

POLITECHNIKA WROCŁAWSKA

SCR - SYSTEMY OPERACYJNE

E04-48C

Sprawozdanie 1

Zadania rozszerzone - lista 4

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1 Polecenie *”strace”*

Polecenie to w języku Linux śledzi sygnały oraz wywołania systemowe w danych procesach. Dzięki odpowiednim flagom może również liczyć czas wywołań, jak i też zliczać ile jest sygnałów w procesie. Polecenie to wykonuje się dopóki nie zażądamy skończenia się instrukcji.

Komenda ta przechwytuje wszystkie wywołania i sygnały przez dany czas, a jej głównymi zastosowaniami jest diagnostyka i debugowanie programów.

Najważniejszymi flagami i poleceniami są:

- **[-o file]** - zapisuje wyjście śledzenia do pliku o podanej nazwie
- **[-p pid]** - rozpoczyna śledzenie procesu o podanym identyfikatorze ID (PID)
- **[-e expr]** - wyrażenie określające w jaki sposób ma odbywać się śledzenie
- **[-c [-dfwzZ]]** - zlicza czas wywołania i błędy dla wywołań systemowych
- **[-t]** - poprzedza każdą linię trace aktualnym czasem

Po wywołaniu komendy *”strace ls -l”* można zobaczyć, na przykład:

- Jaka komenda jest wywoływana:

```
xecve("/usr/bin/ls", ["ls", "-l"], 0x7ffffb581e08 /* 60 vars */) = 0 \newline
```

- Dostęp i otwieranie bibliotek:

```
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
openat(AT_FDCWD, "/lib/x86_64-linux-gnu/libselinux.so.1", O_RDONLY|O_CLOEXEC) = 3
...
openat(AT_FDCWD, "/lib/x86_64-linux-gnu/libc.so.6", O_RDONLY|O_CLOEXEC) = 3
```

- Alokacja pamięci:

```
mmap(NULL, 8192, PROT_READ|PROT_WRITE, MAP_PRIVATE|MAP_ANONYMOUS, -1, 0) = 0x7f20f430a000
mmap(NULL, 174600, PROT_READ, MAP_PRIVATE|MAP_DENYWRITE, 3, 0) = 0x7f20f42df000
mprotect(0x7f20f42e5000, 135168, PROT_NONE) = 0
mmap(0x7f20f42e5000, 102400, PROT_READ|PROT_EXEC, MAP_PRIVATE|MAP_FIXED|MAP_DENYWRITE, 3, 0x6000)
= 0x7f20f42e5000
mmap(0x7f20f42fe000, 28672, PROT_READ, MAP_PRIVATE|MAP_FIXED|MAP_DENYWRITE, 3, 0x1f000)
= 0x7f20f42fe000
mmap(0x7f20f4306000, 8192, PROT_READ|PROT_WRITE, MAP_PRIVATE|MAP_FIXED|MAP_DENYWRITE, 3, 0x26000)
= 0x7f20f4306000
mmap(0x7f20f4308000, 6664, PROT_READ|PROT_WRITE, MAP_PRIVATE|MAP_FIXED|MAP_ANONYMOUS, -1, 0)
= 0x7f20f4308000
```

- Otwieranie ustawień języka:

```
openat(AT_FDCWD, "/usr/share/locale/pl_PL.UTF-8/LC_TIME/coreutils.mo", O_RDONLY) = -1
ENOENT (No such file or directory)
openat(AT_FDCWD, "/usr/share/locale/pl_PL.utf8/LC_TIME/coreutils.mo", O_RDONLY) = -1
ENOENT (No such file or directory)
openat(AT_FDCWD, "/usr/share/locale/pl_PL/LC_TIME/coreutils.mo", O_RDONLY) = -1
ENOENT (No such file or directory)
```

```

openat(AT_FDCWD, "/usr/share/locale/pl.UTF-8/LC_TIME/coreutils.mo", O_RDONLY) = -1
ENOENT (No such file or directory)
openat(AT_FDCWD, "/usr/share/locale/pl.utf8/LC_TIME/coreutils.mo", O_RDONLY) = -1
ENOENT (No such file or directory)
openat(AT_FDCWD, "/usr/share/locale/pl/LC_TIME/coreutils.mo", O_RDONLY) = -1
ENOENT (No such file or directory)

```

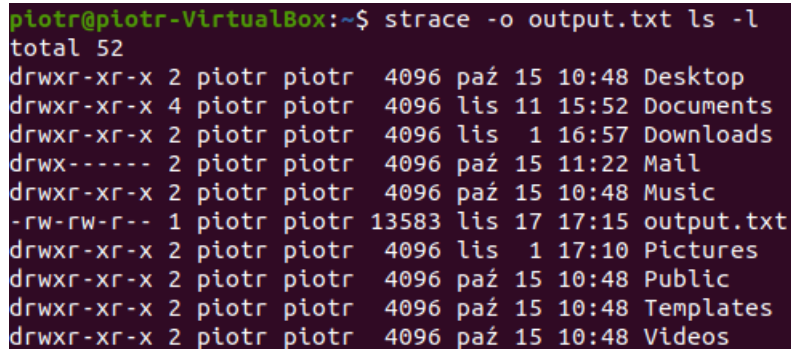
- Zebranie informacji o plikach:

```

lstat("Mail", {st_mode=S_IFDIR|0700, st_size=4096, ...}) = 0
lgetxattr("Mail", "security.selinux", 0x55a78e17a3b0, 255) = -1 ENODATA (No data available)
getxattr("Mail", "system.posix_acl_access", NULL, 0) = -1 ENODATA (No data available)
getxattr("Mail", "system.posix_acl_default", NULL, 0) = -1 ENODATA (No data available)
lstat("Desktop", {st_mode=S_IFDIR|0755, st_size=4096, ...}) = 0
lgetxattr("Desktop", "security.selinux", 0x55a78e17a4e0, 255) = -1 ENODATA (No data available)
getxattr("Desktop", "system.posix_acl_access", NULL, 0) = -1 ENODATA (No data available)
getxattr("Desktop", "system.posix_acl_default", NULL, 0) = -1 ENODATA (No data available)
lstat("Downloads", {st_mode=S_IFDIR|0755, st_size=4096, ...}) = 0
lgetxattr("Downloads", "security.selinux", 0x55a78e17a610, 255) = -1 ENODATA (No data available)
getxattr("Downloads", "system.posix_acl_access", NULL, 0) = -1 ENODATA (No data available)
getxattr("Downloads", "system.posix_acl_default", NULL, 0) = -1 ENODATA (No data available)
lstat("Documents", {st_mode=S_IFDIR|0755, st_size=4096, ...}) = 0
...
lgetxattr("Documents", "security.selinux", 0x55a78e17a740, 255) = -1 ENODATA (No data available)
getxattr("Documents", "system.posix_acl_access", NULL, 0) = -1 ENODATA (No data available)
getxattr("Documents", "system.posix_acl_default", NULL, 0) = -1 ENODATA (No data available)
lstat("Public", {st_mode=S_IFDIR|0755, st_size=4096, ...}) = 0

```

Przykłady wywołań strace z flagami:

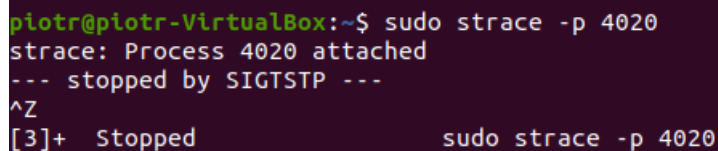


```

piotr@piotr-VirtualBox:~$ strace -o output.txt ls -l
total 52
drwxr-xr-x 2 piotr piotr 4096 paź 15 10:48 Desktop
drwxr-xr-x 4 piotr piotr 4096 lis 11 15:52 Documents
drwxr-xr-x 2 piotr piotr 4096 lis  1 16:57 Downloads
drwx----- 2 piotr piotr 4096 paź 15 11:22 Mail
drwxr-xr-x 2 piotr piotr 4096 paź 15 10:48 Music
-rw-rw-r-- 1 piotr piotr 13583 lis 17 17:15 output.txt
drwxr-xr-x 2 piotr piotr 4096 lis  1 17:10 Pictures
drwxr-xr-x 2 piotr piotr 4096 paź 15 10:48 Public
drwxr-xr-x 2 piotr piotr 4096 paź 15 10:48 Templates
drwxr-xr-x 2 piotr piotr 4096 paź 15 10:48 Videos

```

Rysunek 1: Zapis do pliku



```

piotr@piotr-VirtualBox:~$ sudo strace -p 4020
strace: Process 4020 attached
--- stopped by SIGTSTP ---
^Z
[3]+  Stopped                  sudo strace -p 4020

```

Rysunek 2: Śledzenie procesu


```

piotr@piotr-VirtualBox:~$ strace -c ls -l
total 56
drwxr-xr-x 2 piotr piotr 4096 paź 15 10:48 Desktop
drwxr-xr-x 4 piotr piotr 4096 lis 11 15:52 Documents
drwxr-xr-x 2 piotr piotr 4096 lis 1 16:57 Downloads
drwx----- 2 piotr piotr 4096 paź 15 11:22 Mail
drwxr-xr-x 2 piotr piotr 4096 paź 15 10:48 Music
-rw-rw-r-- 1 piotr piotr 17822 lis 17 17:15 output.txt
drwxr-xr-x 2 piotr piotr 4096 lis 1 17:10 Pictures
drwxr-xr-x 2 piotr piotr 4096 paź 15 10:48 Public
drwxr-xr-x 2 piotr piotr 4096 paź 15 10:48 Templates
drwxr-xr-x 2 piotr piotr 4096 paź 15 10:48 Videos
% time      seconds    usecs/call   calls     errors syscall
-----
 20,06      0,000968         27        35         mmap
 14,88      0,000718         20        35        17 openat
  7,32      0,000353         14        24         close
  6,28      0,000303         18        16         read
  6,13      0,000296         15        19        19 getxattr
  4,91      0,000237        237         1         execve
  4,89      0,000236         11        20         fstat
  4,77      0,000230         23        10        10 lgetxattr
  4,12      0,000199         19        10         mprotect
  3,56      0,000172         86         2         getdents64
  3,46      0,000167         41         4         connect
  2,96      0,000143         14        10         lstat
  2,88      0,000139         12        11         write
  2,63      0,000127         15         8         pread64
  2,42      0,000117         29         4         socket
  1,24      0,000060         30         2         munmap
  1,12      0,000054         54         1         set_tid_address
  1,08      0,000052         26         2         statfs
  0,97      0,000047         15         3         brk
  0,85      0,000041         20         2         access
  0,73      0,000035         17         2         rt_sigaction
  0,73      0,000035         17         2         ioctl
  0,50      0,000024          8         3         lseek
  0,50      0,000024         12         2         arch_prctl
  0,50      0,000024         24         1         prlimit64
  0,19      0,000009          9         1         futex
  0,17      0,000008          8         1         set_robust_list
  0,15      0,000007          7         1         rt_sigprocmask
-----
100.00      0,004825                232        55 total

```

Rysunek 4: Zliczenie czasu wywołania i ilość błędów

```

piotr@piotr-VirtualBox:~$ strace -e open ls -l
total 56
drwxr-xr-x 2 piotr piotr 4096 paź 15 10:48 Desktop
drwxr-xr-x 4 piotr piotr 4096 lis 11 15:52 Documents
drwxr-xr-x 2 piotr piotr 4096 lis 1 16:57 Downloads
drwx----- 2 piotr piotr 4096 paź 15 11:22 Mail
drwxr-xr-x 2 piotr piotr 4096 paź 15 10:48 Music
-rw-rw-r-- 1 piotr piotr 17822 lis 17 17:15 output.txt
drwxr-xr-x 2 piotr piotr 4096 lis 1 17:10 Pictures
drwxr-xr-x 2 piotr piotr 4096 paź 15 10:48 Public
drwxr-xr-x 2 piotr piotr 4096 paź 15 10:48 Templates
drwxr-xr-x 2 piotr piotr 4096 paź 15 10:48 Videos
+++ exited with 0 +++

```

Rysunek 5: Wywołanie z otwarciem

```

piotr@piotr-VirtualBox:~$ strace -t -e open ls -l
total 56
drwxr-xr-x 2 piotr piotr 4096 paź 15 10:48 Desktop
drwxr-xr-x 4 piotr piotr 4096 lis 11 15:52 Documents
drwxr-xr-x 2 piotr piotr 4096 lis 1 16:57 Downloads
drwx----- 2 piotr piotr 4096 paź 15 11:22 Mail
drwxr-xr-x 2 piotr piotr 4096 paź 15 10:48 Music
-rw-rw-r-- 1 piotr piotr 17822 lis 17 17:15 output.txt
drwxr-xr-x 2 piotr piotr 4096 lis 1 17:10 Pictures
drwxr-xr-x 2 piotr piotr 4096 paź 15 10:48 Public
drwxr-xr-x 2 piotr piotr 4096 paź 15 10:48 Templates
drwxr-xr-x 2 piotr piotr 4096 paź 15 10:48 Videos
17:20:47 +++ exited with 0 +++

```

Rysunek 6: Wywołanie z otwarciem i czasem

```

piotr@piotr-VirtualBox:~$ strace -r -e open ls -l
total 56
drwxr-xr-x 2 piotr piotr 4096 paź 15 10:48 Desktop
drwxr-xr-x 4 piotr piotr 4096 lis 11 15:52 Documents
drwxr-xr-x 2 piotr piotr 4096 lis 1 16:57 Downloads
drwx----- 2 piotr piotr 4096 paź 15 11:22 Mail
drwxr-xr-x 2 piotr piotr 4096 paź 15 10:48 Music
-rw-rw-r-- 1 piotr piotr 17822 lis 17 17:15 output.txt
drwxr-xr-x 2 piotr piotr 4096 lis 1 17:10 Pictures
drwxr-xr-x 2 piotr piotr 4096 paź 15 10:48 Public
drwxr-xr-x 2 piotr piotr 4096 paź 15 10:48 Templates
drwxr-xr-x 2 piotr piotr 4096 paź 15 10:48 Videos
0.000000 +++ exited with 0 +++

```

Rysunek 7: Wywołanie z otwarciem i czasem wywołania systemowym

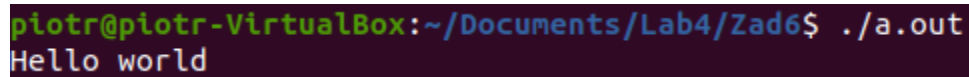
2 Wykorzystanie programu strace

2.1 Analiza *Hello world* na ekranie

Napisano prosty program wypisujący Hello world na ekranie

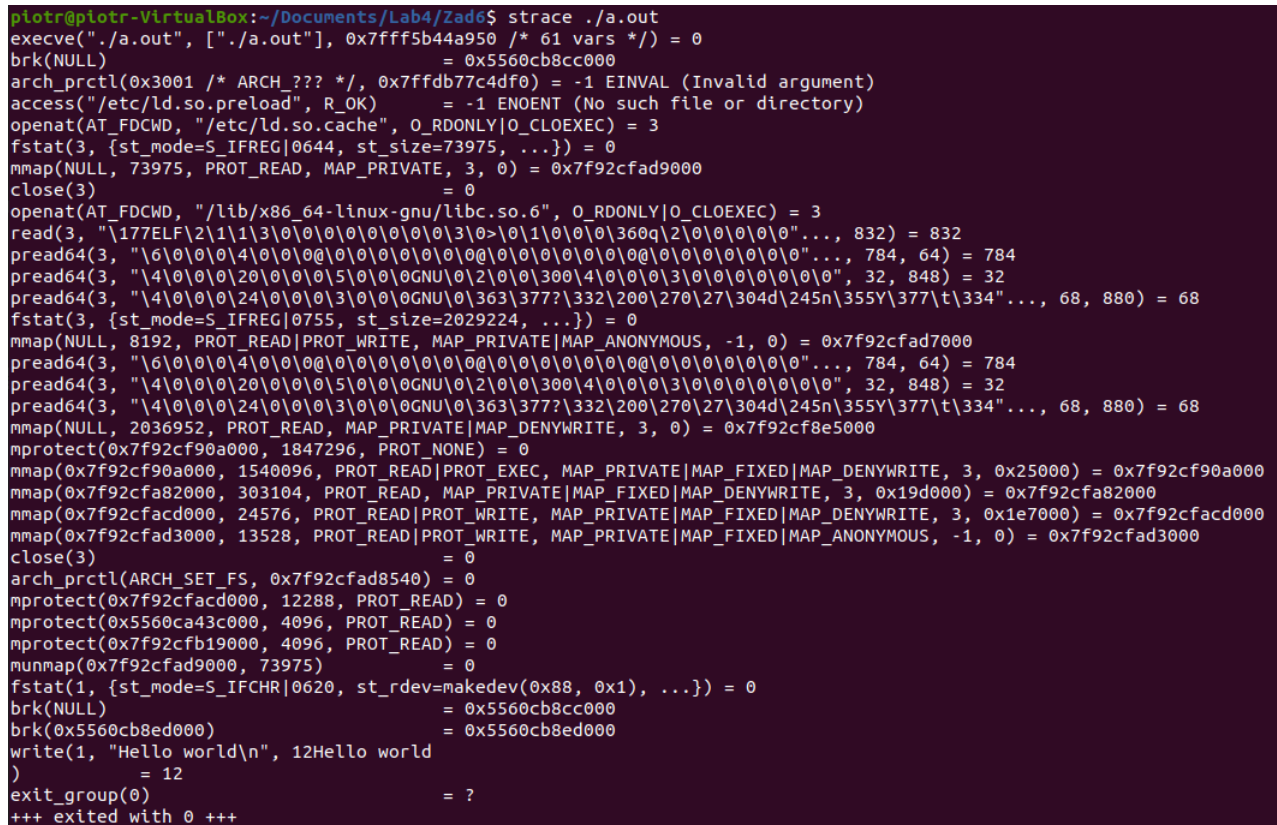
```
1 #include <stdio.h>
2
3 int main()
4 {
5     printf("Hello world\n");
6     return 0;
7 }
```

Wynik programu:



```
piotr@piotr-VirtualBox:~/Documents/Lab4/Zad6$ ./a.out
Hello world
```

Śledzenie programu:



```
piotr@piotr-VirtualBox:~/Documents/Lab4/Zad6$ strace ./a.out
execve("./a.out", ["/a.out"], 0x7fff5b44a950 /* 61 vars */) = 0
brk(NULL) = 0x5560cb8cc000
arch_prctl(0x3001 /* ARCH_??? */, 0x7ffdb77c4df0) = -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=73975, ...}) = 0
mmap(NULL, 73975, PROT_READ, MAP_PRIVATE, 3, 0) = 0x7f92cfad9000
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\3\0\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\0\0\0\0...", 784, 64) = 784
pread64(3, "\4\0\0\0\20\0\0\0\5\0\0\0\0\0\0\0\0\0\0\0\0\0\0\0\0\0\0\0\0\0\0\0\0...", 32, 848) = 32
pread64(3, "\4\0\0\0\24\0\0\0\3\0\0\0\0\0\0\0\0\0\0\0\0\0\0\0\0\0\0\0\0\0\0\0\0...", 68, 880) = 68
fstat(3, {st_mode=S_IFREG|0755, st_size=2029224, ...}) = 0
mmap(NULL, 8192, PROT_READ|PROT_WRITE, MAP_PRIVATE|MAP_ANONYMOUS, -1, 0) = 0x7f92cfad7000
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\0\0\0\0...", 784, 64) = 784
pread64(3, "\4\0\0\0\20\0\0\0\5\0\0\0\0\0\0\0\0\0\0\0\0\0\0\0\0\0\0\0\0\0\0\0\0...", 32, 848) = 32
pread64(3, "\4\0\0\0\24\0\0\0\3\0\0\0\0\0\0\0\0\0\0\0\0\0\0\0\0\0\0\0\0\0\0\0\0...", 68, 880) = 68
mmap(NULL, 2036952, PROT_READ, MAP_PRIVATE|MAP_DENYWRITE, 3, 0) = 0x7f92cf8e5000
mprotect(0x7f92cf90a000, 1847296, PROT_NONE) = 0
mmap(0x7f92cf90a000, 1540096, PROT_READ|PROT_EXEC, MAP_PRIVATE|MAP_FIXED|MAP_DENYWRITE, 3, 0x25000) = 0x7f92cf90a000
mmap(0x7f92cfa82000, 303104, PROT_READ, MAP_PRIVATE|MAP_FIXED|MAP_DENYWRITE, 3, 0x19d000) = 0x7f92cfa82000
mmap(0x7f92cfacd000, 24576, PROT_READ|PROT_WRITE, MAP_PRIVATE|MAP_FIXED|MAP_DENYWRITE, 3, 0x1e7000) = 0x7f92cfacd000
mmap(0x7f92cfad3000, 13528, PROT_READ|PROT_WRITE, MAP_PRIVATE|MAP_FIXED|MAP_ANONYMOUS, -1, 0) = 0x7f92cfad3000
close(3) = 0
arch_prctl(ARCH_SET_FS, 0x7f92cfad8540) = 0
mprotect(0x7f92cfacd000, 12288, PROT_READ) = 0
mprotect(0x5560ca43c000, 4096, PROT_READ) = 0
mprotect(0x7f92cfb19000, 4096, PROT_READ) = 0
munmap(0x7f92cfad9000, 73975) = 0
mknod(1, {st_mode=S_IFCHR|0620, st_rdev=makedev(0x88, 0x1), ...}) = 0
brk(NULL) = 0x5560cb8cc000
brk(0x5560cb8ed000) = 0x5560cb8ed000
write(1, "Hello world\n", 12Hello world
) = 12
exit_group(0) = ?
+++ exited with 0 +++
```

Jak można zauważyć, całość zaczyna się od wywołania komendy poprzez *execve*. Na początku występuje otrzymanie dostępu i otwarcie bibliotek. Po tym następuje działanie procesora, wraz z alokacją pamięci i protekcją. W komendzie *write* można zauważyć *Hello world*, które wypisuje się po zakończeniu programu, a długość tego ciągu wynosi 12 znaków.

Z powyższego obrazka można również odczytać, otwarcie biblioteki **libc.so** w trybie do odczytu (Read only), z nowym deskryptorem równym 3. Potem występuje zmapowanie kodu i zamknięcie biblioteki.

2.2 Wykorzystanie do znalezienia plików konfiguracyjnych

Pliki konfiguracyjne jakie powłoka może odczytać przy starcie można znaleźć używając polecenia strace. Należy użyć polecenia, który będzie śledził wybrany zbiór wywołań systemowych. Można to zrealizować poprzez użycie flagi *-e trace=zbiór*, gdzie naszym zbiorem są pliki otwierane przy starcie powłoki.

Nadawanie dostępu:

```
piotr@piotr-VirtualBox:~$ strace -e trace=open,access bash -i
access("/etc/ld.so.preload", R_OK) = -1 ENOENT (No such file or directory)
access("/usr/bin/bash", X_OK) = 0
access("/usr/bin/bash", R_OK) = 0
access("/usr/bin/bash", X_OK) = 0
access("/usr/bin/bash", R_OK) = 0
access("/etc/terminfo/x/xterm-256color", R_OK) = -1 ENOENT (No such file or directory)
access("/lib/terminfo/x/xterm-256color", R_OK) = 0
--- SIGCHLD {si_signo=SIGCHLD, si_code=CLD_EXITED, si_pid=15333, si_uid=1000, si_status=0, si_etime=0, si_stime=0} ---
--- SIGCHLD {si_signo=SIGCHLD, si_code=CLD_EXITED, si_pid=15337, si_uid=1000, si_status=0, si_etime=0, si_stime=0} ---
```

Czytanie danych:

```
piotr@piotr-VirtualBox:~$ strace -e trace=open,stat bash -i
stat("/home/piotr", {st_mode=S_IFDIR|0755, st_size=4096, ...}) = 0
stat(".", {st_mode=S_IFDIR|0755, st_size=4096, ...}) = 0
stat("/home", {st_mode=S_IFDIR|0755, st_size=4096, ...}) = 0
stat("/home/piotr", {st_mode=S_IFDIR|0755, st_size=4096, ...}) = 0
stat(".", {st_mode=S_IFDIR|0755, st_size=4096, ...}) = 0
stat("/usr/local/sbin/bash", 0x7ffdba2f9eb0) = -1 ENOENT (No such file or directory)
stat("/usr/local/bin/bash", 0x7ffdba2f9eb0) = -1 ENOENT (No such file or directory)
stat("/usr/sbin/bash", 0x7ffdba2f9eb0) = -1 ENOENT (No such file or directory)
stat("/usr/bin/bash", {st_mode=S_IFREG|0755, st_size=1183448, ...}) = 0
stat("/usr/bin/bash", {st_mode=S_IFREG|0755, st_size=1183448, ...}) = 0
stat("/usr/bin/bash", {st_mode=S_IFREG|0755, st_size=1183448, ...}) = 0
stat("/usr/bin/bash", {st_mode=S_IFREG|0755, st_size=1183448, ...}) = 0
stat("/usr/bin/bash", {st_mode=S_IFREG|0755, st_size=1183448, ...}) = 0
stat("/usr/bin/bash", {st_mode=S_IFREG|0755, st_size=1183448, ...}) = 0
stat("/home/piotr/.terminfo", 0x5599e91dfbe0) = -1 ENOENT (No such file or directory)
stat("/etc/terminfo", {st_mode=S_IFDIR|0755, st_size=4096, ...}) = 0
stat("/lib/terminfo", {st_mode=S_IFDIR|0755, st_size=4096, ...}) = 0
stat("/usr/share/terminfo", {st_mode=S_IFDIR|0755, st_size=4096, ...}) = 0
stat("/home/piotr/.sudo_as_admin_successful", {st_mode=S_IFREG|0644, st_size=0, ...}) = 0
--- SIGCHLD {si_signo=SIGCHLD, si_code=CLD_EXITED, si_pid=15356, si_uid=1000, si_status=0, si_etime=0, si_stime=0} ---
--- SIGCHLD {si_signo=SIGCHLD, si_code=CLD_EXITED, si_pid=15360, si_uid=1000, si_status=0, si_etime=0, si_stime=0} ---
stat("/home/piotr/.bash_aliases", 0x7ffdba2f9b40) = -1 ENOENT (No such file or directory)
stat("/usr/share/bash-completion/bash_completion", {st_mode=S_IFREG|0644, st_size=74550, ...}) = 0
stat("/etc/rc.d/init.d", 0x7ffdba2f8b30) = -1 ENOENT (No such file or directory)
stat("/etc/init.d", {st_mode=S_IFDIR|0755, st_size=4096, ...}) = 0
stat("/etc/slackware-version", 0x7ffdba2f8e50) = -1 ENOENT (No such file or directory)
stat("/etc/bash_completion.d", {st_mode=S_IFDIR|0755, st_size=4096, ...}) = 0
stat("/etc/bash_completion.d/apport_completion", {st_mode=S_IFREG|0644, st_size=6636, ...}) = 0
stat("/home/piotr/.bash_history", {st_mode=S_IFREG|0600, st_size=14670, ...}) = 0
```

Jak można zauważyć powtarzające się — *SIGCHLD* ... — należą do open - występują zarówno w jednym, jak i drugim wywołaniu.

Otwieranie danych i bibliotek (open)

```
piotr@piotr-VirtualBox:~$ strace -e trace=openat bash -i
openat(AT_FDCWD, "/etc/ld.so.cache", O_RDONLY|O_CLOEXEC) = 3
openat(AT_FDCWD, "/lib/x86_64-linux-gnu/libtinfo.so.6", O_RDONLY|O_CLOEXEC) = 3
openat(AT_FDCWD, "/lib/x86_64-linux-gnu/libdl.so.2", O_RDONLY|O_CLOEXEC) = 3
openat(AT_FDCWD, "/lib/x86_64-linux-gnu/libc.so.6", O_RDONLY|O_CLOEXEC) = 3
openat(AT_FDCWD, "/dev/tty", O_RDWR|O_NONBLOCK) = 3
openat(AT_FDCWD, "/usr/lib/locale/locale-archive", O_RDONLY|O_CLOEXEC) = 3
openat(AT_FDCWD, "/usr/lib/x86_64-linux-gnu/gconv/gconv-modules.cache", O_RDONLY) = 3
openat(AT_FDCWD, "/etc/nsswitch.conf", O_RDONLY|O_CLOEXEC) = 3
openat(AT_FDCWD, "/etc/ld.so.cache", O_RDONLY|O_CLOEXEC) = 3
openat(AT_FDCWD, "/lib/x86_64-linux-gnu/libnss_files.so.2", O_RDONLY|O_CLOEXEC) = 3
openat(AT_FDCWD, "/etc/passwd", O_RDONLY|O_CLOEXEC) = 3
openat(AT_FDCWD, "/lib/terminfo/x/xterm-256color", O_RDONLY) = 3
openat(AT_FDCWD, "/etc/bash.bashrc", O_RDONLY) = 3
openat(AT_FDCWD, "/home/piotr/.bashrc", O_RDONLY) = 3
openat(AT_FDCWD, "/home/piotr/.bash_history", O_RDONLY) = 3
--- SIGCHLD {si_signo=SIGCHLD, si_code=CLD_EXITED, si_pid=17400, si_uid=1000, si_status=0, si_etime=0, si_stime=0} ---
--- SIGCHLD {si_signo=SIGCHLD, si_code=CLD_EXITED, si_pid=17404, si_uid=1000, si_status=0, si_etime=0, si_stime=0} ---
openat(AT_FDCWD, "/usr/share/bash-completion/bash_completion", O_RDONLY) = 3
openat(AT_FDCWD, "/etc/init.d/", O_RDONLY|O_NONBLOCK|O_CLOEXEC|O_DIRECTORY) = 3
openat(AT_FDCWD, "/etc/bash_completion.d/", O_RDONLY|O_NONBLOCK|O_CLOEXEC|O_DIRECTORY) = 3
openat(AT_FDCWD, "/etc/bash_completion.d/apport_completion", O_RDONLY) = 3
openat(AT_FDCWD, "/home/piotr/.bash_history", O_RDONLY) = 3
openat(AT_FDCWD, "/home/piotr/.bash_history", O_RDONLY) = 3
openat(AT_FDCWD, "/home/piotr/.inputrc", O_RDONLY) = -1 ENOENT (No such file or directory)
openat(AT_FDCWD, "/etc/inputrc", O_RDONLY) = 3
```

W moim systemie zamiast open występuje openat.

2.3 Sprawdzanie czy plik edytowany w pico jest otwarty

Uruchomiono strace i pico w jednym potoku:

```
strace -o output -e trace=openat,close pico program.c
```

Następnie otworzono plik poprzez emacs i zobaczono zawartość:

```
openat(AT_FDCWD, "/etc/ld.so.cache", O_RDONLY|O_CLOEXEC) = 3
close(3) = 0
openat(AT_FDCWD, "/lib/x86_64-linux-gnu/libncursesw.so.6", O_RDONLY|O_CLOEXEC) = 3
close(3) = 0
openat(AT_FDCWD, "/lib/x86_64-linux-gnu/libtinfo.so.6", O_RDONLY|O_CLOEXEC) = 3
close(3) = 0
openat(AT_FDCWD, "/lib/x86_64-linux-gnu/libc.so.6", O_RDONLY|O_CLOEXEC) = 3
close(3) = 0
openat(AT_FDCWD, "/lib/x86_64-linux-gnu/libdl.so.2", O_RDONLY|O_CLOEXEC) = 3
close(3) = 0
openat(AT_FDCWD, "/usr/lib/locale/locale-archive", O_RDONLY|O_CLOEXEC) = 3
close(3) = 0
openat(AT_FDCWD, "/etc/nanorc", O_RDONLY) = 3
openat(AT_FDCWD, "/usr/share/nano", O_RDONLY|O_NONBLOCK|O_CLOEXEC|O_DIRECTORY) = 4
openat(AT_FDCWD, "/usr/lib/x86_64-linux-gnu/gconv/gconv-modules.cache", O_RDONLY) = 5
close(5) = 0
close(4) = 0
openat(AT_FDCWD, "/usr/share/nano/asm.nanorc", O_RDONLY) = 4
close(4) = 0
openat(AT_FDCWD, "/usr/share/nano/autoconf.nanorc", O_RDONLY) = 4
close(4) = 0
openat(AT_FDCWD, "/usr/share/nano/awk.nanorc", O_RDONLY) = 4
close(4) = 0
openat(AT_FDCWD, "/usr/share/nano/changelog.nanorc", O_RDONLY) = 4
close(4) = 0
openat(AT_FDCWD, "/usr/share/nano/cmake.nanorc", O_RDONLY) = 4
close(4) = 0
openat(AT_FDCWD, "/usr/share/nano/c.nanorc", O_RDONLY) = 4
close(4) = 0
openat(AT_FDCWD, "/usr/share/nano/css.nanorc", O_RDONLY) = 4
close(4) = 0
openat(AT_FDCWD, "/usr/share/nano/debian.nanorc", O_RDONLY) = 4
close(4) = 0
openat(AT_FDCWD, "/usr/share/nano/default.nanorc", O_RDONLY) = 4
close(4) = 0
openat(AT_FDCWD, "/usr/share/nano/emacs.nanorc", O_RDONLY) = 4
-:--- output Top L36 (Fundamental)
```

```

close(3) = 0
openat(AT_FDCWD, "/home/piotr/.local/share/nano/search_history", O_RDONLY) = -1 ENOENT (No such file or directory)
openat(AT_FDCWD, "/lib/terminfo/x/xterm-256color", O_RDONLY) = 3
close(3) = 0
close(3) = 0
close(3) = 0
openat(AT_FDCWD, "/etc/nsswitch.conf", O_RDONLY|O_CLOEXEC) = 3
close(3) = 0
openat(AT_FDCWD, "/etc/ld.so.cache", O_RDONLY|O_CLOEXEC) = 3
close(3) = 0
openat(AT_FDCWD, "/lib/x86_64-linux-gnu/libnss_files.so.2", O_RDONLY|O_CLOEXEC) = 3
close(3) = 0
openat(AT_FDCWD, "/etc/passwd", O_RDONLY|O_CLOEXEC) = 3
close(3) = 0
openat(AT_FDCWD, "./.program.c.swp", O_WRONLY|O_CREAT|O_EXCL|O_APPEND, 0666) = 3
close(3) = 0
openat(AT_FDCWD, "/home/piotr/Documents/Lab4/Zad6/program.c", O_RDONLY) = 3
openat(AT_FDCWD, "/usr/share/locale/locale.alias", O_RDONLY|O_CLOEXEC) = 4
close(4) = 0
openat(AT_FDCWD, "/usr/share/locale/en_US.UTF-8/LC_MESSAGES/nano.mo", O_RDONLY) = -1 ENOENT (No such file or directory)
openat(AT_FDCWD, "/usr/share/locale/en_US.utf8/LC_MESSAGES/nano.mo", O_RDONLY) = -1 ENOENT (No such file or directory)
openat(AT_FDCWD, "/usr/share/locale/en_US/LC_MESSAGES/nano.mo", O_RDONLY) = -1 ENOENT (No such file or directory)
openat(AT_FDCWD, "/usr/share/locale/en.UTF-8/LC_MESSAGES/nano.mo", O_RDONLY) = -1 ENOENT (No such file or directory)
openat(AT_FDCWD, "/usr/share/locale/en.utf8/LC_MESSAGES/nano.mo", O_RDONLY) = -1 ENOENT (No such file or directory)
openat(AT_FDCWD, "/usr/share/locale/en/LC_MESSAGES/nano.mo", O_RDONLY) = -1 ENOENT (No such file or directory)
openat(AT_FDCWD, "/usr/share/locale-langpack/en_US.UTF-8/LC_MESSAGES/nano.mo", O_RDONLY) = -1 ENOENT (No such file or directory)
openat(AT_FDCWD, "/usr/share/locale-langpack/en_US.utf8/LC_MESSAGES/nano.mo", O_RDONLY) = -1 ENOENT (No such file or directory)
openat(AT_FDCWD, "/usr/share/locale-langpack/en_US/LC_MESSAGES/nano.mo", O_RDONLY) = -1 ENOENT (No such file or directory)
openat(AT_FDCWD, "/usr/share/locale-langpack/en.UTF-8/LC_MESSAGES/nano.mo", O_RDONLY) = -1 ENOENT (No such file or directory)
openat(AT_FDCWD, "/usr/share/locale-langpack/en.utf8/LC_MESSAGES/nano.mo", O_RDONLY) = -1 ENOENT (No such file or directory)
openat(AT_FDCWD, "/usr/share/locale-langpack/en/LC_MESSAGES/nano.mo", O_RDONLY) = -1 ENOENT (No such file or directory)
close(3) = 0
openat(AT_FDCWD, "/usr/share/nano/c.nanorc", O_RDONLY) = 3
close(3) = 0

```

---- output Bot L106 (Fundamental)

Następnie zedytowano plik program.c poprzez pico i otworzono ponownie plik przez emacs:

```

close(3) = 0
close(3) = 0
openat(AT_FDCWD, "/etc/nsswitch.conf", O_RDONLY|O_CLOEXEC) = 3
close(3) = 0
openat(AT_FDCWD, "/etc/ld.so.cache", O_RDONLY|O_CLOEXEC) = 3
close(3) = 0
openat(AT_FDCWD, "/lib/x86_64-linux-gnu/libnss_files.so.2", O_RDONLY|O_CLOEXEC) = 3
close(3) = 0
openat(AT_FDCWD, "/etc/passwd", O_RDONLY|O_CLOEXEC) = 3
close(3) = 0
openat(AT_FDCWD, "./.program.c.swp", O_WRONLY|O_CREAT|O_EXCL|O_APPEND, 0666) = 3
close(3) = 0
openat(AT_FDCWD, "/home/piotr/Documents/Lab4/Zad6/program.c", O_RDONLY) = 3
openat(AT_FDCWD, "/usr/share/locale/locale.alias", O_RDONLY|O_CLOEXEC) = 4
close(4) = 0
openat(AT_FDCWD, "/usr/share/locale/en_US.UTF-8/LC_MESSAGES/nano.mo", O_RDONLY) = -1 ENOENT (No such file or directory)
openat(AT_FDCWD, "/usr/share/locale/en_US.utf8/LC_MESSAGES/nano.mo", O_RDONLY) = -1 ENOENT (No such file or directory)
openat(AT_FDCWD, "/usr/share/locale/en_US/LC_MESSAGES/nano.mo", O_RDONLY) = -1 ENOENT (No such file or directory)
openat(AT_FDCWD, "/usr/share/locale/en.UTF-8/LC_MESSAGES/nano.mo", O_RDONLY) = -1 ENOENT (No such file or directory)
openat(AT_FDCWD, "/usr/share/locale/en.utf8/LC_MESSAGES/nano.mo", O_RDONLY) = -1 ENOENT (No such file or directory)
openat(AT_FDCWD, "/usr/share/locale/en/LC_MESSAGES/nano.mo", O_RDONLY) = -1 ENOENT (No such file or directory)
openat(AT_FDCWD, "/usr/share/locale-langpack/en_US.UTF-8/LC_MESSAGES/nano.mo", O_RDONLY) = -1 ENOENT (No such file or directory)
openat(AT_FDCWD, "/usr/share/locale-langpack/en_US.utf8/LC_MESSAGES/nano.mo", O_RDONLY) = -1 ENOENT (No such file or directory)
openat(AT_FDCWD, "/usr/share/locale-langpack/en_US/LC_MESSAGES/nano.mo", O_RDONLY) = -1 ENOENT (No such file or directory)
openat(AT_FDCWD, "/usr/share/locale-langpack/en.UTF-8/LC_MESSAGES/nano.mo", O_RDONLY) = -1 ENOENT (No such file or directory)
openat(AT_FDCWD, "/usr/share/locale-langpack/en.utf8/LC_MESSAGES/nano.mo", O_RDONLY) = -1 ENOENT (No such file or directory)
openat(AT_FDCWD, "/usr/share/locale-langpack/en/LC_MESSAGES/nano.mo", O_RDONLY) = -1 ENOENT (No such file or directory)
close(3) = 0
openat(AT_FDCWD, "/usr/share/nano/c.nanorc", O_RDONLY) = 3
close(3) = 0
openat(AT_FDCWD, "/etc/passwd", O_RDONLY|O_CLOEXEC) = 3
close(3) = 0
openat(AT_FDCWD, "./.program.c.swp", O_WRONLY|O_CREAT|O_EXCL|O_APPEND, 0666) = 3
close(3) = 0

```

---- output Bot L135 (Fundamental)

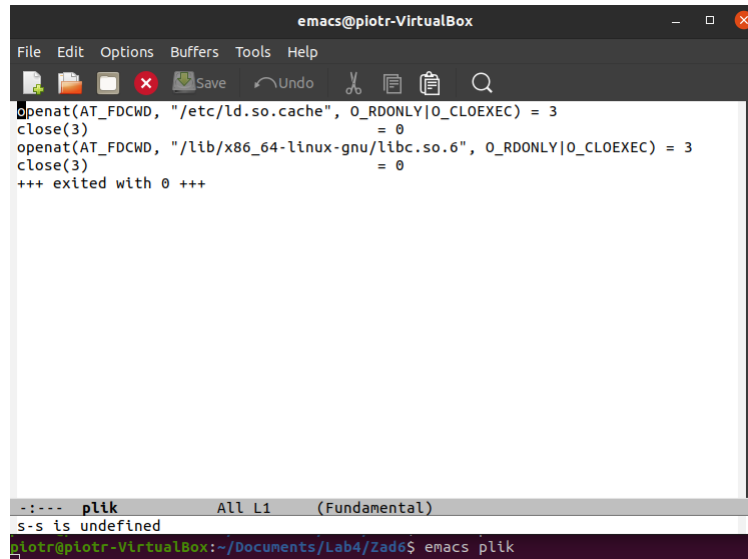
Jak można zauważyć, jedyną różnicą jest dół pliku (to co się działo w nim najpóźniej). Powyższe dwie linijki odpowiadają edycji pliku. Oznacza to, że plik nie jest stale otwarty. Jest on otwierany ponownie przy jego edycji **openat(...)** = **3** i później ponownie zamykany **close(3)** z odpowiednim deskryptorem.

2.4 File deskryptory aplikacji *Hello world*

Po wpisaniu komendy na wyświetlenie `openat` i `close`:

```
strace -o plik -e tracy=openat, close ./a.out
```

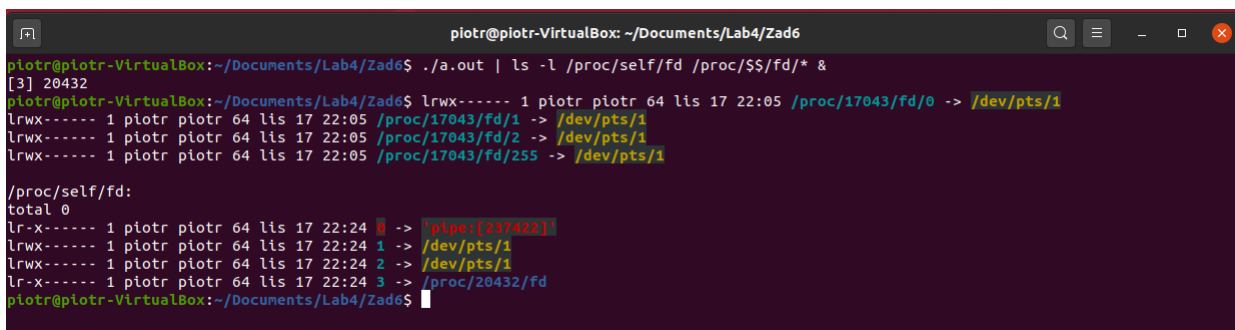
otrzymano następujący rezultat:



```
emacs@piotr-VirtualBox
File Edit Options Buffers Tools Help
Save Undo
openat(AT_FDCWD, "/etc/ld.so.cache", O_RDONLY|O_CLOEXEC) = 3
close(3) = 0
openat(AT_FDCWD, "/lib/x86_64-linux-gnu/libc.so.6", O_RDONLY|O_CLOEXEC) = 3
close(3) = 0
+++ exited with 0 +++
-:--- plik All L1 (Fundamental)
s-s is undefined
piotr@piotr-VirtualBox:~/Documents/Lab4/Zad6$ emacs plik
```

Jak można zauważyć mamy tutaj deskryptor (3). Należy również pamiętać o podstawowych deskryptorach (0) - wejście, (1) - wyjście, (2) - wyjście błędów.

Wszystkie deskryptory można sprawdzić poniższą komendą:



```
piotr@piotr-VirtualBox: ~/Documents/Lab4/Zad6
piotr@piotr-VirtualBox:~/Documents/Lab4/Zad6$ ./a.out | ls -l /proc/self/fd /proc/$$/fd/* &
[3] 20432
piotr@piotr-VirtualBox:~/Documents/Lab4/Zad6$ lrwx----- 1 piotr piotr 64 lis 17 22:05 /proc/17043/fd/0 -> /dev/pts/1
lrwx----- 1 piotr piotr 64 lis 17 22:05 /proc/17043/fd/1 -> /dev/pts/1
lrwx----- 1 piotr piotr 64 lis 17 22:05 /proc/17043/fd/2 -> /dev/pts/1
lrwx----- 1 piotr piotr 64 lis 17 22:05 /proc/17043/fd/255 -> /dev/pts/1

/proc/self/fd:
total 0
lr-x----- 1 piotr piotr 64 lis 17 22:24 0 -> pipe:[237422]
lrwx----- 1 piotr piotr 64 lis 17 22:24 1 -> /dev/pts/1
lrwx----- 1 piotr piotr 64 lis 17 22:24 2 -> /dev/pts/1
lr-x----- 1 piotr piotr 64 lis 17 22:24 3 -> /proc/20432/fd
piotr@piotr-VirtualBox:~/Documents/Lab4/Zad6$
```

Jak widać, w sumie otrzymano 4 deskryptory, w tym 3 podstawowe i jeden, który odpowiada działaniu programu.