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MINISTRY OF HIGHER EDUCATION AND

SCIENTIFIC RESEARCH

Université Echahid Hamma Lakhdar El OUED

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Learn how to download, configure, compile and install a custom Linux kernel

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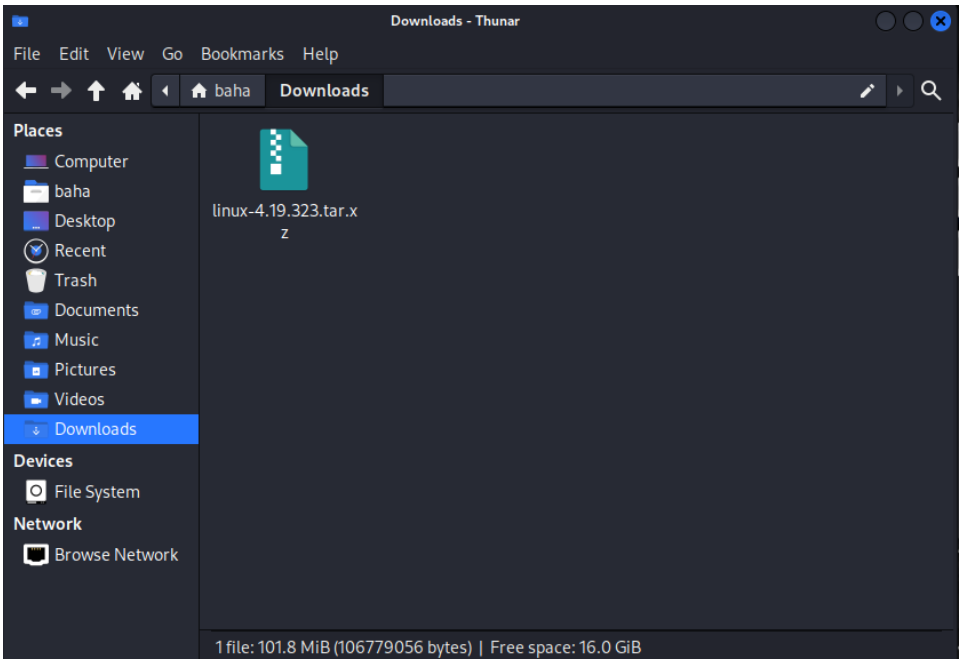
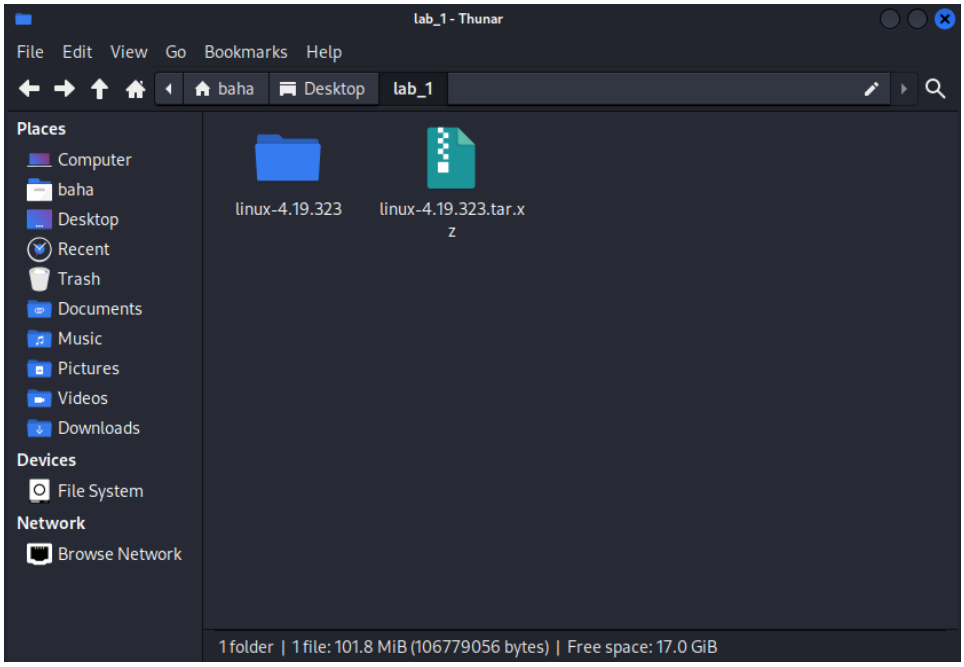
Source Code Download

1. Downloading the Kernel from Kernel.org





Extract the Archive:

```
┌──(baha㉿kali)-[~/Desktop/lab_1]
└─$ tar -xvf linux-4.19.323.tar.xz
linux-4.19.323/
linux-4.19.323/.clang-format
linux-4.19.323/.cocciconfig
linux-4.19.323/.get_maintainer.ignore
linux-4.19.323/.gitattributes
linux-4.19.323/.gitignore
linux-4.19.323/.mailmap
linux-4.19.323/COPYING
linux-4.19.323/CREDITS
linux-4.19.323/Documentation/
linux-4.19.323/Documentation/.gitignore
linux-4.19.323/Documentation/00-INDEX
linux-4.19.323/Documentation/ABI/
linux-4.19.323/Documentation/ABI/README
linux-4.19.323/Documentation/ABI/obsolete/
linux-4.19.323/Documentation/ABI/obsolete/sysfs-bus-usb
linux-4.19.323/Documentation/ABI/obsolete/sysfs-class-typec
linux-4.19.323/Documentation/ABI/obsolete/sysfs-driver-hid-roccat-arvo
linux-4.19.323/Documentation/ABI/obsolete/sysfs-driver-hid-roccat-isku
linux-4.19.323/Documentation/ABI/obsolete/sysfs-driver-hid-roccat-konep
lus
linux-4.19.323/Documentation/ABI/obsolete/sysfs-driver-hid-roccat-konep
ure
linux-4.19.323/Documentation/ABI/obsolete/sysfs-driver-hid-roccat-kovap
lus
linux-4.19.323/Documentation/ABI/obsolete/sysfs-driver-hid-roccat-lua
linux-4.19.323/Documentation/ABI/obsolete/sysfs-driver-hid-roccat-pyra
linux-4.19.323/Documentation/ABI/obsolete/sysfs-driver-hid-roccat-ryos
linux-4.19.323/Documentation/ABI/obsolete/sysfs-driver-hid-roccat-savu
linux-4.19.323/Documentation/ABI/obsolete/sysfs-firmware-acpi
```

Navigate to the Kernel Directory:

```
┌──(baha㉿kali)-[~/Desktop/lab_1]
└─$ cd linux-4.19.323

┌──(baha㉿kali)-[~/Desktop/lab_1/linux-4.19.323]
└─$ sudo apt-get install build-essential libncurses-dev bison flex libssl-dev libel
f-dev
[sudo] password for baha:
```

2. Configuring the Kernel

Install Necessary Packages:

```
┌──(baha㉿kali)-[~/Desktop/lab_1]
└─$ cd linux-4.19.323

┌──(baha㉿kali)-[~/Desktop/lab_1/linux-4.19.323]
└─$ sudo apt-get install build-essential libncurses-dev bison flex libssl-dev libel
f-dev
[sudo] password for baha:
Reading package lists ... Done
Building dependency tree ... Done
Reading state information ... Done
libncurses-dev is already the newest version (6.5-2).
libncurses-dev set to manually installed.
The following additional packages will be installed:
  cpp cpp-14 cpp-14-x86-64-linux-gnu cpp-x86-64-linux-gnu dpkg dpkg-dev g++
  g++-14 g++-14-x86-64-linux-gnu g++-x86-64-linux-gnu gcc gcc-14 gcc-14-base
  gcc-14-x86-64-linux-gnu gcc-x86-64-linux-gnu lib32gcc-s1 lib32stdc++6 libasan8
  libatomic1 libcc1-0 libdpkg-perl libdw1t64 libelf1t64 libfl-dev libfl2
  libgcc-14-dev libgcc-s1 libgfortran5 libgomp1 libhwasan0 libitm1 liblsan0
  libobjc4 libquadmath0 libssl3t64 libstdc++-14-dev libstdc++6 libtsan2 libubsan1
  libzstd-dev openssl openssl-provider-legacy
Suggested packages:
  bison-doc gcc-14-locales cpp-14-doc g++-14-multilib gcc-14-doc gcc-14-multilib
  libssl-doc libstdc++-14-doc
The following NEW packages will be installed:
  bison cpp-14 cpp-14-x86-64-linux-gnu g++-14 g++-14-x86-64-linux-gnu gcc-14
  gcc-14-x86-64-linux-gnu libelf-dev libgcc-14-dev libssl-dev libstdc++-14-dev
  libzstd-dev openssl-provider-legacy
The following packages will be upgraded:
  build-essential cpp cpp-x86-64-linux-gnu dpkg dpkg-dev flex g++
  g++-x86-64-linux-gnu gcc gcc-14-base gcc-x86-64-linux-gnu lib32gcc-s1
  lib32stdc++6 libasan8 libatomic1 libcc1-0 libdpkg-perl libdw1t64 libelf1t64
  libfl-dev libfl2 libgcc-s1 libgfortran5 libgomp1 libhwasan0 libitm1 liblsan0
```

```
Setting up libasan8:amd64 (14.2.0-6) ...
Setting up bison (2:3.8.2+dfsg-1+b2) ...
update-alternatives: using /usr/bin/bison.yacc to provide /usr/bin/yacc (yacc) in a
uto mode
Setting up libtsan2:amd64 (14.2.0-6) ...
Setting up openssl (3.3.2-1) ...
Setting up libcc1-0:amd64 (14.2.0-6) ...
Setting up liblsan0:amd64 (14.2.0-6) ...
Setting up libitm1:amd64 (14.2.0-6) ...
Setting up cpp-x86-64-linux-gnu (4:14.2.0-1) ...
Setting up libfl-dev:amd64 (2.6.4-8.2+b3) ...
Setting up dpkg-dev (1.22.11+kali2) ...
Setting up cpp (4:14.2.0-1) ...
Setting up libgcc-14-dev:amd64 (14.2.0-6) ...
Setting up libstdc++-14-dev:amd64 (14.2.0-6) ...
Setting up gcc-14-x86-64-linux-gnu (14.2.0-6) ...
Setting up gcc-x86-64-linux-gnu (4:14.2.0-1) ...
Setting up gcc-14 (14.2.0-6) ...
Setting up g++-14-x86-64-linux-gnu (14.2.0-6) ...
Setting up g++-x86-64-linux-gnu (4:14.2.0-1) ...
Setting up g++-14 (14.2.0-6) ...
Setting up gcc (4:14.2.0-1) ...
Setting up g++ (4:14.2.0-1) ...
Setting up build-essential (12.12) ...
Processing triggers for kali-menu (2024.3.1) ...
Processing triggers for doc-base (0.11.2) ...
Processing 1 changed doc-base file...
Processing triggers for libc-bin (2.38-13) ...
Processing triggers for man-db (2.12.1-2) ...
Processing triggers for base-files (1:2024.3.0) ...
```

Configure the Kernel:

```
┌──(baha㉿kali)-[~/Desktop/lab_1/linux-4.19.323]
└─$ make menuconfig
  HOSTCC  scripts/basic/fixdep
  UPD     scripts/kconfig/.mconf-cfg
  HOSTCC  scripts/kconfig/mconf.o
  YACC    scripts/kconfig/zconf.tab.c
  LEX     scripts/kconfig/zconf.lex.c
  HOSTCC  scripts/kconfig/zconf.tab.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
  HOSTLD  scripts/kconfig/mconf
scripts/kconfig/mconf  Kconfig
#
# using defaults found in /boot/config-6.8.11-amd64
#
/boot/config-6.8.11-amd64:1678:warning: symbol value 'm' invalid for NF_TABLES_BRID
GE
/boot/config-6.8.11-amd64:4130:warning: symbol value 'm' invalid for JOYSTICK_IFORC
E_USB
/boot/config-6.8.11-amd64:4131:warning: symbol value 'm' invalid for JOYSTICK_IFORC
E_232
/boot/config-6.8.11-amd64:5132:warning: symbol value 'm' invalid for WATCHDOG_CORE
/boot/config-6.8.11-amd64:5744:warning: symbol value 'm' invalid for RADIO_ADAPTERS
/boot/config-6.8.11-amd64:6617:warning: symbol value 'm' invalid for FB_BACKLIGHT
/boot/config-6.8.11-amd64:9661:warning: symbol value 'm' invalid for ANDROID_BINDER
_IPC
```

```
                    Linux/x86 4.19.323 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

      *** Compiler: gcc (Debian 14.2.0-6) 14.2.0 ***
          General setup  --->
      [*] 64-bit kernel
          Processor type and features  --->
      [ ] Force GDS Mitigation
          Power management and ACPI options  --->
          Bus options (PCI etc.)  --->
          Binary Emulations  --->
          Firmware Drivers  --->
      [*] 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  --->
      v(+)

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

3. Compiling the Kernel

Compile the Kernel:

```
┌──(baha㉿kali)-[~/Desktop/lab_1/linux-4.19.323]
└─$ make -j $(nproc)
  HOSTCC  scripts/kconfig/conf.o
  HOSTLD  scripts/kconfig/conf
scripts/kconfig/conf  --syncconfig Kconfig
  SYSTBL  arch/x86/include/generated/asm/syscalls_32.h
  SYSHDR  arch/x86/include/generated/asm/unistd_32_ia32.h
  SYSHDR  arch/x86/include/generated/asm/unistd_64_x32.h
  SYSTBL  arch/x86/include/generated/asm/syscalls_64.h
  HYPERCALLS arch/x86/include/generated/asm/xen-hypercalls.h
  SYSHDR  arch/x86/include/generated/uapi/asm/unistd_32.h
  SYSHDR  arch/x86/include/generated/uapi/asm/unistd_64.h
  SYSHDR  arch/x86/include/generated/uapi/asm/unistd_x32.h
  UPD     include/config/kernel.release
  WRAP    arch/x86/include/generated/uapi/asm/bpf_perf_event.h
  WRAP    arch/x86/include/generated/uapi/asm/poll.h
  UPD     include/generated/uapi/linux/version.h
  UPD     include/generated/utsrelease.h
  DESCEND  objtool
  HOSTCC   /home/baha/Desktop/lab_1/linux-4.19.323/tools/objtool/fixdep.o
  HOSTLD   /home/baha/Desktop/lab_1/linux-4.19.323/tools/objtool/fixdep-in.o
  LINK     /home/baha/Desktop/lab_1/linux-4.19.323/tools/objtool/fixdep
  CC       /home/baha/Desktop/lab_1/linux-4.19.323/tools/objtool/exec-cmd.o
  CC       /home/baha/Desktop/lab_1/linux-4.19.323/tools/objtool/help.o
  CC       /home/baha/Desktop/lab_1/linux-4.19.323/tools/objtool/pager.o
  CC       /home/baha/Desktop/lab_1/linux-4.19.323/tools/objtool/parse-options.o
  GEN      /home/baha/Desktop/lab_1/linux-4.19.323/tools/objtool/arch/x86/lib/inat-
tables.c
  CC       /home/baha/Desktop/lab_1/linux-4.19.323/tools/objtool/arch/x86/decode.o
  CC       /home/baha/Desktop/lab_1/linux-4.19.323/tools/objtool/run-command.o
  CC       /home/baha/Desktop/lab_1/linux-4.19.323/tools/objtool/builtin-check.o
  CC       /home/baha/Desktop/lab_1/linux-4.19.323/tools/objtool/sigchain.o
```

Compile Kernel Modules:

ERROR

```
/bin/sh: 1: bc: not found
make[1]: *** [Kbuild:42: include/generated/timeconst.h] Error 127
make[1]: *** Waiting for unfinished jobs....
make: *** [Makefile:1135: prepare0] Error 2
make: *** Waiting for unfinished jobs....

┌──(baha㉿kali)-[~/Desktop/lab_1/linux-4.19.323]
└─$ make modules
  UPD     include/generated/bounds.h
/bin/sh: 1: bc: not found
make[1]: *** [Kbuild:42: include/generated/timeconst.h] Error 127
make: *** [Makefile:1135: prepare0] Error 2

┌──(baha㉿kali)-[~/Desktop/lab_1/linux-4.19.323]
└─$
```

Sudo apt update

```
┌──(baha㉿kali)-[~/Desktop/lab_1/linux-4.19.323]
└─$ sudo apt update
[sudo] password for baha:
Get:1 http://kali.download/kali kali-rolling InRelease [41.5 kB]
Get:2 http://kali.download/kali kali-rolling/main amd64 Packages [20.2 MB]
Get:3 http://kali.download/kali kali-rolling/main amd64 Contents (deb) [48.3 MB]
77% [3 Contents-amd64 35.0 MB/48.3 MB 72%]                    1389 kB/s 10s
```

```
┌──(baha㉿kali)-[~/Desktop/lab_1/linux-4.19.323]
└─$ sudo apt update
[sudo] password for baha:
Get:1 http://kali.download/kali kali-rolling InRelease [41.5 kB]
Get:2 http://kali.download/kali kali-rolling/main amd64 Packages [20.2 MB]
Get:3 http://kali.download/kali kali-rolling/main amd64 Contents (deb) [48.3 MB]
Get:4 http://kali.download/kali kali-rolling/contrib amd64 Packages [112 kB]
Get:5 http://kali.download/kali kali-rolling/contrib amd64 Contents (deb) [273 kB]
Get:6 http://kali.download/kali kali-rolling/non-free amd64 Packages [197 kB]
Get:7 http://kali.download/kali kali-rolling/non-free amd64 Contents (deb) [876 kB]
Get:8 http://kali.download/kali kali-rolling/non-free-firmware amd64 Packages [10.8
 kB]
Get:9 http://kali.download/kali kali-rolling/non-free-firmware amd64 Contents (deb)
 [23.1 kB]
Fetched 70.1 MB in 1min 44s (672 kB/s)
1741 packages can be upgraded. Run 'apt list --upgradable' to see them.
```

sudo sudo apt install bc

```
┌──(baha㉿kali)-[~/Desktop/lab_1/linux-4.19.323]
└─$ sudo apt install bc
Installing:
  bc

Summary:
  Upgrading: 0, Installing: 1, Removing: 0, Not Upgrading: 1741
  Download size: 103 kB
  Space needed: 242 kB / 18.0 GB available

Get:1 http://kali.download/kali kali-rolling/main amd64 bc amd64 1.07.1-4 [103 kB]
Fetched 103 kB in 48s (2153 B/s)
Selecting previously unselected package bc.
(Reading database ... 396774 files and directories currently installed.)
Preparing to unpack .../archives/bc_1.07.1-4_amd64.deb ...
Unpacking bc (1.07.1-4) ...
Setting up bc (1.07.1-4) ...
Processing triggers for kali-menu (2024.3.1) ...
Processing triggers for doc-base (0.11.2) ...
Processing 1 added doc-base file...
Processing triggers for man-db (2.12.1-2) ...
```

Make modules

```
┌──(baha㉿kali)-[~/Desktop/lab_1/linux-4.19.323]
└─$ make modules
  UPD     include/generated/timeconst.h
  CC      arch/x86/kernel/asm-offsets.s
  UPD     include/generated/asm-offsets.h
  CALL    scripts/checksyscalls.sh
  DESCEND  objtool
  CHK     include/generated/compile.h
  UPD     include/generated/compile.h
  CC      init/main.o
  CC      init/version.o
  CC      init/do_mounts.o
  CC      init/do_mounts_initrd.o
  CC      init/initramfs.o
  CC      init/calibrate.o
  CC      init/init_task.o
  AR      init/built-in.a
  HOSTCC  usr/gen_init_cpio
  GEN     usr/initramfs_data.cpio
  AS      usr/initramfs_data.o
  AR      usr/built-in.a
  AR      arch/x86/crypto/built-in.a
  CC [M]  arch/x86/crypto/glue_helper.o
  AS [M]  arch/x86/crypto/aes-x86_64-asm_64.o
  CC [M]  arch/x86/crypto/aes_glue.o
  LD [M]  arch/x86/crypto/aes-x86_64.o
  AS [M]  arch/x86/crypto/des3_ede-asm_64.o
  CC [M]  arch/x86/crypto/des3_ede_glue.o
  LD [M]  arch/x86/crypto/des3_ede-x86_64.o
  AS [M]  arch/x86/crypto/camellia-x86_64-asm_64.o
  CC [M]  arch/x86/crypto/camellia_glue.o
  LD [M]  arch/x86/crypto/camellia-x86_64.o
  AS [M]  arch/x86/crypto/blowfish-x86_64-asm_64.o
```

```
baha@kali: ~/Desktop/lab_1/linux-4.19.323
File  Actions  Edit  View  Help
  CC [M]  drivers/gpu/drm/nouveau/dispnv50/head917d.o
  CC [M]  drivers/gpu/drm/nouveau/dispnv50/headc37d.o
  CC [M]  drivers/gpu/drm/nouveau/dispnv50/wimm.o
  CC [M]  drivers/gpu/drm/nouveau/dispnv50/wimmc37b.o
  CC [M]  drivers/gpu/drm/nouveau/dispnv50/wndw.o
drivers/gpu/drm/nouveau/dispnv50/wndw.c:572:1: warning: conflicting types for ‘nv50
_wndw_new_’ due to enum/integer mismatch; have ‘int(const struct nv50_wndw_func *,
struct drm_device *, enum drm_plane_type,  const char *, int,  const u32 *, u32,  e
num nv50_disp_interlock_type,  u32,  struct nv50_wndw **)’ {aka ‘int(const struct n
v50_wndw_func *, struct drm_device *, enum drm_plane_type,  const char *, int,  con
st unsigned int *, unsigned int,  enum nv50_disp_interlock_type,  unsigned int,  st
ruct nv50_wndw **)’} [-Wenum-int-mismatch]
  572 | nv50_wndw_new_(const struct nv50_wndw_func *func, struct drm_device *dev,
      | ^~~~~~~~~~~~~~
In file included from drivers/gpu/drm/nouveau/dispnv50/wndw.c:22:
drivers/gpu/drm/nouveau/dispnv50/wndw.h:39:5: note: previous declaration of ‘nv50_w
ndw_new_’ with type ‘int(const struct nv50_wndw_func *, struct drm_device *, enum d
rm_plane_type,  const char *, int,  const u32 *, enum nv50_disp_interlock_type,  u3
2,  u32,  struct nv50_wndw **)’ {aka ‘int(const struct nv50_wndw_func *, struct drm
_device *, enum drm_plane_type,  const char *, int,  const unsigned int *, enum nv5
0_disp_interlock_type,  unsigned int,  unsigned int,  struct nv50_wndw **)’}
   39 | int nv50_wndw_new_(const struct nv50_wndw_func *, struct drm_device *,
      |     ^~~~~~~~~~~~~~
  CC [M]  drivers/gpu/drm/nouveau/dispnv50/wndwc37e.o
  CC [M]  drivers/gpu/drm/nouveau/dispnv50/base.o
  CC [M]  drivers/gpu/drm/nouveau/dispnv50/base507c.o
  CC [M]  drivers/gpu/drm/nouveau/dispnv50/base827c.o
  CC [M]  drivers/gpu/drm/nouveau/dispnv50/base907c.o
  CC [M]  drivers/gpu/drm/nouveau/dispnv50/base917c.o
  CC [M]  drivers/gpu/drm/nouveau/dispnv50/curs.o
  CC [M]  drivers/gpu/drm/nouveau/dispnv50/curs507a.o
  CC [M]  drivers/gpu/drm/nouveau/dispnv50/curs907a.o
  CC [M]  drivers/gpu/drm/nouveau/dispnv50/cursc37a.o
```

Period of execution : 3h

4. Installing the Kernel

Install the Kernel Modules:

```
┌──(baha㉿kali)-[~/Desktop/lab_1/linux-4.19.323]
└─$ sudo make modules_install
[sudo] password for baha:
  INSTALL arch/x86/crypto/aegis128-aesni.ko
  INSTALL arch/x86/crypto/aes-x86_64.ko
  INSTALL arch/x86/crypto/aesni-intel.ko
  INSTALL arch/x86/crypto/blowfish-x86_64.ko
  INSTALL arch/x86/crypto/camellia-aesni-avx-x86_64.ko
  INSTALL arch/x86/crypto/camellia-aesni-avx2.ko
  INSTALL arch/x86/crypto/camellia-x86_64.ko
  INSTALL arch/x86/crypto/cast5-avx-x86_64.ko
  INSTALL arch/x86/crypto/cast6-avx-x86_64.ko
  INSTALL arch/x86/crypto/chacha20-x86_64.ko
  INSTALL arch/x86/crypto/crc32-pclmul.ko
  INSTALL arch/x86/crypto/crc32c-intel.ko
  INSTALL arch/x86/crypto/crct10dif-pclmul.ko
  INSTALL arch/x86/crypto/des3_ede-x86_64.ko
  INSTALL arch/x86/crypto/ghash-clmulni-intel.ko
  INSTALL arch/x86/crypto/glue_helper.ko
  INSTALL arch/x86/crypto/poly1305-x86_64.ko
  INSTALL arch/x86/crypto/serpent-avx-x86_64.ko
  INSTALL arch/x86/crypto/serpent-avx2.ko
  INSTALL arch/x86/crypto/serpent-sse2-x86_64.ko
  INSTALL arch/x86/crypto/sha1-ssse3.ko
  INSTALL arch/x86/crypto/sha256-ssse3.ko
  INSTALL arch/x86/crypto/sha512-ssse3.ko
  INSTALL arch/x86/crypto/twofish-avx-x86_64.ko
  INSTALL arch/x86/crypto/twofish-x86_64-3way.ko
  INSTALL arch/x86/crypto/twofish-x86_64.ko
  INSTALL arch/x86/events/amd/power.ko
  INSTALL arch/x86/events/intel/intel-cstate.ko
  INSTALL arch/x86/events/intel/intel-rapl-perf.ko
```

Install the Kernel:

- **Install the kernel itself:**

ERROR

```
┌──(baha㉿kali)-[~/Desktop/lab_1/linux-4.19.323]
└─$ sudo make install
sh ./arch/x86/boot/install.sh 4.19.323 arch/x86/boot/bzImage \
     System.map "/boot"

 *** Missing file: arch/x86/boot/bzImage
 *** You need to run "make" before "make install".

make[1]: *** [arch/x86/boot/Makefile:155: install] Error 1
make: *** [arch/x86/Makefile:305: install] Error 2
```

make

```
┌──(baha㉿kali)-[~/Desktop/lab_1/linux-4.19.323]
└─$ make
  CALL    scripts/checksyscalls.sh
  DESCEND  objtool
  CHK     include/generated/compile.h

  LDS     arch/x86/boot/compressed/vmlinux.lds
  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
  XZKERN  arch/x86/boot/compressed/vmlinux.bin.xz
  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/kaslr_64.o
  AS      arch/x86/boot/compressed/mem_encrypt.o
  CC      arch/x86/boot/compressed/pgtable_64.o
  CC      arch/x86/boot/compressed/eboot.o
  AS      arch/x86/boot/compressed/efi_stub_64.o
  AS      arch/x86/boot/compressed/efi_thunk_64.o
  LD      arch/x86/boot/compressed/vmlinux
ld: arch/x86/boot/compressed/head_64.o: warning: relocation in read-only section `.
head.text'
ld: warning: creating DT_TEXTREL in a PIE
  CC      arch/x86/boot/a20.o
  AS      arch/x86/boot/bioscall.o
```

sudo make install

```
┌──(baha㉿kali)-[~/Desktop/lab_1/linux-4.19.323]
└─$ sudo make install
sh ./arch/x86/boot/install.sh 4.19.323 arch/x86/boot/bzImage \
        System.map "/boot"
run-parts: executing /etc/kernel/postinst.d/initramfs-tools 4.19.323 /boot/vmlinuz-
4.19.323
update-initramfs: Generating /boot/initrd.img-4.19.323
W: zstd compression (CONFIG_RD_ZSTD) not supported by kernel, using gzip
depmod: WARNING: could not open modules.builtin.modinfo at /var/tmp/mkinitramfs_oAz
B1t/lib/modules/4.19.323: No such file or directory
run-parts: executing /etc/kernel/postinst.d/zz-update-grub 4.19.323 /boot/vmlinuz-4
.19.323
Generating grub configuration file ...
Found theme: /boot/grub/themes/kali/theme.txt
Found background image: /usr/share/images/desktop-base/desktop-grub.png
Found linux image: /boot/vmlinuz-6.8.11-amd64
Found initrd image: /boot/initrd.img-6.8.11-amd64
Found linux image: /boot/vmlinuz-4.19.323
Found initrd image: /boot/initrd.img-4.19.323
Warning: os-prober will not be executed to detect other bootable partitions.
Systems on them will not be added to the GRUB boot configuration.
Check GRUB_DISABLE_OS_PROBER documentation entry.
Adding boot menu entry for UEFI Firmware Settings ...
done
```

Update Boot Loader:

```
┌──(baha㉿kali)-[~/Desktop/lab_1/linux-4.19.323]
└─$ sudo update-grub
Generating grub configuration file ...
Found theme: /boot/grub/themes/kali/theme.txt
Found background image: /usr/share/images/desktop-base/desktop-grub.png
Found linux image: /boot/vmlinuz-6.8.11-amd64
Found initrd image: /boot/initrd.img-6.8.11-amd64
Found linux image: /boot/vmlinuz-4.19.323
Found initrd image: /boot/initrd.img-4.19.323
Warning: os-prober will not be executed to detect other bootable partitions.
Systems on them will not be added to the GRUB boot configuration.
Check GRUB_DISABLE_OS_PROBER documentation entry.
Adding boot menu entry for UEFI Firmware Settings ...
done
```

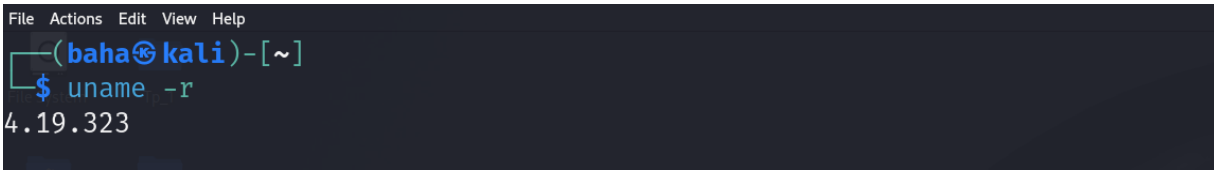
Reboot:

- Reboot your system to boot into the new kernel:

```
┌──(baha㉿kali)-[~/Desktop/lab_1/linux-4.19.323]
└─$ sudo reboot
[sudo] password for baha:
```

Documentation Points

1. **Chosen Method**: I used the official method of downloading, configuring, compiling, and installing the kernel as outlined above.
2. **Justification**: This method is reliable and provides full control over kernel customization. Using `make menuconfig` allows for a tailored configuration, while the official download ensures the latest stable kernel version with security patches and updates.
3. **Kernel Version**: The version can be checked after reboot with: **uname -r**



display the specific version installed.

Source Code Structure of the Linux Kernel

1. `arch/` (Architecture-Specific Code)

- **Purpose**: The `arch/` directory contains the architecture-specific code required for building and running the kernel on different hardware platforms (e.g., x86, ARM, PowerPC, etc.).
- **Content**:
  - Each supported architecture has its own subdirectory within `arch/`, such as `arch/x86/` for x86-based systems, `arch/arm/` for ARM-based systems, and so on.
  - The subdirectories include architecture-specific code for CPU initialization, memory management, and low-level system handling.
- **Example**: If you're building the kernel for an ARM system, the code for ARM-specific handling would reside in `arch/arm/`.

2. `drivers/` (Device Drivers)

- **Purpose**: The `drivers/` directory contains code for various hardware device drivers used by the kernel to interact with devices such as storage devices, network interfaces, sound cards, and more.
- **Content**:
  - Subdirectories within `drivers/` are organized by type of device, such as `drivers/net/` for network drivers, `drivers/usb/` for USB device drivers, `drivers/gpu/` for GPU drivers, etc.
  - This directory allows the kernel to interface with hardware in a standardized way, abstracting the low-level details of different devices.
- **Example**: The driver for an Intel Ethernet card would be found under `drivers/net/ethernet/intel/`.

3. `include/` (Header Files)

- **Purpose**: The `include/` directory contains all the kernel's header files that define data structures, constants, and function prototypes used throughout the kernel source code.
- **Content**:
  - This directory is organized into subdirectories based on functionality. For instance, `include/linux/` contains the primary Linux kernel headers that define structures for process management, file systems, memory management, and other core functionalities.
  - `include/asm/` contains architecture-specific headers.
- **Example**: If you're looking for header files defining structures for process management, you would look under `include/linux/sched.h`.

4. `kernel/` (Core Kernel Code)

- **Purpose**: The `kernel/` directory contains the core functionality of the Linux kernel, such as process scheduling, memory management, and other fundamental operations.
- **Content**:
  - Key subdirectories and files in `kernel/` include the process scheduler (`kernel/sched.c`), the kernel's memory management code (`kernel/memory.c`), and system calls.

    - This directory defines the core behavior of the Linux operating system, providing essential functionality that the rest of the kernel depends on.
- **Example**: The process scheduler code can be found in `kernel/sched.c`, which is responsible for deciding which process runs on the CPU and when.

5. `Documentation/` (Kernel Documentation)

- **Purpose**: The `Documentation/` directory contains extensive documentation about the kernel and its features.
- **Content**:
    - This directory includes information about kernel configuration, how to contribute to the kernel, descriptions of kernel subsystems, and how to use kernel features.
    - The documentation is often written in text format (e.g., `.txt` files) or reStructuredText (`.rst` files) and is used by developers to understand how the kernel works.
- **Example**: You can find details on how to configure the kernel in `Documentation/admin-guide/`.

6. `Makefile` (Build System)

- **Purpose**: The `Makefile` at the root of the kernel source tree controls the kernel build process.
- **Content**:
    - It defines rules and instructions for compiling the kernel and kernel modules.
    - It includes variables for paths, flags, and compiler options, as well as targets for compiling the kernel, building modules, and installing the kernel.
    - The `Makefile` typically invokes other smaller `Makefile`s in subdirectories, organizing the build process for each part of the kernel.
- **Example**: When you run `make` to build the kernel, the top-level `Makefile` is responsible for calling the correct sub-Makefiles for different kernel components and for triggering the compilation of the kernel and modules.

Summary of Key Directories

Directory	Purpose
`arch/`	Contains architecture-specific code for various hardware platforms.
`drivers/`	Contains device drivers for different hardware components.
`include/`	Contains header files defining kernel structures, constants, and function prototypes.
`kernel/`	Contains core kernel functionality such as process scheduling and memory management.
`Documentation/`	Contains documentation about kernel configuration, subsystems, and usage.
`Makefile`	Controls the build process for compiling the kernel and its modules.

Each of these directories plays a crucial role in the Linux kernel's structure, allowing for flexibility, portability, and functionality across a wide range of hardware platforms.

Location of Drivers for Your Hardware

To identify the location of drivers for specific hardware on your system:

1. **Network Drivers**:
   Network device drivers are located in `drivers/net/`. For example, drivers for Ethernet devices like Intel cards might be found in `drivers/net/ethernet/intel/`.
2. **USB Drivers**:
   USB drivers can be found in `drivers/usb/`. For instance, drivers for USB storage devices are in `drivers/usb/storage/`.
3. **GPU (Graphics Processing Unit) Drivers**:
   GPU drivers, including those for Intel, NVIDIA, and AMD cards, are located in `drivers/gpu/`.
4. **Sound Drivers**:
   Sound card drivers are in `drivers/sound/`. For ALSA-based sound drivers, this will be the main location.
5. **Storage Device Drivers**:
   Storage device drivers, including those for hard drives and SSDs, are located in `drivers/block/`.

2 Kernel Configuration

Chosen Configuration Method

- **Chosen Method**: **Menu-based Configuration (`make menuconfig`)**
- **Justification**: I chose this method because it offers an interactive, user-friendly interface that simplifies the configuration process. It allows me to selectively enable or disable kernel features, making it easier to
- understand each option's role and customize the kernel to suit specific requirements. This method is ideal for users who want fine control over their kernel's settings without having to manually edit the `.config` file.

Documented Essential Options

The following 10 essential options are required for a fully functional kernel:

- **`CONFIG_X86`** – Processor architecture (x86-based systems)
- **`CONFIG_EXT4_FS`** – File system support for EXT4
- **`CONFIG_NETDEVICES`** – Enable networking support
- **`CONFIG_PID_NS`** – Enable process ID namespaces
- **`CONFIG_HIGHMEM`** – Enable high memory management for large RAM systems
- **`CONFIG_MODULES`** – Enable kernel modules support
- **`CONFIG_SCSI`** – Enable SCSI storage device support
- **`CONFIG_INET`** – Enable networking (TCP/IP)
- **`CONFIG_USB_SUPPORT`** – Enable USB device support
- **`CONFIG_SECURITY`** – Enable kernel security features (e.g., SELinux)

Necessity of Each Option

- **`CONFIG_X86`**: Necessary for compiling a kernel that works on x86 systems. Without this, the kernel won't be able to interact with x86 hardware.
- **`CONFIG_EXT4_FS`**: EXT4 is a widely used file system, and without this, the system won’t be able to read/write to EXT4-formatted partitions.
- **`CONFIG_NETDEVICES`**: Essential for enabling network interfaces like Ethernet or Wi-Fi, allowing the system to connect to networks.
- **`CONFIG_PID_NS`**: This is critical for isolating processes in containers and virtualized environments.

- **CONFIG_HIGHMEM**: Needed for systems with more than 4GB of RAM to manage memory efficiently.
- **CONFIG_MODULES**: Allows kernel modules to be loaded dynamically, enabling additional functionality without recompiling the kernel.
- **CONFIG_SCSI**: Enables support for SCSI devices, which are commonly used in servers and enterprise environments.
- **CONFIG_INET**: Required for any network communication using IP protocols, essential for Internet and local network connectivity.
- **CONFIG_USB_SUPPORT**: Enables USB devices to be used, which is critical for connecting peripherals and external storage.
- **CONFIG_SECURITY**: Necessary to apply security features, which help protect the system from unauthorized access and attacks.

By selecting and enabling these options, you ensure that the kernel can function properly, interact with hardware, and provide the essential services needed for a running Linux system.

3 Kernel Compilation

Cleaning Previous Builds

```
┌──(baha㉿kali)-[~/Desktop/lab_1/linux-4.19.323]
└─$ make clean
make: Warning: File '.vmlinux.cmd' has modification time 807213 s in the future
make[1]: Warning: File 'Kbuild' has modification time 723549 s in the future
  CLEAN   .
make[1]: warning:  Clock skew detected.  Your build may be incomplete.
make[1]: Warning: File 'arch/x86/Kbuild' has modification time 723549 s in the future
make[2]: Warning: File 'arch/x86/crypto/Makefile' has modification time 723549 s in the
 future
make[3]: Warning: File 'arch/x86/crypto/sha1-mb/Makefile' has modification time 723549
s in the future
make[3]: warning:  Clock skew detected.  Your build may be incomplete.
make[3]: Warning: File 'arch/x86/crypto/sha256-mb/Makefile' has modification time 72354
9 s in the future
make[3]: warning:  Clock skew detected.  Your build may be incomplete.
make[3]: Warning: File 'arch/x86/crypto/sha512-mb/Makefile' has modification time 72354
9 s in the future
make[3]: warning:  Clock skew detected.  Your build may be incomplete.
make[2]: warning:  Clock skew detected.  Your build may be incomplete.
make[2]: Warning: File 'arch/x86/entry/Makefile' has modification time 723549 s in the
future
make[3]: Warning: File 'arch/x86/entry/vdso/Makefile' has modification time 723549 s in
 the future
  CLEAN   arch/x86/entry/vdso
make[3]: warning:  Clock skew detected.  Your build may be incomplete.
make[3]: Warning: File 'arch/x86/entry/vsyscall/Makefile' has modification time 723549
s in the future
make[3]: warning:  Clock skew detected.  Your build may be incomplete.
make[2]: warning:  Clock skew detected.  Your build may be incomplete.
make[2]: Warning: File 'arch/x86/events/Makefile' has modification time 723549 s in the
```

Command **(for a more thorough clean):**

```
┌──(baha㉿kali)-[~/Desktop/lab_1/linux-4.19.323]
└─$ make mrproper
make: Warning: File 'scripts/Makefile.ubsan' has modification time 723435 s in the futu
re
make[1]: Warning: File 'Kbuild' has modification time 723435 s in the future
make[1]: warning:  Clock skew detected.  Your build may be incomplete.
make[1]: Warning: File 'arch/x86/Kbuild' has modification time 723435 s in the future
make[2]: Warning: File 'arch/x86/crypto/Makefile' has modification time 723435 s in the
 future
make[3]: Warning: File 'arch/x86/crypto/sha1-mb/Makefile' has modification time 723435
s in the future
make[3]: warning:  Clock skew detected.  Your build may be incomplete.
make[3]: Warning: File 'arch/x86/crypto/sha256-mb/Makefile' has modification time 72343
5 s in the future
make[3]: warning:  Clock skew detected.  Your build may be incomplete.
make[3]: Warning: File 'arch/x86/crypto/sha512-mb/Makefile' has modification time 72343
5 s in the future
make[3]: warning:  Clock skew detected.  Your build may be incomplete.
make[2]: warning:  Clock skew detected.  Your build may be incomplete.
make[2]: Warning: File 'arch/x86/entry/Makefile' has modification time 723435 s in the
future
make[3]: Warning: File 'arch/x86/entry/vdso/Makefile' has modification time 723435 s in
 the future
make[3]: warning:  Clock skew detected.  Your build may be incomplete.
make[3]: Warning: File 'arch/x86/entry/vsyscall/Makefile' has modification time 723435
s in the future
make[3]: warning:  Clock skew detected.  Your build may be incomplete.
make[2]: warning:  Clock skew detected.  Your build may be incomplete.
make[2]: Warning: File 'arch/x86/events/Makefile' has modification time 723435 s in the
 future
make[3]: Warning: File 'arch/x86/events/amd/Makefile' has modification time 723435 s in
 the future
make[3]: warning:  Clock skew detected.  Your build may be incomplete.
make[3]: Warning: File 'arch/x86/events/intel/Makefile' has modification time 723435 s
in the future
```

Compiling the Kernel

ERROR

```
┌──(baha㉿kali)-[~/Desktop/lab_1/linux-4.19.323]
└─$ make
make: Warning: File 'scripts/Makefile.ubsan' has modification time 723318 s in the futu
re
make[1]: Warning: File 'arch/x86/Makefile' has modification time 723317 s in the future
make[2]: Warning: File 'scripts/Makefile.host' has modification time 723317 s in the fu
ture
  HOSTCC  scripts/basic/fixdep
make[2]: warning:  Clock skew detected.  Your build may be incomplete.
make[2]: Warning: File 'scripts/Makefile.host' has modification time 723317 s in the fu
ture
  HOSTCC  scripts/kconfig/conf.o
  YACC    scripts/kconfig/zconf.tab.c
  LEX     scripts/kconfig/zconf.lex.c
  HOSTCC  scripts/kconfig/zconf.tab.o
  HOSTLD  scripts/kconfig/conf
scripts/kconfig/conf  --syncconfig Kconfig
***
*** Configuration file ".config" not found!
***
*** Please run some configurator (e.g. "make oldconfig" or
*** "make menuconfig" or "make xconfig").
***
make[2]: *** [scripts/kconfig/Makefile:69: syncconfig] Error 1
make[1]: *** [Makefile:561: syncconfig] Error 2
Makefile:644: include/config/auto.conf.cmd: No such file or directory
make: *** [Makefile:656: include/config/auto.conf.cmd] Error 2
```

ERROR

```
┌──(baha㉿kali)-[~/Desktop/lab_1/linux-4.19.323]
└─$ make modules
make: Warning: File 'scripts/Makefile.ubsan' has modification time 723222 s in the futu
re
make[1]: Warning: File 'arch/x86/Makefile' has modification time 723222 s in the future
make[2]: Warning: File 'scripts/Makefile.host' has modification time 723222 s in the fu
ture
  HOSTCC  scripts/basic/fixdep
make[2]: warning:  Clock skew detected.  Your build may be incomplete.
make[2]: Warning: File 'scripts/Makefile.host' has modification time 723222 s in the fu
ture
  HOSTCC  scripts/kconfig/conf.o
  YACC    scripts/kconfig/zconf.tab.c
  LEX     scripts/kconfig/zconf.lex.c
  HOSTCC  scripts/kconfig/zconf.tab.o
  HOSTLD  scripts/kconfig/conf
scripts/kconfig/conf  --syncconfig Kconfig
***
*** Configuration file ".config" not found!
***
*** Please run some configurator (e.g. "make oldconfig" or
*** "make menuconfig" or "make xconfig").
***
make[2]: *** [scripts/kconfig/Makefile:69: syncconfig] Error 1
make[1]: *** [Makefile:561: syncconfig] Error 2
Makefile:644: include/config/auto.conf.cmd: No such file or directory
make: *** [Makefile:656: include/config/auto.conf.cmd] Error 2
```

```
┌──(baha㉿kali)-[~/Desktop/lab_1/linux-4.19.323]
└─$ sudo hwclock --hctosys
[sudo] password for baha:
sudo: hwclock: command not found

┌──(baha㉿kali)-[~/Desktop/lab_1/linux-4.19.323]
└─$ sudo ntpdate pool.ntp.org
sudo: ntpdate: command not found

┌──(baha㉿kali)-[~/Desktop/lab_1/linux-4.19.323]
└─$ make defconfig
make: Warning: File 'arch/x86/Makefile' has modification time 723001 s in the future
make[1]: Warning: File 'scripts/Makefile.host' has modification time 723001 s in the fu
ture
  HOSTCC  scripts/basic/fixdep
make[1]: warning:  Clock skew detected.  Your build may be incomplete.
make[1]: Warning: File 'scripts/Makefile.host' has modification time 723001 s in the fu
ture
  HOSTCC  scripts/kconfig/conf.o
  YACC    scripts/kconfig/zconf.tab.c
  LEX     scripts/kconfig/zconf.lex.c
  HOSTCC  scripts/kconfig/zconf.tab.o
  HOSTLD  scripts/kconfig/conf
*** Default configuration is based on 'x86_64_defconfig'
#
# configuration written to .config
#
make[1]: warning:  Clock skew detected.  Your build may be incomplete.
make: warning:  Clock skew detected.  Your build may be incomplete.
```

```
┌──(baha㉿kali)-[~/Desktop/lab_1/linux-4.19.323]
└─$ make menuconfig
make: Warning: File 'arch/x86/Makefile' has modification time 722971 s in the future
make[1]: Warning: File 'scripts/Makefile.host' has modification time 722971 s in the fu
ture
  HOSTCC  scripts/basic/fixdep
make[1]: warning:  Clock skew detected.  Your build may be incomplete.
make[1]: Warning: File 'scripts/Makefile.host' has modification time 722971 s in the fu
ture
  UPD     scripts/kconfig/.mconf-cfg
  YACC    scripts/kconfig/zconf.tab.c
  LEX     scripts/kconfig/zconf.lex.c
  HOSTCC  scripts/kconfig/zconf.tab.o
  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
  HOSTLD  scripts/kconfig/mconf
scripts/kconfig/mconf  Kconfig


*** End of the configuration.
*** Execute 'make' to start the build or try 'make help'.

make[1]: warning:  Clock skew detected.  Your build may be incomplete.
make: warning:  Clock skew detected.  Your build may be incomplete.
```

Make

```
┌──(baha㉿kali)-[~/Desktop/lab_1/linux-4.19.323]
└─$ make
make: Warning: File 'scripts/Makefile.ubsan' has modification time 722797 s in the futu
re
make[1]: Warning: File 'arch/x86/Makefile' has modification time 722797 s in the future
make[2]: Warning: File 'scripts/Makefile.host' has modification time 722797 s in the fu
ture
  HOSTCC  scripts/basic/fixdep
make[2]: warning:  Clock skew detected.  Your build may be incomplete.
make[2]: Warning: File 'scripts/Makefile.host' has modification time 722796 s in the fu
ture
  HOSTCC  scripts/kconfig/conf.o
  YACC    scripts/kconfig/zconf.tab.c
  LEX     scripts/kconfig/zconf.lex.c
  HOSTCC  scripts/kconfig/zconf.tab.o
  HOSTLD  scripts/kconfig/conf
scripts/kconfig/conf  --syncconfig Kconfig
make[2]: warning:  Clock skew detected.  Your build may be incomplete.
make[1]: warning:  Clock skew detected.  Your build may be incomplete.
make: Warning: File 'scripts/Makefile.ubsan' has modification time 722793 s in the futu
re
make[1]: Warning: File 'arch/x86/Makefile' has modification time 722793 s in the future
make[2]: Warning: File 'scripts/Makefile.host' has modification time 722793 s in the fu
ture
  HOSTCC  scripts/basic/fixdep
make[2]: warning:  Clock skew detected.  Your build may be incomplete.
make[2]: Warning: File 'scripts/Makefile.host' has modification time 722793 s in the fu
ture
  HOSTCC  scripts/kconfig/conf.o
  YACC    scripts/kconfig/zconf.tab.c
  LEX     scripts/kconfig/zconf.lex.c
  HOSTCC  scripts/kconfig/zconf.tab.o
  HOSTLD  scripts/kconfig/conf
scripts/kconfig/conf  --syncconfig Kconfig
make[2]: warning:  Clock skew detected.  Your build may be incomplete.
make[1]: warning:  Clock skew detected.  Your build may be incomplete.
make: Warning: File 'scripts/Makefile.ubsan' has modification time 722789 s in the futu
re
make[1]: Warning: File 'arch/x86/Makefile' has modification time 722789 s in the future
make[2]: Warning: File 'scripts/Makefile.host' has modification time 722789 s in the fu
ture
```

Compiling and Installing Module

Install ccache :

```
┌──(baha㉿kali)-[~/Desktop/lab_1/linux-4.19.323]
└─$ sudo apt install ccache
Installing:
  ccache

Suggested packages:
  distcc  | icecc

Summary:
  Upgrading: 0, Installing: 1, Removing: 0, Not Upgrading: 1741
  Download size: 678 kB
  Space needed: 1816 kB / 14.3 GB available

0% [Working]
```

```
┌──(baha㉿kali)-[~/Desktop/lab_1/linux-4.19.323]
└─$ sudo apt install ccache
Installing:
  ccache

Suggested packages:
  distcc  | icecc

Summary:
  Upgrading: 0, Installing: 1, Removing: 0, Not Upgrading: 1741
  Download size: 678 kB
  Space needed: 1816 kB / 14.3 GB available

Get:1 http://kali.download/kali kali-rolling/main amd64 ccache amd64 4.10.2-1 [678 kB]
Fetched 678 kB in 50s (13.6 kB/s)
Selecting previously unselected package ccache.
(Reading database ... 396792 files and directories currently installed.)
Preparing to unpack .../ccache_4.10.2-1_amd64.deb ...
Unpacking ccache (4.10.2-1) ...
Setting up ccache (4.10.2-1) ...
Updating symlinks in /usr/lib/ccache ...
Processing triggers for kali-menu (2024.3.1) ...
Processing triggers for doc-base (0.11.2) ...
Processing 1 added doc-base file...
Processing triggers for man-db (2.12.1-2) ...
```

4 Kernel Installation

Create an initial RAM disk (Initramfs)

```
┌──(baha㉿kali)-[~/Desktop/lab_1/linux-4.19.323]
└─$ sudo mkinitcpio -p linux
[sudo] password for baha:
sudo: mkinitcpio: command not found

┌──(baha㉿kali)-[~/Desktop/lab_1/linux-4.19.323]
└─$ sudo update-initramfs -u
update-initramfs: Generating /boot/initrd.img-6.8.11-amd64
```

Configure Boot Options

```
┌──(baha㉿kali)-[~/Desktop/lab_1/linux-4.19.323]
└─$ sudo nano /etc/default/grub

┌──(baha㉿kali)-[~/Desktop/lab_1/linux-4.19.323]
└─$ sudo update-grub
Generating grub configuration file ...
Found theme: /boot/grub/themes/kali/theme.txt
Found background image: /usr/share/images/desktop-base/desktop-grub.png
Found linux image: /boot/vmlinuz-6.8.11-amd64
Found initrd image: /boot/initrd.img-6.8.11-amd64
Found linux image: /boot/vmlinuz-4.19.323
Found initrd image: /boot/initrd.img-4.19.323
Warning: os-prober will not be executed to detect other bootable partitions.
Systems on them will not be added to the GRUB boot configuration.
Check GRUB_DISABLE_OS_PROBER documentation entry.
Adding boot menu entry for UEFI Firmware Settings ...
done
```

```
┌──(baha㉿kali)-[~/Desktop/lab_1/linux-4.19.323]
└─$ sudo update-grub
Generating grub configuration file ...
Found theme: /boot/grub/themes/kali/theme.txt
Found background image: /usr/share/images/desktop-base/desktop-grub.png
Found linux image: /boot/vmlinuz-6.8.11-amd64
Found initrd image: /boot/initrd.img-6.8.11-amd64
Found linux image: /boot/vmlinuz-4.19.323
Found initrd image: /boot/initrd.img-4.19.323
Warning: os-prober will not be executed to detect other bootable partitions.
Systems on them will not be added to the GRUB boot configuration.
Check GRUB_DISABLE_OS_PROBER documentation entry.
Adding boot menu entry for UEFI Firmware Settings ...
done

┌──(baha㉿kali)-[~/Desktop/lab_1/linux-4.19.323]
└─$ uname -r
4.19.323
```

Dmesg

```
┌──(baha㉿kali)-[~/Desktop/lab_1/linux-4.19.323]
└─$ dmesg
[    0.000000] Linux version 4.19.323 (baha@kali) (gcc version 14.2.0 (Debian 14.2.0-6)
) #1 SMP Sat Nov 9 13:19:49 CET 2024
[    0.000000] Command line: BOOT_IMAGE=/boot/vmlinuz-4.19.323 root=UUID=dbe8a7f3-f9d9-
4986-b90d-69f7e1a54eed ro single single dis_ucode_ldr
[    0.000000] BIOS-provided physical RAM map:
[    0.000000] BIOS-e820: [mem 0x0000000000000000-0x000000000009fbff] usable
[    0.000000] BIOS-e820: [mem 0x000000000009fc00-0x000000000009ffff] reserved
[    0.000000] BIOS-e820: [mem 0x00000000000f0000-0x00000000000fffff] reserved
[    0.000000] BIOS-e820: [mem 0x0000000000100000-0x00000000dffeffff] usable
[    0.000000] BIOS-e820: [mem 0x00000000dfff0000-0x00000000dfffffff] ACPI data
[    0.000000] BIOS-e820: [mem 0x00000000fec00000-0x00000000fec00fff] reserved
[    0.000000] BIOS-e820: [mem 0x00000000fee00000-0x00000000fee00fff] reserved
[    0.000000] BIOS-e820: [mem 0x00000000fffc0000-0x00000000ffffffff] reserved
[    0.000000] BIOS-e820: [mem 0x0000000100000000-0x000000011fffffff] usable
[    0.000000] NX (Execute Disable) protection: active
[    0.000000] SMBIOS 2.5 present.
[    0.000000] DMI: innotek GmbH VirtualBox/VirtualBox, BIOS VirtualBox 12/01/2006
[    0.000000] Hypervisor detected: KVM
[    0.000000] kvm-clock: Using msrs 4b564d01 and 4b564d00
[    0.000001] kvm-clock: cpu 0, msr 5e201001, primary cpu clock
[    0.000001] kvm-clock: using sched offset of 57028787833394 cycles
[    0.000003] clocksource: kvm-clock: mask: 0xffffffffffffffff max_cycles: 0x1cd42e4df
fb, max_idle_ns: 881590591483 ns
[    0.000005] tsc: Detected 3302.400 MHz processor
[    0.002421] e820: update [mem 0x00000000-0x00000fff] usable ==> reserved
[    0.002422] e820: remove [mem 0x000a0000-0x000fffff] usable
[    0.002425] last_pfn = 0x120000 max_arch_pfn = 0x400000000
[    0.002470] MTRR default type: uncachable
[    0.002471] MTRR fixed ranges disabled:
[    0.002472]   00000-FFFFF uncachable
[    0.002472] MTRR variable ranges disabled:
[    0.002473]   0 disabled
[    0.002473]   1 disabled
[    0.002473]   2 disabled
[    0.002473]   3 disabled
[    0.002474]   4 disabled
[    0.002474]   5 disabled
[    0.002474]   6 disabled
[    0.002474]   7 disabled
[    0.002475] Disabled
```

```
s (8 of them)  to the host: VERR_ACCESS_DENIED
[ 3316.632383] 06:13:51.811942 X11 events  received X11 event (89)
[ 3316.632558] 06:13:51.812092 X11 events  RRScreenChangeNotify event received
[ 3316.637803] 06:13:51.812577 X11 events  Monitor 0 (w,h)=(800,600) (x,y)=(0,0)
[ 3316.638777] Denying userspace vmm call type 0x0000de
[ 3316.639003] 06:13:51.818491 X11 events  Error: Error during sending monitor position
s (8 of them)  to the host: VERR_ACCESS_DENIED
[ 3316.639117] 06:13:51.818717 X11 events  received X11 event (89)
[ 3316.639519] 06:13:51.818826 X11 events  RRScreenChangeNotify event received
[ 3316.639800] 06:13:51.819351 X11 events  Monitor 0 (w,h)=(800,600) (x,y)=(0,0)
[ 3316.640291] Denying userspace vmm call type 0x0000de
[ 3316.640620] 06:13:51.820001 X11 events  Error: Error during sending monitor position
s (8 of them)  to the host: VERR_ACCESS_DENIED
[ 3322.153987] 06:13:57.333071 X11 events  received X11 event (89)
[ 3322.154700] 06:13:57.333702 X11 events  RRScreenChangeNotify event received
[ 3322.249397] 06:13:57.428922 X11 events  Monitor 0 (w,h)=(2560,1600) (x,y)=(0,0)
[ 3322.249905] Denying userspace vmm call type 0x0000de
```

Monitor and Record Resource Usage

```
┌──(baha㉿kali)-[~/Desktop/lab_1/linux-4.19.323]
└─$ htop
Command 'htop' not found, but can be installed with:
sudo apt install htop
Do you want to install it? (N/y)y
sudo apt install htop
Installing:
  htop

Suggested packages:
  strace

Summary:
  Upgrading: 0, Installing: 1, Removing: 0, Not Upgrading: 1741
  Download size: 163 kB
  Space needed: 416 kB / 14.3 GB available

0% [Working]
```

```
┌──(baha㉿kali)-[~/Desktop/lab_1/linux-4.19.323]
└─$ htop
Command 'htop' not found, but can be installed with:
sudo apt install htop
Do you want to install it? (N/y)y
sudo apt install htop
Installing:
  htop

Suggested packages:
  strace

Summary:
  Upgrading: 0, Installing: 1, Removing: 0, Not Upgrading: 1741
  Download size: 163 kB
  Space needed: 416 kB / 14.3 GB available

Get:1 http://mirror.leitecastro.com/kali kali-rolling/main amd64 htop amd64 3.3.0-4 [16
3 kB]
Fetched 163 kB in 49s (3316 B/s)
Selecting previously unselected package htop.
(Reading database ... 396810 files and directories currently installed.)
Preparing to unpack .../htop_3.3.0-4_amd64.deb ...
Unpacking htop (3.3.0-4) ...
Setting up htop (3.3.0-4) ...
Processing triggers for kali-menu (2024.3.1) ...
Processing triggers for desktop-file-utils (0.27-2) ...
Processing triggers for hicolor-icon-theme (0.18-1) ...
Processing triggers for man-db (2.12.1-2) ...
```

Verification and Testing

Kernel Modules Installation Check

```
┌──(baha㉿kali)-[~/Desktop]
└─$ ls /lib/modules/$(uname -r)
build                 modules.builtin            modules.dep.bin   modules.symbols
kernel                modules.builtin.alias.bin  modules.devname   modules.symbols.bin
modules.alias         modules.builtin.bin        modules.order     modules.weakdep
modules.alias.bin     modules.dep                modules.softdep   source
```

```
┌──(baha㉿kali)-[~/Desktop/lab_1]
└─$ ls /lib/modules/$(uname -r)
build                 modules.builtin.bin   modules.symbols
kernel                modules.dep           modules.symbols.bin
modules.alias         modules.dep.bin       modules.weakdep
modules.alias.bin     modules.devname       source
modules.builtin       modules.order
modules.builtin.alias.bin  modules.softdep

┌──(baha㉿kali)-[~/Desktop/lab_1]
└─$ cd linux-4.19.323

┌──(baha㉿kali)-[~/Desktop/lab_1/linux-4.19.323]
└─$ ls /lib/modules/$(uname -r)
build                 modules.builtin.bin   modules.symbols
kernel                modules.dep           modules.symbols.bin
modules.alias         modules.dep.bin       modules.weakdep
modules.alias.bin     modules.devname       source
modules.builtin       modules.order
modules.builtin.alias.bin  modules.softdep
```

Boot Configuration Verification

```
┌──(baha㉿kali)-[~/Desktop/lab_1/linux-4.19.323]
└─$ sudo cat /boot/grub/grub.cfg | grep $(uname -r)
[sudo] password for baha:
        menuentry 'Kali GNU/Linux, with Linux 4.19.323' --class kali --class g
nu-linux --class gnu --class os $menuentry_id_option 'gnulinux-4.19.323-advanc
ed-dbe8a7f3-f9d9-4986-b90d-69f7e1a54eed' {
                echo    'Loading Linux 4.19.323 ...'
                linux   /boot/vmlinuz-4.19.323 root=UUID=dbe8a7f3-f9d9-4986-b9
0d-69f7e1a54eed ro quiet splash quiet splash
                initrd  /boot/initrd.img-4.19.323
        menuentry 'Kali GNU/Linux, with Linux 4.19.323 (recovery mode)' --clas
s kali --class gnu-linux --class gnu --class os $menuentry_id_option 'gnulinux
-4.19.323-recovery-dbe8a7f3-f9d9-4986-b90d-69f7e1a54eed' {
                echo    'Loading Linux 4.19.323 ...'
                linux   /boot/vmlinuz-4.19.323 root=UUID=dbe8a7f3-f9d9-4986-b9
0d-69f7e1a54eed ro single single dis_ucode_ldr quiet splash
                initrd  /boot/initrd.img-4.19.323
```

Kernel Version Verification

```
┌──(baha㉿kali)-[~/Desktop/lab_1/linux-4.19.323]
└─$ sudo cat /boot/grub/grub.cfg | grep $(uname -r)
[sudo] password for baha:
        menuentry 'Kali GNU/Linux, with Linux 4.19.323' --class kali --class g
nu-linux --class gnu --class os $menuentry_id_option 'gnulinux-4.19.323-advanc
ed-dbe8a7f3-f9d9-4986-b90d-69f7e1a54eed' {
                echo    'Loading Linux 4.19.323 ...'
                linux   /boot/vmlinuz-4.19.323 root=UUID=dbe8a7f3-f9d9-4986-b9
0d-69f7e1a54eed ro quiet splash quiet splash
                initrd  /boot/initrd.img-4.19.323
        menuentry 'Kali GNU/Linux, with Linux 4.19.323 (recovery mode)' --clas
s kali --class gnu-linux --class gnu --class os $menuentry_id_option 'gnulinux
-4.19.323-recovery-dbe8a7f3-f9d9-4986-b90d-69f7e1a54eed' {
                echo    'Loading Linux 4.19.323 ...'
                linux   /boot/vmlinuz-4.19.323 root=UUID=dbe8a7f3-f9d9-4986-b9
0d-69f7e1a54eed ro single single dis_ucode_ldr quiet splash
                initrd  /boot/initrd.img-4.19.323

┌──(baha㉿kali)-[~/Desktop/lab_1/linux-4.19.323]
└─$ uname -r
4.19.323

┌──(baha㉿kali)-[~/Desktop/lab_1/linux-4.19.323]
└─$
```