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CS342 - 3

HW-1

1. As instructed, I read first two chapters of the textbook.

2. I installed Ubuntu on my laptop about 1 years ago since I was curious about the Ubuntu and my laptop was not enough hardware capability to run Windows efficiently. However, since I used Ubuntu 18.04, I updated the OS to Ubuntu 20.04 LTS from Software Updater program. The ten command I learnt are below:
   - sudo: It applies the command with root (administrator) permissions.
   - cp: It copies the file to given directory.
   - mv: It moves the specified file to the given directory or rename the specified file to given name.
   - mkdir: It creates the new sub-directory in current directory.
   - touch: It creates the new file in current directory.
   - chmod: It changes the current permissions of the specified file or folder.
   - rmdir: It removes the given directory only if it is empty.
   - cat: It prints the contents of specified file to the terminal.
   - wget: It helps to download the content from the given url.
   - apt: It manages the deb packages for Ubuntu such as installing, updating, or removing. It is used with commands like install, update.
   -
3. Location of my Linux kernel executable is "/boot/vmlinuz-5.4.0-99-generic" directory by "cat /proc/cmdline".

   My kernel version is 5.4.0-99-generic.

4. The subdirectories are arch, fs, LICENSES, net, security, virt, block, crypto, include, sound, certs, Documentation, init, kernel, samples, tools, drivers, ipc, lib, mm, scripts, usr.

5. System calls:

   3: close
   35: nanosleep
   110: getppid
   210: io_cancel

6. Output of “strace ls” command in root:

```
 execve("/bin/ls", ["ls"], 0x7ffe4f543cb0 /* 83 vars */) = 0
brk(NULL)                               = 0x55f05bad3000
arch_prctl(0x3001 /* ARCH_??? */, 0x7ffc4ffcf130) = -1 EINVAL (Invalid argument)
access("/etc/ld.so.preload", R_OK)      = -1 ENOENT (No such file or directory)
openat(AT_FDCWD, "/etc/ld.so.cache", O_RDONLY|O_CLOEXEC) = 3
fstat(3, {st_mode=S_IFREG|0644, st_size=119691, ...}) = 0
mmap(NULL, 119691, PROT_READ, MAP_PRIVATE, 3, 0) = 0x7f76290da000
close(3)                                = 0
openat(AT_FDCWD, "/lib/x86_64-linux-gnu/libselinux.so.1",
O_RDONLY|O_CLOEXEC) = 3
read(3, "\177ELF\2\1\1\0\0\0\0\0\0\0\0\0\3\0>\0\1\0\0\0@p\0\0\0\0\0\0"..., 832) = 832
fstat(3, {st_mode=S_IFREG|0644, st_size=163200, ...}) = 0
mmap(NULL, 8192, PROT_READ|PROT_WRITE,
MAP_PRIVATE|MAP_ANONYMOUS, -1, 0) = 0x7f76290d8000
mmap(NULL, 174600, PROT_READ, MAP_PRIVATE|MAP_DENYWRITE, 3, 0) =
0x7f76290ad000
mprotect(0x7f76290b3000, 135168, PROT_NONE) = 0
mmap(0x7f76290b3000, 102400, PROT_READ|PROT_EXEC,
MAP_PRIVATE|MAP_FIXED|MAP_DENYWRITE, 3, 0x6000) = 0x7f76290b3000
mmap(0x7f76290cc000, 28672, PROT_READ,
MAP_PRIVATE|MAP_FIXED|MAP_DENYWRITE, 3, 0x1f000) = 0x7f76290cc000
mmap(0x7f76290d4000, 8192, PROT_READ|PROT_WRITE,
MAP_PRIVATE|MAP_FIXED|MAP_DENYWRITE, 3, 0x26000) = 0x7f76290d4000
mmap(0x7f76290d6000, 6664, PROT_READ|PROT_WRITE,
MAP_PRIVATE|MAP_FIXED|MAP_ANONYMOUS, -1, 0) = 0x7f76290d6000
close(3)                                = 0
openat(AT_FDCWD, "/lib/x86_64-linux-gnu/libc.so.6", O_RDONLY|O_CLOEXEC) = 3
read(3, "\177ELF\2\1\1\3\0\0\0\0\0\0\0\0\3\0>\0\1\0\0\0\360q\2\0\0\0\0\0"..., 832) = 832
pread64(3, "\6\0\0\0\4\0\0\0@\0\0\0\0\0\0\0@\0\0\0\0\0\0\0@\0\0\0\0\0\0\0"..., 784, 64) =
784
pread64(3, "\4\0\0\0\20\0\0\0\5\0\0\0GNU\0\2\0\0\300\4\0\0\0\3\0\0\0\0\0\0\0", 32, 848)
= 32
pread64(3,
"\4\0\0\0\24\0\0\0\3\0\0\0GNU\0\t\233\222%\274\260\320\31\331\326\10\204\276X>\26
3"..., 68, 880) = 68
fstat(3, {st_mode=S_IFREG|0755, st_size=2029224, ...}) = 0
pread64(3, "\6\0\0\0\4\0\0\0@\0\0\0\0\0\0\0@\0\0\0\0\0\0\0@\0\0\0\0\0\0\0"..., 784, 64) =
784
pread64(3, "\4\0\0\0\20\0\0\0\5\0\0\0GNU\0\2\0\0\300\4\0\0\0\3\0\0\0\0\0\0\0", 32, 848)
= 32
```

```
pread64(3,
"\4\0\0\0\24\0\0\0\3\0\0\0GNU\0\t\233\222%\274\260\320\31\331\326\10\204\276X>\26
3"..., 68, 880) = 68
mmap(NULL, 2036952, PROT_READ, MAP_PRIVATE|MAP_DENYWRITE, 3, 0) =
0x7f7628ebb000
mprotect(0x7f7628ee0000, 1847296, PROT_NONE) = 0
mmap(0x7f7628ee0000, 1540096, PROT_READ|PROT_EXEC,
MAP_PRIVATE|MAP_FIXED|MAP_DENYWRITE, 3, 0x25000) = 0x7f7628ee0000
mmap(0x7f7629058000, 303104, PROT_READ,
MAP_PRIVATE|MAP_FIXED|MAP_DENYWRITE, 3, 0x19d000) = 0x7f7629058000
mmap(0x7f76290a3000, 24576, PROT_READ|PROT_WRITE,
MAP_PRIVATE|MAP_FIXED|MAP_DENYWRITE, 3, 0x1e7000) = 0x7f76290a3000
mmap(0x7f76290a9000, 13528, PROT_READ|PROT_WRITE,
MAP_PRIVATE|MAP_FIXED|MAP_ANONYMOUS, -1, 0) = 0x7f76290a9000
close(3)                                = 0
openat(AT_FDCWD, "/usr/lib/x86_64-linux-gnu/libpcre2-8.so.0",
O_RDONLY|O_CLOEXEC) = 3
read(3, "\177ELF\2\1\1\0\0\0\0\0\0\0\0\0\3\0>\0\1\0\0\0\340\"\0\0\0\0\0\0"..., 832) = 832
fstat(3, {st_mode=S_IFREG|0644, st_size=584392, ...}) = 0
mmap(NULL, 586536, PROT_READ, MAP_PRIVATE|MAP_DENYWRITE, 3, 0) =
0x7f7628e2b000
mmap(0x7f7628e2d000, 409600, PROT_READ|PROT_EXEC,
MAP_PRIVATE|MAP_FIXED|MAP_DENYWRITE, 3, 0x2000) = 0x7f7628e2d000
mmap(0x7f7628e91000, 163840, PROT_READ,
MAP_PRIVATE|MAP_FIXED|MAP_DENYWRITE, 3, 0x66000) = 0x7f7628e91000
mmap(0x7f7628eb9000, 8192, PROT_READ|PROT_WRITE,
MAP_PRIVATE|MAP_FIXED|MAP_DENYWRITE, 3, 0x8d000) = 0x7f7628eb9000
close(3)                                = 0
openat(AT_FDCWD, "/lib/x86_64-linux-gnu/libdl.so.2", O_RDONLY|O_CLOEXEC) =
3
read(3, "\177ELF\2\1\1\0\0\0\0\0\0\0\0\0\3\0>\0\1\0\0\0 \22\0\0\0\0\0\0"..., 832) = 832
fstat(3, {st_mode=S_IFREG|0644, st_size=18816, ...}) = 0
mmap(NULL, 20752, PROT_READ, MAP_PRIVATE|MAP_DENYWRITE, 3, 0) =
0x7f7628e25000
mmap(0x7f7628e26000, 8192, PROT_READ|PROT_EXEC,
MAP_PRIVATE|MAP_FIXED|MAP_DENYWRITE, 3, 0x1000) = 0x7f7628e26000
mmap(0x7f7628e28000, 4096, PROT_READ,
MAP_PRIVATE|MAP_FIXED|MAP_DENYWRITE, 3, 0x3000) = 0x7f7628e28000
mmap(0x7f7628e29000, 8192, PROT_READ|PROT_WRITE,
MAP_PRIVATE|MAP_FIXED|MAP_DENYWRITE, 3, 0x3000) = 0x7f7628e29000
close(3)                                = 0
openat(AT_FDCWD, "/lib/x86_64-linux-gnu/libpthread.so.0",
O_RDONLY|O_CLOEXEC) = 3
```

```
read(3, "\177ELF\2\1\1\0\0\0\0\0\0\0\0\0\3\0>\0\1\0\0\0\220\201\0\0\0\0\0\0"..., 832) =
832
pread64(3,
"\4\0\0\0\24\0\0\0\3\0\0\0GNU\0\345Ga\367\265T\320\374\301V)Yf]\223\337"..., 68,
824) = 68
fstat(3, {st_mode=S_IFREG|0755, st_size=157224, ...}) = 0
pread64(3,
"\4\0\0\0\24\0\0\0\3\0\0\0GNU\0\345Ga\367\265T\320\374\301V)Yf]\223\337"..., 68,
824) = 68
mmap(NULL, 140408, PROT_READ, MAP_PRIVATE|MAP_DENYWRITE, 3, 0) =
0x7f7628e02000
mmap(0x7f7628e09000, 69632, PROT_READ|PROT_EXEC,
MAP_PRIVATE|MAP_FIXED|MAP_DENYWRITE, 3, 0x7000) = 0x7f7628e09000
mmap(0x7f7628e1a000, 20480, PROT_READ,
MAP_PRIVATE|MAP_FIXED|MAP_DENYWRITE, 3, 0x18000) = 0x7f7628e1a000
mmap(0x7f7628e1f000, 8192, PROT_READ|PROT_WRITE,
MAP_PRIVATE|MAP_FIXED|MAP_DENYWRITE, 3, 0x1c000) = 0x7f7628e1f000
mmap(0x7f7628e21000, 13432, PROT_READ|PROT_WRITE,
MAP_PRIVATE|MAP_FIXED|MAP_ANONYMOUS, -1, 0) = 0x7f7628e21000
close(3)                                = 0
mmap(NULL, 8192, PROT_READ|PROT_WRITE,
MAP_PRIVATE|MAP_ANONYMOUS, -1, 0) = 0x7f7628e00000
arch_prctl(ARCH_SET_FS, 0x7f7628e01400) = 0
mprotect(0x7f76290a3000, 12288, PROT_READ) = 0
mprotect(0x7f7628e1f000, 4096, PROT_READ) = 0
mprotect(0x7f7628e29000, 4096, PROT_READ) = 0
mprotect(0x7f7628eb9000, 4096, PROT_READ) = 0
mprotect(0x7f76290d4000, 4096, PROT_READ) = 0
mprotect(0x55f05aeb9000, 4096, PROT_READ) = 0
mprotect(0x7f7629125000, 4096, PROT_READ) = 0
munmap(0x7f76290da000, 119691)          = 0
set_tid_address(0x7f7628e016d0)         = 11259
set_robust_list(0x7f7628e016e0, 24)     = 0
rt_sigaction(SIGRTMIN, {sa_handler=0x7f7628e09bf0, sa_mask=[],
sa_flags=SA_RESTORER|SA_SIGINFO, sa_restorer=0x7f7628e173c0}, NULL, 8) = 0
rt_sigaction(SIGRT_1, {sa_handler=0x7f7628e09c90, sa_mask=[],
sa_flags=SA_RESTORER|SA_RESTART|SA_SIGINFO, sa_restorer=0x7f7628e173c0},
NULL, 8) = 0
rt_sigprocmask(SIG_UNBLOCK, [RTMIN RT_1], NULL, 8) = 0
prlimit64(0, RLIMIT_STACK, NULL, {rlim_cur=8192*1024,
rlim_max=RLIM64_INFINITY}) = 0
statfs("/sys/fs/selinux", 0x7ffc4ffcf080) = -1 ENOENT (No such file or directory)
statfs("/selinux", 0x7ffc4ffcf080)      = -1 ENOENT (No such file or directory)
```

```
brk(NULL)                               = 0x55f05bad3000
brk(0x55f05baf4000)                     = 0x55f05baf4000
openat(AT_FDCWD, "/proc/filesystems", O_RDONLY|O_CLOEXEC) = 3
fstat(3, {st_mode=S_IFREG|0444, st_size=0, ...}) = 0
read(3, "nodev\tsysfs\nnodev\ttmpfs\nnodev\tbd"..., 1024) = 393
read(3, "", 1024)                       = 0
close(3)                                = 0
access("/etc/selinux/config", F_OK)     = -1 ENOENT (No such file or directory)
openat(AT_FDCWD, "/usr/lib/locale/locale-archive", O_RDONLY|O_CLOEXEC) = 3
fstat(3, {st_mode=S_IFREG|0644, st_size=8505296, ...}) = 0
mmap(NULL, 8505296, PROT_READ, MAP_PRIVATE, 3, 0) = 0x7f76285e3000
close(3)                                = 0
ioctl(1, TCGETS, {B38400 opost isig icanon echo ...}) = 0
ioctl(1, TIOCGWINSZ, {ws_row=24, ws_col=80, ws_xpixel=0, ws_ypixel=0}) = 0
openat(AT_FDCWD, ".",
O_RDONLY|O_NONBLOCK|O_CLOEXEC|O_DIRECTORY) = 3
fstat(3, {st_mode=S_IFDIR|0755, st_size=4096, ...}) = 0
getdents64(3, /* 33 entries */, 32768)  = 912
getdents64(3, /* 0 entries */, 32768)   = 0
close(3)                                = 0
fstat(1, {st_mode=S_IFCHR|0620, st_rdev=makedev(0x88, 0), ...}) = 0
write(1, "bin    home\t      lib64\t  opt\t"..., 45bin    home        lib64          opt     snap
usr
) = 45
write(1, "boot   initrd.img     libx32\t  "..., 62boot   initrd.img     libx32   proc  srv
uyap-editor.deb
) = 62
write(1, "cdrom  initrd.img.old  lost+foun"..., 55cdrom  initrd.img.old  lost+found  root
swapfile  var
) = 55
write(1, "dev    lib\t      media\t  run\t "..., 47dev    lib            media        run     sys
vmlinuz
) = 47
write(1, "etc    lib32\t      mnt\t  sbin "..., 52etc    lib32          mnt          sbin  tmp
vmlinuz.old
) = 52
close(1)                                = 0
close(2)                                = 0
exit_group(0)                           = ?
+++ exited with 0 +++
```

7. Real is the time from start to finish the call. It includes all the time.
   User is the CPU time spent in user mode. It is actual CPU time which does not count the blocked times.
   Sys is the CPU time spent in kernel mode. It measures the system call times and user time.
   “time ls” command in root directory:
   real: 3 s
   user: 0 s
   sys: 2 s
   “time cp” command in root directory:
   real: 3 s
   user: 1 s
   sys: 2 s

8. list.c:

```
#include <stdio.h>
#include <stdlib.h>
#include <sys/time.h>

struct listNode {
   int number;
   struct listNode *next;
};

typedef struct listNode ListNode;
typedef ListNode *ListNodePtr;

//Basic functions of linked list
void insert ( ListNodePtr *sPtr, int val);
int isEmpty( ListNodePtr sPtr);

int main( void ) {
   ListNodePtr start = NULL;
```

```
    int item = rand();
    int cnt = 0;

    struct timeval startTime, endTime;
    gettimeofday(&startTime, NULL);
    while (cnt < 10000) {
        insert( &start, item);
        item = rand();
        cnt++;
    }
    gettimeofday(&endTime, NULL);
    //result time in microseconds
    double res = (endTime.tv_sec - startTime.tv_sec) * 1000000 + (endTime.tv_usec -
startTime.tv_usec);
    //Check if the elements are inserted
    if( !isEmpty(start) ){
        printf("The time is %f microseconds\n", res);
    }
    printf("The end\n");
    return 0;
}

void insert( ListNodePtr *sPtr, int val ) {
    ListNodePtr newPtr;
    ListNodePtr prev;
    ListNodePtr curr;

    newPtr = malloc( sizeof( ListNode ) );
```

```
   if( newPtr != NULL ){
      newPtr->number = val;
      newPtr->next = NULL;

      prev = NULL;
      curr = *sPtr;

      while( curr != NULL ) {
         prev = curr;
         curr = curr->next;
      }

      if( prev == NULL ){
         newPtr->next = *sPtr;
         *sPtr = newPtr;
      } else {
         prev->next = newPtr;
         newPtr->next = curr;
      }
   } else {
      printf("No memory available");
   }
}

int isEmpty( ListNodePtr sPtr ) {
   return sPtr == NULL;
}
```

Makefile:

```
all: list
list: list.c
	gcc -Wall -g -o list list.c
clean:
	rm -fr list list.o *~
```