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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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Оценка: _____

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Постановка задачи

Вариант 15.

Есть колода из 52 карт, рассчитать экспериментально (метод Монте-Карло) вероятность того, что сверху лежат две одинаковые карты. Количество раундов задается ключом программы.

Общий метод и алгоритм решения

Использованные системные вызовы:

- write() – записываем число байт из буфера в указанный файловый дескриптор
- pthread_mutex_lock() – блокируем мьютекс
- pthread_mutex_unlock() – разблокируем мьютекс
- pthread_exit() – завершаем вызывающий поток
- sem_post() – инкрементируем значение семафора
- pthread_mutex_init() – инициализируем мьютекс
- pthread_create() – создаем новый поток с атрибутами
- pthread_join() – ожидаем завершение потока
- pthread_mutex_destroy() – уничтожаем незаблокированный мьютекс

Создаем мьютекс для синхронизации доступа к переменной, которая считает количество успешных раундов. Также создаем семафора для синхронизации потоков. Потом реализуем несколько потоков. В каждом потоке проводим заданное в аргументах командной строки число раундов, в каждом из них создаем колоду, случайно мешаем ее, проверяем, одинаковые ли верхние карты. Если карты одинаковые, то увеличиваем местный счетчик.

Перед обновлением глобального счетчика мы блокируем мьютекс. После обновления разблокируем его, увеличиваем значение семафора, что говорит о том, что раунд был завершен.

В конце вычисляем итоговую вероятность одинаковых карт, выводя ее в консоль.

Количество потоков (K)	Производительность
1	0,36с
2	0,10с
8	0,2с

Код программы

main.c

```
#include <pthread.h>
#include <unistd.h>
#include <semaphore.h>
#include <stdlib.h>

sem_t thread_sem;
```

```

#define DECK_SIZE 52
pthread_mutex_t success_mutex = PTHREAD_MUTEX_INITIALIZER;

typedef struct {
    int rounds;
    int successes;
} ThreadData;

void shuffle(int *deck) {
    for (int i = DECK_SIZE - 1; i > 0; i--) {
        int j = rand() & (i + 1);
        int tmp = deck[i];
        deck[i] = deck[j];
        deck[j] = tmp;
    }
}

void* monte_carlo(void* arg) {
    ThreadData *data = (ThreadData*)arg;
    int local_successes = 0;

    for (int i = 0; i < data->rounds; i++) {
        int deck[DECK_SIZE];
        for (int j = 0; j < DECK_SIZE; j++) {
...]        deck[j] = j / 4; //[0 0 0 0 1 1 1 1 2 2 2 2 3 3 3 3 4 4 4 4 5 5 5 5 6 6 6 6
        }

        shuffle(deck);
        if (deck[0] == deck[1]) {
            local_successes++;
        }
    }

    if (pthread_mutex_lock(&success_mutex) != 0) {
        char msg[] = "Error lock mutex\n";
        write(STDERR_FILENO, msg, sizeof(msg) - 1);
        pthread_exit((void*)1);
    }

    data->successes += local_successes;

    if (pthread_mutex_unlock(&success_mutex) != 0) {
        char msg[] = "Error unlock mutex\n";
        write(STDERR_FILENO, msg, sizeof(msg) - 1);
        pthread_exit((void *)1);
    }

    if (sem_post(&thread_sem) != 0) {

```

```

        char msg[] = "Error semaphore post\n";
        write(STDERR_FILENO, msg, sizeof(msg) - 1);
    }

    pthread_exit(NULL);
}

int my_atoi(const char *str, int *out) {
    int result = 0;
    int i = 0;
    if (str[i] == '\0' || str[i] == '-') {
        return -1;
    }

    for (; str[i] != '\0'; i++) {
        if (str[i] < '0' || str[i] > '9') {
            return -1;
        }
        result = result * 10 + (str[i] - '0');
    }
    if (result == 0) {
        return -1;
    }

    *out = result;
    return 0;
}

int probability_convert_str(char *str, double probability) {
    int int_part = (int)probability;
    int frac_part = (int)((probability - int_part) * 10000);

    int i = 0;
    str[i++] = '0' + int_part;
    str[i++] = '.';
    for (int j = 1000; j > 0; j /= 10) {
        str[i++] = '0' + (frac_part / j) % 10;
    }

    str[i++] = '\n';
    return i;
}

int main(int argc, char *argv[]) {
    if (argc != 3) {
        char msg[] = "Usage: ./main <rounds> <max_threads>\n";
        write(STDERR_FILENO, msg, sizeof(msg) - 1);
        return 1;
    }

```

```

}

int rounds;
int max_threads;
if (my_atoi(argv[1], &rounds) != 0 || my_atoi(argv[2], &max_threads) != 0) {
    char msg[] = "Invalid input line arguments\n";
    write(STDERR_FILENO, msg, sizeof(msg) - 1);
    return 1;
}

if (sem_init(&thread_sem, 0, max_threads) != 0) {
    char msg[] = "Error init semaphore\n";
    write(STDERR_FILENO, msg, sizeof(msg) - 1);
    return 1;
}

pthread_t threads[max_threads];
ThreadData data = {rounds / max_threads, 0};

for (int i = 0; i < max_threads; i++) {
    if (sem_wait(&thread_sem) != 0) {
        char msg[] = "Error semaphore wait\n";
        write(STDERR_FILENO, msg, sizeof(msg) - 1);
        return 1;
    }

    if (pthread_create(&threads[i], NULL, monte_carlo, &data) != 0) {
        char msg[] = "Error thread creation\n";
        write(STDERR_FILENO, msg, sizeof(msg) - 1);
        return 1;
    }
}

for (int i = 0; i < max_threads; i++) {
    if (pthread_join(threads[i], NULL) != 0) {
        char msg[] = "Error waiting thread\n";
        write(STDERR_FILENO, msg, sizeof(msg) - 1);
        return 1;
    }
}

double probability = (double)data.successes / rounds;
char buf[4096];
int len = probability_convert_str(buf, probability);
write(STDOUT_FILENO, buf, len);

if (sem_destroy(&thread_sem) != 0) {
    char msg[] = "Error destroy semaphore";
    write(STDERR_FILENO, msg, sizeof(msg) - 1);
}

```

```

        return 1;
    }

    return 0;
}

```

Протокол работы программы

Некорректный ввод:

```

(gdb) run r r
Starting program: /home/ares/MAI_OS/lab02/src/main r r
[Thread debugging using libthread_db enabled]
Using host libthread_db library "/lib/x86_64-linux-gnu/libthread_db.so.1".
Invalid input line arguments
[Inferior 1 (process 286899) exited with code 01]
(gdb) 

```

10 раундов, максимум 4 потока:

```

(gdb) run 10 4
Starting program: /home/ares/MAI_OS/lab02/src/main 10 4
[Thread debugging using libthread_db enabled]
Using host libthread_db library "/lib/x86_64-linux-gnu/libthread_db.so.1".
[New Thread 0x7ffff4e00640 (LWP 287111)]
[New Thread 0x7ffff4400640 (LWP 287112)]
[New Thread 0x7ffff3a00640 (LWP 287113)]
[New Thread 0x7ffff3000640 (LWP 287114)]
[New Thread 0x7ffff2600640 (LWP 287115)]
[Thread 0x7ffff3000640 (LWP 287114) exited]
[Thread 0x7ffff2600640 (LWP 287115) exited]
[Thread 0x7ffff3a00640 (LWP 287113) exited]
[Thread 0x7ffff4400640 (LWP 287112) exited]
0.2000
[Thread 0x7ffff4e00640 (LWP 287111) exited]
[Inferior 1 (process 287110) exited normally]
(gdb) 

```

Последние строки запуска для 1000 раундов и максимум 100 потоков:

```

[Thread 0x7ffffb9800640 (LWP 292942) exited]
[New Thread 0x7ffffb8e00640 (LWP 292943)]
[Thread 0x7ffffb8e00640 (LWP 292943) exited]
[New Thread 0x7ffffb8400640 (LWP 292944)]
[Thread 0x7ffffb8400640 (LWP 292944) exited]
[New Thread 0x7ffffb7a00640 (LWP 292945)]
[Thread 0x7ffffb7a00640 (LWP 292945) exited]
[New Thread 0x7ffffb7000640 (LWP 292946)]
[Thread 0x7ffffb7000640 (LWP 292946) exited]
[New Thread 0x7ffffb6600640 (LWP 292947)]
[Thread 0x7ffffb6600640 (LWP 292947) exited]
0.0660
[Thread 0x7ffff7317340 (LWP 292844) exited]
[Thread 0x7ffff4e00640 (LWP 292847) exited]
[New process 292844]
[Inferior 1 (process 292844) exited normally]
(gdb) ~

```

Strace:

```
strace -f ./main 10 10
```

```

execve("./main", ["/main", "10", "10"], 0x7ffd0ee97138 /* 64 vars */) = 0
brk(NULL)                               = 0x5bee1473d000
arch_prctl(0x3001 /* ARCH_??? */, 0x7fff0802dfe0) = -1 EINVAL (Invalid argument)
mmap(NULL, 8192, PROT_READ|PROT_WRITE, MAP_PRIVATE|MAP_ANONYMOUS, -1,
0) = 0x732db5cde000
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
newfstatat(3, "", {st_mode=S_IFREG|0644, st_size=117899, ...}, AT_EMPTY_PATH) = 0
mmap(NULL, 117899, PROT_READ, MAP_PRIVATE, 3, 0) = 0x732db5cc1000
close(3)                                = 0
openat(AT_FDCWD, "/lib/x86_64-linux-gnu/libc.so.6", O_RDONLY|O_CLOEXEC) = 3
read(3, "\177ELF\2\1\1\3\0\0\0\0\0\0\0\3\0>\0\1\0\0\0P\237\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"..., 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"..., 48, 848) = 48
pread64(3, "\4\0\0\0\24\0\0\0\3\0\0\0GNU\0\1\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"..., 784, 64) = 784
mmap(NULL, 2264656, PROT_READ, MAP_PRIVATE|MAP_DENYWRITE, 3, 0) =
0x732db5a00000
mprotect(0x732db5a28000, 2023424, PROT_NONE) = 0
mmap(0x732db5a28000, 1658880, PROT_READ|PROT_EXEC,

```

```

MAP_PRIVATE|MAP_FIXED|MAP_DENYWRITE, 3, 0x28000) = 0x732db5a28000
mmap(0x732db5bbd000, 360448, PROT_READ,
MAP_PRIVATE|MAP_FIXED|MAP_DENYWRITE, 3, 0x1bd000) = 0x732db5bbd000
mmap(0x732db5c16000, 24576, PROT_READ|PROT_WRITE,
MAP_PRIVATE|MAP_FIXED|MAP_DENYWRITE, 3, 0x215000) = 0x732db5c16000
mmap(0x732db5c1c000, 52816, PROT_READ|PROT_WRITE,
MAP_PRIVATE|MAP_FIXED|MAP_ANONYMOUS, -1, 0) = 0x732db5c1c000
close(3) = 0
mmap(NULL, 12288, PROT_READ|PROT_WRITE, MAP_PRIVATE|MAP_ANONYMOUS, -1,
0) = 0x732db5cbe000
arch_prctl(ARCH_SET_FS, 0x732db5cbe740) = 0
set_tid_address(0x732db5cbea10) = 293122
set_robust_list(0x732db5cbea20, 24) = 0
rseq(0x732db5cbf0e0, 0x20, 0, 0x53053053) = 0
mprotect(0x732db5c16000, 16384, PROT_READ) = 0
mprotect(0x5bee1283c000, 4096, PROT_READ) = 0
mprotect(0x732db5d18000, 8192, PROT_READ) = 0
prlimit64(0, RLIMIT_STACK, NULL, {rlim_cur=8192*1024, rlim_max=RLIM64_INFINITY}) =
0
munmap(0x732db5cc1000, 117899) = 0
rt_sigaction(SIGRT_1, {sa_handler=0x732db5a91870, sa_mask=[],
sa_flags=SA_RESTORER|SA_ONSTACK|SA_RESTART|SA_SIGINFO,
sa_restorer=0x732db5a42520}, 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) = 0x732db5000000
mprotect(0x732db5001000, 8388608, PROT_READ|PROT_WRITE) = 0
getrandom("\x3e\x13\x39\x68\x72\xd2\x48\x20", 8, GRND_NONBLOCK) = 8
brk(NULL) = 0x5bee1473d000
brk(0x5bee1475e000) = 0x5bee1475e000
rt_sigprocmask(SIG_BLOCK, ~[], [], 8) = 0
clone3({flags=CLONE_VM|CLONE_FS|CLONE_FILES|CLONE_SIGHAND|CLONE_THREA
D|CLONE_SYSVSEM|CLONE_SETTLS|CLONE_PARENT_SETTID|CLONE_CHILD_CLEAR
TID, child_tid=0x732db5800910, parent_tid=0x732db5800910, exit_signal=0,
stack=0x732db5000000, stack_size=0x7fff00, tls=0x732db5800640}strace: Process 293123
attached
=> {parent_tid=[293123]}, 88) = 293123
[pid 293123] rseq(0x732db5800fe0, 0x20, 0, 0x53053053 <unfinished ...>
[pid 293122] rt_sigprocmask(SIG_SETMASK, [], <unfinished ...>
[pid 293123] <... rseq resumed>) = 0
[pid 293122] <... rt_sigprocmask resumed>NULL, 8) = 0
[pid 293123] set_robust_list(0x732db5800920, 24 <unfinished ...>
[pid 293122] mmap(NULL, 8392704, PROT_NONE,
MAP_PRIVATE|MAP_ANONYMOUS|MAP_STACK, -1, 0 <unfinished ...>
[pid 293123] <... set_robust_list resumed>) = 0
[pid 293122] <... mmap resumed>) = 0x732db4600000

```



```

[pid 293123] rt_sigprocmask(SIG_SETMASK, [], <unfinished ...>
[pid 293122] mprotect(0x732db4601000, 8388608, PROT_READ|PROT_WRITE <unfinished ...>
[pid 293123] <... rt_sigprocmask resumed>NULL, 8) = 0
[pid 293122] <... mprotect resumed>) = 0
[pid 293123] openat(AT_FDCWD, "/etc/ld.so.cache", O_RDONLY|O_CLOEXEC <unfinished ...>
[pid 293122] futex(0x732db5d1aa98, FUTEX_WAIT_PRIVATE, 2, NULL <unfinished ...>
[pid 293123] <... openat resumed>) = 3
[pid 293123] newfstatat(3, "", {st_mode=S_IFREG|0644, st_size=117899, ...},
AT_EMPTY_PATH) = 0
[pid 293123] mmap(NULL, 117899, PROT_READ, MAP_PRIVATE, 3, 0) = 0x732db5cc1000
[pid 293123] close(3) = 0
[pid 293123] mmap(NULL, 134217728, PROT_NONE,
MAP_PRIVATE|MAP_ANONYMOUS|MAP_NORESERVE, -1, 0) = 0x732dac600000
[pid 293123] munmap(0x732dac600000, 60817408) = 0
[pid 293123] munmap(0x732db4000000, 6291456) = 0
[pid 293123] mprotect(0x732db0000000, 135168, PROT_READ|PROT_WRITE) = 0
[pid 293123] openat(AT_FDCWD, "/lib/x86_64-linux-gnu/libgcc_s.so.1",
O_RDONLY|O_CLOEXEC) = 3
[pid 293123] read(3, "\177ELF\2\1\1\0\0\0\0\0\0\0\0\3\0>\0\1\0\0\0\0\0\0\0\0\0\0"..., 832) =
832
[pid 293123] newfstatat(3, "", {st_mode=S_IFREG|0644, st_size=125488, ...},
AT_EMPTY_PATH) = 0
[pid 293123] mmap(NULL, 127720, PROT_READ, MAP_PRIVATE|MAP_DENYWRITE, 3, 0) =
0x732db5c9e000
[pid 293123] mmap(0x732db5ca1000, 94208, PROT_READ|PROT_EXEC,
MAP_PRIVATE|MAP_FIXED|MAP_DENYWRITE, 3, 0x3000) = 0x732db5ca1000
[pid 293123] mmap(0x732db5cb8000, 16384, PROT_READ,
MAP_PRIVATE|MAP_FIXED|MAP_DENYWRITE, 3, 0x1a000) = 0x732db5cb8000
[pid 293123] mmap(0x732db5cbc000, 8192, PROT_READ|PROT_WRITE,
MAP_PRIVATE|MAP_FIXED|MAP_DENYWRITE, 3, 0x1d000) = 0x732db5cbc000
[pid 293123] close(3) = 0
[pid 293123] mprotect(0x732db5cbc000, 4096, PROT_READ) = 0
[pid 293123] futex(0x732db5d1aa98, FUTEX_WAKE_PRIVATE, 1 <unfinished ...>
[pid 293122] <... futex resumed>) = 0
[pid 293123] <... futex resumed>) = 1
[pid 293122] futex(0x732db5d1aa98, FUTEX_WAKE_PRIVATE, 1) = 0
[pid 293123] munmap(0x732db5cc1000, 117899 <unfinished ...>
[pid 293122] rt_sigprocmask(SIG_BLOCK, ~[], <unfinished ...>
[pid 293123] <... munmap resumed>) = 0
[pid 293122] <... rt_sigprocmask resumed>[], 8) = 0
[pid 293123] futex(0x732db5cbd210, FUTEX_WAKE_PRIVATE, 2147483647 <unfinished ...>
[pid 293122]
clone3({flags=CLONE_VM|CLONE_FS|CLONE_FILES|CLONE_SIGHAND|CLONE_THREA
D|CLONE_SYSVSEM|CLONE_SETTLS|CLONE_PARENT_SETTID|CLONE_CHILD_CLEAR
TID, child_tid=0x732db4e00910, parent_tid=0x732db4e00910, exit_signal=0,
stack=0x732db4600000, stack_size=0x7fff00, tls=0x732db4e00640} <unfinished ...>

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[pid 293123] <... futex resumed>)    = 0
strace: Process 293124 attached
[pid 293123] rt_sigprocmask(SIG_BLOCK, ~[RT_1], <unfinished ...>
[pid 293122] <... clone3 resumed> => {parent_tid=[293124]}, 88) = 293124
[pid 293124] rseq(0x732db4e00fe0, 0x20, 0, 0x53053053 <unfinished ...>
[pid 293123] <... rt_sigprocmask resumed>NULL, 8) = 0
[pid 293122] rt_sigprocmask(SIG_SETMASK, [], <unfinished ...>
[pid 293124] <... rseq resumed>)    = 0
[pid 293123] madvise(0x732db5000000, 8368128, MADV_DONTNEED <unfinished ...>
[pid 293122] <... rt_sigprocmask resumed>NULL, 8) = 0
[pid 293124] set_robust_list(0x732db4e00920, 24 <unfinished ...>
[pid 293123] <... madvise resumed>)    = 0
[pid 293122] mmap(NULL, 8392704, PROT_NONE,
MAP_PRIVATE|MAP_ANONYMOUS|MAP_STACK, -1, 0 <unfinished ...>
[pid 293124] <... set_robust_list resumed>) = 0
[pid 293123] exit(0 <unfinished ...>
[pid 293122] <... mmap resumed>)    = 0x732daf600000
[pid 293124] rt_sigprocmask(SIG_SETMASK, [], <unfinished ...>
[pid 293123] <... exit resumed>)    = ?
[pid 293122] mprotect(0x732daf601000, 8388608, PROT_READ|PROT_WRITE <unfinished ...>
[pid 293124] <... rt_sigprocmask resumed>NULL, 8) = 0
[pid 293122] <... mprotect resumed>)    = 0
[pid 293123] +++ exited with 0 +++
[pid 293124] rt_sigprocmask(SIG_BLOCK, ~[RT_1], <unfinished ...>
[pid 293122] rt_sigprocmask(SIG_BLOCK, ~[], [], 8) = 0
[pid 293124] <... rt_sigprocmask resumed>NULL, 8) = 0
[pid 293122]
clone3({flags=CLONE_VM|CLONE_FS|CLONE_FILES|CLONE_SIGHAND|CLONE_THREA
D|CLONE_SYSVSEM|CLONE_SETTLS|CLONE_PARENT_SETTID|CLONE_CHILD_CLEAR
TID, child_tid=0x732dafa00910, parent_tid=0x732dafa00910, exit_signal=0,
stack=0x732daf600000, stack_size=0x7fff00, tls=0x732dafa00640} <unfinished ...>
[pid 293124] madvise(0x732db4600000, 8368128, MADV_DONTNEEDstrace: Process 293125
attached
) = 0
[pid 293122] <... clone3 resumed> => {parent_tid=[293125]}, 88) = 293125
[pid 293125] rseq(0x732dafa00fe0, 0x20, 0, 0x53053053 <unfinished ...>
[pid 293122] rt_sigprocmask(SIG_SETMASK, [], <unfinished ...>
[pid 293124] exit(0 <unfinished ...>
[pid 293125] <... rseq resumed>)    = 0
[pid 293122] <... rt_sigprocmask resumed>NULL, 8) = 0
[pid 293124] <... exit resumed>)    = ?
[pid 293125] set_robust_list(0x732dafa00920, 24 <unfinished ...>
[pid 293122] mmap(NULL, 8392704, PROT_NONE,
MAP_PRIVATE|MAP_ANONYMOUS|MAP_STACK, -1, 0 <unfinished ...>
[pid 293124] +++ exited with 0 +++
[pid 293125] <... set_robust_list resumed>) = 0

```

```

[pid 293122] <... mmap resumed>)    = 0x732daec00000
[pid 293125] rt_sigprocmask(SIG_SETMASK, [], <unfinished ...>
[pid 293122] mprotect(0x732daec01000, 8388608, PROT_READ|PROT_WRITE <unfinished ...>
[pid 293125] <... rt_sigprocmask resumed>NULL, 8) = 0
[pid 293122] <... mprotect resumed>)    = 0
[pid 293125] rt_sigprocmask(SIG_BLOCK, ~[RT_1], <unfinished ...>
[pid 293122] rt_sigprocmask(SIG_BLOCK, ~[], <unfinished ...>
[pid 293125] <... rt_sigprocmask resumed>NULL, 8) = 0
[pid 293122] <... rt_sigprocmask resumed>[], 8) = 0
[pid 293125] madvise(0x732daf600000, 8368128, MADV_DONTNEED <unfinished ...>
[pid 293122]
clone3({flags=CLONE_VM|CLONE_FS|CLONE_FILES|CLONE_SIGHAND|CLONE_THREA
D|CLONE_SYSVSEM|CLONE_SETTLS|CLONE_PARENT_SETTID|CLONE_CHILD_CLEAR
TID, child_tid=0x732daf400910, parent_tid=0x732daf400910, exit_signal=0,
stack=0x732daec00000, stack_size=0x7fff00, tls=0x732daf400640} <unfinished ...>
[pid 293125] <... madvise resumed>)    = 0
strace: Process 293126 attached
[pid 293125] exit(0 <unfinished ...>
[pid 293122] <... clone3 resumed> => {parent_tid=[293126]}, 88) = 293126
[pid 293126] rseq(0x732daf400fe0, 0x20, 0, 0x53053053 <unfinished ...>
[pid 293125] <... exit resumed>)      = ?
[pid 293122] rt_sigprocmask(SIG_SETMASK, [], <unfinished ...>
[pid 293126] <... rseq resumed>)      = 0
[pid 293122] <... rt_sigprocmask resumed>NULL, 8) = 0
[pid 293125] +++ exited with 0 +++
[pid 293126] set_robust_list(0x732daf400920, 24 <unfinished ...>
[pid 293122] mmap(NULL, 8392704, PROT_NONE,
MAP_PRIVATE|MAP_ANONYMOUS|MAP_STACK, -1, 0 <unfinished ...>
[pid 293126] <... set_robust_list resumed>) = 0
[pid 293122] <... mmap resumed>)      = 0x732dae200000
[pid 293126] rt_sigprocmask(SIG_SETMASK, [], <unfinished ...>
[pid 293122] mprotect(0x732dae201000, 8388608, PROT_READ|PROT_WRITE <unfinished ...>
[pid 293126] <... rt_sigprocmask resumed>NULL, 8) = 0
[pid 293122] <... mprotect resumed>)    = 0
[pid 293126] rt_sigprocmask(SIG_BLOCK, ~[RT_1], <unfinished ...>
[pid 293122] rt_sigprocmask(SIG_BLOCK, ~[], <unfinished ...>
[pid 293126] <... rt_sigprocmask resumed>NULL, 8) = 0
[pid 293122] <... rt_sigprocmask resumed>[], 8) = 0
[pid 293126] madvise(0x732daec00000, 8368128, MADV_DONTNEED <unfinished ...>
[pid 293122]
clone3({flags=CLONE_VM|CLONE_FS|CLONE_FILES|CLONE_SIGHAND|CLONE_THREA
D|CLONE_SYSVSEM|CLONE_SETTLS|CLONE_PARENT_SETTID|CLONE_CHILD_CLEAR
TID, child_tid=0x732daea00910, parent_tid=0x732daea00910, exit_signal=0,
stack=0x732dae200000, stack_size=0x7fff00, tls=0x732daea00640} <unfinished ...>
[pid 293126] <... madvise resumed>)    = 0
strace: Process 293127 attached

```

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[pid 293126] exit(0 <unfinished ...>
[pid 293122] <... clone3 resumed> => {parent_tid=[293127]}, 88) = 293127
[pid 293127] rseq(0x732daea00fe0, 0x20, 0, 0x53053053 <unfinished ...>
[pid 293126] <... exit resumed>)      = ?
[pid 293122] rt_sigprocmask(SIG_SETMASK, [], <unfinished ...>
[pid 293127] <... rseq resumed>)      = 0
[pid 293126] +++ exited with 0 +++
[pid 293122] <... rt_sigprocmask resumed>NULL, 8) = 0
[pid 293127] set_robust_list(0x732daea00920, 24 <unfinished ...>
[pid 293122] mmap(NULL, 8392704, PROT_NONE,
MAP_PRIVATE|MAP_ANONYMOUS|MAP_STACK, -1, 0 <unfinished ...>
[pid 293127] <... set_robust_list resumed>) = 0
[pid 293122] <... mmap resumed>)      = 0x732dad800000
[pid 293127] rt_sigprocmask(SIG_SETMASK, [], <unfinished ...>
[pid 293122] mprotect(0x732dad801000, 8388608, PROT_READ|PROT_WRITE <unfinished ...>
[pid 293127] <... rt_sigprocmask resumed>NULL, 8) = 0
[pid 293122] <... mprotect resumed>)  = 0
[pid 293127] rt_sigprocmask(SIG_BLOCK, ~[RT_1], <unfinished ...>
[pid 293122] rt_sigprocmask(SIG_BLOCK, ~[], <unfinished ...>
[pid 293127] <... rt_sigprocmask resumed>NULL, 8) = 0
[pid 293122] <... rt_sigprocmask resumed>[], 8) = 0
[pid 293127] madvise(0x732dae200000, 8368128, MADV_DONTNEED <unfinished ...>
[pid 293122]
clone3({flags=CLONE_VM|CLONE_FS|CLONE_FILES|CLONE_SIGHAND|CLONE_THREA
D|CLONE_SYSVSEM|CLONE_SETTLS|CLONE_PARENT_SETTID|CLONE_CHILD_CLEAR
TID, child_tid=0x732dae000910, parent_tid=0x732dae000910, exit_signal=0,
stack=0x732dad800000, stack_size=0x7fff00, tls=0x732dae000640} <unfinished ...>
[pid 293127] <... madvise resumed>)    = 0
[pid 293127] exit(0strace: Process 293128 attached
<unfinished ...>
[pid 293122] <... clone3 resumed> => {parent_tid=[293128]}, 88) = 293128
[pid 293127] <... exit resumed>)      = ?
[pid 293122] rt_sigprocmask(SIG_SETMASK, [], <unfinished ...>
[pid 293128] rseq(0x732dae000fe0, 0x20, 0, 0x53053053 <unfinished ...>
[pid 293122] <... rt_sigprocmask resumed>NULL, 8) = 0
[pid 293127] +++ exited with 0 +++
[pid 293128] <... rseq resumed>)      = 0
[pid 293122] mmap(NULL, 8392704, PROT_NONE,
MAP_PRIVATE|MAP_ANONYMOUS|MAP_STACK, -1, 0 <unfinished ...>
[pid 293128] set_robust_list(0x732dae000920, 24 <unfinished ...>
[pid 293122] <... mmap resumed>)      = 0x732dace00000
[pid 293128] <... set_robust_list resumed>) = 0
[pid 293122] mprotect(0x732dace01000, 8388608, PROT_READ|PROT_WRITE <unfinished ...>
[pid 293128] rt_sigprocmask(SIG_SETMASK, [], <unfinished ...>
[pid 293122] <... mprotect resumed>)  = 0
[pid 293128] <... rt_sigprocmask resumed>NULL, 8) = 0

```

```

[pid 293122] rt_sigprocmask(SIG_BLOCK, ~[], <unfinished ...>
[pid 293128] rt_sigprocmask(SIG_BLOCK, ~[RT_1], <unfinished ...>
[pid 293122] <... rt_sigprocmask resumed>[], 8) = 0
[pid 293128] <... rt_sigprocmask resumed>NULL, 8) = 0
[pid 293122]
clone3({flags=CLONE_VM|CLONE_FS|CLONE_FILES|CLONE_SIGHAND|CLONE_THREA
D|CLONE_SYSVSEM|CLONE_SETTLS|CLONE_PARENT_SETTID|CLONE_CHILD_CLEAR
TID, child_tid=0x732dad600910, parent_tid=0x732dad600910, exit_signal=0, stack
=0x732dace00000, stack_size=0x7fff00, tls=0x732dad600640} <unfinished ...>
[pid 293128] madvise(0x732dad800000, 8368128, MADV_DONTNEED) = 0
[pid 293128] exit(0strace: Process 293129 attached
)
= ?
[pid 293122] <... clone3 resumed> => {parent_tid=[293129]}, 88) = 293129
[pid 293129] rseq(0x732dad600fe0, 0x20, 0, 0x53053053 <unfinished ...>
[pid 293122] rt_sigprocmask(SIG_SETMASK, [], <unfinished ...>
[pid 293128] +++ exited with 0 +++
[pid 293129] <... rseq resumed> ) = 0
[pid 293122] <... rt_sigprocmask resumed>NULL, 8) = 0
[pid 293129] set_robust_list(0x732dad600920, 24 <unfinished ...>
[pid 293122] mmap(NULL, 8392704, PROT_NONE,
MAP_PRIVATE|MAP_ANONYMOUS|MAP_STACK, -1, 0 <unfinished ...>
[pid 293129] <... set_robust_list resumed>) = 0
[pid 293122] <... mmap resumed> ) = 0x732dac400000
[pid 293129] rt_sigprocmask(SIG_SETMASK, [], <unfinished ...>
[pid 293122] mprotect(0x732dac401000, 8388608, PROT_READ|PROT_WRITE <unfinished ...>
[pid 293129] <... rt_sigprocmask resumed>NULL, 8) = 0
[pid 293122] <... mprotect resumed> ) = 0
[pid 293129] rt_sigprocmask(SIG_BLOCK, ~[RT_1], <unfinished ...>
[pid 293122] rt_sigprocmask(SIG_BLOCK, ~[], <unfinished ...>
[pid 293129] <... rt_sigprocmask resumed>NULL, 8) = 0
[pid 293122] <... rt_sigprocmask resumed>[], 8) = 0
[pid 293129] madvise(0x732dace00000, 8368128, MADV_DONTNEED <unfinished ...>
[pid 293122]
clone3({flags=CLONE_VM|CLONE_FS|CLONE_FILES|CLONE_SIGHAND|CLONE_THREA
D|CLONE_SYSVSEM|CLONE_SETTLS|CLONE_PARENT_SETTID|CLONE_CHILD_CLEAR
TID, child_tid=0x732dacc00910, parent_tid=0x732dacc00910, exit_signal=0,
stack=0x732dac400000, stack_size=0x7fff00, tls=0x732dacc00640} <unfinished ...>
[pid 293129] <... madvise resumed> ) = 0
[pid 293129] exit(0strace: Process 293130 attached
)
= ?
[pid 293122] <... clone3 resumed> => {parent_tid=[293130]}, 88) = 293130
[pid 293130] rseq(0x732dacc00fe0, 0x20, 0, 0x53053053 <unfinished ...>
[pid 293129] +++ exited with 0 +++
[pid 293122] rt_sigprocmask(SIG_SETMASK, [], <unfinished ...>
[pid 293130] <... rseq resumed> ) = 0
[pid 293122] <... rt_sigprocmask resumed>NULL, 8) = 0

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[pid 293130] set_robust_list(0x732dacc00920, 24 <unfinished ...>
[pid 293122] mmap(NULL, 8392704, PROT_NONE,
MAP_PRIVATE|MAP_ANONYMOUS|MAP_STACK, -1, 0 <unfinished ...>
[pid 293130] <... set_robust_list resumed>) = 0
[pid 293122] <... mmap resumed>) = 0x732daba00000
[pid 293130] rt_sigprocmask(SIG_SETMASK, [], <unfinished ...>
[pid 293122] mprotect(0x732daba01000, 8388608, PROT_READ|PROT_WRITE <unfinished ...>
[pid 293130] <... rt_sigprocmask resumed>NULL, 8) = 0
[pid 293122] <... mprotect resumed>) = 0
[pid 293130] rt_sigprocmask(SIG_BLOCK, ~[RT_1], <unfinished ...>
[pid 293122] rt_sigprocmask(SIG_BLOCK, ~[], <unfinished ...>
[pid 293130] <... rt_sigprocmask resumed>NULL, 8) = 0
[pid 293122] <... rt_sigprocmask resumed>[], 8) = 0
[pid 293130] madvise(0x732dac400000, 8368128, MADV_DONTNEED <unfinished ...>
[pid 293122]
clone3({flags=CLONE_VM|CLONE_FS|CLONE_FILES|CLONE_SIGHAND|CLONE_THREA
D|CLONE_SYSVSEM|CLONE_SETTLS|CLONE_PARENT_SETTID|CLONE_CHILD_CLEAR
TID, child_tid=0x732dac200910, parent_tid=0x732dac200910, exit_signal=0,
stack=0x732daba00000, stack_size=0x7fff00, tls=0x732dac200640} <unfinished ...>
[pid 293130] <... madvise resumed>) = 0
[pid 293130] exit(0strace: Process 293131 attached
) = ?
[pid 293122] <... clone3 resumed>=> {parent_tid=[293131]}, 88) = 293131
[pid 293131] rseq(0x732dac200fe0, 0x20, 0, 0x53053053 <unfinished ...>
[pid 293130] +++ exited with 0 +++
[pid 293122] rt_sigprocmask(SIG_SETMASK, [], <unfinished ...>
[pid 293131] <... rseq resumed>) = 0
[pid 293122] <... rt_sigprocmask resumed>NULL, 8) = 0
[pid 293131] set_robust_list(0x732dac200920, 24 <unfinished ...>
[pid 293122] mmap(NULL, 8392704, PROT_NONE,
MAP_PRIVATE|MAP_ANONYMOUS|MAP_STACK, -1, 0 <unfinished ...>
[pid 293131] <... set_robust_list resumed>) = 0
[pid 293122] <... mmap resumed>) = 0x732dab000000
[pid 293131] rt_sigprocmask(SIG_SETMASK, [], <unfinished ...>
[pid 293122] mprotect(0x732dab001000, 8388608, PROT_READ|PROT_WRITE <unfinished ...>
[pid 293131] <... rt_sigprocmask resumed>NULL, 8) = 0
[pid 293122] <... mprotect resumed>) = 0
[pid 293131] rt_sigprocmask(SIG_BLOCK, ~[RT_1], <unfinished ...>
[pid 293122] rt_sigprocmask(SIG_BLOCK, ~[], <unfinished ...>
[pid 293131] <... rt_sigprocmask resumed>NULL, 8) = 0
[pid 293122] <... rt_sigprocmask resumed>[], 8) = 0
[pid 293131] madvise(0x732daba00000, 8368128, MADV_DONTNEED <unfinished ...>
[pid 293122]
clone3({flags=CLONE_VM|CLONE_FS|CLONE_FILES|CLONE_SIGHAND|CLONE_THREA
D|CLONE_SYSVSEM|CLONE_SETTLS|CLONE_PARENT_SETTID|CLONE_CHILD_CLEAR
TID, child_tid=0x732dab800910, parent_tid=0x732dab800910, exit_signal=0,

```

```

stack=0x732dab000000, stack_size=0x7fff00, tls=0x732dab800640} <unfinished ...>
[pid 293131] <... madvise resumed>)    = 0
[pid 293131] exit(0strace: Process 293132 attached
)
    = ?
[pid 293122] <... clone3 resumed> => {parent_tid=[293132]}, 88) = 293132
[pid 293132] rseq(0x732dab800fe0, 0x20, 0, 0x53053053 <unfinished ...>
[pid 293131] +++ exited with 0 +++
[pid 293122] rt_sigprocmask(SIG_SETMASK, [], <unfinished ...>
[pid 293132] <... rseq resumed>)      = 0
[pid 293122] <... rt_sigprocmask resumed>NULL, 8) = 0
[pid 293132] set_robust_list(0x732dab800920, 24 <unfinished ...>
[pid 293122] munmap(0x732db5000000, 8392704 <unfinished ...>
[pid 293132] <... set_robust_list resumed>) = 0
[pid 293122] <... munmap resumed>)    = 0
[pid 293132] rt_sigprocmask(SIG_SETMASK, [], <unfinished ...>
[pid 293122] munmap(0x732db4600000, 8392704 <unfinished ...>
[pid 293132] <... rt_sigprocmask resumed>NULL, 8) = 0
[pid 293122] <... munmap resumed>)    = 0
[pid 293132] rt_sigprocmask(SIG_BLOCK, ~[RT_1], <unfinished ...>
[pid 293122] munmap(0x732daf600000, 8392704 <unfinished ...>
[pid 293132] <... rt_sigprocmask resumed>NULL, 8) = 0
[pid 293122] <... munmap resumed>)    = 0
[pid 293132] madvise(0x732dab000000, 8368128, MADV_DONTNEED <unfinished ...>
[pid 293122] munmap(0x732daec00000, 8392704 <unfinished ...>
[pid 293132] <... madvise resumed>)    = 0
[pid 293122] <... munmap resumed>)    = 0
[pid 293132] exit(0 <unfinished ...>
[pid 293122] munmap(0x732dae200000, 8392704 <unfinished ...>
[pid 293132] <... exit resumed>)      = ?
[pid 293122] <... munmap resumed>)    = 0
[pid 293132] +++ exited with 0 +++
munmap(0x732dad800000, 8392704)      = 0
write(1, "0.2000\n", 70.2000
)
    = 7
exit_group(0)                        = ?
+++ exited with 0 +++

```

Вывод

Язык Си с библиотеками предоставляет возможность построения многопоточных приложений, дает инструменты для работы с потоками, их ограничения для безопасности. Все это делает разработку на Си многообразнее и интереснее.