# Operating System and Design (19CS2106A)
# Advanced Lab- 6

## Xv6 design, implementation, and customization.

### 1. System call tracing

System call tracing (moderate) ... You have to modify the xv6 kernel to print out a line when each system call is about to return, if the system call's number is set in the mask. The line should contain the process id, the name of the system call and the return value; you don't need to print the system call arguments.

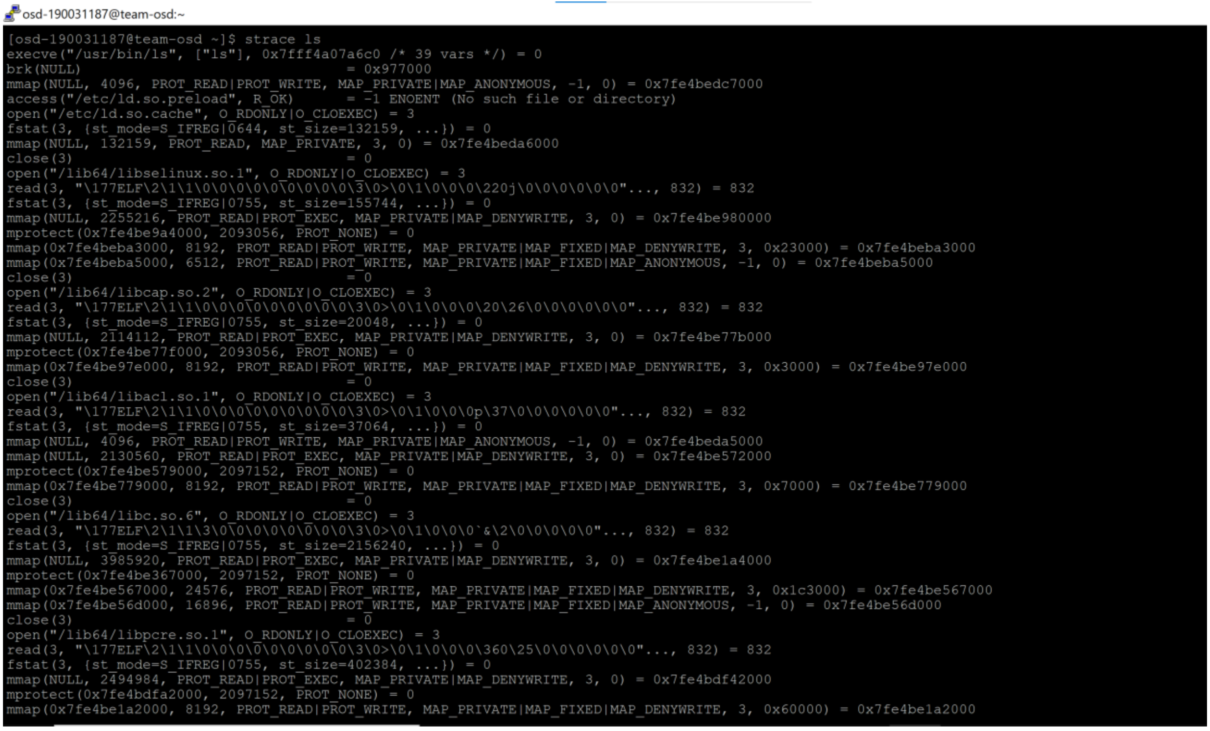
You can use strace command to trace the execution of any executable.

The following example shows the output of strace for the Linux ls command.

Strace monitors the system calls and signals of a specific program. It is helpful when you do not have the source code and would like to debug the execution of a program. strace provides you the execution sequence of a binary from start to end.

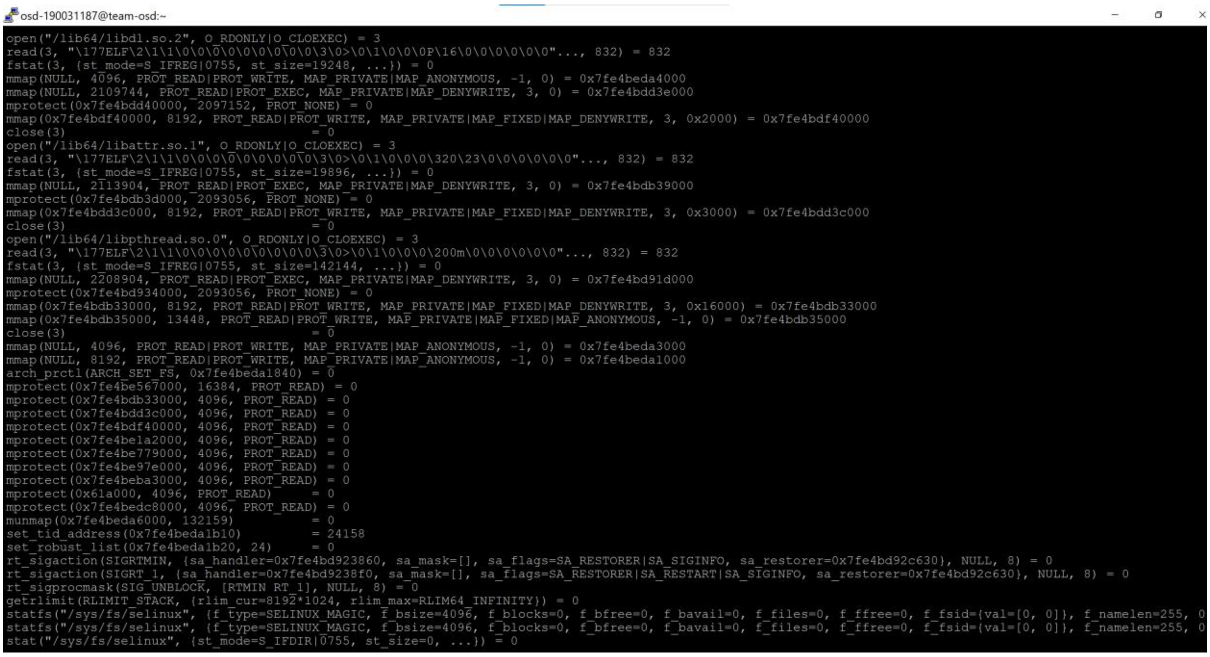
BELOW COMMANDS ARE executed in putty :-------------------

strace ls,

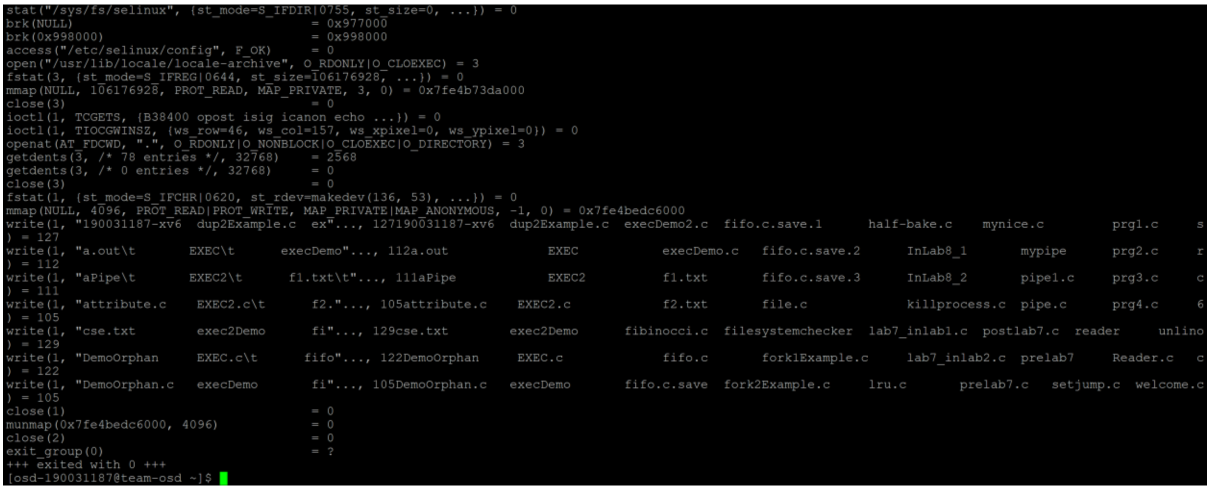


osd-190031187@team-osd:~

```
[osd-190031187@team-osd ~]$ strace ls
execve("/usr/bin/ls", ["ls"], 0x7fff4a07a6c0 /* 39 vars */) = 0
brk(NULL)                               = 0x977000
mmap(NULL, 4096, PROT_READ|PROT_WRITE, MAP_PRIVATE|MAP_ANONYMOUS, -1, 0) = 0x7fe4bedc7000
access("/etc/ld.so.preload", R_OK)      = -1 ENOENT (No such file or directory)
open("/etc/ld.so.cache", O_RDONLY|O_CLOEXEC) = 3
fstat(3, {st_mode=S_IFREG|0644, st_size=132159, ...}) = 0
mmap(NULL, 132159, PROT_READ, MAP_PRIVATE, 3, 0) = 0x7fe4beda6000
close(3)                                = 0
open("/lib64/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\220j\0\0\0\0\0\0"..., 832) = 832
fstat(3, {st_mode=S_IFREG|0755, st_size=155744, ...}) = 0
mmap(NULL, 2255216, PROT_READ|PROT_EXEC, MAP_PRIVATE|MAP_DENYWRITE, 3, 0) = 0x7fe4be980000
mprotect(0x7fe4be9a4000, 2093056, PROT_NONE) = 0
mmap(0x7fe4beba3000, 8192, PROT_READ|PROT_WRITE, MAP_PRIVATE|MAP_FIXED|MAP_DENYWRITE, 3, 0x23000) = 0x7fe4beba3000
mmap(0x7fe4beba5000, 6512, PROT_READ|PROT_WRITE, MAP_PRIVATE|MAP_FIXED|MAP_ANONYMOUS, -1, 0) = 0x7fe4beba5000
close(3)                                = 0
open("/lib64/libcap.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\20\26\0\0\0\0\0\0"..., 832) = 832
fstat(3, {st_mode=S_IFREG|0755, st_size=20048, ...}) = 0
mmap(NULL, 2114112, PROT_READ|PROT_EXEC, MAP_PRIVATE|MAP_DENYWRITE, 3, 0) = 0x7fe4be77b000
mprotect(0x7fe4be77f000, 2093056, PROT_NONE) = 0
mmap(0x7fe4be97e000, 8192, PROT_READ|PROT_WRITE, MAP_PRIVATE|MAP_FIXED|MAP_DENYWRITE, 3, 0x3000) = 0x7fe4be97e000
close(3)                                = 0
open("/lib64/libacl.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\0p\37\0\0\0\0\0\0"..., 832) = 832
fstat(3, {st_mode=S_IFREG|0755, st_size=37064, ...}) = 0
mmap(NULL, 4096, PROT_READ|PROT_WRITE, MAP_PRIVATE|MAP_ANONYMOUS, -1, 0) = 0x7fe4beda5000
mmap(NULL, 2130560, PROT_READ|PROT_EXEC, MAP_PRIVATE|MAP_DENYWRITE, 3, 0) = 0x7fe4be572000
mprotect(0x7fe4be579000, 2097152, PROT_NONE) = 0
mmap(0x7fe4be779000, 8192, PROT_READ|PROT_WRITE, MAP_PRIVATE|MAP_FIXED|MAP_DENYWRITE, 3, 0x7000) = 0x7fe4be779000
close(3)                                = 0
open("/lib64/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`&\2\0\0\0\0\0"..., 832) = 832
fstat(3, {st_mode=S_IFREG|0755, st_size=2156240, ...}) = 0
mmap(NULL, 3985920, PROT_READ|PROT_EXEC, MAP_PRIVATE|MAP_DENYWRITE, 3, 0) = 0x7fe4be1a4000
mprotect(0x7fe4be367000, 2097152, PROT_NONE) = 0
mmap(0x7fe4be567000, 24576, PROT_READ|PROT_WRITE, MAP_PRIVATE|MAP_FIXED|MAP_DENYWRITE, 3, 0x1c3000) = 0x7fe4be567000
mmap(0x7fe4be56d000, 16896, PROT_READ|PROT_WRITE, MAP_PRIVATE|MAP_FIXED|MAP_ANONYMOUS, -1, 0) = 0x7fe4be56d000
close(3)                                = 0
open("/lib64/libpcre.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\360\25\0\0\0\0\0\0"..., 832) = 832
fstat(3, {st_mode=S_IFREG|0755, st_size=402384, ...}) = 0
mmap(NULL, 2494984, PROT_READ|PROT_EXEC, MAP_PRIVATE|MAP_DENYWRITE, 3, 0) = 0x7fe4bdf42000
mprotect(0x7fe4bdfa2000, 2097152, PROT_NONE) = 0
mmap(0x7fe4be1a2000, 8192, PROT_READ|PROT_WRITE, MAP_PRIVATE|MAP_FIXED|MAP_DENYWRITE, 3, 0x60000) = 0x7fe4be1a2000
```

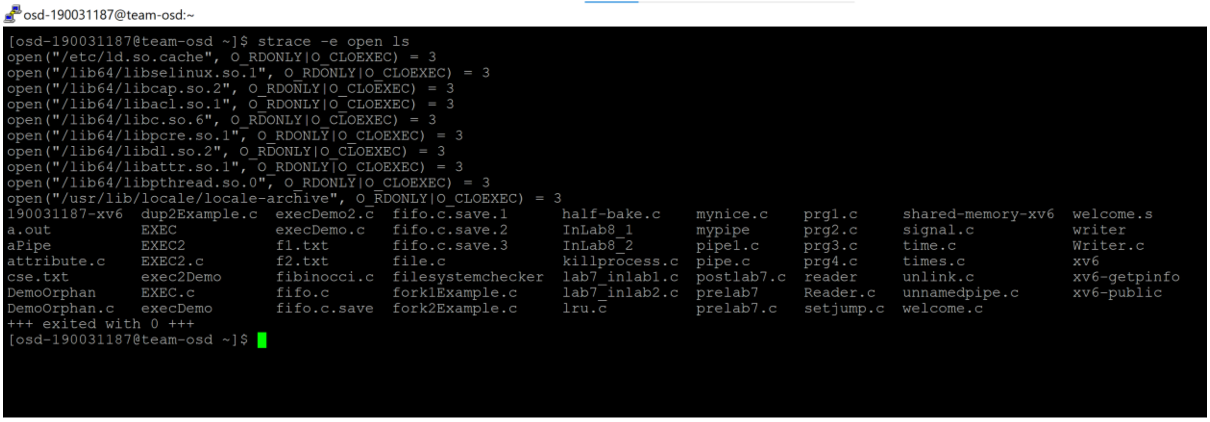


```
open("/lib64/libdl.so.2", O_RDONLY|O_CLOEXEC) = 3
read(3, "\177ELF\2\1\1\0\0\0\0\0\0\0\0\0\3\0>\0\1\0\0\0P\16\0\0\0\0\0\0"..., 832) = 832
fstat(3, {st_mode=S_IFREG|0755, st_size=19248, ...}) = 0
mmap(NULL, 4096, PROT_READ|PROT_WRITE, MAP_PRIVATE|MAP_ANONYMOUS, -1, 0) = 0x7fe4beda4000
mmap(NULL, 2109744, PROT_READ|PROT_EXEC, MAP_PRIVATE|MAP_DENYWRITE, 3, 0) = 0x7fe4bdd3e000
mprotect(0x7fe4bdd40000, 2097152, PROT_NONE) = 0
mmap(0x7fe4bdf40000, 8192, PROT_READ|PROT_WRITE, MAP_PRIVATE|MAP_FIXED|MAP_DENYWRITE, 3, 0x2000) = 0x7fe4bdf40000
close(3)                                = 0
open("/lib64/libattr.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\320\23\0\0\0\0\0\0"..., 832) = 832
fstat(3, {st_mode=S_IFREG|0755, st_size=19896, ...}) = 0
mmap(NULL, 2113904, PROT_READ|PROT_EXEC, MAP_PRIVATE|MAP_DENYWRITE, 3, 0) = 0x7fe4bdb39000
mprotect(0x7fe4bdb3d000, 2093056, PROT_NONE) = 0
mmap(0x7fe4bdd3c000, 8192, PROT_READ|PROT_WRITE, MAP_PRIVATE|MAP_FIXED|MAP_DENYWRITE, 3, 0x3000) = 0x7fe4bdd3c000
close(3)                                = 0
open("/lib64/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\200m\0\0\0\0\0\0"..., 832) = 832
fstat(3, {st_mode=S_IFREG|0755, st_size=142144, ...}) = 0
mmap(NULL, 2208904, PROT_READ|PROT_EXEC, MAP_PRIVATE|MAP_DENYWRITE, 3, 0) = 0x7fe4bd91d000
mprotect(0x7fe4bd934000, 2093056, PROT_NONE) = 0
mmap(0x7fe4bdb33000, 8192, PROT_READ|PROT_WRITE, MAP_PRIVATE|MAP_FIXED|MAP_DENYWRITE, 3, 0x16000) = 0x7fe4bdb33000
mmap(0x7fe4bdb35000, 13448, PROT_READ|PROT_WRITE, MAP_PRIVATE|MAP_FIXED|MAP_ANONYMOUS, -1, 0) = 0x7fe4bdb35000
close(3)                                = 0
mmap(NULL, 4096, PROT_READ|PROT_WRITE, MAP_PRIVATE|MAP_ANONYMOUS, -1, 0) = 0x7fe4beda3000
mmap(NULL, 8192, PROT_READ|PROT_WRITE, MAP_PRIVATE|MAP_ANONYMOUS, -1, 0) = 0x7fe4beda1000
arch_prctl(ARCH_SET_FS, 0x7fe4beda1840) = 0
mprotect(0x7fe4be567000, 16384, PROT_READ) = 0
mprotect(0x7fe4bdb33000, 4096, PROT_READ) = 0
mprotect(0x7fe4bdd3c000, 4096, PROT_READ) = 0
mprotect(0x7fe4bdf40000, 4096, PROT_READ) = 0
mprotect(0x7fe4be1a2000, 4096, PROT_READ) = 0
mprotect(0x7fe4be779000, 4096, PROT_READ) = 0
mprotect(0x7fe4be97e000, 4096, PROT_READ) = 0
mprotect(0x7fe4beba3000, 4096, PROT_READ) = 0
mprotect(0x61a000, 4096, PROT_READ)     = 0
mprotect(0x7fe4bedc8000, 4096, PROT_READ) = 0
munmap(0x7fe4beda6000, 132159)          = 0
set_tid_address(0x7fe4beda1b10)         = 24158
set_robust_list(0x7fe4beda1b20, 24)     = 0
rt_sigaction(SIGRTMIN, {sa_handler=0x7fe4bd923860, sa_mask=[], sa_flags=SA_RESTORER|SA_SIGINFO, sa_restorer=0x7fe4bd92c630}, NULL, 8) = 0
rt_sigaction(SIGRT_1, {sa_handler=0x7fe4bd9238f0, sa_mask=[], sa_flags=SA_RESTORER|SA_RESTART|SA_SIGINFO, sa_restorer=0x7fe4bd92c630}, NULL, 8) = 0
rt_sigprocmask(SIG_UNBLOCK, [RTMIN RT_1], NULL, 8) = 0
getrlimit(RLIMIT_STACK, {rlim_cur=8192*1024, rlim_max=RLIM64_INFINITY}) = 0
statfs("/sys/fs/selinux", {f_type=SELINUX_MAGIC, f_bsize=4096, f_blocks=0, f_bfree=0, f_bavail=0, f_files=0, f_ffree=0, f_fsid={val=[0, 0]}, f_namelen=255, 0
statfs("/sys/fs/selinux", {f_type=SELINUX_MAGIC, f_bsize=4096, f_blocks=0, f_bfree=0, f_bavail=0, f_files=0, f_ffree=0, f_fsid={val=[0, 0]}, f_namelen=255, 0
stat("/sys/fs/selinux", {st_mode=S_IFDIR|0755, st_size=0, ...}) = 0
```



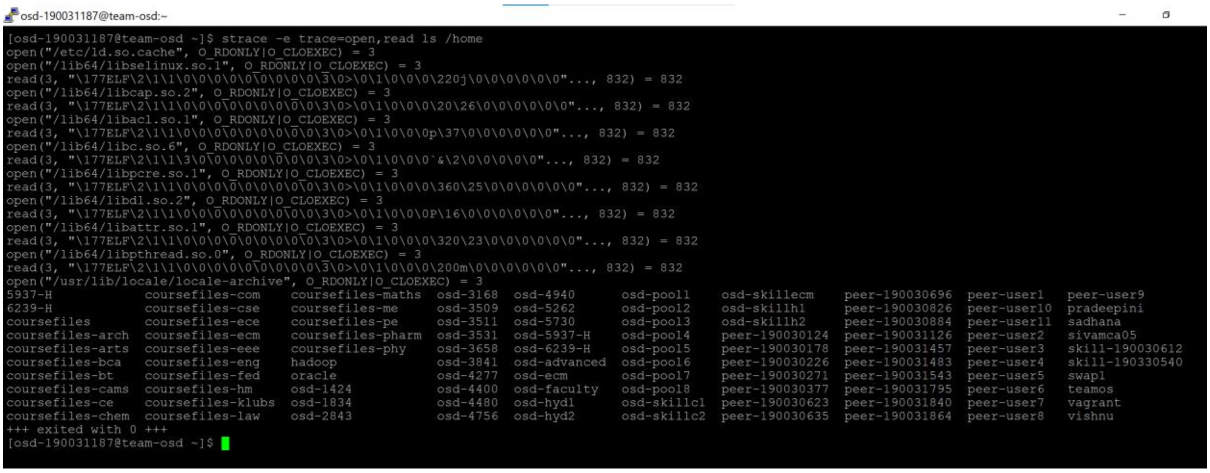
```
stat("/sys/fs/selinux", {st_mode=S_IFDIR|0755, st_size=0, ...}) = 0
brk(NULL)                               = 0x977000
brk(0x998000)                           = 0x998000
access("/etc/selinux/config", F_OK)     = 0
open("/usr/lib/locale/locale-archive", O_RDONLY|O_CLOEXEC) = 3
fstat(3, {st_mode=S_IFREG|0644, st_size=106176928, ...}) = 0
mmap(NULL, 106176928, PROT_READ, MAP_PRIVATE, 3, 0) = 0x7fe4b73da000
close(3)                                = 0
ioctl(1, TCGETS, {B38400 opost isig icanon echo ...}) = 0
ioctl(1, TIOCGWINSZ, {ws_row=46, ws_col=157, ws_xpixel=0, ws_ypixel=0}) = 0
openat(AT_FDCWD, ".", O_RDONLY|O_NONBLOCK|O_CLOEXEC|O_DIRECTORY) = 3
getdents(3, /* 78 entries */, 32768)    = 2568
getdents(3, /* 0 entries */, 32768)     = 0
close(3)                                = 0
fstat(1, {st_mode=S_IFCHR|0620, st_rdev=makedev(136, 53), ...}) = 0
mmap(NULL, 4096, PROT_READ|PROT_WRITE, MAP_PRIVATE|MAP_ANONYMOUS, -1, 0) = 0x7fe4bedc6000
write(1, "190031187-xv6  dup2Example.c  ex"..., 127190031187-xv6  dup2Example.c  execDemo2.c  fifo.c.save.1      half-bake.c    mynice.c        prg1.c     s
) = 127
write(1, "a.out\t       EXEC\t      execDemo"..., 112a.out            EXEC            execDemo.c   fifo.c.save.2      InLab8_1       mypipe      prg2.c     r
) = 112
write(1, "aPipe\t       EXEC2\t      f1.txt\t"..., 111aPipe           EXEC2           f1.txt       fifo.c.save.3      InLab8_2       pipe1.c     prg3.c     c
) = 111
write(1, "attribute.c    EXEC2.c\t      f2."..., 105attribute.c    EXEC2.c         f2.txt       file.c             killprocess.c  pipe.c      prg4.c     6
) = 105
write(1, "cse.txt        exec2Demo      fi"..., 129cse.txt        exec2Demo      fibinocci.c  filesystemchecker  lab7_inlab1.c  postlab7.c  reader     unlino
) = 129
write(1, "DemoOrphan     EXEC.c\t      fifo"..., 122DemoOrphan     EXEC.c          fifo.c       fork1Example.c     lab7_inlab2.c  prelab7     Reader.c   c
) = 122
write(1, "DemoOrphan.c   execDemo       fi"..., 105DemoOrphan.c   execDemo       fifo.c.save  fork2Example.c     lru.c       prelab7.c   setjump.c  welcome.c
) = 105
close(1)                                = 0
munmap(0x7fe4bedc6000, 4096)            = 0
close(2)                                = 0
exit_group(0)                           = ?
+++ exited with 0 +++
[osd-190031187@team-osd ~]$
```

strace -e open ls,



```
[osd-190031187@team-osd ~]$ strace -e open ls
open("/etc/ld.so.cache", O_RDONLY|O_CLOEXEC) = 3
open("/lib64/libselinux.so.1", O_RDONLY|O_CLOEXEC) = 3
open("/lib64/libcap.so.2", O_RDONLY|O_CLOEXEC) = 3
open("/lib64/libacl.so.1", O_RDONLY|O_CLOEXEC) = 3
open("/lib64/libc.so.6", O_RDONLY|O_CLOEXEC) = 3
open("/lib64/libpcre.so.1", O_RDONLY|O_CLOEXEC) = 3
open("/lib64/libdl.so.2", O_RDONLY|O_CLOEXEC) = 3
open("/lib64/libattr.so.1", O_RDONLY|O_CLOEXEC) = 3
open("/lib64/libpthread.so.0", O_RDONLY|O_CLOEXEC) = 3
open("/usr/lib/locale/locale-archive", O_RDONLY|O_CLOEXEC) = 3
190031187-xv6  dup2Example.c  execDemo2.c  fifo.c.save.1      half-bake.c    mynice.c    prg1.c     shared-memory-xv6  welcome.s
a.out          EXEC           execDemo.c   fifo.c.save.2      InLab8_1       mypipe      prg2.c     signal.c           writer
aPipe          EXEC2          f1.txt       fifo.c.save.3      InLab8_2       pipe1.c     prg3.c     time.c             Writer.c
attribute.c    EXEC2.c        f2.txt       file.c             killprocess.c  pipe.c      prg4.c     times.c            xv6
cse.txt        exec2Demo      fibinocci.c  filesystemchecker  lab7_inlab1.c  postlab7.c  reader     unlink.c           xv6-getpinfo
DemoOrphan     EXEC.c         fifo.c       fork1Example.c     lab7_inlab2.c  prelab7     Reader.c   unnamedpipe.c      xv6-public
DemoOrphan.c   execDemo       fifo.c.save  fork2Example.c     lru.c          prelab7.c   setjump.c  welcome.c
+++ exited with 0 +++
[osd-190031187@team-osd ~]$
```

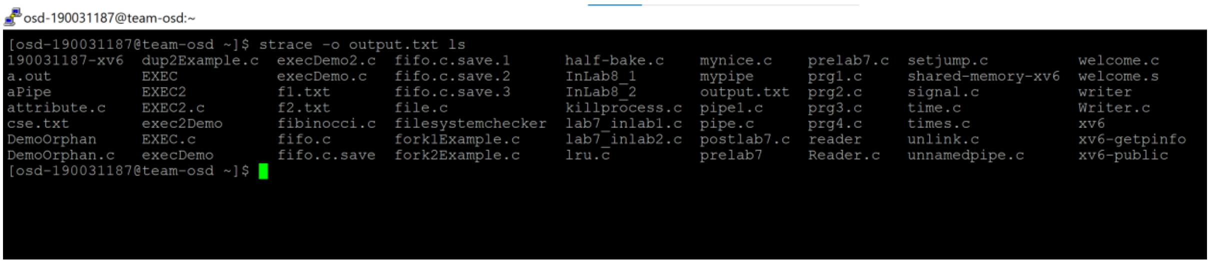
strace -e trace=open,read ls /home



osd-190031187@team-osd:~

```
[osd-190031187@team-osd ~]$ strace -e trace=open,read ls /home
open("/etc/ld.so.cache", O_RDONLY|O_CLOEXEC) = 3
open("/lib64/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\220j\0\0\0\0\0\0"..., 832) = 832
open("/lib64/libcap.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\20\26\0\0\0\0\0\0"..., 832) = 832
open("/lib64/libacl.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\0p\37\0\0\0\0\0\0"..., 832) = 832
open("/lib64/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`&\2\0\0\0\0\0"..., 832) = 832
open("/lib64/libpcre.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\360\25\0\0\0\0\0\0"..., 832) = 832
open("/lib64/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\0P\16\0\0\0\0\0\0"..., 832) = 832
open("/lib64/libattr.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\320\23\0\0\0\0\0\0"..., 832) = 832
open("/lib64/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\200m\0\0\0\0\0\0"..., 832) = 832
open("/usr/lib/locale/locale-archive", O_RDONLY|O_CLOEXEC) = 3
5937-H            coursefiles-com    coursefiles-maths  osd-3168  osd-4940      osd-pool1    osd-skillecm    peer-190030696  peer-user1   peer-user9
6239-H            coursefiles-cse    coursefiles-me     osd-3509  osd-5262      osd-pool2    osd-skillh1     peer-190030826  peer-user10  pradeepini
coursefiles       coursefiles-ece    coursefiles-pe     osd-3511  osd-5730      osd-pool3    osd-skillh2     peer-190030884  peer-user11  sadhana
coursefiles-arch  coursefiles-ecm    coursefiles-pharm  osd-3531  osd-5937-H    osd-pool4    peer-190030124  peer-190031126  peer-user2   sivamca05
coursefiles-arts  coursefiles-eee    coursefiles-phy    osd-3658  osd-6239-H    osd-pool5    peer-190030178  peer-190031457  peer-user3   skill-190030612
coursefiles-bca   coursefiles-eng    hadoop             osd-3841  osd-advanced  osd-pool6    peer-190030226  peer-190031483  peer-user4   skill-190330540
coursefiles-bt    coursefiles-fed    oracle             osd-4277  osd-ecm       osd-pool7    peer-190030271  peer-190031543  peer-user5   swap1
coursefiles-cams  coursefiles-hm     osd-1424           osd-4400  osd-faculty   osd-pool8    peer-190030377  peer-190031795  peer-user6   teamos
coursefiles-ce    coursefiles-klubs  osd-1834           osd-4480  osd-hyd1      osd-skillc1  peer-190030623  peer-190031840  peer-user7   vagrant
coursefiles-chem  coursefiles-law    osd-2843           osd-4756  osd-hyd2      osd-skillc2  peer-190030635  peer-190031864  peer-user8   vishnu
+++ exited with 0 +++
[osd-190031187@team-osd ~]$ 
```

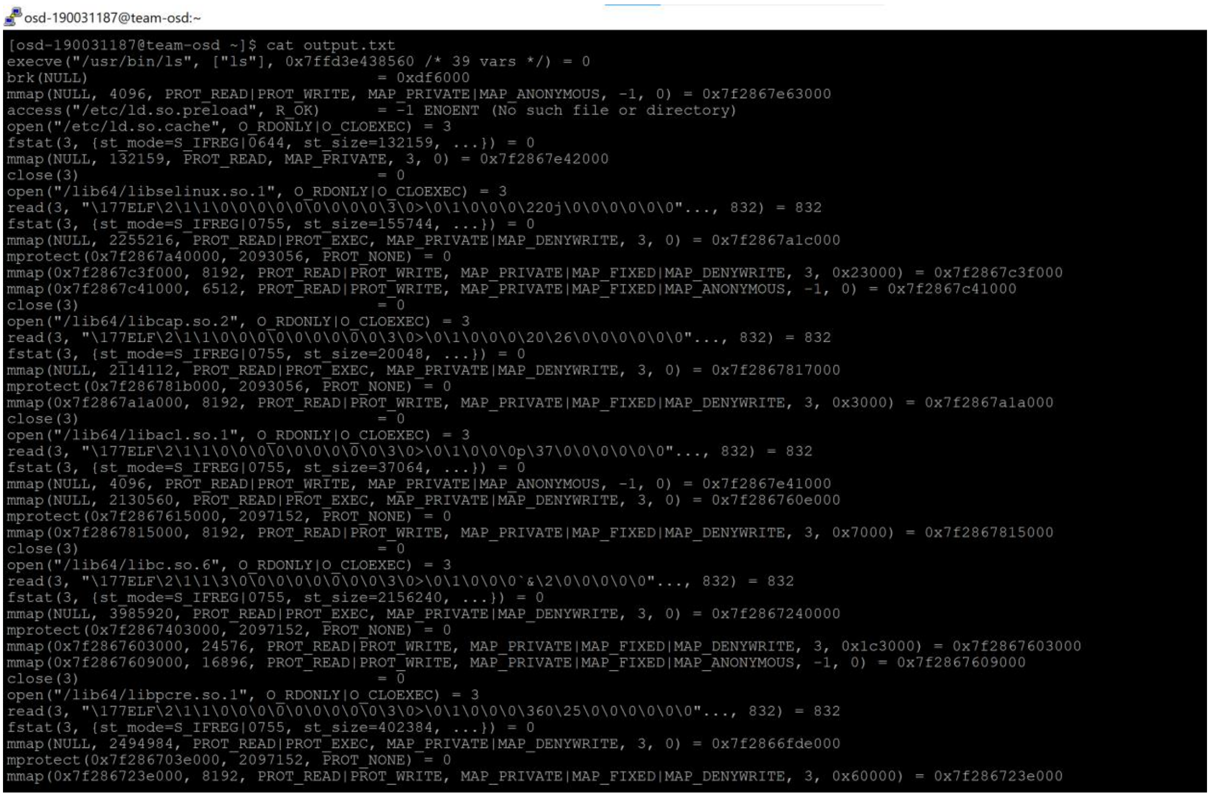
strace -o output.txt ls,



osd-190031187@team-osd:~

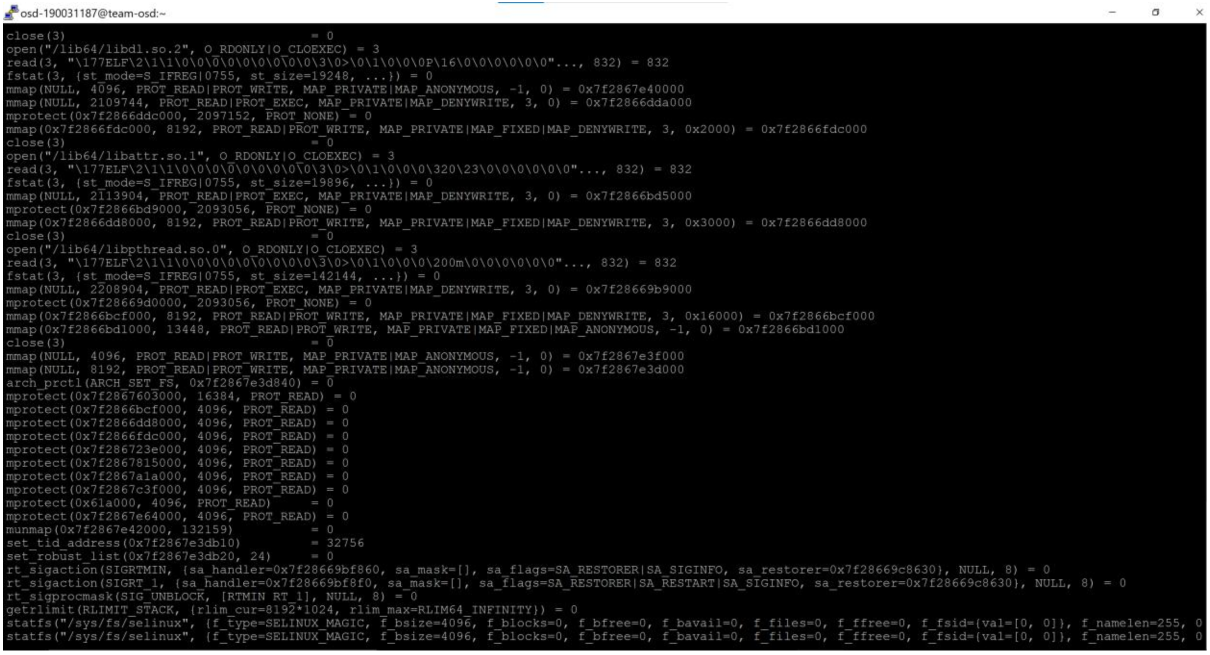
```
[osd-190031187@team-osd ~]$ strace -o output.txt ls
190031187-xv6  dup2Example.c  execDemo2.c  fifo.c.save.1      half-bake.c    mynice.c    prelab7.c   setjump.c          welcome.c
a.out          EXEC           execDemo.c   fifo.c.save.2      InLab8_1       mypipe      prg1.c      shared-memory-xv6  welcome.s
aPipe          EXEC2          f1.txt       fifo.c.save.3      InLab8_2       output.txt  prg2.c      signal.c           writer
attribute.c    EXEC2.c        f2.txt       file.c             killprocess.c  pipe1.c     prg3.c      time.c             Writer.c
cse.txt        exec2Demo      fibinocci.c  filesystemchecker  lab7_inlab1.c  pipe.c      prg4.c      times.c            xv6
DemoOrphan     EXEC.c         fifo.c       fork1Example.c     lab7_inlab2.c  postlab7.c  reader      unlink.c           xv6-getpinfo
DemoOrphan.c   execDemo       fifo.c.save  fork2Example.c     lru.c          prelab7     Reader.c    unnamedpipe.c      xv6-public
[osd-190031187@team-osd ~]$ 
```

cat output.txt



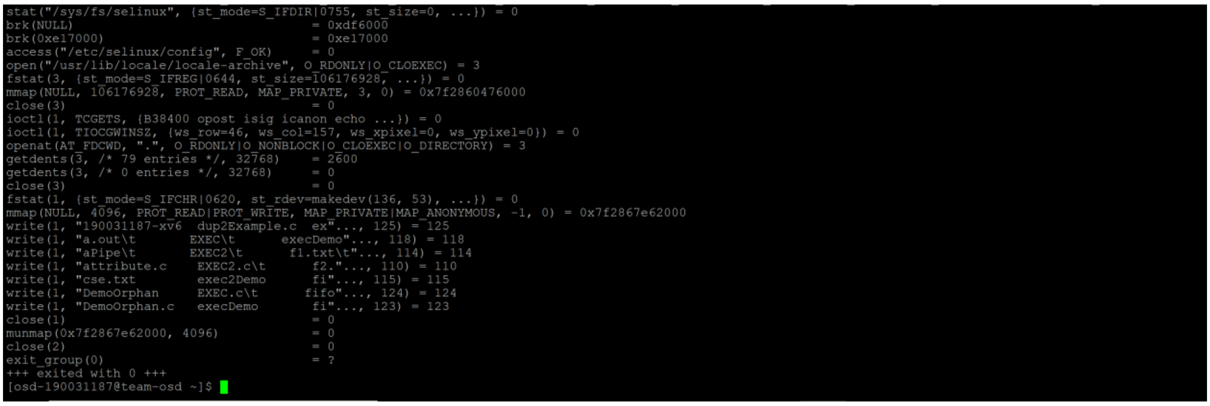
osd-190031187@team-osd:~

```
[osd-190031187@team-osd ~]$ cat output.txt
execve("/usr/bin/ls", ["ls"], 0x7ffd3e438560 /* 39 vars */) = 0
brk(NULL)                               = 0xdf6000
mmap(NULL, 4096, PROT_READ|PROT_WRITE, MAP_PRIVATE|MAP_ANONYMOUS, -1, 0) = 0x7f2867e63000
access("/etc/ld.so.preload", R_OK)      = -1 ENOENT (No such file or directory)
open("/etc/ld.so.cache", O_RDONLY|O_CLOEXEC) = 3
fstat(3, {st_mode=S_IFREG|0644, st_size=132159, ...}) = 0
mmap(NULL, 132159, PROT_READ, MAP_PRIVATE, 3, 0) = 0x7f2867e42000
close(3)                                = 0
open("/lib64/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\220j\0\0\0\0\0\0"..., 832) = 832
fstat(3, {st_mode=S_IFREG|0755, st_size=155744, ...}) = 0
mmap(NULL, 2255216, PROT_READ|PROT_EXEC, MAP_PRIVATE|MAP_DENYWRITE, 3, 0) = 0x7f2867a1c000
mprotect(0x7f2867a40000, 2093056, PROT_NONE) = 0
mmap(0x7f2867c3f000, 8192, PROT_READ|PROT_WRITE, MAP_PRIVATE|MAP_FIXED|MAP_DENYWRITE, 3, 0x23000) = 0x7f2867c3f000
mmap(0x7f2867c41000, 6512, PROT_READ|PROT_WRITE, MAP_PRIVATE|MAP_FIXED|MAP_ANONYMOUS, -1, 0) = 0x7f2867c41000
close(3)                                = 0
open("/lib64/libcap.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\20\26\0\0\0\0\0\0"..., 832) = 832
fstat(3, {st_mode=S_IFREG|0755, st_size=20048, ...}) = 0
mmap(NULL, 2114112, PROT_READ|PROT_EXEC, MAP_PRIVATE|MAP_DENYWRITE, 3, 0) = 0x7f2867817000
mprotect(0x7f286781b000, 2093056, PROT_NONE) = 0
mmap(0x7f2867a1a000, 8192, PROT_READ|PROT_WRITE, MAP_PRIVATE|MAP_FIXED|MAP_DENYWRITE, 3, 0x3000) = 0x7f2867a1a000
close(3)                                = 0
open("/lib64/libacl.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\0p\37\0\0\0\0\0\0"..., 832) = 832
fstat(3, {st_mode=S_IFREG|0755, st_size=37064, ...}) = 0
mmap(NULL, 4096, PROT_READ|PROT_WRITE, MAP_PRIVATE|MAP_ANONYMOUS, -1, 0) = 0x7f2867e41000
mmap(NULL, 2130560, PROT_READ|PROT_EXEC, MAP_PRIVATE|MAP_DENYWRITE, 3, 0) = 0x7f286760e000
mprotect(0x7f2867615000, 2097152, PROT_NONE) = 0
mmap(0x7f2867815000, 8192, PROT_READ|PROT_WRITE, MAP_PRIVATE|MAP_FIXED|MAP_DENYWRITE, 3, 0x7000) = 0x7f2867815000
close(3)                                = 0
open("/lib64/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`&\2\0\0\0\0\0"..., 832) = 832
fstat(3, {st_mode=S_IFREG|0755, st_size=2156240, ...}) = 0
mmap(NULL, 3985920, PROT_READ|PROT_EXEC, MAP_PRIVATE|MAP_DENYWRITE, 3, 0) = 0x7f2867240000
mprotect(0x7f2867403000, 2097152, PROT_NONE) = 0
mmap(0x7f2867603000, 24576, PROT_READ|PROT_WRITE, MAP_PRIVATE|MAP_FIXED|MAP_DENYWRITE, 3, 0x1c3000) = 0x7f2867603000
mmap(0x7f2867609000, 16896, PROT_READ|PROT_WRITE, MAP_PRIVATE|MAP_FIXED|MAP_ANONYMOUS, -1, 0) = 0x7f2867609000
close(3)                                = 0
open("/lib64/libpcre.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\360\25\0\0\0\0\0\0"..., 832) = 832
fstat(3, {st_mode=S_IFREG|0755, st_size=402384, ...}) = 0
mmap(NULL, 2494984, PROT_READ|PROT_EXEC, MAP_PRIVATE|MAP_DENYWRITE, 3, 0) = 0x7f2866fde000
mprotect(0x7f286703e000, 2097152, PROT_NONE) = 0
mmap(0x7f286723e000, 8192, PROT_READ|PROT_WRITE, MAP_PRIVATE|MAP_FIXED|MAP_DENYWRITE, 3, 0x60000) = 0x7f286723e000
```



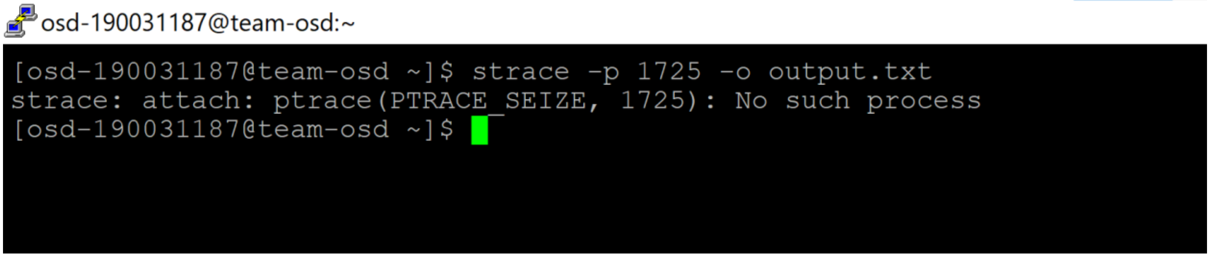
osd-190031187@team-osd:~

```
close(3)                                = 0
open("/lib64/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\0P\16\0\0\0\0\0\0"..., 832) = 832
fstat(3, {st_mode=S_IFREG|0755, st_size=19248, ...}) = 0
mmap(NULL, 4096, PROT_READ|PROT_WRITE, MAP_PRIVATE|MAP_ANONYMOUS, -1, 0) = 0x7f2867e40000
mmap(NULL, 2109744, PROT_READ|PROT_EXEC, MAP_PRIVATE|MAP_DENYWRITE, 3, 0) = 0x7f2866dda000
mprotect(0x7f2866ddc000, 2097152, PROT_NONE) = 0
mmap(0x7f2866fdc000, 8192, PROT_READ|PROT_WRITE, MAP_PRIVATE|MAP_FIXED|MAP_DENYWRITE, 3, 0x2000) = 0x7f2866fdc000
close(3)                                = 0
open("/lib64/libattr.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\320\23\0\0\0\0\0\0"..., 832) = 832
fstat(3, {st_mode=S_IFREG|0755, st_size=19896, ...}) = 0
mmap(NULL, 2113904, PROT_READ|PROT_EXEC, MAP_PRIVATE|MAP_DENYWRITE, 3, 0) = 0x7f2866bd5000
mprotect(0x7f2866bd9000, 2093056, PROT_NONE) = 0
mmap(0x7f2866dd8000, 8192, PROT_READ|PROT_WRITE, MAP_PRIVATE|MAP_FIXED|MAP_DENYWRITE, 3, 0x3000) = 0x7f2866dd8000
close(3)                                = 0
open("/lib64/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\200m\0\0\0\0\0\0"..., 832) = 832
fstat(3, {st_mode=S_IFREG|0755, st_size=142144, ...}) = 0
mmap(NULL, 2208904, PROT_READ|PROT_EXEC, MAP_PRIVATE|MAP_DENYWRITE, 3, 0) = 0x7f28669b9000
mprotect(0x7f28669d0000, 2093056, PROT_NONE) = 0
mmap(0x7f2866bcf000, 8192, PROT_READ|PROT_WRITE, MAP_PRIVATE|MAP_FIXED|MAP_DENYWRITE, 3, 0x16000) = 0x7f2866bcf000
mmap(0x7f2866bd1000, 13448, PROT_READ|PROT_WRITE, MAP_PRIVATE|MAP_FIXED|MAP_ANONYMOUS, -1, 0) = 0x7f2866bd1000
close(3)                                = 0
mmap(NULL, 4096, PROT_READ|PROT_WRITE, MAP_PRIVATE|MAP_ANONYMOUS, -1, 0) = 0x7f2867e3f000
mmap(NULL, 8192, PROT_READ|PROT_WRITE, MAP_PRIVATE|MAP_ANONYMOUS, -1, 0) = 0x7f2867e3d000
arch_prctl(ARCH_SET_FS, 0x7f2867e3d840) = 0
mprotect(0x7f2867603000, 16384, PROT_READ) = 0
mprotect(0x7f2866bcf000, 4096, PROT_READ) = 0
mprotect(0x7f2866dd8000, 4096, PROT_READ) = 0
mprotect(0x7f2866fdc000, 4096, PROT_READ) = 0
mprotect(0x7f286723e000, 4096, PROT_READ) = 0
mprotect(0x7f2867815000, 4096, PROT_READ) = 0
mprotect(0x7f2867a1a000, 4096, PROT_READ) = 0
mprotect(0x7f2867c3f000, 4096, PROT_READ) = 0
mprotect(0x61a000, 4096, PROT_READ)     = 0
mprotect(0x7f2867e64000, 4096, PROT_READ) = 0
munmap(0x7f2867e42000, 132159)          = 0
set_tid_address(0x7f2867e3db10)         = 32756
set_robust_list(0x7f2867e3db20, 24)     = 0
rt_sigaction(SIGRTMIN, {sa_handler=0x7f28669bf860, sa_mask=[], sa_flags=SA_RESTORER|SA_SIGINFO, sa_restorer=0x7f28669c8630}, NULL, 8) = 0
rt_sigaction(SIGRT_1, {sa_handler=0x7f28669bf8f0, sa_mask=[], sa_flags=SA_RESTORER|SA_RESTART|SA_SIGINFO, sa_restorer=0x7f28669c8630}, NULL, 8) = 0
rt_sigprocmask(SIG_UNBLOCK, [RTMIN RT_1], NULL, 8) = 0
getrlimit(RLIMIT_STACK, {rlim_cur=8192*1024, rlim_max=RLIM64_INFINITY}) = 0
statfs("/sys/fs/selinux", {f_type=SELINUX_MAGIC, f_bsize=4096, f_blocks=0, f_bfree=0, f_bavail=0, f_files=0, f_ffree=0, f_fsid={val=[0, 0]}, f_namelen=255, 0
statfs("/sys/fs/selinux", {f_type=SELINUX_MAGIC, f_bsize=4096, f_blocks=0, f_bfree=0, f_bavail=0, f_files=0, f_ffree=0, f_fsid={val=[0, 0]}, f_namelen=255, 0
```



```
stat("/sys/fs/selinux", {st_mode=S_IFDIR|0755, st_size=0, ...}) = 0
brk(NULL)                               = 0xdf6000
brk(0xe17000)                           = 0xe17000
access("/etc/selinux/config", F_OK)     = 0
open("/usr/lib/locale/locale-archive", O_RDONLY|O_CLOEXEC) = 3
fstat(3, {st_mode=S_IFREG|0644, st_size=106176928, ...}) = 0
mmap(NULL, 106176928, PROT_READ, MAP_PRIVATE, 3, 0) = 0x7f2860476000
close(3)                                = 0
ioctl(1, TCGETS, {B38400 opost isig icanon echo ...}) = 0
ioctl(1, TIOCGWINSZ, {ws_row=46, ws_col=157, ws_xpixel=0, ws_ypixel=0}) = 0
openat(AT_FDCWD, ".", O_RDONLY|O_NONBLOCK|O_CLOEXEC|O_DIRECTORY) = 3
getdents(3, /* 79 entries */, 32768)    = 2600
getdents(3, /* 0 entries */, 32768)     = 0
close(3)                                = 0
fstat(1, {st_mode=S_IFCHR|0620, st_rdev=makedev(136, 53), ...}) = 0
mmap(NULL, 4096, PROT_READ|PROT_WRITE, MAP_PRIVATE|MAP_ANONYMOUS, -1, 0) = 0x7f2867e62000
write(1, "190031187-xv6  dup2Example.c  ex"..., 125) = 125
write(1, "a.out\t        EXEC\t       execDemo"..., 118) = 118
write(1, "aPipe\t        EXEC2\t       f1.txt\t"..., 114) = 114
write(1, "attribute.c     EXEC2.c\t       f2."..., 110) = 110
write(1, "cse.txt         exec2Demo       fi"..., 115) = 115
write(1, "DemoOrphan      EXEC.c\t       fifo"..., 124) = 124
write(1, "DemoOrphan.c    execDemo        fi"..., 123) = 123
close(1)                                = 0
munmap(0x7f2867e62000, 4096)            = 0
close(2)                                = 0
exit_group(0)                           = ?
+++ exited with 0 +++
[osd-190031187@team-osd ~]$
```

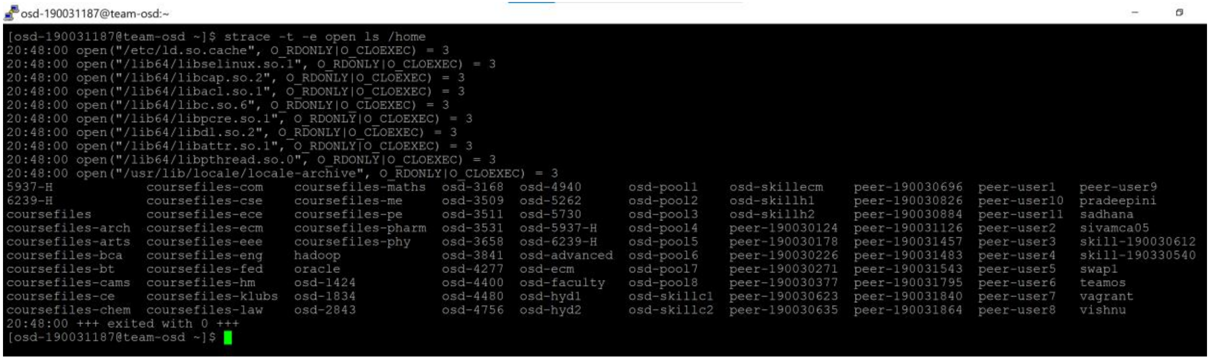
strace -p 1725 -o output.txt,



osd-190031187@team-osd:~

```
[osd-190031187@team-osd ~]$ strace -p 1725 -o output.txt
strace: attach: ptrace(PTRACE_SEIZE, 1725): No such process
[osd-190031187@team-osd ~]$
```

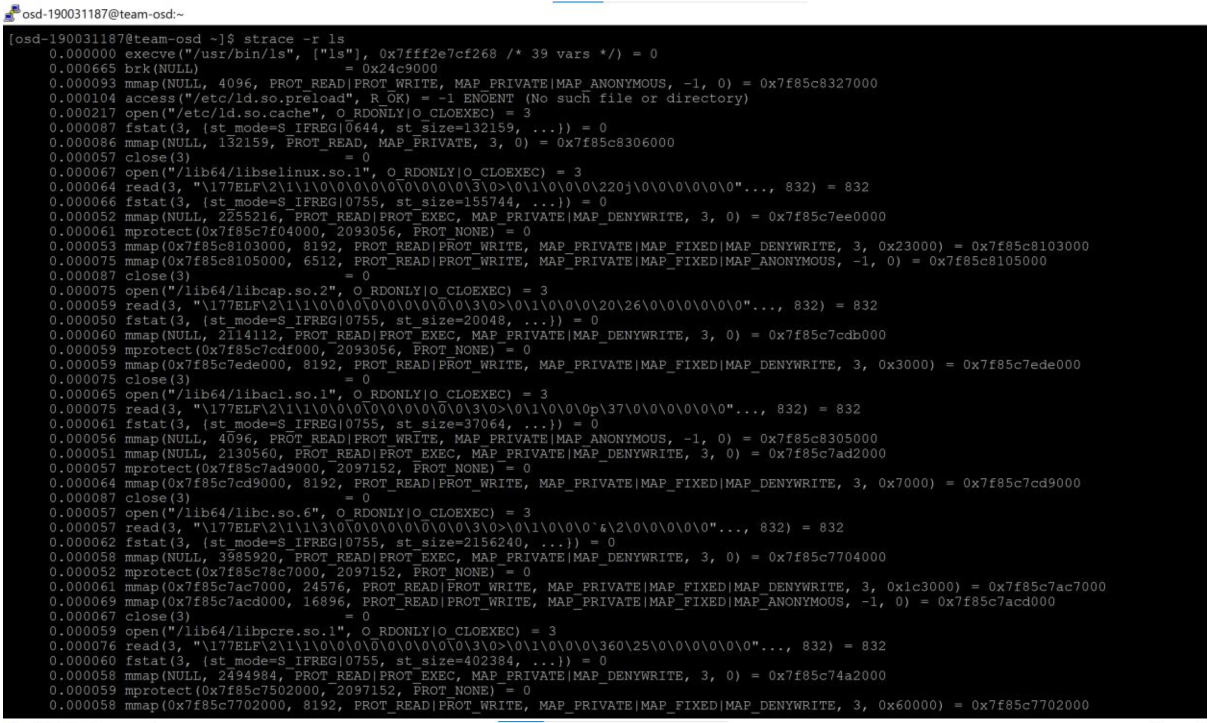
strace -t -e open ls /home,



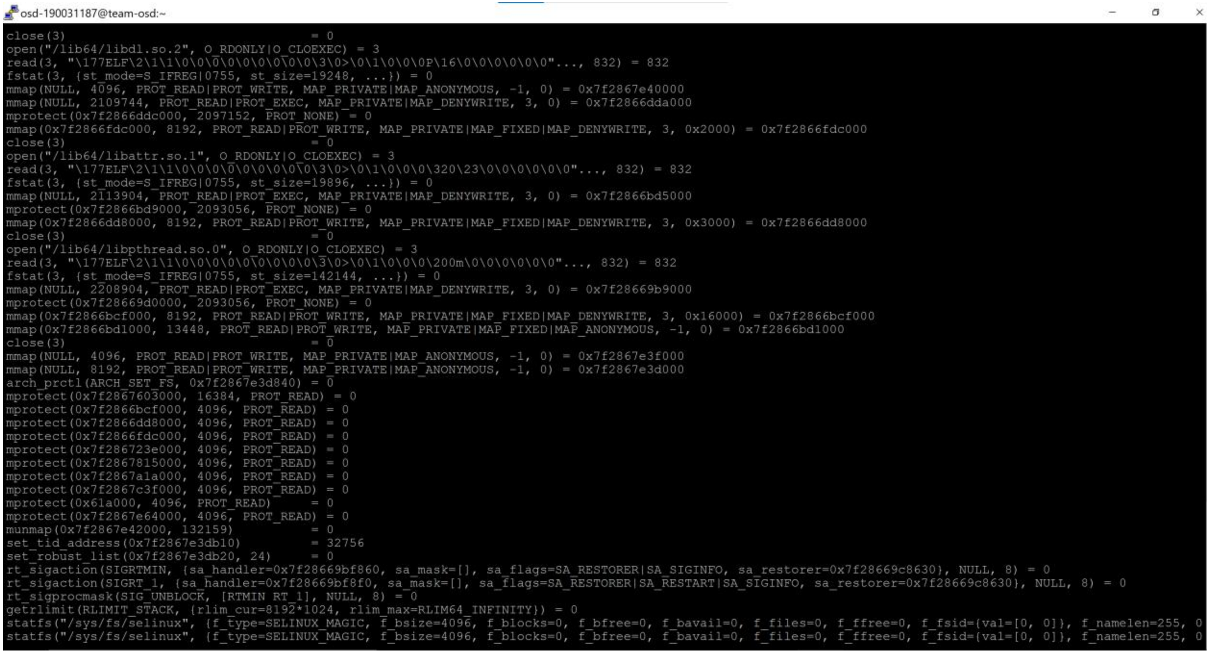
osd-190031187@team-osd:~

```
[osd-190031187@team-osd ~]$ strace -t -e open ls /home
20:48:00 open("/etc/ld.so.cache", O_RDONLY|O_CLOEXEC) = 3
20:48:00 open("/lib64/libselinux.so.1", O_RDONLY|O_CLOEXEC) = 3
20:48:00 open("/lib64/libcap.so.2", O_RDONLY|O_CLOEXEC) = 3
20:48:00 open("/lib64/libacl.so.1", O_RDONLY|O_CLOEXEC) = 3
20:48:00 open("/lib64/libc.so.6", O_RDONLY|O_CLOEXEC) = 3
20:48:00 open("/lib64/libpcre.so.1", O_RDONLY|O_CLOEXEC) = 3
20:48:00 open("/lib64/libdl.so.2", O_RDONLY|O_CLOEXEC) = 3
20:48:00 open("/lib64/libattr.so.1", O_RDONLY|O_CLOEXEC) = 3
20:48:00 open("/lib64/libpthread.so.0", O_RDONLY|O_CLOEXEC) = 3
20:48:00 open("/usr/lib/locale/locale-archive", O_RDONLY|O_CLOEXEC) = 3
5937-H             coursefiles-com    coursefiles-maths  osd-3168  osd-4940      osd-pool1     osd-skillecm     peer-190030696  peer-user1   peer-user9
6239-H             coursefiles-cse    coursefiles-me     osd-3509  osd-5262      osd-pool2     osd-skillh1      peer-190030826  peer-user10  pradeepini
coursefiles        coursefiles-ece    coursefiles-pe     osd-3511  osd-5730      osd-pool3     osd-skillh2      peer-190030884  peer-user11  sadhana
coursefiles-arch   coursefiles-ecm    coursefiles-pharm  osd-3531  osd-5937-H    osd-pool4     peer-190030124   peer-190031126  peer-user2   sivamca05
coursefiles-arts   coursefiles-eee    coursefiles-phy    osd-3658  osd-6239-H    osd-pool5     peer-190030178   peer-190031457  peer-user3   skill-190030612
coursefiles-bca    coursefiles-eng    hadoop             osd-3841  osd-advanced  osd-pool6     peer-190030226   peer-190031483  peer-user4   skill-190330540
coursefiles-bt     coursefiles-fed    oracle             osd-4277  osd-ecm       osd-pool7     peer-190030271   peer-190031543  peer-user5   swap1
coursefiles-cams   coursefiles-hm     osd-1424           osd-4400  osd-faculty   osd-pool8     peer-190030377   peer-190031795  peer-user6   teamos
coursefiles-ce     coursefiles-klubs  osd-1834           osd-4480  osd-hyd1      osd-skillc1   peer-190030623   peer-190031840  peer-user7   vagrant
coursefiles-chem   coursefiles-law    osd-2843           osd-4756  osd-hyd2      osd-skillc2   peer-190030635   peer-190031864  peer-user8   vishnu
20:48:00 +++ exited with 0 +++
[osd-190031187@team-osd ~]$
```

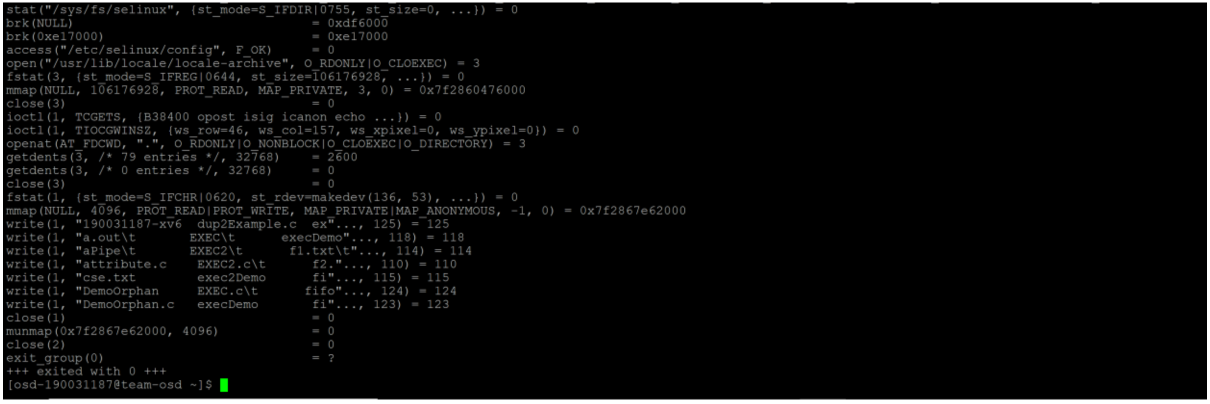
strace -r ls,



```
[osd-190031187@team-osd ~]$ strace -r ls
     0.000000 execve("/usr/bin/ls", ["ls"], 0x7fff2e7cf268 /* 39 vars */) = 0
     0.000665 brk(NULL)                               = 0x24c9000
     0.000093 mmap(NULL, 4096, PROT_READ|PROT_WRITE, MAP_PRIVATE|MAP_ANONYMOUS, -1, 0) = 0x7f85c8327000
     0.000104 access("/etc/ld.so.preload", R_OK) = -1 ENOENT (No such file or directory)
     0.000217 open("/etc/ld.so.cache", O_RDONLY|O_CLOEXEC) = 3
     0.000087 fstat(3, {st_mode=S_IFREG|0644, st_size=132159, ...}) = 0
     0.000086 mmap(NULL, 132159, PROT_READ, MAP_PRIVATE, 3, 0) = 0x7f85c8306000
     0.000057 close(3)                                = 0
     0.000067 open("/lib64/libselinux.so.1", O_RDONLY|O_CLOEXEC) = 3
     0.000064 read(3, "\177ELF\2\1\1\0\0\0\0\0\0\0\0\0\3\0>\0\1\0\0\0\220j\0\0\0\0\0\0"..., 832) = 832
     0.000066 fstat(3, {st_mode=S_IFREG|0755, st_size=155744, ...}) = 0
     0.000052 mmap(NULL, 2255216, PROT_READ|PROT_EXEC, MAP_PRIVATE|MAP_DENYWRITE, 3, 0) = 0x7f85c7ee0000
     0.000061 mprotect(0x7f85c7f04000, 2093056, PROT_NONE) = 0
     0.000053 mmap(0x7f85c8103000, 8192, PROT_READ|PROT_WRITE, MAP_PRIVATE|MAP_FIXED|MAP_DENYWRITE, 3, 0x23000) = 0x7f85c8103000
     0.000075 mmap(0x7f85c8105000, 6512, PROT_READ|PROT_WRITE, MAP_PRIVATE|MAP_FIXED|MAP_ANONYMOUS, -1, 0) = 0x7f85c8105000
     0.000087 close(3)                                = 0
     0.000075 open("/lib64/libcap.so.2", O_RDONLY|O_CLOEXEC) = 3
     0.000059 read(3, "\177ELF\2\1\1\0\0\0\0\0\0\0\0\0\3\0>\0\1\0\0\0\20\26\0\0\0\0\0\0"..., 832) = 832
     0.000050 fstat(3, {st_mode=S_IFREG|0755, st_size=20048, ...}) = 0
     0.000060 mmap(NULL, 2114112, PROT_READ|PROT_EXEC, MAP_PRIVATE|MAP_DENYWRITE, 3, 0) = 0x7f85c7cdb000
     0.000059 mprotect(0x7f85c7cdf000, 2093056, PROT_NONE) = 0
     0.000059 mmap(0x7f85c7ede000, 8192, PROT_READ|PROT_WRITE, MAP_PRIVATE|MAP_FIXED|MAP_DENYWRITE, 3, 0x3000) = 0x7f85c7ede000
     0.000075 close(3)                                = 0
     0.000065 open("/lib64/libacl.so.1", O_RDONLY|O_CLOEXEC) = 3
     0.000075 read(3, "\177ELF\2\1\1\0\0\0\0\0\0\0\0\0\3\0>\0\1\0\0\0p\37\0\0\0\0\0\0"..., 832) = 832
     0.000061 fstat(3, {st_mode=S_IFREG|0755, st_size=37064, ...}) = 0
     0.000056 mmap(NULL, 4096, PROT_READ|PROT_WRITE, MAP_PRIVATE|MAP_ANONYMOUS, -1, 0) = 0x7f85c8305000
     0.000051 mmap(NULL, 2130560, PROT_READ|PROT_EXEC, MAP_PRIVATE|MAP_DENYWRITE, 3, 0) = 0x7f85c7ad2000
     0.000057 mprotect(0x7f85c7ad9000, 2097152, PROT_NONE) = 0
     0.000064 mmap(0x7f85c7cd9000, 8192, PROT_READ|PROT_WRITE, MAP_PRIVATE|MAP_FIXED|MAP_DENYWRITE, 3, 0x7000) = 0x7f85c7cd9000
     0.000087 close(3)                                = 0
     0.000057 open("/lib64/libc.so.6", O_RDONLY|O_CLOEXEC) = 3
     0.000057 read(3, "\177ELF\2\1\1\3\0\0\0\0\0\0\0\0\3\0>\0\1\0\0\0`&\2\0\0\0\0\0"..., 832) = 832
     0.000062 fstat(3, {st_mode=S_IFREG|0755, st_size=2156240, ...}) = 0
     0.000058 mmap(NULL, 3985920, PROT_READ|PROT_EXEC, MAP_PRIVATE|MAP_DENYWRITE, 3, 0) = 0x7f85c7704000
     0.000052 mprotect(0x7f85c78c7000, 2097152, PROT_NONE) = 0
     0.000061 mmap(0x7f85c7ac7000, 24576, PROT_READ|PROT_WRITE, MAP_PRIVATE|MAP_FIXED|MAP_DENYWRITE, 3, 0x1c3000) = 0x7f85c7ac7000
     0.000069 mmap(0x7f85c7acd000, 16896, PROT_READ|PROT_WRITE, MAP_PRIVATE|MAP_FIXED|MAP_ANONYMOUS, -1, 0) = 0x7f85c7acd000
     0.000067 close(3)                                = 0
     0.000059 open("/lib64/libpcre.so.1", O_RDONLY|O_CLOEXEC) = 3
     0.000076 read(3, "\177ELF\2\1\1\0\0\0\0\0\0\0\0\0\3\0>\0\1\0\0\0\360\25\0\0\0\0\0\0"..., 832) = 832
     0.000060 fstat(3, {st_mode=S_IFREG|0755, st_size=402384, ...}) = 0
     0.000058 mmap(NULL, 2494984, PROT_READ|PROT_EXEC, MAP_PRIVATE|MAP_DENYWRITE, 3, 0) = 0x7f85c74a2000
     0.000059 mprotect(0x7f85c7502000, 2097152, PROT_NONE) = 0
     0.000058 mmap(0x7f85c7702000, 8192, PROT_READ|PROT_WRITE, MAP_PRIVATE|MAP_FIXED|MAP_DENYWRITE, 3, 0x60000) = 0x7f85c7702000
```

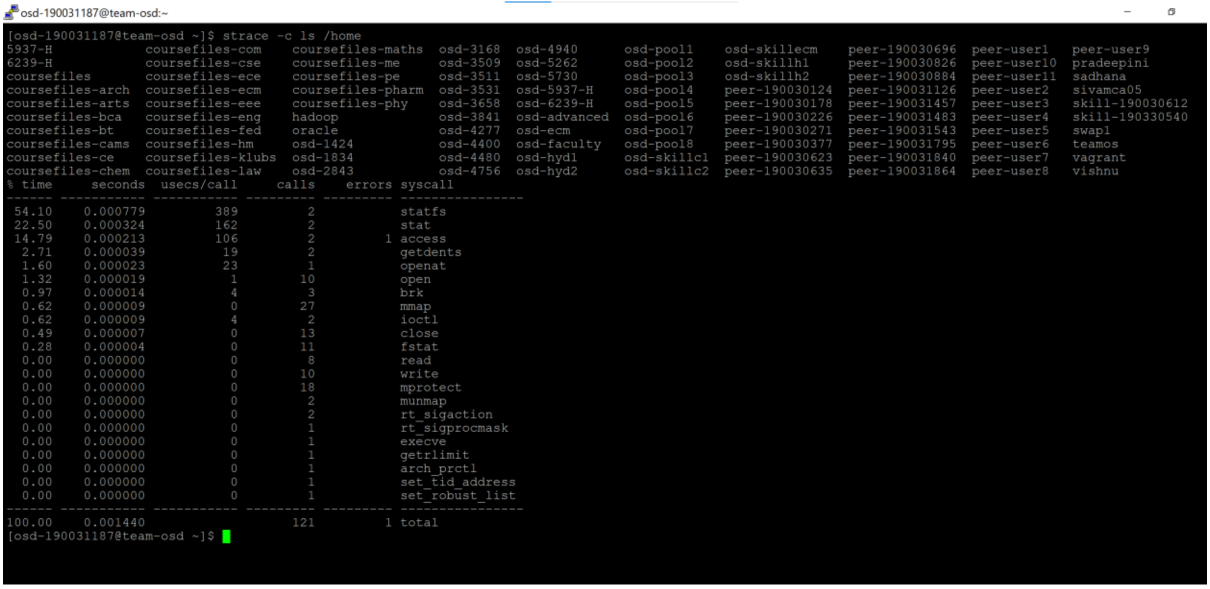


```
close(3)                                = 0
open("/lib64/libdl.so.2", O_RDONLY|O_CLOEXEC) = 3
read(3, "\177ELF\2\1\1\0\0\0\0\0\0\0\0\0\3\0>\0\1\0\0\0P\16\0\0\0\0\0\0"..., 832) = 832
fstat(3, {st_mode=S_IFREG|0755, st_size=19248, ...}) = 0
mmap(NULL, 4096, PROT_READ|PROT_WRITE, MAP_PRIVATE|MAP_ANONYMOUS, -1, 0) = 0x7f2867e40000
mmap(NULL, 2109744, PROT_READ|PROT_EXEC, MAP_PRIVATE|MAP_DENYWRITE, 3, 0) = 0x7f2866dda000
mprotect(0x7f2866ddc000, 2097152, PROT_NONE) = 0
mmap(0x7f2866fdc000, 8192, PROT_READ|PROT_WRITE, MAP_PRIVATE|MAP_FIXED|MAP_DENYWRITE, 3, 0x2000) = 0x7f2866fdc000
close(3)                                = 0
open("/lib64/libattr.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\320\23\0\0\0\0\0\0"..., 832) = 832
fstat(3, {st_mode=S_IFREG|0755, st_size=19896, ...}) = 0
mmap(NULL, 2113904, PROT_READ|PROT_EXEC, MAP_PRIVATE|MAP_DENYWRITE, 3, 0) = 0x7f2866bd5000
mprotect(0x7f2866bd9000, 2093056, PROT_NONE) = 0
mmap(0x7f2866dd8000, 8192, PROT_READ|PROT_WRITE, MAP_PRIVATE|MAP_FIXED|MAP_DENYWRITE, 3, 0x3000) = 0x7f2866dd8000
close(3)                                = 0
open("/lib64/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\200m\0\0\0\0\0\0"..., 832) = 832
fstat(3, {st_mode=S_IFREG|0755, st_size=142144, ...}) = 0
mmap(NULL, 2208904, PROT_READ|PROT_EXEC, MAP_PRIVATE|MAP_DENYWRITE, 3, 0) = 0x7f28669b9000
mprotect(0x7f28669d0000, 2093056, PROT_NONE) = 0
mmap(0x7f2866bcf000, 8192, PROT_READ|PROT_WRITE, MAP_PRIVATE|MAP_FIXED|MAP_DENYWRITE, 3, 0x16000) = 0x7f2866bcf000
mmap(0x7f2866bd1000, 13448, PROT_READ|PROT_WRITE, MAP_PRIVATE|MAP_FIXED|MAP_ANONYMOUS, -1, 0) = 0x7f2866bd1000
close(3)                                = 0
mmap(NULL, 4096, PROT_READ|PROT_WRITE, MAP_PRIVATE|MAP_ANONYMOUS, -1, 0) = 0x7f2867e3f000
mmap(NULL, 8192, PROT_READ|PROT_WRITE, MAP_PRIVATE|MAP_ANONYMOUS, -1, 0) = 0x7f2867e3d000
arch_prctl(ARCH_SET_FS, 0x7f2867e3d840) = 0
mprotect(0x7f2867603000, 16384, PROT_READ) = 0
mprotect(0x7f2866bcf000, 4096, PROT_READ) = 0
mprotect(0x7f2866dd8000, 4096, PROT_READ) = 0
mprotect(0x7f2866fdc000, 4096, PROT_READ) = 0
mprotect(0x7f286723e000, 4096, PROT_READ) = 0
mprotect(0x7f2867815000, 4096, PROT_READ) = 0
mprotect(0x7f2867a1a000, 4096, PROT_READ) = 0
mprotect(0x7f2867c3f000, 4096, PROT_READ) = 0
mprotect(0x61a000, 4096, PROT_READ)     = 0
mprotect(0x7f2867e64000, 4096, PROT_READ) = 0
munmap(0x7f2867e42000, 132159)          = 0
set_tid_address(0x7f2867e3db10)         = 32756
set_robust_list(0x7f2867e3db20, 24)     = 0
rt_sigaction(SIGRTMIN, {sa_handler=0x7f28669bf860, sa_mask=[], sa_flags=SA_RESTORER|SA_SIGINFO, sa_restorer=0x7f28669c8630}, NULL, 8) = 0
rt_sigaction(SIGRT_1, {sa_handler=0x7f28669bf8f0, sa_mask=[], sa_flags=SA_RESTORER|SA_RESTART|SA_SIGINFO, sa_restorer=0x7f28669c8630}, NULL, 8) = 0
rt_sigprocmask(SIG_UNBLOCK, [RTMIN RT_1], NULL, 8) = 0
getrlimit(RLIMIT_STACK, {rlim_cur=8192*1024, rlim_max=RLIM64_INFINITY}) = 0
statfs("/sys/fs/selinux", {f_type=SELINUX_MAGIC, f_bsize=4096, f_blocks=0, f_bfree=0, f_bavail=0, f_files=0, f_ffree=0, f_fsid={val=[0, 0]}, f_namelen=255, 0
statfs("/sys/fs/selinux", {f_type=SELINUX_MAGIC, f_bsize=4096, f_blocks=0, f_bfree=0, f_bavail=0, f_files=0, f_ffree=0, f_fsid={val=[0, 0]}, f_namelen=255, 0
```



```
stat("/sys/fs/selinux", {st_mode=S_IFDIR|0755, st_size=0, ...}) = 0
brk(NULL)                               = 0xdf6000
brk(0xe17000)                           = 0xe17000
access("/etc/selinux/config", F_OK)     = 0
open("/usr/lib/locale/locale-archive", O_RDONLY|O_CLOEXEC) = 3
fstat(3, {st_mode=S_IFREG|0644, st_size=106176928, ...}) = 0
mmap(NULL, 106176928, PROT_READ, MAP_PRIVATE, 3, 0) = 0x7f2860476000
close(3)                                = 0
ioctl(1, TCGETS, {B38400 opost isig icanon echo ...}) = 0
ioctl(1, TIOCGWINSZ, {ws_row=46, ws_col=157, ws_xpixel=0, ws_ypixel=0}) = 0
openat(AT_FDCWD, ".", O_RDONLY|O_NONBLOCK|O_CLOEXEC|O_DIRECTORY) = 3
getdents(3, /* 79 entries */, 32768)    = 2600
getdents(3, /* 0 entries */, 32768)     = 0
close(3)                                = 0
fstat(1, {st_mode=S_IFCHR|0620, st_rdev=makedev(136, 53), ...}) = 0
mmap(NULL, 4096, PROT_READ|PROT_WRITE, MAP_PRIVATE|MAP_ANONYMOUS, -1, 0) = 0x7f2867e62000
write(1, "190031187-xv6  dup2Example.c  ex"..., 125) = 125
write(1, "a.out\t       EXEC\t      execDemo"..., 118) = 118
write(1, "aPipe\t       EXEC2\t      f1.txt\t"..., 114) = 114
write(1, "attribute.c    EXEC2.c\t      f2."..., 110) = 110
write(1, "cse.txt        exec2Demo      fi"..., 115) = 115
write(1, "DemoOrphan     EXEC.c\t      fifo"..., 124) = 124
write(1, "DemoOrphan.c   execDemo       fi"..., 123) = 123
close(1)                                = 0
munmap(0x7f2867e62000, 4096)            = 0
close(2)                                = 0
exit_group(0)                           = ?
+++ exited with 0 +++
[osd-190031187@team-osd ~]$
```

strace -c ls /home



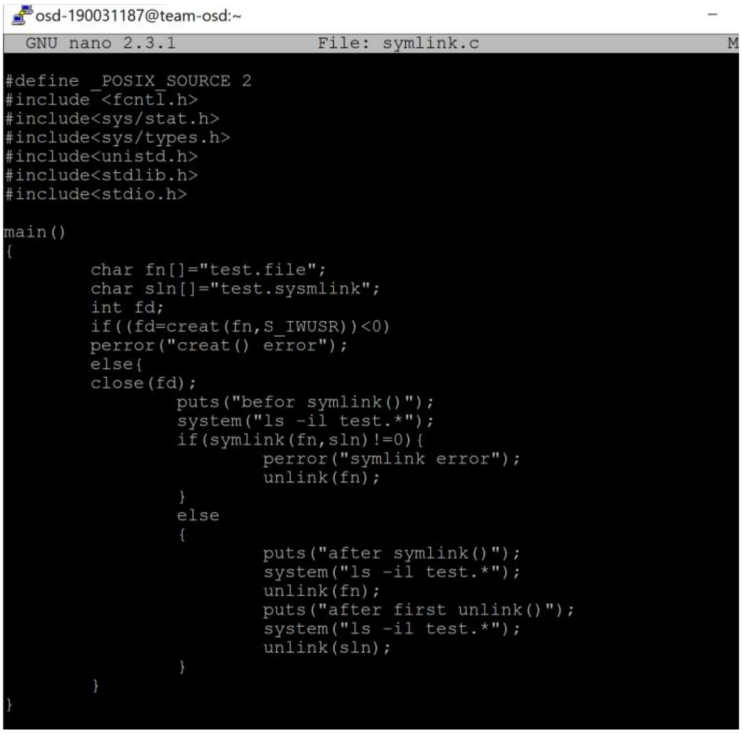
osd-190031187@team-osd:~

```
[osd-190031187@team-osd ~]$ strace -c ls /home
5937-H            coursefiles-com    coursefiles-maths  osd-3168  osd-4940      osd-pool1    osd-skillecm    peer-190030696  peer-user1   peer-user9
6239-H            coursefiles-cse    coursefiles-me     osd-3509  osd-5262      osd-pool2    osd-skillh1     peer-190030826  peer-user10  pradeepini
coursefiles       coursefiles-ece    coursefiles-pe     osd-3511  osd-5730      osd-pool3    osd-skillh2     peer-190030884  peer-user11  sadhana
coursefiles-arch  coursefiles-ecm    coursefiles-pharm  osd-3531  osd-5937-H    osd-pool4    peer-190030124  peer-190031126  peer-user2   sivamca05
coursefiles-arts  coursefiles-eee    coursefiles-phy    osd-3658  osd-6239-H    osd-pool5    peer-190030178  peer-190031457  peer-user3   skill-190030612
coursefiles-bca   coursefiles-eng    hadoop             osd-3841  osd-advanced  osd-pool6    peer-190030226  peer-190031483  peer-user4   skill-190330540
coursefiles-bt    coursefiles-fed    oracle             osd-4277  osd-ecm       osd-pool7    peer-190030271  peer-190031543  peer-user5   swap1
coursefiles-cams  coursefiles-hm     osd-1424           osd-4400  osd-faculty   osd-pool8    peer-190030377  peer-190031795  peer-user6   teamos
coursefiles-ce    coursefiles-klubs  osd-1834           osd-4480  osd-hyd1      osd-skillc1  peer-190030623  peer-190031840  peer-user7   vagrant
coursefiles-chem  coursefiles-law    osd-2843           osd-4756  osd-hyd2      osd-skillc2  peer-190030635  peer-190031864  peer-user8   vishnu
% time     seconds  usecs/call     calls    errors syscall
------ ----------- ----------- --------- --------- ----------------
 54.10    0.000779         389         2           statfs
 22.50    0.000324         162         2           stat
 14.79    0.000213         106         2         1 access
  2.71    0.000039          19         2           getdents
  1.60    0.000023          23         1           openat
  1.32    0.000019           1        10           open
  0.97    0.000014           4         3           brk
  0.62    0.000009           0        27           mmap
  0.62    0.000009           4         2           ioctl
  0.49    0.000007           0        13           close
  0.28    0.000004           0        11           fstat
  0.00    0.000000           0         8           read
  0.00    0.000000           0        10           write
  0.00    0.000000           0        18           mprotect
  0.00    0.000000           0         2           munmap
  0.00    0.000000           0         2           rt_sigaction
  0.00    0.000000           0         1           rt_sigprocmask
  0.00    0.000000           0         1           execve
  0.00    0.000000           0         1           getrlimit
  0.00    0.000000           0         1           arch_prctl
  0.00    0.000000           0         1           set_tid_address
  0.00    0.000000           0         1           set_robust_list
------ ----------- ----------- --------- --------- ----------------
100.00    0.001440                   121         1 total
[osd-190031187@team-osd ~]$
```

## 2. Add support for symbolic links

Symbolic links are basically advanced shortcuts. Create a symbolic link to an individual file or folder, and that link will appear to be the same as the file or folder to Windows—even though it's just a link pointing at the file or folder. A symbolic link is simply a file with a special type (e.g., T_SYMLINK instead of T_FILE or T_DIR) whose contents contain the path being linked to. Turn in a short writeup of how you would change xv6 to support symlinks. Symbolic links were already present by 1978 in minicomputer operating systems from DEC and Data General's RDOS. Today they are supported by the POSIX operating system standard, most Unix-like operating systems such as FreeBSD, Linux, and macOS.

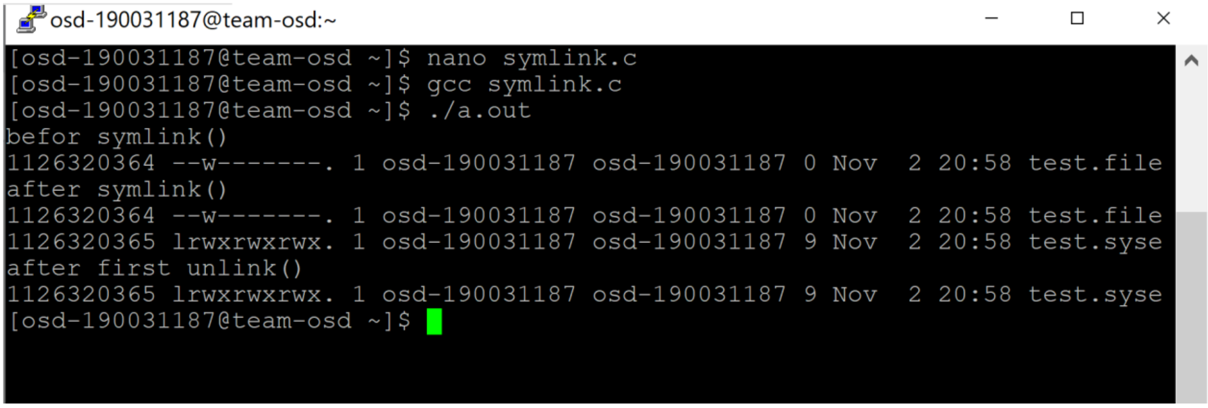
EXAMPLE PROGRAM FOR SYMBOLICLINK AND ITS EXECUTION



osd-190031187@team-osd:~

```
  GNU nano 2.3.1              File: symlink.c                                M

#define _POSIX_SOURCE 2
#include <fcntl.h>
#include<sys/stat.h>
#include<sys/types.h>
#include<unistd.h>
#include<stdlib.h>
#include<stdio.h>

main()
{
        char fn[]="test.file";
        char sln[]="test.sysmlink";
        int fd;
        if((fd=creat(fn,S_IWUSR))<0)
        perror("creat() error");
        else{
        close(fd);
                puts("befor symlink()");
                system("ls -il test.*");
                if(symlink(fn,sln)!=0){
                        perror("symlink error");
                        unlink(fn);
                }
                else
                {
                        puts("after symlink()");
                        system("ls -il test.*");
                        unlink(fn);
                        puts("after first unlink()");
                        system("ls -il test.*");
                        unlink(sln);
                }
        }
}
```

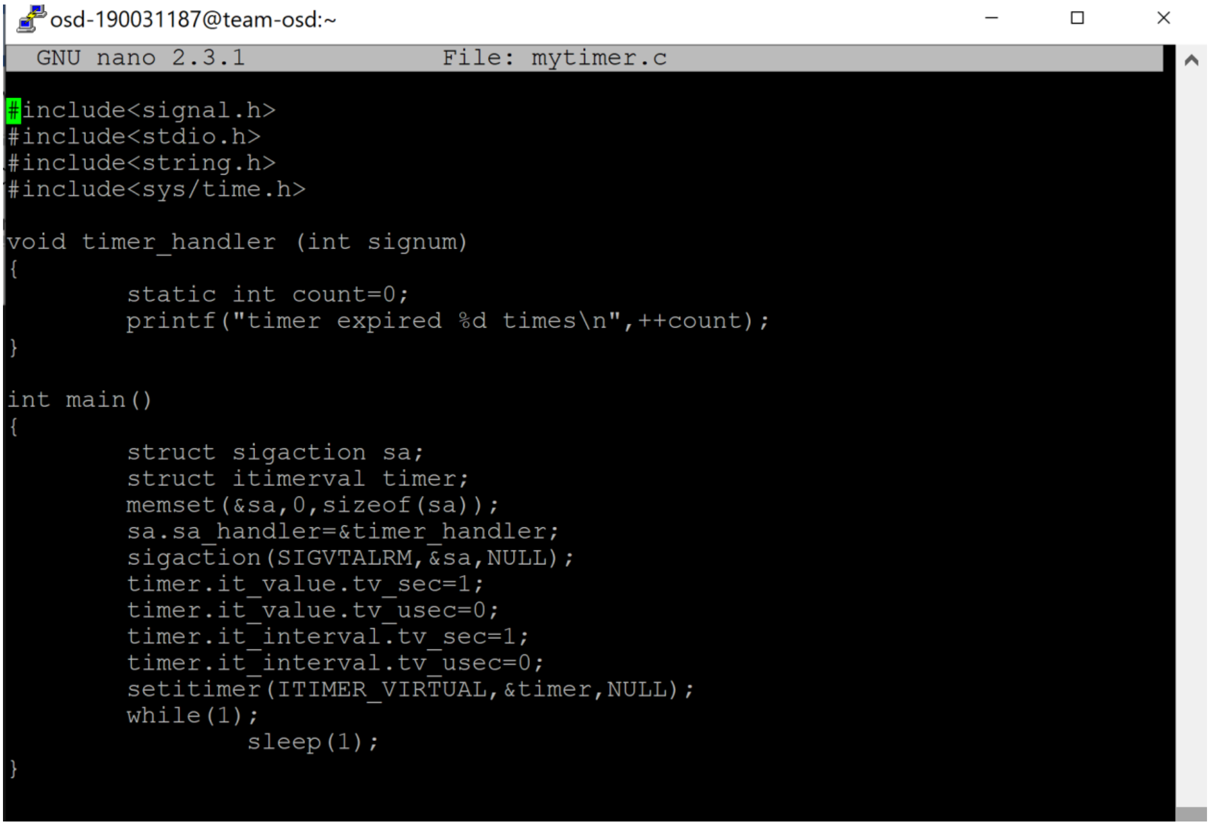
**OUTPUT**



```
[osd-190031187@team-osd ~]$ nano symlink.c
[osd-190031187@team-osd ~]$ gcc symlink.c
[osd-190031187@team-osd ~]$ ./a.out
befor symlink()
1126320364 --w-------. 1 osd-190031187 osd-190031187 0 Nov  2 20:58 test.file
after symlink()
1126320364 --w-------. 1 osd-190031187 osd-190031187 0 Nov  2 20:58 test.file
1126320365 lrwxrwxrwx. 1 osd-190031187 osd-190031187 9 Nov  2 20:58 test.syse
after first unlink()
1126320365 lrwxrwxrwx. 1 osd-190031187 osd-190031187 9 Nov  2 20:58 test.syse
[osd-190031187@team-osd ~]$
```

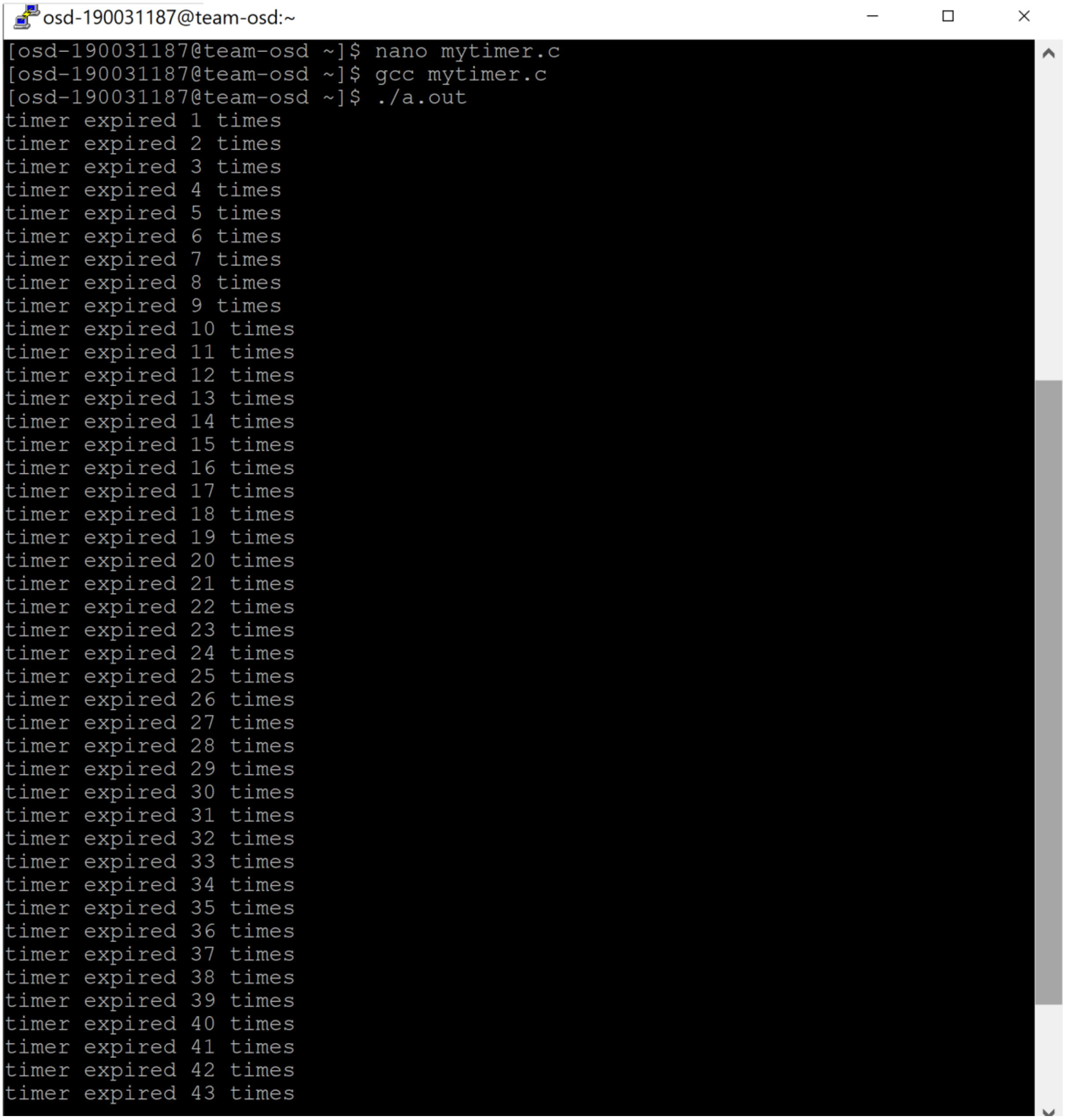
## UNIX system programming

1. program using timer



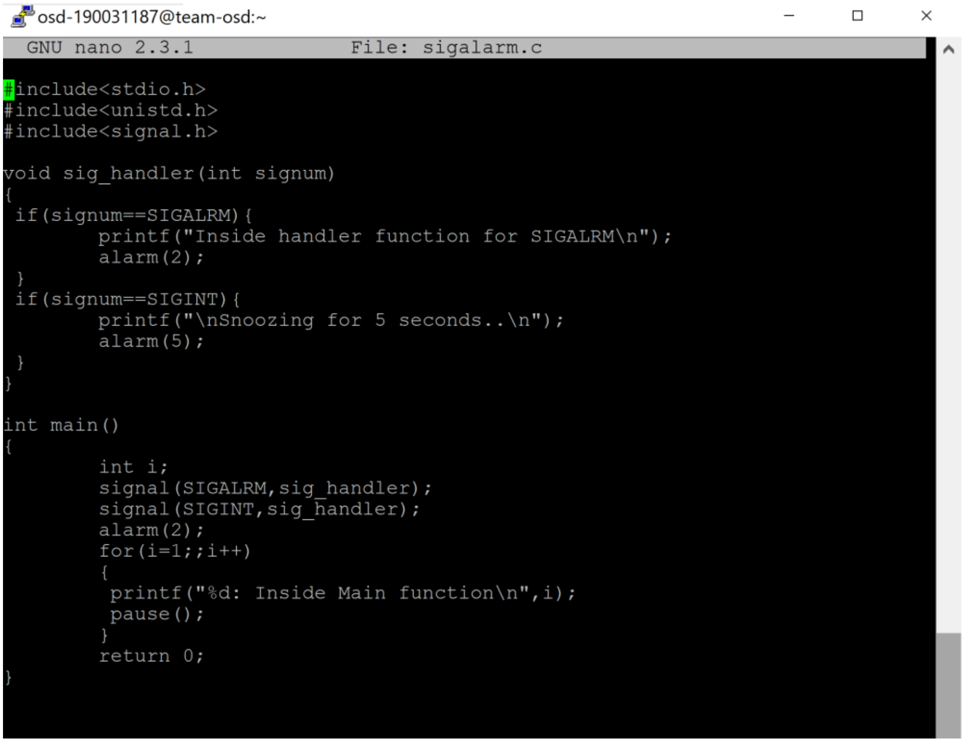
```
#include<signal.h>
#include<stdio.h>
#include<string.h>
#include<sys/time.h>

void timer_handler (int signum)
{
        static int count=0;
        printf("timer expired %d times\n",++count);
}

int main()
{
        struct sigaction sa;
        struct itimerval timer;
        memset(&sa,0,sizeof(sa));
        sa.sa_handler=&timer_handler;
        sigaction(SIGVTALRM,&sa,NULL);
        timer.it_value.tv_sec=1;
        timer.it_value.tv_usec=0;
        timer.it_interval.tv_sec=1;
        timer.it_interval.tv_usec=0;
        setitimer(ITIMER_VIRTUAL,&timer,NULL);
        while(1);
                sleep(1);
}
```

## OUTPUT



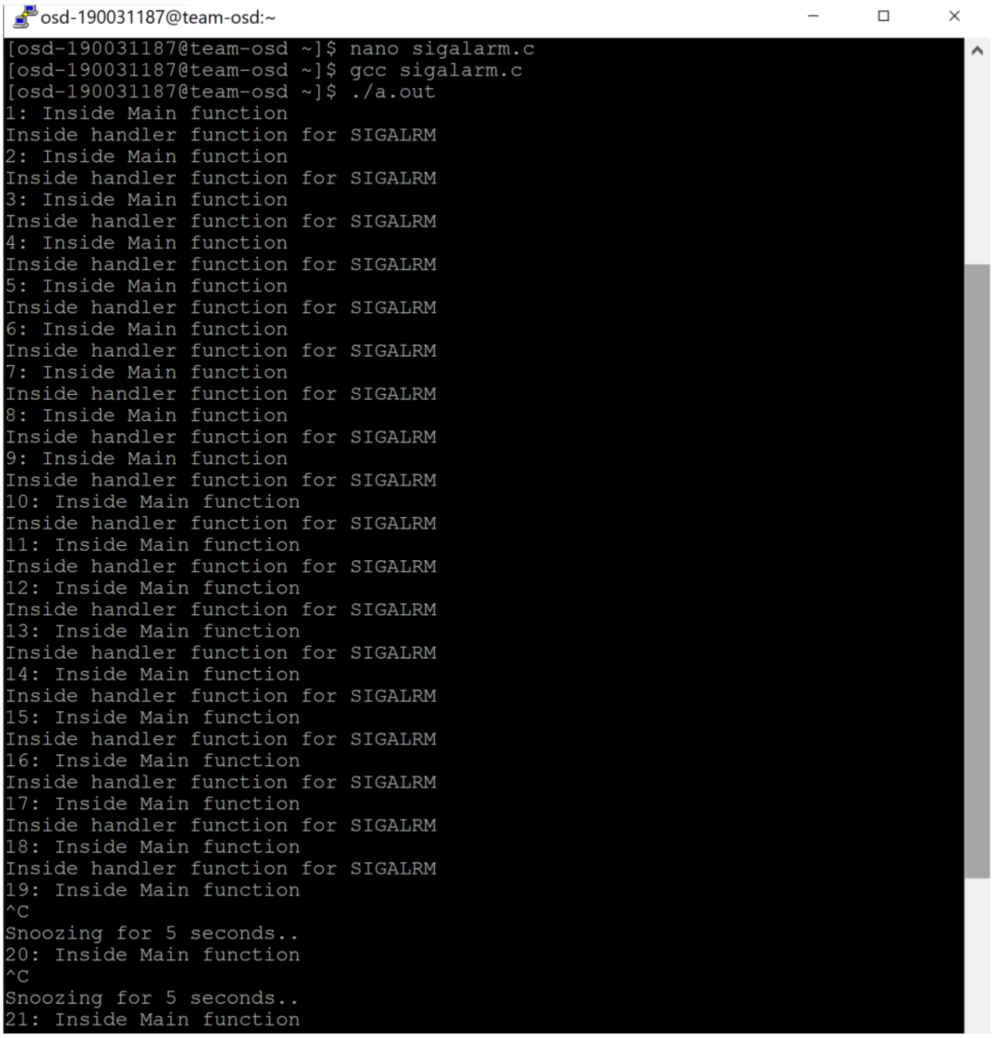
```
[osd-190031187@team-osd ~]$ nano mytimer.c
[osd-190031187@team-osd ~]$ gcc mytimer.c
[osd-190031187@team-osd ~]$ ./a.out
timer expired 1 times
timer expired 2 times
timer expired 3 times
timer expired 4 times
timer expired 5 times
timer expired 6 times
timer expired 7 times
timer expired 8 times
timer expired 9 times
timer expired 10 times
timer expired 11 times
timer expired 12 times
timer expired 13 times
timer expired 14 times
timer expired 15 times
timer expired 16 times
timer expired 17 times
timer expired 18 times
timer expired 19 times
timer expired 20 times
timer expired 21 times
timer expired 22 times
timer expired 23 times
timer expired 24 times
timer expired 25 times
timer expired 26 times
timer expired 27 times
timer expired 28 times
timer expired 29 times
timer expired 30 times
timer expired 31 times
timer expired 32 times
timer expired 33 times
timer expired 34 times
timer expired 35 times
timer expired 36 times
timer expired 37 times
timer expired 38 times
timer expired 39 times
timer expired 40 times
timer expired 41 times
timer expired 42 times
timer expired 43 times
```

2. program using alarm call

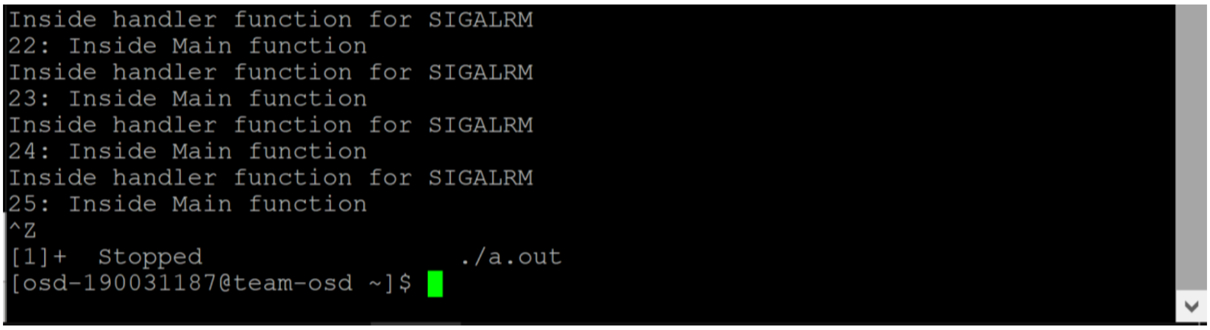


```
  GNU nano 2.3.1            File: sigalarm.c

#include<stdio.h>
#include<unistd.h>
#include<signal.h>

void sig_handler(int signum)
{
 if(signum==SIGALRM){
        printf("Inside handler function for SIGALRM\n");
        alarm(2);
 }
 if(signum==SIGINT){
        printf("\nSnoozing for 5 seconds..\n");
        alarm(5);
 }
}

int main()
{
        int i;
        signal(SIGALRM,sig_handler);
        signal(SIGINT,sig_handler);
        alarm(2);
        for(i=1;;i++)
        {
         printf("%d: Inside Main function\n",i);
         pause();
        }
        return 0;
}
```

## OUTPUT



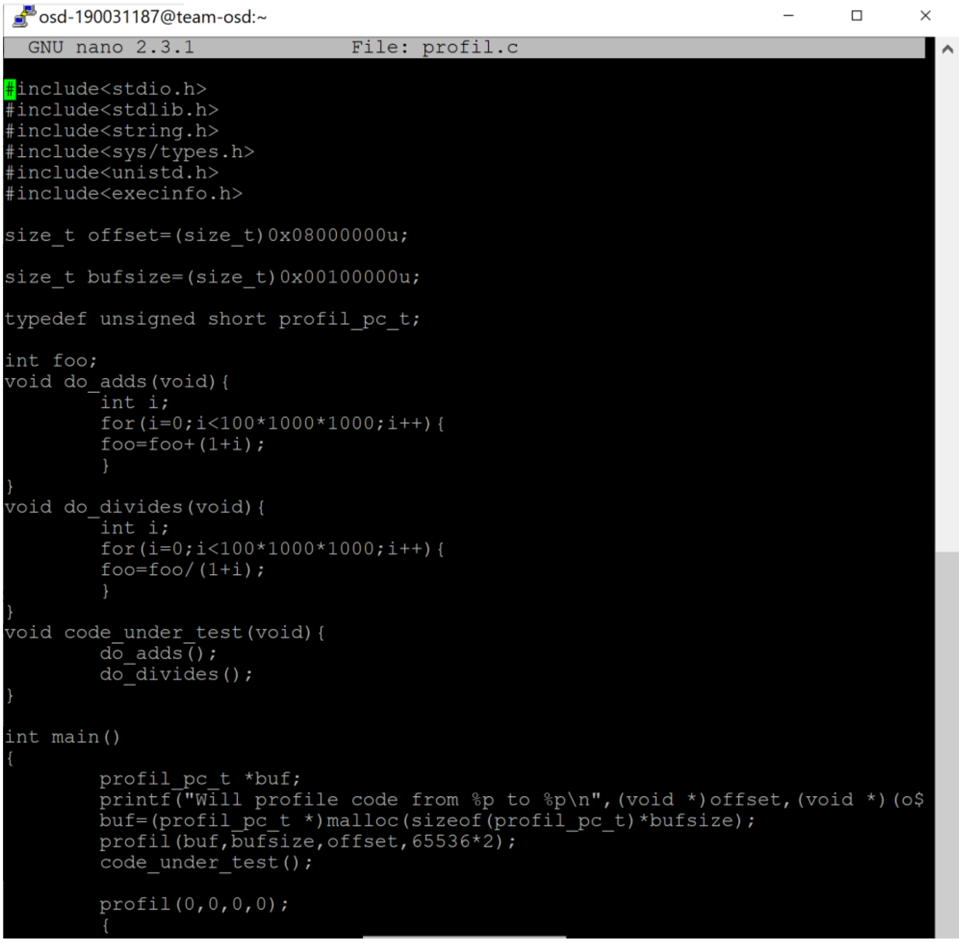
```
[osd-190031187@team-osd ~]$ nano sigalarm.c
[osd-190031187@team-osd ~]$ gcc sigalarm.c
[osd-190031187@team-osd ~]$ ./a.out
1: Inside Main function
Inside handler function for SIGALRM
2: Inside Main function
Inside handler function for SIGALRM
3: Inside Main function
Inside handler function for SIGALRM
4: Inside Main function
Inside handler function for SIGALRM
5: Inside Main function
Inside handler function for SIGALRM
6: Inside Main function
Inside handler function for SIGALRM
7: Inside Main function
Inside handler function for SIGALRM
8: Inside Main function
Inside handler function for SIGALRM
9: Inside Main function
Inside handler function for SIGALRM
10: Inside Main function
Inside handler function for SIGALRM
11: Inside Main function
Inside handler function for SIGALRM
12: Inside Main function
Inside handler function for SIGALRM
13: Inside Main function
Inside handler function for SIGALRM
14: Inside Main function
Inside handler function for SIGALRM
15: Inside Main function
Inside handler function for SIGALRM
16: Inside Main function
Inside handler function for SIGALRM
17: Inside Main function
Inside handler function for SIGALRM
18: Inside Main function
Inside handler function for SIGALRM
19: Inside Main function
^C
Snoozing for 5 seconds..
20: Inside Main function
^C
Snoozing for 5 seconds..
21: Inside Main function
```



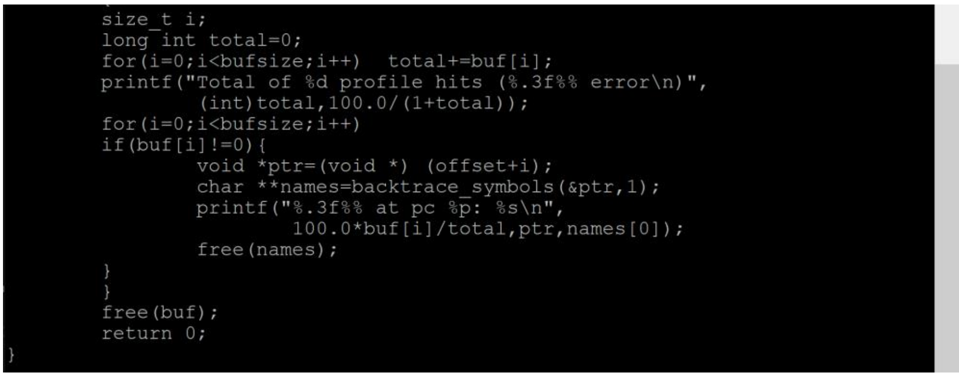
```
Inside handler function for SIGALRM
22: Inside Main function
Inside handler function for SIGALRM
23: Inside Main function
Inside handler function for SIGALRM
24: Inside Main function
Inside handler function for SIGALRM
25: Inside Main function
^Z
[1]+  Stopped                 ./a.out
[osd-190031187@team-osd ~]$ 
```

### 3. program invoking profil system call

The profil() function provides CPU-use statistics by profiling the amount of CPU time expended by a program. The profil() function generates the statistics by creating an execution histogram for a current process.

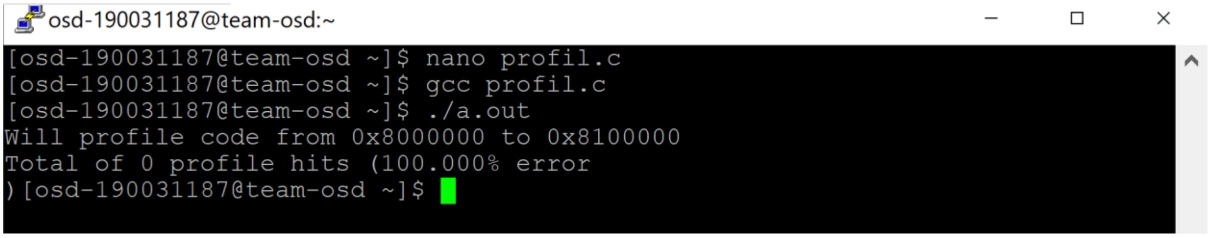


```
  GNU nano 2.3.1             File: profil.c

#include<stdio.h>
#include<stdlib.h>
#include<string.h>
#include<sys/types.h>
#include<unistd.h>
#include<execinfo.h>

size_t offset=(size_t)0x08000000u;

size_t bufsize=(size_t)0x00100000u;

typedef unsigned short profil_pc_t;

int foo;
void do_adds(void){
        int i;
        for(i=0;i<100*1000*1000;i++){
        foo=foo+(1+i);
        }
}
void do_divides(void){
        int i;
        for(i=0;i<100*1000*1000;i++){
        foo=foo/(1+i);
        }
}
void code_under_test(void){
        do_adds();
        do_divides();
}

int main()
{
        profil_pc_t *buf;
        printf("Will profile code from %p to %p\n",(void *)offset,(void *)(o$
        buf=(profil_pc_t *)malloc(sizeof(profil_pc_t)*bufsize);
        profil(buf,bufsize,offset,65536*2);
        code_under_test();

        profil(0,0,0,0);
        {
```



```
        size_t i;
        long int total=0;
        for(i=0;i<bufsize;i++)  total+=buf[i];
        printf("Total of %d profile hits (%.3f%% error\n)",
                (int)total,100.0/(1+total));
        for(i=0;i<bufsize;i++)
        if(buf[i]!=0){
                void *ptr=(void *) (offset+i);
                char **names=backtrace_symbols(&ptr,1);
                printf("%.3f%% at pc %p: %s\n",
                        100.0*buf[i]/total,ptr,names[0]);
                free(names);
        }
        }
        free(buf);
        return 0;
}
```

## OUTPUT



```
[osd-190031187@team-osd ~]$ nano profil.c
[osd-190031187@team-osd ~]$ gcc profil.c
[osd-190031187@team-osd ~]$ ./a.out
Will profile code from 0x8000000 to 0x8100000
Total of 0 profile hits (100.000% error
)[osd-190031187@team-osd ~]$
```