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Кафедра 806 «Вычислительная информатика и программирование»
Факультет: «Информационные технологии и прикладная математика»

Лабораторная работа
Дисциплина: «Объектно-ориентированное программирование»
III семестр
Задание 1: «Простые классы»

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Задание

Создать класс BitString для работы с 128-битовыми строками. Битовая строка должна быть представлена двумя полями типа unsigned long long. Должны быть реализованы все традиционные операции для работы с битами: and, or, xor, not. Реализовать сдвиг влево shiftLeft и сдвиг вправо shiftRight на заданное количество битов. Реализовать операцию вычисления количества единичных битов, операции сравнения по количеству единичных битов. Реализовать операцию проверки включения.

Адрес репозитория на GitHub

Код программы на С++

```
cmake_minimum_required(VERSION 3.2)

project(BitString)

add_executable(BitString
        Source.cpp
        BitString.cpp)

set_property(TARGET BitString PROPERTY CXX_STANDART 11)
```

BitString.cpp

```
#include "BitString.h"
#include <stdlib.h>
#include <iostream>
#include <string>
#include <vector>

BitString::BitString() {

    firstHalf = 0;
    secondHalf = 0;

    std::string str;

    std::cout << '\n' << "Enter string" << '\n';
    std::cin >> str;

    std::string sec(str.size(), '0');
    std::vector<int> v;
    while (str != sec) {
        int a = 0;
        for (int i = 0; i < str.size(); i++) {
            a *= 10;
            a += str[i] - '0';
            str[i] = char('0' + a / 2);
            a %= 2;
        }
        v.push_back(a);
    }



    unsigned long long shs = 1;

    for (int i = 0; i < 64 && i < v.size(); i++) {
        secondHalf += v[i] * shs;
        shs *= 2;
    }

    unsigned long long fhs = 1;

    for (int i = 64; i < v.size(); i++) {
        firstHalf += v[i] * fhs;
        fhs *= 2;
    }

}

BitString::BitString(unsigned long long first, unsigned long long second) {
    firstHalf = first;
    secondHalf = second;
}

BitString* BitString::_not() {

    BitString *bs = new BitString(this -> firstHalf, this -> secondHalf);

    bs -> firstHalf = ~(bs -> firstHalf);
    bs -> secondHalf = ~(bs -> secondHalf);

    return bs;
}
```

```
BitString* BitString::_and(BitString *bs) {

   BitString *bs1 = new BitString(this -> firstHalf, this -> secondHalf);
   bs1 -> firstHalf = bs1 -> firstHalf & bs -> firstHalf;
   bs1 -> secondHalf = bs1 -> secondHalf & bs -> secondHalf;

   return bs1;

}


BitString* BitString::_or(BitString *bs) {

   BitString *bs1 = new BitString(this -> firstHalf, this -> secondHalf);
   bs1 -> firstHalf = bs1 -> firstHalf | bs -> firstHalf;
   bs1 -> secondHalf = bs1 -> secondHalf | bs -> secondHalf;

   return bs1;

}


BitString* BitString::_xor(BitString *bs) {

   BitString *bs1 = new BitString(this -> firstHalf, this -> secondHalf);
   bs1 ->firstHalf = bs1 ->firstHalf ^ bs -> firstHalf;
   bs1 ->secondHalf = bs1 ->secondHalf ^ bs -> secondHalf;

   return bs1;

}

void BitString::shiftLeft(unsigned long long n) {

   unsigned long long pow63 = 1;
   for (int i = 0; i < 63; i++) {
      pow63 *= 2;
   }

   for (int i = 0; i < n; i++) {                          //110100111 << 3 ==
100111000
      firstHalf = firstHalf << 1;
      if (secondHalf >= pow63) {
         firstHalf += 1;
      }
      secondHalf = secondHalf << 1;
   }
}

void BitString::shiftRight(unsigned long long n) {                    //110100111 >> 3
== 000110100

   unsigned long long pow63 = 1;
   for (int i = 0; i < 63; i++) {
      pow63 *= 2;
   }
   for (int i = 0; i < n; i++) {
      secondHalf = secondHalf >> 1;
      if (firstHalf % 2 == 1) {
         secondHalf += pow63;
      }
      firstHalf = firstHalf >> 1;
   }


}

unsigned long long BitString::posBitNumber() {

   BitString *bs1 = new BitString(firstHalf, secondHalf);

   unsigned long long number = 0;

   while (bs1 -> firstHalf != 0) {
      if (bs1 -> firstHalf % 2 == 1) number++;
      bs1 -> firstHalf /= 2;
   }

   while (bs1 -> secondHalf != 0) {
      if (bs1 -> secondHalf % 2 == 1) number++;
      bs1 -> secondHalf /= 2;
   }

   return number;

}

int BitString::compPosBitNumber(BitString *bs) {
   unsigned long long thisNumber = this -> posBitNumber();
```

```
    unsigned long long bsNumber = bs -> posBitNumber();

    if (thisNumber > bsNumber) return 0;
    if (thisNumber < bsNumber) return 1;
    else return 2;

}

void BitString::isArgInThis(BitString *bs) {

    BitString *lbs = new BitString(this -> firstHalf, this -> secondHalf);
    BitString *sbs = new BitString(bs -> firstHalf, bs -> secondHalf);

    std::vector<int> vflbs;
    std::vector<int> vfsbs;

    std::vector<int> vslbs;
    std::vector<int> vssbs;


    while (lbs -> firstHalf != 0) {
        vflbs.push_back(lbs -> firstHalf % 2);
        lbs -> firstHalf /= 2;
    }


    for (int i = vflbs.size(); i < 64 ; i++) {
        vflbs.push_back(0);
    }

    while (lbs -> secondHalf != 0) {
        vslbs.push_back(lbs -> secondHalf % 2);
        lbs -> secondHalf /= 2;
    }
    for (int i = vslbs.size(); i < 64; i++) {
        vslbs.push_back(0);
    }






    while (sbs -> firstHalf != 0) {
        vfsbs.push_back(sbs -> firstHalf % 2);
        sbs -> firstHalf /= 2;
    }

    for (int i = vfsbs.size(); i < 64 ; i++) {
        vfsbs.push_back(0);
    }


    while (sbs -> secondHalf != 0) {
        vssbs.push_back(sbs -> secondHalf % 2);
        sbs -> secondHalf /= 2;
    }
    for (int i = vssbs.size(); i < 64; i++) {
        vssbs.push_back(0);
    }



    for (int i = 0; i < vfsbs.size() && i < vflbs.size(); i++) {

        if (vfsbs[i] == 1 && vflbs[i] != 1) {
            std::cout << "NO\n";
            return;
        }
    }



    for (int i = 0; i < vssbs.size() && i < vslbs.size(); i++) {
        if (vssbs[i] == 1 && vslbs[i] != 1) {
            std::cout << "NO\n";
            return;
        }
    }

    std::cout << "YES\n";

}

void BitString::print() {

    BitString *bs1 = new BitString(firstHalf, secondHalf);

    std::vector<int> v;
    while (bs1 -> firstHalf != 0) {
        v.push_back(bs1 ->firstHalf % 2);
        bs1 -> firstHalf /= 2;
    }

    for (int i = 0; i < 64 - v.size(); i++) {
        std::cout << 0;
    }

    for (int i = v.size() - 1; i >= 0; i--) {
        std::cout << v[i];
    }
    v.clear();

    std::cout << " ";

    while (bs1 -> secondHalf != 0) {
        v.push_back(bs1 -> secondHalf % 2);
        bs1 ->secondHalf /= 2;
    }
    for (int i = 0; i < 64 - v.size(); i++) {
        std::cout << 0;
    }

    for (int i = v.size() - 1; i >= 0; i--) {
        std::cout << v[i];
    }
    std::cout << '\n';

}
```

BitString.h

```
#include <iostream>
#include <string>

class BitString
{
public:

    BitString();
    BitString(unsigned long long first, unsigned long long second);

    BitString* _not();
    BitString* _and(BitString *bs);
    BitString* _or(BitString *bs);
    BitString* _xor(BitString *bs);

    void shiftLeft(unsigned long long n);
    void shiftRight(unsigned long long n);

    unsigned long long posBitNumber();
    int compPosBitNumber(BitString *bs);

    void isArgInThis(BitString *bs);

    void print();

private:
    unsigned long long firstHalf;
    unsigned long long secondHalf;


};
```

Source.cpp

```
#include "BitString.h"

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

    BitString *bs = new BitString();

    BitString *bs1 = new BitString();

    bs -> print();
    bs1 -> print();

    BitString *bsTest = bs -> _not();

    std::cout << "not first number:\n";

    bsTest -> print();

    bsTest = bs -> _and(bs1);

    std::cout << "first and second:\n";

    bsTest -> print();
    bsTest = bs -> _or(bs1);

    std::cout << "first or second:\n";

    bsTest -> print();

    bsTest = bs -> _xor(bs1);

    std::cout << "first xor second:\n";

    bsTest -> print();

    std::cout << "Positive Bit Number of First is " << bs -> posBitNumber() << '\n';

    if (bs -> compPosBitNumber(bs1) == 0) {
        std::cout << "Bit Comparence of first and second shows that first is larger\n";
    } else if (bs -> compPosBitNumber(bs1) == 1) {
        std::cout << "Bit Comparence of first and second shows that second is
larger\n";
    } else {
        std::cout << "Bit Comparence of first and second shows that they are
equal\n";
    }

    std::cout << "Is second in first? : ";
    bs -> isArgInThis(bs1);

    int shift;

    std::cout << "Enter number of bits to shift first number left and second right : ";
    std::cin >> shift;

    bs -> shiftLeft(shift);

    std::cout << "Shifted first left : \n";
    bs -> print();

    bs1 -> shiftRight(shift);

    std::cout << "Shifted second right : \n";
    bs1 -> print();
    return 0;
}
```

file01.test

```
18446744073709551627
11
3
```

file02.test

```
18446744073709551615
156
10
```

Результаты тестов

1

```
Enter string
18446744073709551627

Enter string
11
0000000000000000000000000000000000000000000000000000000000000001
0000000000000000000000000000000000000000000000000000000000001011
0000000000000000000000000000000000000000000000000000000000000000
0000000000000000000000000000000000000000000000000000000000001011
not first number:
1111111111111111111111111111111111111111111111111111111111111110
1111111111111111111111111111111111111111111111111111111111110100
first and second:
0000000000000000000000000000000000000000000000000000000000000000
0000000000000000000000000000000000000000000000000000000000001011
first or second:
0000000000000000000000000000000000000000000000000000000000000001
0000000000000000000000000000000000000000000000000000000000001011
first xor second:
0000000000000000000000000000000000000000000000000000000000000001
0000000000000000000000000000000000000000000000000000000000000000
Positive Bit Number of First is 4
Bit Comparence of first and second shows that first is larger
Is second in first? : YES
Enter number of bits to shift first number left and second right : 3
Shifted first left :
0000000000000000000000000000000000000000000000000000000000001000
0000000000000000000000000000000000000000000000000000000001011000
Shifted second right :
```

```
Enter string
18446744073709551615

Enter string
156
0000000000000000000000000000000000000000000000000000000000000000
1111111111111111111111111111111111111111111111111111111111111111
0000000000000000000000000000000000000000000000000000000000000000
0000000000000000000000000000000000000000000000000000000010011100
not first number:
1111111111111111111111111111111111111111111111111111111111111111
0000000000000000000000000000000000000000000000000000000000000000
first and second:
0000000000000000000000000000000000000000000000000000000000000000
0000000000000000000000000000000000000000000000000000000010011100
first or second:
0000000000000000000000000000000000000000000000000000000000000000
1111111111111111111111111111111111111111111111111111111111111111
first xor second:
0000000000000000000000000000000000000000000000000000000000000000
1111111111111111111111111111111111111111111111111111111101100011
Positive Bit Number of First is 64
Bit Comparence of first and second shows that first is larger
Is second in first? : YES
Enter number of bits to shift first number left and second right : 10
Shifted first left :
0000000000000000000000000000000000000000000000000000001111111111
1111111111111111111111111111111111111111111111111111110000000000
Shifted second right :
```

Объяснение результатов

Программа получает на вход две строки, содержащие числа, которые далее преобразует в 128-битовые строки и выполняет преобразования, требуемые задание лабораторной работы.

Вывод

Были изучены основы ООП и заложен фундамент для будущей учебы и последующего применения знаний в работе.