Московский Авиационный Институт

(Национальный Исследовательский Университет)

Институт №8 “Компьютерные науки и прикладная математика”

Кафедра №806 “Вычислительная математика и программирование”

Лабораторная работа №2 по курсу

«Операционные системы»

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Оценка: _____

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Постановка задачи

Вариант 18.

Цель работы

Приобретение практических навыков в:

● Управление потоками в ОС

● Обеспечение синхронизации между потоками

Составить программу на языке Си, обрабатывающую данные в многопоточном режиме. При обработки использовать стандартные средства создания потоков операционной системы (Windows/Unix). Ограничение максимального количества потоков, работающих в один момент времени, должно быть задано ключом запуска вашей программы.

Найти образец в строке наивным алгоритмом.

Общий метод и алгоритм решения

Использованные системные вызовы:

● int pthread_create(pthread_t *thread, const pthread_attr_t *attr,

● void *(*start)(void *), void *arg)– создание потока

● int pthread_join (pthread_t THREAD_ID, void ** DATA) – ожидание завершения потока

Количество потоков	Время, мс	Ускорение	Эффективность
1	1.4	1	1
2	1384	0.001	0.0005
3	2092	0.00067	0.00022
4	2832	0.00049	0.00012
6	3388	0.00041	0.000068
8	4021	0.00035	0.000044

Данные подсчитаны при строке длины 1000000000, слово находится на позиции 82346

Код программы

main.c

```
#include <stdint.h>
#include <stdbool.h>
#include <stdlib.h>
#include <unistd.h>
#include <fcntl.h>
#include <stdio.h>
#include <string.h>
#include <pthread.h>
#include <limits.h>
#include <time.h>
```

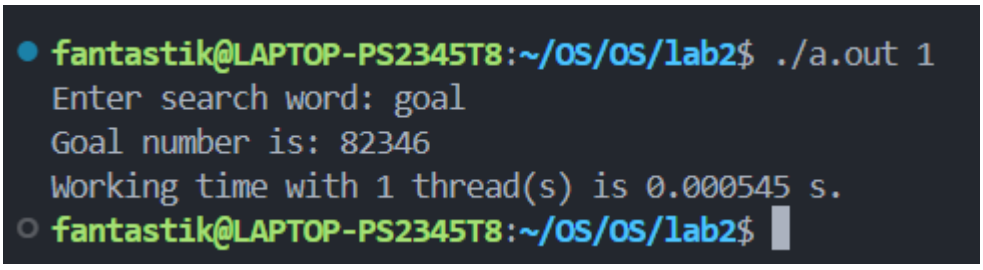
```c
typedef struct thread_data {
    char *word;
    char *string;
    int start;
    int end;
    int found;
} thread_data;

void *naive_search(void *arg) {
    thread_data *data = (thread_data *)arg;

    int m = strlen(data->word);

    for (int i = data->start; i < data->end; i++) {
        int flag = 0;
        for (int j = 0; j < m; j++) {
            if (data->string[i + j] == data->word[j]) {
                flag = 1;
            }
            else {
                flag = 0;
                break;
            }
        }
        if (flag) {
            data->found = i;
            break;
        }
    }
    return NULL;
}

char *get_string() {
    int len = 0;
    int capacity = 1;
    char *s = (char*) malloc(sizeof(char));

    char c = getchar();

    while (c != '\n') {
        s[len++] = c;
        char * for_realloc;

        if (len >= capacity) {
            capacity *= 2;
            for_realloc = (char*) realloc(s, capacity * sizeof(char));

            if(!for_realloc) {
                free(s);
                return NULL;
            }
            s = for_realloc;
        }
```

```
        c = getchar();
    }

    s[len] = '\0';

    return s;
}


int main(int argc, char *argv[]) {
    int threads_num = strtol(argv[1], NULL, 10);

    pthread_t threads[threads_num];
    thread_data threads_data[threads_num];

    size_t size = 1000000000;
    char *string = (char *)malloc(size * sizeof(char));

    if (string == NULL) {
        perror("Failed to allocate memory");
        return 1;
    }

    memset(string, 'A', size);

    int place = 82346;

    string[place + 3] = 'l'; string[place + 2] = 'a'; string[place + 1] = 'o'; string[place]
= 'g';
    printf("Enter search word: ");
    char *word = get_string();

    int part_size = strlen(string) / threads_num;
    int part_remains = strlen(string) % threads_num;

    clock_t start_time = clock();

    for (int i = 0; i < threads_num; i++) {
        threads_data[i].string = string;
        threads_data[i].word = word;
        threads_data[i].found = INT_MAX;

        if(part_remains) {
            threads_data[i].start = i * part_size + 1;
            part_remains--;
        }
        else threads_data[i].start = i * part_size;

        threads_data[i].end = threads_data[i].start + part_size + strlen(word);

        if(pthread_create(&threads[i], NULL, naive_search, &threads_data[i])) {
            free(string); free(word);
            return 1;
        }
    }
```

```c
    int min_ind = INT_MAX;

    for(int i = 0; i < threads_num; i++) {
        pthread_join(threads[i], NULL);
        if (threads_data[i].found < min_ind)
            min_ind = threads_data[i].found;
    }

    clock_t end_time = clock();

    double delta_time = ((double)(end_time - start_time)) / CLOCKS_PER_SEC;


    if (min_ind != INT_MAX)
        printf("Goal number is: %d\n", min_ind);
    else
        printf("Word hasn't been found\n");

    printf("Working time with %d thread(s) is %f s.\n", threads_num, delta_time);

    free(word);
    free(string);
    return 0;
}
```

Протокол работы программы

Тест 1:

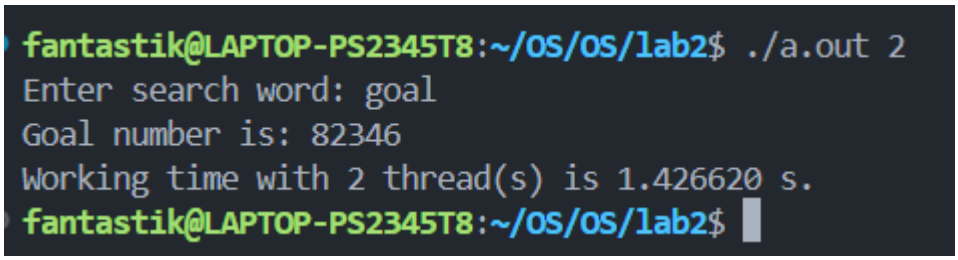


Strace:

```
strace ./a.out 1
execve("./a.out", ["./a.out", "1"], 0x7ffe30de1d18 /* 37 vars */) = 0
brk(NULL)                               = 0x55a52ef77000
mmap(NULL, 8192, PROT_READ|PROT_WRITE, MAP_PRIVATE|MAP_ANONYMOUS, -1, 0) = 0x7ff4c63d0000
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=19791, ...}) = 0
mmap(NULL, 19791, PROT_READ, MAP_PRIVATE, 3, 0) = 0x7ff4c63cb000
close(3)                                = 0
openat(AT_FDCWD, "/lib/x86_64-linux-gnu/libc.so.6", O_RDONLY|O_CLOEXEC) = 3
read(3, "\177ELF\2\1\1\3\0\0\0\0\0\0\0\0\3\0>\0\1\0\0\0\220\243\2\0\0\0\0\0"..., 832) = 832
pread64(3, "\6\0\0\0\4\0\0\0@\0\0\0\0\0\0\0@\0\0\0\0\0\0\0@\0\0\0\0\0\0\0"..., 784, 64) = 784
```

```
fstat(3, {st_mode=S_IFREG|0755, st_size=2125328, ...}) = 0
pread64(3, "\6\0\0\0\4\0\0\0@\0\0\0\0\0\0\0@\0\0\0\0\0\0\0@\0\0\0\0\0\0\0"..., 784, 64) = 784
mmap(NULL, 2170256, PROT_READ, MAP_PRIVATE|MAP_DENYWRITE, 3, 0) = 0x7ff4c61b9000
mmap(0x7ff4c61e1000, 1605632, PROT_READ|PROT_EXEC, MAP_PRIVATE|MAP_FIXED|MAP_DENYWRITE, 3,
0x28000) = 0x7ff4c61e1000
mmap(0x7ff4c6369000, 323584, PROT_READ, MAP_PRIVATE|MAP_FIXED|MAP_DENYWRITE, 3, 0x1b0000) =
0x7ff4c6369000
mmap(0x7ff4c63b8000, 24576, PROT_READ|PROT_WRITE, MAP_PRIVATE|MAP_FIXED|MAP_DENYWRITE, 3,
0x1fe000) = 0x7ff4c63b8000
mmap(0x7ff4c63be000, 52624, PROT_READ|PROT_WRITE, MAP_PRIVATE|MAP_FIXED|MAP_ANONYMOUS, -1, 0) =
0x7ff4c63be000
close(3)                                = 0
mmap(NULL, 12288, PROT_READ|PROT_WRITE, MAP_PRIVATE|MAP_ANONYMOUS, -1, 0) = 0x7ff4c61b6000
arch_prctl(ARCH_SET_FS, 0x7ff4c61b6740) = 0
set_tid_address(0x7ff4c61b6a10)         = 323884
set_robust_list(0x7ff4c61b6a20, 24)     = 0
rseq(0x7ff4c61b7060, 0x20, 0, 0x53053053) = 0
mprotect(0x7ff4c63b8000, 16384, PROT_READ) = 0
mprotect(0x55a52e23e000, 4096, PROT_READ) = 0
mprotect(0x7ff4c6408000, 8192, PROT_READ) = 0
prlimit64(0, RLIMIT_STACK, NULL, {rlim_cur=8192*1024, rlim_max=RLIM64_INFINITY}) = 0
munmap(0x7ff4c63cb000, 19791)           = 0
getrandom("\xef\xc6\x74\x3b\xf1\xf0\x1f\x0c", 8, GRND_NONBLOCK) = 8
brk(NULL)                               = 0x55a52ef77000
brk(0x55a52ef98000)                     = 0x55a52ef98000
mmap(NULL, 1000001536, PROT_READ|PROT_WRITE, MAP_PRIVATE|MAP_ANONYMOUS, -1, 0) = 0x7ff48a809000
fstat(1, {st_mode=S_IFCHR|0620, st_rdev=makedev(0x88, 0x7), ...}) = 0
fstat(0, {st_mode=S_IFCHR|0620, st_rdev=makedev(0x88, 0x7), ...}) = 0
write(1, "Enter search word: ", 19Enter search word: )     = 19
read(0, 0x55a52ef776d0, 1024)           = ? ERESTARTSYS (To be restarted if SA_RESTART is set)
--- SIGWINCH {si_signo=SIGWINCH, si_code=SI_KERNEL} ---
read(0, goal
"goal\n", 1024)                 = 5
clock_gettime(CLOCK_PROCESS_CPUTIME_ID, {tv_sec=0, tv_nsec=686568200}) = 0
rt_sigaction(SIGRT_1, {sa_handler=0x7ff4c6252520, sa_mask=[],
sa_flags=SA_RESTORER|SA_ONSTACK|SA_RESTART|SA_SIGINFO, sa_restorer=0x7ff4c61fe320}, NULL, 8) = 0
rt_sigprocmask(SIG_UNBLOCK, [RTMIN RT_1], NULL, 8) = 0
mmap(NULL, 8392704, PROT_NONE, MAP_PRIVATE|MAP_ANONYMOUS|MAP_STACK, -1, 0) = 0x7ff48a008000
mprotect(0x7ff48a009000, 8388608, PROT_READ|PROT_WRITE) = 0
rt_sigprocmask(SIG_BLOCK, ~[], [], 8)   = 0
clone3({flags=CLONE_VM|CLONE_FS|CLONE_FILES|CLONE_SIGHAND|CLONE_THREAD|CLONE_SYSVSEM|CLONE_SETTLS|
CLONE_PARENT_SETTID|CLONE_CHILD_CLEARTID, child_tid=0x7ff48a808990, parent_tid=0x7ff48a808990,
exit_signal=0, stack=0x7ff48a008000, stack_size=0x7fff80, tls=0x7ff48a8086c0} =>
{parent_tid=[323957]}, 88) = 323957
rt_sigprocmask(SIG_SETMASK, [], NULL, 8) = 0
futex(0x7ff48a808990, FUTEX_WAIT_BITSET|FUTEX_CLOCK_REALTIME, 323957, NULL,
FUTEX_BITSET_MATCH_ANY) = 0
clock_gettime(CLOCK_PROCESS_CPUTIME_ID, {tv_sec=0, tv_nsec=687245400}) = 0
write(1, "Goal number is: 82346\n", 22Goal number is: 82346
) = 22
write(1, "Working time with 1 thread(s) is"..., 45Working time with 1 thread(s) is 0.000677 s.
) = 45
munmap(0x7ff48a809000, 1000001536)      = 0
exit_group(0)                           = ?
+++ exited with 0 +++
```

Тест 2:

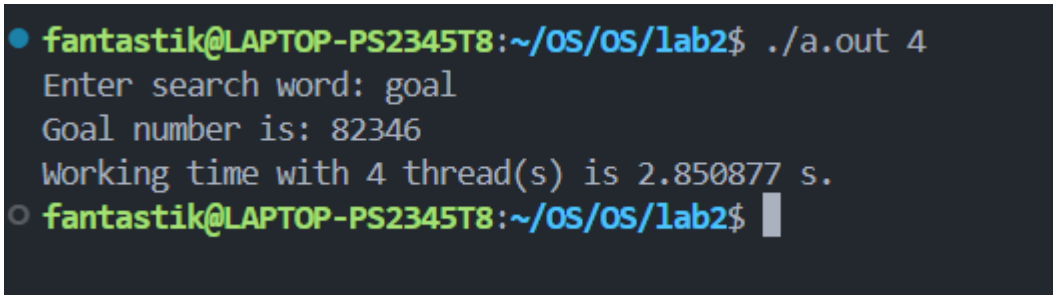


Strace:

```
strace ./a.out 2
execve("./a.out", ["./a.out", "2"], 0x7ffe193b07d8 /* 37 vars */) = 0
brk(NULL)                               = 0x560bf3f3f000
mmap(NULL, 8192, PROT_READ|PROT_WRITE, MAP_PRIVATE|MAP_ANONYMOUS, -1, 0) =
0x7ffa54350000
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=19791, ...}) = 0
mmap(NULL, 19791, PROT_READ, MAP_PRIVATE, 3, 0) = 0x7ffa5434b000
close(3)                                = 0
openat(AT_FDCWD, "/lib/x86_64-linux-gnu/libc.so.6", O_RDONLY|O_CLOEXEC) = 3
read(3, "\177ELF\2\1\1\3\0\0\0\0\0\0\0\0\3\0>\0\1\0\0\0\220\243\2\0\0\0\0"..., 832) = 832
pread64(3, "\6\0\0\0\4\0\0\0@\0\0\0\0\0\0\0@\0\0\0\0\0\0\0@\0\0\0\0\0\0\0"..., 784, 64) = 784
fstat(3, {st_mode=S_IFREG|0755, st_size=2125328, ...}) = 0
pread64(3, "\6\0\0\0\4\0\0\0@\0\0\0\0\0\0\0@\0\0\0\0\0\0\0@\0\0\0\0\0\0\0"..., 784, 64) = 784
mmap(NULL, 2170256, PROT_READ, MAP_PRIVATE|MAP_DENYWRITE, 3, 0) =
0x7ffa54139000
mmap(0x7ffa54161000, 1605632, PROT_READ|PROT_EXEC,
MAP_PRIVATE|MAP_FIXED|MAP_DENYWRITE, 3, 0x28000) = 0x7ffa54161000
mmap(0x7ffa542e9000, 323584, PROT_READ,
MAP_PRIVATE|MAP_FIXED|MAP_DENYWRITE, 3, 0x1b0000) = 0x7ffa542e9000
mmap(0x7ffa54338000, 24576, PROT_READ|PROT_WRITE,
MAP_PRIVATE|MAP_FIXED|MAP_DENYWRITE, 3, 0x1fe000) = 0x7ffa54338000
mmap(0x7ffa5433e000, 52624, PROT_READ|PROT_WRITE,
MAP_PRIVATE|MAP_FIXED|MAP_ANONYMOUS, -1, 0) = 0x7ffa5433e000
close(3)                                = 0
mmap(NULL, 12288, PROT_READ|PROT_WRITE, MAP_PRIVATE|MAP_ANONYMOUS, -1, 0)
= 0x7ffa54136000
arch_prctl(ARCH_SET_FS, 0x7ffa54136740) = 0
set_tid_address(0x7ffa54136a10)         = 324671
set_robust_list(0x7ffa54136a20, 24)     = 0
rseq(0x7ffa54137060, 0x20, 0, 0x53053053) = 0
mprotect(0x7ffa54338000, 16384, PROT_READ) = 0
mprotect(0x560bf39f5000, 4096, PROT_READ) = 0
mprotect(0x7ffa54388000, 8192, PROT_READ) = 0
prlimit64(0, RLIMIT_STACK, NULL, {rlim_cur=8192*1024, rlim_max=RLIM64_INFINITY}) = 0
munmap(0x7ffa5434b000, 19791)           = 0
getrandom("\xad\x78\xc5\xbd\x72\x80\x5d\x57", 8, GRND_NONBLOCK) = 8
brk(NULL)                               = 0x560bf3f3f000
brk(0x560bf3f60000)                     = 0x560bf3f60000
mmap(NULL, 1000001536, PROT_READ|PROT_WRITE, MAP_PRIVATE|MAP_ANONYMOUS,
-1, 0) = 0x7ffa18789000
fstat(1, {st_mode=S_IFCHR|0620, st_rdev=makedev(0x88, 0x7), ...}) = 0
fstat(0, {st_mode=S_IFCHR|0620, st_rdev=makedev(0x88, 0x7), ...}) = 0
write(1, "Enter search word: ", 19Enter search word: )      = 19
read(0, goal
"goal\n", 1024)                 = 5
clock_gettime(CLOCK_PROCESS_CPUTIME_ID, {tv_sec=0, tv_nsec=486763800}) = 0
rt_sigaction(SIGRT_1, {sa_handler=0x7ffa541d2520, sa_mask=[],
sa_flags=SA_RESTORER|SA_ONSTACK|SA_RESTART|SA_SIGINFO,
sa_restorer=0x7ffa5417e320}, NULL, 8) = 0
rt_sigprocmask(SIG_UNBLOCK, [RTMIN RT_1], NULL, 8) = 0
mmap(NULL, 8392704, PROT_NONE, MAP_PRIVATE|MAP_ANONYMOUS|MAP_STACK, -1,
0) = 0x7ffa17f88000
mprotect(0x7ffa17f89000, 8388608, PROT_READ|PROT_WRITE) = 0
```

rt_sigprocmask(SIG_BLOCK, ~[], [], 8)   = 0
clone3({flags=CLONE_VM|CLONE_FS|CLONE_FILES|CLONE_SIGHAND|CLONE_THREAD|CLONE_SYSVSEM|CLONE_SETTLS|CLONE_PARENT_SETTID|CLONE_CHILD_CLEARTID, child_tid=0x7ffa18788990, parent_tid=0x7ffa18788990, exit_signal=0, stack=0x7ffa17f88000, stack_size=0x7fff80, tls=0x7ffa187886c0} => {parent_tid=[324720]}, 88) = 324720
rt_sigprocmask(SIG_SETMASK, [], NULL, 8) = 0
mmap(NULL, 8392704, PROT_NONE, MAP_PRIVATE|MAP_ANONYMOUS|MAP_STACK, -1, 0) = 0x7ffa17787000
mprotect(0x7ffa17788000, 8388608, PROT_READ|PROT_WRITE) = 0
rt_sigprocmask(SIG_BLOCK, ~[], [], 8)   = 0
clone3({flags=CLONE_VM|CLONE_FS|CLONE_FILES|CLONE_SIGHAND|CLONE_THREAD|CLONE_SYSVSEM|CLONE_SETTLS|CLONE_PARENT_SETTID|CLONE_CHILD_CLEARTID, child_tid=0x7ffa17f87990, parent_tid=0x7ffa17f87990, exit_signal=0, stack=0x7ffa17787000, stack_size=0x7fff80, tls=0x7ffa17f876c0} => {parent_tid=[324721]}, 88) = 324721
rt_sigprocmask(SIG_SETMASK, [], NULL, 8) = 0
futex(0x7ffa17f87990, FUTEX_WAIT_BITSET|FUTEX_CLOCK_REALTIME, 324721, NULL, FUTEX_BITSET_MATCH_ANY) = 0
clock_gettime(CLOCK_PROCESS_CPUTIME_ID, {tv_sec=1, tv_nsec=883724200}) = 0
write(1, "Goal number is: 82346\n", 22Goal number is: 82346
) = 22
write(1, "Working time with 2 thread(s) is"..., 45Working time with 2 thread(s) is 1.396961 s.
) = 45
munmap(0x7ffa18789000, 1000001536)   = 0
exit_group(0)   = ?
+++ exited with 0 +++

Тест 3:



Strace:
strace ./a.out 4
execve("./a.out", ["./a.out", "4"], 0x7ffdce555c38 /* 37 vars */) = 0
brk(NULL)   = 0x55ceac51f000
mmap(NULL, 8192, PROT_READ|PROT_WRITE, MAP_PRIVATE|MAP_ANONYMOUS, -1, 0) = 0x7fbd0b652000
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=19791, ...}) = 0
mmap(NULL, 19791, PROT_READ, MAP_PRIVATE, 3, 0) = 0x7fbd0b64d000
close(3)   = 0
openat(AT_FDCWD, "/lib/x86_64-linux-gnu/libc.so.6", O_RDONLY|O_CLOEXEC) = 3
read(3, "\177ELF\2\1\1\3\0\0\0\0\0\0\0\0\3\0>\0\1\0\0\0\220\243\2\0\0\0\0\0"..., 832) = 832
pread64(3, "\6\0\0\0\4\0\0\0@\0\0\0\0\0\0\0@\0\0\0\0\0\0\0@\0\0\0\0\0\0\0"..., 784, 64) = 784
fstat(3, {st_mode=S_IFREG|0755, st_size=2125328, ...}) = 0
pread64(3, "\6\0\0\0\4\0\0\0@\0\0\0\0\0\0\0@\0\0\0\0\0\0\0@\0\0\0\0\0\0\0"..., 784, 64) = 784
mmap(NULL, 2170256, PROT_READ, MAP_PRIVATE|MAP_DENYWRITE, 3, 0) = 0x7fbd0b43b000
mmap(0x7fbd0b463000, 1605632, PROT_READ|PROT_EXEC, MAP_PRIVATE|MAP_FIXED|MAP_DENYWRITE, 3, 0x28000) = 0x7fbd0b463000
mmap(0x7fbd0b5eb000, 323584, PROT_READ, MAP_PRIVATE|MAP_FIXED|MAP_DENYWRITE, 3,

```
0x1b0000) = 0x7fbd0b5eb000
mmap(0x7fbd0b63a000, 24576, PROT_READ|PROT_WRITE,
MAP_PRIVATE|MAP_FIXED|MAP_DENYWRITE, 3, 0x1fe000) = 0x7fbd0b63a000
mmap(0x7fbd0b640000, 52624, PROT_READ|PROT_WRITE,
MAP_PRIVATE|MAP_FIXED|MAP_ANONYMOUS, -1, 0) = 0x7fbd0b640000
close(3)                                = 0
mmap(NULL, 12288, PROT_READ|PROT_WRITE, MAP_PRIVATE|MAP_ANONYMOUS, -1, 0) =
0x7fbd0b438000
arch_prctl(ARCH_SET_FS, 0x7fbd0b438740) = 0
set_tid_address(0x7fbd0b438a10)         = 326159
set_robust_list(0x7fbd0b438a20, 24)     = 0
rseq(0x7fbd0b439060, 0x20, 0, 0x53053053) = 0
mprotect(0x7fbd0b63a000, 16384, PROT_READ) = 0
mprotect(0x55ceab1d7000, 4096, PROT_READ) = 0
mprotect(0x7fbd0b68a000, 8192, PROT_READ) = 0
prlimit64(0, RLIMIT_STACK, NULL, {rlim_cur=8192*1024, rlim_max=RLIM64_INFINITY}) = 0
munmap(0x7fbd0b64d000, 19791)           = 0
getrandom("\x25\x58\xd7\x5e\x56\xa0\xba\x4c", 8, GRND_NONBLOCK) = 8
brk(NULL)                               = 0x55ceac51f000
brk(0x55ceac540000)                     = 0x55ceac540000
mmap(NULL, 1000001536, PROT_READ|PROT_WRITE, MAP_PRIVATE|MAP_ANONYMOUS, -1, 0) =
0x7fbccfa8b000
fstat(1, {st_mode=S_IFCHR|0620, st_rdev=makedev(0x88, 0x7), ...}) = 0
fstat(0, {st_mode=S_IFCHR|0620, st_rdev=makedev(0x88, 0x7), ...}) = 0
write(1, "Enter search word: ", 19Enter search word: )     = 19
read(0, goal
"goal\n", 1024)                 = 5
clock_gettime(CLOCK_PROCESS_CPUTIME_ID, {tv_sec=0, tv_nsec=447976400}) = 0
rt_sigaction(SIGRT_1, {sa_handler=0x7fbd0b4d4520, sa_mask=[],
sa_flags=SA_RESTORER|SA_ONSTACK|SA_RESTART|SA_SIGINFO, sa_restorer=0x7fbd0b480320},
NULL, 8) = 0
rt_sigprocmask(SIG_UNBLOCK, [RTMIN RT_1], NULL, 8) = 0
mmap(NULL, 8392704, PROT_NONE, MAP_PRIVATE|MAP_ANONYMOUS|MAP_STACK, -1, 0) =
0x7fbccf28a000
mprotect(0x7fbccf28b000, 8388608, PROT_READ|PROT_WRITE) = 0
rt_sigprocmask(SIG_BLOCK, ~[], [], 8)   = 0
clone3({flags=CLONE_VM|CLONE_FS|CLONE_FILES|CLONE_SIGHAND|CLONE_THREAD|CLONE_
SYSVSEM|CLONE_SETTLS|CLONE_PARENT_SETTID|CLONE_CHILD_CLEARTID,
child_tid=0x7fbccfa8a990, parent_tid=0x7fbccfa8a990, exit_signal=0, stack=0x7fbccf28a000,
stack_size=0x7fff80, tls=0x7fbccfa8a6c0} => {parent_tid=[326202]}, 88) = 326202
rt_sigprocmask(SIG_SETMASK, [], NULL, 8) = 0
mmap(NULL, 8392704, PROT_NONE, MAP_PRIVATE|MAP_ANONYMOUS|MAP_STACK, -1, 0) =
0x7fbccea89000
mprotect(0x7fbccea8a000, 8388608, PROT_READ|PROT_WRITE) = 0
rt_sigprocmask(SIG_BLOCK, ~[], [], 8)   = 0
clone3({flags=CLONE_VM|CLONE_FS|CLONE_FILES|CLONE_SIGHAND|CLONE_THREAD|CLONE_
SYSVSEM|CLONE_SETTLS|CLONE_PARENT_SETTID|CLONE_CHILD_CLEARTID,
child_tid=0x7fbccf289990, parent_tid=0x7fbccf289990, exit_signal=0, stack=0x7fbccea89000,
stack_size=0x7fff80, tls=0x7fbccf2896c0} => {parent_tid=[326203]}, 88) = 326203
rt_sigprocmask(SIG_SETMASK, [], NULL, 8) = 0
mmap(NULL, 8392704, PROT_NONE, MAP_PRIVATE|MAP_ANONYMOUS|MAP_STACK, -1, 0) =
0x7fbcce288000
mprotect(0x7fbcce289000, 8388608, PROT_READ|PROT_WRITE) = 0
rt_sigprocmask(SIG_BLOCK, ~[], [], 8)   = 0
clone3({flags=CLONE_VM|CLONE_FS|CLONE_FILES|CLONE_SIGHAND|CLONE_THREAD|CLONE_
SYSVSEM|CLONE_SETTLS|CLONE_PARENT_SETTID|CLONE_CHILD_CLEARTID,
child_tid=0x7fbccea88990, parent_tid=0x7fbccea88990, exit_signal=0, stack=0x7fbcce288000,
```

```
stack_size=0x7fff80, tls=0x7fbccea886c0} => {parent_tid=[326204]}, 88) = 326204
rt_sigprocmask(SIG_SETMASK, [], NULL, 8) = 0
mmap(NULL, 8392704, PROT_NONE, MAP_PRIVATE|MAP_ANONYMOUS|MAP_STACK, -1, 0) =
0x7fbccda87000
mprotect(0x7fbccda88000, 8388608, PROT_READ|PROT_WRITE) = 0
rt_sigprocmask(SIG_BLOCK, ~[], [], 8)   = 0
clone3({flags=CLONE_VM|CLONE_FS|CLONE_FILES|CLONE_SIGHAND|CLONE_THREAD|CLONE_
SYSVSEM|CLONE_SETTLS|CLONE_PARENT_SETTID|CLONE_CHILD_CLEARTID,
child_tid=0x7fbcce287990, parent_tid=0x7fbcce287990, exit_signal=0, stack=0x7fbccda87000,
stack_size=0x7fff80, tls=0x7fbcce2876c0} => {parent_tid=[326205]}, 88) = 326205
rt_sigprocmask(SIG_SETMASK, [], NULL, 8) = 0
futex(0x7fbccf289990, FUTEX_WAIT_BITSET|FUTEX_CLOCK_REALTIME, 326203, NULL,
FUTEX_BITSET_MATCH_ANY) = 0
futex(0x7fbccea88990, FUTEX_WAIT_BITSET|FUTEX_CLOCK_REALTIME, 326204, NULL,
FUTEX_BITSET_MATCH_ANY) = 0
clock_gettime(CLOCK_PROCESS_CPUTIME_ID, {tv_sec=3, tv_nsec=459417100}) = 0
write(1, "Goal number is: 82346\n", 22Goal number is: 82346
) = 22
write(1, "Working time with 4 thread(s) is"..., 45Working time with 4 thread(s) is 3.011441 s.
) = 45
munmap(0x7fbccfa8b000, 1000001536)      = 0
exit_group(0)                           = ?
+++ exited with 0 +++
```

Вывод

В процессе выполнения лабораторной работы я научился управлять потоками в операционной системе. В рамках работы была создана и отлажена программа на языке Си, которая складывает массивы, используя потоки, работа с которыми производится через синхронизатор потоков pthread_join() (барьер).