Министерство науки и высшего образования Российской Федерации
ФЕДЕРАЛЬНОЕ ГОСУДАРСТВЕННОЕ АВТОНОМНОЕ ОБРАЗОВАТЕЛЬНОЕ
УЧРЕЖДЕНИЕ ВЫСШЕГО ОБРАЗОВАНИЯ
«НАЦИОНАЛЬНЫЙ ИССЛЕДОВАТЕЛЬСКИЙ УНИВЕРСИТЕТ ИТМО»
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Лабораторная работа №1
“Операционные системы”

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Задание

Лабораторная работа №1

Вариант:

A=200;B=0x1D284B2F;C=mmap;D=25;E=46;F=nocache;G=27;H=seq;I=20;J=sum;K=cv

Разработать программу на языке C, которая осуществляет следующие действия

- Создает область памяти размером A мегабайт, начинающихся с адреса B (если возможно) при помощи C=(malloc, mmap) заполненную случайными числами /dev/urandom в D потоков. 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 E мегабайт с использованием F=(блочного, некешируемого) обращения к диску. Размер блока ввода-вывода G байт. Преподаватель выдает в качестве задания последовательность записи/чтения блоков H=(последовательный, заданный или случайный)
- Генерацию данных и запись осуществлять в бесконечном цикле.
- В отдельных I потоках осуществлять чтение данных из файлов и подсчитывать агрегированные характеристики данных - J=(сумму, среднее значение, максимальное, минимальное значение).
- Чтение и запись данных в/из файла должна быть защищена примитивами синхронизации K=(futex, cv, sem, 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.

Код программы

```
#include <stdio.h>
#include <sys/mman.h>
#include <pthread.h>
#include <stdlib.h>
#include <stdint.h>

//A=200;B=0x1D284B2F;C=mmap;D=25;E=46;F=nocache;G=27;H=seq;I=20;J=sum;K=cv
#define ALLOCATE_MEMORY 200 // A
#define ADDRESS 0x1D284B2F // B
//#define mmap // C
#define GENERATED_THREADS_AMOUNT 25 // D
#define FILE_SIZE 46 // E
//#define nocache //F
#define BLOCK_SIZE_BYTES 27 // G
//#define seq // H
#define READ_THREADS_AMOUNT 20 // I
//#define sum // J
//#define cv // K

#define IN_BYTES (1024 * 1024)

#define INTEGER_GENERATED ((ALLOCATE_MEMORY * IN_BYTES) / GENERATED_THREADS_AMOUNT)
#define REMAINDER_GENERATED ((ALLOCATE_MEMORY * IN_BYTES) % GENERATED_THREADS_AMOUNT)

#define COUNT_FILES (ALLOCATE_MEMORY / FILE_SIZE)

#define URANDOM "/dev/urandom"
```

```
uint8_t *address;
FILE **files;
pthread_mutex_t mutexes[COUNT_FILES];
pthread_cond_t conds[COUNT_FILES];
int check[COUNT_FILES];

struct GenDataThread {
    size_t start;
    size_t end;
    FILE *urandom;
};

struct WritableDataThread {
    int threadId;
    int sizeMemory;
};

struct ReadableDataThread {
    int fileId;
    int threadId;
};

void generateInMemory();
void *writeInMemory(void *);
void writeInFiles();
void *writeInFile(void *);
void createFiles();
void readFromFiles();
_Noreturn void *readFromFile(void *);

int main() {
```

```
printf("Allocate memory. Press a key to start");
getchar();

address = mmap(
        (void*) ADDRESS,
        ALLOCATE_MEMORY * IN_BYTES,
        PROT_READ | PROT_WRITE,
        MAP_PRIVATE | MAP_ANONYMOUS,
        -1, 0);

if (address == MAP_FAILED) {
    perror("Error address a file");
    exit(EXIT_FAILURE);
}

printf("Write data to memory. Press a key to start");
getchar();

generateInMemory();

printf("Deallocate memory. Press a key to start");
getchar();

munmap(address, ALLOCATE_MEMORY * IN_BYTES);

printf("Infinity writing and reading. Press a key to start");
getchar();



int firstRun = 1;
```

```
    createFiles();

    while (1) {

        address = mmap(
                (void*) ADDRESS,
                ALLOCATE_MEMORY * IN_BYTES,
                PROT_READ | PROT_WRITE,
                MAP_PRIVATE | MAP_ANONYMOUS,
                -1, 0);
        if (address == MAP_FAILED) {
            perror("Error address a file");
            exit(EXIT_FAILURE);
        }

        generateInMemory();
        writeInFiles();

        if (firstRun) {
            readFromFiles();
            firstRun = 0;
        }
    }

    return 0;
}

void generateInMemory() {
    FILE *urandom = fopen(URANDOM, "r");
    pthread_t memoryThreads[GENERATED_THREADS_AMOUNT];
```

```
    struct GenDataThread *genDataThread = (struct GenDataThread *)
malloc(GENERATED_THREADS_AMOUNT * sizeof(struct GenDataThread));

    for (int i = 0; i < GENERATED_THREADS_AMOUNT - 1; i++) {

        genDataThread[i].start = (size_t) i * INTEGER_GENERATED;

        genDataThread[i].end = (size_t) (i + 1) * INTEGER_GENERATED;

        genDataThread[i].urandom = urandom;


        pthread_create(&(memoryThreads[i]), NULL, writeInMemory, &(genDataThread[i]));

    }


    genDataThread[GENERATED_THREADS_AMOUNT - 1].start = (size_t)
(GENERATED_THREADS_AMOUNT - 1) * INTEGER_GENERATED;

    genDataThread[GENERATED_THREADS_AMOUNT - 1].end = (size_t)
(GENERATED_THREADS_AMOUNT - 1) * INTEGER_GENERATED +
REMAINDER_GENERATED;

    genDataThread[GENERATED_THREADS_AMOUNT - 1].urandom = urandom;


    pthread_create(&(memoryThreads[GENERATED_THREADS_AMOUNT - 1]),

                   NULL,

                   writeInMemory,

                   &(genDataThread[GENERATED_THREADS_AMOUNT - 1]));


    for (int i = 0; i < GENERATED_THREADS_AMOUNT; i++) {

        pthread_join(memoryThreads[i], NULL);

    }


    fclose(urandom);

}


void *writeInMemory(void *dataThread) {

    struct GenDataThread *genDataThread = (struct GenDataThread *) dataThread;

    for (size_t i = genDataThread->start; i < genDataThread->end; i++) {
```

```
        uint8_t number = 0;
        fread(&number, 1, 1, genDataThread->urandom);
        address[i] = number;
    }
    return NULL;
}

void writeInFiles() {
    pthread_t *filesThreads = malloc(COUNT_FILES * sizeof(pthread_t));
    struct WritableDataThread *writableDataThread = (struct WritableDataThread *)
malloc(COUNT_FILES * sizeof(struct WritableDataThread));
    for (int i = 0; i < COUNT_FILES; i++) {
        writableDataThread[i].threadId = i;
        writableDataThread[i].sizeMemory = ((i + 1) * FILE_SIZE) < ALLOCATE_MEMORY
                ? FILE_SIZE * IN_BYTES
                : (ALLOCATE_MEMORY - i * FILE_SIZE) * IN_BYTES;

        pthread_create(&(filesThreads[i]), NULL, writeInFile, &(writableDataThread[i]));
    }

    for (int i = 0; i < COUNT_FILES; i++) {
        pthread_join(filesThreads[i], NULL);
    }

    free(filesThreads);
}

void *writeInFile(void *dataThread) {
    struct WritableDataThread *writableDataThread = (struct WritableDataThread *) dataThread;
    int threadId = writableDataThread->threadId;
    int sizeMemory = writableDataThread->sizeMemory;
```

```
    pthread_mutex_t *mutex = &(mutexes[threadId]);
    pthread_cond_t *cond = &(conds[threadId]);
    FILE *file = files[threadId];

    fseek(file, 0, SEEK_SET);
    size_t offsetMinor = threadId * FILE_SIZE * IN_BYTES;
    for (int i = 0; i < sizeMemory; i += BLOCK_SIZE_BYTES) {
        pthread_mutex_lock(mutex);
        check[threadId] = 1;

        int nelts = (i + BLOCK_SIZE_BYTES) < sizeMemory? BLOCK_SIZE_BYTES: (sizeMemory -
i);
        size_t offsetMajor = offsetMinor + i;
        fwrite((address + offsetMajor), 1, nelts, file);
        fflush(file);

        check[threadId] = 0;
        pthread_cond_signal(cond);
        pthread_mutex_unlock(mutex);
    }

    return NULL;
}

void createFiles() {
    files = (FILE **) malloc(COUNT_FILES * sizeof(FILE *));
    char filename[20];
    for (int i = 0; i < COUNT_FILES; i++) {
        sprintf(filename, "file%d", i);
        files[i] = fopen(filename, "w+b");
```

```
        pthread_mutex_init(&(mutexes[i]), NULL);
        pthread_cond_init(&(conds[i]), NULL);
    }
}

void readFromFiles() {
    pthread_t *readFiles = (pthread_t *) malloc(READ_THREADS_AMOUNT * sizeof(pthread_t));
    struct ReadableDataThread *readableDataThread = (struct ReadableDataThread *)
malloc(READ_THREADS_AMOUNT * sizeof(struct ReadableDataThread));
    for (int i = 0; i < READ_THREADS_AMOUNT; i++) {
        readableDataThread[i].threadId = i;
        readableDataThread[i].fileId = i % COUNT_FILES;

        pthread_create(&(readFiles[i]), NULL, readFromFile, &(readableDataThread[i]));
    }

}

_Noreturn void *readFromFile(void *dataThread) {
    struct ReadableDataThread *readableDataThread = (struct ReadableDataThread *) dataThread;
    int fileId = readableDataThread->fileId;
    pthread_mutex_t *mutex = &(mutexes[fileId]);
    pthread_cond_t *cond = &(conds[fileId]);
    FILE *file = files[fileId];

    while (1) {
        fseek(file, 0, SEEK_SET);
        unsigned long long sum = 0;
        for (int i = 0; i < FILE_SIZE * IN_BYTES; i++) {
            pthread_mutex_lock(mutex);
```

```
            while (check[fileId]) {
                pthread_cond_wait(cond, mutex);
            }

            uint8_t number;
            fread(&number, 1, 1, file);
            sum += number;

            pthread_mutex_unlock(mutex);
        }
        printf("Sum in file %d with thread %d is equal %llu\n", fileId, readableDataThread->threadId,sum);
    }
}
```

Сбор статистики

ps -A | grep <name>
pmap -x <PID>

Before allocation

```
24533:   /home/iman/CLionProjects/OS_lab1/cmake-build-debug/OS_lab1
Address           Kbytes     RSS   Dirty Mode  Mapping
000056078d828000       4       4       4 r---- OS_lab1
000056078d829000       4       4       4 r-x-- OS_lab1
000056078d82a000       4       4       4 r---- OS_lab1
000056078d82b000       4       4       4 r---- OS_lab1
000056078d82c000       4       4       4 rw--- OS_lab1
000056078ef4c000     132       4       4 rw---   [ anon ]
00007f2518ab5000     148     144       0 r---- libc-2.31.so
00007f2518ada000    1504     772       0 r-x-- libc-2.31.so
00007f2518c52000     296     120       0 r---- libc-2.31.so
00007f2518c9c000       4       0       0 ----- libc-2.31.so
00007f2518c9d000      12      12      12 r---- libc-2.31.so
00007f2518ca0000      12      12      12 rw--- libc-2.31.so
00007f2518ca3000      16      16      16 rw---   [ anon ]
00007f2518cad000      28      28       0 r---- libpthread-2.31.so
00007f2518cb4000      68      68       0 r-x-- libpthread-2.31.so
00007f2518cc5000      20       0       0 r---- libpthread-2.31.so
00007f2518cca000       4       4       4 r---- libpthread-2.31.so
00007f2518ccb000       4       4       4 rw--- libpthread-2.31.so
00007f2518ccc000      16       4       4 rw---   [ anon ]
00007f2518cea000      12       8       8 rw---   [ anon ]
00007f2518ced000       4       4       0 r---- ld-2.31.so
00007f2518cee000     140     140       0 r-x-- ld-2.31.so
00007f2518d11000      32      32       0 r---- ld-2.31.so
00007f2518d1a000       4       4       4 r---- ld-2.31.so
00007f2518d1b000       4       4       4 rw--- ld-2.31.so
00007f2518d1c000      12       8       8 rw---   [ anon ]
00007ffef33d6000     132      12      12 rw---   [ stack ]
00007ffef33fd000      12       0       0 r----   [ anon ]
00007ffef3400000       4       4       0 r-x--   [ anon ]
ffffffffff600000       4       0       0 --x--   [ anon ]
---------------- ------- ------- -------
total kB            2644    1424     112
```

After allocation

```
24533:   /home/iman/CLionProjects/OS_lab1/cmake-build-debug/OS_lab1
Address           Kbytes     RSS   Dirty Mode  Mapping
000000001d284000  204800       0       0 rw---   [ anon ]
000056078d828000       4       4       0 r---- OS_lab1
000056078d829000       4       4       0 r-x-- OS_lab1
000056078d82a000       4       4       0 r---- OS_lab1
000056078d82b000       4       4       4 r---- OS_lab1
000056078d82c000       4       4       4 rw--- OS_lab1
000056078ef4c000     132       4       4 rw---   [ anon ]
00007f2518ab5000     148     144       0 r---- libc-2.31.so
00007f2518ada000    1504     812       0 r-x-- libc-2.31.so
00007f2518c52000     296     120       0 r---- libc-2.31.so
00007f2518c9c000       4       0       0 ----- libc-2.31.so
00007f2518c9d000      12      12      12 r---- libc-2.31.so
00007f2518ca0000      12      12      12 rw--- libc-2.31.so
00007f2518ca3000      16      16      16 rw---   [ anon ]
00007f2518cad000      28      28       0 r---- libpthread-2.31.so
00007f2518cb4000      68      68       0 r-x-- libpthread-2.31.so
00007f2518cc5000      20       0       0 r---- libpthread-2.31.so
00007f2518cca000       4       4       4 r---- libpthread-2.31.so
00007f2518ccb000       4       4       4 rw--- libpthread-2.31.so
00007f2518ccc000      16       4       4 rw---   [ anon ]
00007f2518cea000      12       8       8 rw---   [ anon ]
00007f2518ced000       4       4       0 r---- ld-2.31.so
00007f2518cee000     140     140       0 r-x-- ld-2.31.so
00007f2518d11000      32      32       0 r---- ld-2.31.so
00007f2518d1a000       4       4       4 r---- ld-2.31.so
00007f2518d1b000       4       4       4 rw--- ld-2.31.so
00007f2518d1c000      12       8       8 rw---   [ anon ]
00007ffef33d6000     132      12      12 rw---   [ stack ]
00007ffef33fd000      12       0       0 r----   [ anon ]
00007ffef3400000       4       4       0 r-x--   [ anon ]
ffffffffff600000       4       0       0 --x--   [ anon ]
---------------- ------- ------- -------
total kB          207444    1464     100
```

After generate

```
24533:   /home/iman/CLionProjects/OS_lab1/cmake-build-debug/OS_lab1
Address           Kbytes     RSS   Dirty Mode  Mapping
000000001d284000  204800  196608  196608 rw---   [ anon ]
000056078d828000       4       4       0 r---- OS_lab1
000056078d829000       4       4       0 r-x-- OS_lab1
000056078d82a000       4       4       0 r---- OS_lab1
000056078d82b000       4       4       4 r---- OS_lab1
000056078d82c000       4       4       4 rw--- OS_lab1
000056078ef4c000     132      12      12 rw---   [ anon ]
00007f2507aa3000       4       0       0 -----   [ anon ]
00007f2507aa4000    8192       8       8 rw---   [ anon ]
00007f25082a4000       4       0       0 -----   [ anon ]
00007f25082a5000    8192       8       8 rw---   [ anon ]
00007f2508aa5000       4       0       0 -----   [ anon ]
00007f2508aa6000    8192       8       8 rw---   [ anon ]
00007f25092a6000       4       0       0 -----   [ anon ]
00007f25092a7000    8192       8       8 rw---   [ anon ]
00007f2510000000     132       8       8 rw---   [ anon ]
00007f2510021000   65404       0       0 -----   [ anon ]
00007f2518ab5000     148     144       0 r---- libc-2.31.so
00007f2518ada000    1504     972       0 r-x-- libc-2.31.so
00007f2518c52000     296     120       0 r---- libc-2.31.so
00007f2518c9c000       4       0       0 ----- libc-2.31.so
00007f2518c9d000      12      12      12 r---- libc-2.31.so
00007f2518ca0000      12      12      12 rw--- libc-2.31.so
00007f2518ca3000      16      16      16 rw---   [ anon ]
00007f2518cad000      28      28       0 r---- libpthread-2.31.so
00007f2518cb4000      68      68       0 r-x-- libpthread-2.31.so
00007f2518cc5000      20       0       0 r---- libpthread-2.31.so
00007f2518cca000       4       4       4 r---- libpthread-2.31.so
00007f2518ccb000       4       4       4 rw--- libpthread-2.31.so
00007f2518ccc000      16       4       4 rw---   [ anon ]
00007f2518cea000      12       8       8 rw---   [ anon ]
00007f2518ced000       4       4       0 r---- ld-2.31.so
00007f2518cee000     140     140       0 r-x-- ld-2.31.so
00007f2518d11000      32      32       0 r---- ld-2.31.so
00007f2518d1a000       4       4       4 r---- ld-2.31.so
00007f2518d1b000       4       4       4 rw--- ld-2.31.so
00007f2518d1c000      12       8       8 rw---   [ anon ]
00007ffef33d6000     132      12      12 rw---   [ stack ]
00007ffef33fd000      12       0       0 r----   [ anon ]
00007ffef3400000       4       4       0 r-x--   [ anon ]
ffffffffff600000       4       0       0 --x--   [ anon ]
---------------- ------- ------- -------
total kB          305764  198280  196756
```

After deallocation

```
24533:   /home/iman/CLionProjects/OS_lab1/cmake-build-debug/OS_lab1
Address           Kbytes     RSS   Dirty Mode  Mapping
000056078d828000       4       4       0 r---- OS_lab1
000056078d829000       4       4       0 r-x-- OS_lab1
000056078d82a000       4       4       0 r---- OS_lab1
000056078d82b000       4       4       4 r---- OS_lab1
000056078d82c000       4       4       4 rw--- OS_lab1
000056078ef4c000     132      12      12 rw---   [ anon ]
00007f2507aa3000       4       0       0 -----   [ anon ]
00007f2507aa4000    8192       8       8 rw---   [ anon ]
00007f25082a4000       4       0       0 -----   [ anon ]
00007f25082a5000    8192       8       8 rw---   [ anon ]
00007f2508aa5000       4       0       0 -----   [ anon ]
00007f2508aa6000    8192       8       8 rw---   [ anon ]
00007f25092a6000       4       0       0 -----   [ anon ]
00007f25092a7000    8192       8       8 rw---   [ anon ]
00007f2510000000     132       8       8 rw---   [ anon ]
00007f2510021000   65404       0       0 -----   [ anon ]
00007f2518ab5000     148     144       0 r---- libc-2.31.so
00007f2518ada000    1504     972       0 r-x-- libc-2.31.so
00007f2518c52000     296     120       0 r---- libc-2.31.so
00007f2518c9c000       4       0       0 ----- libc-2.31.so
00007f2518c9d000      12      12      12 r---- libc-2.31.so
00007f2518ca0000      12      12      12 rw--- libc-2.31.so
00007f2518ca3000      16      16      16 rw---   [ anon ]
00007f2518cad000      28      28       0 r---- libpthread-2.31.so
00007f2518cb4000      68      68       0 r-x-- libpthread-2.31.so
00007f2518cc5000      20       0       0 r---- libpthread-2.31.so
00007f2518cca000       4       4       4 r---- libpthread-2.31.so
00007f2518ccb000       4       4       4 rw--- libpthread-2.31.so
00007f2518ccc000      16       4       4 rw---   [ anon ]
00007f2518cea000      12       8       8 rw---   [ anon ]
00007f2518ced000       4       4       0 r---- ld-2.31.so
00007f2518cee000     140     140       0 r-x-- ld-2.31.so
00007f2518d11000      32      32       0 r---- ld-2.31.so
00007f2518d1a000       4       4       4 r---- ld-2.31.so
00007f2518d1b000       4       4       4 rw--- ld-2.31.so
00007f2518d1c000      12       8       8 rw---   [ anon ]
00007ffef33d6000     132      12      12 rw---   [ stack ]
00007ffef33fd000      12       0       0 r----   [ anon ]
00007ffef3400000       4       4       0 r-x--   [ anon ]
ffffffffff600000       4       0       0 --x--   [ anon ]
---------------- ------- ------- -------
total kB          100964    1672     148
```

Системные вызовы:

strace -p <**PID**>

```
strace: Process 26815 attached
read(0, "\n", 1024)                     = 1
mmap(0x1d284b2f, 209715200, PROT_READ|PROT_WRITE, MAP_PRIVATE|MAP_ANONYMOUS, -1, 0) = 0x1d284000
write(1, "Write data to memory. Press a ke"..., 42) = 42
read(0, "\n", 1024)                     = 1
openat(AT_FDCWD, "/dev/urandom", O_RDONLY) = 3
mmap(NULL, 8392704, PROT_NONE, MAP_PRIVATE|MAP_ANONYMOUS|MAP_STACK, -1, 0) = 0x7fa99d5a4000
mprotect(0x7fa99d5a5000, 8388608, PROT_READ|PROT_WRITE) = 0
clone(child_stack=0x7fa99dda3fb0, flags=CLONE_VM|CLONE_FS|CLONE_FILES|CLONE_SIGHAND|CLONE_THREAD|
_tidptr=0x7fa99dda49d0) = 26838
mmap(NULL, 8392704, PROT_NONE, MAP_PRIVATE|MAP_ANONYMOUS|MAP_STACK, -1, 0) = 0x7fa99cda3000
mprotect(0x7fa99cda4000, 8388608, PROT_READ|PROT_WRITE) = 0
clone(child_stack=0x7fa99d5a2fb0, flags=CLONE_VM|CLONE_FS|CLONE_FILES|CLONE_SIGHAND|CLONE_THREAD|
_tidptr=0x7fa99d5a39d0) = 26839
mmap(NULL, 8392704, PROT_NONE, MAP_PRIVATE|MAP_ANONYMOUS|MAP_STACK, -1, 0) = 0x7fa99c5a2000
mprotect(0x7fa99c5a3000, 8388608, PROT_READ|PROT_WRITE) = 0
clone(child_stack=0x7fa99cda1fb0, flags=CLONE_VM|CLONE_FS|CLONE_FILES|CLONE_SIGHAND|CLONE_THREAD|
_tidptr=0x7fa99cda29d0) = 26840
mmap(NULL, 8392704, PROT_NONE, MAP_PRIVATE|MAP_ANONYMOUS|MAP_STACK, -1, 0) = 0x7fa9977ff000
mprotect(0x7fa997800000, 8388608, PROT_READ|PROT_WRITE) = 0
clone(child_stack=0x7fa997ffefb0, flags=CLONE_VM|CLONE_FS|CLONE_FILES|CLONE_SIGHAND|CLONE_THREAD|
_tidptr=0x7fa997fff9d0) = 26841
mmap(NULL, 8392704, PROT_NONE, MAP_PRIVATE|MAP_ANONYMOUS|MAP_STACK, -1, 0) = 0x7fa996ffe000
mprotect(0x7fa996fff000, 8388608, PROT_READ|PROT_WRITE) = 0
clone(child_stack=0x7fa9977fdfb0, flags=CLONE_VM|CLONE_FS|CLONE_FILES|CLONE_SIGHAND|CLONE_THREAD|
```

...

```
futex(0x7fa99dda49d0, FUTEX_WAIT, 26838, NULL) = 0
futex(0x7fa99cda29d0, FUTEX_WAIT, 26840, NULL) = 0
futex(0x7fa997fff9d0, FUTEX_WAIT, 26841, NULL) = 0
munmap(0x7fa99d5a4000, 8392704)         = 0
munmap(0x7fa99cda3000, 8392704)         = 0
munmap(0x7fa99c5a2000, 8392704)         = 0
munmap(0x7fa9977ff000, 8392704)         = 0
munmap(0x7fa996ffe000, 8392704)         = 0
munmap(0x7fa9967fd000, 8392704)         = 0
munmap(0x7fa995ffc000, 8392704)         = 0
munmap(0x7fa9957fb000, 8392704)         = 0
munmap(0x7fa994ffa000, 8392704)         = 0
munmap(0x7fa9947f9000, 8392704)         = 0
munmap(0x7fa993ff8000, 8392704)         = 0
munmap(0x7fa9937f7000, 8392704)         = 0
munmap(0x7fa992ff6000, 8392704)         = 0
munmap(0x7fa9927f5000, 8392704)         = 0
munmap(0x7fa991ff4000, 8392704)         = 0
munmap(0x7fa9917f3000, 8392704)         = 0
futex(0x7fa98f7ee9d0, FUTEX_WAIT, 26858, NULL) = 0
munmap(0x7fa990ff2000, 8392704)         = 0
munmap(0x7fa9907f1000, 8392704)         = 0
munmap(0x7fa98fff0000, 8392704)         = 0
munmap(0x7fa98f7ef000, 8392704)         = 0
munmap(0x7fa98efee000, 8392704)         = 0
close(3)                                = 0
write(1, "Deallocate memory. Press a key t"..., 39) = 39
```

Threads процессы

ps -T -p <pid>

```
  PID    SPID TTY          TIME CMD
26314   26314 ?        00:00:00 OS_lab1
26314   26323 ?        00:00:03 OS_lab1
26314   26324 ?        00:00:03 OS_lab1
26314   26325 ?        00:00:03 OS_lab1
26314   26326 ?        00:00:03 OS_lab1
26314   26327 ?        00:00:03 OS_lab1
26314   26328 ?        00:00:03 OS_lab1
26314   26329 ?        00:00:03 OS_lab1
26314   26330 ?        00:00:03 OS_lab1
26314   26331 ?        00:00:03 OS_lab1
26314   26332 ?        00:00:03 OS_lab1
26314   26333 ?        00:00:03 OS_lab1
26314   26334 ?        00:00:03 OS_lab1
26314   26335 ?        00:00:03 OS_lab1
26314   26336 ?        00:00:03 OS_lab1
26314   26337 ?        00:00:03 OS_lab1
26314   26338 ?        00:00:03 OS_lab1
26314   26339 ?        00:00:03 OS_lab1
26314   26340 ?        00:00:03 OS_lab1
26314   26341 ?        00:00:03 OS_lab1
26314   26342 ?        00:00:03 OS_lab1
26314   26343 ?        00:00:03 OS_lab1
26314   26344 ?        00:00:03 OS_lab1
26314   26345 ?        00:00:03 OS_lab1
26314   26346 ?        00:00:03 OS_lab1
```

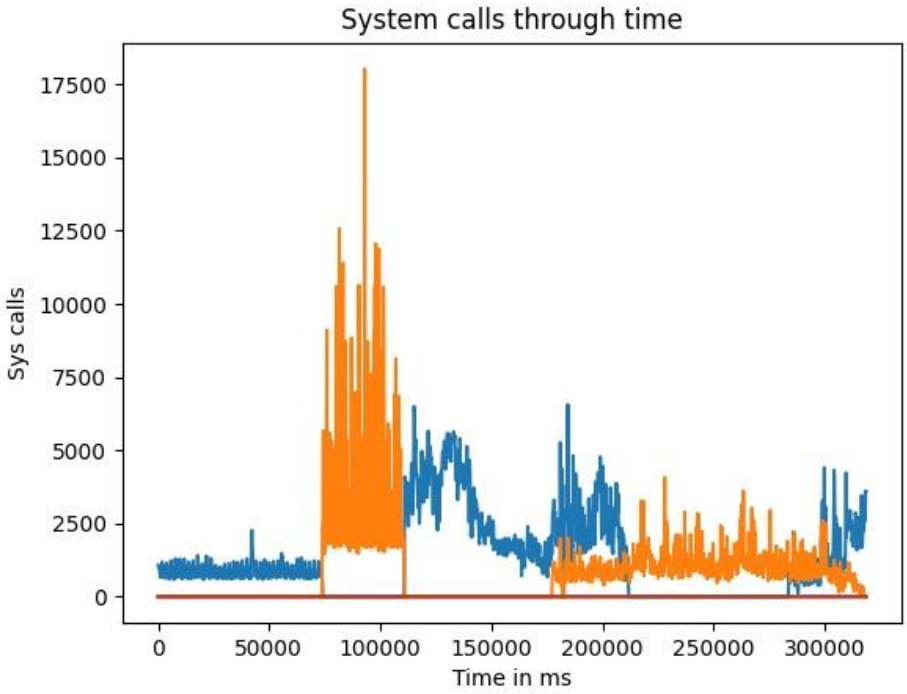
top

```
top - 16:02:00 up  5:55,  1 user,  load average: 17.93, 11.28, 8.09
Threads:  45 total,  34 running,  11 sleeping,   0 stopped,   0 zombie
%Cpu(s): 78.6 us, 21.1 sy,  0.0 ni,  0.2 id,  0.0 wa,  0.0 hi,  0.0 si,  0.0 st
MiB Mem :   7479.2 total,    223.8 free,   5977.0 used,   1278.4 buff/cache
MiB Swap:   7813.0 total,   6006.7 free,   1806.3 used.    701.0 avail Mem

    PID USER      PR  NI    VIRT    RES    SHR S  %CPU  %MEM     TIME+ COMMAND
  26520 iman      20   0 1043204 219008   1460 R   9.3   2.9   0:00.34 OS_lab1
  26521 iman      20   0 1043204 219008   1460 R   9.3   2.9   0:00.33 OS_lab1
  26532 iman      20   0 1043204 219008   1460 R   9.3   2.9   0:00.33 OS_lab1
  26517 iman      20   0 1043204 219008   1460 S   9.0   2.9   0:00.32 OS_lab1
  26524 iman      20   0 1043204 219008   1460 R   9.0   2.9   0:00.34 OS_lab1
  26528 iman      20   0 1043204 219008   1460 R   9.0   2.9   0:00.33 OS_lab1
  26522 iman      20   0 1043204 219008   1460 S   8.7   2.9   0:00.33 OS_lab1
  26526 iman      20   0 1043204 219008   1460 S   8.7   2.9   0:00.33 OS_lab1
  26529 iman      20   0 1043204 219008   1460 S   8.7   2.9   0:00.31 OS_lab1
  26533 iman      20   0 1043204 219008   1460 S   8.7   2.9   0:00.32 OS_lab1
  26547 iman      20   0 1043204 219008   1460 R   8.7   2.9   0:00.31 OS_lab1
  26516 iman      20   0 1043204 219008   1460 R   8.3   2.9   0:00.32 OS_lab1
  26518 iman      20   0 1043204 219008   1460 S   8.3   2.9   0:00.32 OS_lab1
  26525 iman      20   0 1043204 219008   1460 R   8.3   2.9   0:00.31 OS_lab1
  26530 iman      20   0 1043204 219008   1460 S   8.3   2.9   0:00.31 OS_lab1
  26544 iman      20   0 1043204 219008   1460 R   8.3   2.9   0:00.31 OS_lab1
  26551 iman      20   0 1043204 219008   1460 R   8.3   2.9   0:00.29 OS_lab1
  26552 iman      20   0 1043204 219008   1460 R   8.3   2.9   0:00.31 OS_lab1
  26553 iman      20   0 1043204 219008   1460 R   8.3   2.9   0:00.29 OS_lab1
  26514 iman      20   0 1043204 219008   1460 R   8.0   2.9   0:00.32 OS_lab1
  26519 iman      20   0 1043204 219008   1460 R   8.0   2.9   0:00.29 OS_lab1
  26527 iman      20   0 1043204 219008   1460 R   8.0   2.9   0:00.30 OS_lab1
  26534 iman      20   0 1043204 219008   1460 R   8.0   2.9   0:00.29 OS_lab1
  26538 iman      20   0 1043204 219008   1460 R   8.0   2.9   0:00.28 OS_lab1
  26542 iman      20   0 1043204 219008   1460 R   8.0   2.9   0:00.29 OS_lab1
  26545 iman      20   0 1043204 219008   1460 R   8.0   2.9   0:00.30 OS_lab1
  26550 iman      20   0 1043204 219008   1460 R   8.0   2.9   0:00.28 OS_lab1
  26554 iman      20   0 1043204 219008   1460 R   8.0   2.9   0:00.28 OS_lab1
  26556 iman      20   0 1043204 219008   1460 S   8.0   2.9   0:00.29 OS_lab1
  26557 iman      20   0 1043204 219008   1460 R   8.0   2.9   0:00.27 OS_lab1
  26523 iman      20   0 1043204 219008   1460 S   7.7   2.9   0:00.30 OS_lab1
  26535 iman      20   0 1043204 219008   1460 R   7.7   2.9   0:00.28 OS_lab1
  26536 iman      20   0 1043204 219008   1460 R   7.7   2.9   0:00.28 OS_lab1
  26537 iman      20   0 1043204 219008   1460 R   7.7   2.9   0:00.27 OS_lab1
  26539 iman      20   0 1043204 219008   1460 R   7.7   2.9   0:00.27 OS_lab1
  26548 iman      20   0 1043204 219008   1460 R   7.7   2.9   0:00.28 OS_lab1
  26549 iman      20   0 1043204 219008   1460 R   7.7   2.9   0:00.29 OS_lab1
  26555 iman      20   0 1043204 219008   1460 R   7.7   2.9   0:00.28 OS_lab1
  26531 iman      20   0 1043204 219008   1460 S   7.3   2.9   0:00.28 OS_lab1
  26540 iman      20   0 1043204 219008   1460 R   7.3   2.9   0:00.28 OS_lab1
  26543 iman      20   0 1043204 219008   1460 R   7.3   2.9   0:00.27 OS_lab1
  26546 iman      20   0 1043204 219008   1460 R   7.3   2.9   0:00.27 OS_lab1
  26515 iman      20   0 1043204 219008   1460 R   7.0   2.9   0:00.29 OS_lab1
  26541 iman      20   0 1043204 219008   1460 R   7.0   2.9   0:00.27 OS_lab1
  26314 iman      20   0 1043204 219008   1460 S   0.0   2.9   0:00.67 OS_lab1
```

Запуск скрипта systemtap во время бесконечно цикла

```
global read, write, start, open, close

probe begin {
   start = gettimeofday_s()
}
probe syscall.write {
   if (pid() == target())
      write += 1
}

probe syscall.read {
   if (pid() == target())
      read += 1
}

probe syscall.open {
   if (pid() == target())
      open += 1
}

probe syscall.close {
   if (pid() == target())
      close += 1
}

probe timer.ms(200) {
   printf("%d\t%d\t%d\t%d\t%16d\n", read, write, open, close, task_stime())
   read=0
   write=0
   open = 0
   close = 0
}
```

```
                                  read      read              write     write
          name     open      read MB tot    B avg     write MB tot     B avg
       OS_lab1        0    828105    3234     4095  20646553     531        26
```



Оранжевая - write
Синяя - read
Красная - open
Зеленая - close

Вывод

В ходе выполнения лабораторной работы мы написали многопоточную программу на языке C и поработали с инструментами мониторинга ОС и процессов.