Department of Computer Science and Information Engineering CSC006, Assignment 2 System calls

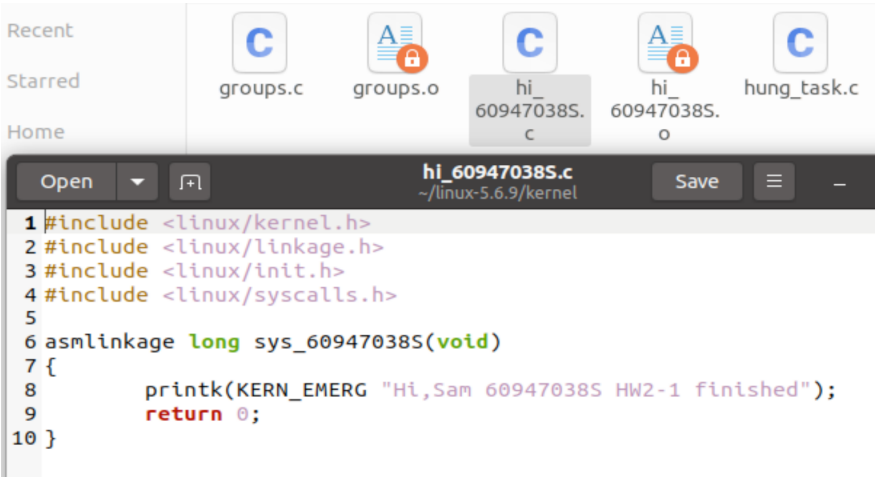
60947038S

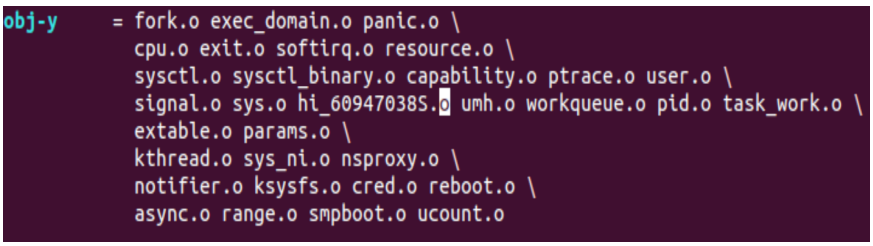
Hw2-1 Implementation Steps:

Step1: 建立並確保 hi_60947038S.c 能和 kernel source code 一起被 compiler 編譯

至 linux-5.6.9/kernel 建立 hi_60947038S.c 並打上程式碼。

在 Makefile 中找到一行 obj-y 在裡面加入：hi_60947038S.o

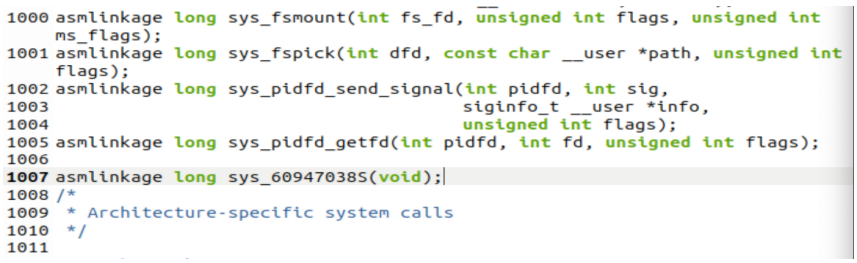




Step2: 定義我們 new system call function 的 prototype

至 linux-5.6.9/include/linux/syscalls.h,

加入程式碼: asmlinkage long sys_60947038S(void);



Step3: 設定 system call 編號為 335

至 linux/arch/x86/syscalls/syscall_64.tbl,

加入一行:335　64　hi_60947038S　sys_60947038S

```
341 330     common  pkey_alloc            __x64_sys_pkey_alloc
342 331     common  pkey_free             __x64_sys_pkey_free
343 332     common  statx                 __x64_sys_statx
344 333     common  io_pgetevents         __x64_sys_io_pgetevents
345 334     common  rseq                  __x64_sys_rseq
346 335     common  hi_60947038S          sys_60947038S
```

Step4:安裝需要使用的套件

輸入指令:

sudo apt-get install build-essential manpages-dev libncurses5-dev flex bison openssl libssl-dev libelf-dev libudev-dev libpci-dev libiberty-dev autoconf ncurses-dev

Step5: Compile Kernel/Install Kernel

sudo make mrproper

cp –v /boot/config-$(uname -r) .config

sudo make menuconfig

sudo make clean

sudo make –j 8

sudo make modules

sudo make modules_install

sudo make install

Step6: Demonstration 測試 system call

cd /etc/default

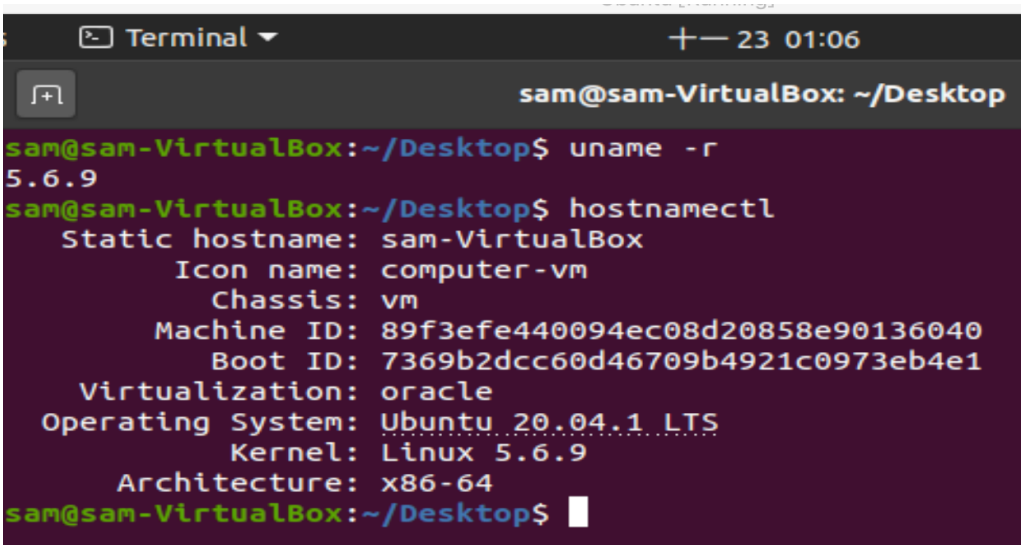
sudo gedit grub

sudo update-grub

Open　grub /etc/default

```
1 # If you change this file, run 'update-grub' afterwards to update
2 # /boot/grub/grub.cfg.
3 # For full documentation of the options in this file, see:
4 #   info -f grub -n 'Simple configuration'
5
6 GRUB_DEFAULT=0
7 GRUB_TIMEOUT_STYLE=menu
8 GRUB_TIMEOUT=60
9 GRUB_DISTRIBUTOR=`lsb_release -i -s 2> /dev/null || echo Debian`
10 GRUB_CMDLINE_LINUX_DEFAULT="quiet splash"
11 GRUB_CMDLINE_LINUX=""
```

reboot 開啟編譯好的 kernel:



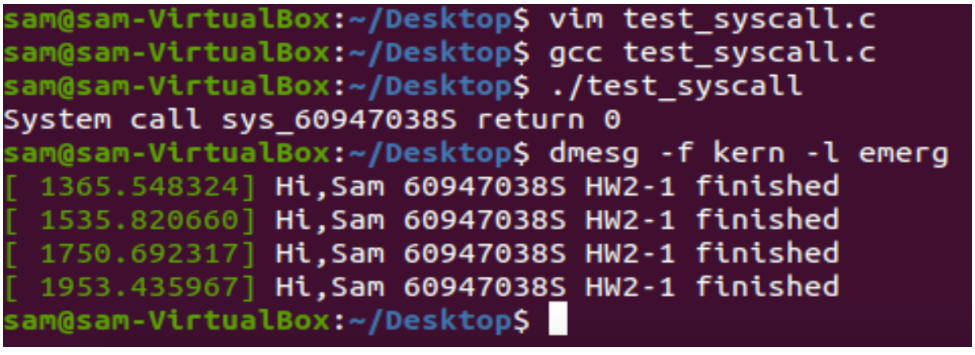
寫一個 C program :test_syscall.c 來測試 syscall

完成 coding 並編譯:*gcc test_syscall.c*

執行 test_syscall 將 kernel log 印在 terminal 上:*dmesg –f kern –l emerg*

結果 system call 成功回傳 0 並且印出 kernel log 在 terminal 上！

測試成功！！



Hw2-2 Implementation Steps:

2-2 的部分因為環境問題所以改用 linux-5.0.0，且 2-1 的部份必須也在 linux-5.0.0 上重做一次。

Step1:新增一個標頭檔

至 linux-5.0.0/include/linux 建立 prinfo.h 並打上程式碼

```
#ifndef _LINUX_PRINFO_H
#define _LINUX_PRINFO_H

#ifndef __KERNEL__
//if the header files are from loadable kernel modules.
#include <linux/types.h>
#include <linux/pid.h>

#else
//else the header files are from the use-space programs.

#include <asm/unistd.h>
#include <sys/types.h>

#endif
struct prinfo{
        long state;/*current process state*/
        long nice;/*process nice value*/
        pid_t pid;/*process id*/
        pid_t parent_pid;/*process id of parent*/
        pid_t youngest_child_pid;/*process of youngest child*/
        unsigned long start_time;/*process start time*/
        long user_time;/*CPU time for user mode*/
        long sys_time;/*CPU time for kernel mode*/
        long uid;/*user id for process owner*/
        char comm[16];/*name of the program executed */
};

#endif
```

Step2:建立 syscall 程式碼、以及 Makefile 到 info 目錄下:

至 linux-5.0.0/info/info.c ，輸入程式碼，程式碼請見 info.c

至 linux-5.0.0/info/Makefile，輸入一行: obj-y := info.o

回到 linux-5.0.0/Makefile 中，找到 1017 行的位置加入…../ info (hint:注意空白)，目的是告知系統 syscall 在此目錄下

```
ifeq ($(KBUILD_EXTMOD),)
core-y          += kernel/ certs/ mm/ fs/ ipc/ security/ crypto/ block/ info/
vmlinux-dirs    := $(patsubst %/,%,$(filter %/, $(init-y) $(init-m) \
                     $(core-y) $(core-m) $(drivers-y) $(drivers-m) \
                     $(net-y) $(net-m) $(libs-y) $(libs-m) $(virt-y)))

vmlinux-alldirs := $(sort $(vmlinux-dirs) Documentation \
                     $(patsubst %/,%,$(filter %/, $(init-) $(core-) \
                        $(drivers-) $(net-) $(libs-) $(virt-))))
```

至 linux-5.0.0/include/linux/syscalls.h，定義系統呼叫標頭檔

```
#include <linux/personality.h>
#include <linux/prinfo.h>
#include <trace/syscall.h>
```

```
asmlinkage long sys_pidfd_getfd(int pidfd, int fd, unsigned int flags);

asmlinkage long sys_60947038S(void);
asmlinkage long sys_getPrinfo(struct prinfo *info);
/*
 * Architecture-specific system calls
 */
```

至 linux-5.0.0/arch/x86/entry/syscalls/syscall_64.tbl，設定 syscall table

```
333     common  io_pgetevents          __x64_sys_io_pgetevents
334     common  rseq                   __x64_sys_rseq
335     common  hi_60947038S           sys_60947038S
336     common  info                   sys_getPrinfo
```

Step3:編譯 kernel 並 reboot

Step4: Demonstration 測試 system call

寫一個 C program: test_syscall2.c 測試 sys_getPrinfo

```c
#include "prinfo.h"
#include <linux/unistd.h>
#include <stdio.h>

long getProcessInfo(struct prinfo *info){
        return syscall(336,info);
}

int main(void){
        struct prinfo info;
        long num;
        int f_name;
        for(int i=0;i<=30000;i++)
        {
                for(int j=0;j<=1000;j++){
                f_name=f_name+1;
                }
        }
        num = getProcessInfo(&info);
        printf("state:%ld\n",info.state);
        printf("nice:%ld\n",info.nice);
        printf("pid:%d\n",info.pid);
        printf("parent pid:%d\n",info.parent_pid);
        printf("pid youngestchild:%d\n",info.youngest_child_pid);
        printf("start time:%ld\n",info.start_time);
        printf("user time:%ld\n",info.user_time);
        printf("system time:%ld\n",info.sys_time);
        printf("user id:%ld\n",info.uid);
        printf("name of program:%s\n",info.comm);
}
```

測試成功！

gcc test_syscall2.c

./a.out

dmesg

UserSpace result: (./a.out)

Kernel log result: (dmesg)

```
[  314.953277] Current state of process: 0
[  314.953279] Process nice value: -817180573
[  314.953280] Process id: 2591
[  314.953281] Process id of parent: 2452
[  314.953281] Pid of youngest child: 2591
[  314.953282] Start time value: 315005906486
[  314.953282] CPU time spent in user mode: 72000000
[  314.953282] CPU time spend in system mode: 4000000
[  314.953283] User id of process owner: 1000
[  314.953284] Name of program executed: a.out
```

Comment:

Hw2-1:剛開始做新增一個簡單的 system call 的題目時，對於很多步驟都不太了解其內容、目的及原因，所以導致做得非常混亂且編譯一直沒有辦法過關，甚至也不知道編譯失敗要執行 make clean/make mrproper，清除那些編譯過程會出現的多餘的檔案以及一些.o 檔，才不會重複出錯。後來在網路上研讀了"鳥哥 Linux"學到了很多，才慢慢的能一步一步完成功課。Hw2-2:對我來說真的比較困難一點，因為我對 C program 比較不熟悉，所以上面的程式碼我做了好長一段時間的查詢、debugging 才完成。成功完成後真的覺得學到了很多，對於客製 system call 的做法有很深刻的了解，也更清楚了解 kernel 底層對於 system call 是如何運作的。

Reference:

https://it.livekn.com/2013/01/kernel-system-call.html
https://medium.com/anubhav-shrimal/adding-a-hello-world-system-call-to-linux-kernel-dad32875872
https://linuxconfig.org/introduction-to-the-linux-kernel-log-levels
https://stackoverflow.com/questions/59994792/error-conflicting-types-when-trying-to-make-a-simple-syscall
https://dev.to/stalim/comment/lp3f
https://stackoverflow.com/questions/33398815/ubuntu-15-10-kernel-4-2-hello-world-kernel-module-makefile-error
https://huenlil.pixnet.net/blog/post/23507650