Add System Call on Linux Kernel

Step#1 (Install Dependencies)

```
$ sudo apt install build-essential libncurses-dev libssl-dev libelf-dev
bison flex -y
```

Step#2 (Download Linux Kernel Source and Uzip The Kernel Source)

```
$ sudo apt install wget
$ wget https://cdn.kernel.org/pub/linux/kernel/v5.x/linux-5.15.12.tar.xz
$ tar -xvf linux-5.15.12.tar.xz
```

Step#3 Create System call sys_hello

```
nahid@cseru:~/Desktop$ cd linux-5.15.12/

nahid@cseru:~/Desktop$ mkdir hello && cd hello
nahid@cseru:~/Desktop$ vim hello.c
```

`hello.c`:

```
#include <linux/kernel.h>
#include <linux/syscalls.h>

asmlinkage long __x64_sys_hello(void) {
        printk("CSE RU is the Best\n");
        return 0;
}
```

Makefile:

```
nahid@cseru:~/Desktop$ vim Makefile
```

```
obj-y := hello.o
```

On nahid@cseru:~/Desktop/linux-5.15.13$ vim Makefile

```
.............................

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/ block/
hello/

vmlinux-dirs    := $(patsubst %/,%,$(filter %/, \
                     $(core-y) $(core-m) $(drivers-y) $(drivers-m) \
                     $(libs-y) $(libs-m)))

.............................
```

In nahid@cseru:~/Desktop/linux-5.15.13$ vim arch/x86/entry/syscalls/syscall_64.tbl

```
.......................................

447     common  memfd_secret            sys_memfd_secret
448     common  process_mrelease        sys_process_mrelease

449     64      hello                   sys_hello

.......................................
```

Next in nahid@cseru:~/Desktop/linux-5.15.13$ vim include/linux/syscalls.h

```
.................

asmlinkage long __x64_sys_hello(void);

.................
```

Step#4 Compile

Remove all the compiled object files from the source code.

```
nahid@cseru:~/Desktop$ cd linux-5.15.13/

nahid@cseru:~/Desktop/linux-5.15.13$ make clean

  CLEAN   arch/x86/crypto
  CLEAN   arch/x86/entry/vdso
  CLEAN   arch/x86/kernel/cpu
  CLEAN   arch/x86/kernel
  CLEAN   arch/x86/purgatory
  CLEAN   arch/x86/realmode/rm
  CLEAN   certs
  CLEAN   crypto/asymmetric_keys
  CLEAN   drivers/gpu/drm/radeon
  CLEAN   drivers/scsi/aic7xxx
  CLEAN   drivers/scsi
  CLEAN   drivers/tty/vt
  CLEAN   fs/unicode
  CLEAN   kernel/debug/kdb
  CLEAN   kernel
  CLEAN   security/apparmor
  CLEAN   security/selinux
  CLEAN   security/tomoyo
  CLEAN   usr
  CLEAN   arch/x86/tools
  CLEAN    resolve_btfids
```

Install Dependencies#2

```
nahid@cseru:~/Desktop/linux-5.15.13$ sudo apt-get install libncurses5-dev
gcc make git exuberant-ctags bc libssl-dev

[sudo] password for nahid:
Reading package lists... Done
Building dependency tree
Reading state information... Done
bc is already the newest version (1.07.1-2build1).
```

```
exuberant-ctags is already the newest version (1:5.9~svn20110310-12).
gcc is already the newest version (4:9.3.0-1ubuntu2).
libncurses5-dev is already the newest version (6.2-0ubuntu2).
make is already the newest version (4.2.1-1.2).
git is already the newest version (1:2.25.1-1ubuntu3.2).
libssl-dev is already the newest version (1.1.1f-1ubuntu2.10).
0 upgraded, 0 newly installed, 0 to remove and 0 not upgraded.
```

Reconfiguration your `.config` file

```
nahid@cseru:~/Desktop/linux-5.15.13$ cp /boot/config-`uname -r`* .config

cp: overwrite '.config'? y
```

```
nahid@cseru:~/Desktop/linux-5.15.13$ vim .config

# .......................
You can change your config file .config

CONFIG_SYSTEM_TRUSTED_KEYS="debian/canonical-certs.pem"

to

CONFIG_SYSTEM_TRUSTED_KEYS=""


And also remove another "debian/....pem" record. This msg just below the 5
or 6 lines of the previous
config.
```

I am not clearly understand the concept of `make defconfig`. If you want to know more about this.

make defconfig

```
nahid@cseru:~/Desktop/linux-5.15.13$ make defconfig
  HOSTCC  scripts/basic/fixdep
  HOSTCC  scripts/kconfig/conf.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/conf
*** Default configuration is based on 'x86_64_defconfig'

#
# configuration written to .config
#
```

Check again and you must remove **"debian/canonical-certs.pem"** from `.config` file.

```
nahid@cseru:~/Desktop/linux-5.15.13$ vim .config
```

Find number of CPU Cores:

```
nahid@cseru:~/Desktop/linux-5.15.13$ nproc
4 # for my case
```

Put the core numbers with `make -j4`

```
nahid@cseru:~/Desktop/linux-5.15.13$ make -j4

  SYNC    include/config/auto.conf.cmd
  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
  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
  HOSTCC  arch/x86/tools/relocs_32.o
  HOSTCC  arch/x86/tools/relocs_64.o
  HOSTCC  arch/x86/tools/relocs_common.o
  HOSTCC  scripts/selinux/genheaders/genheaders
  HOSTCC  scripts/selinux/mdp/mdp
  HOSTCC  scripts/kallsyms
  HOSTLD  arch/x86/tools/relocs
  HOSTCC  scripts/sorttable
  HOSTCC  scripts/asn1_compiler
  DESCEND objtool
  HOSTCC  scripts/extract-cert
  HOSTCC  /home/nahid/Desktop/linux-5.15.13/tools/objtool/fixdep.o
  HOSTLD  /home/nahid/Desktop/linux-5.15.13/tools/objtool/fixdep-in.o
  LINK    /home/nahid/Desktop/linux-5.15.13/tools/objtool/fixdep
  CC      /home/nahid/Desktop/linux-5.15.13/tools/objtool/exec-cmd.o
  CC      /home/nahid/Desktop/linux-5.15.13/tools/objtool/help.o
  CC      /home/nahid/Desktop/linux-
5.15.13/tools/objtool/arch/x86/special.o
  CC      /home/nahid/Desktop/linux-5.15.13/tools/objtool/weak.o
```

```
  CC      /home/nahid/Desktop/linux-5.15.13/tools/objtool/pager.o
  CC      /home/nahid/Desktop/linux-5.15.13/tools/objtool/check.o
  CC      /home/nahid/Desktop/linux-5.15.13/tools/objtool/parse-options.o
  CC      /home/nahid/Desktop/linux-5.15.13/tools/objtool/arch/x86/decode.o
  CC      /home/nahid/Desktop/linux-5.15.13/tools/objtool/run-command.o
  CC      /home/nahid/Desktop/linux-5.15.13/tools/objtool/special.o
  CC      /home/nahid/Desktop/linux-5.15.13/tools/objtool/orc_gen.o
  CC      /home/nahid/Desktop/linux-5.15.13/tools/objtool/sigchain.o
  CC      /home/nahid/Desktop/linux-5.15.13/tools/objtool/orc_dump.o
  LD      /home/nahid/Desktop/linux-5.15.13/tools/objtool/arch/x86/objtool-
in.o
  CC      /home/nahid/Desktop/linux-5.15.13/tools/objtool/builtin-check.o
  CC      /home/nahid/Desktop/linux-5.15.13/tools/objtool/subcmd-config.o
  CC      /home/nahid/Desktop/linux-5.15.13/tools/objtool/builtin-orc.o
  LD      /home/nahid/Desktop/linux-5.15.13/tools/objtool/libsubcmd-in.o
  AR      /home/nahid/Desktop/linux-5.15.13/tools/objtool/libsubcmd.a
  CC      /home/nahid/Desktop/linux-5.15.13/tools/objtool/elf.o
  CC      /home/nahid/Desktop/linux-5.15.13/tools/objtool/objtool.o
  CC      /home/nahid/Desktop/linux-5.15.13/tools/objtool/libstring.o
  CC      /home/nahid/Desktop/linux-5.15.13/tools/objtool/libctype.o
  CC      /home/nahid/Desktop/linux-5.15.13/tools/objtool/str_error_r.o
  CC      /home/nahid/Desktop/linux-5.15.13/tools/objtool/librbtree.o
  HOSTCC  scripts/mod/mk_elfconfig
  CC      scripts/mod/empty.o
  CC      scripts/mod/devicetable-offsets.s
  MKELF   scripts/mod/elfconfig.h
  HOSTCC  scripts/mod/modpost.o
  HOSTCC  scripts/mod/sumversion.o
  LD      /home/nahid/Desktop/linux-5.15.13/tools/objtool/objtool-in.o

  +=================================================================+
  +-----------------------------------------------------------------+
     It takes 10 min to 4 hours Depend on your system. Be patient!
  +-----------------------------------------------------------------+
  +=================================================================+

  CC      arch/x86/boot/compressed/ident_map_64.o
  CC      arch/x86/boot/video-vga.o
  CC      arch/x86/boot/video-vesa.o
  CC      arch/x86/boot/video-bios.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/acpi.o
  AS      arch/x86/boot/compressed/efi_thunk_64.o
  CC      arch/x86/boot/compressed/misc.o
  GZIP    arch/x86/boot/compressed/vmlinux.bin.gz
  HOSTCC  arch/x86/boot/tools/build
  CPUSTR  arch/x86/boot/cpustr.h
  CC      arch/x86/boot/cpu.o
  MKPIGGY arch/x86/boot/compressed/piggy.S
  AS      arch/x86/boot/compressed/piggy.o
  LD      arch/x86/boot/compressed/vmlinux
```

```
  ZOFFSET arch/x86/boot/zoffset.h
  OBJCOPY arch/x86/boot/vmlinux.bin
  AS      arch/x86/boot/header.o
  LD      arch/x86/boot/setup.elf
  OBJCOPY arch/x86/boot/setup.bin
  BUILD   arch/x86/boot/bzImage

Kernel: arch/x86/boot/bzImage is ready  (#4)
```

See the changes with `ls` command

```
nahid@cseru:~/Desktop/linux-5.15.13$ ls

arch     CREDITS        fs       ipc      lib          mm
modules.builtin.modinfo  samples   System.map  vmlinux
block    crypto         hello    Kbuild   LICENSES     Module.symvers
modules.order            scripts   tools       vmlinux-gdb.py
certs    Documentation  include  Kconfig  MAINTAINERS  modules-only.symvers
net                      security  usr         vmlinux.o
COPYING  drivers        init     kernel   Makefile     modules.builtin
README                   sound     virt        vmlinux.symvers
```

Modules Install

```
nahid@cseru:~/Desktop/linux-5.15.13$ sudo make modules_install install

[sudo] password for nahid:
  INSTALL
/lib/modules/5.15.13/kernel/drivers/thermal/intel/x86_pkg_temp_thermal.ko
  INSTALL /lib/modules/5.15.13/kernel/fs/efivarfs/efivarfs.ko
  INSTALL /lib/modules/5.15.13/kernel/net/ipv4/netfilter/iptable_nat.ko
  INSTALL /lib/modules/5.15.13/kernel/net/netfilter/nf_log_syslog.ko
  INSTALL /lib/modules/5.15.13/kernel/net/netfilter/xt_LOG.ko
  INSTALL /lib/modules/5.15.13/kernel/net/netfilter/xt_MASQUERADE.ko
  INSTALL /lib/modules/5.15.13/kernel/net/netfilter/xt_addrtype.ko
  INSTALL /lib/modules/5.15.13/kernel/net/netfilter/xt_mark.ko
  INSTALL /lib/modules/5.15.13/kernel/net/netfilter/xt_nat.ko
  DEPMOD  /lib/modules/5.15.13
sh ./arch/x86/boot/install.sh 5.15.13 \
    arch/x86/boot/bzImage System.map "/boot"
run-parts: executing /etc/kernel/postinst.d/apt-auto-removal 5.15.13
/boot/vmlinuz-5.15.13
run-parts: executing /etc/kernel/postinst.d/dkms 5.15.13 /boot/vmlinuz-
5.15.13
 * dkms: running auto installation service for kernel 5.15.13
[ OK ]
run-parts: executing /etc/kernel/postinst.d/initramfs-tools 5.15.13
/boot/vmlinuz-5.15.13
update-initramfs: Generating /boot/initrd.img-5.15.13
```

```
I: The initramfs will attempt to resume from /dev/sda8
I: (UUID=e9891e40-6ed1-4a0d-ba9a-41968a922e48)
I: Set the RESUME variable to override this.
run-parts: executing /etc/kernel/postinst.d/unattended-upgrades 5.15.13
/boot/vmlinuz-5.15.13
run-parts: executing /etc/kernel/postinst.d/update-notifier 5.15.13
/boot/vmlinuz-5.15.13
run-parts: executing /etc/kernel/postinst.d/xx-update-initrd-links 5.15.13
/boot/vmlinuz-5.15.13
I: /vmlinuz.old is now a symlink to boot/vmlinuz-5.11.0-44-generic
I: /initrd.img.old is now a symlink to boot/initrd.img-5.11.0-44-generic
I: /vmlinuz is now a symlink to boot/vmlinuz-5.15.13
I: /initrd.img is now a symlink to boot/initrd.img-5.15.13
run-parts: executing /etc/kernel/postinst.d/zz-update-grub 5.15.13
/boot/vmlinuz-5.15.13
Sourcing file `/etc/default/grub'
Sourcing file `/etc/default/grub.d/init-select.cfg'
Generating grub configuration file ...
Found linux image: /boot/vmlinuz-5.15.13
Found initrd image: /boot/initrd.img-5.15.13
Found linux image: /boot/vmlinuz-5.11.0-44-generic
Found initrd image: /boot/initrd.img-5.11.0-44-generic
Found linux image: /boot/vmlinuz-5.11.0-43-generic
Found initrd image: /boot/initrd.img-5.11.0-43-generic
Found memtest86+ image: /boot/memtest86+.elf
Found memtest86+ image: /boot/memtest86+.bin
Found Windows 10 on /dev/sda1
done
```

Finally perform `sudo make install`

```
nahid@cseru:~/Desktop/linux-5.15.13$ sudo make install

sh ./arch/x86/boot/install.sh 5.15.13 \
    arch/x86/boot/bzImage System.map "/boot"
run-parts: executing /etc/kernel/postinst.d/apt-auto-removal 5.15.13
/boot/vmlinuz-5.15.13
run-parts: executing /etc/kernel/postinst.d/dkms 5.15.13 /boot/vmlinuz-
5.15.13
 * dkms: running auto installation service for kernel 5.15.13
[ OK ]
run-parts: executing /etc/kernel/postinst.d/initramfs-tools 5.15.13
/boot/vmlinuz-5.15.13
update-initramfs: Generating /boot/initrd.img-5.15.13
I: The initramfs will attempt to resume from /dev/sda8
I: (UUID=e9891e40-6ed1-4a0d-ba9a-41968a922e48)
I: Set the RESUME variable to override this.
run-parts: executing /etc/kernel/postinst.d/unattended-upgrades 5.15.13
/boot/vmlinuz-5.15.13
run-parts: executing /etc/kernel/postinst.d/update-notifier 5.15.13
/boot/vmlinuz-5.15.13
```

```
run-parts: executing /etc/kernel/postinst.d/xx-update-initrd-links 5.15.13
/boot/vmlinuz-5.15.13
run-parts: executing /etc/kernel/postinst.d/zz-update-grub 5.15.13
/boot/vmlinuz-5.15.13
Sourcing file `/etc/default/grub'
Sourcing file `/etc/default/grub.d/init-select.cfg'
Generating grub configuration file ...
Found linux image: /boot/vmlinuz-5.15.13
Found initrd image: /boot/initrd.img-5.15.13
Found linux image: /boot/vmlinuz-5.15.13.old
Found initrd image: /boot/initrd.img-5.15.13
Found linux image: /boot/vmlinuz-5.11.0-44-generic
Found initrd image: /boot/initrd.img-5.11.0-44-generic
Found linux image: /boot/vmlinuz-5.11.0-43-generic
Found initrd image: /boot/initrd.img-5.11.0-43-generic
Found memtest86+ image: /boot/memtest86+.elf
Found memtest86+ image: /boot/memtest86+.bin
Found Windows 10 on /dev/sda1
done
```

Update Grub `sudo update-grub`

```
nahid@cseru:~/Desktop/linux-5.15.13$ sudo update-grub

Sourcing file `/etc/default/grub'
Sourcing file `/etc/default/grub.d/init-select.cfg'
Generating grub configuration file ...
Found linux image: /boot/vmlinuz-5.15.13
Found initrd image: /boot/initrd.img-5.15.13
Found linux image: /boot/vmlinuz-5.15.13.old
Found initrd image: /boot/initrd.img-5.15.13
Found linux image: /boot/vmlinuz-5.11.0-44-generic
Found initrd image: /boot/initrd.img-5.11.0-44-generic
Found linux image: /boot/vmlinuz-5.11.0-43-generic
Found initrd image: /boot/initrd.img-5.11.0-43-generic
Found memtest86+ image: /boot/memtest86+.elf
Found memtest86+ image: /boot/memtest86+.bin
Found Windows 10 on /dev/sda1
done
```

Reboot the system

```
nahid@cseru:~/Desktop/linux-5.15.13$ reboot
```

Final Step

Check kernel version

```
nahid@cseru:~/Desktop/linux-5.15.13$ uname -r
5.15.13
```

Check your system call is work or not???

```
nahid@cseru:~/Desktop/linux-5.15.13$ vim main.c
```

```c
#include <stdio.h>
#include <linux/kernel.h>
#include <sys/syscall.h>
#include <unistd.h>

int main() {
    long int hello = syscall(449);
    printf("%ld\n", hello);
}
```

Compile and Execute

```
nahid@cseru:~/Desktop/linux-5.15.13$ gcc main.c -o main
nahid@cseru:~/Desktop/linux-5.15.13$ ./main
0    # 0 for success
```

Run `dmesg` command.

`dmesg` is used to examine or control the `kernel` ring `buffer`.

```
nahid@cseru:~/Desktop/linux-5.15.13$ dmesg | tail -5                    # show
last five lines
```