Московский Авиационный Институт

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Институт №8 “Компьютерные науки и прикладная математика”

Кафедра №806 “Вычислительная математика и программирование”

Лабораторная работа №2 по курсу

«Операционные системы»

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Постановка задачи

Цель работы:

Целью является приобретение практических навыков в:

- **Управление потоками в ОС**
- **Обеспечение синхронизации между потоками**

Задание:

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. Так же необходимо уметь продемонстрировать количество потоков, используемое вашей программой с помощью стандартных средств операционной системы. В отчете привести исследование зависимости ускорения и эффективности алгоритма от входных данных и количества потоков. Получившиеся результаты необходимо объяснить.

Вариант 3) Отсортировать массив целых чисел при помощи параллельной сортировки

Общий метод и алгоритм решения

Использованные системные вызовы:

- ssize_t write(int _fd, const void *_buf, size_t _n); – Записывает N байт из буфер(BUF) в файл (FD). Возвращает количество записанных байт или -1.
- void exit(int _status); – выполняет немедленное завершение программы. Все используемые программой потоки закрываются, и временные файлы удаляются, управление возвращается ОС или другой программе.
- int pthread_create(pthread_t *_restrict_____newthread, const pthread_attr_t *__restrict_ _attr, void *(*start_routine)(void *), void *restrict_____arg) — создаёт поток с рутиной (стартовой функцией) и заданными аргументами
- int pthread_join(pthread_t th, void **thread_return) — дожидается завершения потока.

Для mutex реализации были использованы:
pthread_mutex_t – тип данных;
int pthread_mutex_init(pthread_mutex_t *mutex, const pthread_mutexattr_t *mutexattr) – инициализация мьютекса;
int pthread_mutex_lock(pthread_mutex_t *mutex) – блокировка мьютекса;
int pthread_mutex_unlock(pthread_mutex_t *mutex) – разблокировка мьютекса;
int pthread_mutex_destroy(pthread_mutex_t *mutex) – удаление мьютекса;

Программа запускается с аргументами – количество элементов массива и число потоков, которые могут работать одновременно. Это число используется для управления созданием потоков.
Инициализируется мьютекс, который будет использоваться для синхронизации доступа к данным.

Создается структура TASK для работы с потоками. Массив из случайных чисел разбивается на несколько диапазонов и в массив потоков передаеются начала и окончания этих диапазонов. Число элементов в каждом массиве определяется по формуле len = MAX_ARRAY_ELEMENTS / MAX_THREADS.

Если количество активных потоков достигает MAX_THREADS, программа ждёт завершения всех этих потоков перед созданием новых.
После завершения всех вычислений выполняется ожидание завершения оставшихся запущенных потоков.
Программа измеряет и выводит затраченное время на выполнение умножения матриц. Это время рассчитывается с помощью стандартной структуры timespec и clock_gettime.

Уничтожение мьютекса после использования.

Узнаем количество логических ядер

irina@Irina-VivoBook src % sysctl -n hw.logicalcpu
4

Число потоков	Время выполнения	Ускорение	Эффективность
1	49344	1,00	1,00
2	27614	1,79	0,895
3	25148	1,96	0,653
4	22725	2,17	0,542
5	21403	2,31	0,462
6	20896	2,36	0,393
7	19226	2,57	0,367
8	16373	3,01	0,376

Код программы

main.c:

```
#include <stdio.h>
#include <stdlib.h>
#include <time.h>
#include <stdint.h>

#if defined (WIN32) || (_WIN64)

#include <windows.h>
#define pthread_t DWORD
#define pthread_create(THREAD_ID_PTR, ATTR, ROUTINE, PARAMS) CreateThread(NULL,0,
(LPTHREAD_START_ROUTINE)ROUTINE,(void*)PARAMS,0,THREAD_ID_PTR)
#define sleep(ms) Sleep(ms)

#else // Linux

#include <pthread.h>
#include <unistd.h>

#endif

typedef struct TASK
{
   int low;
   int high;
   int busy;
   int* a;
}TASK;


void merge(int* a, int low, int mid, int high)
{

   int n1 = mid - low + 1;
   int n2 = high - mid;

   int* left = (int*)malloc(n1 * sizeof(int));
   int* right = (int*)malloc(n2 * sizeof(int));

   int i;
   int j;
```

```
    for (i = 0; i < n1; i++)
        left[i] = a[i + low];


    for (i = 0; i < n2; i++)
        right[i] = a[i + mid + 1];

    int k = low;

    i = j = 0;


    while (i < n1 && j < n2)
    {
        if (left[i] <= right[j])
            a[k++] = left[i++];
        else
            a[k++] = right[j++];
    }


    while (i < n1)
        a[k++] = left[i++];


    while (j < n2)
        a[k++] = right[j++];

    free(left);
    free(right);
}

void merge_sort(int* a, int low, int high)
{
    int mid = low + (high - low) / 2;

    if (low < high)
    {
        merge_sort(a, low, mid);

        merge_sort(a, mid + 1, high);

        merge(a, low, mid, high);
    }
}


void* merge_sort_thread(void* arg)
{
```

```
    TASK* task = (TASK*)arg;
    int low;
    int high;


    low = task->low;
    high = task->high;

    int mid = low + (high - low) / 2;

    if (low < high)
    {
        merge_sort(task->a, low, mid);
        merge_sort(task->a, mid + 1, high);
        merge(task->a, low, mid, high);
    }
    task->busy = 0;
    return 0;
}


int main(int argc, char** argv)
{
    char* sz;

    int MAX_ARRAY_ELEMENTS = 100000000;
    int MAX_THREADS = 1;

    char msg[1024];
    uint32_t msg_len;

    if (argc < 3) {
        msg_len = snprintf(msg, sizeof(msg) - 1, "usage: %s array_count thread_count\n", argv[0]);
        write(STDERR_FILENO, msg, msg_len);
        exit(EXIT_SUCCESS);
    }

    if (argc == 3)
    {
        MAX_ARRAY_ELEMENTS = atoi(argv[1]);
        MAX_THREADS = atoi(argv[2]);
    }

    float time_sec = (float)clock() / CLOCKS_PER_SEC;
    long int start_time;
    start_time = time(NULL);
    msg_len = snprintf(msg, sizeof(msg) - 1, "Now time is: %s", ctime(&start_time));
    write(STDERR_FILENO, msg, msg_len);
```

```
    msg_len = snprintf(msg, sizeof(msg) - 1, "Array[%d]\nThreads[%d]\n", MAX_ARRAY_ELEMENTS,
MAX_THREADS);
    write(STDERR_FILENO, msg, msg_len);

    int* array = (int*)malloc(sizeof(int) * MAX_ARRAY_ELEMENTS);

    clock_t time_start = clock();

    srand(time_start);
    int i;
    for (i = 0; i < MAX_ARRAY_ELEMENTS; i++)
        array[i] = rand();

    msg_len = snprintf(msg, sizeof(msg) - 1, "Array Randomized\n");
    write(STDERR_FILENO, msg, msg_len);

    pthread_t* threads = (pthread_t*)malloc(sizeof(pthread_t) * MAX_THREADS);
    TASK* tasklist = (TASK*)malloc(sizeof(TASK) * MAX_THREADS);


    int len = MAX_ARRAY_ELEMENTS / MAX_THREADS;

    TASK* task;
    int low = 0;


    for (i = 0; i < MAX_THREADS; i++, low += len)
    {
        task = &tasklist[i];
        task->a = array;
        task->busy = 1;

        task->low = low;
        task->high = low + len - 1;
        if (i == (MAX_THREADS - 1))
            task->high = MAX_ARRAY_ELEMENTS - 1;

        pthread_create(&threads[i], 0, merge_sort_thread, task);
    }

#if defined (WIN32) || (_WIN64)
    // ожидаем выполнение всех потоков для windows
    for (i = 0; i < MAX_THREADS; i++)
        while (tasklist[i].busy)
            sleep(10);
#else // Linux
    // ожидаем выполнение всех потоков
    // wait for all threads
    for(i = 0; i < MAX_THREADS; i++)
```

```
        pthread_join(threads[i], NULL);
#endif


    TASK* taskm = &tasklist[0];
    for (i = 1; i < MAX_THREADS; i++)
    {
        TASK* task = &tasklist[i];
        merge(taskm->a, taskm->low, task->low - 1, task->high);
    }


    int last = 0;
    for (i = 0; i < MAX_ARRAY_ELEMENTS; i++)
    {
        if (array[i] < last)
        {
            msg_len = snprintf(msg, sizeof(msg) - 1, "Array is not sorted!\n");
            write(STDERR_FILENO, msg, msg_len);
            return 0;
        }
        last = array[i];
    }

    long int end_time = time(NULL);
    msg_len = snprintf(msg, sizeof(msg) - 1, "Now time is: %s", ctime(&end_time));
    write(STDERR_FILENO, msg, msg_len);
    msg_len = snprintf(msg, sizeof(msg) - 1, "Array sorted in %ld Seconds\n", time(NULL) - start_time);
    write(STDERR_FILENO, msg, msg_len);


    free(tasklist);
    free(threads);

    return 0;
}
```

Протокол работы программы

```
irina@Irina-VivoBook:~/Prog/Prog_C/Kurs2/LabOS/Lab02$ gcc merge_sort.c
irina@Irina-VivoBook:~/Prog/Prog_C/Kurs2/LabOS/Lab02$ ./a.out
usage: ./a.out array_count thread_count
irina@Irina-VivoBook:~/Prog/Prog_C/Kurs2/LabOS/Lab02$ ./a.out 100000000 1
Now time is: Tue Dec  3 11:08:25 2024
Array[100000000]
Threads[1]
Array Randomized
Now time is: Tue Dec  3 11:09:14 2024
Array sorted in 49344 ms
irina@Irina-VivoBook:~/Prog/Prog_C/Kurs2/LabOS/Lab02$ ./a.out 100000000 2
Now time is: Tue Dec  3 11:09:21 2024
Array[100000000]
Threads[2]
```

```
Array Randomized
Now time is: Tue Dec  3 11:09:48 2024
Array sorted in 27614 ms
irina@Irina-VivoBook:~/Prog/Prog_C/Kurs2/LabOS/Lab02$ ./a.out 100000000 3
Now time is: Tue Dec  3 11:09:53 2024
Array[100000000]
Threads[3]
Array Randomized
Now time is: Tue Dec  3 11:10:18 2024
Array sorted in 25148 ms
irina@Irina-VivoBook:~/Prog/Prog_C/Kurs2/LabOS/Lab02$ ./a.out 100000000 4
Now time is: Tue Dec  3 11:10:23 2024
Array[100000000]
Threads[4]
Array Randomized
Now time is: Tue Dec  3 11:10:45 2024
Array sorted in 22725 ms
irina@Irina-VivoBook:~/Prog/Prog_C/Kurs2/LabOS/Lab02$ ./a.out 100000000 5
Now time is: Tue Dec  3 11:10:49 2024
Array[100000000]
Threads[5]
Array Randomized
Now time is: Tue Dec  3 11:11:11 2024
Array sorted in 21403 ms
irina@Irina-VivoBook:~/Prog/Prog_C/Kurs2/LabOS/Lab02$ ./a.out 100000000 6
Now time is: Tue Dec  3 11:11:15 2024
Array[100000000]
Threads[6]
Array Randomized
Now time is: Tue Dec  3 11:11:37 2024
Array sorted in 20896 ms
irina@Irina-VivoBook:~/Prog/Prog_C/Kurs2/LabOS/Lab02$ ./a.out 100000000 7
Now time is: Tue Dec  3 11:11:41 2024
Array[100000000]
Threads[7]
Array Randomized
Now time is: Tue Dec  3 11:12:04 2024
Array sorted in 19226 ms
irina@Irina-VivoBook:~/Prog/Prog_C/Kurs2/LabOS/Lab02$ ./a.out 100000000 8
Now time is: Tue Dec  3 11:12:08 2024
Array[100000000]
Threads[8]
Array Randomized
Now time is: Tue Dec  3 11:12:31 2024
Array sorted in 16373 ms
```

Strace:(сортировка 100000000 элементов массива в 8 потоках)

```
irina@Irina-VivoBook:~/Prog/Prog_C/Kurs2/LabOS/Lab02$ strace -f ./a.out 100000000 8
execve("./a.out", ["./a.out", "100000000", "8"], 0x7ffd9625e418 /* 46 vars */) = 0
brk(NULL)                               = 0x646e9edab000
arch_prctl(0x3001 /* ARCH_??? */, 0x7ffede0fd860) = -1 EINVAL (Недопустимый аргумент)
mmap(NULL, 8192, PROT_READ|PROT_WRITE, MAP_PRIVATE|MAP_ANONYMOUS, -1, 0) =
0x7cf0422cb000
access("/etc/ld.so.preload", R_OK)      = -1 ENOENT (Нет такого файла или каталога)
openat(AT_FDCWD, "/etc/ld.so.cache", O_RDONLY|O_CLOEXEC) = 3
newfstatat(3, "", {st_mode=S_IFREG|0644, st_size=63951, ...}, AT_EMPTY_PATH) = 0
mmap(NULL, 63951, PROT_READ, MAP_PRIVATE, 3, 0) = 0x7cf0422bb000
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\0P\237\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
pread64(3, "\4\0\0\0 \0\0\0\5\0\0\0GNU\0\2\0\0\300\4\0\0\0\3\0\0\0\0\0\0\0"..., 48, 848) = 48
pread64(3, "\4\0\0\0\24\0\0\0\3\0\0\0GNU\0I\17\357\204\3$\f\221\2039x\324\224\323\236S"..., 68, 896)
= 68
newfstatat(3, "", {st_mode=S_IFREG|0755, st_size=2220400, ...}, AT_EMPTY_PATH) = 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, 2264656, PROT_READ, MAP_PRIVATE|MAP_DENYWRITE, 3, 0) = 0x7cf042000000
mprotect(0x7cf042028000, 2023424, PROT_NONE) = 0
mmap(0x7cf042028000, 1658880, PROT_READ|PROT_EXEC, MAP_PRIVATE|MAP_FIXED|
MAP_DENYWRITE, 3, 0x28000) = 0x7cf042028000
mmap(0x7cf0421bd000, 360448, PROT_READ, MAP_PRIVATE|MAP_FIXED|MAP_DENYWRITE, 3,
0x1bd000) = 0x7cf0421bd000
mmap(0x7cf042216000, 24576, PROT_READ|PROT_WRITE, MAP_PRIVATE|MAP_FIXED|
MAP_DENYWRITE, 3, 0x215000) = 0x7cf042216000
mmap(0x7cf04221c000, 52816, PROT_READ|PROT_WRITE, MAP_PRIVATE|MAP_FIXED|
MAP_ANONYMOUS, -1, 0) = 0x7cf04221c000
close(3)                                = 0
mmap(NULL, 12288, PROT_READ|PROT_WRITE, MAP_PRIVATE|MAP_ANONYMOUS, -1, 0) =
0x7cf0422b8000
arch_prctl(ARCH_SET_FS, 0x7cf0422b8740) = 0
set_tid_address(0x7cf0422b8a10)         = 3456
set_robust_list(0x7cf0422b8a20, 24)     = 0
rseq(0x7cf0422b90e0, 0x20, 0, 0x53053053) = 0
mprotect(0x7cf042216000, 16384, PROT_READ) = 0
mprotect(0x646e9ebbf000, 4096, PROT_READ) = 0
mprotect(0x7cf042305000, 8192, PROT_READ) = 0
prlimit64(0, RLIMIT_STACK, NULL, {rlim_cur=8192*1024, rlim_max=RLIM64_INFINITY}) = 0
munmap(0x7cf0422bb000, 63951)           = 0
clock_gettime(CLOCK_PROCESS_CPUTIME_ID, {tv_sec=0, tv_nsec=2310418}) = 0
getrandom("\x99\x7d\x2c\xf5\x15\x51\xfd\x83", 8, GRND_NONBLOCK) = 8
brk(NULL)                               = 0x646e9edab000
brk(0x646e9edcc000)                     = 0x646e9edcc000
openat(AT_FDCWD, "/etc/localtime", O_RDONLY|O_CLOEXEC) = 3
newfstatat(3, "", {st_mode=S_IFREG|0644, st_size=1535, ...}, AT_EMPTY_PATH) = 0
newfstatat(3, "", {st_mode=S_IFREG|0644, st_size=1535, ...}, AT_EMPTY_PATH) = 0
read(3, "TZif2\0\0\0\0\0\0\0\0\0\0\0\0\0\0\0\0\0\0\0\21\0\0\0\21\0\0\0\0"..., 4096) = 1535
lseek(3, -927, SEEK_CUR)                = 608
read(3, "TZif2\0\0\0\0\0\0\0\0\0\0\0\0\0\0\0\0\0\0\0\21\0\0\0\21\0\0\0\0"..., 4096) = 927
close(3)                                = 0
```

```
write(2, "Now time is: Tue Dec  3 11:12:55"..., 38Now time is: Tue Dec  3 11:12:55 2024
) = 38
write(2, "Array[100000000]\nThreads[8]\n", 28Array[100000000]
Threads[8]
) = 28
mmap(NULL, 400003072, PROT_READ|PROT_WRITE, MAP_PRIVATE|MAP_ANONYMOUS, -1, 0)
= 0x7cf02a200000
clock_gettime(CLOCK_PROCESS_CPUTIME_ID, {tv_sec=0, tv_nsec=2952002}) = 0
write(2, "Array Randomized\n", 17Array Randomized
)      = 17
rt_sigaction(SIGRT_1, {sa_handler=0x7cf042091870, sa_mask=[], sa_flags=SA_RESTORER|
SA_ONSTACK|SA_RESTART|SA_SIGINFO, sa_restorer=0x7cf042042520}, 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) =
0x7cf029800000
mprotect(0x7cf029801000, 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=0x7cf02a000910, parent_tid=0x7cf02a000910, exit_signal=0, stack=0x7cf029800000,
stack_size=0x7fff00, tls=0x7cf02a000640}strace: Process 3457 attached
 => {parent_tid=[3457]}, 88) = 3457
[pid  3456] rt_sigprocmask(SIG_SETMASK, [],  <unfinished ...>
[pid  3457] rseq(0x7cf02a000fe0, 0x20, 0, 0x53053053 <unfinished ...>
[pid  3456] <... rt_sigprocmask resumed>NULL, 8) = 0
[pid  3457] <... rseq resumed>)         = 0
[pid  3456] mmap(NULL, 8392704, PROT_NONE, MAP_PRIVATE|MAP_ANONYMOUS|
MAP_STACK, -1, 0 <unfinished ...>
[pid  3457] set_robust_list(0x7cf02a000920, 24 <unfinished ...>
[pid  3456] <... mmap resumed>)         = 0x7cf028e00000
[pid  3457] <... set_robust_list resumed>) = 0
[pid  3456] mprotect(0x7cf028e01000, 8388608, PROT_READ|PROT_WRITE <unfinished ...>
[pid  3457] rt_sigprocmask(SIG_SETMASK, [],  <unfinished ...>
[pid  3456] <... mprotect resumed>)     = 0
[pid  3457] <... rt_sigprocmask resumed>NULL, 8) = 0
[pid  3456] rt_sigprocmask(SIG_BLOCK, ~[],  <unfinished ...>
[pid  3457] mmap(NULL, 134217728, PROT_NONE, MAP_PRIVATE|MAP_ANONYMOUS|
MAP_NORESERVE, -1, 0 <unfinished ...>
[pid  3456] <... rt_sigprocmask resumed>[], 8) = 0
[pid  3457] <... mmap resumed>)         = 0x7cf020e00000
[pid  3456] clone3({flags=CLONE_VM|CLONE_FS|CLONE_FILES|CLONE_SIGHAND|
CLONE_THREAD|CLONE_SYSVSEM|CLONE_SETTLS|CLONE_PARENT_SETTID|
CLONE_CHILD_CLEARTID, child_tid=0x7cf029600910, parent_tid=0x7cf029600910, exit_signal=0,
stack=0x7cf028e00000, stack_size=0x7fff00, tls=0x7cf029600640} <unfinished ...>
[pid  3457] munmap(0x7cf020e00000, 52428800strace: Process 3458 attached
) = 0
[pid  3456] <... clone3 resumed> => {parent_tid=[3458]}, 88) = 3458
[pid  3458] rseq(0x7cf029600fe0, 0x20, 0, 0x53053053 <unfinished ...>
[pid  3457] munmap(0x7cf028000000, 14680064 <unfinished ...>
[pid  3456] rt_sigprocmask(SIG_SETMASK, [],  <unfinished ...>
[pid  3458] <... rseq resumed>)         = 0
[pid  3456] <... rt_sigprocmask resumed>NULL, 8) = 0
[pid  3457] <... munmap resumed>)       = 0
[pid  3456] mmap(NULL, 8392704, PROT_NONE, MAP_PRIVATE|MAP_ANONYMOUS|
```

```
MAP_STACK, -1, 0 <unfinished ...>
[pid  3458] set_robust_list(0x7cf029600920, 24 <unfinished ...>
[pid  3456] <... mmap resumed>)         = 0x7cf028400000
[pid  3457] mprotect(0x7cf024000000, 135168, PROT_READ|PROT_WRITE <unfinished ...>
[pid  3456] mprotect(0x7cf028401000, 8388608, PROT_READ|PROT_WRITE <unfinished ...>
[pid  3458] <... set_robust_list resumed>) = 0
[pid  3456] <... mprotect resumed>)     = 0
[pid  3457] <... mprotect resumed>)     = 0
[pid  3458] rt_sigprocmask(SIG_SETMASK, [],  <unfinished ...>
[pid  3456] rt_sigprocmask(SIG_BLOCK, ~[],  <unfinished ...>
[pid  3458] <... rt_sigprocmask resumed>NULL, 8) = 0
[pid  3458] mmap(NULL, 134217728, PROT_NONE, MAP_PRIVATE|MAP_ANONYMOUS|
MAP_NORESERVE, -1, 0) = 0x7cf01c000000
[pid  3458] munmap(0x7cf020000000, 67108864) = 0
[pid  3458] mprotect(0x7cf01c000000, 135168, PROT_READ|PROT_WRITE) = 0
[pid  3456] <... rt_sigprocmask resumed>[], 8) = 0
[pid  3456] clone3({flags=CLONE_VM|CLONE_FS|CLONE_FILES|CLONE_SIGHAND|
CLONE_THREAD|CLONE_SYSVSEM|CLONE_SETTLS|CLONE_PARENT_SETTID|
CLONE_CHILD_CLEARTID, child_tid=0x7cf028c00910, parent_tid=0x7cf028c00910, exit_signal=0,
stack=0x7cf028400000, stack_size=0x7fff00, tls=0x7cf028c00640}strace: Process 3459 attached
 => {parent_tid=[3459]}, 88) = 3459
[pid  3456] rt_sigprocmask(SIG_SETMASK, [],  <unfinished ...>
[pid  3459] rseq(0x7cf028c00fe0, 0x20, 0, 0x53053053 <unfinished ...>
[pid  3456] <... rt_sigprocmask resumed>NULL, 8) = 0
[pid  3459] <... rseq resumed>)         = 0
[pid  3456] mmap(NULL, 8392704, PROT_NONE, MAP_PRIVATE|MAP_ANONYMOUS|
MAP_STACK, -1, 0) = 0x7cf023600000
[pid  3459] set_robust_list(0x7cf028c00920, 24 <unfinished ...>
[pid  3456] mprotect(0x7cf023601000, 8388608, PROT_READ|PROT_WRITE) = 0
[pid  3459] <... set_robust_list resumed>) = 0
[pid  3456] rt_sigprocmask(SIG_BLOCK, ~[],  <unfinished ...>
[pid  3459] rt_sigprocmask(SIG_SETMASK, [],  <unfinished ...>
[pid  3456] <... rt_sigprocmask resumed>[], 8) = 0
[pid  3456] clone3({flags=CLONE_VM|CLONE_FS|CLONE_FILES|CLONE_SIGHAND|
CLONE_THREAD|CLONE_SYSVSEM|CLONE_SETTLS|CLONE_PARENT_SETTID|
CLONE_CHILD_CLEARTID, child_tid=0x7cf023e00910, parent_tid=0x7cf023e00910, exit_signal=0,
stack=0x7cf023600000, stack_size=0x7fff00, tls=0x7cf023e00640} <unfinished ...>
[pid  3459] <... rt_sigprocmask resumed>NULL, 8) = 0
strace: Process 3460 attached
[pid  3456] <... clone3 resumed> => {parent_tid=[3460]}, 88) = 3460
[pid  3459] mmap(0x7cf020000000, 67108864, PROT_NONE, MAP_PRIVATE|MAP_ANONYMOUS|
MAP_NORESERVE, -1, 0 <unfinished ...>
[pid  3460] rseq(0x7cf023e00fe0, 0x20, 0, 0x53053053 <unfinished ...>
[pid  3456] rt_sigprocmask(SIG_SETMASK, [],  <unfinished ...>
[pid  3459] <... mmap resumed>)         = 0x7cf018000000
[pid  3456] <... rt_sigprocmask resumed>NULL, 8) = 0
[pid  3460] <... rseq resumed>)         = 0
[pid  3456] mmap(NULL, 8392704, PROT_NONE, MAP_PRIVATE|MAP_ANONYMOUS|
MAP_STACK, -1, 0 <unfinished ...>
[pid  3459] mprotect(0x7cf018000000, 135168, PROT_READ|PROT_WRITE <unfinished ...>
[pid  3456] <... mmap resumed>)         = 0x7cf022c00000
[pid  3460] set_robust_list(0x7cf023e00920, 24 <unfinished ...>
[pid  3459] <... mprotect resumed>)     = 0
[pid  3456] mprotect(0x7cf022c01000, 8388608, PROT_READ|PROT_WRITE <unfinished ...>
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[pid  3460] <... set_robust_list resumed>) = 0
[pid  3456] <... mprotect resumed>)     = 0
[pid  3456] rt_sigprocmask(SIG_BLOCK, ~[], [], 8) = 0
[pid  3456] clone3({flags=CLONE_VM|CLONE_FS|CLONE_FILES|CLONE_SIGHAND|
CLONE_THREAD|CLONE_SYSVSEM|CLONE_SETTLS|CLONE_PARENT_SETTID|
CLONE_CHILD_CLEARTID, child_tid=0x7cf023400910, parent_tid=0x7cf023400910, exit_signal=0,
stack=0x7cf022c00000, stack_size=0x7fff00, tls=0x7cf023400640} => {parent_tid=[3461]}, 88) = 3461
[pid  3456] rt_sigprocmask(SIG_SETMASK, [], NULL, 8) = 0
[pid  3456] mmap(NULL, 8392704, PROT_NONE, MAP_PRIVATE|MAP_ANONYMOUS|
MAP_STACK, -1, 0) = 0x7cf022200000
[pid  3456] mprotect(0x7cf022201000, 8388608, PROT_READ|PROT_WRITE) = 0
[pid  3456] rt_sigprocmask(SIG_BLOCK, ~[], [], 8) = 0
[pid  3456] clone3({flags=CLONE_VM|CLONE_FS|CLONE_FILES|CLONE_SIGHAND|
CLONE_THREAD|CLONE_SYSVSEM|CLONE_SETTLS|CLONE_PARENT_SETTID|
CLONE_CHILD_CLEARTID, child_tid=0x7cf022a00910, parent_tid=0x7cf022a00910, exit_signal=0,
stack=0x7cf022200000, stack_size=0x7fff00, tls=0x7cf022a00640} => {parent_tid=[3462]}, 88) = 3462
[pid  3456] rt_sigprocmask(SIG_SETMASK, [], NULL, 8) = 0
[pid  3456] mmap(NULL, 8392704, PROT_NONE, MAP_PRIVATE|MAP_ANONYMOUS|
MAP_STACK, -1, 0) = 0x7cf021800000
[pid  3456] mprotect(0x7cf021801000, 8388608, PROT_READ|PROT_WRITE) = 0
[pid  3456] rt_sigprocmask(SIG_BLOCK, ~[], [], 8) = 0
[pid  3456] clone3({flags=CLONE_VM|CLONE_FS|CLONE_FILES|CLONE_SIGHAND|
CLONE_THREAD|CLONE_SYSVSEM|CLONE_SETTLS|CLONE_PARENT_SETTID|
CLONE_CHILD_CLEARTID, child_tid=0x7cf022000910, parent_tid=0x7cf022000910, exit_signal=0,
stack=0x7cf021800000, stack_size=0x7fff00, tls=0x7cf022000640} => {parent_tid=[3463]}, 88) = 3463
[pid  3456] rt_sigprocmask(SIG_SETMASK, [], NULL, 8) = 0
[pid  3456] mmap(NULL, 8392704, PROT_NONE, MAP_PRIVATE|MAP_ANONYMOUS|
MAP_STACK, -1, 0) = 0x7cf020e00000
[pid  3456] mprotect(0x7cf020e01000, 8388608, PROT_READ|PROT_WRITE) = 0
[pid  3456] rt_sigprocmask(SIG_BLOCK, ~[], [], 8) = 0
[pid  3456] clone3({flags=CLONE_VM|CLONE_FS|CLONE_FILES|CLONE_SIGHAND|
CLONE_THREAD|CLONE_SYSVSEM|CLONE_SETTLS|CLONE_PARENT_SETTID|
CLONE_CHILD_CLEARTID, child_tid=0x7cf021600910, parent_tid=0x7cf021600910, exit_signal=0,
stack=0x7cf020e00000, stack_size=0x7fff00, tls=0x7cf021600640} => {parent_tid=[3464]}, 88) = 3464
[pid  3456] rt_sigprocmask(SIG_SETMASK, [], NULL, 8) = 0
[pid  3456] futex(0x7cf02a000910, FUTEX_WAIT_BITSET|FUTEX_CLOCK_REALTIME, 3457,
NULL, FUTEX_BITSET_MATCH_ANYstrace: Process 3461 attached
 <unfinished ...>
[pid  3461] rseq(0x7cf023400fe0, 0x20, 0, 0x53053053) = 0
[pid  3461] set_robust_list(0x7cf023400920, 24) = 0
[pid  3461] rt_sigprocmask(SIG_SETMASK, [], NULL, 8) = 0
[pid  3461] mmap(NULL, 134217728, PROT_NONE, MAP_PRIVATE|MAP_ANONYMOUS|
MAP_NORESERVE, -1, 0) = 0x7cf010000000
[pid  3461] munmap(0x7cf014000000, 67108864) = 0
[pid  3461] mprotect(0x7cf010000000, 135168, PROT_READ|PROT_WRITE) = 0
strace: Process 3464 attached
strace: Process 3463 attached
strace: Process 3462 attached
[pid  3460] rt_sigprocmask(SIG_SETMASK, [],  <unfinished ...>
[pid  3462] rseq(0x7cf022a00fe0, 0x20, 0, 0x53053053) = 0
[pid  3460] <... rt_sigprocmask resumed>NULL, 8) = 0
[pid  3462] set_robust_list(0x7cf022a00920, 24) = 0
[pid  3462] rt_sigprocmask(SIG_SETMASK, [], NULL, 8) = 0
[pid  3462] mmap(0x7cf014000000, 67108864, PROT_NONE, MAP_PRIVATE|MAP_ANONYMOUS|
MAP_NORESERVE, -1, 0) = 0x7cf00c000000
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[pid  3460] mmap(0x7cf014000000, 67108864, PROT_NONE, MAP_PRIVATE|MAP_ANONYMOUS|
MAP_NORESERVE, -1, 0 <unfinished ...>
[pid  3462] mprotect(0x7cf00c000000, 135168, PROT_READ|PROT_WRITE) = 0
[pid  3460] <... mmap resumed>)         = 0x7cf008000000
[pid  3460] mprotect(0x7cf008000000, 135168, PROT_READ|PROT_WRITE <unfinished ...>
[pid  3463] rseq(0x7cf022000fe0, 0x20, 0, 0x53053053 <unfinished ...>
[pid  3464] rseq(0x7cf021600fe0, 0x20, 0, 0x53053053 <unfinished ...>
[pid  3460] <... mprotect resumed>)     = 0
[pid  3463] <... rseq resumed>)         = 0
[pid  3464] <... rseq resumed>)         = 0
[pid  3464] set_robust_list(0x7cf021600920, 24 <unfinished ...>
[pid  3463] set_robust_list(0x7cf022000920, 24 <unfinished ...>
[pid  3464] <... set_robust_list resumed>) = 0
[pid  3463] <... set_robust_list resumed>) = 0
[pid  3464] rt_sigprocmask(SIG_SETMASK, [],  <unfinished ...>
[pid  3463] rt_sigprocmask(SIG_SETMASK, [],  <unfinished ...>
[pid  3464] <... rt_sigprocmask resumed>NULL, 8) = 0
[pid  3463] <... rt_sigprocmask resumed>NULL, 8) = 0
[pid  3464] mmap(NULL, 134217728, PROT_NONE, MAP_PRIVATE|MAP_ANONYMOUS|
MAP_NORESERVE, -1, 0 <unfinished ...>
[pid  3463] mmap(NULL, 134217728, PROT_NONE, MAP_PRIVATE|MAP_ANONYMOUS|
MAP_NORESERVE, -1, 0 <unfinished ...>
[pid  3464] <... mmap resumed>)         = 0x7cf000000000
[pid  3463] <... mmap resumed>)         = 0x7ceff8000000
[pid  3464] munmap(0x7cf004000000, 67108864 <unfinished ...>
[pid  3463] munmap(0x7ceffc000000, 67108864 <unfinished ...>
[pid  3464] <... munmap resumed>)       = 0
[pid  3463] <... munmap resumed>)       = 0
[pid  3464] mprotect(0x7cf000000000, 135168, PROT_READ|PROT_WRITE <unfinished ...>
[pid  3463] mprotect(0x7ceff8000000, 135168, PROT_READ|PROT_WRITE <unfinished ...>
[pid  3464] <... mprotect resumed>)     = 0
[pid  3463] <... mprotect resumed>)     = 0
[pid  3458] mprotect(0x7cf01c021000, 69632, PROT_READ|PROT_WRITE) = 0
[pid  3458] openat(AT_FDCWD, "/proc/sys/vm/overcommit_memory", O_RDONLY|O_CLOEXEC) = 3
[pid  3458] read(3, "0", 1)             = 1
[pid  3458] close(3)                    = 0
[pid  3458] madvise(0x7cf01c022000, 65536, MADV_DONTNEED) = 0
[pid  3461] mprotect(0x7cf010021000, 69632, PROT_READ|PROT_WRITE) = 0
[pid  3461] madvise(0x7cf010022000, 65536, MADV_DONTNEED) = 0
[pid  3457] mprotect(0x7cf024021000, 69632, PROT_READ|PROT_WRITE) = 0
[pid  3457] madvise(0x7cf024022000, 65536, MADV_DONTNEED) = 0
[pid  3462] mprotect(0x7cf00c021000, 69632, PROT_READ|PROT_WRITE) = 0
[pid  3462] madvise(0x7cf00c022000, 65536, MADV_DONTNEED <unfinished ...>
[pid  3461] madvise(0x7cf010022000, 65536, MADV_DONTNEED) = 0
[pid  3461] mmap(NULL, 196608, PROT_READ|PROT_WRITE, MAP_PRIVATE|
MAP_ANONYMOUS, -1, 0) = 0x7cf042288000
[pid  3461] mmap(NULL, 196608, PROT_READ|PROT_WRITE, MAP_PRIVATE|
MAP_ANONYMOUS, -1, 0) = 0x7cf042258000
[pid  3462] <... madvise resumed>)      = 0
[pid  3461] munmap(0x7cf042288000, 196608) = 0
[pid  3461] munmap(0x7cf042258000, 196608) = 0
[pid  3458] mprotect(0x7cf01c032000, 196608, PROT_READ|PROT_WRITE) = 0
[pid  3458] madvise(0x7cf01c022000, 262144, MADV_DONTNEED) = 0
[pid  3459] mprotect(0x7cf018021000, 69632, PROT_READ|PROT_WRITE) = 0
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[pid  3460] mprotect(0x7cf008021000, 69632, PROT_READ|PROT_WRITE) = 0
[pid  3463] mprotect(0x7ceff8021000, 69632, PROT_READ|PROT_WRITE <unfinished ...>
[pid  3457] mprotect(0x7cf024032000, 196608, PROT_READ|PROT_WRITE) = 0
[pid  3457] madvise(0x7cf024022000, 262144, MADV_DONTNEED) = 0
[pid  3463] <... mprotect resumed>)     = 0
[pid  3462] mprotect(0x7cf00c032000, 196608, PROT_READ|PROT_WRITE <unfinished ...>
[pid  3464] mprotect(0x7cf000021000, 69632, PROT_READ|PROT_WRITE <unfinished ...>
[pid  3462] <... mprotect resumed>)     = 0
[pid  3461] mprotect(0x7cf010032000, 196608, PROT_READ|PROT_WRITE) = 0
[pid  3464] <... mprotect resumed>)     = 0
[pid  3462] madvise(0x7cf00c022000, 262144, MADV_DONTNEED <unfinished ...>
[pid  3461] madvise(0x7cf010022000, 262144, MADV_DONTNEED <unfinished ...>
[pid  3462] <... madvise resumed>)      = 0
[pid  3461] <... madvise resumed>)      = 0
[pid  3461] mmap(NULL, 393216, PROT_READ|PROT_WRITE, MAP_PRIVATE|
MAP_ANONYMOUS, -1, 0) = 0x7cf042258000
[pid  3461] mmap(NULL, 393216, PROT_READ|PROT_WRITE, MAP_PRIVATE|
MAP_ANONYMOUS, -1, 0) = 0x7cf041fa0000
[pid  3461] munmap(0x7cf042258000, 393216) = 0
[pid  3461] munmap(0x7cf041fa0000, 393216) = 0
[pid  3458] mprotect(0x7cf01c062000, 389120, PROT_READ|PROT_WRITE) = 0
[pid  3463] mprotect(0x7ceff8032000, 196608, PROT_READ|PROT_WRITE) = 0
[pid  3462] mprotect(0x7cf00c062000, 389120, PROT_READ|PROT_WRITE) = 0
[pid  3460] mprotect(0x7cf008032000, 196608, PROT_READ|PROT_WRITE <unfinished ...>
[pid  3459] mprotect(0x7cf018032000, 196608, PROT_READ|PROT_WRITE) = 0
[pid  3460] <... mprotect resumed>)     = 0
[pid  3457] mprotect(0x7cf024062000, 389120, PROT_READ|PROT_WRITE <unfinished ...>
[pid  3464] mprotect(0x7cf000032000, 196608, PROT_READ|PROT_WRITE) = 0
[pid  3457] <... mprotect resumed>)     = 0
[pid  3464] mprotect(0x7cf000062000, 389120, PROT_READ|PROT_WRITE) = 0
[pid  3458] mmap(NULL, 782336, PROT_READ|PROT_WRITE, MAP_PRIVATE|
MAP_ANONYMOUS, -1, 0) = 0x7cf02a141000
[pid  3458] munmap(0x7cf02a141000, 782336 <unfinished ...>
[pid  3463] mprotect(0x7ceff8062000, 389120, PROT_READ|PROT_WRITE <unfinished ...>
[pid  3458] <... munmap resumed>)       = 0
[pid  3463] <... mprotect resumed>)     = 0
[pid  3459] mprotect(0x7cf018062000, 389120, PROT_READ|PROT_WRITE) = 0
[pid  3460] mprotect(0x7cf008062000, 389120, PROT_READ|PROT_WRITE <unfinished ...>
[pid  3461] mprotect(0x7cf010062000, 389120, PROT_READ|PROT_WRITE <unfinished ...>
[pid  3460] <... mprotect resumed>)     = 0
[pid  3461] <... mprotect resumed>)     = 0
[pid  3461] mprotect(0x7cf0100c1000, 782336, PROT_READ|PROT_WRITE) = 0
[pid  3461] madvise(0x7cf010022000, 1433600, MADV_DONTNEED) = 0
[pid  3464] mprotect(0x7cf0000c1000, 782336, PROT_READ|PROT_WRITE) = 0
[pid  3464] madvise(0x7cf000022000, 1433600, MADV_DONTNEED) = 0
[pid  3462] mprotect(0x7cf00c0c1000, 782336, PROT_READ|PROT_WRITE) = 0
[pid  3457] mprotect(0x7cf0240c1000, 782336, PROT_READ|PROT_WRITE) = 0
[pid  3457] madvise(0x7cf024022000, 1433600, MADV_DONTNEED <unfinished ...>
[pid  3462] madvise(0x7cf00c022000, 1433600, MADV_DONTNEED) = 0
[pid  3457] <... madvise resumed>)      = 0
[pid  3463] mprotect(0x7ceff80c1000, 782336, PROT_READ|PROT_WRITE) = 0
[pid  3459] mprotect(0x7cf0180c1000, 782336, PROT_READ|PROT_WRITE) = 0
[pid  3463] madvise(0x7ceff8022000, 1433600, MADV_DONTNEED) = 0
[pid  3459] madvise(0x7cf018022000, 1433600, MADV_DONTNEED) = 0
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[pid  3460] mprotect(0x7cf0080c1000, 782336, PROT_READ|PROT_WRITE <unfinished ...>
[pid  3464] madvise(0x7cf000022000, 1433600, MADV_DONTNEED <unfinished ...>
[pid  3460] <... mprotect resumed>)     = 0
[pid  3464] <... madvise resumed>)      = 0
[pid  3464] mmap(NULL, 1564672, PROT_READ|PROT_WRITE, MAP_PRIVATE|
MAP_ANONYMOUS, -1, 0) = 0x7cf02a082000
[pid  3464] mmap(NULL, 1564672, PROT_READ|PROT_WRITE, MAP_PRIVATE|
MAP_ANONYMOUS, -1, 0) = 0x7cf029682000
[pid  3460] madvise(0x7cf008022000, 1433600, MADV_DONTNEED) = 0
[pid  3464] munmap(0x7cf02a082000, 1564672) = 0
[pid  3464] munmap(0x7cf029682000, 1564672) = 0
[pid  3461] mprotect(0x7cf010180000, 1560576, PROT_READ|PROT_WRITE) = 0
[pid  3458] mprotect(0x7cf01c0c1000, 782336, PROT_READ|PROT_WRITE) = 0
[pid  3458] mprotect(0x7cf01c180000, 1560576, PROT_READ|PROT_WRITE) = 0
[pid  3457] mprotect(0x7cf024180000, 1560576, PROT_READ|PROT_WRITE <unfinished ...>
[pid  3460] mprotect(0x7cf008180000, 1560576, PROT_READ|PROT_WRITE <unfinished ...>
[pid  3457] <... mprotect resumed>)     = 0
[pid  3460] <... mprotect resumed>)     = 0
[pid  3462] mprotect(0x7cf00c180000, 1560576, PROT_READ|PROT_WRITE) = 0
[pid  3464] mprotect(0x7cf000180000, 1560576, PROT_READ|PROT_WRITE <unfinished ...>
[pid  3463] mprotect(0x7ceff8180000, 1560576, PROT_READ|PROT_WRITE <unfinished ...>
[pid  3464] <... mprotect resumed>)     = 0
[pid  3459] mprotect(0x7cf018180000, 1560576, PROT_READ|PROT_WRITE <unfinished ...>
[pid  3463] <... mprotect resumed>)     = 0
[pid  3459] <... mprotect resumed>)     = 0
[pid  3464] mmap(NULL, 3125248, PROT_READ|PROT_WRITE, MAP_PRIVATE|
MAP_ANONYMOUS, -1, 0) = 0x7cf020a00000
[pid  3464] munmap(0x7cf020a00000, 3125248) = 0
[pid  3457] mprotect(0x7cf0242fd000, 3125248, PROT_READ|PROT_WRITE) = 0
[pid  3457] madvise(0x7cf024022000, 6119424, MADV_DONTNEED) = 0
[pid  3458] mprotect(0x7cf01c2fd000, 3125248, PROT_READ|PROT_WRITE) = 0
[pid  3458] madvise(0x7cf01c022000, 6119424, MADV_DONTNEED) = 0
[pid  3461] mprotect(0x7cf0102fd000, 3125248, PROT_READ|PROT_WRITE) = 0
[pid  3461] madvise(0x7cf010022000, 6119424, MADV_DONTNEED) = 0
[pid  3460] mprotect(0x7cf0082fd000, 3125248, PROT_READ|PROT_WRITE) = 0
[pid  3463] mprotect(0x7ceff82fd000, 3125248, PROT_READ|PROT_WRITE) = 0
[pid  3460] madvise(0x7cf008022000, 6119424, MADV_DONTNEED) = 0
[pid  3462] mprotect(0x7cf00c2fd000, 3125248, PROT_READ|PROT_WRITE) = 0
[pid  3463] madvise(0x7ceff8022000, 6119424, MADV_DONTNEED) = 0
[pid  3464] mprotect(0x7cf0002fd000, 3125248, PROT_READ|PROT_WRITE) = 0
[pid  3459] mprotect(0x7cf0182fd000, 3125248, PROT_READ|PROT_WRITE) = 0
[pid  3462] madvise(0x7cf00c022000, 6119424, MADV_DONTNEED) = 0
[pid  3464] madvise(0x7cf000022000, 6119424, MADV_DONTNEED) = 0
[pid  3464] mmap(NULL, 6250496, PROT_READ|PROT_WRITE, MAP_PRIVATE|
MAP_ANONYMOUS, -1, 0) = 0x7cf020800000
[pid  3464] mmap(NULL, 6250496, PROT_READ|PROT_WRITE, MAP_PRIVATE|
MAP_ANONYMOUS, -1, 0) = 0x7cf020200000
[pid  3459] madvise(0x7cf018022000, 6119424, MADV_DONTNEED) = 0
[pid  3464] munmap(0x7cf020800000, 6250496) = 0
[pid  3464] munmap(0x7cf020200000, 6250496) = 0
[pid  3458] mprotect(0x7cf01c5f8000, 6250496, PROT_READ|PROT_WRITE) = 0
[pid  3457] mprotect(0x7cf0245f8000, 6250496, PROT_READ|PROT_WRITE) = 0
[pid  3458] madvise(0x7cf01c022000, 12369920, MADV_DONTNEED) = 0
[pid  3463] mprotect(0x7ceff85f8000, 6250496, PROT_READ|PROT_WRITE) = 0
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[pid  3457] madvise(0x7cf024022000, 12369920, MADV_DONTNEED) = 0
[pid  3463] madvise(0x7ceff8022000, 12369920, MADV_DONTNEED) = 0
[pid  3461] mprotect(0x7cf0105f8000, 6250496, PROT_READ|PROT_WRITE) = 0
[pid  3462] mprotect(0x7cf00c5f8000, 6250496, PROT_READ|PROT_WRITE) = 0
[pid  3461] madvise(0x7cf010022000, 12369920, MADV_DONTNEED) = 0
[pid  3462] madvise(0x7cf00c022000, 12369920, MADV_DONTNEED) = 0
[pid  3459] mprotect(0x7cf0185f8000, 6250496, PROT_READ|PROT_WRITE) = 0
[pid  3460] mprotect(0x7cf0085f8000, 6250496, PROT_READ|PROT_WRITE) = 0
[pid  3459] madvise(0x7cf018022000, 12369920, MADV_DONTNEED) = 0
[pid  3460] madvise(0x7cf008022000, 12369920, MADV_DONTNEED) = 0
[pid  3458] madvise(0x7cf01c022000, 12369920, MADV_DONTNEED) = 0
[pid  3458] mmap(NULL, 12500992, PROT_READ|PROT_WRITE, MAP_PRIVATE|
MAP_ANONYMOUS, -1, 0) = 0x7cf020200000
[pid  3458] mmap(NULL, 12500992, PROT_READ|PROT_WRITE, MAP_PRIVATE|
MAP_ANONYMOUS, -1, 0) = 0x7cf017400000
[pid  3464] mprotect(0x7cf0005f8000, 6250496, PROT_READ|PROT_WRITE) = 0
[pid  3464] madvise(0x7cf000022000, 12369920, MADV_DONTNEED) = 0
[pid  3464] mmap(NULL, 12500992, PROT_READ|PROT_WRITE, MAP_PRIVATE|
MAP_ANONYMOUS, -1, 0) = 0x7cf016800000
[pid  3464] mmap(NULL, 12500992, PROT_READ|PROT_WRITE, MAP_PRIVATE|
MAP_ANONYMOUS, -1, 0) = 0x7cf015c00000
[pid  3458] munmap(0x7cf020200000, 12500992) = 0
[pid  3458] munmap(0x7cf017400000, 12500992) = 0
[pid  3461] mprotect(0x7cf010bee000, 12500992, PROT_READ|PROT_WRITE) = 0
[pid  3464] munmap(0x7cf016800000, 12500992) = 0
[pid  3464] munmap(0x7cf015c00000, 12500992) = 0
[pid  3461] madvise(0x7cf010022000, 24870912, MADV_DONTNEED) = 0
[pid  3457] mprotect(0x7cf024bee000, 12500992, PROT_READ|PROT_WRITE) = 0
[pid  3462] mprotect(0x7cf00cbee000, 12500992, PROT_READ|PROT_WRITE) = 0
[pid  3462] madvise(0x7cf00c022000, 24870912, MADV_DONTNEED) = 0
[pid  3463] mprotect(0x7ceff8bee000, 12500992, PROT_READ|PROT_WRITE) = 0
[pid  3457] madvise(0x7cf024022000, 24870912, MADV_DONTNEED) = 0
[pid  3463] madvise(0x7ceff8022000, 24870912, MADV_DONTNEED) = 0
[pid  3459] mprotect(0x7cf018bee000, 12500992, PROT_READ|PROT_WRITE) = 0
[pid  3459] madvise(0x7cf018022000, 24870912, MADV_DONTNEED) = 0
[pid  3460] mprotect(0x7cf008bee000, 12500992, PROT_READ|PROT_WRITE) = 0
[pid  3460] madvise(0x7cf008022000, 24870912, MADV_DONTNEED) = 0
[pid  3461] madvise(0x7cf010022000, 24870912, MADV_DONTNEED) = 0
[pid  3461] mmap(NULL, 25001984, PROT_READ|PROT_WRITE, MAP_PRIVATE|
MAP_ANONYMOUS, -1, 0) = 0x7cf016800000
[pid  3461] mmap(NULL, 25001984, PROT_READ|PROT_WRITE, MAP_PRIVATE|
MAP_ANONYMOUS, -1, 0) = 0x7cf015000000
[pid  3461] munmap(0x7cf016800000, 25001984) = 0
[pid  3461] munmap(0x7cf015000000, 25001984) = 0
[pid  3461] rt_sigprocmask(SIG_BLOCK, ~[RT_1], NULL, 8) = 0
[pid  3461] madvise(0x7cf022c00000, 8368128, MADV_DONTNEED) = 0
[pid  3461] exit(0)                     = ?
[pid  3461] +++ exited with 0 +++
[pid  3462] mprotect(0x7cf00d7da000, 24997888, PROT_READ|PROT_WRITE) = 0
[pid  3457] mprotect(0x7cf0257da000, 24997888, PROT_READ|PROT_WRITE) = 0
[pid  3462] madvise(0x7cf00c021000, 49872896, MADV_DONTNEED <unfinished ...>
[pid  3458] mprotect(0x7cf01cbee000, 12500992, PROT_READ|PROT_WRITE <unfinished ...>
[pid  3462] <... madvise resumed>)      = 0
[pid  3458] <... mprotect resumed>)     = 0
```

```
[pid  3462] rt_sigprocmask(SIG_BLOCK, ~[RT_1], NULL, 8) = 0
[pid  3462] madvise(0x7cf022200000, 8368128, MADV_DONTNEED) = 0
[pid  3462] exit(0)                     = ?
[pid  3462] +++ exited with 0 +++
[pid  3464] mprotect(0x7cf000bee000, 12500992, PROT_READ|PROT_WRITE) = 0
[pid  3457] madvise(0x7cf024021000, 49872896, MADV_DONTNEED) = 0
[pid  3457] rt_sigprocmask(SIG_BLOCK, ~[RT_1], NULL, 8) = 0
[pid  3457] madvise(0x7cf029800000, 8368128, MADV_DONTNEED) = 0
[pid  3457] exit(0)                     = ?
[pid  3457] +++ exited with 0 +++
[pid  3456] <... futex resumed>)        = 0
[pid  3456] futex(0x7cf029600910, FUTEX_WAIT_BITSET|FUTEX_CLOCK_REALTIME, 3458,
NULL, FUTEX_BITSET_MATCH_ANY <unfinished ...>
[pid  3458] mprotect(0x7cf01d7da000, 24997888, PROT_READ|PROT_WRITE) = 0
[pid  3464] mprotect(0x7cf0017da000, 24997888, PROT_READ|PROT_WRITE) = 0
[pid  3458] madvise(0x7cf01c021000, 49872896, MADV_DONTNEED) = 0
[pid  3458] rt_sigprocmask(SIG_BLOCK, ~[RT_1], NULL, 8) = 0
[pid  3458] madvise(0x7cf028e00000, 8368128, MADV_DONTNEED) = 0
[pid  3458] exit(0)                     = ?
[pid  3458] +++ exited with 0 +++
[pid  3456] <... futex resumed>)        = 0
[pid  3456] futex(0x7cf028c00910, FUTEX_WAIT_BITSET|FUTEX_CLOCK_REALTIME, 3459,
NULL, FUTEX_BITSET_MATCH_ANY <unfinished ...>
[pid  3464] madvise(0x7cf000021000, 49872896, MADV_DONTNEED) = 0
[pid  3464] rt_sigprocmask(SIG_BLOCK, ~[RT_1], NULL, 8) = 0
[pid  3464] madvise(0x7cf020e00000, 8368128, MADV_DONTNEED) = 0
[pid  3464] exit(0)                     = ?
[pid  3464] +++ exited with 0 +++
[pid  3459] mprotect(0x7cf0197da000, 24997888, PROT_READ|PROT_WRITE) = 0
[pid  3463] mprotect(0x7ceff97da000, 24997888, PROT_READ|PROT_WRITE) = 0
[pid  3459] madvise(0x7cf018021000, 49872896, MADV_DONTNEED) = 0
[pid  3459] rt_sigprocmask(SIG_BLOCK, ~[RT_1], NULL, 8) = 0
[pid  3459] madvise(0x7cf028400000, 8368128, MADV_DONTNEED) = 0
[pid  3459] exit(0)                     = ?
[pid  3456] <... futex resumed>)        = 0
[pid  3459] +++ exited with 0 +++
[pid  3456] futex(0x7cf023e00910, FUTEX_WAIT_BITSET|FUTEX_CLOCK_REALTIME, 3460,
NULL, FUTEX_BITSET_MATCH_ANY <unfinished ...>
[pid  3463] madvise(0x7ceff8021000, 49872896, MADV_DONTNEED) = 0
[pid  3463] rt_sigprocmask(SIG_BLOCK, ~[RT_1], NULL, 8) = 0
[pid  3463] madvise(0x7cf021800000, 8368128, MADV_DONTNEED) = 0
[pid  3463] exit(0)                     = ?
[pid  3463] +++ exited with 0 +++
[pid  3460] mprotect(0x7cf0097da000, 24997888, PROT_READ|PROT_WRITE) = 0
[pid  3460] madvise(0x7cf008021000, 49872896, MADV_DONTNEED) = 0
[pid  3460] rt_sigprocmask(SIG_BLOCK, ~[RT_1], NULL, 8) = 0
[pid  3460] madvise(0x7cf023600000, 8368128, MADV_DONTNEED) = 0
[pid  3460] exit(0)                     = ?
[pid  3460] +++ exited with 0 +++
<... futex resumed>)                    = 0
munmap(0x7cf029800000, 8392704)         = 0
munmap(0x7cf028e00000, 8392704)         = 0
munmap(0x7cf028400000, 8392704)         = 0
munmap(0x7cf023600000, 8392704)         = 0
```

```
mmap(NULL, 50003968, PROT_READ|PROT_WRITE, MAP_PRIVATE|MAP_ANONYMOUS, -1, 0) =
0x7cf015000000
mmap(NULL, 50003968, PROT_READ|PROT_WRITE, MAP_PRIVATE|MAP_ANONYMOUS, -1, 0) =
0x7cf005000000
munmap(0x7cf015000000, 50003968)        = 0
munmap(0x7cf005000000, 50003968)        = 0
mmap(NULL, 100003840, PROT_READ|PROT_WRITE, MAP_PRIVATE|MAP_ANONYMOUS, -1, 0)
= 0x7ceff2000000
mmap(NULL, 50003968, PROT_READ|PROT_WRITE, MAP_PRIVATE|MAP_ANONYMOUS, -1, 0) =
0x7cf015000000
munmap(0x7ceff2000000, 100003840)       = 0
munmap(0x7cf015000000, 50003968)        = 0
mmap(NULL, 150003712, PROT_READ|PROT_WRITE, MAP_PRIVATE|MAP_ANONYMOUS, -1, 0)
= 0x7cefef000000
mmap(NULL, 50003968, PROT_READ|PROT_WRITE, MAP_PRIVATE|MAP_ANONYMOUS, -1, 0) =
0x7cf015000000
munmap(0x7cefef000000, 150003712)       = 0
munmap(0x7cf015000000, 50003968)        = 0
mmap(NULL, 200003584, PROT_READ|PROT_WRITE, MAP_PRIVATE|MAP_ANONYMOUS, -1, 0)
= 0x7cefec000000
mmap(NULL, 50003968, PROT_READ|PROT_WRITE, MAP_PRIVATE|MAP_ANONYMOUS, -1, 0) =
0x7cf015000000
munmap(0x7cefec000000, 200003584)       = 0
munmap(0x7cf015000000, 50003968)        = 0
mmap(NULL, 250003456, PROT_READ|PROT_WRITE, MAP_PRIVATE|MAP_ANONYMOUS, -1, 0)
= 0x7cefe9000000
mmap(NULL, 50003968, PROT_READ|PROT_WRITE, MAP_PRIVATE|MAP_ANONYMOUS, -1, 0) =
0x7cf015000000
munmap(0x7cefe9000000, 250003456)       = 0
munmap(0x7cf015000000, 50003968)        = 0
mmap(NULL, 300003328, PROT_READ|PROT_WRITE, MAP_PRIVATE|MAP_ANONYMOUS, -1, 0)
= 0x7cefe6000000
mmap(NULL, 50003968, PROT_READ|PROT_WRITE, MAP_PRIVATE|MAP_ANONYMOUS, -1, 0) =
0x7cf015000000
munmap(0x7cefe6000000, 300003328)       = 0
munmap(0x7cf015000000, 50003968)        = 0
mmap(NULL, 350003200, PROT_READ|PROT_WRITE, MAP_PRIVATE|MAP_ANONYMOUS, -1, 0)
= 0x7cefe3200000
mmap(NULL, 50003968, PROT_READ|PROT_WRITE, MAP_PRIVATE|MAP_ANONYMOUS, -1, 0) =
0x7cf015000000
munmap(0x7cefe3200000, 350003200)       = 0
munmap(0x7cf015000000, 50003968)        = 0
newfstatat(AT_FDCWD, "/etc/localtime", {st_mode=S_IFREG|0644, st_size=1535, ...}, 0) = 0
write(2, "Now time is: Tue Dec  3 11:13:18"..., 38Now time is: Tue Dec  3 11:13:18 2024
) = 38
write(2, "Array sorted in 23 Seconds\n", 27Array sorted in 23 Seconds
) = 27
exit_group(0)                           = ?
+++ exited with 0 +++
```

Вывод

В ходе написания данной лабораторной работы я научилась создавать программы, работающие с несколькими потоками, а также синхронизировать их между собой. В результате тестирования программы, я проанализировала каким образом количество потоков влияет на эффективность и ускорение работы программы. Оказалось, что большое количество потоков даёт хорошее ускорение на больших количествах входных данных, но эффективность использования ресурсов находится на приемлемом уровне только на небольшом количестве потоков, не превышающем количества логических ядер процессора. Лабораторная работа была довольно интересна, так как я впервые работал с многопоточностью и синхронизацией на СИ.