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Кафедра вычислительной математики и программирования

Курсовой проект по курсу

«Операционные системы»

Тема работы
“Морской бой на memory-mapped files”

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Содержание

Репозиторий

https://github.com/kappaprideonly/mai-os-labs

Постановка задачи

Морской бой. Общение между сервером и клиентом необходимо организовать при помощи memory map. Каждый игрок должен при запуске ввести свой логин. Для каждого игрока должна вестись статистика игр (сколько побед/поражений). Игрок может посмотреть свою статистику.

Общие сведения о программе

Для выполнения данной курсовой работы я предварительно реализовал 7 файлов с кодом:

CMakeLists.txt - описание процесса сборки проекта

mappedFile.h - реализация mapped file. Содержит структуру, в которой хранится файловый дескриптор и массив чаров.

game.hpp - отдельный файл классов игрока и игры.

mutex.h - заголовочный файл для общего мьютекса.

mutex.cpp - реализация общего мьютекса для процессов.

server.cpp - реализация программы сервера.

client.cpp - реализация программы клиента.

Общий метод и алгоритм решения

CMakeLists.txt

```
add_executable(serverGame server.cpp include/game.hpp include/mutex.h
include/mappedFile.h src/mutex.cpp)
add_executable(clientGame client.cpp include/game.hpp include/mutex.h
include/mappedFile.h src/mutex.cpp)

target_include_directories(serverGame PRIVATE include)
target_include_directories(clientGame PRIVATE include)

target_link_libraries(serverGame PRIVATE Threads::Threads)
target_link_libraries(clientGame PRIVATE Threads::Threads)
```

По сути, две работающие программы. В начале запускается сервер, после два клиента. При команде create создается игра. При команде connect игрок присоединяется к текущей игре. Далее при помощи внутриигровых команд shoot и stats игроки могут стрелять по чужому полю и смотреть свою статистику. Все действия обрабатываются на сервере.

Исходный код

mappedFile.h

```
#ifndef MAPPED_FILE_H
#define MAPPED_FILE_H
#define _MAPPED_SIZE 8192
#define _SHM_OPEN_MODE S_IWUSR | S_IRUSR | S_IRGRP | S_IROTH
#define _BUFFER_NAME "mybuffer.buf"
#define _MUTEX_NAME "mymutex.mutex"
#define _MSG_SEP '$'

struct TMappedFile {
   int fd;
   char *data;
};
#endif
```

game.hpp

```
#ifndef PLAYERANDGAME_H
```

```
#define PLAYERANDGAME_H

#include <algorithm>
#include <vector>
#include <string>
#include <iostream>

class TPlayer {
   public:
        std::string username;
        std::vector<std::vector<char>> field;
        int wins{};
        int loses{};
        int kills{};
        int misses{};
        int wounds{};
        bool turn{};
        TPlayer() : field(12, std::vector<char> (12, '.'))  {}
        void ErasePlayer() {
            username = "";
            wins = 0;
            loses = 0;
            kills = 0;
            misses = 0;
            wounds = 0;
            turn = false;
        }
};
class TGame {
   public:
        std:: string name;
        std:: string password;
        bool connected{};
        bool created{};
        void EraseGame() {
            name = "";
            password = "";
            connected = false;
            created = false;
        }
};
void RandomLocation(std::vector<std::vector<char>> &field) {
   int j =- 1;
   int k;
   int v;
```

```
    int l;
    int x[2];
    int y;
    srand(time(0));
    for (l = 4; l > 0; l--) {
        for (k = 5; k - l; k--) {
            v = 1&rand();
            do { for (x[v] = 1 + rand() % 10, x[1 - v] = 1 + rand() % 7, y
= j = 0; j - l; y |= field[x[0]][x[1]] != '.', x[1 - v]++, j++); }
while(y);
            x[1 - v] -= l + 1, field[x[0]][x[1]] = '/', x[v]--,
field[x[0]][x[1]] = '/', x [v] += 2, field[x[0]][x[1]] = '/', x[v]--, x[1
- v]++;
            for (j = -1; ++j - l; field[x[0]][x[1]] = 'X', x[v]--,
field[x[0]][x[1]] = '/', x[v] += 2, field[x[0]][x[1]] = '/', x[v]--, x[1 -
v]++);
            field[x[0]][x[1]] = '/', x[v]--, field[x[0]][x[1]] = '/',
x[v]+=2, field[x[0]][x[1]] = '/';
        }
    }
    for (int i = 0; i < 12; ++i) {
        std::replace(field[i].begin(), field[i].end(), '/', '.');
    }
}
void PrintField(std::vector<std::vector<char>> &field) {
    for (int i = 1; i < 11; ++i) {
        for (int j = 1; j < 11; ++j) {
            std:: cout << field[i][j];
        }
        std:: cout << std:: endl;
    }
}
bool WonGame(std::vector<std::vector<char>> &field) {
    for (int i = 1; i < 11; ++i) {
        for (int j = 1; j < 11; ++j) {
            if (field[i][j] == 'X') {
                return false;
            }
        }
    }
    return true;
}
void PrepareField(std::vector<std::vector<char>>& field) {
    for (int i = 0; i < 12; i++) {
        field[i].clear();
```

```
        field[i] = std::vector<char>(12, '.');
    }
}
#endif
```

mutex.h

```
#ifndef SHARED_MUTEX_H
#define SHARED_MUTEX_H
#include <pthread.h>
struct TCommonMutex {
    pthread_mutex_t *ptr;  // Pointer to the pthread mutex and shared
memory segment
    int shm_fd;            // Descriptor of shared memory object
    char *name;            // Name of the mutex and associated shared
memory object
    int created;           // 1 if created new mutex, 0 if mutex was
retrieved from memory
};
TCommonMutex SharedMutexInit(const char *name);
int SharedMutexDestroy(TCommonMutex mutex);
#endif
```

mutex.cpp

```
#include <cerrno>
#include <fcntl.h>
#include <linux/limits.h>
#include <cstdio>
#include <cstdlib>
#include <cstring>
#include <sys/mman.h>
#include <unistd.h>
#include <iostream>

#include "mutex.h"

TCommonMutex SharedMutexInit(const char *name) {
    TCommonMutex mutex = {nullptr, 0, nullptr, 0};
    errno = 0;
    mutex.shm_fd = shm_open(name, O_RDWR, 0660);
```

```
    if (errno == ENOENT) {
        mutex.shm_fd = shm_open(name, O_RDWR | O_CREAT, 0660);
        mutex.created = 1;
    }
    if (mutex.shm_fd == -1) {
        std:: cout << "An error while shm_open has been detected!" << std::
endl;
        return mutex;
    }
    if (ftruncate(mutex.shm_fd, sizeof(pthread_mutex_t)) != 0) {
        std:: cout << "An error while ftruncate has been detected!" <<
std:: endl;
        return mutex;
    }
    void *address = mmap(nullptr, sizeof(pthread_mutex_t), PROT_READ |
PROT_WRITE, MAP_SHARED, mutex.shm_fd, 0);
    if (address == MAP_FAILED) {
        std:: cout << "An error with mmaping has been detected!" << std::
endl;
        return mutex;
    }
    auto *mutexPtr = (pthread_mutex_t *)address;
    // If shared memory was just created -- initialize the mutex as well.
    if (mutex.created != 0) {
        pthread_mutexattr_t attr; // Deadlock to common shared data!
        if (pthread_mutexattr_init(&attr) != 0) {
            std:: cout << "An error while pthread_mutexattr_init has been
detected!" << std:: endl;
            return mutex;
        }
        if (pthread_mutexattr_setpshared(&attr, PTHREAD_PROCESS_SHARED) !=
0) { // PTHREAD_PROCESS_SHARED - may be operated on by any thread in any
process that has access to it
            std:: cout << "An error while pthread_mutexattr_setpshared has
been detected!" << std:: endl;
            return mutex;
        } //pthread_mutexattr_setpsharedshall set the process-shared
attribute in an initialized attributes object referenced by attr.
        if (pthread_mutex_init(mutexPtr, &attr) != 0) {
            std:: cout << "An error while pthread_mutex_init has been
detected!" << std:: endl;
            return mutex;
        }
    }
    mutex.ptr = mutexPtr;
```

```
    mutex.name = (char *)malloc(NAME_MAX + 1);
    strcpy(mutex.name, name);
    return mutex;
}
int SharedMutexDestroy(TCommonMutex mutex) {
    if ((errno = pthread_mutex_destroy(mutex.ptr)) != 0) {
        std:: cout << "An error while destroying mutex has been detected!"
<< std:: endl;
        return -1;
    }
    if (munmap((void *)mutex.ptr, sizeof(pthread_mutex_t)) != 0) {
        std:: cout << "An error while munmap has been detected!" << std::
endl;
        return -1;
    }
    mutex.ptr = nullptr;
    if (close(mutex.shm_fd) != 0) {
        std:: cout << "An error while closing has been detected!" << std::
endl;
        return -1;
    }
    mutex.shm_fd = 0;
    if (shm_unlink(mutex.name) != 0) {
        std:: cout << "An error while shm_unlink has been detected!" <<
std:: endl;
        return -1;
    }
    free(mutex.name);
    return 0;
}
```

client.cpp

```
#include <iostream>
#include <fcntl.h>
#include <unistd.h>
#include <pthread.h>
#include <sys/mman.h>
#include <cassert>
#include <cstring>
#include <vector>
#include <algorithm>
#include <sys/stat.h>
#include <fstream>
```

```
#include "mappedFile.h"
#include "game.hpp"
#include "mutex.h"

TMappedFile mappedFile;
TCommonMutex mutex;
std:: string nickname;
bool playing = false;
std:: string currentGame;

void SendMessage (const std:: string &message) {
   if (pthread_mutex_lock(mutex.ptr) != 0) {
       std:: cout << "An error while locking mutex has been detected!" <<
std:: endl;
       exit(EXIT_FAILURE);
   }
   memset(mappedFile.data, '\0', _MAPPED_SIZE);
   sprintf(mappedFile.data, "%s", message.c_str());
   pthread_mutex_unlock(mutex.ptr);
}

bool ReceiveAnswer() {
   if (mappedFile.data[0] != 'T' || mappedFile.data[1] != 'O' ||
mappedFile.data[2] != _MSG_SEP) {
       return false;
   }
   std:: string message = mappedFile.data;
   std:: vector<std:: string> serverCommands;
   std:: string string;
   for (char i : message) {
       if (i == _MSG_SEP) {
           serverCommands.push_back(string);
           string = "";
       }
       else {
           string.push_back(i);
       }
   }
   if (serverCommands[1] == nickname) {
       if (pthread_mutex_lock(mutex.ptr) != 0) {
           std:: cout << "An error while locking mutex has been detected!"
<< std:: endl;
           exit(EXIT_FAILURE);
```

```
        }
        memset(mappedFile.data, '\0', _MAPPED_SIZE);
        pthread_mutex_unlock(mutex.ptr);
        if (serverCommands[2] == "gamecreated") {
            playing = true;
            std:: cout << "Created successfully!" << std:: endl;
            std:: cout << "You are a player №1, cause you have created the
game. Your field has been prepared!" << std:: endl;
            return true;
        }
        if (serverCommands[2] == "connected") {
            std:: cout << "Connected sucessfully" << std:: endl;
            std:: cout << "You are a player №2, cause you have connected to
the game. Your field has been prepared!" << std:: endl;
            playing = true;
            return true;
        }
        if (serverCommands[2] == "notatgame") {
            playing = true;
            std:: cout << "You can't play without another player!" << std::
endl;;
            return true;
        }
        if (serverCommands[2] == "gamenotexists") {
            std:: cout << "Game with this name not exists" << std:: endl;
            playing = false;
            currentGame = "";
            return true;
        }
        if (serverCommands[2] == "wrongpassword") {
            std:: cout << "Wrong password has been detected!" << std::
endl;
            playing = false;
            currentGame = "";
            return true;
        }
        if (serverCommands[2] == "notyourturn") {
            std:: cout << "It's not your turn now!" << std:: endl;
            playing = true;
            return true;
        }
        if (serverCommands[2] == "youwounded") {
            playing = true;
            std:: cout << "You have wounded enemy's ship! Please enter
coordinates again!" << std:: endl;
```

```
            return true;
        }
        if (serverCommands[2] == "youmissed") {
            playing = true;
            std:: cout << "Unfortunately you have missed! Now it's your
enemy's turn!" << std:: endl;
            return true;
        }
        if (serverCommands[2] == "youkilled") {
            playing = true;
            std:: cout << "Congrats, you have KILLED enemy's ship! Please
enter coordinates again!" << std:: endl;
            return true;
        }
        if (serverCommands[2] == "zeroplaces") {
            playing = false;
            std:: cout << "Sorry, but you can not create a game or connect
to existing game. There are not free places!" << std:: endl;
            return true;
        }
        if (serverCommands[2] == "yourepeated") {
            playing = true;
            std:: cout << "You have already entered these coordinates!
Please enter something new." << std:: endl;
            return true;
        }
        if (serverCommands[2] == "disconnected") {
            std:: cout << "You have successfully disconnected from the
server!" << std:: endl;
            playing = false;
            return true;
        }
        if (serverCommands[2] == "youwon") {
            std:: cout << "YOU WON THE GAME!" << std:: endl;
            playing = false;
            return true;
        }
        if (serverCommands[2] == "stats") {
            int wins = stoi(serverCommands[3]);
            int loses = stoi(serverCommands[4]);
            int kills = stoi(serverCommands[5]);
            int misses = stoi(serverCommands[6]);
            int wounds = stoi(serverCommands[7]);
            std:: cout << "You have " << wins << " wins and " << loses << "
loses!" << std:: endl;
```

```
            std:: cout << "FULL STATISTICS: " << std:: endl;
            std:: cout << '\t' << kills << " kills" << std:: endl;
            std:: cout << '\t' << wounds << " wounds" << std:: endl;
            std:: cout << '\t' << misses << " misses" << std:: endl;
            playing = true;
            return true;
        }
        else {
            std:: cout  << "Warning: unknown message has been detected!" <<
std::endl;
            playing = false;
            return true;
        }
        return true;
    }
    return false;
}

void Help() {
    std:: cout << "Follow next rules: " << std:: endl;
    std:: cout << '\t' << "create for creating a new game" << std:: endl;
    std:: cout << '\t' << "connect for connecting to the server" << std::
endl;
    std:: cout << '\t' << "shoot for shooting at enemy's ship" << std::
endl;
    std:: cout << '\t' << "stats for checking your stats" << std:: endl;
    std:: cout << '\t' << "disconnect for leaving from the server" << std::
endl;
    std:: cout << '\t' << "quit for leaving from the program" << std::
endl;
    std:: cout << '\t' << "help for checking rules" << std:: endl;
}

int main() {
    mappedFile.fd = shm_open(_BUFFER_NAME, O_RDWR, _SHM_OPEN_MODE);
    if (mappedFile.fd == -1 ) {
        std:: cout << "An error while shm_open has been detected!" << std::
endl;
        exit(EXIT_FAILURE);
    }
    mutex = SharedMutexInit(_MUTEX_NAME);
    mappedFile.data = (char*)mmap(0, _MAPPED_SIZE, PROT_READ | PROT_WRITE,
MAP_SHARED, mappedFile.fd, 0);
    if (mappedFile.data == MAP_FAILED) {
```

```
        std:: cout << "An error while mmaping has been detected!" << std::
endl;
    }
    std:: cout << "Welcome to the SeaBattle! Please enter your nickname: "
<< std:: endl;
    std:: cout << "> ";
    std:: cin >> nickname;
    std:: cout << "Hello, " << nickname << "!" << std::endl;
    Help();
    std:: string command;
    while (std:: cout << "> " && std:: cin >> command) {
        if (!playing && command == "create") {
            std:: string gamename;
            std:: string password;
            std:: cin >> gamename >> password;
            currentGame = gamename;
            std::string on = "ON";
            std:: string serverMessage = on + _MSG_SEP + nickname +
_MSG_SEP + "create" + _MSG_SEP + gamename + _MSG_SEP + password +
_MSG_SEP;
            SendMessage (serverMessage);
            bool hasnotanswer = true;
            while (hasnotanswer) {
                hasnotanswer = !ReceiveAnswer();
            }
        }
        else if (playing && command == "create") {
            std:: string gamename;
            std:: string password;
            std:: cin >> gamename >> password;
            std:: cout << "Can't create a new game, you are playing now!
Please enter another command!" << std:: endl;
            continue;
        }
        else if (!playing && command == "connect") {
            std:: string gamename;
            std:: string password;
            std:: cin >> gamename >> password;
            currentGame = gamename;
            std::string on = "ON";
            std:: string serverMessage = on + _MSG_SEP + nickname +
_MSG_SEP + "connect" + _MSG_SEP + gamename + _MSG_SEP + password +
_MSG_SEP;
            SendMessage (serverMessage);
            bool hasnotanswer = true;
```

```
            while (hasnotanswer) {
                hasnotanswer = !ReceiveAnswer();
            }
        }
        else if (playing && command == "connect") {
            std:: string gamename;
            std:: string password;
            std:: cin >> gamename >> password;
            std:: cout << "Can't connect to a new game, you've already
connected! Please enter another command!" << std:: endl;
            continue;
        }
        else if (playing && command == "shoot") {
            int number;
            char letter;
            std:: cin >> letter >> number;
            if ((!((letter >= 'A') && (letter <= 'J'))) || ((number < 1) ||
(number > 10))) {
                std:: cout << "Please enter letter between A and J and
number between 1 and 10!" << std:: endl;
                continue;
            }
            else {
                std:: string on = "ON";
                std:: string serverMessage = on + _MSG_SEP + nickname +
_MSG_SEP + "shoot" + _MSG_SEP + currentGame + _MSG_SEP + letter + _MSG_SEP
+ std:: to_string(number) + _MSG_SEP;
                SendMessage (serverMessage);
                bool hasnotanswer = true;
                while (hasnotanswer) {
                    hasnotanswer = !ReceiveAnswer();
                }
            }
        }
        else if (playing && command == "stats") {
            std::string on = "ON";
            std:: string serverMessage = on + _MSG_SEP + nickname +
_MSG_SEP + "stats" + _MSG_SEP + currentGame + _MSG_SEP;
            SendMessage (serverMessage);
            bool hasnotanswer = true;
            while (hasnotanswer) {
                hasnotanswer = !ReceiveAnswer();
            }
        }
        else if (!playing && command == "shoot") {
```

```
            int number;
            char letter;
            std:: cin >> letter >> number;
            std:: cout << "You are not in the game right now. Please create
a game or connect to the existing one!" << std:: endl;
            continue;
        }
        else if (playing && command == "disconnect") {
            std:: string on = "ON";
            std:: string serverMessage = on + _MSG_SEP + nickname +
_MSG_SEP + "disconnect" + _MSG_SEP + currentGame + _MSG_SEP;
            SendMessage (serverMessage);
            bool hasnotanswer = true;
            while (hasnotanswer) {
                hasnotanswer = !ReceiveAnswer();
            }
        }
        else if (command == "help") {
            Help();
        }
        else if (!playing && command == "quit") {
            break;
        }
        else {
            std:: cout << "Wrong input!" << std:: endl;
        }
    }
    return 0;
}
```

server.cpp;

```
#include <fcntl.h>
#include <pthread.h>
#include <sys/mman.h>
#include <sys/stat.h>
#include <unistd.h>
#include <cassert>
#include <cstring>
#include <iostream>
#include <map>
#include <vector>
#include <fstream>
```

```
#include "game.hpp"
#include "mappedFile.h"
#include "mutex.h"


int main() {
   TPlayer creator;
   TPlayer connector;
   TGame game;
   TMappedFile mappedFile;
   std:: string clientMessage;
   mappedFile.fd = shm_open(_BUFFER_NAME, O_RDWR | O_CREAT,
_SHM_OPEN_MODE);
   if (mappedFile.fd == -1) {
       std:: cout << "Error with shm_open function has been detected!" <<
std:: endl;
       exit(EXIT_FAILURE);
   }
   if (ftruncate(mappedFile.fd, _MAPPED_SIZE) == -1) {
       std:: cout << "An error while ftruncate has been detected!" <<
std:: endl;
       exit(EXIT_FAILURE);
   }
   mappedFile.data = (char *)mmap(0, _MAPPED_SIZE, PROT_READ | PROT_WRITE,
MAP_SHARED, mappedFile.fd, 0);
   if (mappedFile.data == MAP_FAILED) {
       std:: cout << "An error with mmap function has been detected!" <<
std:: endl;
       exit(EXIT_FAILURE);
   }
   memset(mappedFile.data, '\0', _MAPPED_SIZE);
   TCommonMutex mutex = SharedMutexInit(_MUTEX_NAME);
   if (mutex.created == 0) {
       std:: cout << "FROM SERVER: Mutex has been already created!" <<
std:: endl;
   }
   else {
       errno = 0;
   }
   std:: cout << "Server is working now! Please start a game and it will
be displayed here!" << std:: endl;
   while (true) {
       if (mappedFile.data[0] == EOF) {
           break;
       }
```

```
        if (mappedFile.data[0] == '\0') {
            continue;
        }
        if (!(mappedFile.data[0] == 'O' && mappedFile.data[1] == 'N' &&
              mappedFile.data[2] == _MSG_SEP)) {
            continue;
        }
        std:: cout << "FROM SERVER: Locking mutex" << std:: endl;
        if (pthread_mutex_lock(mutex.ptr) != 0) {
            std:: cout << "An error while locking mutex has been detected!"
<< std:: endl;
            exit(EXIT_FAILURE);
        }
        clientMessage = mappedFile.data;
        std:: cout << "FROM SERVER: Has received next message from client:
" << clientMessage << std:: endl;
        memset(mappedFile.data, '\0', _MAPPED_SIZE);
        std:: vector<std:: string> clientCommands;
        std:: string string;
        for (char i : clientMessage) {
            if (i == _MSG_SEP) {
                clientCommands.push_back(string);
                string = "";
            }
            else {
                string.push_back(i);
            }
        }
        if (clientCommands[2] == "create") {
            if (game.created || game.name == clientCommands[3]) {
                std:: string to = "TO";
                std:: string playerMessage = to + _MSG_SEP +
clientCommands[1] + _MSG_SEP + "zeroplaces" + _MSG_SEP;
                sprintf(mappedFile.data, "%s", playerMessage.c_str());
                std:: cout << "FROM SERVER: Sending to client next message:
" << playerMessage << std:: endl;
            }
            else {
                game.created = true;
                creator.turn = true;
                connector.turn = false;
                creator.username = clientCommands[1];
                RandomLocation(creator.field);
                game.name = clientCommands[3];
                game.password = clientCommands[4];
```

```
                std:: string to = "TO";
                std:: string playerMessage = to + _MSG_SEP +
clientCommands[1] + _MSG_SEP + "gamecreated" + _MSG_SEP;
                sprintf(mappedFile.data, "%s", playerMessage.c_str());
                std:: cout << "FROM SERVER: Sending to client next message:
" << playerMessage << std:: endl;
            }
        }
        else if (clientCommands[2] == "connect") {
            if (game.connected) {
                std:: string to = "TO";
                std:: string playerMessage = to + _MSG_SEP +
clientCommands[1] + _MSG_SEP + "zeroplaces" + _MSG_SEP;
                sprintf(mappedFile.data, "%s", playerMessage.c_str());
                std:: cout << "FROM SERVER: Sending to client next message:
" << playerMessage << std:: endl;
            }
            else {
                if (game.name == clientCommands[3]) {
                    if (game.password == clientCommands[4]) {
                        game.connected = true;
                        connector.turn = false;
                        creator.turn = true;
                        connector.username = clientCommands[1];
                        RandomLocation(connector.field);
                        std:: string to = "TO";
                        std:: string playerMessage = to + _MSG_SEP +
clientCommands[1] + _MSG_SEP + "connected" + _MSG_SEP;
                        sprintf(mappedFile.data, "%s",
playerMessage.c_str());
                        std:: cout << "FROM SERVER: Sending to client next
message: " << playerMessage << std:: endl;
                    }
                    else {
                        game.connected = false;
                        std:: string to = "TO";
                        std:: string playerMessage = to + _MSG_SEP +
clientCommands[1] + _MSG_SEP + "wrongpassword" + _MSG_SEP;
                        sprintf(mappedFile.data, "%s",
playerMessage.c_str());
                        std:: cout << "FROM SERVER: Sending to client next
message: " << playerMessage << std:: endl;
                    }
                }
                else {
```

```
                    game.connected = false;
                    std:: string to = "TO";
                    std:: string playerMessage = to + _MSG_SEP +
clientCommands[1] + _MSG_SEP + "gamenotexists" + _MSG_SEP;
                    sprintf(mappedFile.data, "%s", playerMessage.c_str());
                    std:: cout << "FROM SERVER: Sending to client next
message:" << playerMessage << std:: endl;
                }
            }
        }
        else if (clientCommands[2] == "shoot") {
            if (!game.connected) {
                std:: string to = "TO";
                std:: string playerMessage = to + _MSG_SEP +
clientCommands[1] + _MSG_SEP + "notatgame" + _MSG_SEP;
                sprintf(mappedFile.data, "%s", playerMessage.c_str());
                std:: cout << "FROM SERVER: Sending to client next message:
" << playerMessage << std:: endl;
            }
            if (clientCommands[1] == connector.username) {
                if (connector.turn && !creator.turn) {
                    if (game.name == clientCommands[3]) {
                        int number = std:: stoi(clientCommands[5]);
                        std:: string l = clientCommands[4];
                        char letter = l[0];
                        if (creator.field[number][int(letter) - int('A') +
1] == 'X' &&
                        (creator.field[number][int(letter) - int('A') + 2]
== '.' || creator.field[number][int(letter) - int('A') + 2] == 'm' ||
creator.field[number][int(letter) - int('A') + 2] == 'w') &&
                        (creator.field[number - 1][int(letter) - int('A') +
1] == '.' || creator.field[number - 1][int(letter) - int('A') + 1] == 'm'
|| creator.field[number - 1][int(letter) - int('A') + 1] == 'w') &&
                        (creator.field[number - 1][int(letter) - int('A') +
2] == '.' || creator.field[number - 1][int(letter) - int('A') + 2] == 'm'
|| creator.field[number - 1][int(letter) - int('A') + 2] == 'w') &&
                        (creator.field[number + 1][int(letter) - int('A') +
1] == '.' || creator.field[number + 1][int(letter) - int('A') + 1] == 'm'
|| creator.field[number + 1][int(letter) - int('A') + 1] == 'w') &&
                        (creator.field[number + 1][int(letter) - int('A') +
2] == '.' || creator.field[number + 1][int(letter) - int('A') + 2] == 'm'
|| creator.field[number + 1][int(letter) - int('A') + 2] == 'w')) {
                            creator.field[number][int(letter) - int('A') +
1] = 'w';
                            connector.wounds++;
```

```
                            connector.kills++;
                            connector.turn = true;
                            creator.turn = false;
                            if (WonGame(creator.field)) {
                                std:: string to = "TO";
                                std:: string playerMessage = to + _MSG_SEP
+ clientCommands[1] + _MSG_SEP + "youwon" + _MSG_SEP;
                                sprintf(mappedFile.data, "%s",
playerMessage.c_str());
                                std:: cout << "FROM SERVER: Sending to
connector next message:" << playerMessage << std:: endl;
                                connector.wins++;
                                creator.loses++;
                                std:: ofstream fout("Statistics.txt",
std::ios_base::app);
                                fout << connector.username << ": " <<
connector.wins << " wins, " << connector.loses << " loses, " <<
connector.kills << " kills, " << connector.misses << " misses, " <<
connector.wounds << " wounds, " << std:: endl;
                                fout << creator.username << ": " <<
creator.wins << " wins, " << creator.loses << " loses, " << creator.kills
<< " kills, " << creator.misses << " misses, " << creator.wounds << "
wounds, " << std:: endl;
                                creator.ErasePlayer();
                                connector.ErasePlayer();
                                PrepareField(creator.field);
                                PrepareField(connector.field);
                                game.EraseGame();
                            }
                            else {
                                std:: string to = "TO";
                                std:: string playerMessage = to + _MSG_SEP
+ clientCommands[1] + _MSG_SEP + "youkilled" + _MSG_SEP;
                                sprintf(mappedFile.data, "%s",
playerMessage.c_str());
                                std:: cout << "FROM SERVER: Sending to
client next message:" << playerMessage << std:: endl;
                            }
                        }
                        else if (creator.field[number][int(letter) -
int('A') + 1] == 'w' || creator.field[number][int(letter) - int('A') + 1]
== 'm') {
                            connector.turn = true;
                            creator.turn = false;
                            std:: string to = "TO";
```

```
                            std:: string playerMessage = to + _MSG_SEP +
clientCommands[1] + _MSG_SEP + "yourepeated" + _MSG_SEP;
                            sprintf(mappedFile.data, "%s",
playerMessage.c_str());
                            std:: cout << "FROM SERVER: Sending to client
next message:" << playerMessage << std:: endl;
                        }
                        else if (creator.field[number][int(letter) -
int('A') + 1] == 'X' &&
                        creator.field[number][int(letter) - int('A') + 2]
== 'X' &&
                        (creator.field[number - 1][int(letter) - int('A') +
1] == '.' || creator.field[number - 1][int(letter) - int('A') + 1] == 'm'
|| creator.field[number - 1][int(letter) - int('A') + 1] == 'w') &&
                        (creator.field[number - 1][int(letter) - int('A') +
2] == '.' || creator.field[number - 1][int(letter) - int('A') + 2] == 'm'
|| creator.field[number - 1][int(letter) - int('A') + 2] == 'w') &&
                        (creator.field[number + 1][int(letter) - int('A') +
1] == '.' || creator.field[number + 1][int(letter) - int('A') + 1] == 'm'
|| creator.field[number + 1][int(letter) - int('A') + 1] == 'w') &&
                        (creator.field[number + 1][int(letter) - int('A') +
2] == '.' || creator.field[number + 1][int(letter) - int('A') + 2] == 'm'
|| creator.field[number + 1][int(letter) - int('A') + 2] == 'w')) {
                            creator.field[number][int(letter) - int('A') +
1] = 'w';
                            connector.wounds++;
                            connector.turn = true;
                            creator.turn = false;
                            std:: string to = "TO";
                            std:: string playerMessage = to + _MSG_SEP +
clientCommands[1] + _MSG_SEP + "youwounded" + _MSG_SEP;
                            sprintf(mappedFile.data, "%s",
playerMessage.c_str());
                            std:: cout << "FROM SERVER: Sending to client
next message: " << playerMessage << std:: endl;
                        }
                        else if (creator.field[number][int(letter) -
int('A') + 1] == 'X' && (creator.field[number][int(letter) - int('A') + 2]
== '.' || creator.field[number][int(letter) - int('A') + 2] == 'm' ||
creator.field[number][int(letter) - int('A') + 2] == 'w') &&
                        creator.field[number - 1][int(letter) - int('A') +
1] == 'X' &&
                        (creator.field[number - 1][int(letter) - int('A') +
2] == '.' || creator.field[number - 1][int(letter) - int('A') + 2] == 'm'
|| creator.field[number - 1][int(letter) - int('A') + 2] == 'w') &&
```

```
                        (creator.field[number + 1][int(letter) - int('A') +
1] == '.' || creator.field[number + 1][int(letter) - int('A') + 1] == 'm'
|| creator.field[number + 1][int(letter) - int('A') + 1] == 'w') &&
                        (creator.field[number + 1][int(letter) - int('A') +
2] == '.' || creator.field[number + 1][int(letter) - int('A') + 2] == 'm'
|| creator.field[number + 1][int(letter) - int('A') + 2] == 'w')) {
                            creator.field[number][int(letter) - int('A') +
1] = 'w';
                            connector.wounds++;
                            connector.turn = true;
                            creator.turn = false;
                            std:: string to = "TO";
                            std:: string playerMessage = to + _MSG_SEP +
clientCommands[1] + _MSG_SEP + "youwounded" + _MSG_SEP;
                            sprintf(mappedFile.data, "%s",
playerMessage.c_str());
                            std:: cout << "FROM SERVER: Sending to client
next message: " << playerMessage << std:: endl;
                        }
                        else if (creator.field[number][int(letter) -
int('A') + 1] == 'X' &&
                        (creator.field[number][int(letter) - int('A') + 2]
== '.' || creator.field[number][int(letter) - int('A') + 2] == 'm' ||
creator.field[number][int(letter) - int('A') + 2] == 'w') &&
                        (creator.field[number - 1][int(letter) - int('A') +
1] == '.' || creator.field[number - 1][int(letter) - int('A') + 1] == 'm'
|| creator.field[number - 1][int(letter) - int('A') + 1] == 'w') &&
                        (creator.field[number - 1][int(letter) - int('A') +
2] == '.' || creator.field[number - 1][int(letter) - int('A') + 2] == 'm'
|| creator.field[number - 1][int(letter) - int('A') + 2] == 'w') &&
                        creator.field[number + 1][int(letter) - int('A') +
1] == 'X' &&
                        (creator.field[number + 1][int(letter) - int('A') +
2] == '.' || creator.field[number + 1][int(letter) - int('A') + 2] == 'm'
|| creator.field[number + 1][int(letter) - int('A') + 2] == 'w')) {
                            creator.field[number][int(letter) - int('A') +
1] = 'w';
                            connector.wounds++;
                            connector.turn = true;
                            creator.turn = false;
                            std:: string to = "TO";
                            std:: string playerMessage = to + _MSG_SEP +
clientCommands[1] + _MSG_SEP + "youwounded" + _MSG_SEP;
                            sprintf(mappedFile.data, "%s",
playerMessage.c_str());
```

```
                        std:: cout << "FROM SERVER: Sending to client
next message: " << playerMessage << std:: endl;
                    }
                    else if (creator.field[number][int(letter) -
int('A') + 1] == 'X' && creator.field[number + 1][int(letter) - int('A') +
1] == 'X') {
                        creator.field[number][int(letter) - int('A') +
1] = 'w';
                        connector.wounds++;
                        connector.turn = true;
                        creator.turn = false;
                        std:: string to = "TO";
                        std:: string playerMessage = to + _MSG_SEP +
clientCommands[1] +
                                                    _MSG_SEP + "youwounded" +
_MSG_SEP;
                        sprintf(mappedFile.data, "%s",
playerMessage.c_str());
                        std:: cout << "FROM SERVER: Sending to client
next message: " << playerMessage << std:: endl;
                    }
                    else if (creator.field[number][int(letter) -
int('A') + 1] == '.') {
                        connector.misses++;
                        connector.turn = false;
                        creator.turn = true;
                        creator.field[number][int(letter) - int('A') +
1] = 'm';
                        std:: string to = "TO";
                        std:: string playerMessage = to + _MSG_SEP +
clientCommands[1] + _MSG_SEP + "youmissed" + _MSG_SEP;
                        sprintf(mappedFile.data, "%s",
playerMessage.c_str());
                        std:: cout << "FROM SERVER: Sending to client
next message: " << playerMessage << std:: endl;
                    }
                    std:: cout << "Current state of " <<
creator.username << "'s field is: " << std:: endl;
                    PrintField(creator.field);
                }
                else {
                    std:: string to = "TO";
                    std:: string playerMessage = to + _MSG_SEP +
clientCommands[1] + _MSG_SEP + "gamenotexists" + _MSG_SEP;
```

```
                        sprintf(mappedFile.data, "%s",
playerMessage.c_str());
                        std:: cout << "FROM SERVER: Sending to client next
message: " << playerMessage << std:: endl;
                    }
                }
                else {
                    std:: string to = "TO";
                    std:: string playerMessage = to + _MSG_SEP +
clientCommands[1] + _MSG_SEP + "notyourturn" + _MSG_SEP;
                    sprintf(mappedFile.data, "%s", playerMessage.c_str());
                    std:: cout << "FROM SERVER: Sending to client next
message: " << playerMessage << std:: endl;
                }
            }
            else if (clientCommands[1] == creator.username) {
                if (creator.turn && !connector.turn) {
                    if (game.name == clientCommands[3]) {
                        int number = std::stoi(clientCommands[5]);
                        std:: string l = clientCommands[4];
                        char letter = l[0];
                        if (connector.field[number][int(letter) - int('A')
+ 1] == 'X' &&
                        (connector.field[number][int(letter) - int('A') +
2] == '.' || connector.field[number][int(letter) - int('A') + 2] == 'm' ||
connector.field[number][int(letter) - int('A') + 2] == 'w') &&
                        (connector.field[number - 1][int(letter) - int('A')
+ 1] == '.' || connector.field[number - 1][int(letter) - int('A') + 1] ==
'm' || connector.field[number - 1][int(letter) - int('A') + 1] == 'w') &&
                        (connector.field[number - 1][int(letter) - int('A')
+ 2] == '.' || connector.field[number - 1][int(letter) - int('A') + 2] ==
'm' || connector.field[number - 1][int(letter) - int('A') + 2] == 'w') &&
                        (connector.field[number + 1][int(letter) - int('A')
+ 1] == '.' || connector.field[number + 1][int(letter) - int('A') + 1] ==
'm' || connector.field[number + 1][int(letter) - int('A') + 1] == 'w') &&
                        (connector.field[number + 1][int(letter) - int('A')
+ 2] == '.' || connector.field[number + 1][int(letter) - int('A') + 2] ==
'm' || connector.field[number + 1][int(letter) - int('A') + 2] == 'w')) {
                            connector.field[number][int(letter) - int('A')
+ 1] = 'w';
                            creator.kills++;
                            creator.wounds++;
                            creator.turn = true;
                            connector.turn = false;
                            if (WonGame(connector.field)) {
```

```
                                std:: string to = "TO";
                                std:: string playerMessage = to + _MSG_SEP
+ clientCommands[1] + _MSG_SEP + "youwon" + _MSG_SEP;
                                sprintf(mappedFile.data, "%s",
playerMessage.c_str());
                                std:: cout << "FROM SERVER: Sending to
creator next message: " << playerMessage << std:: endl;
                                creator.wins++;
                                connector.loses++;
                                std:: ofstream fout("Statistics.txt",
std::ios_base::app);
                                fout << connector.username << ": " <<
connector.wins << " wins, " << connector.loses << " loses, " <<
connector.kills << " kills, " << connector.misses << " misses, " <<
connector.wounds << " wounds." << std:: endl;
                                fout << creator.username << ": " <<
creator.wins << " wins, " << creator.loses << " loses, " << creator.kills
<< " kills, " << creator.misses << " misses, " << creator.wounds << "
wounds. " << std:: endl;
                                creator.ErasePlayer();
                                connector.ErasePlayer();
                                PrepareField(creator.field);
                                PrepareField(connector.field);
                                game.EraseGame();
                            }
                            else {
                                std:: string to = "TO";
                                std:: string playerMessage = to + _MSG_SEP
+ clientCommands[1] + _MSG_SEP + "youkilled" + _MSG_SEP;
                                sprintf(mappedFile.data, "%s",
playerMessage.c_str());
                                std:: cout << "FROM SERVER: Sending to
client next message: " << playerMessage << std:: endl;
                            }
                        }
                        else if (connector.field[number][int(letter) -
int('A') + 1] == 'w' || connector.field[number][int(letter) - int('A') +
1] == 'm') {
                            creator.turn = true;
                            connector.turn = false;
                            std:: string to = "TO";
                            std:: string playerMessage = to + _MSG_SEP +
clientCommands[1] + _MSG_SEP + "yourepeated" + _MSG_SEP;
                            sprintf(mappedFile.data, "%s",
playerMessage.c_str());
```

```
                        std:: cout << "FROM SERVER: Sending to client
next message: " << playerMessage << std:: endl;
                    }
                    else if (connector.field[number][int(letter) -
int('A') + 1] == 'X' &&
                    connector.field[number][int(letter) - int('A') + 2]
== 'X' &&
                    (connector.field[number - 1][int(letter) - int('A')
+ 1] == '.' || connector.field[number - 1][int(letter) - int('A') + 1] ==
'm' || connector.field[number - 1][int(letter) - int('A') + 1] == 'w') &&
                    (connector.field[number - 1][int(letter) - int('A')
+ 2] == '.' || connector.field[number - 1][int(letter) - int('A') + 2] ==
'm' || connector.field[number - 1][int(letter) - int('A') + 2] == 'w') &&
                    (connector.field[number + 1][int(letter) - int('A')
+ 1] == '.' || connector.field[number + 1][int(letter) - int('A') + 1] ==
'm' || connector.field[number + 1][int(letter) - int('A') + 1] == 'w') &&
                    (connector.field[number + 1][int(letter) - int('A')
+ 2] == '.' || connector.field[number + 1][int(letter) - int('A') + 2] ==
'm' || connector.field[number + 1][int(letter) - int('A') + 2] == 'w')) {
                        connector.field[number][int(letter) - int('A')
+ 1] = 'w';
                        creator.wounds++;
                        creator.turn = true;
                        connector.turn = false;
                        std:: string to = "TO";
                        std:: string playerMessage = to + _MSG_SEP +
clientCommands[1] + _MSG_SEP + "youwounded" + _MSG_SEP;
                        sprintf(mappedFile.data, "%s",
playerMessage.c_str());
                        std:: cout << "FROM SERVER: Sending to client
next message: " << playerMessage << std:: endl;
                    }
                    else if (connector.field[number][int(letter) -
int('A') + 1] == 'X' && (connector.field[number][int(letter) - int('A') +
2] == '.' || connector.field[number][int(letter) - int('A') + 2] == 'm' ||
connector.field[number][int(letter) - int('A') + 2] == 'w') &&
                    connector.field[number - 1][int(letter) - int('A')
+ 1] == 'X' &&
                    (connector.field[number - 1][int(letter) - int('A')
+ 2] == '.' || connector.field[number - 1][int(letter) - int('A') + 2] ==
'm' || connector.field[number - 1][int(letter) - int('A') + 2] == 'w') &&
                    (connector.field[number + 1][int(letter) - int('A')
+ 1] == '.' || connector.field[number + 1][int(letter) - int('A') + 1] ==
'm' || connector.field[number + 1][int(letter) - int('A') + 1] == 'w') &&
```

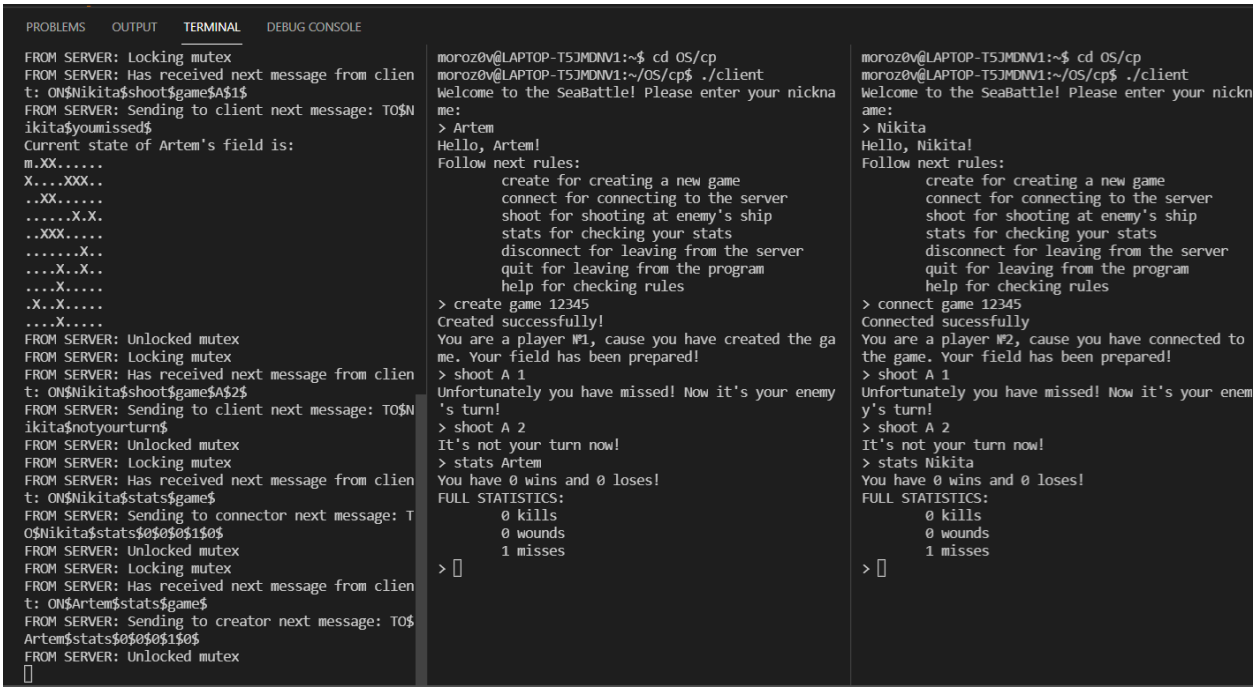
```
                        (connector.field[number + 1][int(letter) - int('A')
+ 2] == '.' || connector.field[number + 1][int(letter) - int('A') + 2] ==
'm' || connector.field[number + 1][int(letter) - int('A') + 2] == 'w')) {
                            connector.field[number][int(letter) - int('A')
+ 1] = 'w';
                            creator.wounds++;
                            creator.turn = true;
                            connector.turn = false;
                            std:: string to = "TO";
                            std:: string playerMessage = to + _MSG_SEP +
clientCommands[1] + _MSG_SEP + "youwounded" + _MSG_SEP;
                            sprintf(mappedFile.data, "%s",
playerMessage.c_str());
                            std:: cout << "FROM SERVER: Sending to client
next message: " << playerMessage << std:: endl;
                        }
                        else if (connector.field[number][int(letter) -
int('A') + 1] == 'X' &&
                        (connector.field[number][int(letter) - int('A') +
2] == '.' || connector.field[number][int(letter) - int('A') + 2] == 'm' ||
connector.field[number][int(letter) - int('A') + 2] == 'w') &&
                        (connector.field[number - 1][int(letter) - int('A')
+ 1] == '.' || connector.field[number - 1][int(letter) - int('A') + 1] ==
'm' || connector.field[number - 1][int(letter) - int('A') + 1] == 'w') &&
                        (connector.field[number - 1][int(letter) - int('A')
+ 2] == '.' || connector.field[number - 1][int(letter) - int('A') + 2] ==
'm' || connector.field[number - 1][int(letter) - int('A') + 2] == 'w') &&
                        connector.field[number + 1][int(letter) - int('A')
+ 1] == 'X' &&
                        (connector.field[number + 1][int(letter) - int('A')
+ 2] == '.' || connector.field[number + 1][int(letter) - int('A') + 2] ==
'm' || connector.field[number + 1][int(letter) - int('A') + 2] == 'w')) {
                            connector.field[number][int(letter) - int('A')
+ 1] = 'w';
                            creator.wounds++;
                            creator.turn = true;
                            connector.turn = false;
                            std:: string to = "TO";
                            std:: string playerMessage = to + _MSG_SEP +
clientCommands[1] + _MSG_SEP + "youwounded" + _MSG_SEP;
                            sprintf(mappedFile.data, "%s",
playerMessage.c_str());
                            std:: cout << "FROM SERVER: Sending to client
next message: " << playerMessage << std:: endl;
                        }
```

```
                        else if (connector.field[number][int(letter) -
int('A') + 1] == 'X' && connector.field[number + 1][int(letter) - int('A')
+ 1] == 'X') {
                            connector.field[number][int(letter) - int('A')
+ 1] = 'w';
                            connector.wounds++;
                            connector.turn = true;
                            creator.turn = false;
                            std:: string to = "TO";
                            std:: string playerMessage = to + _MSG_SEP +
clientCommands[1] +
                                                    _MSG_SEP + "youwounded" +
_MSG_SEP;
                            sprintf(mappedFile.data, "%s",
playerMessage.c_str());
                            std:: cout << "FROM SERVER: Sending to client
next message: " << playerMessage << std:: endl;
                        }
                        else if (connector.field[number][int(letter) -
int('A') + 1] == '.') {
                            creator.misses++;
                            creator.turn = false;
                            connector.turn = true;
                            connector.field[number][int(letter) - int('A')
+ 1] = 'm';
                            std:: string to = "TO";
                            std:: string playerMessage = to + _MSG_SEP +
clientCommands[1] + _MSG_SEP + "youmissed" + _MSG_SEP;
                            sprintf(mappedFile.data, "%s",
playerMessage.c_str());
                            std:: cout << "FROM SERVER: Sending to client
next message: " << playerMessage << std:: endl;
                        }
                        std:: cout << "Current state of " <<
connector.username << "'s field is: " << std:: endl;
                        PrintField(connector.field);
                    }
                    else {
                        std:: string to = "TO";
                        std:: string playerMessage = to + _MSG_SEP +
clientCommands[1] + _MSG_SEP + "gamenotexists" + _MSG_SEP;
                        sprintf(mappedFile.data, "%s",
playerMessage.c_str());
                        std:: cout << "FROM SERVER: Sending to client next
message: " << playerMessage << std:: endl;
```

```
                    }
                }
                else {
                    creator.turn = false;
                    std:: string to = "TO";
                    std:: string playerMessage = to + _MSG_SEP +
clientCommands[1] + _MSG_SEP + "notyourturn" + _MSG_SEP;
                    sprintf(mappedFile.data, "%s", playerMessage.c_str());
                    std:: cout << "FROM SERVER: Sending to client next
message: " << playerMessage << std:: endl;
                }
            }
        }
        else if (clientCommands[2] == "disconnect") {
            if (clientCommands[1] == creator.username) {
                creator.turn = false;
                connector.turn = true;
                game.connected = false;
                std:: string to = "TO";
                std:: string playerMessage = to + _MSG_SEP +
clientCommands[1] + _MSG_SEP + "disconnected" + _MSG_SEP;
                sprintf(mappedFile.data, "%s", playerMessage.c_str());
                std::cout << "FROM SERVER: Sending to client next message:
" << playerMessage << std::endl;
                game.created = false;
            }
            else {
                creator.turn = true;
                connector.turn = false;
                game.connected = false;
                std:: string to = "TO";
                std:: string playerMessage = to + _MSG_SEP +
connector.username + _MSG_SEP + "disconnected" + _MSG_SEP;
                sprintf(mappedFile.data, "%s", playerMessage.c_str());
                std::cout << "FROM SERVER: Sending to client next message:
" << playerMessage << std:: endl;
            }
        }
        else if (clientCommands[2] == "stats") {
            if (creator.username == clientCommands[1]) {
                std:: string to = "TO";
                std:: string playerMessage = to + _MSG_SEP +
clientCommands[1] + _MSG_SEP + "stats" + _MSG_SEP + std::
to_string(creator.wins) + _MSG_SEP + std:: to_string(creator.loses) +
_MSG_SEP + std:: to_string(creator.kills) + _MSG_SEP + std::
```

```
to_string(creator.misses) + _MSG_SEP + std:: to_string(creator.wounds) +
_MSG_SEP;
                sprintf(mappedFile.data, "%s", playerMessage.c_str());
                std:: cout << "FROM SERVER: Sending to creator next
message: " << playerMessage << std:: endl;
            }
            else {
                std:: string to = "TO";
                std:: string playerMessage = to + _MSG_SEP +
clientCommands[1] + _MSG_SEP + "stats" + _MSG_SEP + std::
to_string(connector.wins) + _MSG_SEP + std:: to_string(connector.loses) +
_MSG_SEP + std:: to_string(connector.kills) + _MSG_SEP + std::
to_string(connector.misses) + _MSG_SEP + std:: to_string(connector.wounds)
+ _MSG_SEP;
                sprintf(mappedFile.data, "%s", playerMessage.c_str());
                std:: cout << "FROM SERVER: Sending to connector next
message: " << playerMessage << std::endl;
            }
        }
        pthread_mutex_unlock(mutex.ptr);
        std:: cout << "FROM SERVER: Unlocked mutex" << std:: endl;
    }
    if (SharedMutexDestroy(mutex) == -1) {
        std:: cout << "An error while destroying mutex has been detected!"
<< std:: endl;
        exit(EXIT_FAILURE);
    }
    if (shm_unlink(_BUFFER_NAME) == -1) {
        std:: cout << "An error while shm_unlink has been detected!" <<
std:: endl;
        exit(EXIT_FAILURE);
    }
    return 0;
}
```

Демонстрация работы программы



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