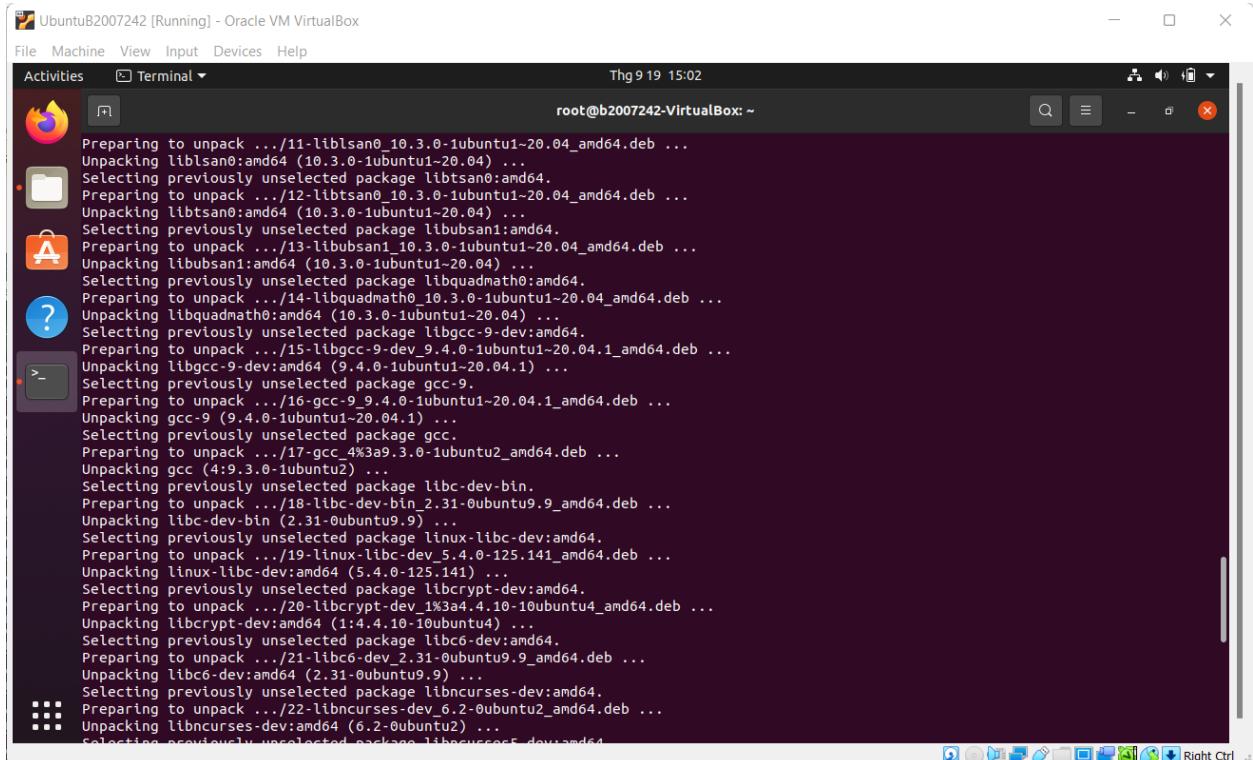
```

libbinutils:amd64 (2.34-6ubuntu1.3) ...
Setting up libbinutils:amd64 (2.34-6ubuntu1.3) ...
libctf0:amd64 (2.34-6ubuntu1.3) ...
Setting up libctf0:amd64 (2.34-6ubuntu1.3) ...
libctf-nobfd0:amd64 (2.34-6ubuntu1.3) ...
Setting up libctf-nobfd0:amd64 (2.34-6ubuntu1.3) ...
libitm1:amd64 (2.34-6ubuntu1.3) ...
Setting up libitm1:amd64 (2.34-6ubuntu1.3) ...
liblsan0:amd64 (2.34-6ubuntu1.3) ...
Setting up liblsan0:amd64 (2.34-6ubuntu1.3) ...
libncurses-dev:amd64 (2.34-6ubuntu1.3) ...
Setting up libncurses-dev:amd64 (2.34-6ubuntu1.3) ...
libquadmath0:amd64 (2.34-6ubuntu1.3) ...
Setting up libquadmath0:amd64 (2.34-6ubuntu1.3) ...
libtsan0:amd64 (2.34-6ubuntu1.3) ...
Setting up libtsan0:amd64 (2.34-6ubuntu1.3) ...
libubsan1:amd64 (2.34-6ubuntu1.3) ...
Setting up libubsan1:amd64 (2.34-6ubuntu1.3) ...
make:amd64 (4.2.1-1.2) ...
Setting up make:amd64 (4.2.1-1.2) ...
manpages-dev:all (5.05-1) ...
Setting up manpages-dev:all (5.05-1) ...

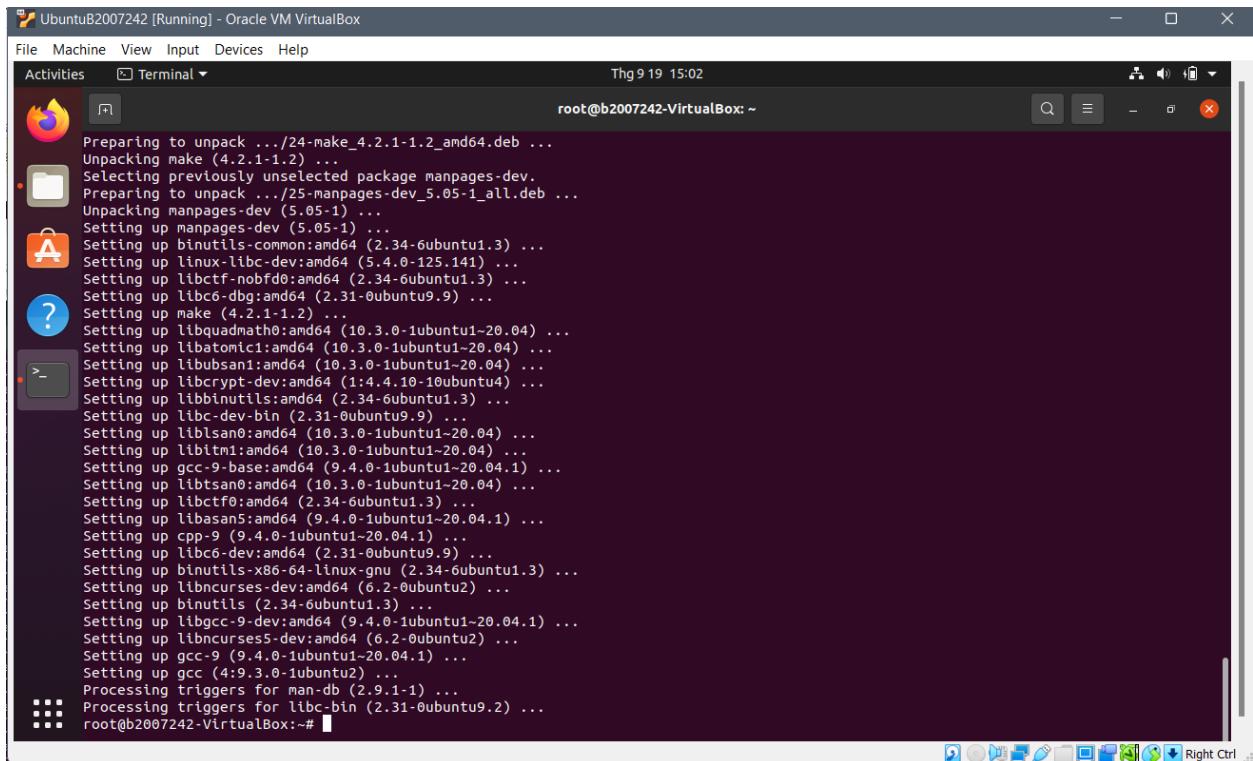
```



```
(Reading database ... 156348 files and directories currently installed.)  
Preparing to unpack .../00-binutils-common_2.34-6ubuntu1.3_amd64.deb ...  
Unpacking binutils-common:amd64 (2.34-6ubuntu1.3) ...  
Selecting previously unselected package libbinutils:amd64.  
Preparing to unpack .../01-libbinutils_2.34-6ubuntu1.3_amd64.deb ...  
Unpacking libbinutils:amd64 (2.34-6ubuntu1.3) ...  
Selecting previously unselected package libctf-nobfd0:amd64.  
Preparing to unpack .../02-libctf-nobfd0_2.34-6ubuntu1.3_amd64.deb ...  
Unpacking libctf-nobfd0:amd64 (2.34-6ubuntu1.3) ...  
Selecting previously unselected package libctf0:amd64.  
Preparing to unpack .../03-libctf0_2.34-6ubuntu1.3_amd64.deb ...  
Unpacking libctf0:amd64 (2.34-6ubuntu1.3) ...  
Selecting previously unselected package libbinutils-x86-64-linux-gnu.  
Preparing to unpack .../04-binutils-x86-64-linux-gnu_2.34-6ubuntu1.3_amd64.deb ...  
Unpacking binutils-x86-64-linux-gnu (2.34-6ubuntu1.3) ...  
Selecting previously unselected package binutils.  
Preparing to unpack .../05-binutils_2.34-6ubuntu1.3_amd64.deb ...  
Unpacking binutils (2.34-6ubuntu1.3) ...  
Preparing to unpack .../06-cpp-9_9.4.0-1ubuntu1~20.04.1_amd64.deb ...  
Unpacking cpp-9 (9.4.0-1ubuntu1~20.04.1) over (9.3.0-17ubuntu1~20.04) ...  
Preparing to unpack .../07-gcc-9-base_9.4.0-1ubuntu1~20.04.1_amd64.deb ...  
Unpacking gcc-9-base:amd64 (9.4.0-1ubuntu1~20.04.1) over (9.3.0-17ubuntu1~20.04) ...  
Selecting previously unselected package libitm1:amd64.  
Preparing to unpack .../08-libitm1_10.3.0-1ubuntu1~20.04_amd64.deb ...  
Unpacking libitm1:amd64 (10.3.0-1ubuntu1~20.04) ...  
Selecting previously unselected package libatomici:amd64.  
Preparing to unpack .../09-libatomici_10.3.0-1ubuntu1~20.04_amd64.deb ...  
Unpacking libatomici:amd64 (10.3.0-1ubuntu1~20.04) ...  
Selecting previously unselected package libasan5:amd64.  
Preparing to unpack .../10-libasan5_9.4.0-1ubuntu1~20.04.1_amd64.deb ...  
Unpacking libasan5:amd64 (9.4.0-1ubuntu1~20.04.1) ...  
Selecting previously unselected package liblsan0:amd64.  
Preparing to unpack .../11-liblsan0_10.3.0-1ubuntu1~20.04_amd64.deb ...  
Unpacking liblsan0:amd64 (10.3.0-1ubuntu1~20.04) ...  
Selecting previously unselected package libtsan0:amd64.  
Preparing to unpack .../12-libtsan0_10.3.0-1ubuntu1~20.04_amd64.deb ...  
Unpacking libtsan0:amd64 (10.3.0-1ubuntu1~20.04) ...  
Selecting previously unselected package libubsan1:amd64.  
Preparing to unpack .../13-libubsan1_10.3.0-1ubuntu1~20.04_amd64.deb ...  
Unpacking libubsan1:amd64 (10.3.0-1ubuntu1~20.04) ...  
Selecting previously unselected package libquadmath0:amd64.  
Preparing to unpack .../14-libquadmath0_10.3.0-1ubuntu1~20.04_amd64.deb ...  
Unpacking libquadmath0:amd64 (10.3.0-1ubuntu1~20.04) ...  
Selecting previously unselected package libgcc-9-dev:amd64.  
Preparing to unpack .../15-libgcc-9-dev_9.4.0-1ubuntu1~20.04.1_amd64.deb ...  
Unpacking libgcc-9-dev:amd64 (9.4.0-1ubuntu1~20.04.1) ...  
Selecting previously unselected package gcc-9.  
Preparing to unpack .../16-gcc-9_9.4.0-1ubuntu1~20.04.1_amd64.deb ...  
Unpacking gcc-9 (9.4.0-1ubuntu1~20.04.1) ...  
Selecting previously unselected package gcc.  
Preparing to unpack .../17-gcc_4%3a9.3.0-1ubuntu2_amd64.deb ...  
Unpacking gcc (4:9.3.0-1ubuntu2) ...  
Selecting previously unselected package libc-dev-bin.  
Preparing to unpack .../18-libc-dev-bin_2.31-0ubuntu9.9_amd64.deb ...  
Unpacking libc-dev-bin (2.31-0ubuntu9.9) ...  
Selecting previously unselected package linux-libc-dev:amd64.  
Preparing to unpack .../19-linux-libc-dev_5.4.0-125.141_amd64.deb ...  
Unpacking linux-libc-dev:amd64 (5.4.0-125.141) ...  
Selecting previously unselected package libcrypt-dev:amd64.  
Preparing to unpack .../20-libcrypt-dev_1%3a4.4.10-10ubuntu4_amd64.deb ...  
Unpacking libcrypt-dev:amd64 (1:4.4.10-10ubuntu4) ...  
Selecting previously unselected package libc6-dev:amd64.  
Preparing to unpack .../21-libc6-dev_2.31-0ubuntu9.9_amd64.deb ...  
Unpacking libc6-dev:amd64 (2.31-0ubuntu9.9) ...  
Selecting previously unselected package libncurses-dev:amd64.  
Preparing to unpack .../22-libncurses-dev_6.2-0ubuntu2_amd64.deb ...  
Unpacking libncurses-dev:amd64 (6.2-0ubuntu2) ...  
Selecting previously unselected package libncurses5-dev:amd64.
```



```
Preparing to unpack .../11-liblsan0_10.3.0-1ubuntu1~20.04_amd64.deb ...  
Unpacking liblsan0:amd64 (10.3.0-1ubuntu1~20.04) ...  
Selecting previously unselected package libtsan0:amd64.  
Preparing to unpack .../12-libtsan0_10.3.0-1ubuntu1~20.04_amd64.deb ...  
Unpacking libtsan0:amd64 (10.3.0-1ubuntu1~20.04) ...  
Selecting previously unselected package libubsan1:amd64.  
Preparing to unpack .../13-libubsan1_10.3.0-1ubuntu1~20.04_amd64.deb ...  
Unpacking libubsan1:amd64 (10.3.0-1ubuntu1~20.04) ...  
Selecting previously unselected package libquadmath0:amd64.  
Preparing to unpack .../14-libquadmath0_10.3.0-1ubuntu1~20.04_amd64.deb ...  
Unpacking libquadmath0:amd64 (10.3.0-1ubuntu1~20.04) ...  
Selecting previously unselected package libgcc-9-dev:amd64.  
Preparing to unpack .../15-libgcc-9-dev_9.4.0-1ubuntu1~20.04.1_amd64.deb ...  
Unpacking libgcc-9-dev:amd64 (9.4.0-1ubuntu1~20.04.1) ...  
Selecting previously unselected package gcc-9.  
Preparing to unpack .../16-gcc-9_9.4.0-1ubuntu1~20.04.1_amd64.deb ...  
Unpacking gcc-9 (9.4.0-1ubuntu1~20.04.1) ...  
Selecting previously unselected package gcc.  
Preparing to unpack .../17-gcc_4%3a9.3.0-1ubuntu2_amd64.deb ...  
Unpacking gcc (4:9.3.0-1ubuntu2) ...  
Selecting previously unselected package libc-dev-bin.  
Preparing to unpack .../18-libc-dev-bin_2.31-0ubuntu9.9_amd64.deb ...  
Unpacking libc-dev-bin (2.31-0ubuntu9.9) ...  
Selecting previously unselected package linux-libc-dev:amd64.  
Preparing to unpack .../19-linux-libc-dev_5.4.0-125.141_amd64.deb ...  
Unpacking linux-libc-dev:amd64 (5.4.0-125.141) ...  
Selecting previously unselected package libcrypt-dev:amd64.  
Preparing to unpack .../20-libcrypt-dev_1%3a4.4.10-10ubuntu4_amd64.deb ...  
Unpacking libcrypt-dev:amd64 (1:4.4.10-10ubuntu4) ...  
Selecting previously unselected package libc6-dev:amd64.  
Preparing to unpack .../21-libc6-dev_2.31-0ubuntu9.9_amd64.deb ...  
Unpacking libc6-dev:amd64 (2.31-0ubuntu9.9) ...  
Selecting previously unselected package libncurses-dev:amd64.  
Preparing to unpack .../22-libncurses-dev_6.2-0ubuntu2_amd64.deb ...  
Unpacking libncurses-dev:amd64 (6.2-0ubuntu2) ...  
Selecting previously unselected package libncurses5-dev:amd64.
```



UbuntuB2007242 [Running] - Oracle VM VirtualBox

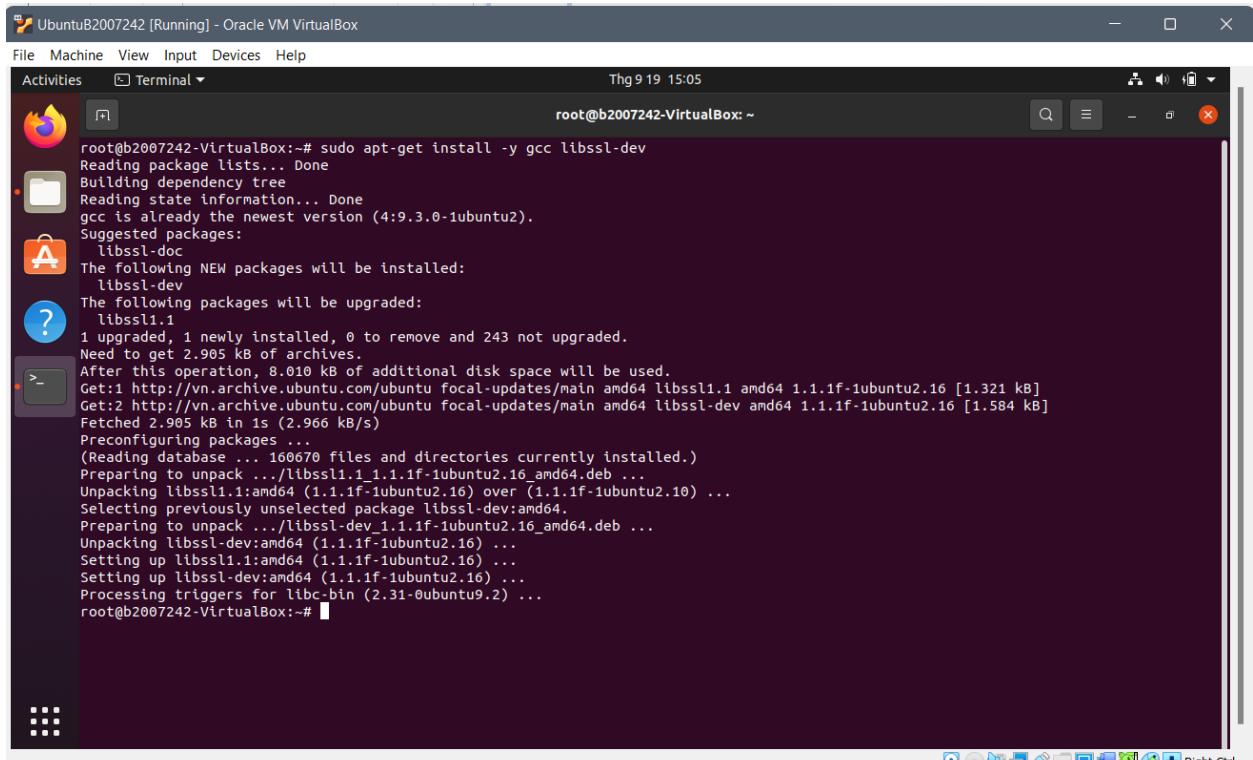
File Machine View Input Devices Help

Activities Terminal

root@b2007242-VirtualBox: ~

```
Preparing to unpack .../24-make_4.2.1-1.2_amd64.deb ...
Unpacking make (4.2.1-1.2) ...
Selecting previously unselected package manpages-dev.
Preparing to unpack .../25-manpages-dev_5.05-1_all.deb ...
Unpacking manpages-dev (5.05-1) ...
Setting up manpages-dev (5.05-1) ...
Setting up binutils-common:amd64 (2.34-6ubuntu1.3) ...
Setting up linux-libc-dev:amd64 (5.4.0-125.141) ...
Setting up libctf-nobfd0:amd64 (2.34-6ubuntu1.3) ...
Setting up libc6-dbg:amd64 (2.31-0ubuntu9.9) ...
Setting up make (4.2.1-1.2) ...
Setting up libquadmath0:amd64 (10.3.0-1ubuntu1-20.04) ...
Setting up libatomic1:amd64 (10.3.0-1ubuntu1-20.04) ...
Setting up libubsan1:amd64 (10.3.0-1ubuntu1-20.04) ...
Setting up libcrypt-dev:amd64 (1:4.4.10-10ubuntu4) ...
Setting up libbinutils:amd64 (2.34-6ubuntu1.3) ...
Setting up libc-dev-bin (2.31-0ubuntu9.9) ...
Setting up libasan0:amd64 (10.3.0-1ubuntu1-20.04) ...
Setting up libitm1:amd64 (10.3.0-1ubuntu1-20.04) ...
Setting up gcc-9-base:amd64 (9.4.0-1ubuntu1-20.04.1) ...
Setting up libtsan0:amd64 (10.3.0-1ubuntu1-20.04) ...
Setting up libctf0:amd64 (2.34-6ubuntu1.3) ...
Setting up libasan5:amd64 (9.4.0-1ubuntu1-20.04.1) ...
Setting up cpp-9 (9.4.0-1ubuntu1-20.04.1) ...
Setting up libc6-dev:amd64 (2.31-0ubuntu9.9) ...
Setting up binutils-x86-64-linux-gnu (2.34-6ubuntu1.3) ...
Setting up libncurses-dev:amd64 (6.2-0ubuntu2) ...
Setting up binutils (2.34-6ubuntu1.3) ...
Setting up libgcc-9-dev:amd64 (9.4.0-1ubuntu1-20.04.1) ...
Setting up libncurses5-dev:amd64 (6.2-0ubuntu2) ...
Setting up gcc-9 (9.4.0-1ubuntu1-20.04.1) ...
Setting up gcc (4:9.3.0-1ubuntu2) ...
Processing triggers for man-db (2.9.1-1) ...
Processing triggers for libc-bin (2.31-0ubuntu9.2) ...
root@b2007242-VirtualBox:~#
```

\$sudo apt-get install -y gcc libssl-dev



UbuntuB2007242 [Running] - Oracle VM VirtualBox

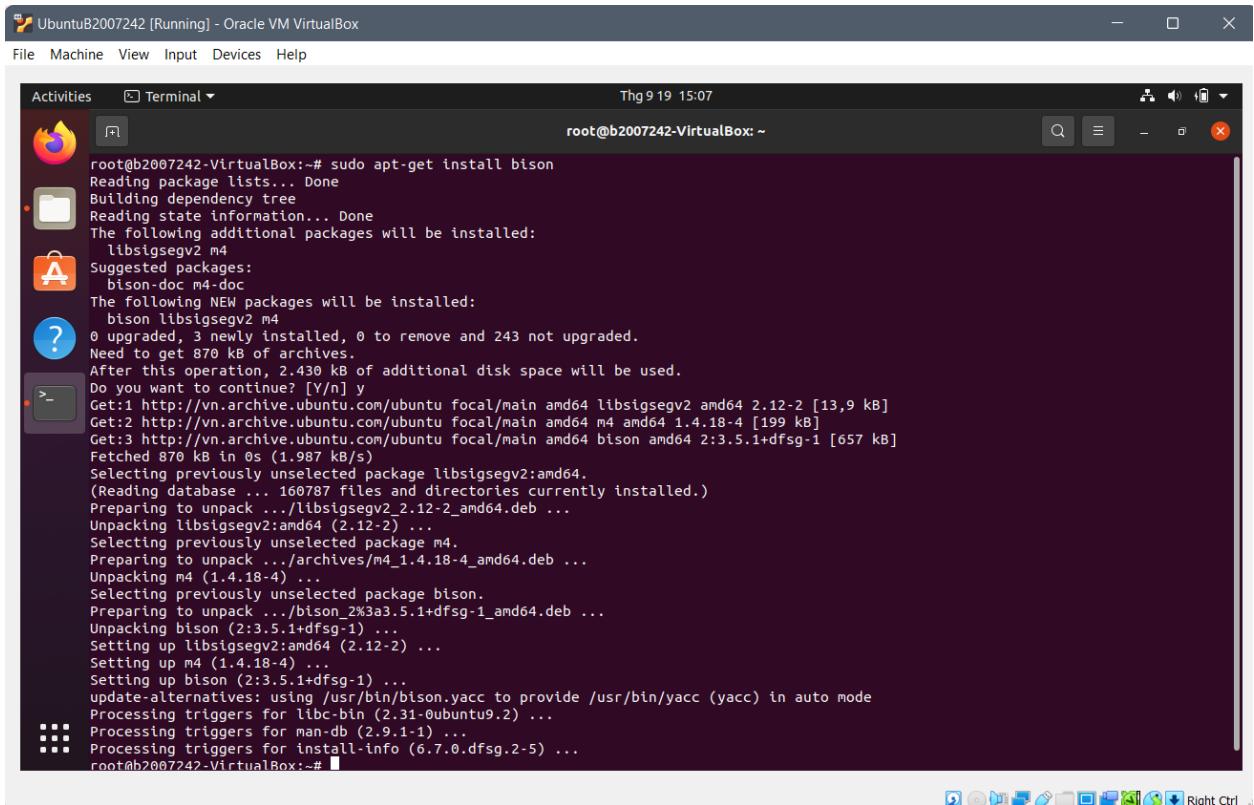
File Machine View Input Devices Help

Activities Terminal

root@b2007242-VirtualBox: ~

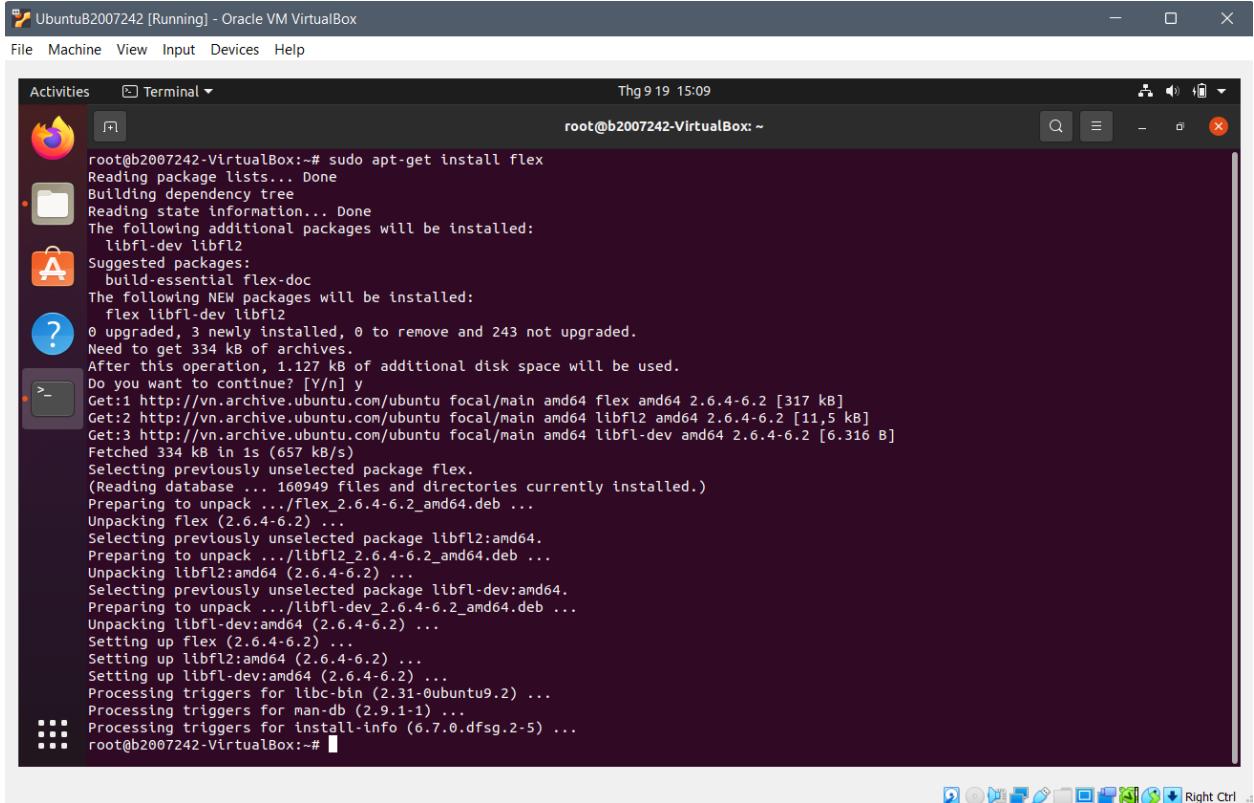
```
root@b2007242-VirtualBox:~# sudo apt-get install -y gcc libssl-dev
Reading package lists... Done
Building dependency tree
Reading state information... Done
gcc is already the newest version (4:9.3.0-1ubuntu2).
Suggested packages:
  libssl-doc
The following NEW packages will be installed:
  libssl-dev
The following packages will be upgraded:
  libssl1.1
1 upgraded, 1 newly installed, 0 to remove and 243 not upgraded.
Need to get 2.905 kB of archives.
After this operation, 8.010 kB of additional disk space will be used.
Get:1 http://vn.archive.ubuntu.com/ubuntu focal-updates/main amd64 libssl1.1 amd64 1.1.1f-1ubuntu2.16 [1.321 kB]
Get:2 http://vn.archive.ubuntu.com/ubuntu focal-updates/main amd64 libssl-dev amd64 1.1.1f-1ubuntu2.16 [1.584 kB]
Fetched 2.905 kB in 1s (2.966 kB/s)
Preconfiguring packages...
(Reading database ... 166670 files and directories currently installed.)
Preparing to unpack .../libssl1.1_1.1.1f-1ubuntu2.16_amd64.deb ...
Unpacking libssl1.1:amd64 (1.1.1f-1ubuntu2.16) over (1.1.1f-1ubuntu2.10) ...
Selecting previously unselected package libssl-dev:amd64.
Preparing to unpack .../libssl-dev_1.1.1f-1ubuntu2.16_amd64.deb ...
Unpacking libssl-dev:amd64 (1.1.1f-1ubuntu2.16) ...
Setting up libssl1.1:amd64 (1.1.1f-1ubuntu2.16) ...
Setting up libssl-dev:amd64 (1.1.1f-1ubuntu2.16) ...
Processing triggers for libc-bin (2.31-0ubuntu9.2) ...
root@b2007242-VirtualBox:~#
```

\$sudo apt-get install bison



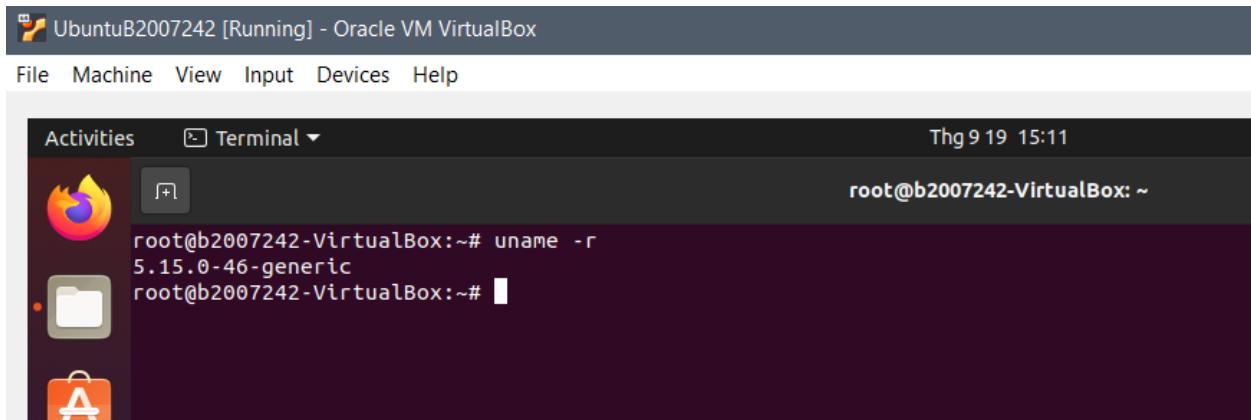
```
root@b2007242-VirtualBox:~# sudo apt-get install bison
Reading package lists... Done
Building dependency tree
Reading state information... Done
The following additional packages will be installed:
  libsigsegv2 m4
Suggested packages:
  bison-doc m4-doc
The following NEW packages will be installed:
  bison libsigsegv2 m4
0 upgraded, 3 newly installed, 0 to remove and 243 not upgraded.
Need to get 870 kB of archives.
After this operation, 2,430 kB of additional disk space will be used.
Do you want to continue? [Y/n] y
Get:1 http://vn.archive.ubuntu.com/ubuntu focal/main amd64 libsigsegv2 amd64 2.12-2 [13,9 kB]
Get:2 http://vn.archive.ubuntu.com/ubuntu focal/main amd64 m4 amd64 1.4.18-4 [199 kB]
Get:3 http://vn.archive.ubuntu.com/ubuntu focal/main amd64 bison amd64 2:3.5.1+dfsg-1 [657 kB]
Fetched 870 kB in 0s (1,987 kB/s)
Selecting previously unselected package libsigsegv2:amd64.
(Reading database ... 160787 files and directories currently installed.)
Preparing to unpack .../libsigsegv2_2.12-2_amd64.deb ...
Unpacking libsigsegv2:amd64 (2.12-2) ...
Selecting previously unselected package m4.
Preparing to unpack .../archives/m4_1.4.18-4_amd64.deb ...
Unpacking m4 (1.4.18-4) ...
Selecting previously unselected package bison.
Preparing to unpack .../bison_2:3.5.1+dfsg-1_amd64.deb ...
Unpacking bison (2:3.5.1+dfsg-1) ...
Setting up libsigsegv2:amd64 (2.12-2) ...
Setting up m4 (1.4.18-4) ...
Setting up bison (2:3.5.1+dfsg-1) ...
update-alternatives: using /usr/bin/bison.yacc to provide /usr/bin/yacc (yacc) in auto mode
Processing triggers for libc-bin (2.31-0ubuntu9.2) ...
Processing triggers for man-db (2.9.1-1) ...
Processing triggers for install-info (6.7.0.dfsg.2-5) ...
root@b2007242-VirtualBox:~#
```

\$sudo apt-get install flex



```
root@b2007242-VirtualBox:~# sudo apt-get install flex
Reading package lists... Done
Building dependency tree
Reading state information... Done
The following additional packages will be installed:
  libfl-dev libfl2
Suggested packages:
  build-essential flex-doc
The following NEW packages will be installed:
  flex libfl-dev libfl2
0 upgraded, 3 newly installed, 0 to remove and 243 not upgraded.
Need to get 334 kB of archives.
After this operation, 1,127 kB of additional disk space will be used.
Do you want to continue? [Y/n] y
Get:1 http://vn.archive.ubuntu.com/ubuntu focal/main amd64 flex amd64 2.6.4-6.2 [317 kB]
Get:2 http://vn.archive.ubuntu.com/ubuntu focal/main amd64 libfl2 amd64 2.6.4-6.2 [11,5 kB]
Get:3 http://vn.archive.ubuntu.com/ubuntu focal/main amd64 libfl-dev amd64 2.6.4-6.2 [6,316 B]
Fetched 334 kB in 1s (657 kB/s)
Selecting previously unselected package flex.
(Reading database ... 160949 files and directories currently installed.)
Preparing to unpack .../flex_2.6.4-6.2_amd64.deb ...
Unpacking flex (2.6.4-6.2) ...
Selecting previously unselected package libfl2:amd64.
Preparing to unpack .../libfl2_2.6.4-6.2_amd64.deb ...
Unpacking libfl2:amd64 (2.6.4-6.2) ...
Selecting previously unselected package libfl-dev:amd64.
Preparing to unpack .../libfl-dev_2.6.4-6.2_amd64.deb ...
Unpacking libfl-dev:amd64 (2.6.4-6.2) ...
Setting up flex (2.6.4-6.2) ...
Setting up libfl2:amd64 (2.6.4-6.2) ...
Setting up libfl-dev:amd64 (2.6.4-6.2) ...
Processing triggers for libc-bin (2.31-0ubuntu9.2) ...
Processing triggers for man-db (2.9.1-1) ...
Processing triggers for install-info (6.7.0.dfsg.2-5) ...
root@b2007242-VirtualBox:~#
```

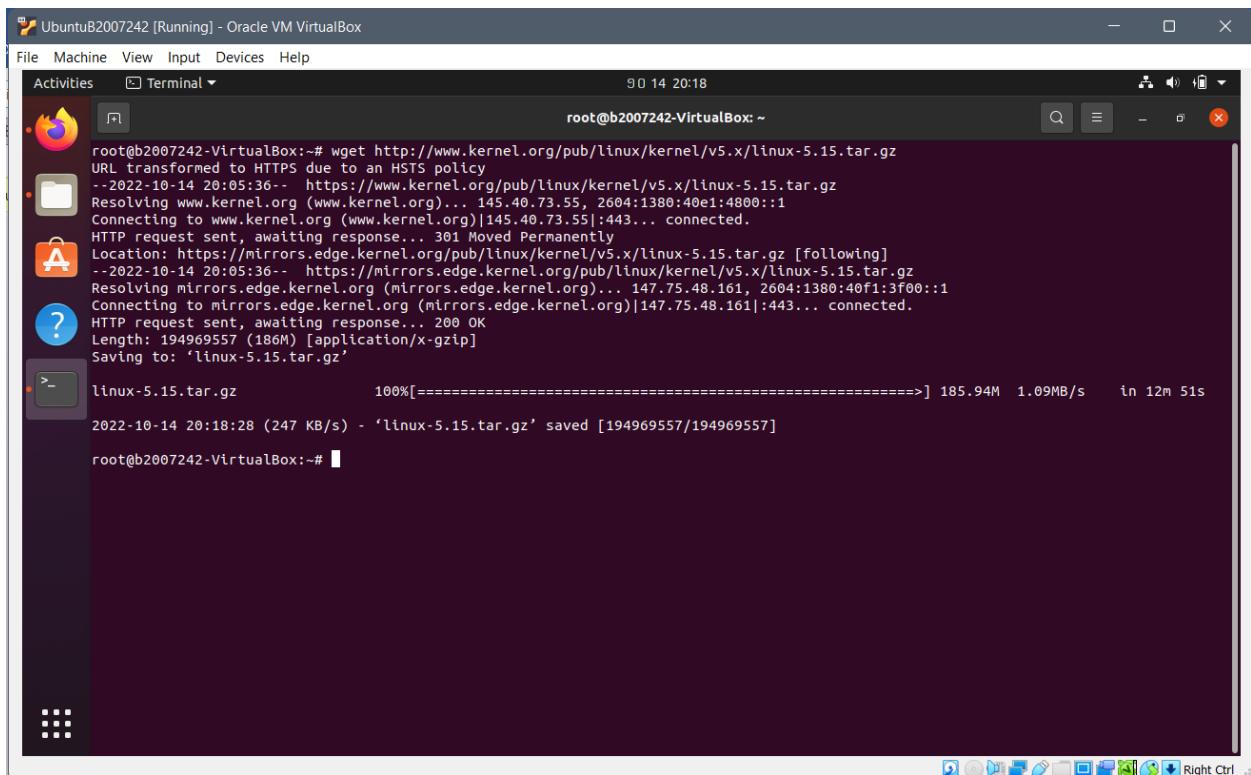
2. Xác định phiên bản hiện tại của kernel



3. Download source code của kernel

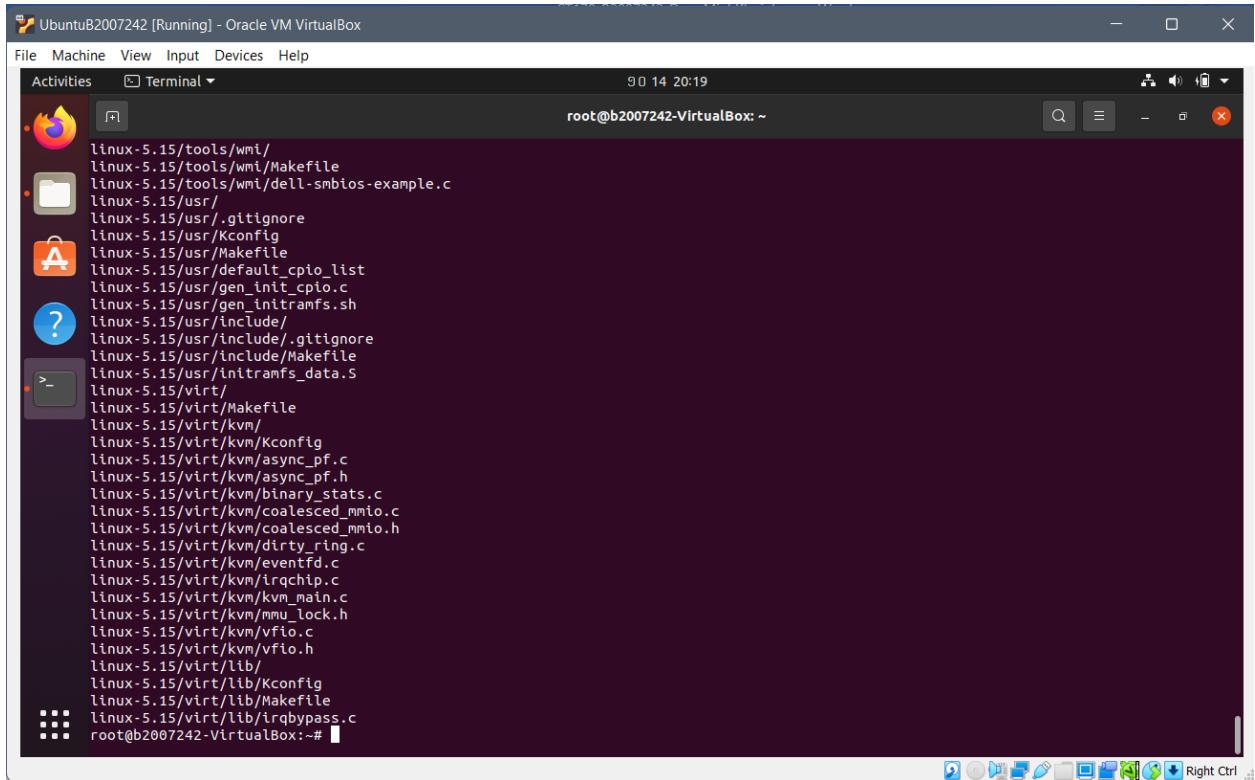
- Download source code của kernel hiện tại:

wget <http://www.kernel.org/pub/linux/kernel/v5.x/linux-5.15.tar.gz> :



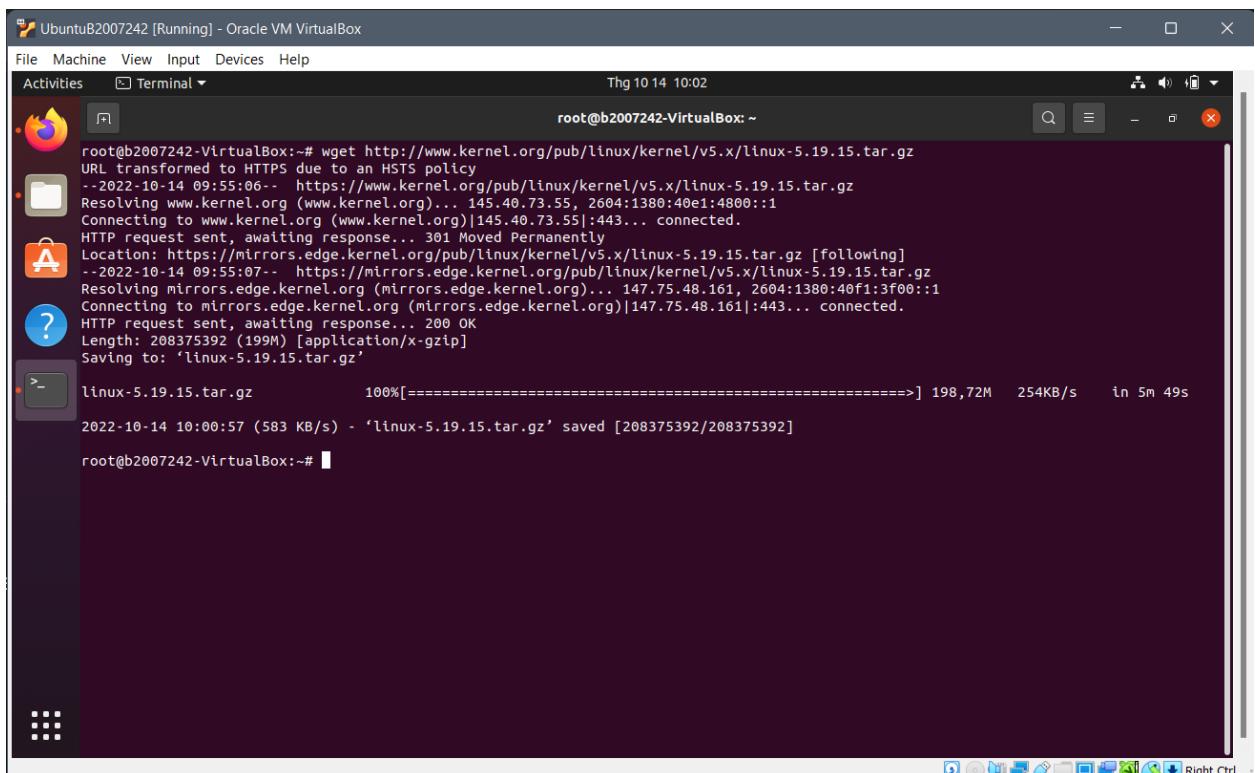
- Giải nén kernel hiện tại:

tar xvzf linux-5.15.tar.gz



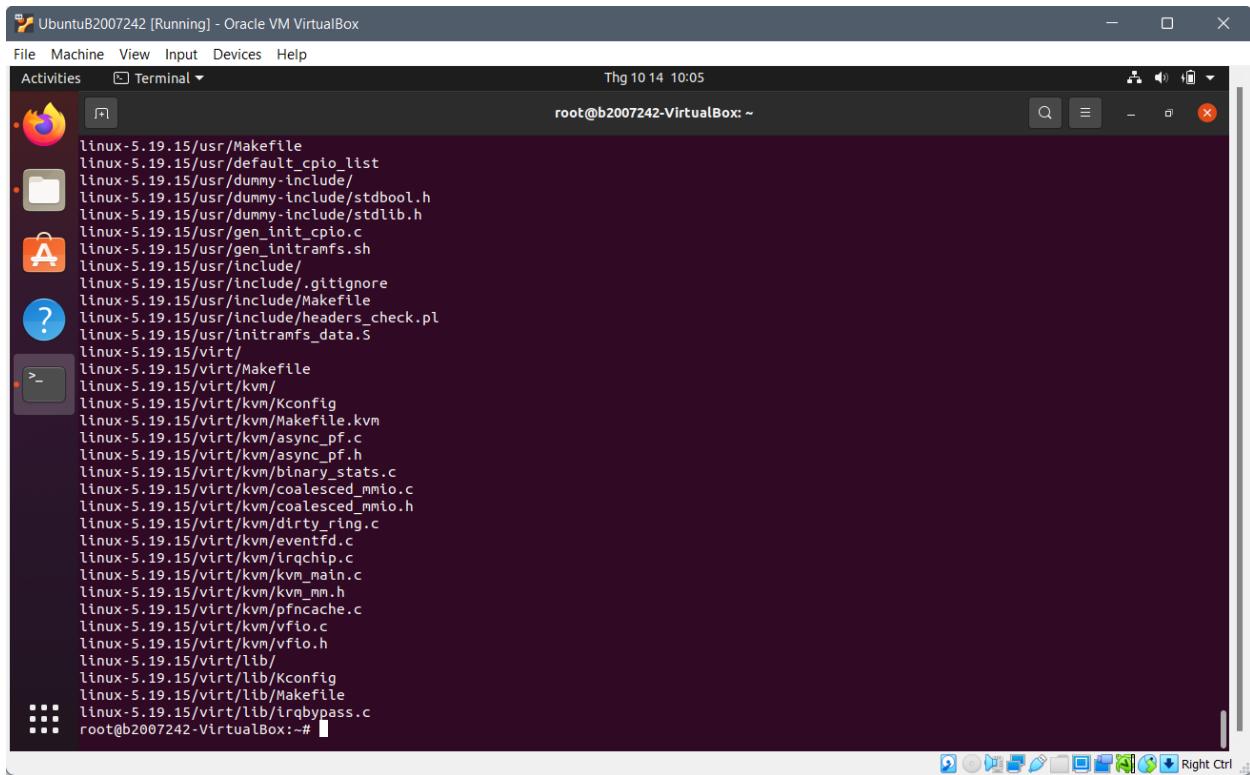
- Download source code của kernel mới:

wget <http://www.kernel.org/pub/linux/kernel/v5.x/linux-5.19.15.tar.gz> :



- Giải nén kernel 5.19.15:

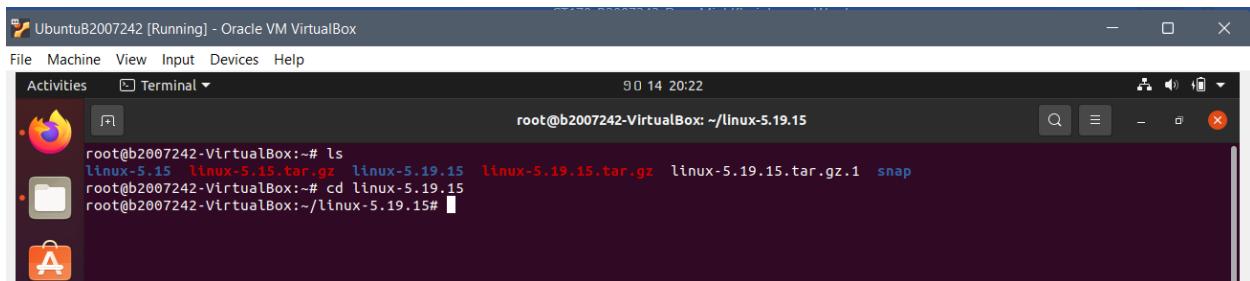
```
# tar xvzf linux-5.19.15.tar.gz
```



```
UbuntuB2007242 [Running] - Oracle VM VirtualBox
File Machine View Input Devices Help
Activities Terminal Thg 10 14 10:05
root@b2007242-VirtualBox: ~
linux-5.19.15/usr/Makefile
linux-5.19.15/usr/default_cpio_list
linux-5.19.15/usr/dummy-include/
linux-5.19.15/usr/dummy-include/stdbool.h
linux-5.19.15/usr/dummy-include/stdcblib.h
linux-5.19.15/usr/gen_init_cpio.c
linux-5.19.15/usr/gen_intramfs.sh
linux-5.19.15/usr/include/
linux-5.19.15/usr/include/.gitignore
linux-5.19.15/usr/include/Makefile
linux-5.19.15/usr/include/headers_check.pl
linux-5.19.15/usr/intramfs_data.S
linux-5.19.15/virt/
linux-5.19.15/virt/Makefile
linux-5.19.15/virt/kvm/
linux-5.19.15/virt/kvm/Kconfig
linux-5.19.15/virt/kvm/Makefile.kvm
linux-5.19.15/virt/kvm/async_pf.c
linux-5.19.15/virt/kvm/async_pf.h
linux-5.19.15/virt/kvm/binary_stats.c
linux-5.19.15/virt/kvm/coalesced_mmio.c
linux-5.19.15/virt/kvm/coalesced_mmio.h
linux-5.19.15/virt/kvm/dirty_ring.c
linux-5.19.15/virt/kvm/eventfd.c
linux-5.19.15/virt/kvm/irqchip.c
linux-5.19.15/virt/kvm/kvm_main.c
linux-5.19.15/virt/kvm/kvm_mm.h
linux-5.19.15/virt/kvm/pfnCache.c
linux-5.19.15/virt/kvm/vfio.c
linux-5.19.15/virt/kvm/vfio.h
linux-5.19.15/virt/lib/
linux-5.19.15/virt/lib/Kconfig
linux-5.19.15/virt/lib/Makefile
linux-5.19.15/virt/lib/lrqbypass.c
root@b2007242-VirtualBox:~#
```

B. CẤU HÌNH KERNEL MỚI

1. Đảm bảo đường dẫn hiện tại ở `~/linux-5.19.15` và “`linux-5.19.15`” ở top directory của kernel source.

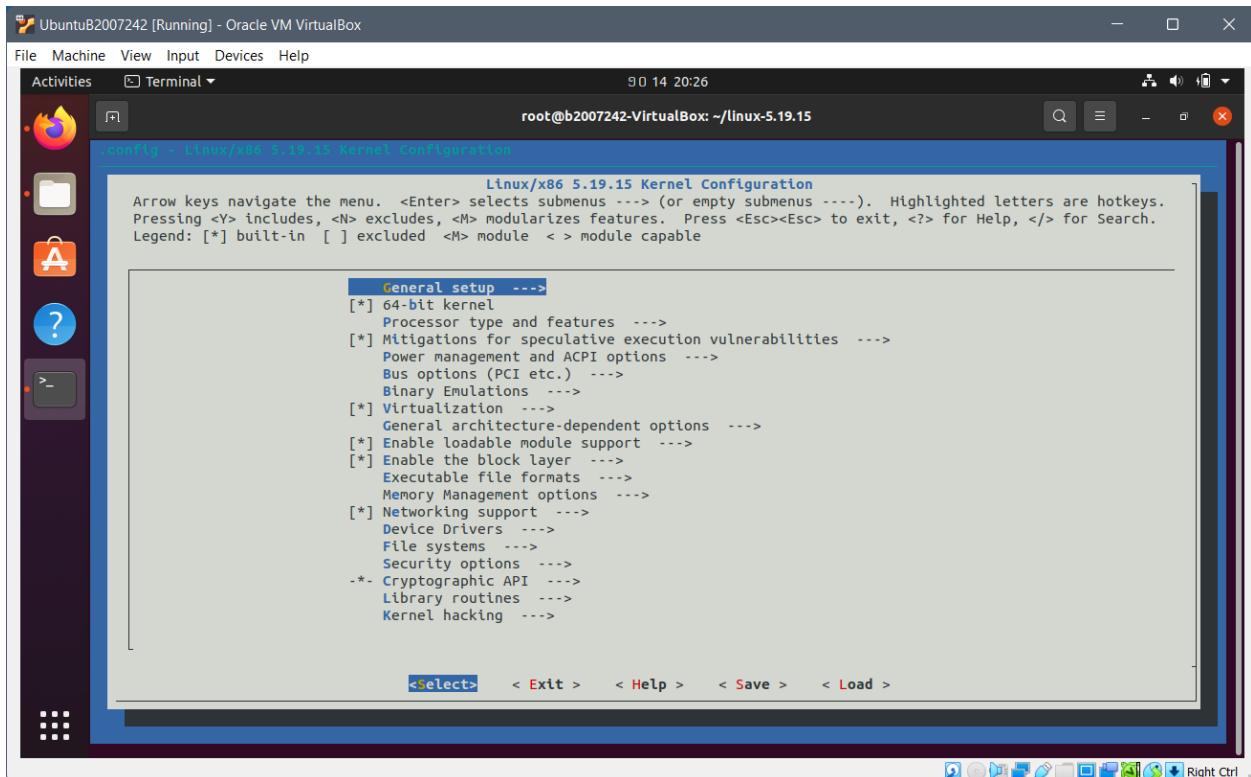


```
UbuntuB2007242 [Running] - Oracle VM VirtualBox
File Machine View Input Devices Help
Activities Terminal 9 0 14 20:22
root@b2007242-VirtualBox: ~/linux-5.19.15
root@b2007242-VirtualBox:~# ls
linux-5.15  linux-5.15.tar.gz  linux-5.19.15  linux-5.19.15.tar.gz  linux-5.19.15.tar.gz.1  snap
root@b2007242-VirtualBox:~# cd linux-5.19.15
root@b2007242-VirtualBox:~/linux-5.19.15#
```

2. Tạo file cấu hình (config file)

```
# make menuconfig
```

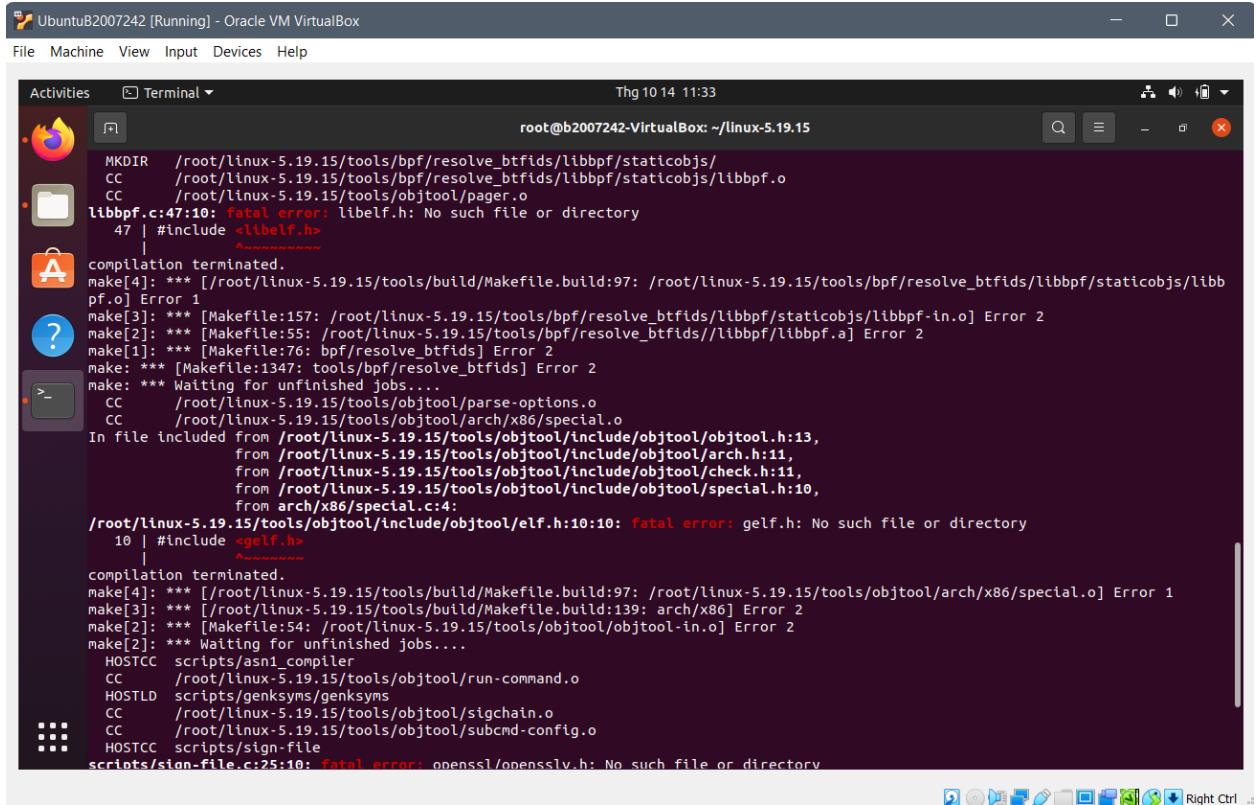
```
root@b2007242-VirtualBox: ~/linux-5.19.15# make menuconfig
HOSTCC scripts/basic/fixdep
HOSTCC scripts/kconfig/mconf-cfg
HOSTCC scripts/kconfig/mconf.o
HOSTCC scripts/kconfig/lxdialog/checklist.o
HOSTCC scripts/kconfig/lxdialog/inputbox.o
HOSTCC scripts/kconfig/lxdialog/menubox.o
HOSTCC scripts/kconfig/lxdialog/textbox.o
HOSTCC scripts/kconfig/lxdialog/util.o
HOSTCC scripts/kconfig/lxdialog/yesno.o
HOSTCC scripts/kconfig/confdata.o
HOSTCC scripts/kconfig/expr.o
LEX scripts/kconfig/lexer.lex.c
YACC scripts/kconfig/parser.tab.[ch]
HOSTCC scripts/kconfig/lexer.lex.o
HOSTCC scripts/kconfig/menu.o
HOSTCC scripts/kconfig/parser.tab.o
HOSTCC scripts/kconfig/preprocess.o
HOSTCC scripts/kconfig/symbol.o
HOSTCC scripts/kconfig/util.o
HOSTLD scripts/kconfig/mconf
#
# using defaults found in /boot/config-5.15.0-50-generic
#
.config:434:warning: symbol value 'm' invalid for I8K
.config:1997:warning: symbol value 'm' invalid for MCTP
.config:8857:warning: symbol value 'm' invalid for VIDEO_ZORAN_DC30
.config:8858:warning: symbol value 'm' invalid for VIDEO_ZORAN_ZR36060
.config:8859:warning: symbol value 'm' invalid for VIDEO_ZORAN_BUZ
.config:8860:warning: symbol value 'm' invalid for VIDEO_ZORAN_DC10
.config:8861:warning: symbol value 'm' invalid for VIDEO_ZORAN_LML33
.config:8862:warning: symbol value 'm' invalid for VIDEO_ZORAN_LML33R10
.config:8863:warning: symbol value 'm' invalid for VIDEO_ZORAN_AV36EYES
.config:9954:warning: symbol value 'm' invalid for ANDROID_BINDER_IPC
.config:9955:warning: symbol value 'm' invalid for ANDROID_BINDERFS
.config:10712:warning: symbol value 'm' invalid for CRYPTO_BLAKE2S_X86
```



C. BIÊN DỊCH KERNEL

1. Tại ~/linux-5.15.19, tạo kernel image nén (compressed kernel image)

make -j4



```
UbuntuB2007242 [Running] - Oracle VM VirtualBox
File Machine View Input Devices Help
Activities Terminal Thg 10 14 11:33
root@b2007242-VirtualBox:~/linux-5.19.15
MKDIR /root/linux-5.19.15/tools/bpf/resolve_btfids/libbpf/staticobjs/
CC /root/linux-5.19.15/tools/bpf/resolve_btfids/libbpf/staticobjs/libbpf.o
CC /root/linux-5.19.15/tools/objtool/pager.o
libbpf.c:47:10: fatal error: libelf.h: No such file or directory
47 | #include <libelf.h>
| ^~~~~~
compilation terminated.
make[4]: *** [/root/linux-5.19.15/tools/build/Makefile.build:97: /root/linux-5.19.15/tools/bpf/resolve_btfids/libbpf/staticobjs/libbpf.o] Error 1
make[3]: *** [Makefile:157: /root/linux-5.19.15/tools/bpf/resolve_btfids/libbpf/staticobjs/libbpf-in.o] Error 2
make[2]: *** [Makefile:55: /root/linux-5.19.15/tools/bpf/resolve_btfids//libbpf/libbpf.a] Error 2
make[1]: *** [Makefile:76: bpf/resolve_btfids] Error 2
make: *** [Makefile:1347: tools/bpf/resolve_btfids] Error 2
make: *** Waiting for unfinished jobs...
CC /root/linux-5.19.15/tools/objtool/parse-options.o
CC /root/linux-5.19.15/tools/objtool/arch/x86/special.o
In file included from /root/linux-5.19.15/tools/objtool/include/objtool/objtool.h:13,
                 from /root/linux-5.19.15/tools/objtool/include/objtool/arch.h:11,
                 from /root/linux-5.19.15/tools/objtool/include/objtool/check.h:11,
                 from /root/linux-5.19.15/tools/objtool/include/objtool/special.h:10,
                 from arch/x86/special.c:4:
/root/linux-5.19.15/tools/objtool/include/objtool/elf.h:10:10: fatal error: gelf.h: No such file or directory
10 | #include <gelf.h>
| ^~~~~~
compilation terminated.
make[4]: *** [/root/linux-5.19.15/tools/build/Makefile.build:97: /root/linux-5.19.15/tools/objtool/arch/x86/special.o] Error 1
make[3]: *** [Makefile:54: /root/linux-5.19.15/tools/objtool/objtool-in.o] Error 2
make[2]: *** [Makefile:54: /root/linux-5.19.15/tools/objtool/objtool-in.o] Error 2
make[1]: *** Waiting for unfinished jobs...
HOSTCC scripts/asm1_compiler
CC /root/linux-5.19.15/tools/objtool/run-command.o
HOSTLD scripts/genksyms/genksyms
CC /root/linux-5.19.15/tools/objtool/sigchain.o
CC /root/linux-5.19.15/tools/objtool/subcmd-config.o
HOSTCC scripts/sign-file
scripts/sign-file.c:25:10: fatal error: openssl/opensslv.h: No such file or directory
```

=> Lỗi không tìm thấy thư viện **gelf.h** và **libelf.h**

*sửa lỗi: chạy câu lệnh ***sudo apt-get install libelf-dev***

```
root@b2007242-VirtualBox:~/linux-5.19.15# apt-get install libelf-dev
Reading package lists... Done
Building dependency tree
Reading state information... Done
The following additional packages will be installed:
  zlib1g zlib1g-dev
The following NEW packages will be installed:
  libelf-dev zlib1g-dev
The following packages will be upgraded:
  zlib1g
1 upgraded, 2 newly installed, 0 to remove and 93 not upgraded.
Need to get 266 kB of archives.
After this operation, 988 kB of additional disk space will be used.
Do you want to continue? [Y/n] y
Get:1 http://vn.archive.ubuntu.com/ubuntu focal-updates/main amd64 zlib1g amd64 1:1.2.11.dfsg-2ubuntu1.4 [53,9 kB]
Get:2 http://vn.archive.ubuntu.com/ubuntu focal-updates/main amd64 libelf-dev amd64 1:1.2.11.dfsg-2ubuntu1.4 [155 kB]
Get:3 http://vn.archive.ubuntu.com/ubuntu focal/main amd64 libelf-dev amd64 0.176-1.1build1 [57,0 kB]
Fetched 266 kB in 1s (393 kB/s)
(Reading database ... 161030 files and directories currently installed.)
Preparing to unpack .../zlib1g_1%3a1.2.11.dfsg-2ubuntu1.4_amd64.deb ...
Unpacking zlib1g:amd64 (1:1.2.11.dfsg-2ubuntu1.4) over (1:1.2.11.dfsg-2ubuntu1.3) ...
Setting up zlib1g:amd64 (1:1.2.11.dfsg-2ubuntu1.4) ...
Selecting previously unselected package libelf-dev:amd64.
(Reading database ... 161030 files and directories currently installed.)
Preparing to unpack .../zlib1g-dev_1%3a1.2.11.dfsg-2ubuntu1.4_amd64.deb ...
Unpacking zlib1g-dev:amd64 (1:1.2.11.dfsg-2ubuntu1.4) ...
Selecting previously unselected package libelf-dev:amd64.
Preparing to unpack .../libelf-dev_0.176-1.1build1_amd64.deb ...
Unpacking libelf-dev:amd64 (0.176-1.1build1) ...
Setting up libelf-dev:amd64 (0.176-1.1build1) ...
Processing triggers for man-db (2.9.1-1) ...
Processing triggers for libc-bin (2.31-0ubuntu9.7) ...
root@b2007242-VirtualBox:~/linux-5.19.15#
```

→ Chạy lại lệnh ***make -j4***:

```
root@b2007242-VirtualBox:~/linux-5.19.15# make -j4
Processing triggers for libc-bin (2.31-0ubuntu9.2) ...
root@b2007242-VirtualBox:~/linux-5.19.15# make -j4
  DESCEND objtool
  DESCEND bpf/resolve_btfids
  CC      scripts/mod/empty.o
HOSTCC  scripts/mod/mk_elfconfig
  CC      scripts/mod/devicetable-offsets.s
make[3]: Nothing to be done for 'install_headers'.
  CC      /root/linux-5.19.15/tools/bpf/resolve_btfids/libbpf/staticobjs/libbpf.o
  MKELF   scripts/mod/elfconfig.h
  CC      /root/linux-5.19.15/tools/bpf/resolve_btfids/libbpf/staticobjs/bpf.o
HOSTCC  scripts/mod/modpost.o
  CC      /root/linux-5.19.15/tools/objtool/arch/x86/special.o
  MKDIR   /root/linux-5.19.15/tools/objtool/arch/x86/lib/
  GEN     /root/linux-5.19.15/tools/objtool/arch/x86/lib/inat-tables.c
  CC      /root/linux-5.19.15/tools/objtool/arch/x86/decode.o
  CC      /root/linux-5.19.15/tools/bpf/resolve_btfids/libbpf/staticobjs/nlatr.o
  UPD    scripts/mod/devicetable-offsets.h
HOSTCC  scripts/mod/sumversion.o
  CC      /root/linux-5.19.15/tools/bpf/resolve_btfids/libbpf/staticobjs/btf.o
HOSTCC  scripts/mod/ffile2alias.o
  LD      /root/linux-5.19.15/tools/objtool/arch/x86/objtool-in.o
  CC      /root/linux-5.19.15/tools/objtool/weak.o
  CC      /root/linux-5.19.15/tools/objtool/check.o
HOSTLD  scripts/mod/modpost
  CC      kernel/bounds.s
  UPD    include/generated/timeconst.h
  UPD    include/generated/bounds.h
CALL    scripts/atomic/check-atomics.sh
  CC      arch/x86/kernel/asm-offsets.s
  CC      /root/linux-5.19.15/tools/bpf/resolve_btfids/libbpf/staticobjs/libbpf_errno.o
  CC      /root/linux-5.19.15/tools/bpf/resolve_btfids/libbpf/staticobjs/str_error.o
  CC      /root/linux-5.19.15/tools/bpf/resolve_btfids/libbpf/staticobjs/netlink.o
  UPD    include/generated/asm-offsets.h
CALL    scripts/checksyscalls.sh
  CC      /root/linux-5.19.15/tools/objtool/special.o
```

• • •

```

root@b2007242-VirtualBox:~/linux-5.19.15#
CC [M] arch/x86/kvm/i8254.o
AR arch/x86/built-in.a
CC [M] arch/x86/kvm/ioapic.o
CC [M] arch/x86/kvm/irq_comm.o
CC [M] arch/x86/kvm/cpuid.o
CC [M] arch/x86/kvm/pmu.o
CC [M] arch/x86/kvm/mtrr.o
CC [M] arch/x86/kvm/hyperv.o
CC [M] arch/x86/kvm/debugfs.o
CC [M] arch/x86/kvm/mmio/mmu.o
CC [M] arch/x86/kvm/mmio/page_track.o
CC [M] arch/x86/kvm/mmio/spte.o
CC [M] arch/x86/kvm/kvm_onhyperv.o
CC [M] arch/x86/kvm/mmio/tdp_iter.o
CC [M] arch/x86/kvm/mmio/tdp_mmio.o
CC [M] arch/x86/kvm/xen.o
CC [M] arch/x86/kvm/vmx/vmx.o
AS [M] arch/x86/kvm/vmx/vmenter.o
CC [M] arch/x86/kvm/vmx/pmu_intel.o
CC [M] arch/x86/kvm/vmx/vmcs12.o
CC [M] arch/x86/kvm/vmx/evmcs.o
CC [M] arch/x86/kvm/vmx/nested.o
CC [M] arch/x86/kvm/vmx/posted_intr.o
CC [M] arch/x86/kvm/vmx/sgx.o
CC [M] arch/x86/kvm/svm/svm.o
AS [M] arch/x86/kvm/svm/vmenter.o
CC [M] arch/x86/kvm/svm/pmu.o
CC [M] arch/x86/kvm/svm/nested.o
CC [M] arch/x86/kvm/svm/avic.o
CC [M] arch/x86/kvm/svm/sev.o
CC [M] arch/x86/kvm/svm_onhyperv.o
LD [M] arch/x86/kvm/kvm.o
LD [M] arch/x86/kvm/kvm-intel.o
LD [M] arch/x86/kvm/kvm-amd.o
root@b2007242-VirtualBox:~/linux-5.19.15#

```

2. Biên dịch kernel modules:

make modules

→ Bị lỗi:

```

root@b2007242-VirtualBox:~/linux-5.19.15# make modules
CALL scripts/checksyscalls.sh
CALL scripts/atomic/check-atomics.sh
DESCEND objtool
DESCEND bpf/resolve_btfids
CHK include/generated/compile.h
CHK kernel/kheaders_data.tar.xz
make[1]: *** No rule to make target 'debian/canonical-certs.pem', needed by 'certs/x509_certificate_list'. Stop.
make: *** [Makefile:1846: certs] Error 2
root@b2007242-VirtualBox:~/linux-5.19.15#

```

→ fix lỗi:

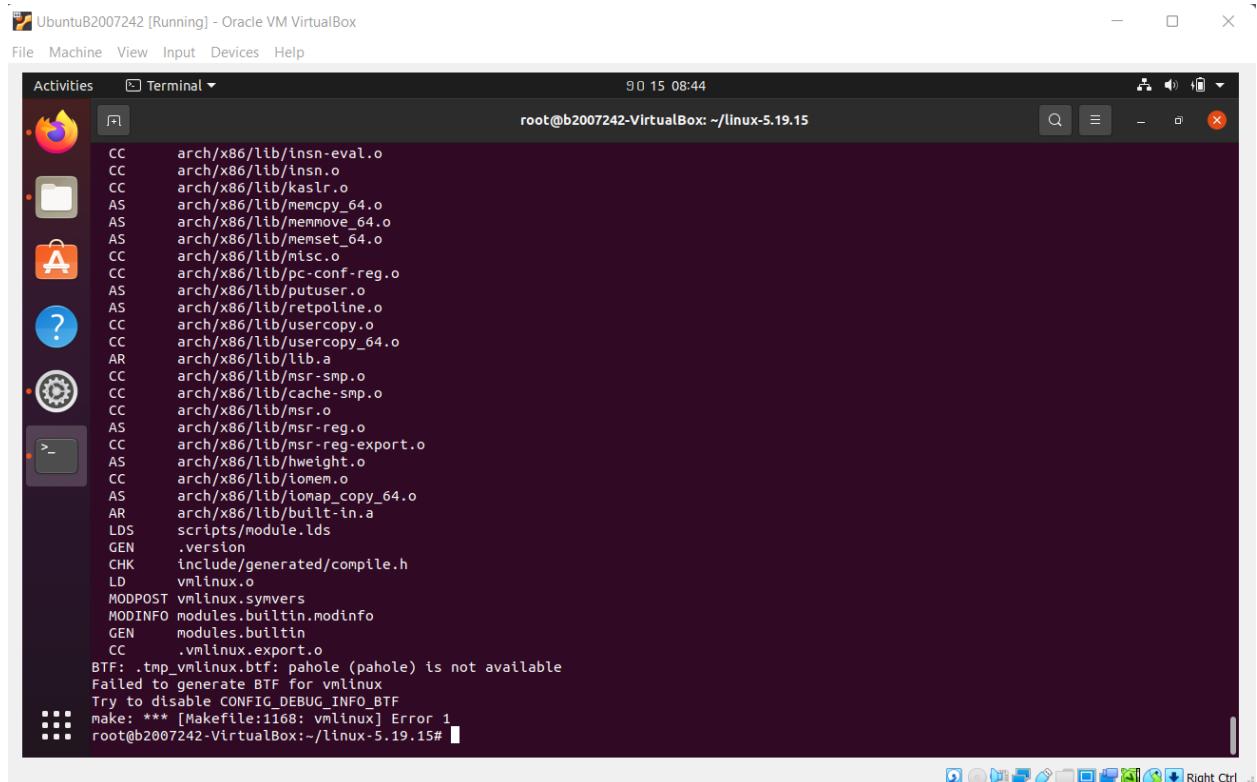
1. thực hiện câu lệnh: **nano .config**

2. sử dụng Ctrl + W: tìm tới dòng **debian/canonical-certs.pem**

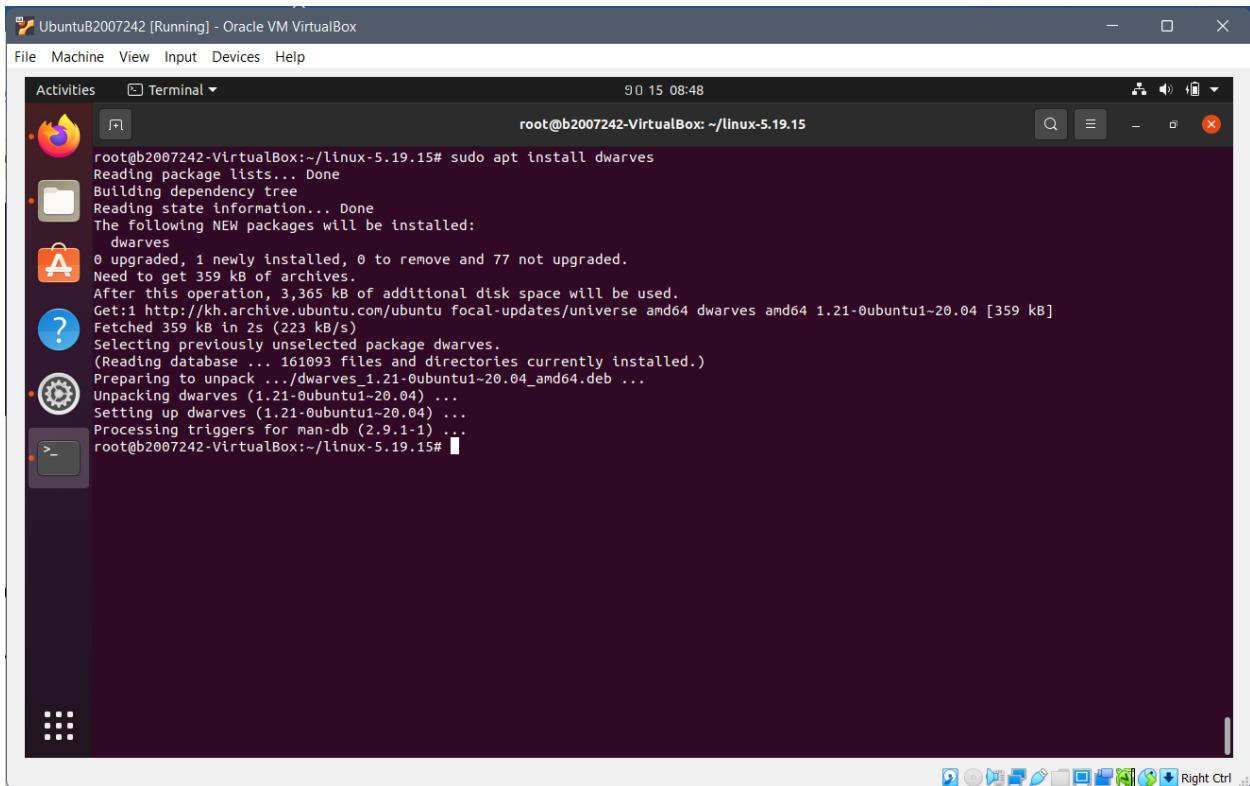
3. sau khi thực hiện thay đổi và lưu lại:

```
#  
# Certificates for signature checking  
#  
CONFIG_MODULE_SIG_KEY="certs/signing_key.pem"  
CONFIG_SYSTEM_TRUSTED_KEYRING=y  
CONFIG_SYSTEM_TRUSTED_KEYS=""  
CONFIG_SYSTEM_EXTRA_CERTIFICATE=y  
CONFIG_SYSTEM_EXTRA_CERTIFICATE_SIZE=4096  
CONFIG_SECONDARY_TRUSTED_KEYRING=y  
CONFIG_SYSTEM_BLACKLIST_KEYRING=y  
CONFIG_SYSTEM_BLACKLIST_HASH_LIST=""  
CONFIG_SYSTEM_REVOCATION_LIST=y  
CONFIG_SYSTEM_REVOCATION_KEYS=""  
# end of Certificates for signature checking
```

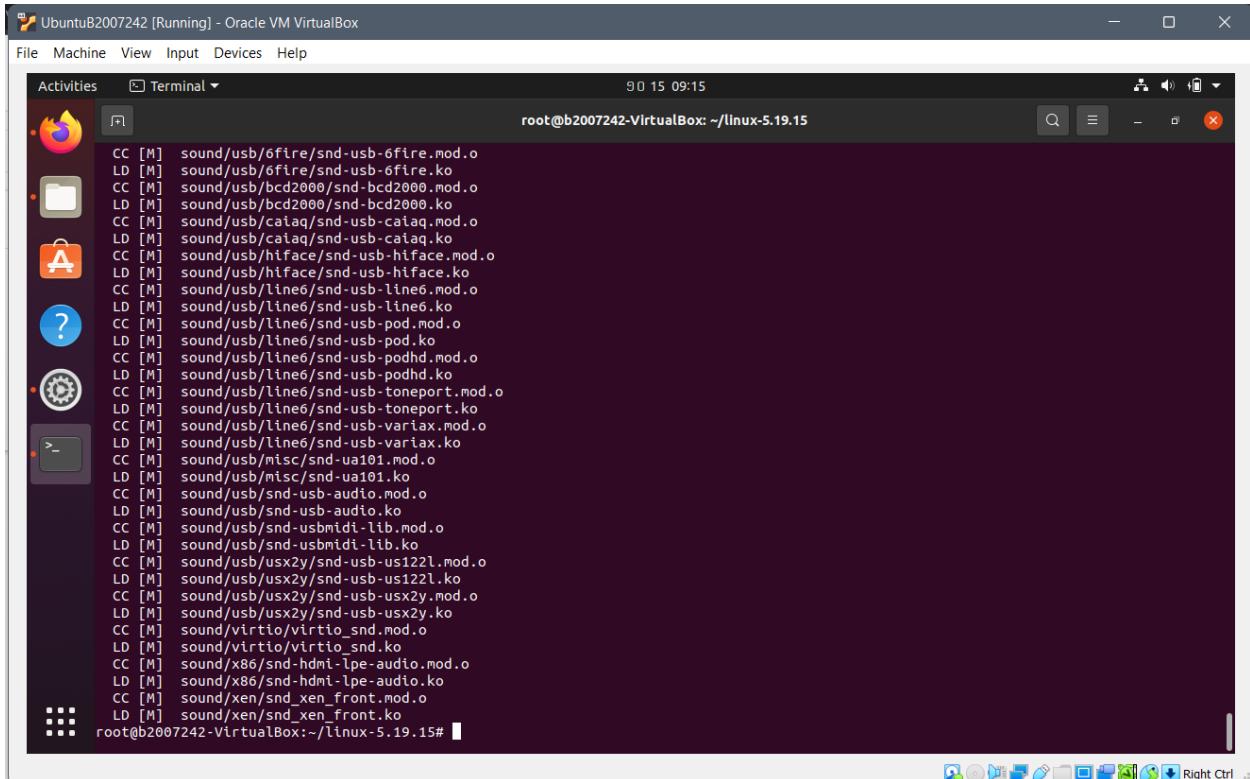
→ Chạy lại: bị lỗi (lần chạy này mất khoảng 3 tiếng)



→ Sửa lỗi : chạy lệnh **sudo apt install dwarves**



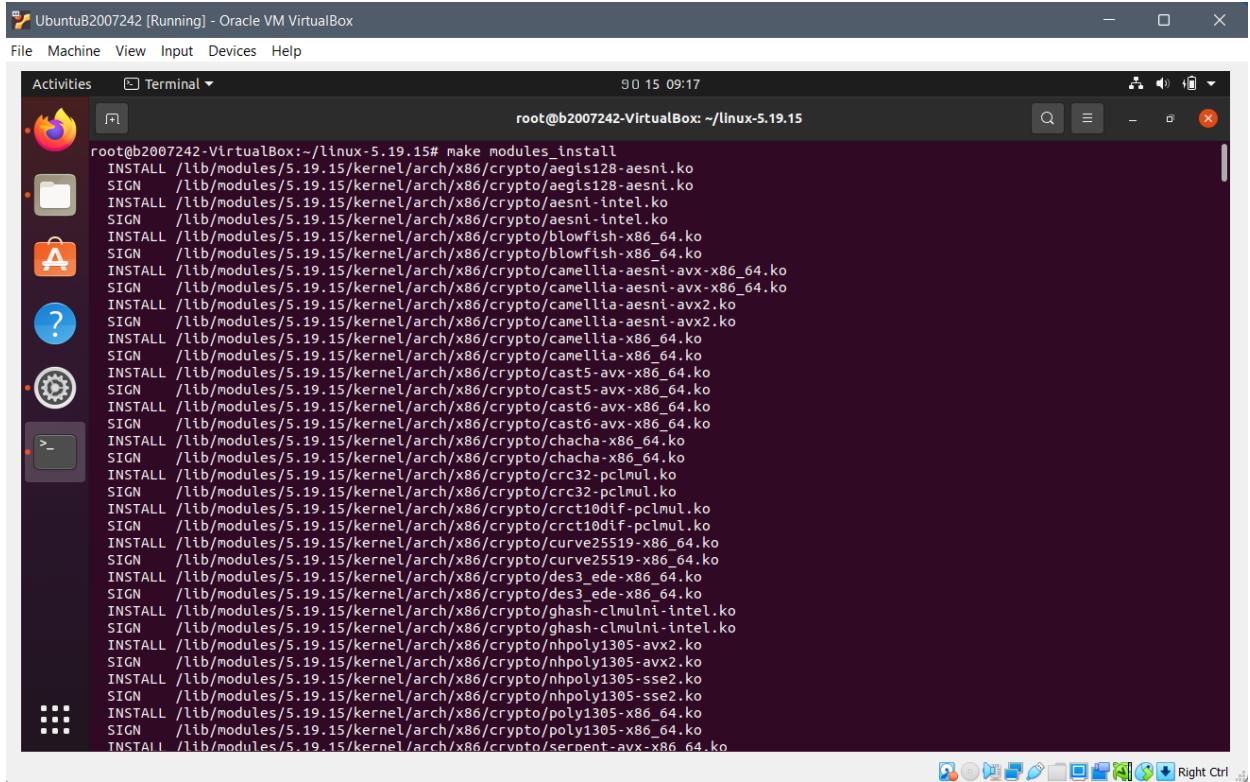
→ chạy lại : Thành công



D. CÀI ĐẶT KERNEL

1. Cài đặt kernel modules

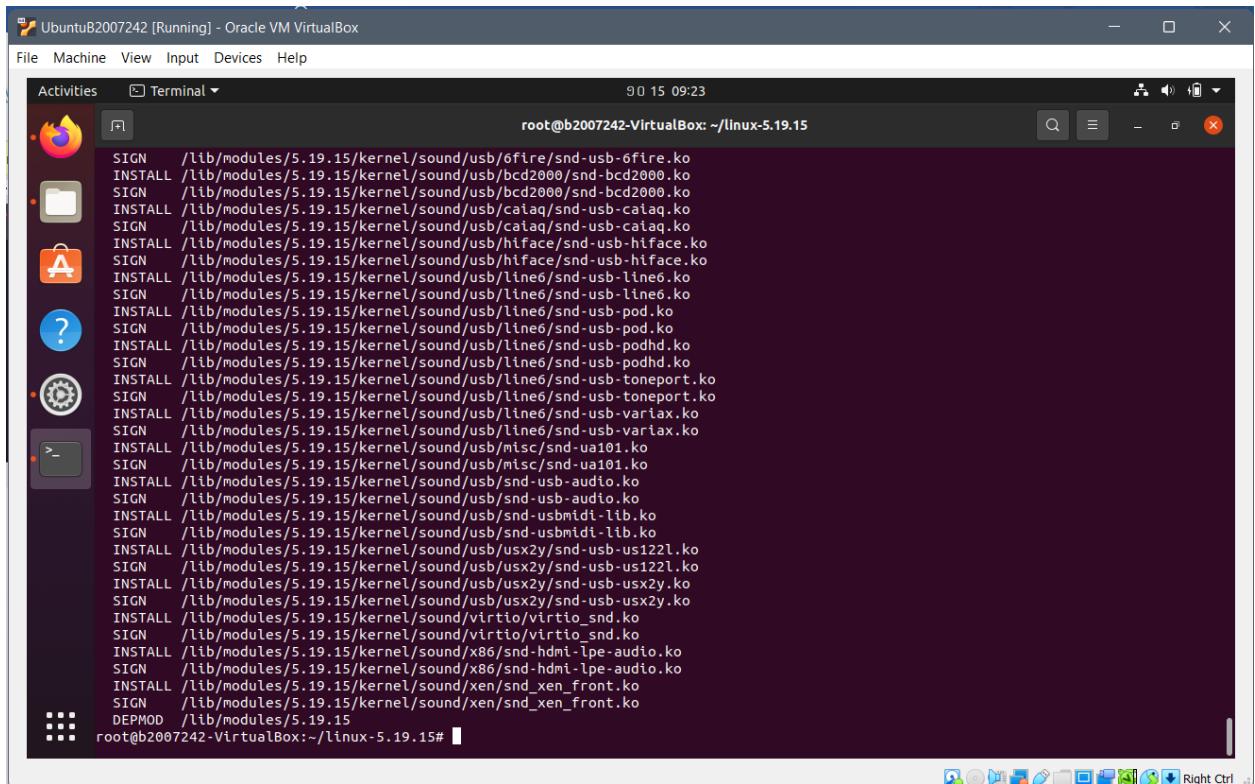
make modules_install



The screenshot shows a terminal window titled "root@b2007242-VirtualBox: ~/linux-5.19.15". The window displays the command "make modules_install" being run, followed by a long list of kernel module installation commands. The terminal is running on an Ubuntu 20.04 LTS system within a VirtualBox environment. The desktop icons for various applications like the Dash, Home, Applications, Help, and Terminal are visible on the left.

```
root@b2007242-VirtualBox:~/linux-5.19.15# make modules_install
INSTALL /lib/modules/5.19.15/kernel/arch/x86/crypto/aegis128-aesni.ko
SIGN /lib/modules/5.19.15/kernel/arch/x86/crypto/aegis128-aesni.ko
INSTALL /lib/modules/5.19.15/kernel/arch/x86/crypto/aesnl-intel.ko
SIGN /lib/modules/5.19.15/kernel/arch/x86/crypto/aesnl-intel.ko
INSTALL /lib/modules/5.19.15/kernel/arch/x86/crypto/blowfish-x86_64.ko
SIGN /lib/modules/5.19.15/kernel/arch/x86/crypto/blowfish-x86_64.ko
INSTALL /lib/modules/5.19.15/kernel/arch/x86/crypto/camellia-aesni-avx-x86_64.ko
SIGN /lib/modules/5.19.15/kernel/arch/x86/crypto/camellia-aesni-avx-x86_64.ko
INSTALL /lib/modules/5.19.15/kernel/arch/x86/crypto/camellia-aesni-avx2.ko
SIGN /lib/modules/5.19.15/kernel/arch/x86/crypto/camellia-aesni-avx2.ko
INSTALL /lib/modules/5.19.15/kernel/arch/x86/crypto/camellia-x86_64.ko
SIGN /lib/modules/5.19.15/kernel/arch/x86/crypto/camellia-x86_64.ko
INSTALL /lib/modules/5.19.15/kernel/arch/x86/crypto/cast5-avx-x86_64.ko
SIGN /lib/modules/5.19.15/kernel/arch/x86/crypto/cast5-avx-x86_64.ko
INSTALL /lib/modules/5.19.15/kernel/arch/x86/crypto/crc32-pclmul.ko
SIGN /lib/modules/5.19.15/kernel/arch/x86/crypto/crc32-pclmul.ko
INSTALL /lib/modules/5.19.15/kernel/arch/x86/crypto/crc32-pclmul.ko
SIGN /lib/modules/5.19.15/kernel/arch/x86/crypto/crc32-pclmul.ko
INSTALL /lib/modules/5.19.15/kernel/arch/x86/crypto/curve25519-x86_64.ko
SIGN /lib/modules/5.19.15/kernel/arch/x86/crypto/curve25519-x86_64.ko
INSTALL /lib/modules/5.19.15/kernel/arch/x86/crypto/des3_ede-x86_64.ko
SIGN /lib/modules/5.19.15/kernel/arch/x86/crypto/des3_ede-x86_64.ko
INSTALL /lib/modules/5.19.15/kernel/arch/x86/crypto/ghash-clmulni-intel.ko
SIGN /lib/modules/5.19.15/kernel/arch/x86/crypto/ghash-clmulni-intel.ko
INSTALL /lib/modules/5.19.15/kernel/arch/x86/crypto/nhpoly1305-avx2.ko
SIGN /lib/modules/5.19.15/kernel/arch/x86/crypto/nhpoly1305-avx2.ko
INSTALL /lib/modules/5.19.15/kernel/arch/x86/crypto/nhpoly1305-sse2.ko
SIGN /lib/modules/5.19.15/kernel/arch/x86/crypto/nhpoly1305-sse2.ko
INSTALL /lib/modules/5.19.15/kernel/arch/x86/crypto/poly1305-x86_64.ko
SIGN /lib/modules/5.19.15/kernel/arch/x86/crypto/poly1305-x86_64.ko
INSTALL /lib/modules/5.19.15/kernel/arch/x86/crypt/serpent-avx-x86_64.ko
```

• • •

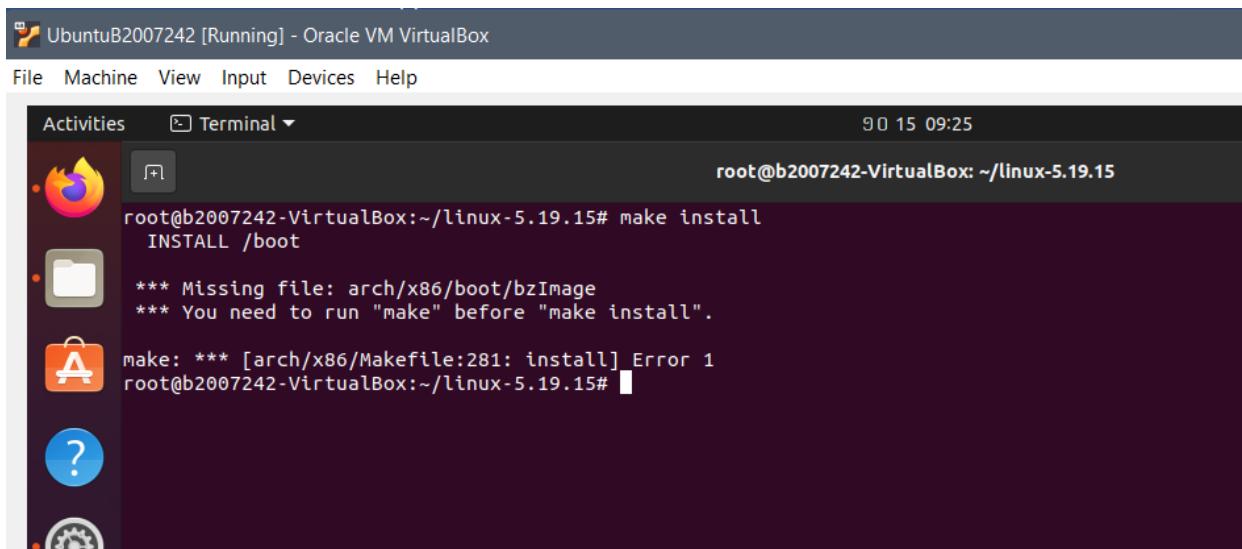


```
SIGN  /lib/modules/5.19.15/kernel/sound/usb/6fire.ko
INSTALL /lib/modules/5.19.15/kernel/sound/usb/bcd2000/snd-bcd2000.ko
SIGN  /lib/modules/5.19.15/kernel/sound/usb/bcd2000/snd-bcd2000.ko
INSTALL /lib/modules/5.19.15/kernel/sound/usb/caiq/snd-usb-caiq.ko
SIGN  /lib/modules/5.19.15/kernel/sound/usb/caiq/snd-usb-caiq.ko
INSTALL /lib/modules/5.19.15/kernel/sound/usb/hiface/snd-usb-hiface.ko
SIGN  /lib/modules/5.19.15/kernel/sound/usb/hiface/snd-usb-hiface.ko
INSTALL /lib/modules/5.19.15/kernel/sound/usb/line6/snd-usb-line6.ko
SIGN  /lib/modules/5.19.15/kernel/sound/usb/line6/snd-usb-line6.ko
INSTALL /lib/modules/5.19.15/kernel/sound/usb/line6/snd-usb-pod.ko
SIGN  /lib/modules/5.19.15/kernel/sound/usb/line6/snd-usb-pod.ko
INSTALL /lib/modules/5.19.15/kernel/sound/usb/line6/snd-usb-podhd.ko
SIGN  /lib/modules/5.19.15/kernel/sound/usb/line6/snd-usb-podhd.ko
INSTALL /lib/modules/5.19.15/kernel/sound/usb/line6/snd-usb-toneport.ko
SIGN  /lib/modules/5.19.15/kernel/sound/usb/line6/snd-usb-toneport.ko
INSTALL /lib/modules/5.19.15/kernel/sound/usb/line6/snd-usb-variax.ko
SIGN  /lib/modules/5.19.15/kernel/sound/usb/line6/snd-usb-variax.ko
INSTALL /lib/modules/5.19.15/kernel/sound/usb/misc/snd-ua101.ko
SIGN  /lib/modules/5.19.15/kernel/sound/usb/misc/snd-ua101.ko
INSTALL /lib/modules/5.19.15/kernel/sound/usb/snd-usb-audio.ko
SIGN  /lib/modules/5.19.15/kernel/sound/usb/snd-usb-audio.ko
INSTALL /lib/modules/5.19.15/kernel/sound/usb/snd-usbmidi-lib.ko
SIGN  /lib/modules/5.19.15/kernel/sound/usb/snd-usbmidi-lib.ko
INSTALL /lib/modules/5.19.15/kernel/sound/usb/usx2y/snd-usb-us122l.ko
SIGN  /lib/modules/5.19.15/kernel/sound/usb/usx2y/snd-usb-us122l.ko
INSTALL /lib/modules/5.19.15/kernel/sound/usb/usx2y/snd-usb-usx2y.ko
SIGN  /lib/modules/5.19.15/kernel/sound/usb/usx2y/snd-usb-usx2y.ko
INSTALL /lib/modules/5.19.15/kernel/sound/virtio/virtio_snd.ko
SIGN  /lib/modules/5.19.15/kernel/sound/virtio/virtio_snd.ko
INSTALL /lib/modules/5.19.15/kernel/sound/x86/snd-hdmi-lpe-audio.ko
SIGN  /lib/modules/5.19.15/kernel/sound/x86/snd-hdmi-lpe-audio.ko
INSTALL /lib/modules/5.19.15/kernel/sound/xen/snd_xen_front.ko
SIGN  /lib/modules/5.19.15/kernel/sound/xen/snd_xen_front.ko
DEPMOD /lib/modules/5.19.15
root@b2007242-VirtualBox:~/linux-5.19.15#
```

2. Cài đặt kernel

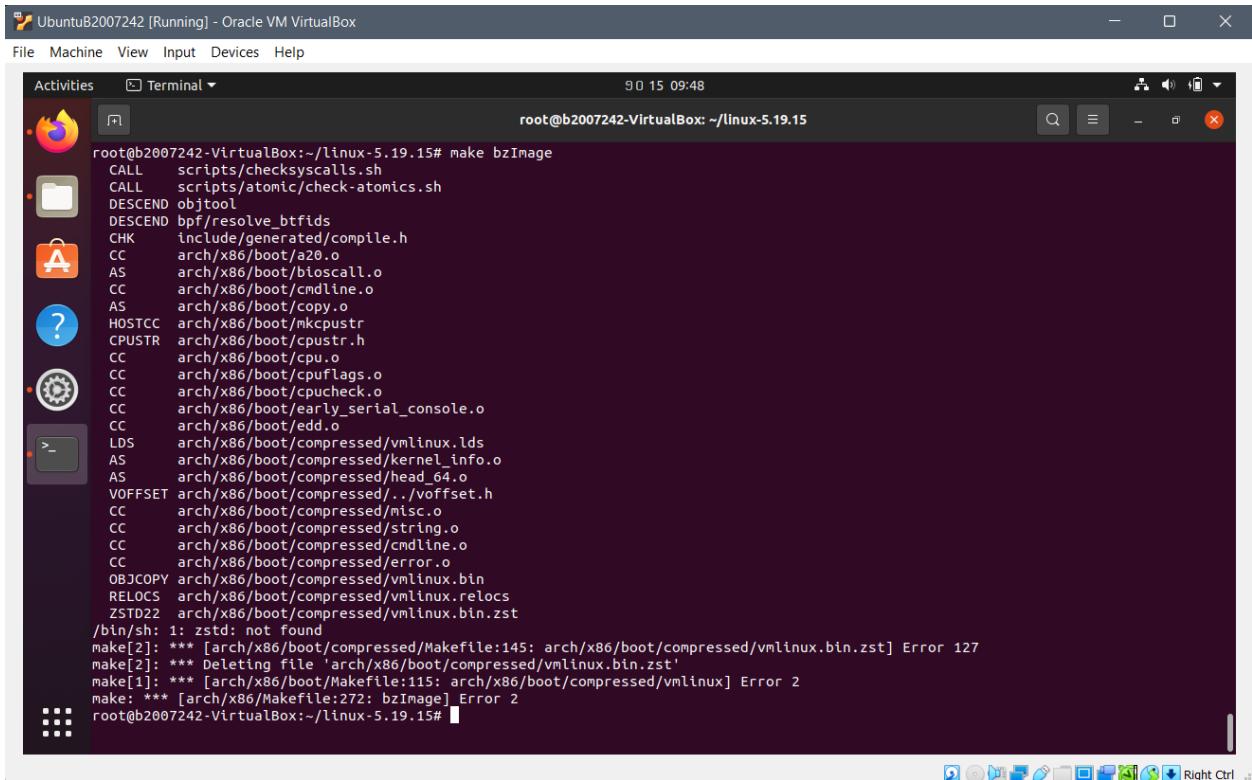
make install

→ Lỗi:



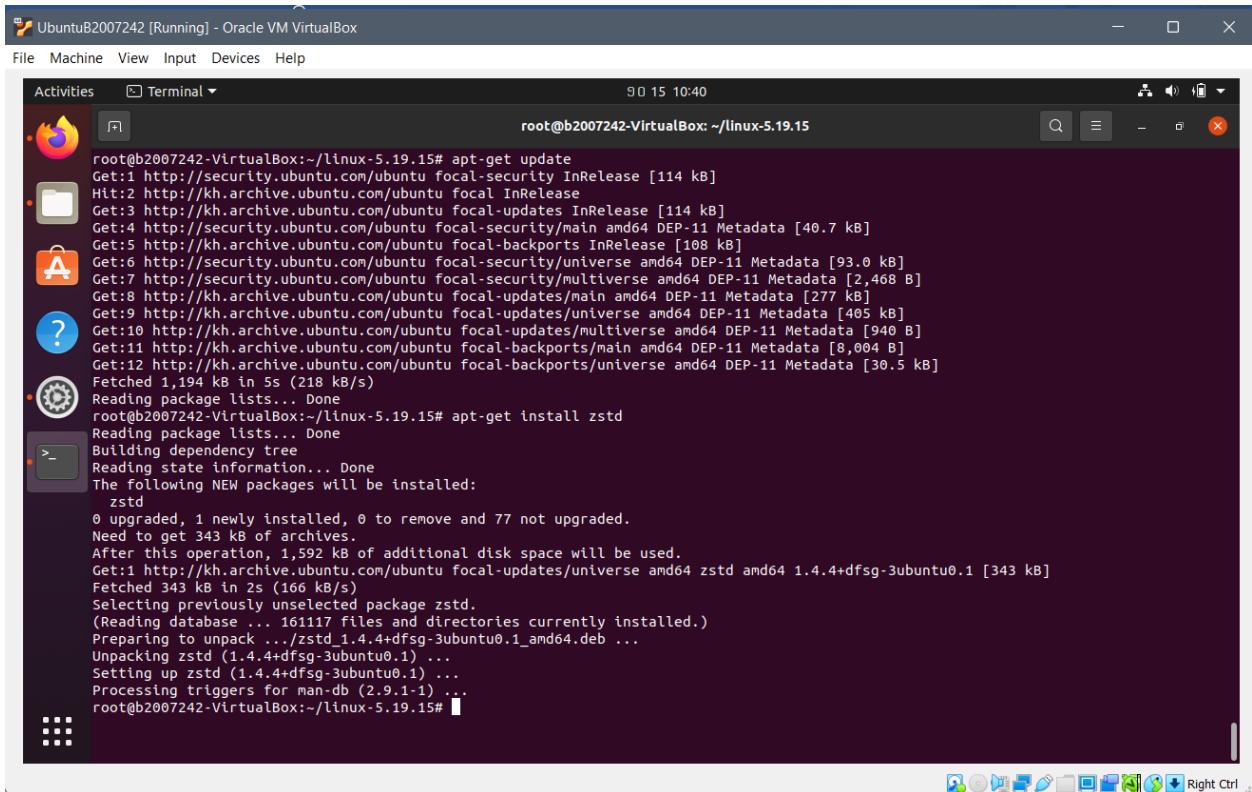
```
root@b2007242-VirtualBox:~/linux-5.19.15# make install
INSTALL /boot
*** Missing file: arch/x86/boot/bzImage
*** You need to run "make" before "make install".
make: *** [arch/x86/Makefile:281: install] Error 1
root@b2007242-VirtualBox:~/linux-5.19.15#
```

→ Chạy lệnh: *make bzImage*



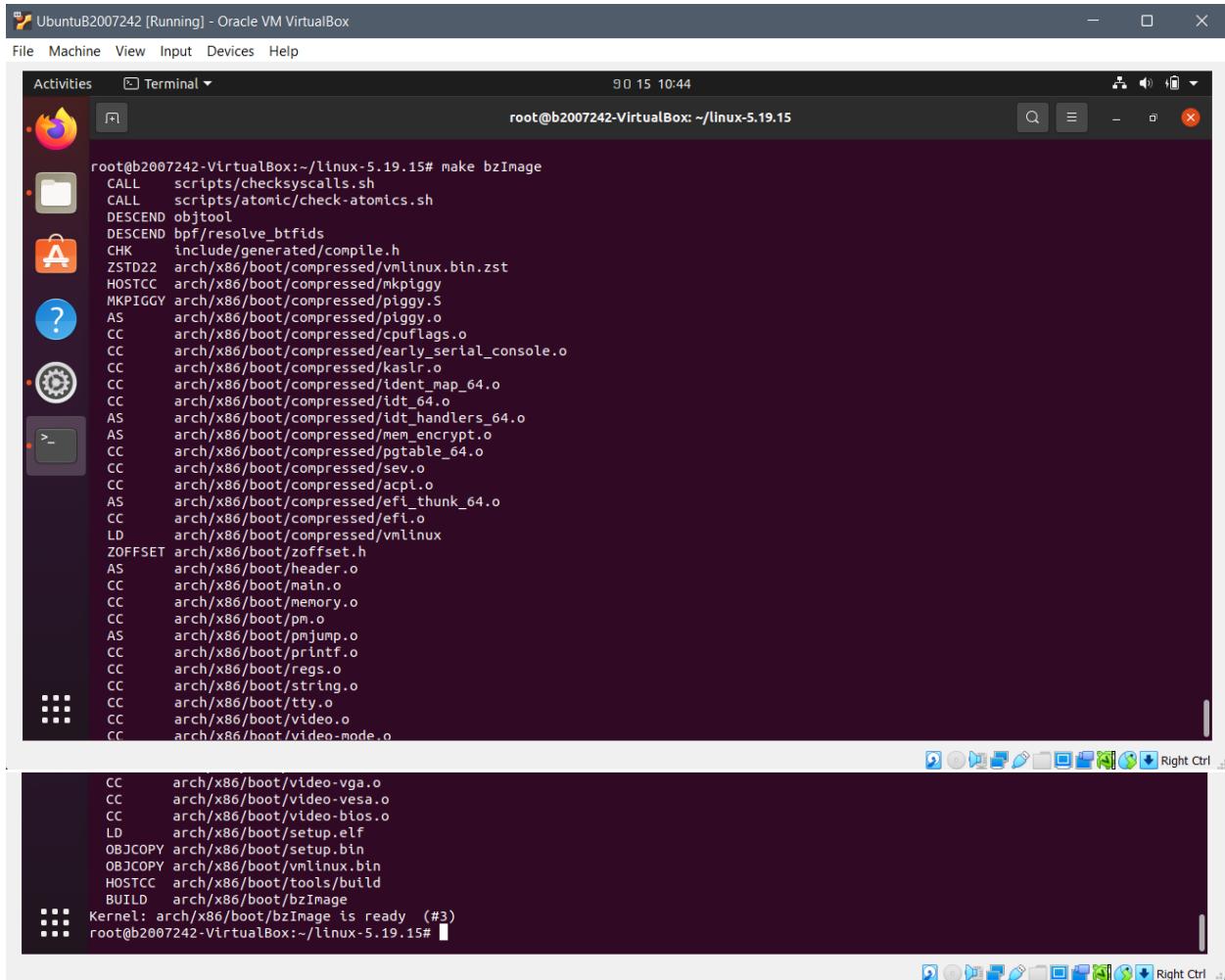
```
root@b2007242-VirtualBox:~/linux-5.19.15# make bzImage
  CALL  scripts/checksyscalls.sh
  CALL  scripts/atomic/check-atomics.sh
DESCEND objtool
DESCEND bpf/resolve_btfd
CHK  include/generated/compile.h
CC    arch/x86/boot/a20.o
AS    arch/x86/boot/bioscall.o
CC    arch/x86/boot/cmdline.o
AS    arch/x86/boot/copy.o
HOSTCC arch/x86/boot/mcpustr
CPUSR arch/x86/boot/cpustr.h
CC    arch/x86/boot/cpu.o
CC    arch/x86/boot/cpuflags.o
CC    arch/x86/boot/cpuchek.o
CC    arch/x86/boot/early_serial_console.o
CC    arch/x86/boot/edd.o
LDS   arch/x86/boot/compressed/vmlinux.lds
AS    arch/x86/boot/compressed/kernel_info.o
AS    arch/x86/boot/compressed/head_64.o
VOFFSET arch/x86/boot/compressed//voffset.h
CC    arch/x86/boot/compressed/misc.o
CC    arch/x86/boot/compressed/string.o
CC    arch/x86/boot/compressed/cmdline.o
CC    arch/x86/boot/compressed/error.o
OBJCOPY arch/x86/boot/compressed/vmlinux.bin
RELOCS arch/x86/boot/compressed/vmlinux.relocs
ZSTD22 arch/x86/boot/compressed/vmlinux.bin.zst
/bin/sh: 1: zstd: not found
make[2]: *** [arch/x86/boot/compressed/Makefile:145: arch/x86/boot/compressed/vmlinux.bin.zst] Error 127
make[2]: *** Deleting file 'arch/x86/boot/compressed/vmlinux.bin.zst'
make[1]: *** [arch/x86/Makefile:115: arch/x86/boot/compressed/vmlinux] Error 2
make: *** [arch/x86/Makefile:27: bzImage] Error 2
root@b2007242-VirtualBox:~/linux-5.19.15#
```

→ Sửa lỗi: chạy 2 lệnh: *apt-get update* và *apt-get install zstd*



```
root@b2007242-VirtualBox:~/linux-5.19.15# apt-get update
Get:1 http://security.ubuntu.com/ubuntu focal-security InRelease [114 kB]
Hit:2 http://kh.archive.ubuntu.com/ubuntu focal InRelease
Get:3 http://kh.archive.ubuntu.com/ubuntu focal-updates InRelease [114 kB]
Get:4 http://security.ubuntu.com/ubuntu focal-security/main amd64 DEP-11 Metadata [40.7 kB]
Get:5 http://kh.archive.ubuntu.com/ubuntu focal-backports InRelease [108 kB]
Get:6 http://security.ubuntu.com/ubuntu focal-security/universe amd64 DEP-11 Metadata [93.0 kB]
Get:7 http://security.ubuntu.com/ubuntu focal-security/multiverse amd64 DEP-11 Metadata [2,468 B]
Get:8 http://kh.archive.ubuntu.com/ubuntu focal-updates/main amd64 DEP-11 Metadata [277 kB]
Get:9 http://kh.archive.ubuntu.com/ubuntu focal-updates/universe amd64 DEP-11 Metadata [405 kB]
Get:10 http://kh.archive.ubuntu.com/ubuntu focal-updates/multiverse amd64 DEP-11 Metadata [940 B]
Get:11 http://kh.archive.ubuntu.com/ubuntu focal-backports/main amd64 DEP-11 Metadata [8,004 B]
Get:12 http://kh.archive.ubuntu.com/ubuntu focal-backports/universe amd64 DEP-11 Metadata [30.5 kB]
Fetched 1,194 kB in 5s (218 kB/s)
Reading package lists... Done
root@b2007242-VirtualBox:~/linux-5.19.15# apt-get install zstd
Reading package lists... Done
Building dependency tree
Reading state information... Done
The following NEW packages will be installed:
  zstd
0 upgraded, 1 newly installed, 0 to remove and 77 not upgraded.
Need to get 343 kB of archives.
After this operation, 1,592 kB of additional disk space will be used.
Get:1 http://kh.archive.ubuntu.com/ubuntu focal-updates/universe amd64 zstd amd64 1.4.4+dfsg-3ubuntu0.1 [343 kB]
Fetched 343 kB in 2s (166 kB/s)
Selecting previously unselected package zstd.
(Reading database ... 161117 files and directories currently installed.)
Preparing to unpack .../zstd_1.4.4+dfsg-3ubuntu0.1_amd64.deb ...
Unpacking zstd (1.4.4+dfsg-3ubuntu0.1) ...
Setting up zstd (1.4.4+dfsg-3ubuntu0.1) ...
Processing triggers for man-db (2.9.1-1) ...
root@b2007242-VirtualBox:~/linux-5.19.15#
```

→ Rồi chạy lại *make bzImage*



The screenshot shows a terminal window titled "UbuntuB2007242 [Running] - Oracle VM VirtualBox". The terminal is running as root on a Linux system. The command "make bzImage" is being executed, and the output shows the compilation of various kernel components into a bzImage file. The terminal window has a dark background with light-colored text. The status bar at the bottom right shows icons for network, battery, and system status.

```
root@b2007242-VirtualBox:~/linux-5.19.15# make bzImage
  CALL  scripts/checksyscalls.sh
  CALL  scripts/atomic/check-atomics.sh
DESCEND objtool
DESCEND bpf/resolve_btfids
CHK  include/generated/compile.h
ZSTD22 arch/x86/boot/compressed/vmlinux.bin.zst
HOSTCC arch/x86/boot/compressed/mkpiggy
MKPIGGY arch/x86/boot/compressed/piggy.S
AS  arch/x86/boot/compressed/piggy.o
CC  arch/x86/boot/compressed/cpuflags.o
CC  arch/x86/boot/compressed/early_serial_console.o
CC  arch/x86/boot/compressed/kaslr.o
CC  arch/x86/boot/compressed/ident_map_64.o
CC  arch/x86/boot/compressed/idt_64.o
AS  arch/x86/boot/compressed/idt_handlers_64.o
AS  arch/x86/boot/compressed/mem_encrypt.o
CC  arch/x86/boot/compressed/pgtable_64.o
CC  arch/x86/boot/compressed/sev.o
CC  arch/x86/boot/compressed/acpi.o
AS  arch/x86/boot/compressed/efi_thunk_64.o
CC  arch/x86/boot/compressed/efi.o
LD  arch/x86/boot/compressed/vmlinux
ZOFFSET arch/x86/boot/zoffset.h
AS  arch/x86/boot/header.o
CC  arch/x86/boot/main.o
CC  arch/x86/boot/memory.o
CC  arch/x86/boot/pm.o
AS  arch/x86/boot/pmjump.o
CC  arch/x86/boot/printf.o
CC  arch/x86/boot/regs.o
CC  arch/x86/boot/string.o
CC  arch/x86/boot/tty.o
CC  arch/x86/boot/video.o
CC  arch/x86/boot/video-mode.o
CC  arch/x86/boot/video-vga.o
CC  arch/x86/boot/video-vesa.o
CC  arch/x86/boot/video-bios.o
LD  arch/x86/boot/setup.elf
OBJCOPY arch/x86/boot/setup.bin
OBJCOPY arch/x86/boot/vmlinux.bin
HOSTCC arch/x86/boot/tools/build
BUILD arch/x86/boot/bzImage
[...]
Kernel: arch/x86/boot/bzImage is ready  (#3)
root@b2007242-VirtualBox:~/linux-5.19.15#
```

Sau đó chạy lại lệnh **make install**:

```
root@b2007242-VirtualBox:~/linux-5.19.15# make install
  INSTALL /boot
run-parts: executing /etc/kernel/postinst.d/apt-auto-remove 5.19.15 /boot/vmlinuz-5.19.15
run-parts: executing /etc/kernel/postinst.d/initramfs-tools 5.19.15 /boot/vmlinuz-5.19.15
update-initramfs: Generating /boot/initrd.img-5.19.15
run-parts: executing /etc/kernel/postinst.d/unattended-upgrades 5.19.15 /boot/vmlinuz-5.19.15
run-parts: executing /etc/kernel/postinst.d/update-notifier 5.19.15 /boot/vmlinuz-5.19.15
run-parts: executing /etc/kernel/postinst.d/xx-update-initrd-links 5.19.15 /boot/vmlinuz-5.19.15
I: /boot/initrd.img.old is now a symlink to initrd.img-5.19.15
I: /boot/initrd.img is now a symlink to initrd.img-5.19.15
run-parts: executing /etc/kernel/postinst.d/zzz-update-grub 5.19.15 /boot/vmlinuz-5.19.15
Sourcing file '/etc/default/grub'
Sourcing file '/etc/default/grub.d/init-select.cfg'
Generating grub configuration file ...
Found linux image: /boot/vmlinuz-5.19.15
Found initrd image: /boot/initrd.img-5.19.15
Found linux image: /boot/vmlinuz-5.15.0-50-generic
Found initrd image: /boot/initrd.img-5.15.0-50-generic
Found linux image: /boot/vmlinuz-5.13.0-30-generic
Found initrd image: /boot/initrd.img-5.13.0-30-generic
Found memtest86+ image: /boot/memtest86+.elf
Found memtest86+ image: /boot/memtest86+.bin
done
root@b2007242-VirtualBox:~/linux-5.19.15#
```

E. THAY ĐỔI FILE CẤU HÌNH GRUB (GRUB CONFIGURATION FILE)

1.Thay đổi file cấu hình grub:

vim /etc/default/grub

→ Do vim không tìm thấy nên thay vim thành trình soạn thảo **nano**

```
root@b2007242-VirtualBox:~/linux-5.19.15# vim /etc/default/grub
Command 'vim' not found, but can be installed with:
apt install vim          # version 2:8.1.2269-1ubuntu5.9, or
apt install vim-tiny      # version 2:8.1.2269-1ubuntu5.9
apt install neovim        # version 0.4.3-3
apt install vim-athena    # version 2:8.1.2269-1ubuntu5.9
apt install vim-gtk3       # version 2:8.1.2269-1ubuntu5.9
apt install vim-nox        # version 2:8.1.2269-1ubuntu5.9
root@b2007242-VirtualBox:~/linux-5.19.15# nano /etc/default/grub
```

2.Thực hiện các thay đổi sau:

GRUB_DEFAULT=0

GRUB_TIMEOUT=25

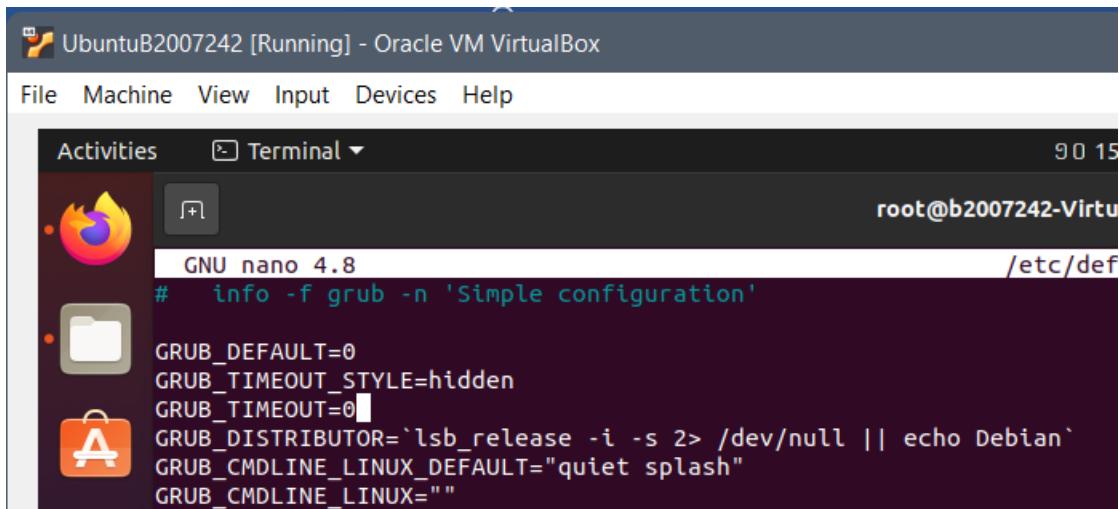
→ Sau khi mở lên:

1. Nhấn ctrl + W : copy GRUB_DEFAULT hoặc GRUB_TIMEOUT để tìm.

2 . Tiến hành thay đổi như trên.

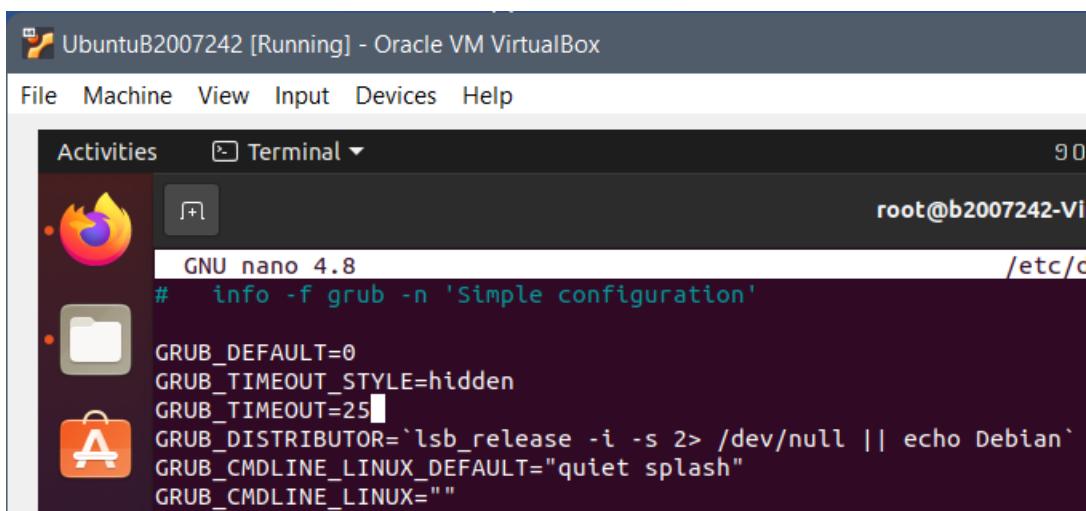
3. Nhấn Ctrl + X để thoát và lưu lại.

*Trước khi chỉnh sửa:



```
GNU nano 4.8
#   info -f grub -n 'Simple configuration'
GRUB_DEFAULT=0
GRUB_TIMEOUT_STYLE=hidden
GRUB_TIMEOUT=0
GRUB_DISTRIBUTOR=`lsb_release -i -s 2> /dev/null || echo Debian`
GRUB_CMDLINE_LINUX_DEFAULT="quiet splash"
GRUB_CMDLINE_LINUX=""
```

*Sau khi chỉnh sửa:



```
GNU nano 4.8
#   info -f grub -n 'Simple configuration'
GRUB_DEFAULT=0
GRUB_TIMEOUT_STYLE=hidden
GRUB_TIMEOUT=25
GRUB_DISTRIBUTOR=`lsb_release -i -s 2> /dev/null || echo Debian`
GRUB_CMDLINE_LINUX_DEFAULT="quiet splash"
GRUB_CMDLINE_LINUX=""
```

F. REBOOT VM

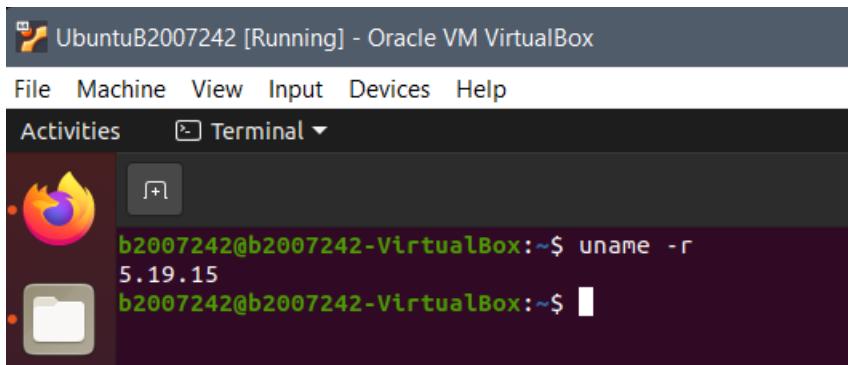
1. Reboot kernel mới:

```
# reboot
```

2. Sau khi boot, kiểm tra thông tin kernel mới có đúng chưa:

```
# uname -r
```

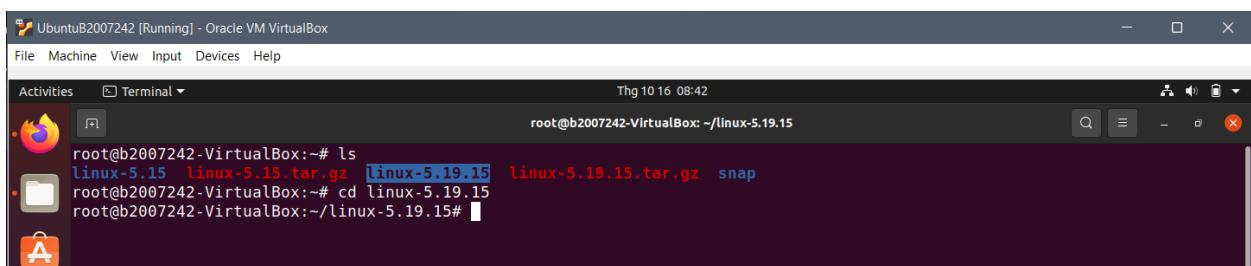
→ Kết quả : **đúng**:



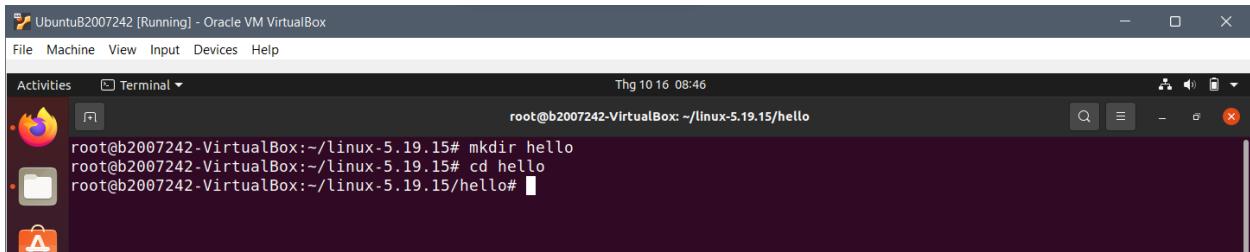
PHẦN 2: THÊM LỜI GỌI HỆ THỐNG VÀO LINUX KERNEL (2.0 điểm)

** Chuẩn bị một máy ảo khác giống như phần 1 có phiên bản là 5.15 và download những phần cần thiết.

Bước 1: chọn đường dẫn vào thư mục linux-5.19.15



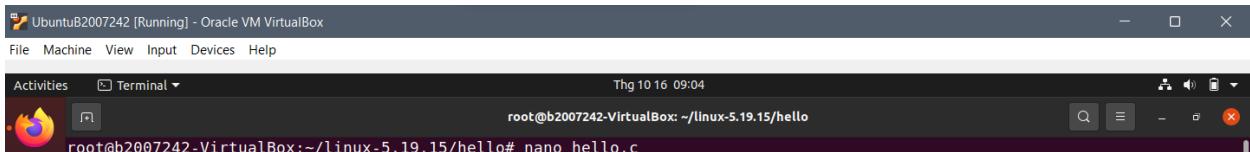
Bước 2: tạo thư mục hello bằng câu lệnh **mkdir hello** sau đó truy cập vào thư mục hello :



A screenshot of a Linux desktop environment (Ubuntu) within a VirtualBox window. The terminal window shows the command: `root@b2007242-VirtualBox:~/linux-5.19.15/hello# mkdir hello`. The terminal title bar says "UbuntuB2007242 [Running] - Oracle VM VirtualBox". The desktop background is dark.

Bước 3: Định nghĩa lời gọi hệ thống mới.

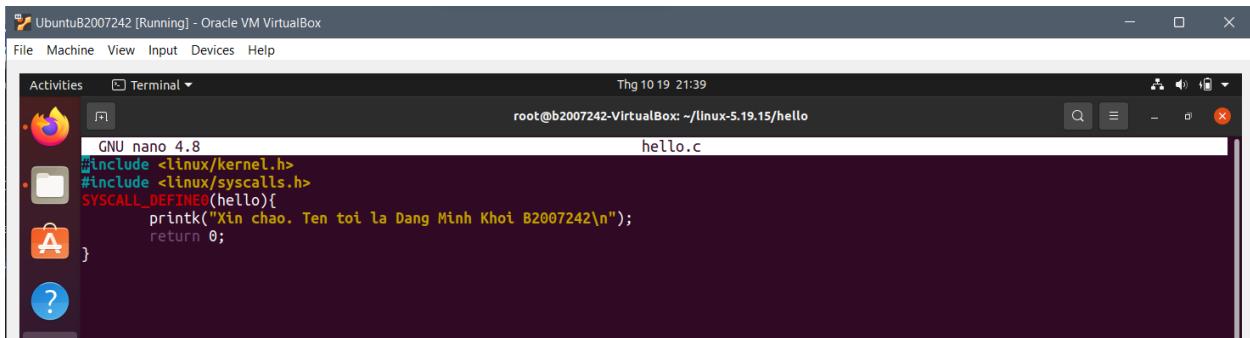
+ Mở thư mục hello.c: ***nano hello.c*** (sử dụng trình soạn thảo của nano).



A screenshot of a Linux desktop environment (Ubuntu) within a VirtualBox window. The terminal window shows the command: `root@b2007242-VirtualBox:~/linux-5.19.15/hello# nano hello.c`. The terminal title bar says "UbuntuB2007242 [Running] - Oracle VM VirtualBox". The desktop background is dark.

+ Sau đó code vào file hello.c nội dung:

```
#include <linux/kernel.h>
#include <linux/syscalls.h>
SYSCALL_DEFINE0(hello){
    printk("Xin chao. Ten toi la Dang Minh Khoi B2007242\n");
    return 0;
}
```



A screenshot of a Linux desktop environment (Ubuntu) within a VirtualBox window. The terminal window shows the content of the file "hello.c" being edited in nano. The code is identical to the one above. The terminal title bar says "UbuntuB2007242 [Running] - Oracle VM VirtualBox". The desktop background is dark.

+ Nhấn Ctrl + X để thoát và nhấn Y để lưu cuối cùng nhấn Enter.

+ Cũng trong /root/linux-5.19.15/hello, tạo tập tin Makefile với nội dung:

```
obj-y := hello.o
#nano Makefile
```

```
UbuntuB2007242 [Running] - Oracle VM VirtualBox
File Machine View Input Devices Help
Activities Terminal
GNU nano 4.8
obj-y := hello.o
Makefile
Modified
```

Điều này nhằm để đảm bảo tập tin `hello.c` được biên dịch và nằm trong kernel source code.

Bước 4: Chỉnh sửa tập tin /root/linux-5.19.15/Makefile.

+ Truy cập vào `linux-5.19.15`: `cd /root/linux-5.19.15`

```
UbuntuB2007242 [Running] - Oracle VM VirtualBox
File Machine View Input Devices Help
Activities Terminal
Thg 10 16 09:06
root@b2007242-VirtualBox:~/linux-5.19.15#
root@b2007242-VirtualBox:~/linux-5.19.15#
```

+ Chạy câu lệnh: `#nano Makefile`

- Tìm dòng có nội dung dưới đây:

`core-y += kernel/ mm/ fs/ ipc/ security/ crypto/`

- Thêm “`hello/`” vào cuối dòng:

`core-y += kernel/ mm/ fs/ ipc/ security/ crypto/ hello/`

```
UbuntuB2007242 [Running] - Oracle VM VirtualBox
File Machine View Input Devices Help
Activities Terminal
Thg 10 16 09:13
root@b2007242-VirtualBox:~/linux-5.19.15#
root@b2007242-VirtualBox:~/linux-5.19.15# nano Makefile
# INSTALL_MOD_PATH specifies a prefix to MODLIB for module directory
# relocations required by build roots. This is not defined in the
# makefile but the argument can be passed to make if needed.
#
MODLIB = $(INSTALL_MOD_PATH)/lib/modules/$(KERNELRELEASE)
export MODLIB
PHONY += prepare
export extmod_prefix = $(if $(KBUILD_EXTMOD),$(KBUILD_EXTMOD)\/)
export MODORDER := $(extmod_prefix)modules.order
export MODULES_NSDEPS := $(extmod_prefix)modules.nsdeps
ifeq ($(KBUILD_EXTMOD),)
core-y           += kernel/ certs/ mm/ fs/ ipc/ security/ crypto/ hello/
core-$(CONFIG_BLOCK) += block/
core-$(CONFIG_IOURING) += io_uring/
vmlinux-dirs    := $(patsubst %,%,$(filter %, \

```

+ Sau đó nhấn `Ctrl + X` để thoát và nhấn `Y` để lưu cuối cùng nhấn `Enter`.

Bước 5: Thêm lời gọi hệ thống mới vào bảng gọi hệ thống (system call table).

+ Truy cập đường dẫn sau:

```
#cd /root/linux-5.19.15/arch/x86/entry/syscalls/
```

+ Chỉnh sửa tập tin syscall_64.tbl

```
#nano syscall_64.tbl
```

+ Di chuyển đến phần có ghi như sau:

```
GNU nano 4.8          syscall_64.tbl
332    common  statx      sys_statx
333    common  io_pgetevents sys_io_pgetevents
334    common  rseq       sys_rseq
# don't use numbers 387 through 423, add new calls after the last
# 'common' entry
424    common  send_signal sys_send_signal
```

+ Sau đó di chuyển đến cuối dòng nằm trong phần cho phép thêm lời gọi hàm mới, rồi thêm 1 dòng như sau:

```
451           common     hello      sys_hello
```

```
GNU nano 4.8
424 common pidfd_send_signal sys_pidfd_send_signal
425 common io_uring_setup sys_io_uring_setup
426 common io_uring_enter sys_io_uring_enter
427 common io_uring_register sys_io_uring_register
428 common open_tree sys_open_tree
429 common move_mount sys_move_mount
430 common fsopen sys_fsopen
431 common fsconfig sys_fsconfig
432 common fsmount sys_fsmount
433 common fspick sys_fspick
434 common pidfd_open sys_pidfd_open
435 common clone3 sys_clone3
436 common close_range sys_close_range
437 common openat2 sys_openat2
438 common pidfd_getfd sys_pidfd_getfd
439 common faccessat2 sys_faccessat2
440 common process_madvise sys_process_madvise
441 common epoll_pwait2 sys_epoll_pwait2
442 common mount_setattr sys_mount setattr
443 common quotactl_fd sys_quotactl_fd
444 common landlock_create_ruleset sys_landlock_create_ruleset
445 common landlock_add_rule sys_landlock_add_rule
446 common landlock_restrict_self sys_landlock_restrict_self
447 common memfd_secret sys_memfd_secret
448 common process_mrelease sys_process_mrelease
449 common futex_waitv sys_futex_waitv
450 common set_mempolicy_home_node sys_set_mempolicy_home_node
451 common hello sys_hello

#
^G Get Help ^O Write Out ^W Where Is ^K Cut Text ^J Justify ^C Cur Pos M-U Undo
^X Exit ^R Read File ^A Replace ^U Paste Text ^T To Spell ^L Go To Line M-E Redo
Right Ctrl
```

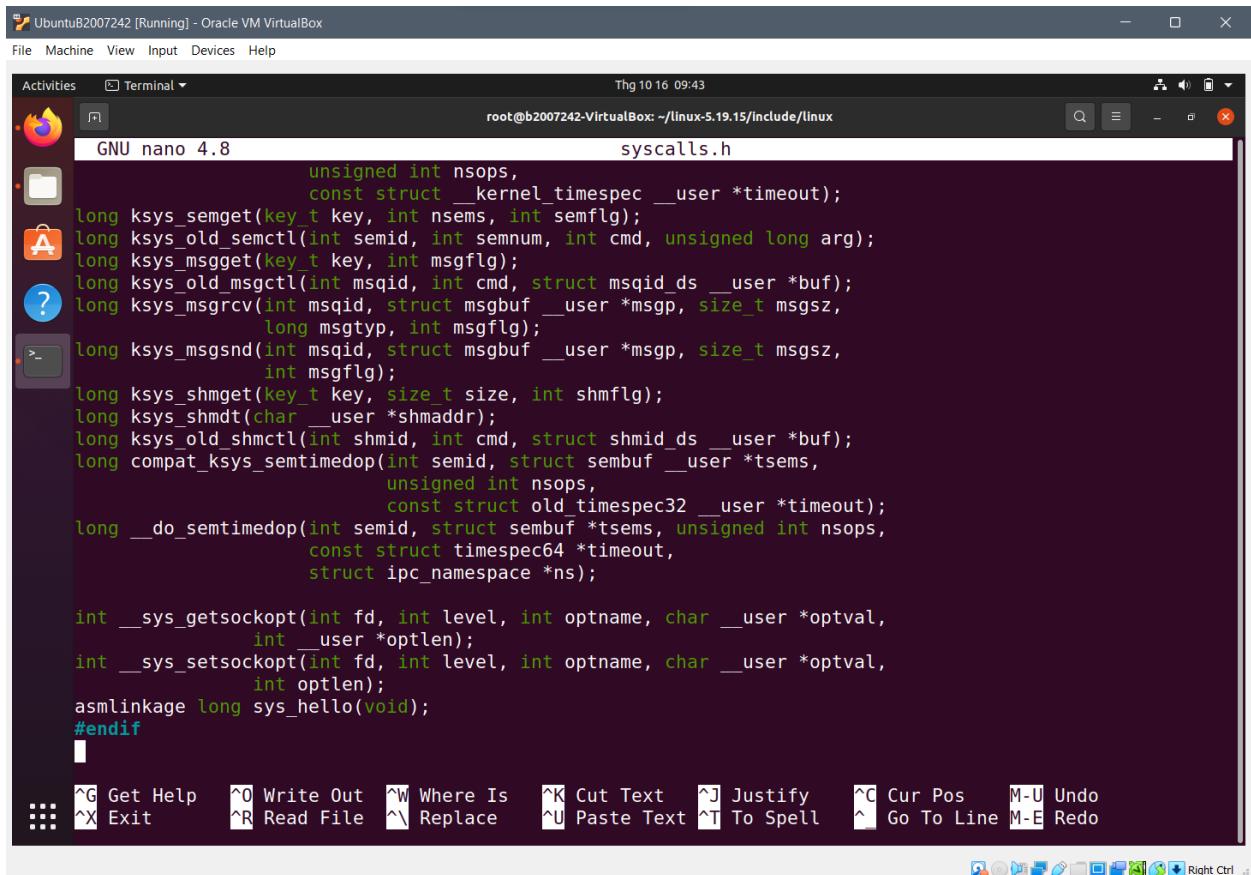
Chú ý: Cần biết **451** là số thứ tự tiếp theo của dòng trước nó, và ta cần nhớ nó để sử dụng cho các bước sau. 64 là hệ 64-bit.

Bước 6: Thêm lời gọi hệ thống sys_hello() vào system call header file.

#cd /root/linux-5.19.15/include/linux

#nano syscalls.h

Thêm dòng “**asmlinkage long sys_hello(void);**” vào trước dòng **#endif** cuối cùng



```
UbuntuB2007242 [Running] - Oracle VM VirtualBox
File Machine View Input Devices Help
Activities Terminal
GNU nano 4.8 syscalls.h
Thg 10 16 09:43
root@b2007242-VirtualBox: ~/linux-5.19.15/include/linux
long ksys_semget(key_t key, int nsems, int semflg);
long ksys_old_semtimedop(int semid, int semnum, int cmd, unsigned long arg);
long ksys_msgrcv(int msqid, struct msqid_ds __user *buf, size_t msgsz,
                 long msgtyp, int msgflg);
long ksys_msgsnd(int msqid, struct msqbuf __user *msgp, size_t msgsz,
                  int msgflg);
long ksys_shmget(key_t key, size_t size, int shmfld);
long ksys_shmdt(char __user *shmaddr);
long ksys_old_shmctl(int shmid, int cmd, struct shmid_ds __user *buf);
long compat_ksys_semtimedop(int semid, struct sembuf __user *tsems,
                            unsigned int nsops,
                            const struct old_timespec32 __user *timeout);
long __do_semtimedop(int semid, struct sembuf *tsems, unsigned int nsops,
                     const struct timespec64 *timeout,
                     struct ipc_namespace *ns);

int __sys_getsockopt(int fd, int level, int optname, char __user *optval,
                     int __user *optlen);
int __sys_setsockopt(int fd, int level, int optname, char __user *optval,
                     int optlen);
asmlinkage long sys_hello(void);
#endif
```

^G Get Help ^O Write Out ^W Where Is ^K Cut Text ^J Justify ^C Cur Pos M-U Undo
^X Exit ^R Read File ^\ Replace ^U Paste Text ^T To Spell ^L Go To Line M-E Redo

Bước 7: Biên dịch lại kernel

→ Các bước giống bài 1

→ Tới bước ***make modules*** thì lỗi:

```

UbuntuB2007242 [Running] - Oracle VM VirtualBox
File Machine View Input Devices Help
Activities Terminal Thg 10 19 14:44
root@b2007242-VirtualBox: ~/linux-5.19.15

CC      arch/x86/lib/delay.o
CC      arch/x86/lib/error-inject.o
CC      arch/x86/lib/insn-eval.o
CC      arch/x86/lib/usercopy.o
CC      arch/x86/lib/usercopy_64.o
AR      arch/x86/lib/lib.a
CC      arch/x86/lib/msr.o
AR      arch/x86/lib/built-in.a
GEN     .version
CHK     include/generated/compile.h
UPD     include/generated/compile.h
CC      init/version.o
AR      init/built-in.a
LD      vmlinux.o
MODPOST vmlinux.symvers
MODINFO modules.builtin.modinfo
GEN     modules.builtin
CC      .vmlinux.export.o
LD      .tmp_vmlinux.btf
BTF     .btf.vmlinux.bin.o
Killed
LD      .tmp_vmlinux.kallsyms1
KSYM   .tmp_vmlinux.kallsyms1.S
AS     .tmp_vmlinux.kallsyms1.S
LD      .tmp_vmlinux.kallsyms2
KSYM   .tmp_vmlinux.kallsyms2.S
AS     .tmp_vmlinux.kallsyms2.S
LD      vmlinux
BTFIDS vmlinux
FAILED: load BTF from vmlinux: No such file or directory
make: *** [Makefile:1168: vmlinux] Error 255
make: *** Deleting file 'vmlinux'

```

→ Sửa lỗi:

- 1 Thực hiện ***nano .config***
2. Tìm dòng **CONFIG_DEBUG_INFO_BTF=y** và thay đổi thành **CONFIG_DEBUG_INFO_BTF=n**

```

UbuntuB2007242 [Running] - Oracle VM VirtualBox
File Machine View Input Devices Help
Activities Terminal Thg 10 19 14:42
root@b2007242-VirtualBox: ~/linux-5.19.15

GNU nano 4.8          .config          Modified
# CONFIG_DEBUG_INFO_SPLIT is not set
CONFIG_DEBUG_INFO_BTF=n
CONFIG_PAHOLE_HAS_SPLIT_BTF=y
CONFIG_DEBUG_INFO_BTF_MODULES=y
CONFIG_MODULE_ALLOW_BTF_MISMATCH=y
CONFIG_GDB_SCRIPTS=y
CONFIG_FRAME_WARN=1024
# CONFIG_STRIP_ASM_SYMS is not set
# CONFIG_READABLE_ASM is not set

```

Bước 8: Sau khi reboot lại thành công tiến hành kiểm tra lời gọi hệ thống

```
#cd ~
```

```
#nano userspace.c
```

Nội dung của userspace.c

```
#include <stdio.h>
#include <linux/kernel.h>
#include <sys/syscall.h>
#include <unistd.h>
int main() {
    long int nmt = syscall(451);
    printf("System call sys_hello returned %ld\n", nmt);
    return 0;
}
```

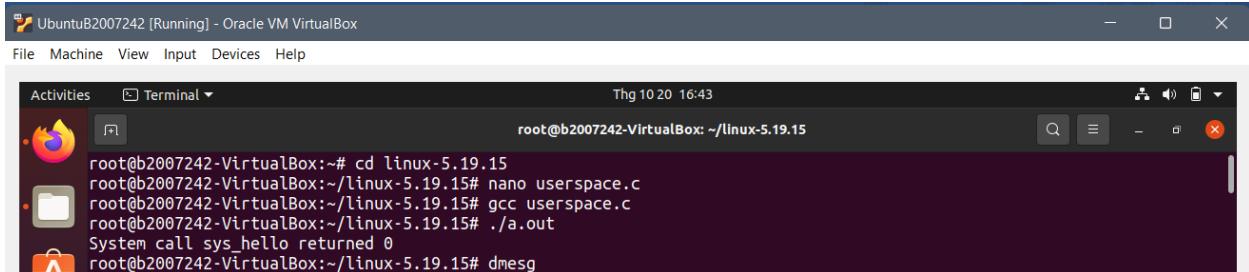
Số 451 là thứ tự lời gọi hệ thống trong system call table mà ta đã nhớ.



Biên dịch userspace.c

```
#gcc userspace.c
```

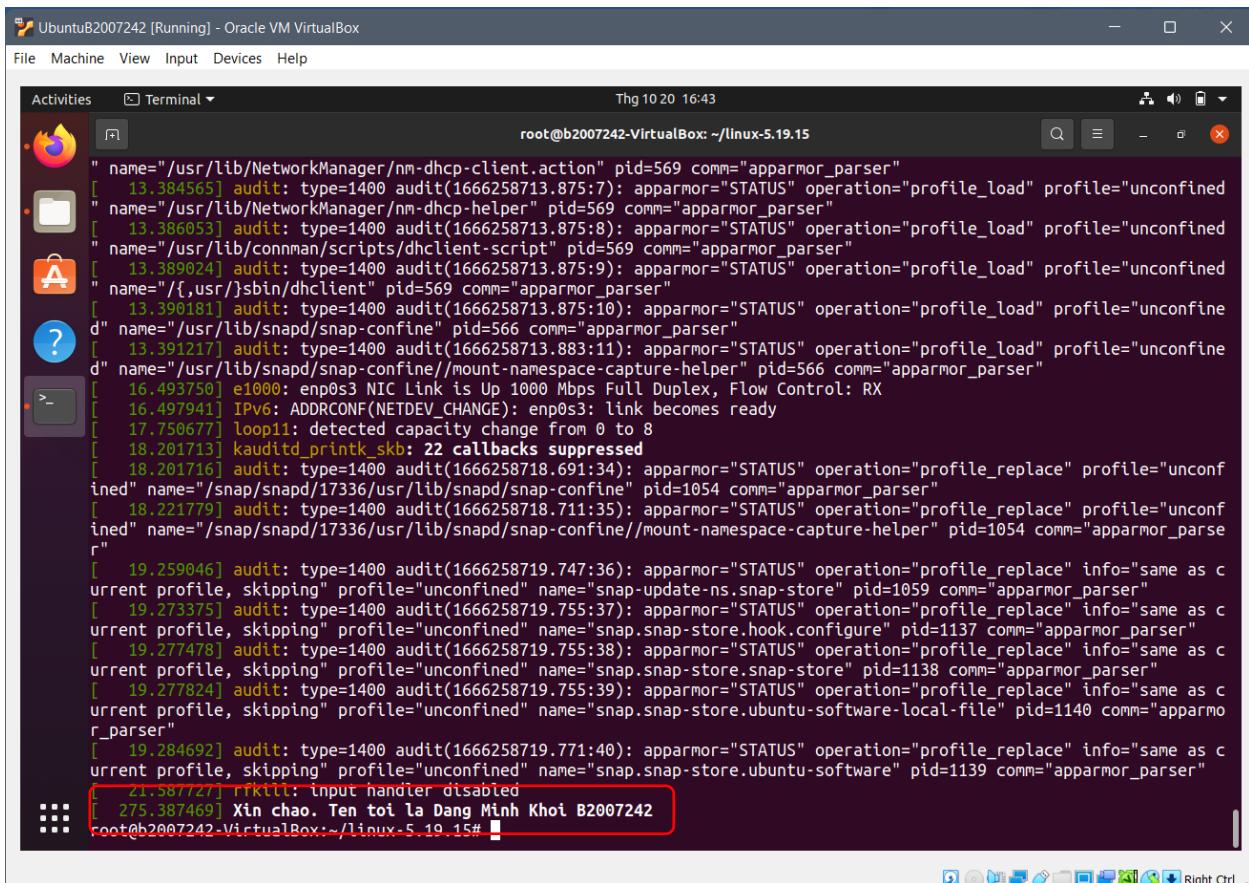
```
#!/a.out
```



```
UbuntuB2007242 [Running] - Oracle VM VirtualBox
File Machine View Input Devices Help
Activities Terminal Thg 10 20 16:43
root@b2007242-VirtualBox:~/linux-5.19.15
root@b2007242-VirtualBox:~/linux-5.19.15# cd linux-5.19.15
root@b2007242-VirtualBox:~/linux-5.19.15# nano userspace.c
root@b2007242-VirtualBox:~/linux-5.19.15# gcc userspace.c
root@b2007242-VirtualBox:~/linux-5.19.15# ./a.out
System call sys_hello returned 0
root@b2007242-VirtualBox:~/linux-5.19.15# dmesg
```

→ Test message of kernel: để xem thông điệp của kernel in ra màn hình dùng lệnh sau:

#**dmesg**



```
UbuntuB2007242 [Running] - Oracle VM VirtualBox
File Machine View Input Devices Help
Activities Terminal Thg 10 20 16:43
root@b2007242-VirtualBox:~/linux-5.19.15
[ 13.384565] audit: type=1400 audit(1666258713.875:7): apparmor="STATUS" operation="profile_load" profile="unconfined" name="/usr/lib/NetworkManager/nm-dhcp-client.action" pid=569 comm="apparmor_parser"
[ 13.386053] audit: type=1400 audit(1666258713.875:8): apparmor="STATUS" operation="profile_load" profile="unconfined" name="/usr/lib/NetworkManager/nm-dhcp-helper" pid=569 comm="apparmor_parser"
[ 13.389024] audit: type=1400 audit(1666258713.875:9): apparmor="STATUS" operation="profile_load" profile="unconfined" name="/usr/lib/connman/scripts/dhclient-script" pid=569 comm="apparmor_parser"
[ 13.390181] audit: type=1400 audit(1666258713.875:10): apparmor="STATUS" operation="profile_load" profile="unconfined" name="/{,usr/}sbin/dhclient" pid=569 comm="apparmor_parser"
[ 13.391217] audit: type=1400 audit(1666258713.883:11): apparmor="STATUS" operation="profile_load" profile="unconfined" name="/usr/lib/snapd/snap-confine" pid=566 comm="apparmor_parser"
[ 13.391217] audit: type=1400 audit(1666258713.883:11): apparmor="STATUS" operation="profile_load" profile="unconfined" name="/usr/lib/snapd/snap-confine//mount-namespace-capture-helper" pid=566 comm="apparmor_parser"
[ 16.493750] e1000: enp0s3 NIC Link is Up 1000 Mbps Full Duplex, Flow Control: RX
[ 16.497941] IPv6: ADDRCONF(NETDEV_CHANGE): enp0s3: link becomes ready
[ 17.750677] loop01: detected capacity change from 0 to 8
[ 18.201713] kaudited_printk_skb: 22 callbacks suppressed
[ 18.201716] audit: type=1400 audit(1666258718.691:34): apparmor="STATUS" operation="profile_replace" profile="unconfined" name="/snap/snapd/17336/usr/lib/snapd/snap-confine" pid=1054 comm="apparmor_parser"
[ 18.221779] audit: type=1400 audit(1666258718.711:35): apparmor="STATUS" operation="profile_replace" profile="unconfined" name="/snap/snapd/17336/usr/lib/snapd/snap-confine//mount-namespace-capture-helper" pid=1054 comm="apparmor_parser"
[ 19.259046] audit: type=1400 audit(1666258719.747:36): apparmor="STATUS" operation="profile_replace" info="same as current profile, skipping" profile="unconfined" name="snap-update-ns.snap-store" pid=1059 comm="apparmor_parser"
[ 19.273375] audit: type=1400 audit(1666258719.755:37): apparmor="STATUS" operation="profile_replace" info="same as current profile, skipping" profile="unconfined" name="snap.snap-store.hook.configure" pid=1137 comm="apparmor_parser"
[ 19.277478] audit: type=1400 audit(1666258719.755:38): apparmor="STATUS" operation="profile_replace" info="same as current profile, skipping" profile="unconfined" name="snap.snap-store.snap-store" pid=1138 comm="apparmor_parser"
[ 19.277824] audit: type=1400 audit(1666258719.755:39): apparmor="STATUS" operation="profile_replace" info="same as current profile, skipping" profile="unconfined" name="snap.snap-store.ubuntu-software-local-file" pid=1140 comm="apparmor_parser"
[ 19.284692] audit: type=1400 audit(1666258719.771:40): apparmor="STATUS" operation="profile_replace" info="same as current profile, skipping" profile="unconfined" name="snap.snap-store.ubuntu-software" pid=1139 comm="apparmor_parser"
[ 21.587471] rtkit: input handler disabled
[ 275.387469] Xin chao. Ten toi la Dang Minh Khoi B2007242
root@b2007242-VirtualBox:~/linux-5.19.15#
```

Hoàn tất.