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высшего образования
«СИБИРСКИЙ ФЕДЕРАЛЬНЫЙ УНИВЕРСИТЕТ»

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ОТЧЕТ О ЛАБОРАТОРНОЙ РАБОТЕ № 8

Безопасность системных программ
Тема

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Красноярск 2021

1 Цель

Исследование вопросов безопасности в GNU/Linux.

2 Задачи

1. Ознакомиться с теоретическими сведениями по проблеме обеспечения информационной безопасности в ОС GNU/Linux.

2. Модифицировать результаты выполнения ЛР 7 добавлением использования программных средств обеспечения информационной безопасности в ОС GNU/Linux. Обеспечить сборку программы с использованием скрипта `configure` и утилиты GNU `make`. Серверная часть должна запускаться только привилегированным пользователем, а клиентская часть для передачи сообщений должна пройти процедуру аутентификации.

3. Используя изученные механизмы, разработать и отладить серверную и клиентскую части приложения.

4. Написать отчет и представить его к защите с исходными текстами программ, предварительно загрузив код и отчет в электронный курс в виде единственного архива формата `*.tar.gz`. Исходные тексты программ должны содержать комментарии в стиле системы `doxygen`.

Описание варианта:

Программа принимает от пользователя три строки, (первая и третья строки — это правильные рациональные или десятичные дроби вида «1/3» или «0,5», вторая строка — это знак арифметической операции вида «+», «-», «*», «/» либо операции сравнения «<», «>», «=», «!=», «>=», «<=»), выполняет требуемую операцию над полученными операндами, и выводит результат на экран. Обеспечить также сокращение дроби при необходимости. Если оба операнда арифметической операции являются рациональными дробями, результатом тоже

должна быть рациональная дробь. Для операций сравнения достаточно результата «Истина» или «Ложь».

3 Исходные тексты программ

На листинге 1 представлен код программы algorithm.c.

Листинг 1 – Код программы с основным алгоритмом

```
/*! \file    algorithm.c
 *  \brief   Fraction calculation and comparison
 *  \author  Nikitin Alexander, KI19-17/1Б
 */
#include <string.h>
#include <stdlib.h>
#include <stdbool.h>
#include <math.h>
#include <stdio.h>
#include "algorithm.h"

/*! \brief Checks if the string contains only digits
 *
 *  \param[in] string Numeric or non-numeric string
 *
 *  \return Is the string contains only digits or not (true or false)
 */
bool checkInt(char* string)
{
    char* intChars = "0123456789";

    for (int i = 0; i < strlen(string); i++)
    {
        // Проверка минуса перед числом
        if (i == 0 && string[i] == '-')
            continue;

        if (strchr(intChars, string[i]) == NULL)
            return false;
    }
    return true;
}

/*! \brief Divides fraction in two parts and returns both of the values. First
part is numeric part, second part is
 * fractional part. Both are integers.
 */
```

```

* \param[in] string Source fraction
* \param[in] pos Position of separator (',' or '/')
*
* \return First and second numbers of fraction
*/
struct fractionParts splitFraction(char* string, int pos)
{
    struct fractionParts output;

    char* firstPart = NULL;
    char* secondPart = NULL;

    int firstNumber;
    int secondNumber;

    char* pEnd = NULL;

    if (pos <= 0 || pos > strlen(string))
    {
        output.isWrong = true;
        return output;
    }

    // Срез целой части
    for (int i = 0; i < pos; i++)
    {
        firstPart = realloc(firstPart, i + 2);
        firstPart[i] = string[i];
    }
    firstPart[pos] = '\0';

    // Срез дробной части
    for (int i = pos + 1, j = 0; i < strlen(string); i++, j++)
    {
        secondPart = realloc(secondPart, j + 2);
        secondPart[j] = string[i];
    }
    secondPart[strlen(string) - pos - 1] = '\0';

    if (!checkInt(firstPart) || !checkInt(secondPart))
    {
        output.isWrong = true;
    }
}

```

```

        return output;
    }

    if (firstPart[0] == '-')
        output.isNegative = true;
    else
        output.isNegative = false;

    firstNumber = abs(strtol(firstPart, &pEnd, 10));
    secondNumber = abs(strtol(secondPart, &pEnd, 10));

    output.firstPart = firstNumber;
    output.secondPart = secondNumber;
    output.isWrong = false;

    return output;
}

/*! \brief Tries to transform string into fractionString.
 *
 * \param[in] fractionString Potential fractionString (X.X or X/X)
 *
 * \return All essential information about fraction (if fraction.isWrong ==
false)
 */
fractionInfo_t makeIntoFraction(char* fractionString)
{
    char fractionSeparator;
    char fractionSeparatorString[2];

    struct fractionParts fraction;
    fractionInfo_t convertedFraction;

    printf("%s\n", fractionString);

    fractionSeparator = strpbrk(fractionString, "/,.")[0];
    fractionSeparatorString[0] = fractionSeparator;
    int posSeparator = (int) strcspn(fractionString, fractionSeparatorString) +
1;

    fraction = splitFraction(fractionString, posSeparator - 1);

```

```

    if (fraction.isWrong)
    {
        convertedFraction.isWrong = true;
        return convertedFraction;
    }

    // Заполнение информации о дроби
    convertedFraction.firstPart = fraction.firstPart;
    convertedFraction.secondPart = fraction.secondPart;
    convertedFraction.isNegative = fraction.isNegative;

    switch (fractionSeparator)
    {
    case '/':
    {
        convertedFraction.type = COMMON;
        if (convertedFraction.secondPart == 0)
            convertedFraction.isWrong = true;
        else
            convertedFraction.isWrong = false;
        return convertedFraction;
    }

    case ',':
    case '.':
    {
        convertedFraction.type = DECIMAL;
        convertedFraction.isWrong = false;
        return convertedFraction;
    }

    default:
    {
        convertedFraction.isWrong = true;
        return convertedFraction;
    }
    }
}

/*! \brief Calculates the highest power of the number. For example, 1274 = 1 *
10^3 + 2 * 10^2 + 7 * 10^1 + 4 * 10^0.
* So, the highest power (10^3) is 4.
*

```

```

* \param[in] number Source number
*
* \return The highest power
*/
int calculateHighestPower(int number)
{
    int power = 0;

    while (abs(number) > 0)
    {
        number /= 10;
        power++;
    }
    return power;
}

/*! \brief Calculates the highest negative power of the decimal number. For
example, 12.74 = 1 * 10^1 + 2 * 10^0
* + 7 * 10^-1 + 4 * 10^-2. So, the highest negative power (10^-2) is -2.
*
* \param[in] number Source number
*
* \return The highest negative power. Maximum value is MAX_DECIMAL_PART_LENGTH.
*/
int calculateHighestNegativePower(double number)
{
    int power = 0;
    while ((number - (int) number) != 0 && power <= MAX_DECIMAL_PART_LENGTH)
    {
        number *= 10;
        power++;
    }

    return power;
}

/*! \brief Finds and returns simple dividers of the number. For example, simple
dividers of 60 are 2, 2, 3, 5.
*
* \param[in] number Positive integer number
*
* \return Simple dividers of a number

```



```

*/
arrayInfo_t findSimpleDividers(int number)
{
    arrayInfo_t dividers;
    int length = 0;
    int i = 2;
    int j = 0;

    int numberCopy = number;

    while (numberCopy > 1)
    {
        while (numberCopy % i == 0)
        {
            numberCopy /= i;
            length++;
        }
        i++;
    }

    // !
    int* dividersArray = (int*) malloc(length * sizeof(int));
    i = 2;
    numberCopy = number;
    while (numberCopy > 1)
    {
        while (numberCopy % i == 0)
        {
            numberCopy /= i;
            dividersArray[j] = i;
            j++;
        }
        i++;
    }
    dividers.array = dividersArray;
    dividers.length = length;

    return dividers;
}

/*! \brief Subtract one array from another and returns the result. For example,
(3, 4, 2, 6, 2) - (2, 6) = (3, 4, 2)

```

```

*
* \param[in] minuend The minuend array
* \param[in] subtrahend The subtrahend array
*
* \return The residual array
*/
arrayInfo_t subtractArrays(arrayInfo_t minuend, arrayInfo_t subtrahend)
{
    arrayInfo_t residual;

    if (subtrahend.length == 0)
        return minuend;

    if (minuend.length == 0)
    {
        residual.array = NULL;
        residual.length = 0;
        return residual;
    }

    // Вспомогательный массив для определения, какие элементы удалять
    int minuendIndexes[minuend.length];
    for (int i = 0; i < minuend.length; i++)
    {
        minuendIndexes[i] = i;
    }

    int count = 0;
    for (int i = 0; i < subtrahend.length; i++)
    {
        for (int j = 0; j < minuend.length; j++)
        {
            if ((minuend.array[j] == subtrahend.array[i]) && (minuendIndexes[j]
!= -1))
            {
                minuendIndexes[j] = -1;
                count++;
                break;
            }
        }
    }
}

```

```

int* residualArray = (int*) malloc((minuend.length - count) * sizeof(int));

count = 0;
for (int i = 0; i < minuend.length; i++)
    if (minuendIndexes[i] != -1)
    {
        residualArray[count] = minuend.array[i];
        count++;
    }

residual.array = residualArray;
residual.length = count;

return residual;
}

/*! \brief Finds least common multiple of two numbers.
 *
 * \param[in] number1 First number of LCM
 * \param[in] number2 Second number of LCM
 *
 * \return Least common multiple
 */
int findLCM(int number1, int number2)
{
    arrayInfo_t dividers1 = findSimpleDividers(number1);

    arrayInfo_t dividers2 = findSimpleDividers(number2);
    arrayInfo_t remainingDividers = subtractArrays(dividers2, dividers1);
    int LCM = 1;

    for (int i = 0; i < dividers1.length; i++)
        LCM *= dividers1.array[i];

    // Домножаю только неповторяющиеся значения
    for (int i = 0; i < remainingDividers.length; i++)
    {
        LCM *= remainingDividers.array[i];
    }

    return LCM;
}

```

```

/*! \brief Finds greatest common divisor of two numbers.
*
* \param[in] number1 First number of GCD
* \param[in] number2 Second number of GCD
*
* \return Greatest common divisor
*/
int findGCD(int number1, int number2)
{
    int GCD = 1;
    if (number1 == 0 || number2 == 0)
        return GCD;

    GCD = number1 * number2 / findLCM(number1, number2);
    return GCD;
}

/*! \brief Reduce fraction to a common denominator.
*
* \param[in] fraction Source fraction
*
* \return Nothing
*/
void reduceFraction(fractionInfo_t* fraction)
{
    if (fraction->type == DECIMAL)
    {
        fraction->isWrong = true;
        return;
    }

    int GCD = findGCD(fraction->firstPart, fraction->secondPart);
    fraction->firstPart /= GCD;
    fraction->secondPart /= GCD;
}

/*! \brief Transforms fraction into decimal number.
*
* \param[in] fraction Source fraction
*
* \return Decimal (double) format of fraction

```

```

*/
double toDouble(fractionInfo_t fraction)
{
    double doubleFraction;
    if (fraction.type == COMMON)
        doubleFraction = (double) fraction.firstPart / (double)
fraction.secondPart;
    else
        doubleFraction = (double) fraction.firstPart +
            (double) fraction.secondPart / pow(10,
calculateHighestPower(fraction.secondPart));

    if (fraction.isNegative)
        doubleFraction *= -1;

    return doubleFraction;
}

/*! \brief Performs arithmetic operations on two fractions. Possible operations
are '+', '-', '*', '/'. Fractions
* can be decimal or common. If both are common, the result is common, too. In
other cases it is decimal.
*
* \param[in] fraction1 First part of arithmetic operation
* \param[in] fraction2 Second part of arithmetic operation
* \param[in] operation Operation type ('+', '-', '*', or '/')
*
* \return Result of arithmetic operation
*/
fractionInfo_t calculate(fractionInfo_t fraction1, fractionInfo_t fraction2,
char* operation)
{
    enum Case
    {
        Plus, Minus, Multiply, Divide
    };

    enum Case operationCode;
    if (strcmp(operation, "+") == 0)
        operationCode = Plus;
    else if (strcmp(operation, "-") == 0)
        operationCode = Minus;

```

```

else if (strcmp(operation, "*") == 0)
    operationCode = Multiply;
else
    operationCode = Divide;

fractionInfo_t result;
if (fraction1.type == COMMON && fraction2.type == COMMON)
{
    int LCM = findLCM(fraction1.secondPart, fraction2.secondPart);
    result.type = COMMON;

    // Учет знака
    if (fraction1.isNegative)
        fraction1.firstPart *= -1;

    if (fraction2.isNegative)
        fraction2.firstPart *= -1;

    switch (operationCode)
    {
    case Plus:
        result.firstPart = fraction1.firstPart * LCM / fraction1.secondPart +
            fraction2.firstPart * LCM / fraction2.secondPart;
        result.secondPart = LCM;
        break;

    case Minus:
        result.firstPart = fraction1.firstPart * LCM / fraction1.secondPart -
            fraction2.firstPart * LCM / fraction2.secondPart;
        result.secondPart = LCM;
        break;

    case Multiply:
        result.firstPart = fraction1.firstPart * fraction2.firstPart;
        result.secondPart = fraction1.secondPart * fraction2.secondPart;
        break;

    case Divide:
        result.firstPart = fraction1.firstPart * fraction2.secondPart;
        result.secondPart = fraction1.secondPart * fraction2.firstPart;
        break;
    }
}

```

```

    }

    if ((result.firstPart < 0 && result.secondPart > 0) || (result.firstPart
> 0 && result.secondPart < 0))
        result.isNegative = true;
    else
        result.isNegative = false;

    result.firstPart = abs(result.firstPart);
    result.secondPart = abs(result.secondPart);

    result.isWrong = false;

    reduceFraction(&result);
    return result;
}
else
{
    result.type = DECIMAL;

    double decimal1 = toDouble(fraction1);
    double decimal2 = toDouble(fraction2);

    double resultDecimal;

    switch (operationCode)
    {
    case Plus:
        resultDecimal = decimal1 + decimal2;
        break;

    case Minus:
        resultDecimal = decimal1 - decimal2;
        break;

    case Multiply:
        resultDecimal = decimal1 * decimal2;
        break;

    case Divide:
        resultDecimal = decimal1 / decimal2;
        break;
    }
}

```

```

    }

    if (resultDecimal < 0)
    {
        result.isNegative = true;
        resultDecimal *= -1;
    }
    else
        result.isNegative = false;

    int negativePower = calculateHighestNegativePower(resultDecimal);

    result.firstPart = (int) resultDecimal;
    result.secondPart = (int) (resultDecimal * pow(10, negativePower) -
                               (int) resultDecimal * pow(10, negativePower));

    result.isWrong = false;
    return result;
}
}

/*! \brief Compares two fractions. Possible comparison operations are '>', '<',
'=', '!=', '>=', '<='.
* Fractions can be decimal or common. Returns true or false.
*
* \param[in] fraction1 First part of comparison
* \param[in] fraction2 Second part of comparison
* \param[in] operation Operation type ('>', '<', '=', '!=', '>=', or '<=')
*
* \return Result of comparison (true or false)
*/
int compare(fractionInfo_t fraction1, fractionInfo_t fraction2, char* operation)
{
    enum Case
    {
        Lesser, Greater, Equal, NotEqual, GreaterEqual, LesserEqual
    };

    enum Case operationCode;
    if (strcmp(operation, "<") == 0)
        operationCode = Lesser;
    else if (strcmp(operation, ">") == 0)

```



```

        operationCode = Greater;
    else if (strcmp(operation, "=") == 0)
        operationCode = Equal;
    else if (strcmp(operation, "!=") == 0)
        operationCode = NotEqual;
    else if (strcmp(operation, ">=") == 0)
        operationCode = GreaterEqual;
    else
        operationCode = LesserEqual;

    double decimal1 = toDouble(fraction1);
    double decimal2 = toDouble(fraction2);

    switch (operationCode)
    {
    case Lesser:
        return decimal1 < decimal2;

    case Greater:
        return decimal1 > decimal2;

    case Equal:
        return decimal1 == decimal2;

    case NotEqual:
        return decimal1 != decimal2;

    case GreaterEqual:
        return decimal1 >= decimal2;

    case LesserEqual:
        return decimal1 <= decimal2;
    }
}

```

На листинге 2 представлен код программы socketOperations.c.

Листинг 2 – Код программы с операциями по управлению TCP-сокетами

```

/#!/ \file    socketOperations.c
*  \brief    Working with TCP sockets.
*
*  \details  Has a various amount of TCP socket operating functions like server
and client creation

```

```

*   and sending data between them.
*
*   \author Nikitin Alexander, KI19-17/1B
*/

#include <string.h>
#include <stdlib.h>
#include <sys/un.h>
#include <sys/socket.h>
#include <netinet/in.h>
#include <arpa/inet.h>
#include <stdio.h>
#include <stdbool.h>

#include "socketOperations.h"

/*! \brief Writes the buffer content into socket.
*
*   \param[in] s File descriptor of socket
*   \param[in] buf The information to be written
*   \param[in] len Length of this information
*
*   \return Is the operation successful.
*/
bool sendSocketBuf(int s, void* buf, int len)
{
    int writeError = send(s, buf, len, 0);
    if (writeError == -1)
    {
        perror("Write length error");
        return false;
    }
    return true;
}

/*! \brief Writes the text into socket.
*
*   \param[in] socketFileDescriptor File descriptor of socket
*   \param[in] text Text that will be written into socket
*
*   \return Nothing.
*/

```

```

void sendSocketText(int socketFileDescriptor, char* text)
{
    int length = strlen(text) + 1;

    // Записываем длину
    sendSocketBuf(socketFileDescriptor, &length, sizeof(int));
    // Записываем строку
    sendSocketBuf(socketFileDescriptor, text, length);
}

/*! \brief Read the information from socket and saves it into the buffer.
 *
 * \param[in] s File descriptor of socket
 * \param[out] buf The information to be read
 * \param[in] len Length of this information
 *
 * \return Is the operation successful.
 */
bool readSocketBuf(int s, void* buf, int len)
{
    int recvError = recv(s, buf, len, 0);
    if (recvError == -1)
    {
        perror("Socket read error");
        return false;
    }
    return true;
}

/*! \brief Read the text from socket.
 *
 * \param[in] clientSocketFileDescriptor File descriptor of socket
 * \param[out] text Text that where the information from socket will be written
 *
 * \return Is the operation successful.
 */
bool receiveSocketText(int clientSocketFileDescriptor, char** text)
{
    int length;

    if (!readSocketBuf(clientSocketFileDescriptor, &length, sizeof(int)))
        return false;

```

```

    char temp[length];
    *text = malloc(sizeof(char) * length);

    if (!readSocketBuf(clientSocketFileDescriptor, temp, length))
        return false;

    strcpy(*text, temp);

    return true;
}

/*! \brief Creates a TCP socket for a client part.
 *
 * \return File descriptor of the socket.
 */
int createClientTCPSocket()
{
    int socketFileDescriptor = socket(AF_INET, SOCK_STREAM, 0);
    if (socketFileDescriptor == -1)
    {
        perror("Socket creation error");
        return -1;
    }
    return socketFileDescriptor;
}

/*! \brief Creates a TCP socket for a server part.
 *
 * \return File descriptor of the socket.
 */
int createServerTCPSocket()
{
    int socketFileDescriptor = socket(AF_INET, SOCK_STREAM, 0);
    int i = 1;
    int setsockError = setsockopt(socketFileDescriptor, SOL_SOCKET, SO_REUSEADDR,
                                   (const char*) &i, sizeof(i)
    );

    if (socketFileDescriptor == -1 || setsockError == -1)
    {
        perror("Socket creation error");
    }
}

```

```

        return -1;
    }
    return socketFileDescriptor;
}

/*! \brief Creates the name to the TCP socket and binds it to it.
 *
 * \param[in] socketFileDescriptor File descriptor of socket
 * \param[in] port TCP port
 *
 * \return Is the operation successful.
 */
bool bindTCPSocket(int socketFileDescriptor, char* port)
{
    int portNumber = strtol(port, NULL, 10);

    struct sockaddr_in name;
    name.sin_family = AF_INET;
    name.sin_port = htons((u_short) portNumber);
    name.sin_addr.s_addr = INADDR_ANY;

    int bindError = bind(socketFileDescriptor, (const struct sockaddr*) &name,
sizeof(name));
    if (bindError == -1)
    {
        perror("Bind error");
        return false;
    }

    return true;
}

/*! \brief Connects socket to the server.
 *
 * \param[in] socketFileDescriptor File descriptor of socket
 * \param[in] serverIP An IP to connect the socket
 * \param[in] port TCP port
 *
 * \return Is the operation successful.
 */
bool connectTCPSocket(int socketFileDescriptor, char* serverIP, char* port)
{

```

```

    struct sockaddr_in name;
    memset((char*) &name, 0, sizeof(name));

    name.sin_family = AF_INET;
    name.sin_addr.s_addr = inet_addr(serverIP);

    int portNumber = strtol(port, NULL, 10);

    if (name.sin_addr.s_addr == INADDR_NONE)
    {
        puts("Incorrect IP address!");
        return EXIT_FAILURE;
    }
    name.sin_port = htons((u_short) portNumber);

    int connectionError = connect(socketFileDescriptor, (struct sockaddr*) &name,
(socklen_t)
    sizeof(name));
    if (connectionError == -1)
    {
        perror("Connection error");
        return false;
    }

    return true;
}

/*! \brief Switch server into the ready-to-listen to sockets state.
*
* \param[in] socketFileDescriptor File descriptor of socket
*
* \return Is the operation successful.
*/
bool serverListen(int socketFileDescriptor)
{
    int listenError = listen(socketFileDescriptor, BACKLOG_NUMBER);
    if (listenError == -1)
    {
        perror("Listen error");
        return false;
    }
}

```

```

        return true;
    }

    /*! \brief Switch server into the waiting-for-sockets state.
    *
    * \param[in] socketFileDescriptor File descriptor of socket
    *
    * \return Is the operation successful.
    */
int acceptTCPSocket(int socketFileDescriptor)
{
    struct sockaddr_in clientName;
    socklen_t clientNameLength = sizeof(clientName);

    int clientSocketFileDescriptor = accept(socketFileDescriptor, (struct
sockaddr*) &clientName, &clientNameLength
    );

    if (clientSocketFileDescriptor == -1)
    {
        perror("Accept error");
        return -1;
    }

    return clientSocketFileDescriptor;
}

```

На листинге 3 представлен код программы client.c.

Листинг 3 – Код клиентской части программы

```

/*! \file    client.c
* \brief    client part of project.
*
* \details  Sends the info to server and takes the processed info.
*
* \author   Nikitin Alexander, KI19-17/1Б
*/

#include <stdio.h>
#include <string.h>
#include <stdlib.h>
#include <unistd.h>

```

```

#include <stdbool.h>
#include <ctype.h>
#include <fcntl.h>
#include <sys/types.h>
#include <sys/stat.h>

#include "client.h"
#include "socketOperations.h"
#include "signals.h"
#include "log.h"
#include "security.h"

#define RADIX 10
#define NUMBER_OF_COMPARISON_OPERATORS 10
#define MAX_LENGTH_COMPARISON_OPERATORS 2

/*! \brief Strrev function from <string.h> which is not available in Linux.
 *
 * \param[in] str Source string
 *
 * \return Reversed string
 */
char* strrev(char* str)
{
    if (!str || !*str)
        return str;

    int i = strlen(str) - 1, j = 0;

    char ch;
    while (i > j)
    {
        ch = str[i];
        str[i] = str[j];
        str[j] = ch;
        i--;
        j++;
    }
    return str;
}

///*! \brief Inputs the string from user console (tty) into the variable

```



```

// *
// * \param[out] word String variable of arbitrary length
// *
// * \return Nothing
// */
void inputString(char** word)
{
    int count = 0;
    char inputChar = 0;

    int fd = open("/dev/tty", O_RDWR | O_NOCTTY);
    FILE* tty = fdopen(fd, "w+");

    fflush(tty);

    *word = NULL;
    while (1)
    {
        inputChar = getc(tty);
        if (inputChar == '\n')
            if (count != 0) // обработка считывания единичного \n
                break;
            else
                continue;
        else
        {
            *word = realloc(*word, count + 1);
            if (*word == NULL)
                perror("Realloc has returned a NULL pointer");

            (*word)[count] = inputChar;
            count++;
        }
    }
    (*word)[count] = '\0';
}

/*! \brief Checks whether the string is fraction-type (x/x, x.x) or not.
*
* \param[in] string Verifiable string
*
* \return Is the string fraction-type or not

```

```

*/
bool checkFraction(char* string)
{
    char* endPtr = NULL;

    strtol(string, &endPtr, RADIX);
    if (strcmp(string, endPtr) == 0 || (endPtr[0] != '.' && endPtr[0] != '/' &&
endPtr[0] != ',')) // Если строка не
        // начинается с символа и первая часть не заканчивается разделителем
        return false;

    strcpy(string, strrev(string));
    strtol(string, &endPtr, RADIX);
    if (strcmp(string, endPtr) == 0 || (endPtr[0] != '.' && endPtr[0] != '/' &&
endPtr[0] != ',')) // Если строка не
        // начинается с символа и первая часть не заканчивается разделителем
        return false;

    strrev(string);
    return true;
}

/*! \brief Checks if the operation type is supportable in the program.
* List of operations: ("+", "-", "*", "/", "<", ">", "=", "!", ">=", "<=")
*
* \param[in] operation Operation string
*
* \return If the operator is appropriate (true or false)
*/
bool checkOperation(char* operation)
{
    char
allOperations[NUMBER_OF_COMPARISON_OPERATORS][MAX_LENGTH_COMPARISON_OPERATORS +
1]
        = {"+", "-", "*", "/", "<", ">", "=", "!", ">=", "<="};

    for (int i = 0; i < sizeof(allOperations) / sizeof(*allOperations); i++)
        if (strcmp(allOperations[i], operation) == 0)
            return true;

    return false;
}

```

```

/*! \brief Checks if the string is a natural number
 *
 * \param[in] string String that may be a number or not
 *
 * \return true or false
 */
bool checkNat(char* string)
{
    for (int i = 0; string[i] != '\0'; i++)
        if (!isdigit(string[i]))
            return false;

    if (strtol(string, NULL, 10) <= 0)
        return false;
    return true;
}

/*! \brief Checks if the string is a natural number or 0
 *
 * \param[in] string String that may be a number or not
 *
 * \return true or false
 */
bool checkNat0(char* string)
{
    for (int i = 0; string[i] != '\0'; i++)
        if (!isdigit(string[i]))
            return false;

    if (strtol(string, NULL, 10) < 0)
        return false;
    return true;
}

/*! \brief Outputs the console parameters to the user
 *
 * \return Nothing
 */
void printArguments()
{
    printf("-i - (optional) server IP assignment;\n"
           "-p - port assignment\n")

```

```

        "-l - (optional) log name assignment\n"
        "-t - (optional) client life time assignment\n"
        "-h - (optional) show help\n"
        "-c - (optional) check if the disk is full\n"
        "You need to enter password to run this program.\n");
    }

    /*! \brief Client main function
    * \param argc Number of command line arguments
    * \param argv An array of command line arguments.
    * \return Integer 0 upon exit success,
    *         or EXIT_FAILURE otherwise.
    */
    int main(int argc, const char* argv[])
    {
        registerHandler();

        char* firstFraction = NULL;
        char* secondFraction = NULL;
        char* operationSign = NULL;

        if (argc == 1)
        {
            printArguments();
            exit(EXIT_SUCCESS);
        }

        auth();

        // Задаем значения по умолчанию
        char* serverIP = "127.0.0.1";
        char* port = NULL;
        char* logPath = "./logs/clients.log";
        int time = 60;

        int opt;
        bool diskCheck = false;
        while((opt = getopt(argc, (char* const*) argv, "i:p:l:t:hc")) != -1)
        {
            switch(opt)
            {
                case 'i':

```

```

        serverIP = (char*) optarg;
        break;

case 'p':
    port = (char*) optarg;
    break;

case 'l':
    if (strlen(optarg) > MAX_LOG_LENGTH)
    {
        printf("Log name must be less than 30 symbols\n");
        exit(EXIT_SUCCESS);
    }

    logPath = (char*) optarg;
    break;

case 't':
    if (!checkNat(optarg))
    {
        printf("Time must be a number!\n");
    }
    time = strtol(optarg, NULL, 10);
    break;

case 'h':
    printArguments();
    exit(EXIT_SUCCESS);
    break;

case 'c':
    diskCheck = true;
    break;

case '?':
    printf("Unknown option: %c\n", optopt);
    exit(EXIT_FAILURE);
    break;
}

}

if (port == NULL)

```

```

{
    printf("Port number must be specified!\n");
    exit(EXIT_SUCCESS);
}

bool isWrong = false;

if (!checkNat0(port))
{
    printf("Incorrect port number: %s.\n", port);
    isWrong = true;
}

if (time <= 0)
{
    printf("Incorrect time: %d.\n", time);
    isWrong = true;
}

if (isWrong)
    return EXIT_FAILURE;

if (diskCheck)
    checkFullness(logPath);

int socketFileDescriptor;
while (true)
{
    setTimerClient(time);
    do
    {
        puts("Input first fraction:");
        inputString(&firstFraction);
    } while (!checkFraction(firstFraction));

    do
    {
        puts("Input operation:");
        inputString(&operationSign);
    } while (!checkOperation(operationSign));

    do

```

```

    {
        puts("Input second fraction:");
        inputString(&secondFraction);
    } while (!checkFraction(secondFraction));

    socketFileDescriptor = createClientTCPSocket();
    connectTCPSocket(socketFileDescriptor, serverIP, port);

    sendSocketText(socketFileDescriptor, firstFraction);
    sendSocketText(socketFileDescriptor, operationSign);
    sendSocketText(socketFileDescriptor, secondFraction);

    char    buffer[strlen(firstFraction)    +    strlen(operationSign)    +
strlen(secondFraction) + 3];
    strcpy(buffer, firstFraction);
    strcat(buffer, " ");
    strcat(buffer, operationSign);
    strcat(buffer, " ");
    strcat(buffer, secondFraction);
    strcat(buffer, "\n");

    if (diskCheck)
        checkFullness(logPath);
    writeLog(logPath, buffer);

    char* info = NULL;
    receiveSocketText(socketFileDescriptor, &info);
    printf("\n%s\n", info);
    free(info);

    close(socketFileDescriptor);
}
return 0;
}

```

На листинге 4 представлен код программы server.c.

Листинг 4 – Код серверной части программы

```

/*! \file    server.c
*   \brief   Server part of project.
*
*   \details Accepts the info from client, process it and returns back.
*

```

```

* \author Nikitin Alexander, KI19-17/1B
*/

#include <string.h>
#include <stdio.h>
#include <unistd.h>
#include <stdbool.h>
#include <ctype.h>
#include <stdlib.h>
#include <fcntl.h>
#include <sys/types.h>
#include <sys/stat.h>

#include "algorithm.h"
#include "server.h"
#include "socketOperations.h"
#include "signals.h"
#include "log.h"
#include "security.h"

/*! \brief Checks if the string is a natural number
*
* \param[in] string String that may be a number or not
*
* \return true or false
*/
bool checkNat(char* string)
{
    for (int i = 0; string[i] != '\0'; i++)
        if (!isdigit(string[i]))
            return false;

    if (strtol(string, NULL, 10) <= 0)
        return false;
    return true;
}

/*! \brief Checks if the string is a natural number or 0
*
* \param[in] string String that may be a number or not
*
* \return true or false

```



```

    */
bool checkNat0(char* string)
{
    for (int i = 0; string[i] != '\0'; i++)
        if (!isdigit(string[i]))
            return false;

    if (strtoul(string, NULL, 10) < 0)
        return false;
    return true;
}

/*! \brief Outputs the console parameters to the user
 *
 * \return Nothing
 */
void printArguments()
{
    printf("-p - port assignment\n"
           "-l - (optional) log name assignment\n"
           "-t - (optional) server life time assignment\n"
           "-h - (optional) show help\n"
           "-c - (optional) check if the disk is full\n"
           "You need to be a root to run this program.\n");
}

/*! \brief Calculates the file size
 *
 * \param fd File descriptor
 *
 * \return File size
 */
int getFileSize(int fd)
{
    struct stat info;
    int fstatSuccess = fstat(fd, &info);
    if (fstatSuccess)
    {
        perror("Getting file info went wrong");
    }

    return info.st_size;
}

```

```

}

/*! \brief Checks if the same copy of server is currently run. If it is so, kills
the program.
*
* \return Nothing
*/
void checkServerUnique()
{
    int fd = open(SERVER_UNIQUE_FILE_PATH, O_RDONLY | O_CREAT , 0666);
    if (getFileSize(fd) != 0)
    {
        printf("Server must be unique!\n");
        exit(EXIT_SUCCESS);
    }
    close(fd);
}

/*! \brief Block the server not allowing another copy of the server to be run.
*
* \return Nothing
*/
void block()
{
    char* message = "Closed";
    int fd = open(SERVER_UNIQUE_FILE_PATH, O_WRONLY | O_CREAT , 0660);
    int wrErr = write(fd, message, strlen(message));
    if (wrErr == -1)
    {
        perror("Write error");
        exit(EXIT_FAILURE);
    }
    close(fd);
}

/*! \brief Server main function
* \param[in] argc Number of command line arguments
* \param[in] argv An array of command line arguments.
* \return Integer 0 upon exit success,
*         or EXIT_FAILURE otherwise.
*/
int main(int argc, const char* argv[])

```

```

{
    registerHandler();

    char* socketFirstFraction = NULL;
    char* socketOperation = NULL;
    char* socketSecondFraction = NULL;

    fractionInfo_t firstFraction;
    fractionInfo_t secondFraction;
    fractionInfo_t result;

    if (argc == 1)
    {
        printArguments();
        exit(EXIT_SUCCESS);
    }

    rootCheck();
    checkServerUnique();

    // Задаем значения по умолчанию
    char* port = NULL;
    char* logPath = "./logs/clients.log";
    int time = 60;

    int opt;
    bool diskCheck = false;
    while((opt = getopt(argc, (char* const*) argv, "p:l:t:hc")) != -1)
    {
        switch(opt)
        {
            case 'p':
                port = (char*) optarg;
                break;

            case 'l':
                if (strlen(optarg) > MAX_LOG_LENGTH)
                {
                    printf("Log name must be less than 30 symbols\n");
                    exit(EXIT_SUCCESS);
                }
                logPath = optarg;

```

```

        break;

    case 't':
        if (!checkNat(optarg))
        {
            printf("Time must be a number!\n");
        }
        time = strtol(optarg, NULL, 10);
        break;

    case 'h':
        printArguments();
        exit(EXIT_SUCCESS);
        break;

    case 'c':
        diskCheck = true;
        break;

    case '?':
        printf("Unknown option: %c\n", optopt);
        exit(EXIT_FAILURE);
        break;
    }
}

if (port == NULL)
{
    printf("Port number must be specified!\n");
    exit(EXIT_SUCCESS);
}

bool isWrong = false;

if (!checkNat0(port))
{
    printf("Incorrect port number: %s.\n", port);
    isWrong = true;
}

if (time <= 0)
{

```

```

        printf("Incorrect time: %d.\n", time);
        isWrong = true;
    }

    if (isWrong)
        return EXIT_FAILURE;

    if (diskCheck)
        checkFullness(logPath);

    block();
    puts("Server is running.");

    int socketFileDescriptor = createServerTCPSocket();

    bindTCPSocket(socketFileDescriptor, port);

    serverListen(socketFileDescriptor);
    puts("Server is listening.");

    int clientSocketFileDescriptor;
    while (true)
    {
        setTimerServer(time);
        clientSocketFileDescriptor = acceptTCPSocket(socketFileDescriptor);
        printf("The socket has been connected to the server.\n");

        receiveSocketText(clientSocketFileDescriptor, &socketFirstFraction);
        printf("The information from socket has been received. Content: %s\n",
socketFirstFraction);
        receiveSocketText(clientSocketFileDescriptor, &socketOperation);
        printf("The information from socket has been received. Content: %s\n",
socketOperation);
        receiveSocketText(clientSocketFileDescriptor, &socketSecondFraction);
        printf("The information from socket has been received. Content: %s\n",
socketSecondFraction);

        firstFraction = makeIntoFraction(socketFirstFraction);
        secondFraction = makeIntoFraction(socketSecondFraction);

        char* sentInfo = malloc( sizeof (char) * (sizeof (socketFirstFraction) +
sizeof (socketOperation)

```

```

+                                                                    sizeof
(socketSecondFraction) + 40));

    if (firstFraction.isWrong || secondFraction.isWrong)
    {
        sprintf(sentInfo, "%s", "Incorrect fraction information!");
        continue;
    }

    if (strcmp(socketOperation, "+") == 0 || strcmp(socketOperation, "-") ==
0 ||
        strcmp(socketOperation, "/") == 0 || strcmp(socketOperation, "*") ==
0)
    {
        result = calculate(firstFraction, secondFraction, socketOperation);

        if (result.type == COMMON)
            if (result.isNegative)
                sprintf(sentInfo, "%s %s %s = -%d/%d\n", socketFirstFraction,
socketOperation,
                                socketSecondFraction,          result.firstPart,
result.secondPart);
            else
                sprintf(sentInfo, "%s %s %s = %d/%d\n", socketFirstFraction,
socketOperation,
                                socketSecondFraction,          result.firstPart,
result.secondPart);
            else
                if (result.isNegative)
                    sprintf(sentInfo, "%s %s %s = -%d.%d\n", socketFirstFraction,
socketOperation,
                                socketSecondFraction,          result.firstPart,
result.secondPart);
                else
                    sprintf(sentInfo, "%s %s %s = %d.%d\n", socketFirstFraction,
socketOperation,
                                socketSecondFraction,          result.firstPart,
result.secondPart);
        }
        else if (compare(firstFraction, secondFraction, socketOperation))
            sprintf(sentInfo, "%s %s %s: True\n", socketFirstFraction,
socketOperation,

```

```

        socketSecondFraction);
    else
        sprintf(sentInfo, "%s %s %s: False\n", socketFirstFraction,
socketOperation,
        socketSecondFraction);

    printf("\n%s\n", sentInfo);

    if (diskCheck)
        checkFullness(logPath);
    writeLog(logPath, sentInfo);

    sendSocketText(clientSocketFileDescriptor, sentInfo);

    free(socketFirstFraction);
    free(socketOperation);
    free(socketSecondFraction);
    free(sentInfo);

    close(clientSocketFileDescriptor);
}
return 0;
}

```

На листинге 5 представлен код программы signals.c.

Листинг 5 – Код программы по обработке сигналов

```

/#!/file    signals.c
* \brief    Working with signals.
*
* \details  Have functions of processing different signals and setting out the
timer for program existence.
*
* \author   Nikitin Alexander, KI19-17/1B
*/

#include <sys/time.h>
#include <signal.h>
#include <stdlib.h>
#include <string.h>
#include <stdio.h>

#include "signals.h"

```

```

#include "log.h"

const char* g_errorLogPath = "./logs/errors.log";

/*! \brief Crashes handler.
 *
 * \param signo The number of signal to handle
 *
 * \return Nothing
 */
void crashHandler(int signo)
{
    if (signo == SIGABRT)
    {
        printf("Abort has happened!\n");
        writeLog((char*) g_errorLogPath, "Abort has happened.");
    }
    else if (signo == SIGFPE)
    {
        printf("Arithmetical operation error has happened!\n");
        writeLog((char*) g_errorLogPath, "Arithmetical operation error has
happened.");
    }
    else if (signo == SIGBUS)
    {
        printf("Hardware error has happened!\n");
        writeLog((char*) g_errorLogPath, "Hardware error has happened.");
    }
    else if (signo == SIGILL)
    {
        printf("Not permitted instruction error has happened!\n");
        writeLog((char*) g_errorLogPath, "Not permitted instruction error has
happened.");
    }
    else if (signo == SIGSEGV)
    {
        printf("Segmentation error has happened!\n");
        writeLog((char*) g_errorLogPath, "Segmentation error has happened.");
    }
    else if (signo == SIGSYS)
    {
        printf("Impermissible system call error has happened!\n");

```



```

        writeLog((char*) g_errorLogPath, "Impermissible system call error has
happened.");
    }
    else if (signo == SIGTRAP)
    {
        printf("Breakpoint has been reached!\n");
        writeLog((char*) g_errorLogPath, "Breakpoint has been reached.");
    }
    else if (signo == SIGXCPU)
    {
        printf("Process resources limit has been exceeded!\n");
        writeLog((char*) g_errorLogPath, "Process resources limit has been
exceeded.");
    }
    else if (signo == SIGXFSZ)
    {
        printf("File resources limit has been exceeded!\n");
        writeLog((char*) g_errorLogPath, "File resources limit has been
exceeded.");
    }
    else
    {
        fprintf(stderr, "Unexpected signal!\n");
        exit(ERROR_CODE);
    }
    exit(SUCCESS_CODE);
}

/*! \brief Handles handle function to all crash signals.
*
* \return Nothing
*/
void registerHandler()
{
    if (signal(SIGABRT, crashHandler) == SIG_ERR)
    {
        fprintf(stderr, "It's impossible to handle SIGABRT!\n");
        writeLog((char*) g_errorLogPath, "It's impossible to handle SIGABRT.");
        exit (ERROR_CODE);
    }
    if (signal(SIGFPE, crashHandler) == SIG_ERR)
    {

```

```

        fprintf(stderr, "It's impossible to handle SIGFPE!\n");
        writeLog((char*) g_errorLogPath, "It's impossible to handle SIGFPE.");
        exit (ERROR_CODE);
    }
    if (signal(SIGBUS, crashHandler) == SIG_ERR)
    {
        fprintf(stderr, "It's impossible to handle SIGBUS!\n");
        writeLog((char*) g_errorLogPath, "It's impossible to handle SIGBUS.");
        exit (ERROR_CODE);
    }
    if (signal(SIGILL, crashHandler) == SIG_ERR)
    {
        fprintf(stderr, "It's impossible to handle SIGILL!\n");
        writeLog((char*) g_errorLogPath, "It's impossible to handle SIGILL.");
        exit (ERROR_CODE);
    }
    if (signal(SIGSEGV, crashHandler) == SIG_ERR)
    {
        fprintf(stderr, "It's impossible to handle SIGSEGV!\n");
        writeLog((char*) g_errorLogPath, "It's impossible to handle SIGSEGV.");
        exit (ERROR_CODE);
    }
    if (signal(SIGSYS, crashHandler) == SIG_ERR)
    {
        fprintf(stderr, "It's impossible to handle SIGSYS!\n");
        writeLog((char*) g_errorLogPath, "It's impossible to handle SIGSYS.");
        exit (ERROR_CODE);
    }
    if (signal(SIGTRAP, crashHandler) == SIG_ERR)
    {
        fprintf(stderr, "It's impossible to handle SIGTRAP!\n");
        writeLog((char*) g_errorLogPath, "It's impossible to handle SIGTRAP.");
        exit (ERROR_CODE);
    }
    if (signal(SIGXCPU, crashHandler) == SIG_ERR)
    {
        fprintf(stderr, "It's impossible to handle SIGXCPU!\n");
        writeLog((char*) g_errorLogPath, "It's impossible to handle SIGXCPU.");
        exit (ERROR_CODE);
    }
    if (signal(SIGXFSZ, crashHandler) == SIG_ERR)
    {

```

```

        fprintf(stderr, "It's impossible to handle SIGXFSZ!\n");
        writeLog((char*) g_errorLogPath, "It's impossible to handle SIGXFSZ.");
        exit (ERROR_CODE);
    }
}

/*! \brief Server timer handler.
 *
 * \param signo The number of signal to handle
 *
 * \return Nothing
 */
void serverExpirationHandler(int signum)
{
    puts("Server is shutting down.");
    exit(EXPIRATION_EXIT_CODE);
}

/*! \brief Client timer handler.
 *
 * \param signo The number of signal to handle
 *
 * \return Nothing
 */
void clientExpirationHandler(int signum)
{
    puts("Client has stopped working.");
    exit(EXPIRATION_EXIT_CODE);
}

/*! \brief Sets a time to a server and shuts down the server after the expiration
of it.
 *
 * \param sec The time for server to survive
 *
 * \return Nothing
 */
void setTimerServer(int sec)
{
    struct sigaction sa;
    struct itimerval timer;

```

```

memset (&sa, 0, sizeof (sa));
sa.sa_handler = &serverExpirationHandler;
sigaction (SIGALRM, &sa, NULL);

timer.it_value.tv_sec = sec;
timer.it_value.tv_usec = SERVER_INACTIVITY_TIME_MS;

timer.it_interval.tv_sec = 0;
timer.it_interval.tv_usec = 0;

setitimer(ITIMER_REAL, &timer, NULL);
}

/*! \brief Sets a time to a client and kills him after the expiration of it.
 *
 * \param sec The time for client to survive
 *
 * \return Nothing
 */
void setTimerClient(int sec)
{
    struct sigaction sa;
    struct itimerval timer;

    memset (&sa, 0, sizeof (sa));
    sa.sa_handler = &clientExpirationHandler;
    sigaction (SIGALRM, &sa, NULL);

    timer.it_value.tv_sec = sec;
    timer.it_value.tv_usec = CLIENT_INACTIVITY_TIME_MS;

    timer.it_interval.tv_sec = 0;
    timer.it_interval.tv_usec = 0;

    setitimer(ITIMER_REAL, &timer, NULL);
}

```

На листинге 6 представлен код программы log.c.

Листинг 6 – Код программы по работе с log-файлами

```

/*! \file    log.c
 * \brief    Working with log files.

```

```

*
*  \details Writes the information into log files.
*
*  \author Nikitin Alexander, KI19-17/1B
*/

#include <fcntl.h>
#include <string.h>
#include <sys/stat.h>
#include <sys/types.h>
#include <unistd.h>
#include <time.h>
#include <stdio.h>
#include <stdlib.h>

#include "log.h"

/*! \brief Checks whether the disk with the file has free space or not.
*
*  \param[in] logPath Path to the file to check
*
*  \return Is the disk full.
*/
void checkFullness(char* logPath)
{
    int fd = open(logPath, O_WRONLY | O_CREAT | O_APPEND, 0660);
    int wrErr = write(fd, "", 0);
    if (wrErr == -1)
    {
        perror("Write error");
        exit(EXIT_EMPTYNESS);
    }
    close(fd);
}

/*! \brief Writes the information into the log file adding current time.
*
*  \param[in] logPath Path to the file to write
*  \param[in] info Information to be written
*
*  \return Is the operation successful.
*/

```

```

void writeLog(char* logPath, char* info)
{
    time_t rawtime;
    struct tm * timeinfo;

    time ( &rawtime );
    timeinfo = localtime ( &rawtime );
    char* timeStr = asctime (timeinfo);
    timeStr[strlen(timeStr) - 1] = ':';

    int fd = open(logPath, O_WRONLY | O_CREAT | O_APPEND, 0660);
    write(fd, timeStr, strlen(timeStr));
    write(fd, "\n", 1);
    write(fd, info, strlen(info));
    write(fd, "\n", 1);
    fsync(fd);
    close(fd);
}

```

На листинге 7 представлен код программы security.c.

Листинг 7 – Код программы по работе с безопасностью системы

```

#include <sys/types.h>
#include <unistd.h>
#include <stdio.h>
#include <stdlib.h>
#include <security/pam_appl.h>
#include <security/pam_misc.h>

#include "security.h"

/*! \brief Checks is the current user root. If he is not, kills the program.
 *
 * \return Nothing
 */
void rootCheck()
{
    if (geteuid() != ROOT_ID)
    {
        puts("You are not authorized as a root to run this program!");
        exit(EXIT_FAILURE);
    }
}

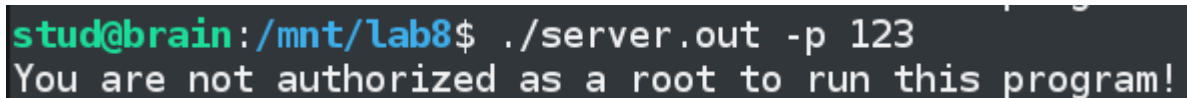
```

```

/!* \brief Invites user for authentication . If the password is wrong, kills the
program.
*
* \return Nothing
*/
void auth()
{
    pam_handle_t* pamh;
    struct pam_conv pamc;
    pamc.conv = &misc_conv;
    pamc.appdata_ptr = NULL;
    pam_start("su", getenv("USER"), &pamc, &pamh);
    if (pam_authenticate(pamh, 0) != PAM_SUCCESS)
    {
        puts("Password is incorrect!\n");
        exit(EXIT_FAILURE);
    }
    pam_end(pamh, 0);
}

```

4 Тестовые примеры работы программы



```

stud@brain:/mnt/lab8$ ./server.out -p 123
You are not authorized as a root to run this program!

```

Рисунок 1 – Попытка запустить сервер не root-пользователем

```
stud@brain:/mnt/lab8$ ./client.out -p 123
Password:
Input first fraction:
█
```

Рисунок 2 – Запуск клиента с паролем

```
Input first fraction:
1/3
Input operation:
+
Input second fraction:
23/45

1/3 + 23/45 = 38/45

Input first fraction:
█
```

Рисунок 3 – Сложение обыкновенных дробей

```
The socket has been connected to the server.
The information from socket has been received. Content: 1/3
The information from socket has been received. Content: +
The information from socket has been received. Content: 23/45
```

Рисунок 4 – Серверный вывод информации о полученном сокете

```
Input first fraction:
-23/4
Input operation:
+
Input second fraction:
43/19

-23/4 + 43/19 = -265/76

Input first fraction:
█
```

Рисунок 5 – Ввод и обработка отрицательных значений


```
Input first fraction:
20/19
Input operation:
*
Input second fraction:
43/76

20/19 * 43/76 = 215/361

Input first fraction:
█
```

Рисунок 6 – Умножение обыкновенных дробей

```
Input first fraction:
12.3
Input operation:
*
Input second fraction:
3.2

12.3 * 3.2 = 39.360

Input first fraction:
█
```

Рисунок 7 – Умножение десятичных дробей

```
Input first fraction:
12.3
Input operation:
+
Input second fraction:
43.65

12.3 + 43.65 = 55.95

Input first fraction:
█
```

Рисунок 8 – Сложение десятичных дробей

```
Input first fraction:
1/3
Input operation:
+
Input second fraction:
0.5

1/3 + 0.5 = 0.833

Input first fraction:
█
```

Рисунок 9 – Смешанное сложение дробей

```
Input first fraction:
1/3
Input operation:
*
Input second fraction:
0.5

1/3 * 0.5 = 0.166

Input first fraction:
█
```

Рисунок 10 – Смешанное произведение дробей