Университет ИТМО
факультет ПИиКТ

Лабораторная работа №1 по операционным системам

Выполнил:

Нестерчук Павел, Аман Даниил

группа P33211

Преподаватель:

Покид Александр Владимирович

г. Санкт-Петербург

2020 год

Текст задания:

Разработать программу на языке C, которая осуществляет следующие действия:

- Создает область памяти размером **133** мегабайт, начинающихся с адреса **0x095FA0F5** (если возможно) при помощи **malloc**, заполненную случайными числами /dev/urandom в **62** потока. Используя системные средства мониторинга, определите адрес начала в адресном пространстве процесса и характеристики выделенных участков памяти. Замеры виртуальной/физической памяти необходимо снять:
1. До аллокации
2. После аллокации
3. После заполнения участка данными
4. После деаллокации
- Записывает область памяти в файлы одинакового размера **160** мегабайт с использованием некешируемого обращения к диску. Размер блока ввода-вывода **62** байт. Преподаватель выдает в качестве задания последовательность записи/чтения блоков – случайный.
- Генерацию данных и запись осуществлять в бесконечном цикле.
- В отдельных **42** потоках осуществлять чтение данных из файлов и подсчитывать агрегированные характеристики данных – **минимальное значение**.
- Чтение и запись данных в/из файла должна быть защищена примитивами синхронизации **flock**.
- По заданию преподавателя изменить приоритеты потоков и описать изменения в характеристиках программы.

Для запуска программы возможно использовать операционную систему Windows 10 или Debian/Ubuntu в виртуальном окружении.

Измерить значения затраченного процессорного времени на выполнение программы и на операции ввода-вывода используя системные утилиты.

Отследить трассу системных вызовов.

Используя stap построить графики системных характеристик.

Замеры памяти:

Осуществлены с помощью утилиты free и просмотра /proc/[PID]/maps.
PID получен с помощью top.

```
#### До аллокации ####
free -h
              total        used        free      shared  buff/cache   available
Mem:          7.9Gi       6.3Gi       1.4Gi        17Mi       223Mi       1.5Gi
Swap:          24Gi       1.7Gi        22Gi


$ cat /proc/2731/maps

7fc2d69a0000-7fc2d69a3000 rw-p 00000000 00:00 0
... (libc, pthread and ld sections)
7fc2d6bd9000-7fc2d6bda000 r--p 00000000 00:00 231614             /home/neerd/LabOs1/os
7fc2d6bda000-7fc2d6bdb000 r-xp 00001000 00:00 231614             /home/neerd/LabOs1/os
7fc2d6bdb000-7fc2d6bdc000 r--p 00002000 00:00 231614             /home/neerd/LabOs1/os
7fc2d6bdc000-7fc2d6bdd000 r--p 00002000 00:00 231614             /home/neerd/LabOs1/os
7fc2d6bdd000-7fc2d6bde000 rw-p 00003000 00:00 231614             /home/neerd/LabOs1/os
7ffff2d55000-7ffff2d76000 rw-p 00000000 00:00 0                 [heap]
7ffffa244000-7ffffaa44000 rw-p 00000000 00:00 0                 [stack]
7ffffaa72000-7ffffaa73000 r-xp 00000000 00:00 0                 [vdso]


#### После аллокации ####
$ free -h
              total        used        free      shared  buff/cache   available
Mem:          7.9Gi       6.3Gi       1.3Gi        17Mi       223Mi       1.4Gi
Swap:          24Gi       2.1Gi        21Gi


$ cat /proc/2731/maps
7fc2ce490000-7fc2d6991000 rw-p 00000000 00:00 0
7fc2d69a0000-7fc2d69a3000 rw-p 00000000 00:00 0
... (libc, pthread and ld sections)
7fc2d6bd9000-7fc2d6bda000 r--p 00000000 00:00 231614             /home/neerd/LabOs1/os
7fc2d6bda000-7fc2d6bdb000 r-xp 00001000 00:00 231614             /home/neerd/LabOs1/os
7fc2d6bdb000-7fc2d6bdc000 r--p 00002000 00:00 231614             /home/neerd/LabOs1/os
7fc2d6bdc000-7fc2d6bdd000 r--p 00002000 00:00 231614             /home/neerd/LabOs1/os
7fc2d6bdd000-7fc2d6bde000 rw-p 00003000 00:00 231614             /home/neerd/LabOs1/os
7ffff2d55000-7ffff2d76000 rw-p 00000000 00:00 0                 [heap]
7ffffa244000-7ffffaa44000 rw-p 00000000 00:00 0                 [stack]
7ffffaa72000-7ffffaa73000 r-xp 00000000 00:00 0                 [vdso]

#### После заполнения данными ####
$ free -h
              total        used        free      shared  buff/cache   available
Mem:          7.9Gi       6.8Gi       853Mi        17Mi       223Mi       946Mi
Swap:          24Gi       2.0Gi        22Gi


$ cat /proc/2731/maps
7fc299e10000-7fc299e11000 ---p 00000000 00:00 0
7fc299e11000-7fc29a611000 rw-p 00000000 00:00 0
7fc29a620000-7fc29a621000 ---p 00000000 00:00 0
7fc29a621000-7fc29ae21000 rw-p 00000000 00:00 0
and so on... (threads contexts)
7fc2cdc80000-7fc2cdc81000 ---p 00000000 00:00 0
7fc2cdc81000-7fc2ce481000 rw-p 00000000 00:00 0
7fc2ce490000-7fc2d6991000 rw-p 00000000 00:00 0
```

```
7fc2d69a0000-7fc2d69a3000 rw-p 00000000 00:00 0
... (libc, pthread and ld sections)
7fc2d6bd9000-7fc2d6bda000 r--p 00000000 00:00 231614         /home/neerd/LabOs1/os
7fc2d6bda000-7fc2d6bdb000 r-xp 00001000 00:00 231614         /home/neerd/LabOs1/os
7fc2d6bdb000-7fc2d6bdc000 r--p 00002000 00:00 231614         /home/neerd/LabOs1/os
7fc2d6bdc000-7fc2d6bdd000 r--p 00002000 00:00 231614         /home/neerd/LabOs1/os
7fc2d6bdd000-7fc2d6bde000 rw-p 00003000 00:00 231614         /home/neerd/LabOs1/os
7ffff2d55000-7ffff2d76000 rw-p 00000000 00:00 0             [heap]
7ffffa244000-7ffffaa44000 rw-p 00000000 00:00 0             [stack]
7ffffaa72000-7ffffaa73000 r-xp 00000000 00:00 0             [vdso]
```

```
neerd@WIN-5PTDMP8HM50: /tmp

0001bfb0: 83ec 1319 54db 58e5 744c deea 6ccd 1773    ....T.X.tL..l..s
0001bfc0: 5c07 530c 0d78 a46e 0dd6 7f8e f112 f4cc    \.S..x.n........
0001bfd0: b521 0f70 e3df a5ca 3235 1f87 575f a1d5    .!.p....25..W_..
0001bfe0: ddb9 241d 36ae c066 7731 95e5 16fd a26a    ..$.6..fw1.....j
0001bff0: 9336 211b 81a5 a9c3 51c8 0572 0751 8501    .6!.....Q..r.Q..
0001c000: 5a55 ec7c 95ae fbd5 5871 0915 9c2d ee9e    ZU.|....Xq...-..
0001c010: ac19 5bae 8f16 a1cf 4a49 9f97 e0c7 dadb    ..[.....JI......
0001c020: 059c 06be 31b8 474e 91f8 8090 b938 a72a    ....1.GN.....8.*
0001c030: 79d2 0a11 e2b6 f112 09ef b7db 122d feee    y............-..
0001c040: 3cff b0b9 b9af 809e e4ac c942 7930 e715    <..........By0..
0001c050: 0a15 6264 62d9 6856 a0d7 1693 125e 477b    ..bdb.hV.....^G{
0001c060: 8be8 678b f44f 7dfa 51d7 4dd6 a24b 56f7    ..g..O}.Q.M..KV.
0001c070: ad35 18b2 2d05 576e ead5 755a 7017 8fd5    .5..-.Wn..uZp...
0001c080: f861 4e5c 3c56 fe55 d965 3be9 f0af 54c0    .aN\<V.U.e;...T.
0001c090: 83b2 f4ea 433f d4ef ea3b e81e c114 b5d0    ....C?...;......
0001c0a0: 14a5 5e3a d68e 4bad 72f7 5bcb a288 d5eb    ..^:..K.r.[.....
0001c0b0: d5de 3ba7 a21c fffb 3403 3c78 cbda 5dc1    ..;.....4.<x..].
0001c0c0: c347 718e 3c92 999e db5f 082c e5ac 574b    .Gq.<....._.,..WK
0001c0d0: c2f6 a5a0 947a 50d9 7203 c78a 17b0 42d3    .....zP.r.....B.
0001c0e0: 9bb4 da85 b459 702a 80f8 b7b5 0bfc 6c2f    .....Yp*......l/
0001c0f0: 4c47 4be4 5af7 5450 adef 0d54 d12a 100d    LGK.Z.TP...T.*..
0001c100: 6fe8 5e94 bb10 6788 6afe 37ee 409b ead0    o.^...g.j.7.@...
0001c110: 421c bee2 47c9 34a1 cb96 51a3 edb4 24d9    B...G.4...Q...$.
0001c120: 98a0 eb72 2a7e 9af8 a58f 17b6 0c12 adbf    ...r*~..........
0001c130: 725c 4f39 373c 03bb 83ba 2aae 7593 db9d    r\O97<....*.u...
0001c140: 6238 4063 a4e5 f9c1 79ed b612 8d5c a3f5    b8@c....y....\..
0001c150: bb70 8eca 5ca0 e649 8801 83ae 712c 7c07    .p..\..I....q,|.
0001c160: c8de e3e0 e928 eafc 57e3 f607 bb05 3fa5    .....(..W.....?.
0001c170: 9622 f9d6 bfa4 483e 856a 2aa8 9dd5 457d    ."....H>.j*...E}
0001c180: 53b4 d89c 4e7f 41b1 609e dd16 e101 b358    S...N.A.`......X
0001c190: 3ddd d262 4212 ed89 a85c 4256 2b02 d8ec    =..bB....\BV+...
0001c1a0: e181 6fe5 ba9b a772 2d6e 83a9 17b4 1a18    ..o....r-n......
0001c1b0: f1e8 f605 2206 3528 6a13 598b b647 0353    ....".5(j.Y..G.S
0001c1c0: 49bd 67be 109e af84 711a cc3c 6eb3 b89e    I.g.....q..<n...
0001c1d0: 4b07 9b11 be6f a848 c102 3c35 98da c920    K....o.H..<5...
0001c1e0: 8584 5819 9a4d 37c9 f9ee 45aa 6abb 21bf    ..X..M7...E.j.!.
0001c1f0: d458 7dad b878 5dcd 8c5d a03c 8115 e901    .X}..x]..].<....
0001c200: 0895 d849 1355 5aab f383 fc16 481f 0ff2    ...I.UZ.....H...
0001c210: 78d0 6780 9428 2262 21fb 0d6e bec9 364b    x.g..("b!..n..6K
0001c220: 0083 60ad 2493 20d7 a65a cd40 fb26 0f34    ..`.$. ..Z.@.&.4
0001c230: d1ef 3513 21fb 83cf a971 5d96 8b34 ad34    ..5.!....q]..4.4
0001c240: 0f2e 1a49 4413 0493 f92a 8862 d4c4 13fa    ...ID....*.b....
0001c250: f792 7126 a5b2 adc5 6a5f 09b1 7217 12ad    ..q&....j_..r...
0001c260: 1c6e 4949 8d20 737c f075 fb24 b772 2c1f    .nII. s|.u.$.r,.
0001c270: d251 8bd8 dd40 66ab cbd7 84d6 18be 718d    .Q...@f.......q.
0001c280: 1dbe 3011 7389 b730 79fb 285d a566 21d8    ..0.s..0y.(].f!.
0001c290: ca42 3540 83f5 6c16 0af8 df1a 00c9 3dc8    .B5@..l.......=.
0001c2a0: baa8 7f8f 21d7 71f1 4200 6b78 4dcc 07ca    ....!.q.B.kxM...
:
```

```
© Выбрать neerd@WIN-5PTDMP8HM50: ~/LabOs1
[read    16] RELEASE, aggregated result: 339
[read    18] ACQUIRE (for the 16 time)
[read    18] RELEASE, aggregated result: 1143
[read    14] ACQUIRE (for the 21 time)
[read    14] RELEASE, aggregated result: 15627
[write    6] ACQUIRE (for the 17 time)
[write    6] RELEASE
[read    17] ACQUIRE (for the 20 time)
[read    17] RELEASE, aggregated result: 1046
[read    21] ACQUIRE (for the 16 time)
[read    21] RELEASE, aggregated result: 0
[read    20] ACQUIRE (for the 18 time)
[read    20] RELEASE, aggregated result: 5171
[read    19] ACQUIRE (for the 20 time)
[read    19] RELEASE, aggregated result: 3679
[read    23] ACQUIRE (for the 17 time)
[read    23] RELEASE, aggregated result: 0
[read    26] ACQUIRE (for the 15 time)
[read    26] RELEASE, aggregated result: 2758
[read    24] ACQUIRE (for the 18 time)
[read    24] RELEASE, aggregated result: 0
[read    22] ACQUIRE (for the 21 time)
[read    22] RELEASE, aggregated result: 3226
[read    25] ACQUIRE (for the 19 time)
[read    25] RELEASE, aggregated result: 8206
[read    27] ACQUIRE (for the 18 time)
[read    27] RELEASE, aggregated result: 4481
[read    28] ACQUIRE (for the 18 time)
[read    28] RELEASE, aggregated result: 5226
[read    28] ACQUIRE (for the 19 time)
[read    28] RELEASE, aggregated result: 5226
[write    2] ACQUIRE (for the 18 time)
[write    2] RELEASE
[read    30] ACQUIRE (for the 17 time)
[read    30] RELEASE, aggregated result: 0
[read    30] ACQUIRE (for the 18 time)
[read    30] RELEASE, aggregated result: 0
[read    34] ACQUIRE (for the 15 time)
[read    34] RELEASE, aggregated result: 0
[read    31] ACQUIRE (for the 19 time)
[read    31] RELEASE, aggregated result: 21743
[read    36] ACQUIRE (for the 15 time)
[read    36] RELEASE, aggregated result: 15056
[read    32] ACQUIRE (for the 20 time)
[read    32] RELEASE, aggregated result: 1625
[read    33] ACQUIRE (for the 20 time)
[read    33] RELEASE, aggregated result: 0
[read    35] ACQUIRE (for the 19 time)
[read    35] RELEASE, aggregated result: 2524
[read    38] ACQUIRE (for the 17 time)
[read    38] RELEASE, aggregated result: 8665
[read    37] ACQUIRE (for the 19 time)
[read    37] RELEASE, aggregated result: 253
[write   14] ACQUIRE (for the 16 time)
[write   14] RELEASE
[read    39] ACQUIRE (for the 19 time)
[read    39] RELEASE, aggregated result: 8618
[write    3] ACQUIRE (for the 15 time)
[write    3] RELEASE
[read    40] ACQUIRE (for the 20 time)
[read    40] RELEASE, aggregated result: 2453
[read    41] ACQUIRE (for the 19 time)
```

```
#### После деаллокации ####
$ free -h
              total        used        free      shared  buff/cache   available
Mem:          7.9Gi       6.6Gi       1.0Gi        17Mi       223Mi       1.1Gi
Swap:          24Gi       2.1Gi        21Gi


$ cat /proc/2731/maps
7f7bca320000-7f7bca321000 ---p 00000000 00:00 0
7f7bca321000-7f7bcab21000 rw-p 00000000 00:00 0
7f7bcab30000-7f7bcab31000 ---p 00000000 00:00 0
7f7bcab31000-7f7bcb331000 rw-p 00000000 00:00 0
and so on... (threads contexts)
7f7bdcd71000-7f7bdd571000 rw-p 00000000 00:00 0
7f7bdd580000-7f7bdd581000 ---p 00000000 00:00 0
7f7bdd581000-7f7bddd81000 rw-p 00000000 00:00 0
7f7bddd90000-7f7bddd91000 ---p 00000000 00:00 0
7f7bddd91000-7f7bde591000 rw-p 00000000 00:00 0
7f7bde5a0000-7f7bde5a1000 ---p 00000000 00:00 0
7f7bde5a1000-7f7bdeda1000 rw-p 00000000 00:00 0
7f7bdedb0000-7f7bdedb1000 ---p 00000000 00:00 0
7f7bdedb1000-7f7bdf5b1000 rw-p 00000000 00:00 0
7f7bdf5c0000-7f7bdf5c1000 ---p 00000000 00:00 0
7f7bdf5c1000-7f7bdfdc1000 rw-p 00000000 00:00 0
7f7bdfdd0000-7f7bdfdd1000 ---p 00000000 00:00 0
7f7bdfdd1000-7f7be05d1000 rw-p 00000000 00:00 0
7f7be05e0000-7f7be05e1000 ---p 00000000 00:00 0
7f7be05e1000-7f7be0de1000 rw-p 00000000 00:00 0
7f7c06eb0000-7f7c06eb3000 rw-p 00000000 00:00 0
... (libc, pthread and ld sections)
7fc2d6bd9000-7fc2d6bda000 r--p 00000000 00:00 231614          /home/neerd/LabOs1/os
7fc2d6bda000-7fc2d6bdb000 r-xp 00001000 00:00 231614          /home/neerd/LabOs1/os
7fc2d6bdb000-7fc2d6bdc000 r--p 00002000 00:00 231614          /home/neerd/LabOs1/os
7fc2d6bdc000-7fc2d6bdd000 r--p 00002000 00:00 231614          /home/neerd/LabOs1/os
7fc2d6bdd000-7fc2d6bde000 rw-p 00003000 00:00 231614          /home/neerd/LabOs1/os
7ffff2d55000-7ffff2d76000 rw-p 00000000 00:00 0              [heap]
7ffffa244000-7ffffaa44000 rw-p 00000000 00:00 0              [stack]
7ffffaa72000-7ffffaa73000 r-xp 00000000 00:00 0              [vdso]
```

Затраченное процессорное время:

```
$ vmstat 1
procs ---------memory---------- --swap-- -----io----- --system-- ------cpu-----
 r  b   swpd   free   buff  cache   si   so    bi    bo   in   cs us sy id wa st
 2  0      0 7242524  22360 417244    0    0     3   339    8   25  1  1 98  0  0
 1  0      0 7242516  22360 417244    0    0     0     0  112  199  4 11 85  0  0
 1  1      0 7241196  22368 417236    0    0     0 165064  120  245  5 10 85  1  0
 1  0      0 7242516  22368 417244    0    0     0 72516  340  843  5 10 85  0  0
 1  0      0 7242516  22368 417244    0    0     0     0  111  208  3 11 85  0  0
 2  0      0 7242516  22368 417244    0    0     0     0  113  208  5 10 85  0  0
 1  0      0 7242516  22368 417244    0    0     0     0  149  292  6  9 85  0  0
 1  0      0 7242516  22376 417236    0    0     0    12  242  552  5  9 86  0  0
 1  0      0 7242740  22376 417236    0    0     0 237568  155  399  5 10 84  1  0
 1  0      0 7242484  22376 417236    0    0     0     0  127  216  4 11 85  0  0
 1  0      0 7242484  22376 417236    0    0     0     0  221  488  6  9 85  0  0
 1  0      0 7242484  22376 417236    0    0     0     0  177  359  5 10 85  0  0
 1  0      0 7242484  22384 417228    0    0     0    12  117  210  4 11 85  0  0
 1  0      0 7242484  22384 417228    0    0     0 237568  138  303  4 10 85  1  0
 1  0      0 7242452  22384 417228    0    0     0     0  298  664  5 10 85  0  0
 1  0      0 7242452  22384 417228    0    0     0     0  117  196  5 10 85  0  0
 2  0      0 7242452  22384 417228    0    0     0     0  108  217  6  9 85  0  0
 1  0      0 7242452  22392 417220    0    0     0    12  101  205  4 10 85  0  0
```

```
1  0        0 7242252  22392 417220     0     0        0 237568  364  928  4 10 85  0  0
1  0        0 7242444  22392 417220     0     0        0      0  109  200  4 10 85  0  0
1  0        0 7242444  22392 417220     0     0        0      0  105  183  4 11 86  0  0
1  0        0 7242444  22392 417220     0     0        0      0  123  222  4 11 85  0  0
1  0        0 7242444  22400 417212     0     0        0     12  278  633  6  9 86  0  0
0  2        0 7241292  22400 417212     0     0        0  83432  111  214  4 11 85  1  0
2  0        0 7242484  22400 417212     0     0        0 154136  172  402  4 10 86  0  0
1  0        0 7242484  22400 417212     0     0        0      0  148  318  4 11 85  0  0
1  0        0 7242484  22400 417212     0     0        0      0  238  575  4 11 86  0  0
2  0        0 7242484  22408 417204     0     0        0     12  110  208  4 11 85  0  0
1  0        0 7242484  22408 417244     0     0        0      0  108  207  5 10 85  0  0
1  0        0 7242324  22408 417244     0     0        0 237572  241  600  3 11 84  1  0
1  0        0 7242324  22408 417244     0     0        0      0  180  428  4 10 86  0  0
1  0        0 7242484  22408 417244     0     0        0      0  117  216  6  9 85  0  0
2  0        0 7242484  22416 417236     0     0        0     12  115  233  4 11 85  0  0
1  0        0 7242484  22416 417236     0     0        0      0  266  607  5 10 85  0  0
1  0        0 7242732  22416 417244     0     0        0 237568  166  399  4 11 83  2  0
1  0        0 7242572  22416 417244     0     0        0      0  114  214  3 12 85  0  0
1  0        0 7242572  22416 417244     0     0        0      0  114  241  4 11 85  0  0
1  0        0 7242572  22424 417244     0     0        0     12  289  663  5  9 86  0  0
2  0        0 7242572  22424 417244     0     0        0      0  118  220  5 10 85  0  0
1  1        0 7241228  22424 417244     0     0        0 197420  130  326  4 11 84  1  0
1  0        0 7242548  22424 417244     0     0        0  40148  169  387  5 10 85  0  0
1  0        0 7242548  22424 417244     0     0        0      0  248  554  6  9 86  0  0
1  0        0 7242548  22432 417236     0     0        0     12  106  221  4 11 85  0  0
1  0        0 7242548  22432 417236     0     0        0      0  110  213  5 10 86  0  0
1  0        0 7242548  22432 417236     0     0        0      0  191  413  5 10 85  0  0
1  0        0 7242324  22432 417236     0     0        0 237568  302  770  4 11 85  0  0
1  0        0 7242548  22432 417236     0     0        0      0  113  220  5 10 85  0  0
1  0        0 7242548  22440 417228     0     0        0     12  104  207  5 10 85  0  0
1  0        0 7242548  22440 417228     0     0        0      0  161  330  4 11 86  0  0
1  0        0 7242548  22440 417228     0     0        0      0  227  513  4 11 86  0  0
1  0        0 7242516  22440 417228     0     0        0 237568  157  369  4 10 86  0  0
1  0        0 7242516  22440 417228     0     0        0      0   96  173  4 10 86  0  0
1  0        0 7242516  22448 417220     0     0        0     12   97  191  4 11 86  0  0
1  0        0 7242516  22448 417244     0     0        0      0  233  512  4 11 85  0  0
3  0        0 7242516  22448 417244     0     0        0      0  159  344  5 10 85  0  0
1  0        0 7242292  22448 417244     0     0        0 237568  171  441  4 10 85  0  0
1  0        0 7242292  22448 417244     0     0        0      0   99  191  4 10 86  0  0
2  0        0 7242484  22456 417236     0     0        0     12  216  469  4 11 85  0  0
1  0        0 7242484  22456 417236     0     0        0      0  182  416  5 10 86  0  0
1  0        0 7242484  22456 417236     0     0        0      0  114  226  4 11 85  0  0
2  1        0 7241388  22456 417236     0     0        0  82236  110  211  5 10 85  0  0
1  0        0 7242484  22456 417244     0     0        0 155332  300  727  4 10 86  0  0
1  0        0 7242484  22464 417236     0     0        0     12  178  383  4 10 85  0  0
2  0        0 7242484  22464 417244     0     0        0      0  114  220  4 11 85  0  0
1  0        0 7242484  22464 417244     0     0        0      0  111  199  4 11 85  0  0
1  0        0 7242484  22464 417244     0     0        0      0  270  623  4 10 86  0  0
1  0        0 7242484  22464 417244     0     0        0 237568  183  469  4 10 86  0  0


$ strace -cf ./os
% time     seconds  usecs/call     calls    errors syscall
------ ------------ ----------- --------- --------- ----------------
 98.44 33430.399366    69501869       481        19 futex
  0.94   319.753166    39969145         8           read
  0.26    87.474557          43   2032062           write
  0.23    78.620466          38   2031738           lseek
  0.12    42.393346      362336       117           getrandom
  0.00     0.371305        3536       105           set_robust_list
  0.00     0.098642         835       118           mmap
  0.00     0.067742         651       104           madvise
  0.00     0.023084         221       104           clone
```

```
0.00      0.009774         89        109              mprotect
0.00      0.006132         52        116              flock
0.00      0.000000          0          4              close
0.00      0.000000          0          8          8 stat
0.00      0.000000          0          5              fstat
0.00      0.000000          0         61          1 munmap
0.00      0.000000          0          3              brk
0.00      0.000000          0          2              rt_sigaction
0.00      0.000000          0          1              rt_sigprocmask
0.00      0.000000          0          1          1 access
0.00      0.000000          0          2              nanosleep
0.00      0.000000          0          1              execve
0.00      0.000000          0          1              ftruncate
0.00      0.000000          0          1              arch_prctl
0.00      0.000000          0          1              set_tid_address
0.00      0.000000          0         12          8 openat
0.00      0.000000          0          1              prlimit64
------ ----------- ----------- --------- --------- ----------------
100.00 33959.217580               4065166          37 total
```

Трасса системных вызовов:

Main thread
```
$ strace -o syscalls.log ./os
```

Startup
```
execve("./os", ["./os"], 0x7fffcb7b8140 /* 16 vars */) = 0

brk(NULL)                               = 0x7fffbef7d000

access("/etc/ld.so.preload", R_OK)      = -1 ENOENT (No such file or directory)
```

Looking for shared libraries
```
openat(AT_FDCWD, "/lib/x86_64-linux-gnu/libpthread.so.0", 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@l\0\0\0\0\0\0"..., 832) = 832

fstat(3, {st_mode=S_IFREG|0755, st_size=146968, ...}) = 0

mmap(NULL, 8192, PROT_READ|PROT_WRITE, MAP_PRIVATE|MAP_ANONYMOUS, -1, 0) = 0x7f98abff0000

mmap(NULL, 132288, PROT_READ, MAP_PRIVATE|MAP_DENYWRITE, 3, 0) = 0x7f98abfcf000

mmap(0x7f98abfd5000, 61440, PROT_READ|PROT_EXEC, MAP_PRIVATE|MAP_FIXED|MAP_DENYWRITE, 3, 0x6000)
= 0x7f98abfd5000

mmap(0x7f98abfe4000, 24576, PROT_READ, MAP_PRIVATE|MAP_FIXED|MAP_DENYWRITE, 3, 0x15000) =
0x7f98abfe4000

mmap(0x7f98abfea000, 8192, PROT_READ|PROT_WRITE, MAP_PRIVATE|MAP_FIXED|MAP_DENYWRITE, 3, 0x1a000)
= 0x7f98abfea000

mmap(0x7f98abfec000, 13504, PROT_READ|PROT_WRITE, MAP_PRIVATE|MAP_FIXED|MAP_ANONYMOUS, -1, 0) =
0x7f98abfec000

close(3)

...
```

Expanding executables
```
read(3, "\177ELF\2\1\1\3\0\0\0\0\0\0\0\0\3\0>\0\1\0\0\0@l\0\0\0\0\0\0"..., 832) = 832
fstat(3, {st_mode=S_IFREG|0755, st_size=146968, ...}) = 0
mmap(NULL, 8192, PROT_READ|PROT_WRITE, MAP_PRIVATE|MAP_ANONYMOUS, -1, 0) = 0x7f1fa4aff000
...
```

Temp files
openat(AT_FDCWD, "/tmp/os-rand-file-0", O_RDWR|O_CREAT, 0644) = 3

ftruncate(3, 167772160)   = 0

...

fstat(0, {st_mode=S_IFCHR|0660, st_rdev=makedev(0x4, 0x1), ...}) = 0

ioctl(0, TCGETS, {B38400 opost isig icanon echo ...}) = 0

brk(NULL)   = 0x7fffbef7d000

brk(0x7fffbef9e000)   = 0x7fffbef9e000

read(0, "\n", 4096)   = 1

Memory allocation
mmap(NULL, 139464704, PROT_READ|PROT_WRITE, MAP_PRIVATE|MAP_ANONYMOUS, -1, 0) = 0x7f98a38e0000

fstat(1, {st_mode=S_IFCHR|0660, st_rdev=makedev(0x4, 0x1), ...}) = 0

ioctl(1, TCGETS, {B38400 opost isig icanon echo ...}) = 0

write(1, "Memory allocated\n", 17)   = 17

read(0, "\n", 4096)   = 1

Creating threads
mmap(NULL, 8392704, PROT_NONE, MAP_PRIVATE|MAP_ANONYMOUS|MAP_STACK, -1, 0) = 0x7f98a30d0000

mprotect(0x7f98a30d1000, 8388608, PROT_READ|PROT_WRITE) = 0

clone(child_stack=0x7f98a38cffb0,
flags=CLONE_VM|CLONE_FS|CLONE_FILES|CLONE_SIGHAND|CLONE_THREAD|CLONE_SYSVSEM|CLONE_SETTLS|CLONE_P
ARENT_SETTID|CLONE_CHILD_CLEARTID, parent_tidptr=0x7f98a38d09d0, tls=0x7f98a38d0700,
child_tidptr=0x7f98a38d09d0) = 232

write(2, " 1. Created write thread for bl"..., 55) = 55

...

read(0, "\n", 1024)   = 1

Clearing threads and semaphores
futex(0x7f98a38d09d0, FUTEX_WAIT, 232, NULL) = 0

futex(0x7f98a30c09d0, FUTEX_WAIT, 233, NULL) = 0

futex(0x7f98a28b09d0, FUTEX_WAIT, 234, NULL) = 0

munmap(0x7f98a30d0000, 8392704)   = 0

futex(0x7f98a10809d0, FUTEX_WAIT, 237, NULL) = 0

munmap(0x7f98a28c0000, 8392704)   = 0

futex(0x7f98a08709d0, FUTEX_WAIT, 238, NULL) = 0

munmap(0x7f98a20b0000, 8392704)   = 0

munmap(0x7f98a18a0000, 8392704)   = 0

futex(0x7f989f8509d0, FUTEX_WAIT, 240, NULL) = 0

...

Closing tmp files
close(3)   = 0
write(1, "All threads are terminated\n", 27) = 27

Unmap and exit

```
munmap(0x7f98a38e0000, 139464704)      = 0

read(0, "\n", 4096)                    = 1

exit_group(0)                          = ?
```

Write thread
$ strace -p 6702

It just waits, then seeks and writes 62 bytes and waits again
```
futex(0x7ff284f265c0, FUTEX_WAIT_PRIVATE, 2, NULL) = -1 EAGAIN (Resource temporarily
unavailable)
futex(0x7ff284f265c0, FUTEX_WAKE_PRIVATE, 1) = 0

write(3, "+S`\367}\243\np7G\333\37/60RaH>;R</M\201\331\277T5\205(\375"..., 62) = 62
lseek(3, 93444489, SEEK_SET)           = 93444489
write(3,
"\303\30\322\357M\37\226b\375\213&\204W\327\303M\272\365\337r\251\312\273)\7/\203M\270\
205\352y"..., 62) = 62
lseek(3, 49566032, SEEK_SET)           = 49566032
write(3,
"\10\366\337$\355\375V\341\333\27\275\244-A\200\250\217\300\215e\336\206\276G{X\377\10_
8rB"..., 62) = 62
lseek(3, 145750147, SEEK_SET)          = 145750147
write(3,
"\301c\35x\f\313\247g\312<EH\312\374d%v\330;\3753Y\260\363\222\354\333\277\241\252\256Z
"..., 62) = 62
lseek(3, 34877698, SEEK_SET)           = 34877698
write(3,
"\377i%1\177\367\301\35ci\220d-\251\247&\300\372\3561\32\3c\255\263\32j\372\336A\231`".
.., 62) = 62
lseek(3, 12464200, SEEK_SET)           = 12464200
write(3,
"\310\347\253\361t\344\236\313\213VB\205\337\306\322\316\303m\230\3130\257>\361\234\236
?h\\QSE"..., 62) = 62
lseek(3, 40172987, SEEK_SET)           = 40172987
write(3,
"\231\n\"@\\9\376jY\"\200\254;\314\303g\223@\226\24\21\201\233\37\347\n\364\322\246\234
S\375"..., 62) = 62
lseek(3, 71893794, SEEK_SET)           = 71893794
write(3,
"\361\365\312\344\236\235&\336\265\251O\7\t\301-\372\260Q[\246\223\\\30|\5h\264\304\262
\20R\251"..., 62) = 62
lseek(3, 166523333, SEEK_SET)          = 166523333
write(3,
"0bLZ\210\314/\27Q\23\224\304\257b\t\333\to\316\1775\4<\246\306\362e\25628W{"..., 62) =
62
lseek(3, 107825305, SEEK_SET)          = 107825305
write(3,
"V+\352\364I&\343SP\34\\\333\362k\227\v\331\226\331\327\244$\251e\206g^iEB\210\347"...,
62) = 62
lseek(3, 55137685, SEEK_SET)           = 55137685
```

Вывод:

В процессе выполнения лабораторной работы я освоил низкоуровневое многопоточное программирование и узнал много нового о мониторинге ядра в операционной системе. WSL не позволил мне прикоснуться к systemtap, поэтому я постарался максимально полно подсчитать характеристики с помощью других утилит.