Automating Linux Kernel Compilation with Shell Scripting

Version: 6.11.7

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Assignment: **03**

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Contents

1. Introduction

This report describes the approach taken to automate the Linux kernel compilation process using a Bash script, along with challenges encountered and solutions applied.

2. Approach

The primary steps in the Bash script `kernel_automator_TazmeenAfroz_22P-9252.sh` include:

- Downloading the specified kernel version from an official source.
- Verifying the integrity of the downloaded file.
- Extracting the kernel source code.
- Configuring the kernel settings, including disabling conflicting security certificates.
- Compiling the kernel and its modules.
- Installing the compiled kernel and updating the bootloader.

3. Step wise procedure

3.1. Downloading the kernal resource

```
echo "Downloading Linux kernel version $version..."
if wget $url -O $file_name; then
    echo "Kernel downloaded successfully."
else
    echo "Failed to download the kernel."
    exit 1
fi
```

3.2. Verifying the integrity

```
sha256sum $file_name
```

3.3. Extracting the Source Code and Change directory to the kernel source

```
echo "Extracting the kernel source."
if tar xvf $file_name; then
    echo "Kernel source extracted successfully."
else
    echo "Failed to extract the kernel source."
    exit 1
fi

cd $directory || {
echo "Kernel directory not found";
 exit 1;
 }
```

3.4. Installing Dependencies

```
echo "Installing dependencies."
if sudo apt-get install -y git fakeroot build-essential ncurses-dev xz-utils libssl-dev bc flex libelf-dev bison ; then
    echo "Dependencies installed successfully."
else
    echo "Failed to install dependencies."
    exit 1
fi
```

3.5. Configuring the Kernel

```
echo "Configuring the kernel."
if cp -v /boot/config-$(uname -r) .config; then
    echo "Existing system configuration copied."
else
    echo "Failed to copy the system configuration."
    exit 1
fi


# Disable conflicting security certificates

scripts/config --disable SYSTEM_TRUSTED_KEYS
```

```
scripts/config --disable SYSTEM_REVOCATION_KEYS
```

Launching menuconfig for kernel customization

```
echo "Launching menuconfig for kernel customization..."
if make menuconfig; then
    echo "Kernel configured successfully."
else
    echo "Kernel configuration failed."
    exit 1
fi
```

3.6. Compiling the Kernel

```
echo "Compiling the kernel."
if make -j$(nproc); then
    echo "Kernel compiled successfully."
else
    echo "Kernel compilation failed."
    exit 1
fi
```

3.7. Install kernel modules

```
echo "Installing kernel modules."
if sudo make modules_install;
then
    echo "Kernel modules installed successfully."
else
    echo "Failed to install kernel modules."
    exit 1
fi
```

3.8. Install the kernel

```
echo "Installing the kernel."
if sudo make install; then
    echo "Kernel installed successfully."
else
    echo "Kernel installation failed."
    exit 1
```

```
fi
```

3.9. Updating the Bootloader

```
echo "Updating the bootloader (GRUB)."
if sudo update-initramfs -c -k $version && sudo update-grub
   ; then
    echo "Bootloader updated successfully."
else
    echo "Failed to update the bootloader."
    exit 1
fi
```

3.10. Rebooting and Verification

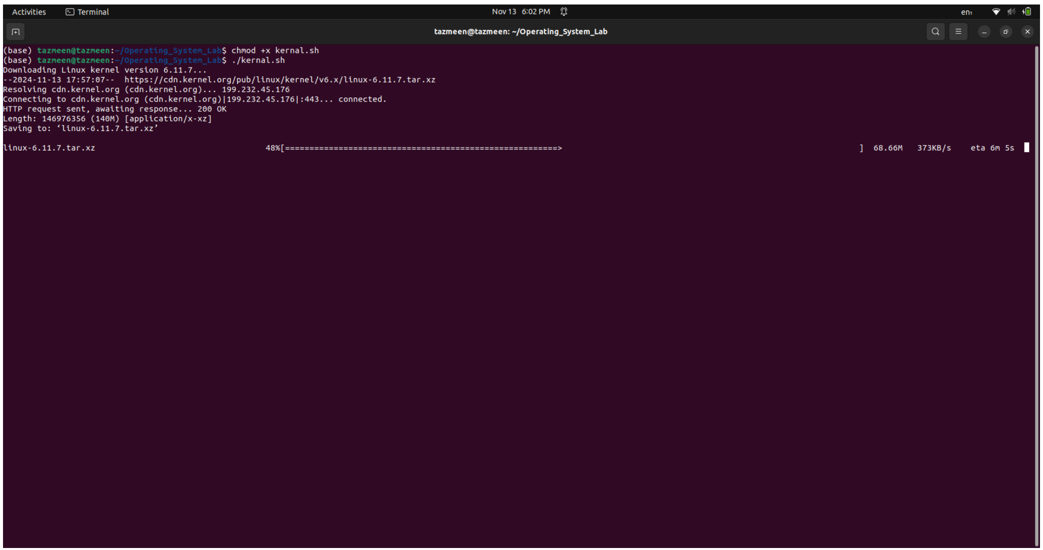
```
echo "Rebooting the system."
read -p "Press Y to reboot now or N to reboot later: "
   choice
if [[ $choice == "Y" || $choice == "y" ]]; then
    sudo reboot
else
    echo "Reboot manually to apply the new kernel."
fi
```

Upon rebooting, I confirmed that the new kernel was active by running:

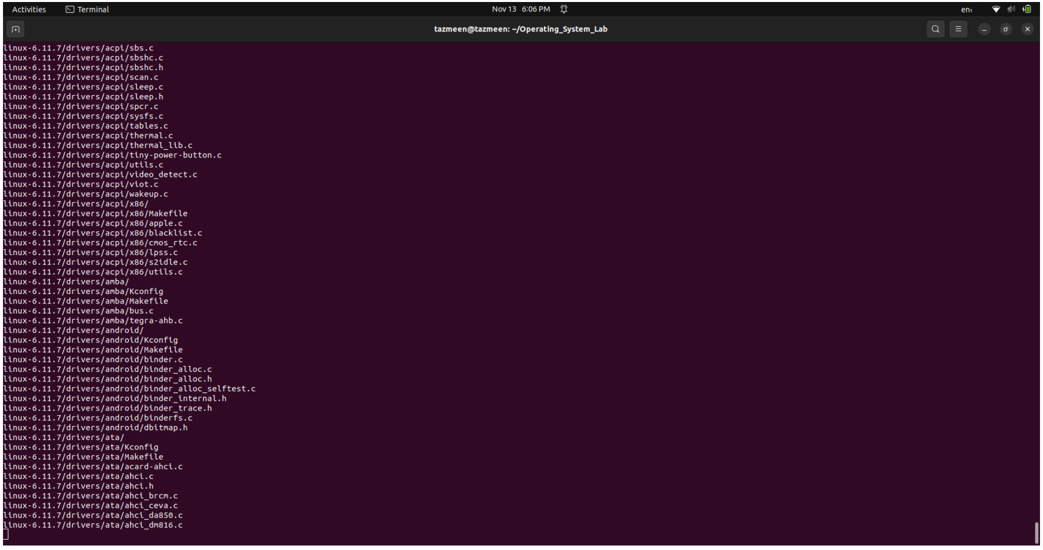
```
uname -r
```

4. Automation Process Screenshots

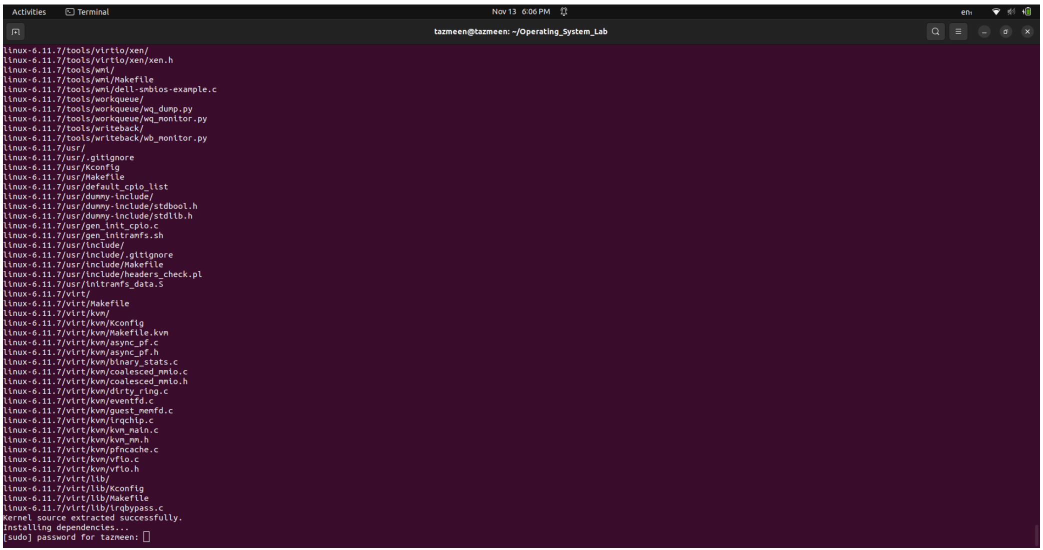
Below are screenshots taken during the automation process.



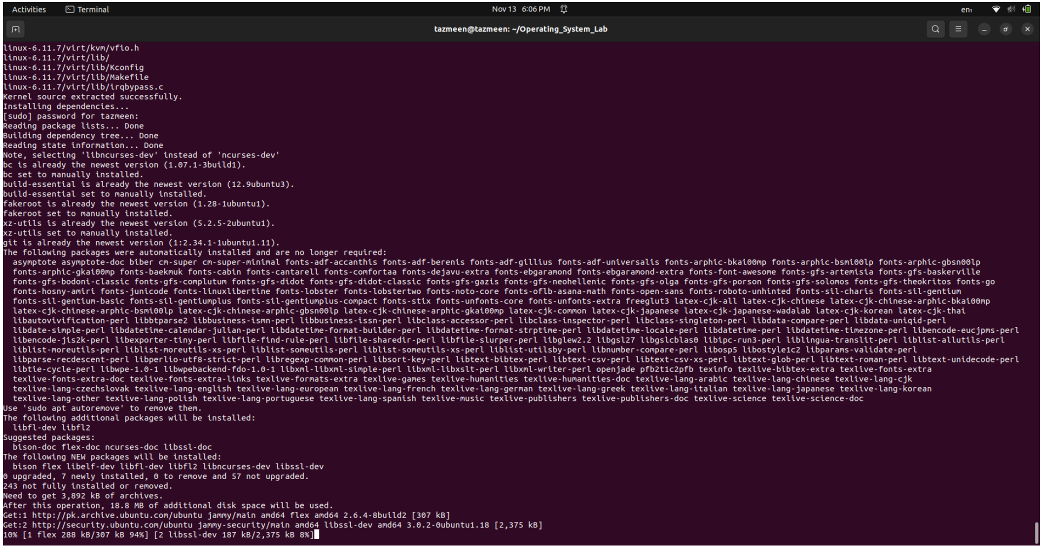
```
(base) tazmeen@tazmeen:~/Operating_System_Lab$ chmod +x kernal.sh
(base) tazmeen@tazmeen:~/Operating_System_Lab$ ./kernal.sh
Downloading Linux kernel version 6.11.7...
--2024-11-13 17:57:07--  https://cdn.kernel.org/pub/linux/kernel/v6.x/linux-6.11.7.tar.xz
Resolving cdn.kernel.org (cdn.kernel.org)... 199.232.45.176
Connecting to cdn.kernel.org (cdn.kernel.org)|199.232.45.176|:443... connected.
HTTP request sent, awaiting response... 200 OK
Length: 146976356 (140M) [application/x-xz]
Saving to: ‘linux-6.11.7.tar.xz’

linux-6.11.7.tar.xz                          48%[=========================================================>                                                    ]  68.66M   373KB/s    eta 6m 5s
```



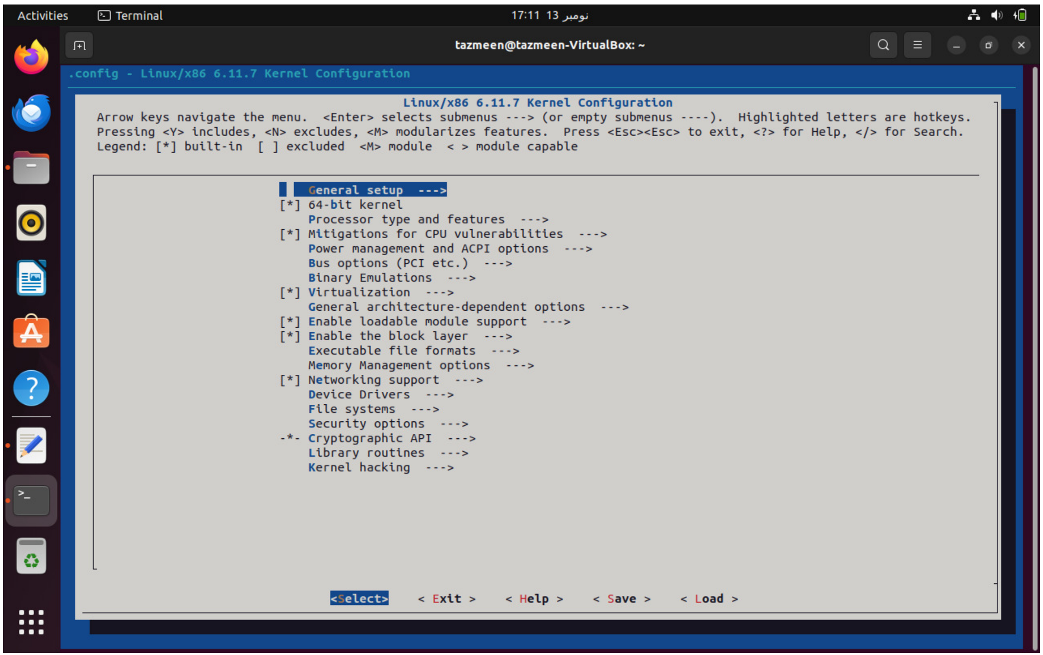
```
linux-6.11.7/drivers/acpi/sbs.c
linux-6.11.7/drivers/acpi/sbshc.c
linux-6.11.7/drivers/acpi/sbshc.h
linux-6.11.7/drivers/acpi/scan.c
linux-6.11.7/drivers/acpi/sleep.c
linux-6.11.7/drivers/acpi/sleep.h
linux-6.11.7/drivers/acpi/spcr.c
linux-6.11.7/drivers/acpi/sysfs.c
linux-6.11.7/drivers/acpi/tables.c
linux-6.11.7/drivers/acpi/thermal.c
linux-6.11.7/drivers/acpi/thermal_lib.c
linux-6.11.7/drivers/acpi/tiny-power-button.c
linux-6.11.7/drivers/acpi/utils.c
linux-6.11.7/drivers/acpi/video_detect.c
linux-6.11.7/drivers/acpi/viot.c
linux-6.11.7/drivers/acpi/wakeup.c
linux-6.11.7/drivers/acpi/x86/
linux-6.11.7/drivers/acpi/x86/Makefile
linux-6.11.7/drivers/acpi/x86/apple.c
linux-6.11.7/drivers/acpi/x86/blacklist.c
linux-6.11.7/drivers/acpi/x86/cmos_rtc.c
linux-6.11.7/drivers/acpi/x86/lpss.c
linux-6.11.7/drivers/acpi/x86/s2idle.c
linux-6.11.7/drivers/acpi/x86/utils.c
linux-6.11.7/drivers/amba/
linux-6.11.7/drivers/amba/Kconfig
linux-6.11.7/drivers/amba/Makefile
linux-6.11.7/drivers/amba/bus.c
linux-6.11.7/drivers/amba/tegra-ahb.c
linux-6.11.7/drivers/android/
linux-6.11.7/drivers/android/Kconfig
linux-6.11.7/drivers/android/Makefile
linux-6.11.7/drivers/android/binder.c
linux-6.11.7/drivers/android/binder_alloc.c
linux-6.11.7/drivers/android/binder_alloc.h
linux-6.11.7/drivers/android/binder_alloc_selftest.c
linux-6.11.7/drivers/android/binder_internal.h
linux-6.11.7/drivers/android/binder_trace.h
linux-6.11.7/drivers/android/binderfs.c
linux-6.11.7/drivers/android/dbitmap.h
linux-6.11.7/drivers/ata/
linux-6.11.7/drivers/ata/Kconfig
linux-6.11.7/drivers/ata/Makefile
linux-6.11.7/drivers/ata/acard-ahci.c
linux-6.11.7/drivers/ata/ahci.c
linux-6.11.7/drivers/ata/ahci.h
linux-6.11.7/drivers/ata/ahci_brcm.c
linux-6.11.7/drivers/ata/ahci_ceva.c
linux-6.11.7/drivers/ata/ahci_da850.c
linux-6.11.7/drivers/ata/ahci_dm816.c
```



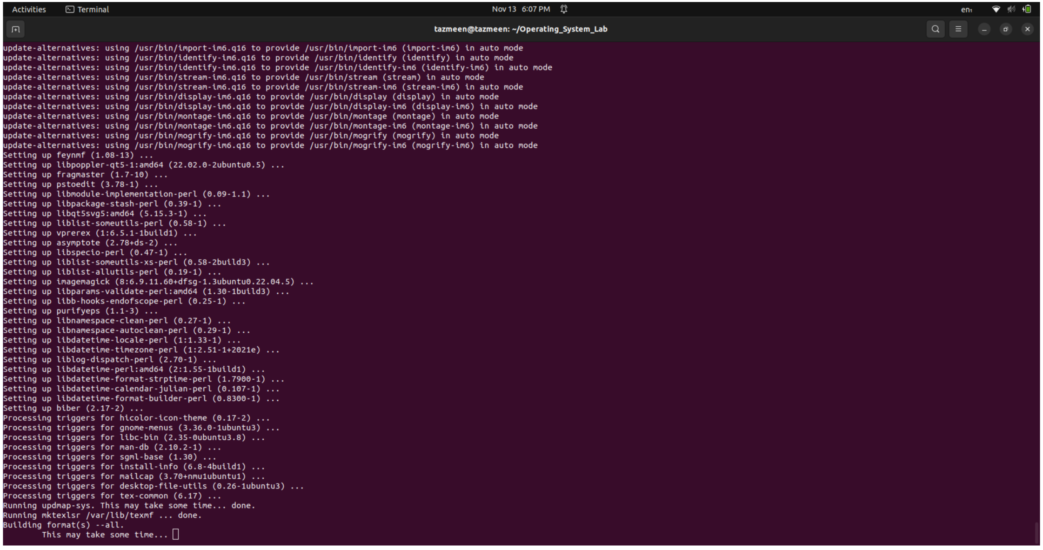
```
linux-6.11.7/tools/virtio/xen/
linux-6.11.7/tools/virtio/xen/xen.h
linux-6.11.7/tools/wmi/
linux-6.11.7/tools/wmi/Makefile
linux-6.11.7/tools/wmi/dell-smbios-example.c
linux-6.11.7/tools/workqueue/
linux-6.11.7/tools/workqueue/wq_dump.py
linux-6.11.7/tools/workqueue/wq_monitor.py
linux-6.11.7/tools/writeback/
linux-6.11.7/tools/writeback/wb_monitor.py
linux-6.11.7/usr/
linux-6.11.7/usr/.gitignore
linux-6.11.7/usr/Kconfig
linux-6.11.7/usr/Makefile
linux-6.11.7/usr/default_cpio_list
linux-6.11.7/usr/dummy-include/
linux-6.11.7/usr/dummy-include/stdbool.h
linux-6.11.7/usr/dummy-include/stdlib.h
linux-6.11.7/usr/gen_init_cpio.c
linux-6.11.7/usr/gen_initramfs.sh
linux-6.11.7/usr/include/
linux-6.11.7/usr/include/.gitignore
linux-6.11.7/usr/include/Makefile
linux-6.11.7/usr/include/headers_check.pl
linux-6.11.7/usr/initramfs_data.S
linux-6.11.7/virt/
linux-6.11.7/virt/Makefile
linux-6.11.7/virt/kvm/
linux-6.11.7/virt/kvm/Kconfig
linux-6.11.7/virt/kvm/Makefile.kvm
linux-6.11.7/virt/kvm/async_pf.c
linux-6.11.7/virt/kvm/async_pf.h
linux-6.11.7/virt/kvm/binary_stats.c
linux-6.11.7/virt/kvm/coalesced_mmio.c
linux-6.11.7/virt/kvm/coalesced_mmio.h
linux-6.11.7/virt/kvm/dirty_ring.c
linux-6.11.7/virt/kvm/eventfd.c
linux-6.11.7/virt/kvm/guest_memfd.c
linux-6.11.7/virt/kvm/irqchip.c
linux-6.11.7/virt/kvm/kvm_main.c
linux-6.11.7/virt/kvm/kvm_mm.h
linux-6.11.7/virt/kvm/pfncache.c
linux-6.11.7/virt/kvm/vfio.c
linux-6.11.7/virt/kvm/vfio.h
linux-6.11.7/virt/lib/
linux-6.11.7/virt/lib/Kconfig
linux-6.11.7/virt/lib/Makefile
linux-6.11.7/virt/lib/irqbypass.c
Kernel source extracted successfully.
Installing dependencies...
[sudo] password for tazmeen: 
```



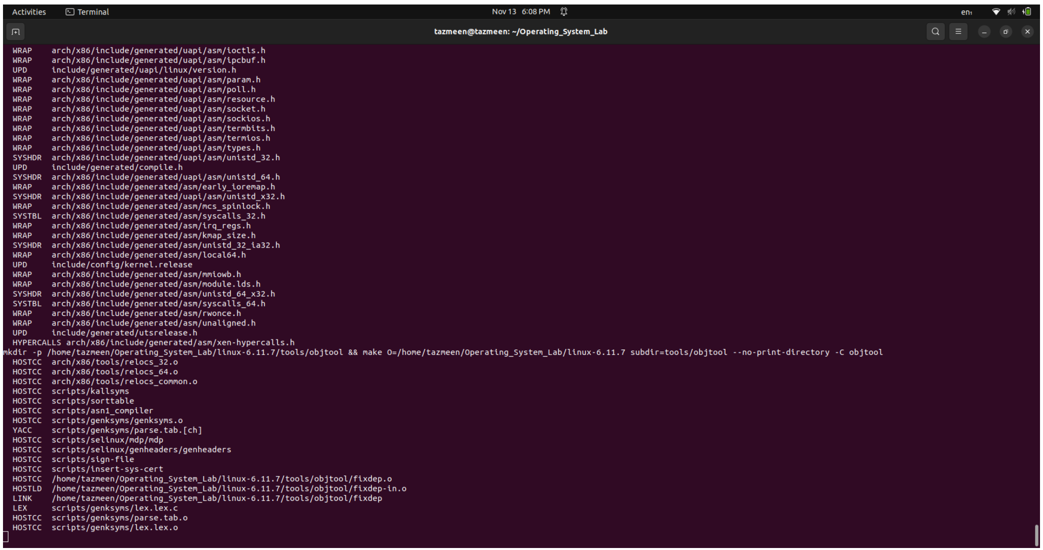
```
linux-6.11.7/virt/kvm/vfio.h
linux-6.11.7/virt/lib/
linux-6.11.7/virt/lib/Kconfig
linux-6.11.7/virt/lib/Makefile
linux-6.11.7/virt/lib/irqbypass.c
Kernel source extracted successfully.
Installing dependencies...
[sudo] password for tazmeen:
Reading package lists... Done
Building dependency tree... Done
Reading state information... Done
Note, selecting 'libncurses-dev' instead of 'ncurses-dev'
bc is already the newest version (1.07.1-3build1).
bc set to manually installed.
build-essential is already the newest version (12.9ubuntu3).
build-essential set to manually installed.
fakeroot is already the newest version (1.28-1ubuntu1).
fakeroot set to manually installed.
xz-utils is already the newest version (5.2.5-2ubuntu1).
xz-utils set to manually installed.
git is already the newest version (1:2.34.1-1ubuntu1.11).
The following packages were automatically installed and are no longer required:
  asymptote asymptote-doc biber cm-super cm-super-minimal fonts-adf-accanthis fonts-adf-berenis fonts-adf-gillius fonts-adf-universalis fonts-arphic-bkai00mp fonts-arphic-bsmi00lp fonts-arphic-gbsn00lp
  fonts-arphic-gkai00mp fonts-baekmuk fonts-cabin fonts-cantarell fonts-comfortaa fonts-dejavu-extra fonts-ebgaramond fonts-ebgaramond-extra fonts-font-awesome fonts-gfs-artemisia fonts-gfs-baskerville
  fonts-gfs-bodoni-classic fonts-gfs-complutum fonts-gfs-didot fonts-gfs-didot-classic fonts-gfs-gazis fonts-gfs-neohellenic fonts-gfs-olga fonts-gfs-porson fonts-gfs-solomos fonts-gfs-theokritos fonts-go
  fonts-hosny-amiri fonts-junicode fonts-linuxlibertine fonts-lobster fonts-lobstertwo fonts-noto-core fonts-oflb-asana-math fonts-open-sans fonts-roboto-unhinted fonts-sil-charis fonts-sil-gentium
  fonts-sil-gentium-basic fonts-sil-gentiumplus fonts-sil-gentiumplus-compact fonts-stix fonts-unfonts-core fonts-unfonts-extra freeglut3 latex-cjk-all latex-cjk-chinese latex-cjk-chinese-arphic-bkai00mp
  latex-cjk-chinese-arphic-bsmi00lp latex-cjk-chinese-arphic-gbsn00lp latex-cjk-chinese-arphic-gkai00mp latex-cjk-common latex-cjk-japanese latex-cjk-japanese-wadalab latex-cjk-korean latex-cjk-thai
  libautovivification-perl libbtparse2 libbusiness-ismn-perl libbusiness-issn-perl libclass-accessor-perl libclass-inspector-perl libclass-singleton-perl libdata-compare-perl libdata-uniqid-perl
  libdate-simple-perl libdatetime-calendar-julian-perl libdatetime-format-builder-perl libdatetime-format-strptime-perl libdatetime-locale-perl libdatetime-perl libdatetime-timezone-perl libencode-eucjpms-perl
  libencode-jis2k-perl libexporter-tiny-perl libfile-find-rule-perl libfile-sharedir-perl libfile-slurper-perl libglew2.2 libgsl27 libgslcblas0 libipc-run3-perl liblingua-translit-perl liblist-allutils-perl
  liblist-moreutils-perl liblist-moreutils-xs-perl liblist-someutils-perl liblist-someutils-xs-perl liblist-utilsby-perl libnumber-compare-perl libosp5 libostyle1c2 libparams-validate-perl
  libparse-recdescent-perl libperlio-utf8-strict-perl libregexp-common-perl libsort-key-perl libtext-bibtex-perl libtext-csv-perl libtext-csv-xs-perl libtext-glob-perl libtext-roman-perl libtext-unidecode-perl
  libtie-cycle-perl libwpe-1.0-1 libwpebackend-fdo-1.0-1 libxml-libxml-simple-perl libxml-libxslt-perl libxml-writer-perl openjade pfb2t1c2pfb texinfo texlive-bibtex-extra texlive-fonts-extra
  texlive-fonts-extra-doc texlive-fonts-extra-links texlive-formats-extra texlive-games texlive-humanities texlive-humanities-doc texlive-lang-arabic texlive-lang-chinese texlive-lang-cjk
  texlive-lang-czechslovak texlive-lang-english texlive-lang-european texlive-lang-french texlive-lang-german texlive-lang-greek texlive-lang-italian texlive-lang-japanese texlive-lang-korean
  texlive-lang-other texlive-lang-polish texlive-lang-portuguese texlive-lang-spanish texlive-music texlive-publishers texlive-publishers-doc texlive-science texlive-science-doc
Use 'sudo apt autoremove' to remove them.
The following additional packages will be installed:
  libfl-dev libfl2
Suggested packages:
  bison-doc flex-doc ncurses-doc libssl-doc
The following NEW packages will be installed:
  bison flex libelf-dev libfl-dev libfl2 libncurses-dev libssl-dev
0 upgraded, 7 newly installed, 0 to remove and 57 not upgraded.
243 not fully installed or removed.
Need to get 3,892 kB of archives.
After this operation, 18.8 MB of additional disk space will be used.
Get:1 http://pk.archive.ubuntu.com/ubuntu jammy/main amd64 flex amd64 2.6.4-8build2 [307 kB]
Get:2 http://security.ubuntu.com/ubuntu jammy-security/main amd64 libssl-dev amd64 3.0.2-0ubuntu1.18 [2,375 kB]
10% [1 flex 288 kB/307 kB 94%] [2 libssl-dev 187 kB/2,375 kB 8%]
```



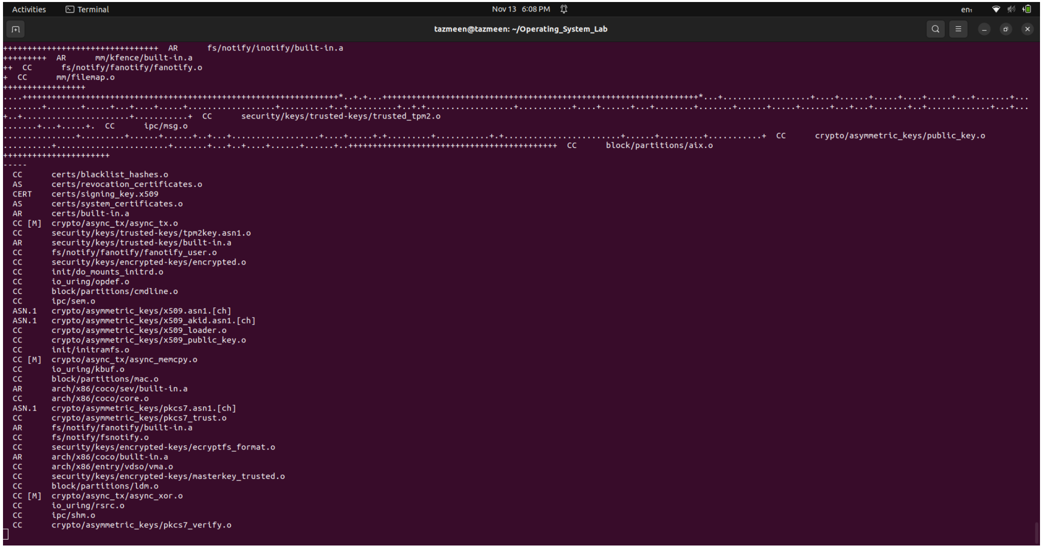
```
.config - Linux/x86 6.11.7 Kernel Configuration
                          Linux/x86 6.11.7 Kernel Configuration
  Arrow keys navigate the menu.  <Enter> selects submenus ---> (or empty submenus ----).  Highlighted letters are hotkeys.
  Pressing <Y> includes, <N> excludes, <M> modularizes features.  Press <Esc><Esc> to exit, <?> for Help, </> for Search.
  Legend: [*] built-in  [ ] excluded  <M> module  < > module capable

                            General setup  --->
                        [*] 64-bit kernel
                            Processor type and features  --->
                        [*] Mitigations for CPU vulnerabilities  --->
                            Power management and ACPI options  --->
                            Bus options (PCI etc.)  --->
                            Binary Emulations  --->
                        [*] Virtualization  --->
                            General architecture-dependent options  --->
                        [*] Enable loadable module support  --->
                        [*] Enable the block layer  --->
                            Executable file formats  --->
                            Memory Management options  --->
                        [*] Networking support  --->
                            Device Drivers  --->
                            File systems  --->
                            Security options  --->
                        -*- Cryptographic API  --->
                            Library routines  --->
                            Kernel hacking  --->

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



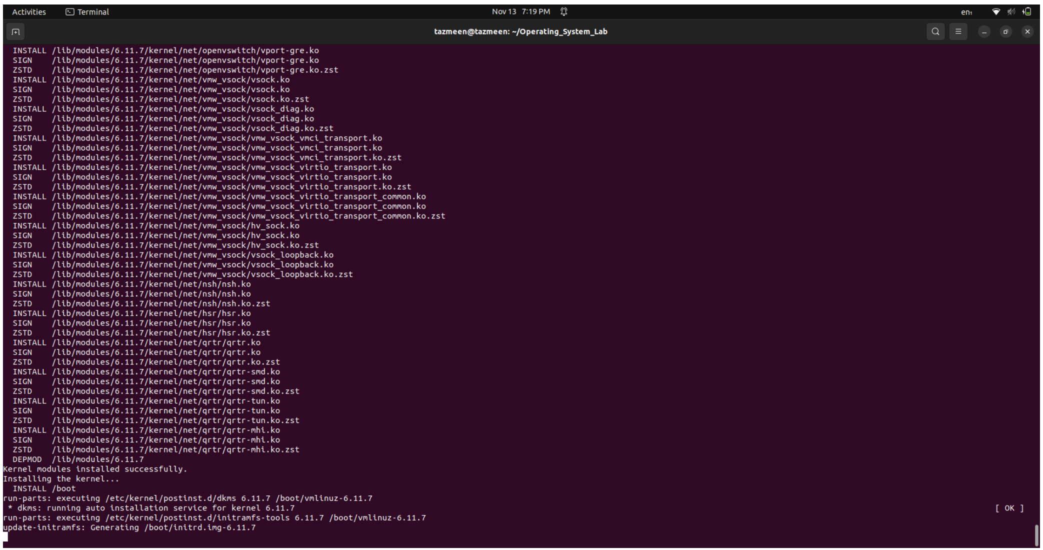
```
update-alternatives: using /usr/bin/import-im6.q16 to provide /usr/bin/import-im6 (import-im6) in auto mode
update-alternatives: using /usr/bin/identify-im6.q16 to provide /usr/bin/identify (identify) in auto mode
update-alternatives: using /usr/bin/identify-im6.q16 to provide /usr/bin/identify-im6 (identify-im6) in auto mode
update-alternatives: using /usr/bin/stream-im6.q16 to provide /usr/bin/stream (stream) in auto mode
update-alternatives: using /usr/bin/stream-im6.q16 to provide /usr/bin/stream-im6 (stream-im6) in auto mode
update-alternatives: using /usr/bin/display-im6.q16 to provide /usr/bin/display (display) in auto mode
update-alternatives: using /usr/bin/display-im6.q16 to provide /usr/bin/display-im6 (display-im6) in auto mode
update-alternatives: using /usr/bin/montage-im6.q16 to provide /usr/bin/montage (montage) in auto mode
update-alternatives: using /usr/bin/montage-im6.q16 to provide /usr/bin/montage-im6 (montage-im6) in auto mode
update-alternatives: using /usr/bin/mogrify-im6.q16 to provide /usr/bin/mogrify (mogrify) in auto mode
update-alternatives: using /usr/bin/mogrify-im6.q16 to provide /usr/bin/mogrify-im6 (mogrify-im6) in auto mode
Setting up feynmf (1.08-13) ...
Setting up libpoppler-qt5-1:amd64 (22.02.0-2ubuntu0.5) ...
Setting up fragmaster (1.7-10) ...
Setting up pstoedit (3.78-1) ...
Setting up libmodule-implementation-perl (0.09-1.1) ...
Setting up libpackage-stash-perl (0.39-1) ...
Setting up libqt5svg5:amd64 (5.15.3-1) ...
Setting up liblist-someutils-perl (0.58-1) ...
Setting up vprerex (1:6.5.1-1build1) ...
Setting up asymptote (2.78+ds-2) ...
Setting up libspecio-perl (0.47-1) ...
Setting up liblist-someutils-xs-perl (0.58-2build3) ...
Setting up liblist-allutils-perl (0.19-1) ...
Setting up imagemagick (8:6.9.11.60+dfsg-1.3ubuntu0.22.04.5) ...
Setting up libparams-validate-perl:amd64 (1.30-1build3) ...
Setting up libb-hooks-endofscope-perl (0.25-1) ...
Setting up purifyeps (1.1-3) ...
Setting up libnamespace-clean-perl (0.27-1) ...
Setting up libnamespace-autoclean-perl (0.29-1) ...
Setting up libdatetime-locale-perl (1:1.33-1) ...
Setting up libdatetime-timezone-perl (1:2.51-1+2021e) ...
Setting up liblog-dispatch-perl (2.70-1) ...
Setting up libdatetime-perl:amd64 (2:1.55-1build1) ...
Setting up libdatetime-format-strptime-perl (1.7900-1) ...
Setting up libdatetime-calendar-julian-perl (0.107-1) ...
Setting up libdatetime-format-builder-perl (0.8300-1) ...
Setting up biber (2.17-2) ...
Processing triggers for hicolor-icon-theme (0.17-2) ...
Processing triggers for gnome-menus (3.36.0-1ubuntu3) ...
Processing triggers for libc-bin (2.35-0ubuntu3.8) ...
Processing triggers for man-db (2.10.2-1) ...
Processing triggers for sgml-base (1.30) ...
Processing triggers for install-info (6.8-4build1) ...
Processing triggers for mailcap (3.70+nmu1ubuntu1) ...
Processing triggers for desktop-file-utils (0.26-1ubuntu3) ...
Processing triggers for tex-common (6.17) ...
Running updmap-sys. This may take some time... done.
Running mktexlsr /var/lib/texmf ... done.
Building format(s) --all.
        This may take some time... 
```



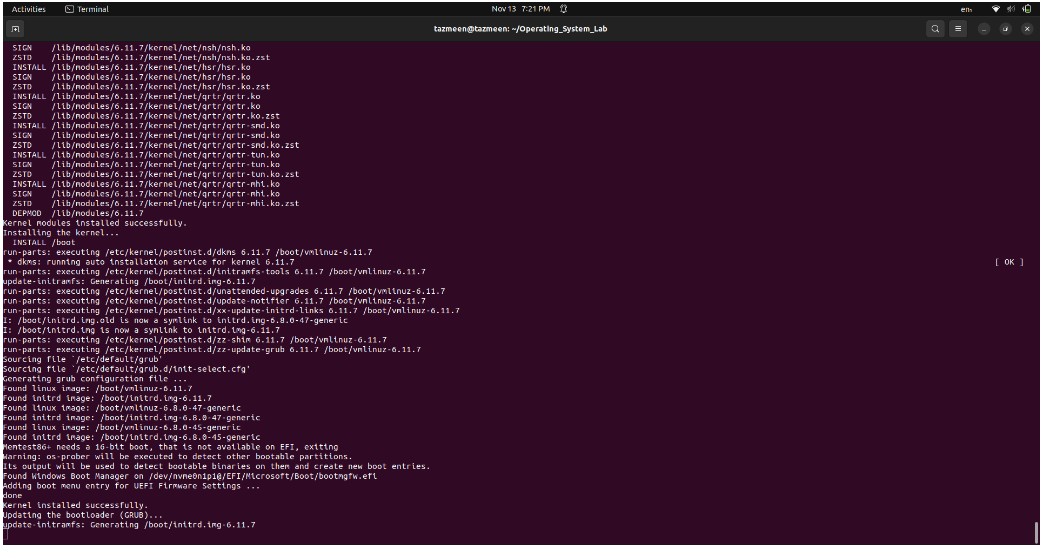
```
  WRAP    arch/x86/include/generated/uapi/asm/ioctls.h
  WRAP    arch/x86/include/generated/uapi/asm/ipcbuf.h
  UPD     include/generated/uapi/linux/version.h
  WRAP    arch/x86/include/generated/uapi/asm/param.h
  WRAP    arch/x86/include/generated/uapi/asm/poll.h
  WRAP    arch/x86/include/generated/uapi/asm/resource.h
  WRAP    arch/x86/include/generated/uapi/asm/socket.h
  WRAP    arch/x86/include/generated/uapi/asm/sockios.h
  WRAP    arch/x86/include/generated/uapi/asm/termbits.h
  WRAP    arch/x86/include/generated/uapi/asm/termios.h
  WRAP    arch/x86/include/generated/uapi/asm/types.h
  SYSHDR  arch/x86/include/generated/uapi/asm/unistd_32.h
  UPD     include/generated/compile.h
  SYSHDR  arch/x86/include/generated/uapi/asm/unistd_64.h
  WRAP    arch/x86/include/generated/asm/early_ioremap.h
  SYSHDR  arch/x86/include/generated/uapi/asm/unistd_x32.h
  WRAP    arch/x86/include/generated/asm/mcs_spinlock.h
  SYSTBL  arch/x86/include/generated/asm/syscalls_32.h
  WRAP    arch/x86/include/generated/asm/irq_regs.h
  WRAP    arch/x86/include/generated/asm/kmap_size.h
  SYSHDR  arch/x86/include/generated/asm/unistd_32_ia32.h
  WRAP    arch/x86/include/generated/asm/local64.h
  UPD     include/config/kernel.release
  WRAP    arch/x86/include/generated/asm/mmiowb.h
  WRAP    arch/x86/include/generated/asm/module.lds.h
  SYSHDR  arch/x86/include/generated/asm/unistd_64_x32.h
  SYSTBL  arch/x86/include/generated/asm/syscalls_64.h
  WRAP    arch/x86/include/generated/asm/rwonce.h
  WRAP    arch/x86/include/generated/asm/unaligned.h
  UPD     include/generated/utsrelease.h
  HYPERCALLS arch/x86/include/generated/asm/xen-hypercalls.h
mkdir -p /home/tazmeen/Operating_System_Lab/linux-6.11.7/tools/objtool && make O=/home/tazmeen/Operating_System_Lab/linux-6.11.7 subdir=tools/objtool --no-print-directory -C objtool
  HOSTCC  arch/x86/tools/relocs_32.o
  HOSTCC  arch/x86/tools/relocs_64.o
  HOSTCC  arch/x86/tools/relocs_common.o
  HOSTCC  scripts/kallsyms
  HOSTCC  scripts/sorttable
  HOSTCC  scripts/asn1_compiler
  HOSTCC  scripts/genksyms/genksyms.o
  YACC    scripts/genksyms/parse.tab.[ch]
  HOSTCC  scripts/selinux/mdp/mdp
  HOSTCC  scripts/selinux/genheaders/genheaders
  HOSTCC  scripts/sign-file
  HOSTCC  scripts/insert-sys-cert
  HOSTCC  /home/tazmeen/Operating_System_Lab/linux-6.11.7/tools/objtool/fixdep.o
  HOSTLD  /home/tazmeen/Operating_System_Lab/linux-6.11.7/tools/objtool/fixdep-in.o
  LINK    /home/tazmeen/Operating_System_Lab/linux-6.11.7/tools/objtool/fixdep
  LEX     scripts/genksyms/lex.lex.c
  HOSTCC  scripts/genksyms/parse.tab.o
  HOSTCC  scripts/genksyms/lex.lex.o
```



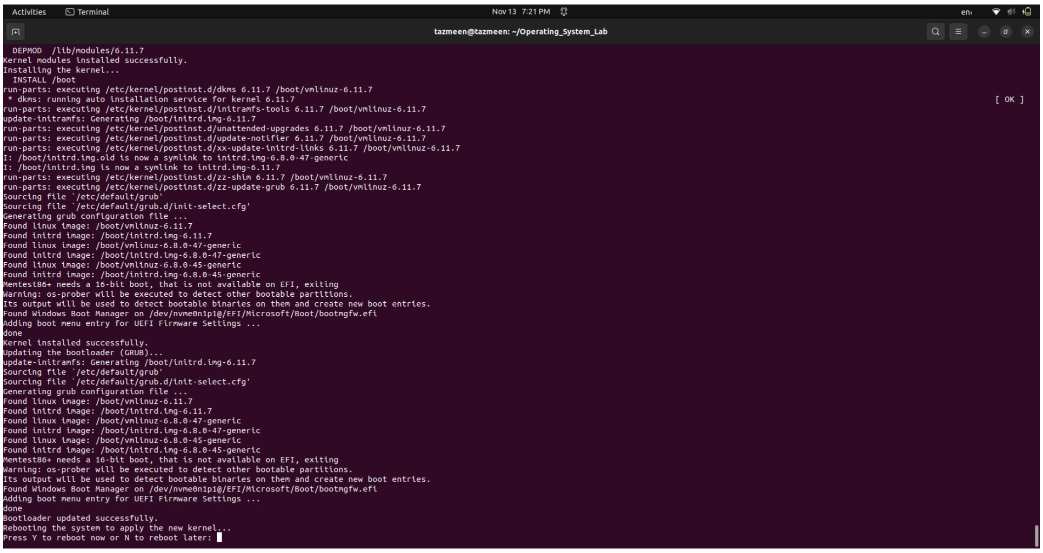
```
++++++++++++++++++++++++++++++++  AR      fs/notify/inotify/built-in.a
+++++++++  AR      mm/kfence/built-in.a
++  CC      fs/notify/fanotify/fanotify.o
+  CC      mm/filemap.o
+++++++++++++++++
....+++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++*..+.+...++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++*...+.................+....+......+.....+....+.....+...+.......+...
........+.......+.....+...+....+.....+.................+..........+..+..........+..+.+.................+...........+..........+....+......+...+........+.......+......+.....+......+...+...+.......+..+.............+...+...
+..+......................+...........+  CC      security/keys/trusted-keys/trusted_tpm2.o
.......+...+.....+.  CC      ipc/msg.o
...............+.........+......+......+..+...+.................+....+.....+.+.........+..........+.+...........+.+.......................+......+.........+..........+  CC      crypto/asymmetric_keys/public_key.o
..........+.......................+.......+...+..+....+......+......+..+++++++++++++++++++++++++++++++++++++++++++++++++++++  CC      block/partitions/aix.o
++++++++++++++++++++++
-----
  CC      certs/blacklist_hashes.o
  AS      certs/revocation_certificates.o
  CERT    certs/signing_key.x509
  AS      certs/system_certificates.o
  AR      certs/built-in.a
  CC [M]  crypto/async_tx/async_tx.o
  CC      security/keys/trusted-keys/tpm2key.asn1.o
  AR      security/keys/trusted-keys/built-in.a
  CC      fs/notify/fanotify/fanotify_user.o
  CC      security/keys/encrypted-keys/encrypted.o
  CC      init/do_mounts_initrd.o
  CC      io_uring/opdef.o
  CC      block/partitions/cmdline.o
  CC      ipc/sem.o
  ASN.1   crypto/asymmetric_keys/x509.asn1.[ch]
  ASN.1   crypto/asymmetric_keys/x509_akid.asn1.[ch]
  CC      crypto/asymmetric_keys/x509_loader.o
  CC      crypto/asymmetric_keys/x509_public_key.o
  CC      init/initramfs.o
  CC [M]  crypto/async_tx/async_memcpy.o
  CC      io_uring/kbuf.o
  CC      block/partitions/mac.o
  AR      arch/x86/coco/sev/built-in.a
  CC      arch/x86/coco/core.o
  ASN.1   crypto/asymmetric_keys/pkcs7.asn1.[ch]
  CC      crypto/asymmetric_keys/pkcs7_trust.o
  AR      fs/notify/fanotify/built-in.a
  CC      fs/notify/fsnotify.o
  CC      security/keys/encrypted-keys/ecryptfs_format.o
  AR      arch/x86/coco/built-in.a
  CC      arch/x86/entry/vdso/vma.o
  CC      security/keys/encrypted-keys/masterkey_trusted.o
  CC      block/partitions/ldm.o
  CC [M]  crypto/async_tx/async_xor.o
  CC      io_uring/rsrc.o
  CC      ipc/shm.o
  CC      crypto/asymmetric_keys/pkcs7_verify.o
```



```
  INSTALL /lib/modules/6.11.7/kernel/net/openvswitch/vport-gre.ko
  SIGN    /lib/modules/6.11.7/kernel/net/openvswitch/vport-gre.ko
  ZSTD    /lib/modules/6.11.7/kernel/net/openvswitch/vport-gre.ko.zst
  INSTALL /lib/modules/6.11.7/kernel/net/vmw_vsock/vsock.ko
  SIGN    /lib/modules/6.11.7/kernel/net/vmw_vsock/vsock.ko
  ZSTD    /lib/modules/6.11.7/kernel/net/vmw_vsock/vsock.ko.zst
  INSTALL /lib/modules/6.11.7/kernel/net/vmw_vsock/vsock_diag.ko
  SIGN    /lib/modules/6.11.7/kernel/net/vmw_vsock/vsock_diag.ko
  ZSTD    /lib/modules/6.11.7/kernel/net/vmw_vsock/vsock_diag.ko.zst
  INSTALL /lib/modules/6.11.7/kernel/net/vmw_vsock/vmw_vsock_vmci_transport.ko
  SIGN    /lib/modules/6.11.7/kernel/net/vmw_vsock/vmw_vsock_vmci_transport.ko
  ZSTD    /lib/modules/6.11.7/kernel/net/vmw_vsock/vmw_vsock_vmci_transport.ko.zst
  INSTALL /lib/modules/6.11.7/kernel/net/vmw_vsock/vmw_vsock_virtio_transport.ko
  SIGN    /lib/modules/6.11.7/kernel/net/vmw_vsock/vmw_vsock_virtio_transport.ko
  ZSTD    /lib/modules/6.11.7/kernel/net/vmw_vsock/vmw_vsock_virtio_transport.ko.zst
  INSTALL /lib/modules/6.11.7/kernel/net/vmw_vsock/vmw_vsock_virtio_transport_common.ko
  SIGN    /lib/modules/6.11.7/kernel/net/vmw_vsock/vmw_vsock_virtio_transport_common.ko
  ZSTD    /lib/modules/6.11.7/kernel/net/vmw_vsock/vmw_vsock_virtio_transport_common.ko.zst
  INSTALL /lib/modules/6.11.7/kernel/net/vmw_vsock/hv_sock.ko
  SIGN    /lib/modules/6.11.7/kernel/net/vmw_vsock/hv_sock.ko
  ZSTD    /lib/modules/6.11.7/kernel/net/vmw_vsock/hv_sock.ko.zst
  INSTALL /lib/modules/6.11.7/kernel/net/vmw_vsock/vsock_loopback.ko
  SIGN    /lib/modules/6.11.7/kernel/net/vmw_vsock/vsock_loopback.ko
  ZSTD    /lib/modules/6.11.7/kernel/net/vmw_vsock/vsock_loopback.ko.zst
  INSTALL /lib/modules/6.11.7/kernel/net/nsh/nsh.ko
  SIGN    /lib/modules/6.11.7/kernel/net/nsh/nsh.ko
  ZSTD    /lib/modules/6.11.7/kernel/net/nsh/nsh.ko.zst
  INSTALL /lib/modules/6.11.7/kernel/net/hsr/hsr.ko
  SIGN    /lib/modules/6.11.7/kernel/net/hsr/hsr.ko
  ZSTD    /lib/modules/6.11.7/kernel/net/hsr/hsr.ko.zst
  INSTALL /lib/modules/6.11.7/kernel/net/qrtr/qrtr.ko
  SIGN    /lib/modules/6.11.7/kernel/net/qrtr/qrtr.ko
  ZSTD    /lib/modules/6.11.7/kernel/net/qrtr/qrtr.ko.zst
  INSTALL /lib/modules/6.11.7/kernel/net/qrtr/qrtr-smd.ko
  SIGN    /lib/modules/6.11.7/kernel/net/qrtr/qrtr-smd.ko
  ZSTD    /lib/modules/6.11.7/kernel/net/qrtr/qrtr-smd.ko.zst
  INSTALL /lib/modules/6.11.7/kernel/net/qrtr/qrtr-tun.ko
  SIGN    /lib/modules/6.11.7/kernel/net/qrtr/qrtr-tun.ko
  ZSTD    /lib/modules/6.11.7/kernel/net/qrtr/qrtr-tun.ko.zst
  INSTALL /lib/modules/6.11.7/kernel/net/qrtr/qrtr-mhi.ko
  SIGN    /lib/modules/6.11.7/kernel/net/qrtr/qrtr-mhi.ko
  ZSTD    /lib/modules/6.11.7/kernel/net/qrtr/qrtr-mhi.ko.zst
  DEPMOD  /lib/modules/6.11.7
Kernel modules installed successfully.
Installing the kernel...
  INSTALL /boot
run-parts: executing /etc/kernel/postinst.d/dkms 6.11.7 /boot/vmlinuz-6.11.7
 * dkms: running auto installation service for kernel 6.11.7                                     [ OK ]
run-parts: executing /etc/kernel/postinst.d/initramfs-tools 6.11.7 /boot/vmlinuz-6.11.7
update-initramfs: Generating /boot/initrd.img-6.11.7
```



```
  SIGN    /lib/modules/6.11.7/kernel/net/nsh/nsh.ko
  ZSTD    /lib/modules/6.11.7/kernel/net/nsh/nsh.ko.zst
  INSTALL /lib/modules/6.11.7/kernel/net/hsr/hsr.ko
  SIGN    /lib/modules/6.11.7/kernel/net/hsr/hsr.ko
  ZSTD    /lib/modules/6.11.7/kernel/net/hsr/hsr.ko.zst
  INSTALL /lib/modules/6.11.7/kernel/net/qrtr/qrtr.ko
  SIGN    /lib/modules/6.11.7/kernel/net/qrtr/qrtr.ko
  ZSTD    /lib/modules/6.11.7/kernel/net/qrtr/qrtr.ko.zst
  INSTALL /lib/modules/6.11.7/kernel/net/qrtr/qrtr-smd.ko
  SIGN    /lib/modules/6.11.7/kernel/net/qrtr/qrtr-smd.ko
  ZSTD    /lib/modules/6.11.7/kernel/net/qrtr/qrtr-smd.ko.zst
  INSTALL /lib/modules/6.11.7/kernel/net/qrtr/qrtr-tun.ko
  SIGN    /lib/modules/6.11.7/kernel/net/qrtr/qrtr-tun.ko
  ZSTD    /lib/modules/6.11.7/kernel/net/qrtr/qrtr-tun.ko.zst
  INSTALL /lib/modules/6.11.7/kernel/net/qrtr/qrtr-mhi.ko
  SIGN    /lib/modules/6.11.7/kernel/net/qrtr/qrtr-mhi.ko
  ZSTD    /lib/modules/6.11.7/kernel/net/qrtr/qrtr-mhi.ko.zst
  DEPMOD  /lib/modules/6.11.7
Kernel modules installed successfully.
Installing the kernel...
  INSTALL /boot
run-parts: executing /etc/kernel/postinst.d/dkms 6.11.7 /boot/vmlinuz-6.11.7
 * dkms: running auto installation service for kernel 6.11.7                                     [ OK ]
run-parts: executing /etc/kernel/postinst.d/initramfs-tools 6.11.7 /boot/vmlinuz-6.11.7
update-initramfs: Generating /boot/initrd.img-6.11.7
run-parts: executing /etc/kernel/postinst.d/unattended-upgrades 6.11.7 /boot/vmlinuz-6.11.7
run-parts: executing /etc/kernel/postinst.d/update-notifier 6.11.7 /boot/vmlinuz-6.11.7
run-parts: executing /etc/kernel/postinst.d/xx-update-initrd-links 6.11.7 /boot/vmlinuz-6.11.7
I: /boot/initrd.img.old is now a symlink to initrd.img-6.8.0-47-generic
I: /boot/initrd.img is now a symlink to initrd.img-6.11.7
run-parts: executing /etc/kernel/postinst.d/zz-shim 6.11.7 /boot/vmlinuz-6.11.7
run-parts: executing /etc/kernel/postinst.d/zz-update-grub 6.11.7 /boot/vmlinuz-6.11.7
Sourcing file `/etc/default/grub'
Sourcing file `/etc/default/grub.d/init-select.cfg'
Generating grub configuration file ...
Found linux image: /boot/vmlinuz-6.11.7
Found initrd image: /boot/initrd.img-6.11.7
Found linux image: /boot/vmlinuz-6.8.0-47-generic
Found initrd image: /boot/initrd.img-6.8.0-47-generic
Found linux image: /boot/vmlinuz-6.8.0-45-generic
Found initrd image: /boot/initrd.img-6.8.0-45-generic
Memtest86+ needs a 16-bit boot, that is not available on EFI, exiting
Warning: os-prober will be executed to detect other bootable partitions.
Its output will be used to detect bootable binaries on them and create new boot entries.
Found Windows Boot Manager on /dev/nvme0n1p1@/EFI/Microsoft/Boot/bootmgfw.efi
Adding boot menu entry for UEFI Firmware Settings ...
done
Kernel installed successfully.
Updating the bootloader (GRUB)...
update-initramfs: Generating /boot/initrd.img-6.11.7
```



```
  DEPMOD  /lib/modules/6.11.7
Kernel modules installed successfully.
Installing the kernel...
  INSTALL /boot
run-parts: executing /etc/kernel/postinst.d/dkms 6.11.7 /boot/vmlinuz-6.11.7
 * dkms: running auto installation service for kernel 6.11.7                                                                              [ OK ]
run-parts: executing /etc/kernel/postinst.d/initramfs-tools 6.11.7 /boot/vmlinuz-6.11.7
update-initramfs: Generating /boot/initrd.img-6.11.7
run-parts: executing /etc/kernel/postinst.d/unattended-upgrades 6.11.7 /boot/vmlinuz-6.11.7
run-parts: executing /etc/kernel/postinst.d/update-notifier 6.11.7 /boot/vmlinuz-6.11.7
run-parts: executing /etc/kernel/postinst.d/xx-update-initrd-links 6.11.7 /boot/vmlinuz-6.11.7
I: /boot/initrd.img.old is now a symlink to initrd.img-6.8.0-47-generic
I: /boot/initrd.img is now a symlink to initrd.img-6.11.7
run-parts: executing /etc/kernel/postinst.d/zz-shim 6.11.7 /boot/vmlinuz-6.11.7
run-parts: executing /etc/kernel/postinst.d/zz-update-grub 6.11.7 /boot/vmlinuz-6.11.7
Sourcing file `/etc/default/grub'
Sourcing file `/etc/default/grub.d/init-select.cfg'
Generating grub configuration file ...
Found linux image: /boot/vmlinuz-6.11.7
Found initrd image: /boot/initrd.img-6.11.7
Found linux image: /boot/vmlinuz-6.8.0-47-generic
Found initrd image: /boot/initrd.img-6.8.0-47-generic
Found linux image: /boot/vmlinuz-6.8.0-45-generic
Found initrd image: /boot/initrd.img-6.8.0-45-generic
Memtest86+ needs a 16-bit boot, that is not available on EFI, exiting
Warning: os-prober will be executed to detect other bootable partitions.
Its output will be used to detect bootable binaries on them and create new boot entries.
Found Windows Boot Manager on /dev/nvme0n1p1@/EFI/Microsoft/Boot/bootmgfw.efi
Adding boot menu entry for UEFI Firmware Settings ...
done
Kernel installed successfully.
Updating the bootloader (GRUB)...
update-initramfs: Generating /boot/initrd.img-6.11.7
Sourcing file `/etc/default/grub'
Sourcing file `/etc/default/grub.d/init-select.cfg'
Generating grub configuration file ...
Found linux image: /boot/vmlinuz-6.11.7
Found initrd image: /boot/initrd.img-6.11.7
Found linux image: /boot/vmlinuz-6.8.0-47-generic
Found initrd image: /boot/initrd.img-6.8.0-47-generic
Found linux image: /boot/vmlinuz-6.8.0-45-generic
Found initrd image: /boot/initrd.img-6.8.0-45-generic
Memtest86+ needs a 16-bit boot, that is not available on EFI, exiting
Warning: os-prober will be executed to detect other bootable partitions.
Its output will be used to detect bootable binaries on them and create new boot entries.
Found Windows Boot Manager on /dev/nvme0n1p1@/EFI/Microsoft/Boot/bootmgfw.efi
Adding boot menu entry for UEFI Firmware Settings ...
done
Bootloader updated successfully.
Rebooting the system to apply the new kernel...
Press Y to reboot now or N to reboot later: 
```

The output confirmed that kernel version 6.11.1 was successfully running.

5. Challenges and Solutions

Throughout the kernel compilation process, I encountered few issues that required troubleshooting and custom solutions.

5.1. Challenge: Extended Compilation Time

The kernel compilation process was lengthy, taking several hours. T

5.2. Challenge: Make Error - SYSTEM_TRUSTED_KEYS

During compilation, an error occurred related to make compilation. This error was particularly frustrating as it interrupted the build process after significant progress.

Solution: After researching the issue, I found that disabling these options would bypass the error. I resolved it using the following commands in a shell script, which automatically reconfigured these options:

```
scripts/config --disable SYSTEM_TRUSTED_KEYS
scripts/config --disable SYSTEM_REVOCATION_KEYS
```

By running these commands, I successfully disabled the problematic configuration settings and resumed the compilation without further issues.