МОСКОВСКИЙ АВИАЦИОННЫЙ ИНСТИТУТ
(НАЦИОНАЛЬНЫЙ ИССЛЕДОВАТЕЛЬСКИЙ УНИВЕРСИТЕТ)

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Лабораторная работа №1
по курсу «Операционные системы»

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Условие

Родительский процесс создает два дочерних процесса. Первой строкой пользователь в консоль родительского процесса вводит имя файла, которое будет использовано для открытия File с таким именем на запись для child1. Аналогично для второй строки и процесса child2. Родительский и дочерний процесс должны быть представлены разными программами. Родительский процесс принимает от пользователя строки произвольной длины и пересылает их в pipe1 или в pipe2 в зависимости от правила фильтрации. Процесс child1 и child2 производят работу над строками. Процессы пишут результаты своей работы в стандартный вывод.

Цель работы

Изучение механизмов создания процессов, организации межпроцессного взаимодействия через pipes и обработки данных в многопроцессной архитектуре.

Задание

Правило фильтрации: нечетные строки отправляются в pipe1, четные в pipe2. Дочерние процессы инвертируют строки.

Вариант

21

Метод решения

Данная программа реализует многопроцессную обработку текстовых данных с использованием каналов (pipes) для межпроцессного взаимодействия. Основной алгоритм: родительский процесс читает строки из стандартного ввода и направляет нечетные строки первому дочернему процессу, четные - второму. Каждый дочерний процесс получает строки из своего канала, реверсирует их и записывает в указанный файл.

Ключевые компоненты:
ParentProcess - управляет каналами и дочерними процессами
Pipe - кросс-платформенная реализация каналов
ChildProcess - запускает дочерние процессы
ChildProcessor - обрабатывает данные в дочерних процессах

Системные вызовы:
Windows: CreatePipe, CreateProcess, ReadFile, WriteFile
Linux: pipe, fork, execl, read, write

Программа использует объектно-ориентированный подход с инкапсуляцией платформозависимых особенностей, что обеспечивает кроссплатформенность и четкое разделение ответственности между модулями.

Описание программы

Программа реализует многопроцессную обработку текстовых данных через каналы (pipes). Родительский процесс читает строки из стандартного ввода и распределяет их между двумя дочерними процессами: нечетные строки отправляются первому процессу, четные - второму.
Каждый дочерний процесс переворачивает полученные строки задом наперед и записывает результат в указанный файл.

Архитектура программы включает несколько модулей.
В main.cpp находится точка входа, создающая ParentProcess.
Класс ParentProcess (process.cpp) управляет всей работой: создает каналы, запрашивает имена файлов, запускает дочерние процессы и распределяет данные.
Класс Pipe (pipe.cpp) инкапсулирует работу с каналами, используя CreatePipe на Windows и pipe на Linux. Класс ChildProcess (childProcess.cpp/hpp) отвечает за запуск дочерних процессов через CreateProcess (Windows) или fork/execl (Linux).
ChildProcessor (childProcessor.cpp/hpp) обрабатывает данные в дочерних процессах: читает из канала, переворачивает строки и записывает в файл.

Результаты

Разработанная программа успешно реализует многопроцессную архитектуру для параллельной обработки текстовых данных.
В ходе решения были достигнуты следующие ключевые результаты:
Корректная работа системы межпроцессного взаимодействия
Реализованы два независимых канала передачи данных между родительским и дочерними процессами
Обеспечено четкое распределение строк по принципу четности/нечетности
Достигнута синхронизация процессов через блокирующие операции чтения/записи
Кросс-платформенная функциональность
Программа корректно работает как в Windows, так и в Linux/Unix системах
Реализована унифицированная абстракция для работы с каналами через класс Pipe
Обеспечен единый интерфейс для создания процессов на разных платформах

Выводы

В ходе лабораторной работы успешно разработана многопроцессная система обработки текстовых данных с использованием межпроцессного взаимодействия через каналы. Программа демонстрирует корректную работу в кросс-платформенном режиме на Windows и Unix системах.

Исходная программа

```
#include "process.hpp"

int main() {
    ParentProcess parent;
    parent.start();
    return 0;
}
```

Листинг 1: main.cpp - точка входа, создает ParentProcess

```
#include <iostream>
#include <string>
#include "process.hpp"

#ifdef _WIN32
    #include <windows.h>
    #include <io.h>
    #define close _close
    #define read _read
    #define write _write
#else
    #include <unistd.h>
    #include <sys/wait.h>
    #include <fcntl.h>
#endif

ParentProcess::ParentProcess() {
    std::string file1, file2;
    std::cout << "    child1: ";
    std::getline(std::cin, file1);
    std::cout << "    child2: ";
    std::getline(std::cin, file2);

    pipe1 = new Pipe();
    pipe2 = new Pipe();
    child1 = new ChildProcess(pipe1, file1, true);
    child2 = new ChildProcess(pipe2, file2, false);
}

void ParentProcess::start() {
    child1->execute();
    child2->execute();

    close(pipe1->getReadFd());
    close(pipe2->getReadFd());

    std::string line;
    int line_number = 0;

    while (std::getline(std::cin, line))
    {
        line_number++;
        if (line_number % 2 == 1) {
            write(pipe1->getWriteFd(), line.c_str(), line.length());
            write(pipe1->getWriteFd(), "\n", 1);
```

```
        } else {
            write(pipe2->getWriteFd(), line.c_str(), line.length());
            write(pipe2->getWriteFd(), "\n", 1);
        }
    }

    close(pipe1->getWriteFd());
    close(pipe2->getWriteFd());

#ifdef _WIN32
    Sleep(1000);
#else
    /*
    int status1, status2;
    waitpid(child1->getPid(), &status1, 0);
    waitpid(child2->getPid(), &status2, 0);
    */
#endif
}

ParentProcess::~ParentProcess() {
    delete child1;
    delete child2;
    delete pipe1;
    delete pipe2;
}
```

Листинг 2: process.cpp - класс ParentProcess, управляет дочерними процессами

```
#include <string>
#include <iostream>
#include <cstdlib>
#include "childProcess.hpp"

#ifdef _WIN32
    #include <windows.h>
#else
    #include <unistd.h>
    #include <sys/wait.h>
#endif

ChildProcess::ChildProcess(Pipe* p, const std::string& f, bool is_c1)
    : pipe(p), file_name(f), is_child1(is_c1), pid(-1) {}

void ChildProcess::execute() {
#ifdef _WIN32
    STARTUPINFOA si;
    PROCESS_INFORMATION pi;
    ZeroMemory(&si, sizeof(si));
    si.cb = sizeof(si);
    ZeroMemory(&pi, sizeof(pi));

    std::string read_fd_str = std::to_string((int)pipe->getReadFd());
    std::string prefix = is_child1 ? "child1" : "child2";

    std::string command = "child.exe " + prefix + " " + file_name + " " + read_fd_str;

```

```
    if (!CreateProcess(NULL, (LPSTR)command.c_str(), NULL, NULL,
                       TRUE, 0, NULL, NULL, &si, &pi)) {
        std::cerr << "   " << std::endl;
        exit(1);
    }

    pid = pi.dwProcessId;
    CloseHandle(pi.hThread);
#else
    pid = fork();
    if (pid == -1) {
        perror("   ");
        exit(1);
    }

    if (pid == 0) {
        close(pipe->getWriteFd());

        std::string read_fd_str = std::to_string(pipe->getReadFd());
        std::string prefix = is_child1 ? "child1" : "child2";

        execl("./child", "./child", prefix.c_str(), file_name.c_str(),
              read_fd_str.c_str(), nullptr);

        perror("    ");
        exit(1);
    }
    else {
        close(pipe->getReadFd());
    }
#endif
}

#ifdef _WIN32
DWORD ChildProcess::getPid() const {
    return pid;
}
#else
pid_t ChildProcess::getPid() const {
    return pid;
}
#endif
```

Листинг 3: childProcess.cpp - класс ChildProcess, запуск дочерних процессов

```
#include <iostream>
#include <cstdlib>
#include <string>
#include "childProcessor.hpp"

#ifdef _WIN32
    #include <windows.h>
    #include <io.h>
#endif

int main(int argc, char* argv[]) {
    if (argc != 4) {
```

```
        std::cerr << ": " << argv[0] << " <prefix> <output_file> <read_fd>" << std::
            endl;
        return 1;
    }

    std::string prefix = argv[1];
    std::string output_file = argv[2];
    int read_fd = std::atoi(argv[3]);

    std::cout << prefix << ":    " << output_file << std::endl;

    ChildProcessor processor(prefix);
    return processor.process(read_fd, output_file);
}
```

Листинг 4: child main.cpp - точка входа дочернего процесса

```
#include <iostream>
#include <string>
#include <cstdlib>
#include "childProcessor.hpp"

#ifdef _WIN32
    #include <windows.h>
    #include <io.h>
    #include <fcntl.h>
    #define close _close
    #define read _read
    #define write _write
    #define open _open
    #define O_WRONLY _O_WRONLY
    #define O_CREAT _O_CREAT
    #define O_TRUNC _O_TRUNC
#else
    #include <unistd.h>
    #include <fcntl.h>
#endif

ChildProcessor::ChildProcessor(const std::string& pref) : prefix(pref) {}

std::string ChildProcessor::reverseString(const std::string& s) {
    size_t len = s.length();
    std::string result;
    for (size_t i = len; i > 0; --i) {
        result += s[i - 1];
    }
    return result;
}

int ChildProcessor::process(int read_fd, const std::string& output_file) {
#ifdef _WIN32
    int fd = open(output_file.c_str(), O_WRONLY | O_CREAT | O_TRUNC, _S_IREAD |
        _S_IWRITE);
#else
    int fd = open(output_file.c_str(), O_WRONLY | O_CREAT | O_TRUNC, 0644);
#endif

```

```
    if (fd == -1) {
        perror("     ");
        return 1;
    }

    ssize_t count;
    while ((count = read(read_fd, buffer, sizeof(buffer) - 1)) > 0)
    {
        buffer[count] = '\0';
        std::string line(buffer);
        std::string reversed = reverseString(line);
        write(fd, reversed.c_str(), reversed.length());
    }

    if (count == -1) {
        perror("   ");
    }

    close(read_fd);
    close(fd);
    return 0;
}
```

Листинг 5: childProcessor.cpp - класс ChildProcessor, обработка строк

```
#include <iostream>
#include <cstdlib>
#include "pipe.hpp"

#ifdef _WIN32
#include <io.h>
#define close _close
#define read _read
#define write _write
#endif

Pipe::Pipe() {
#ifdef _WIN32
    SECURITY_ATTRIBUTES sa;
    sa.nLength = sizeof(SECURITY_ATTRIBUTES);
    sa.bInheritHandle = TRUE;
    sa.lpSecurityDescriptor = NULL;

    if (!CreatePipe(&read_fd, &write_fd, &sa, 0)) {
        std::cerr << "   " << std::endl;
        exit(1);
    }
#else
    if (pipe(fd) == -1) {
        perror("   ");
        exit(1);
    }
#endif
}

int Pipe::getReadFd() const {
#ifdef _WIN32
```

```
    return (int)read_fd;
#else
    return fd[0];
#endif
}

int Pipe::getWriteFd() const {
#ifdef _WIN32
    return (int)write_fd;
#else
    return fd[1];
#endif
}

Pipe::~Pipe() {
#ifdef _WIN32
    CloseHandle(read_fd);
    CloseHandle(write_fd);
#else
    close(fd[0]);
    close(fd[1]);
#endif
}
```

Листинг 6: pipe.cpp - класс Pipe, работа с каналами

Системные вызовы

```
274130 execve("./parent",["./parent"],0x7ffcd3e49d68 /* 36 vars */) = 0
274130 brk(NULL)                           = 0x63bd01b85000
274130 mmap(NULL,8192,PROT_READ|PROT_WRITE,MAP_PRIVATE|MAP_ANONYMOUS,-1,0)
= 0x79c2f692d000
274130 access("/etc/ld.so.preload",R_OK) = -1 ENOENT (No such file or directory)
274130 openat(AT_FDCWD,"/etc/ld.so.cache",O_RDONLY|O_CLOEXEC) = 3
274130 fstat(3,{st_mode=S_IFREG|0644,st_size=33163,...}) = 0
274130 mmap(NULL,33163,PROT_READ,MAP_PRIVATE,3,0) = 0x79c2f6924000
274130 close(3)                            = 0
274130 openat(AT_FDCWD,"/lib/x86_64-linux-gnu/libstdc++.so.6",O_RDONLY|O_CLOEXEC)
= 3
274130 read(3,"\177ELF\2\1\1\3\0\0\0\0\0\0\0\0\3\0>\0\1\0\0\0\0\0\0\0\0\0\0\0"...,832
= 832
274130 fstat(3,{st_mode=S_IFREG|0644,st_size=2592224,...}) = 0
274130 mmap(NULL,2609472,PROT_READ,MAP_PRIVATE|MAP_DENYWRITE,3,0) = 0x79c2f6600000
274130 mmap(0x79c2f669d000,1343488,PROT_READ|PROT_EXEC,MAP_PRIVATE|MAP_FIXED|MAP_DENY
= 0x79c2f669d000
274130 mmap(0x79c2f67e5000,552960,PROT_READ,MAP_PRIVATE|MAP_FIXED|MAP_DENYWRITE,3,0x1
= 0x79c2f67e5000
274130 mmap(0x79c2f686c000,57344,PROT_READ|PROT_WRITE,MAP_PRIVATE|MAP_FIXED|MAP_DENYW
= 0x79c2f686c000
274130 mmap(0x79c2f687a000,12608,PROT_READ|PROT_WRITE,MAP_PRIVATE|MAP_FIXED|MAP_ANONY
= 0x79c2f687a000
274130 close(3)                            = 0
```

```
274130 openat(AT_FDCWD,"/lib/x86_64-linux-gnu/libgcc_s.so.1",O_RDONLY|O_CLOEXEC)
= 3
274130 read(3,"\177ELF\2\1\1\0\0\0\0\0\0\0\0\0\3\0>\0\1\0\0\0\0\0\0\0\0\0\0\0"...,832
= 832
274130 fstat(3,{st_mode=S_IFREG|0644,st_size=183024,...}) = 0
274130 mmap(NULL,185256,PROT_READ,MAP_PRIVATE|MAP_DENYWRITE,3,0) = 0x79c2f68f6000
274130 mmap(0x79c2f68fa000,147456,PROT_READ|PROT_EXEC,MAP_PRIVATE|MAP_FIXED|MAP_DENYW
= 0x79c2f68fa000
274130 mmap(0x79c2f691e000,16384,PROT_READ,MAP_PRIVATE|MAP_FIXED|MAP_DENYWRITE,3,0x28
= 0x79c2f691e000
274130 mmap(0x79c2f6922000,8192,PROT_READ|PROT_WRITE,MAP_PRIVATE|MAP_FIXED|MAP_DENYWR
= 0x79c2f6922000
274130 close(3)                         = 0
274130 openat(AT_FDCWD,"/lib/x86_64-linux-gnu/libc.so.6",O_RDONLY|O_CLOEXEC)
= 3
274130 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
274130 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"...,78
= 784
274130 fstat(3,{st_mode=S_IFREG|0755,st_size=2125328,...}) = 0
274130 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"...,78
= 784
274130 mmap(NULL,2170256,PROT_READ,MAP_PRIVATE|MAP_DENYWRITE,3,0) = 0x79c2f6200000
274130 mmap(0x79c2f6228000,1605632,PROT_READ|PROT_EXEC,MAP_PRIVATE|MAP_FIXED|MAP_DENY
= 0x79c2f6228000
274130 mmap(0x79c2f63b0000,323584,PROT_READ,MAP_PRIVATE|MAP_FIXED|MAP_DENYWRITE,3,0x1
= 0x79c2f63b0000
274130 mmap(0x79c2f63ff000,24576,PROT_READ|PROT_WRITE,MAP_PRIVATE|MAP_FIXED|MAP_DENYW
= 0x79c2f63ff000
274130 mmap(0x79c2f6405000,52624,PROT_READ|PROT_WRITE,MAP_PRIVATE|MAP_FIXED|MAP_ANONY
= 0x79c2f6405000
274130 close(3)                         = 0
274130 openat(AT_FDCWD,"/lib/x86_64-linux-gnu/libm.so.6",O_RDONLY|O_CLOEXEC)
= 3
274130 read(3,"\177ELF\2\1\1\3\0\0\0\0\0\0\0\0\3\0>\0\1\0\0\0\0\0\0\0\0\0\0\0"...,832
= 832
274130 fstat(3,{st_mode=S_IFREG|0644,st_size=952616,...}) = 0
274130 mmap(NULL,950296,PROT_READ,MAP_PRIVATE|MAP_DENYWRITE,3,0) = 0x79c2f6517000
274130 mmap(0x79c2f6527000,520192,PROT_READ|PROT_EXEC,MAP_PRIVATE|MAP_FIXED|MAP_DENYW
= 0x79c2f6527000
274130 mmap(0x79c2f65a6000,360448,PROT_READ,MAP_PRIVATE|MAP_FIXED|MAP_DENYWRITE,3,0x8
= 0x79c2f65a6000
274130 mmap(0x79c2f65fe000,8192,PROT_READ|PROT_WRITE,MAP_PRIVATE|MAP_FIXED|MAP_DENYWR
= 0x79c2f65fe000
274130 close(3)                         = 0
274130 mmap(NULL,8192,PROT_READ|PROT_WRITE,MAP_PRIVATE|MAP_ANONYMOUS,-1,0)
= 0x79c2f68f4000
274130 mmap(NULL,12288,PROT_READ|PROT_WRITE,MAP_PRIVATE|MAP_ANONYMOUS,-1,0)
```

```
= 0x79c2f68f1000
274130 arch_prctl(ARCH_SET_FS,0x79c2f68f1740) = 0
274130 set_tid_address(0x79c2f68f1a10)  = 274130
274130 set_robust_list(0x79c2f68f1a20,24) = 0
274130 rseq(0x79c2f68f2060,0x20,0,0x53053053) = 0
274130 mprotect(0x79c2f63ff000,16384,PROT_READ) = 0
274130 mprotect(0x79c2f65fe000,4096,PROT_READ) = 0
274130 mprotect(0x79c2f6922000,4096,PROT_READ) = 0
274130 mprotect(0x79c2f686c000,45056,PROT_READ) = 0
274130 mprotect(0x63bcc532c000,4096,PROT_READ) = 0
274130 mprotect(0x79c2f6965000,8192,PROT_READ) = 0
274130 prlimit64(0,RLIMIT_STACK,NULL,{rlim_cur=8192*1024,rlim_max=RLIM64_INFINITY})
= 0
274130 munmap(0x79c2f6924000,33163)    = 0
274130 futex(0x79c2f687a7bc,FUTEX_WAKE_PRIVATE,2147483647) = 0
274130 getrandom("\x2c\x58\x54\xd0\x53\xf6\x8a\x94",8,GRND_NONBLOCK) = 8
274130 brk(NULL)                        = 0x63bd01b85000
274130 brk(0x63bd01ba6000)              = 0x63bd01ba6000
274130 fstat(1,{st_mode=S_IFCHR|0620,st_rdev=makedev(0x88,0x5),...}) = 0
274130 write(1,"\320\222\320\262\320\265\320\264\320\270\321\202\320\265 \320\270\320
\321\204\320\260\320\271\320\273\320\260"...,48) = 48
274130 fstat(0,{st_mode=S_IFCHR|0620,st_rdev=makedev(0x88,0x5),...}) = 0
274130 read(0,"file1\n",1024)           = 6
274130 write(1,"\320\222\320\262\320\265\320\264\320\270\321\202\320\265 \320\270\320
\321\204\320\260\320\271\320\273\320\260"...,48) = 48
274130 read(0,"file2\n",1024)           = 6
274130 pipe2([3,4],0)                   = 0
274130 pipe2([5,6],0)                   = 0
274130 clone(child_stack=NULL,flags=CLONE_CHILD_CLEARTID|CLONE_CHILD_SETTID|SIGCHLD,c
= 274150
274150 set_robust_list(0x79c2f68f1a20,24 <unfinished ...>
274130 close(3 <unfinished ...>
274150 <... set_robust_list resumed>)   = 0
274130 <... close resumed>)             = 0
274150 close(4 <unfinished ...>
274130 clone(child_stack=NULL,flags=CLONE_CHILD_CLEARTID|CLONE_CHILD_SETTID|SIGCHLD
<unfinished ...>
274150 <... close resumed>)             = 0
274150 execve("./child",["./child","child1","file1","3"],0x7ffd73be59b8 /*
36 vars */ <unfinished ...>
274130 <... clone resumed>,child_tidptr=0x79c2f68f1a10) = 274151
274130 close(5 <unfinished ...>
274151 set_robust_list(0x79c2f68f1a20,24 <unfinished ...>
274130 <... close resumed>)             = 0
274151 <... set_robust_list resumed>)   = 0
274130 close(3 <unfinished ...>
274150 <... execve resumed>)            = 0
274130 <... close resumed>)             = -1 EBADF (Bad file descriptor)
```

```
274151 close(6 <unfinished ...>
274150 brk(NULL <unfinished ...>
274130 close(5 <unfinished ...>
274151 <... close resumed>)             = 0
274150 <... brk resumed>)               = 0x575e53eab000
274130 <... close resumed>)             = -1 EBADF (Bad file descriptor)
274151 execve("./child",["./child","child2","file2","5"],0x7ffd73be59b8 /*
36 vars */ <unfinished ...>
274150 mmap(NULL,8192,PROT_READ|PROT_WRITE,MAP_PRIVATE|MAP_ANONYMOUS,-1,0 <unfinished
...>
274130 read(0, <unfinished ...>
274150 <... mmap resumed>)              = 0x709cf5de7000
274150 access("/etc/ld.so.preload",R_OK <unfinished ...>
274151 <... execve resumed>)            = 0
274150 <... access resumed>)            = -1 ENOENT (No such file or directory)
274151 brk(NULL <unfinished ...>
274150 openat(AT_FDCWD,"/etc/ld.so.cache",O_RDONLY|O_CLOEXEC <unfinished ...>
274151 <... brk resumed>)               = 0x5cc3d829f000
274150 <... openat resumed>)            = 4
274150 fstat(4, <unfinished ...>
274151 mmap(NULL,8192,PROT_READ|PROT_WRITE,MAP_PRIVATE|MAP_ANONYMOUS,-1,0)
= 0x77760c0ae000
274150 <... fstat resumed>{st_mode=S_IFREG|0644,st_size=33163,...}) = 0
274151 access("/etc/ld.so.preload",R_OK <unfinished ...>
274150 mmap(NULL,33163,PROT_READ,MAP_PRIVATE,4,0 <unfinished ...>
274151 <... access resumed>)            = -1 ENOENT (No such file or directory)
274150 <... mmap resumed>)              = 0x709cf5dde000
274151 openat(AT_FDCWD,"/etc/ld.so.cache",O_RDONLY|O_CLOEXEC <unfinished ...>
274150 close(4 <unfinished ...>
274151 <... openat resumed>)            = 3
274150 <... close resumed>)             = 0
274151 fstat(3, <unfinished ...>
274150 openat(AT_FDCWD,"/lib/x86_64-linux-gnu/libstdc++.so.6",O_RDONLY|O_CLOEXEC
<unfinished ...>
274151 <... fstat resumed>{st_mode=S_IFREG|0644,st_size=33163,...}) = 0
274150 <... openat resumed>)            = 4
274151 mmap(NULL,33163,PROT_READ,MAP_PRIVATE,3,0 <unfinished ...>
274150 read(4, <unfinished ...>
274151 <... mmap resumed>)              = 0x77760c0a5000
274150 <... read resumed>"\177ELF\2\1\1\3\0\0\0\0\0\0\0\0\3\0>\0\1\0\0\0\0\0\0\0\0\0\0
= 832
274151 close(3)                         = 0
274150 fstat(4, <unfinished ...>
274151 openat(AT_FDCWD,"/lib/x86_64-linux-gnu/libstdc++.so.6",O_RDONLY|O_CLOEXEC
<unfinished ...>
274150 <... fstat resumed>{st_mode=S_IFREG|0644,st_size=2592224,...}) = 0
274151 <... openat resumed>)            = 3
274150 mmap(NULL,2609472,PROT_READ,MAP_PRIVATE|MAP_DENYWRITE,4,0 <unfinished
```

```
...>
274151 read(3, <unfinished ...>
274150 <... mmap resumed>)              = 0x709cf5a00000
274151 <... read resumed>"\177ELF\2\1\1\3\0\0\0\0\0\0\0\0\3\0>\0\1\0\0\0\0\0\0\0\0\0\0
= 832
274150 mmap(0x709cf5a9d000,1343488,PROT_READ|PROT_EXEC,MAP_PRIVATE|MAP_FIXED|MAP_DENY
<unfinished ...>
274151 fstat(3, <unfinished ...>
274150 <... mmap resumed>)              = 0x709cf5a9d000
274151 <... fstat resumed>{st_mode=S_IFREG|0644,st_size=2592224,...}) = 0
274150 mmap(0x709cf5be5000,552960,PROT_READ,MAP_PRIVATE|MAP_FIXED|MAP_DENYWRITE,4,0x1
<unfinished ...>
274151 mmap(NULL,2609472,PROT_READ,MAP_PRIVATE|MAP_DENYWRITE,3,0 <unfinished
...>
274150 <... mmap resumed>)              = 0x709cf5be5000
274151 <... mmap resumed>)              = 0x77760be00000
274150 mmap(0x709cf5c6c000,57344,PROT_READ|PROT_WRITE,MAP_PRIVATE|MAP_FIXED|MAP_DENYW
<unfinished ...>
274151 mmap(0x77760be9d000,1343488,PROT_READ|PROT_EXEC,MAP_PRIVATE|MAP_FIXED|MAP_DENY
<unfinished ...>
274150 <... mmap resumed>)              = 0x709cf5c6c000
274151 <... mmap resumed>)              = 0x77760be9d000
274150 mmap(0x709cf5c7a000,12608,PROT_READ|PROT_WRITE,MAP_PRIVATE|MAP_FIXED|MAP_ANONY
<unfinished ...>
274151 mmap(0x77760bfe5000,552960,PROT_READ,MAP_PRIVATE|MAP_FIXED|MAP_DENYWRITE,3,0x1
<unfinished ...>
274150 <... mmap resumed>)              = 0x709cf5c7a000
274151 <... mmap resumed>)              = 0x77760bfe5000
274150 close(4 <unfinished ...>
274151 mmap(0x77760c06c000,57344,PROT_READ|PROT_WRITE,MAP_PRIVATE|MAP_FIXED|MAP_DENYW
<unfinished ...>
274150 <... close resumed>)             = 0
274151 <... mmap resumed>)              = 0x77760c06c000
274150 openat(AT_FDCWD,"/lib/x86_64-linux-gnu/libgcc_s.so.1",O_RDONLY|O_CLOEXEC
<unfinished ...>
274151 mmap(0x77760c07a000,12608,PROT_READ|PROT_WRITE,MAP_PRIVATE|MAP_FIXED|MAP_ANONY
<unfinished ...>
274150 <... openat resumed>)            = 4
274151 <... mmap resumed>)              = 0x77760c07a000
274150 read(4, <unfinished ...>
274151 close(3 <unfinished ...>
274150 <... read resumed>"\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
274151 <... close resumed>)             = 0
274150 fstat(4, <unfinished ...>
274151 openat(AT_FDCWD,"/lib/x86_64-linux-gnu/libgcc_s.so.1",O_RDONLY|O_CLOEXEC
<unfinished ...>
274150 <... fstat resumed>{st_mode=S_IFREG|0644,st_size=183024,...}) = 0
```

```
274151 <... openat resumed>)            = 3
274151 read(3, <unfinished ...>
274150 mmap(NULL,185256,PROT_READ,MAP_PRIVATE|MAP_DENYWRITE,4,0 <unfinished
...>
274151 <... read resumed>"\177ELF\2\1\1\0\0\0\0\0\0\0\0\0\3\0>\0\1\0\0\0\0\0\0\0\0\0\
= 832
274150 <... mmap resumed>)              = 0x709cf5db0000
274151 fstat(3, <unfinished ...>
274150 mmap(0x709cf5db4000,147456,PROT_READ|PROT_EXEC,MAP_PRIVATE|MAP_FIXED|MAP_DENYW
<unfinished ...>
274151 <... fstat resumed>{st_mode=S_IFREG|0644,st_size=183024,...}) = 0
274150 <... mmap resumed>)              = 0x709cf5db4000
274151 mmap(NULL,185256,PROT_READ,MAP_PRIVATE|MAP_DENYWRITE,3,0 <unfinished
...>
274150 mmap(0x709cf5dd8000,16384,PROT_READ,MAP_PRIVATE|MAP_FIXED|MAP_DENYWRITE,4,0x28
<unfinished ...>
274151 <... mmap resumed>)              = 0x77760bdd2000
274150 <... mmap resumed>)              = 0x709cf5dd8000
274151 mmap(0x77760bdd6000,147456,PROT_READ|PROT_EXEC,MAP_PRIVATE|MAP_FIXED|MAP_DENYW
<unfinished ...>
274150 mmap(0x709cf5ddc000,8192,PROT_READ|PROT_WRITE,MAP_PRIVATE|MAP_FIXED|MAP_DENYWR
<unfinished ...>
274151 <... mmap resumed>)              = 0x77760bdd6000
274150 <... mmap resumed>)              = 0x709cf5ddc000
274151 mmap(0x77760bdfa000,16384,PROT_READ,MAP_PRIVATE|MAP_FIXED|MAP_DENYWRITE,3,0x28
<unfinished ...>
274150 close(4 <unfinished ...>
274151 <... mmap resumed>)              = 0x77760bdfa000
274150 <... close resumed>)             = 0
274151 mmap(0x77760bdfe000,8192,PROT_READ|PROT_WRITE,MAP_PRIVATE|MAP_FIXED|MAP_DENYWR
<unfinished ...>
274150 openat(AT_FDCWD,"/lib/x86_64-linux-gnu/libc.so.6",O_RDONLY|O_CLOEXEC
<unfinished ...>
274151 <... mmap resumed>)              = 0x77760bdfe000
274150 <... openat resumed>)            = 4
274151 close(3 <unfinished ...>
274150 read(4, <unfinished ...>
274151 <... close resumed>)             = 0
274150 <... read resumed>"\177ELF\2\1\1\3\0\0\0\0\0\0\0\0\3\0>\0\1\0\0\0\220\243\2\0\
= 832
274151 openat(AT_FDCWD,"/lib/x86_64-linux-gnu/libc.so.6",O_RDONLY|O_CLOEXEC
<unfinished ...>
274150 pread64(4, <unfinished ...>
274151 <... openat resumed>)            = 3
274150 <... pread64 resumed>"\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\
= 784
274151 read(3, <unfinished ...>
274150 fstat(4, <unfinished ...>
```

```
274151 <... read resumed>"\177ELF\2\1\1\3\0\0\0\0\0\0\0\0\3\0>\0\1\0\0\0\220\243\2\0\
= 832
274150 <... fstat resumed>{st_mode=S_IFREG|0755,st_size=2125328,...}) = 0
274151 pread64(3, <unfinished ...>
274150 pread64(4, <unfinished ...>
274151 <... pread64 resumed>"\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
274150 <... pread64 resumed>"\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
274151 fstat(3, <unfinished ...>
274150 mmap(NULL,2170256,PROT_READ,MAP_PRIVATE|MAP_DENYWRITE,4,0 <unfinished
...>
274151 <... fstat resumed>{st_mode=S_IFREG|0755,st_size=2125328,...}) = 0
274150 <... mmap resumed>)              = 0x709cf5600000
274151 pread64(3, <unfinished ...>
274150 mmap(0x709cf5628000,1605632,PROT_READ|PROT_EXEC,MAP_PRIVATE|MAP_FIXED|MAP_DENY
<unfinished ...>
274151 <... pread64 resumed>"\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
274150 <... mmap resumed>)              = 0x709cf5628000
274151 mmap(NULL,2170256,PROT_READ,MAP_PRIVATE|MAP_DENYWRITE,3,0 <unfinished
...>
274150 mmap(0x709cf57b0000,323584,PROT_READ,MAP_PRIVATE|MAP_FIXED|MAP_DENYWRITE,4,0x1
<unfinished ...>
274151 <... mmap resumed>)              = 0x77760ba00000
274150 <... mmap resumed>)              = 0x709cf57b0000
274151 mmap(0x77760ba28000,1605632,PROT_READ|PROT_EXEC,MAP_PRIVATE|MAP_FIXED|MAP_DENY
<unfinished ...>
274150 mmap(0x709cf57ff000,24576,PROT_READ|PROT_WRITE,MAP_PRIVATE|MAP_FIXED|MAP_DENYW
<unfinished ...>
274151 <... mmap resumed>)              = 0x77760ba28000
274150 <... mmap resumed>)              = 0x709cf57ff000
274151 mmap(0x77760bbb0000,323584,PROT_READ,MAP_PRIVATE|MAP_FIXED|MAP_DENYWRITE,3,0x1
<unfinished ...>
274150 mmap(0x709cf5805000,52624,PROT_READ|PROT_WRITE,MAP_PRIVATE|MAP_FIXED|MAP_ANONY
<unfinished ...>
274151 <... mmap resumed>)              = 0x77760bbb0000
274150 <... mmap resumed>)              = 0x709cf5805000
274151 mmap(0x77760bbff000,24576,PROT_READ|PROT_WRITE,MAP_PRIVATE|MAP_FIXED|MAP_DENYW
<unfinished ...>
274150 close(4 <unfinished ...>
274151 <... mmap resumed>)              = 0x77760bbff000
274150 <... close resumed>)             = 0
274151 mmap(0x77760bc05000,52624,PROT_READ|PROT_WRITE,MAP_PRIVATE|MAP_FIXED|MAP_ANONY
<unfinished ...>
274150 openat(AT_FDCWD,"/lib/x86_64-linux-gnu/libm.so.6",O_RDONLY|O_CLOEXEC
<unfinished ...>
274151 <... mmap resumed>)              = 0x77760bc05000
```

```
274150 <... openat resumed>)            = 4
274151 close(3 <unfinished ...>
274150 read(4, <unfinished ...>
274151 <... close resumed>)             = 0
274150 <... read resumed>"\177ELF\2\1\1\3\0\0\0\0\0\0\0\0\3\0>\0\1\0\0\0\0\0\0\0\0\0\0
= 832
274151 openat(AT_FDCWD,"/lib/x86_64-linux-gnu/libm.so.6",O_RDONLY|O_CLOEXEC
<unfinished ...>
274150 fstat(4, <unfinished ...>
274151 <... openat resumed>)            = 3
274150 <... fstat resumed>{st_mode=S_IFREG|0644,st_size=952616,...}) = 0
274151 read(3, <unfinished ...>
274150 mmap(NULL,950296,PROT_READ,MAP_PRIVATE|MAP_DENYWRITE,4,0 <unfinished
...>
274151 <... read resumed>"\177ELF\2\1\1\3\0\0\0\0\0\0\0\0\3\0>\0\1\0\0\0\0\0\0\0\0\0\0
= 832
274150 <... mmap resumed>)              = 0x709cf5cc7000
274151 fstat(3, <unfinished ...>
274150 mmap(0x709cf5cd7000,520192,PROT_READ|PROT_EXEC,MAP_PRIVATE|MAP_FIXED|MAP_DENYW
<unfinished ...>
274151 <... fstat resumed>{st_mode=S_IFREG|0644,st_size=952616,...}) = 0
274150 <... mmap resumed>)              = 0x709cf5cd7000
274151 mmap(NULL,950296,PROT_READ,MAP_PRIVATE|MAP_DENYWRITE,3,0 <unfinished
...>
274150 mmap(0x709cf5d56000,360448,PROT_READ,MAP_PRIVATE|MAP_FIXED|MAP_DENYWRITE,4,0x8
<unfinished ...>
274151 <... mmap resumed>)              = 0x77760bce9000
274150 <... mmap resumed>)              = 0x709cf5d56000
274151 mmap(0x77760bcf9000,520192,PROT_READ|PROT_EXEC,MAP_PRIVATE|MAP_FIXED|MAP_DENYW
<unfinished ...>
274150 mmap(0x709cf5dae000,8192,PROT_READ|PROT_WRITE,MAP_PRIVATE|MAP_FIXED|MAP_DENYWR
<unfinished ...>
274151 <... mmap resumed>)              = 0x77760bcf9000
274150 <... mmap resumed>)              = 0x709cf5dae000
274151 mmap(0x77760bd78000,360448,PROT_READ,MAP_PRIVATE|MAP_FIXED|MAP_DENYWRITE,3,0x8
<unfinished ...>
274150 close(4 <unfinished ...>
274151 <... mmap resumed>)              = 0x77760bd78000
274150 <... close resumed>)             = 0
274151 mmap(0x77760bdd0000,8192,PROT_READ|PROT_WRITE,MAP_PRIVATE|MAP_FIXED|MAP_DENYWR
<unfinished ...>
274150 mmap(NULL,8192,PROT_READ|PROT_WRITE,MAP_PRIVATE|MAP_ANONYMOUS,-1,0 <unfinished
...>
274151 <... mmap resumed>)              = 0x77760bdd0000
274150 <... mmap resumed>)              = 0x709cf5cc5000
274151 close(3 <unfinished ...>
274150 mmap(NULL,12288,PROT_READ|PROT_WRITE,MAP_PRIVATE|MAP_ANONYMOUS,-1,0
<unfinished ...>
```

```
274151 <... close resumed>)             = 0
274150 <... mmap resumed>)              = 0x709cf5cc2000
274151 mmap(NULL,8192,PROT_READ|PROT_WRITE,MAP_PRIVATE|MAP_ANONYMOUS,-1,0 <unfinished
...>
274150 arch_prctl(ARCH_SET_FS,0x709cf5cc2740 <unfinished ...>
274151 <... mmap resumed>)              = 0x77760c0a3000
274150 <... arch_prctl resumed>)        = 0
274151 mmap(NULL,12288,PROT_READ|PROT_WRITE,MAP_PRIVATE|MAP_ANONYMOUS,-1,0
<unfinished ...>
274150 set_tid_address(0x709cf5cc2a10 <unfinished ...>
274151 <... mmap resumed>)              = 0x77760c0a0000
274150 <... set_tid_address resumed>)   = 274150
274151 arch_prctl(ARCH_SET_FS,0x77760c0a0740 <unfinished ...>
274150 set_robust_list(0x709cf5cc2a20,24 <unfinished ...>
274151 <... arch_prctl resumed>)        = 0
274150 <... set_robust_list resumed>)   = 0
274151 set_tid_address(0x77760c0a0a10 <unfinished ...>
274150 rseq(0x709cf5cc3060,0x20,0,0x53053053 <unfinished ...>
274151 <... set_tid_address resumed>)   = 274151
274150 <... rseq resumed>)              = 0
274151 set_robust_list(0x77760c0a0a20,24) = 0
274150 mprotect(0x709cf57ff000,16384,PROT_READ <unfinished ...>
274151 rseq(0x77760c0a1060,0x20,0,0x53053053 <unfinished ...>
274150 <... mprotect resumed>)          = 0
274151 <... rseq resumed>)              = 0
274150 mprotect(0x709cf5dae000,4096,PROT_READ <unfinished ...>
274151 mprotect(0x77760bbff000,16384,PROT_READ <unfinished ...>
274150 <... mprotect resumed>)          = 0
274151 <... mprotect resumed>)          = 0
274150 mprotect(0x709cf5ddc000,4096,PROT_READ <unfinished ...>
274151 mprotect(0x77760bdd0000,4096,PROT_READ <unfinished ...>
274150 <... mprotect resumed>)          = 0
274151 <... mprotect resumed>)          = 0
274151 mprotect(0x77760bdfe000,4096,PROT_READ) = 0
274150 mprotect(0x709cf5c6c000,45056,PROT_READ) = 0
274151 mprotect(0x77760c06c000,45056,PROT_READ <unfinished ...>
274150 mprotect(0x575e22ada000,4096,PROT_READ <unfinished ...>
274151 <... mprotect resumed>)          = 0
274150 <... mprotect resumed>)          = 0
274151 mprotect(0x5cc39ee78000,4096,PROT_READ <unfinished ...>
274150 mprotect(0x709cf5e1f000,8192,PROT_READ <unfinished ...>
274151 <... mprotect resumed>)          = 0
274150 <... mprotect resumed>)          = 0
274151 mprotect(0x77760c0e6000,8192,PROT_READ <unfinished ...>
274150 prlimit64(0,RLIMIT_STACK,NULL, <unfinished ...>
274151 <... mprotect resumed>)          = 0
274150 <... prlimit64 resumed>{rlim_cur=8192*1024,rlim_max=RLIM64_INFINITY})
= 0
```

```
274151 prlimit64(0,RLIMIT_STACK,NULL,{rlim_cur=8192*1024,rlim_max=RLIM64_INFINITY})
= 0
274150 munmap(0x709cf5dde000,33163 <unfinished ...>
274151 munmap(0x77760c0a5000,33163 <unfinished ...>
274150 <... munmap resumed>)            = 0
274151 <... munmap resumed>)            = 0
274150 futex(0x709cf5c7a7bc,FUTEX_WAKE_PRIVATE,2147483647) = 0
274151 futex(0x77760c07a7bc,FUTEX_WAKE_PRIVATE,2147483647) = 0
274150 getrandom("\xcd\xa7\x97\x3c\x1d\x9a\xd8\x81",8,GRND_NONBLOCK) = 8
274151 getrandom( <unfinished ...>
274150 brk(NULL <unfinished ...>
274151 <... getrandom resumed>"\xf5\x9d\xac\xba\x11\xff\xdd\xc4",8,GRND_NONBLOCK)
= 8
274150 <... brk resumed>)               = 0x575e53eab000
274151 brk(NULL <unfinished ...>
274150 brk(0x575e53ecc000 <unfinished ...>
274151 <... brk resumed>)               = 0x5cc3d829f000
274150 <... brk resumed>)               = 0x575e53ecc000
274151 brk(0x5cc3d82c0000)              = 0x5cc3d82c0000
274150 fstat(1, <unfinished ...>
274151 fstat(1, <unfinished ...>
274150 <... fstat resumed>{st_mode=S_IFCHR|0620,st_rdev=makedev(0x88,0x5),...})
= 0
274151 <... fstat resumed>{st_mode=S_IFCHR|0620,st_rdev=makedev(0x88,0x5),...})
= 0
274150 write(1,"child1: \320\267\320\260\320\277\321\203\321\211\320\265\320\275
\321\201 \321\204\320\260\320\271"...,45 <unfinished ...>
274151 write(1,"child2: \320\267\320\260\320\277\321\203\321\211\320\265\320\275
\321\201 \321\204\320\260\320\271"...,45 <unfinished ...>
274150 <... write resumed>)             = 45
274151 <... write resumed>)             = 45
274150 openat(AT_FDCWD,"file1",O_WRONLY|O_CREAT|O_TRUNC,0644 <unfinished ...>
274151 openat(AT_FDCWD,"file2",O_WRONLY|O_CREAT|O_TRUNC,0644) = 3
274150 <... openat resumed>)            = 4
274151 read(5, <unfinished ...>
274150 read(3, <unfinished ...>
274130 <... read resumed>"hello\n",1024) = 6
274130 write(4,"hello",5)              = 5
274150 <... read resumed>"hello",255)  = 5
274130 write(4,"\n",1 <unfinished ...>
274150 write(4,"olleh",5 <unfinished ...>
274130 <... write resumed>)             = 1
274150 <... write resumed>)             = 5
274130 read(0, <unfinished ...>
274150 read(3,"\n",255)                = 1
274150 write(4,"\n",1)                 = 1
274150 read(3, <unfinished ...>
274130 <... read resumed>"rabbit\n",1024) = 7
```

```
274130 write(6,"rabbit",6)            = 6
274151 <... read resumed>"rabbit",255) = 6
274130 write(6,"\n",1)                = 1
274151 write(3,"tibbar",6 <unfinished ...>
274130 read(0, <unfinished ...>
274151 <... write resumed>)             = 6
274151 read(5,"\n",255)               = 1
274151 write(3,"\n",1)                = 1
274151 read(5, <unfinished ...>
274130 <... read resumed>"dig\n",1024) = 4
274130 write(4,"dig",3)               = 3
274150 <... read resumed>"dig",255)    = 3
274130 write(4,"\n",1 <unfinished ...>
274150 write(4,"gid",3 <unfinished ...>
274130 <... write resumed>)             = 1
274150 <... write resumed>)             = 3
274130 read(0, <unfinished ...>
274150 read(3,"\n",255)               = 1
274150 write(4,"\n",1)                = 1
274150 read(3, <unfinished ...>
274130 <... read resumed>"big\n",1024) = 4
274130 write(6,"big",3)               = 3
274151 <... read resumed>"big",255)    = 3
274130 write(6,"\n",1 <unfinished ...>
274151 write(3,"gib",3 <unfinished ...>
274130 <... write resumed>)             = 1
274151 <... write resumed>)             = 3
274130 read(0, <unfinished ...>
274151 read(5,"\n",255)               = 1
274151 write(3,"\n",1)                = 1
274151 read(5, <unfinished ...>
274130 <... read resumed>0x63bd01b976c0,1024) = ? ERESTARTSYS (To be restarted
if SA_RESTART is set)
274151 <... read resumed>0x7fffcc9869d0,255) = ? ERESTARTSYS (To be restarted
if SA_RESTART is set)
274150 <... read resumed>0x7ffc28419ee0,255) = ? ERESTARTSYS (To be restarted
if SA_RESTART is set)
274130 ---SIGINT {si_signo=SIGINT,si_code=SI_KERNEL} ---
274151 ---SIGINT {si_signo=SIGINT,si_code=SI_KERNEL} ---
274150 ---SIGINT {si_signo=SIGINT,si_code=SI_KERNEL} ---
274130 +++ killed by SIGINT +++
274151 +++ killed by SIGINT +++
274150 +++ killed by SIGINT +++
```