**Lab-11**

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**Aim: Write a program to implement DES cipher.**

* **Encryption**
* **Decryption**

**Source Code:**

**Programming Language : C++**

**Ans:**

#include "../functions.h"

//Function Declaration

string bin2hex(string str);

string hex2bin(string str);

string hex2bin(string str);

string int2bin(int num);

int bin2num(string bin);

string expansion(string s);

string xor\_(string s1, string s2);

string applySbox(string str);

string straightD(string str);

string initialPertmutation(string str);

string f(string r, string key);

pair<string, string> get\_data();

string finalPermutation(string str);

string mixer(string left0, string right0,string key);

string encryption(string pt, string key);

string decryption(string encrypted, string key);

void printValuesOfEachStep(string key, string r\_expanded, string r\_xored, string r\_sbox, string r\_dbox);

string bin2hex(string str)

{

    unordered\_map<string, char> bin;

    bin.insert({string("0000"), '0'});

    bin.insert({string("0001"), '1'});

    bin.insert({string("0010"), '2'});

    bin.insert({string("0011"), '3'});

    bin.insert({string("0100"), '4'});

    bin.insert({string("0101"), '5'});

    bin.insert({string("0110"), '6'});

    bin.insert({string("0111"), '7'});

    bin.insert({string("1000"), '8'});

    bin.insert({string("1001"), '9'});

    bin.insert({string("1010"), 'A'});

    bin.insert({string("1011"), 'B'});

    bin.insert({string("1100"), 'C'});

    bin.insert({string("1101"), 'D'});

    bin.insert({string("1110"), 'E'});

bin.insert({string("1111"), 'F'});

    string hex = "";

    for (int i = 0; i <= (str.length() - 3); i += 4)

    {

        string temp = str.substr(i, 4);

        hex += bin[temp];

    }

    return hex;

}

string hex2bin(string str)

{

    unordered\_map<char, string> hex;

    hex.insert({'0', string("0000")});

    hex.insert({'1', string("0001")});

    hex.insert({'2', string("0010")});

    hex.insert({'3', string("0011")});

    hex.insert({'4', string("0100")});

    hex.insert({'5', string("0101")});

    hex.insert({'6', string("0110")});

    hex.insert({'7', string("0111")});

    hex.insert({'8', string("1000")});

    hex.insert({'9', string("1001")});

    hex.insert({'A', string("1010")});

    hex.insert({'B', string("1011")});

    hex.insert({'C', string("1100")});

    hex.insert({'D', string("1101")});

    hex.insert({'E', string("1110")});

hex.insert({'F', string("1111")});

    string binary = "";

    for (char ch : str)

    {

        binary += hex[ch];

    }

    return binary;

}

string int2bin(int num)

{

    unordered\_map<int, string> bin;

    bin.insert({0, string("0000")});

    bin.insert({1, string("0001")});

    bin.insert({2, string("0010")});

    bin.insert({3, string("0011")});

    bin.insert({4, string("0100")});

    bin.insert({5, string("0101")});

    bin.insert({6, string("0110")});

    bin.insert({7, string("0111")});

    bin.insert({8, string("1000")});

    bin.insert({9, string("1001")});

    bin.insert({10, string("1010")});

    bin.insert({11, string("1011")});

    bin.insert({12, string("1100")});

    bin.insert({13, string("1101")});

    bin.insert({14, string("1110")});

    bin.insert({15, string("1111")});

    return bin[num];

}

int bin2num(string bin)

{

    unordered\_map<string, int> number;

    number.insert({string("0000"), 0});

    number.insert({string("0001"), 1});

    number.insert({string("0010"), 2});

    number.insert({string("0011"), 3});

    number.insert({string("0100"), 4});

    number.insert({string("0101"), 5});

    number.insert({string("0110"), 6});

    number.insert({string("0111"), 7});

    number.insert({string("1000"), 8});

    number.insert({string("1001"), 9});

    number.insert({string("1010"), 10});

    number.insert({string("1011"), 11});

    number.insert({string("1100"), 12});

    number.insert({string("1101"), 13});

    number.insert({string("1110"), 14});

    number.insert({string("1111"), 15});

    return number[bin];

}

// P-box

string expansion(string s)

{

    s = hex2bin(s);

    int expansion\_p\_box[48] = {

        32, 1, 2, 3, 4, 5, 4, 5,

        6, 7, 8, 9, 8, 9, 10, 11,

        12, 13, 12, 13, 14, 15, 16, 17,

        16, 17, 18, 19, 20, 21, 20, 21,

        22, 23, 24, 25, 24, 25, 26, 27,

        28, 29, 28, 29, 30, 31, 32, 1};

    string result = "";

    int len = s.length();

    for (int i = 0; i < 48; i++)

    {

        result += s[expansion\_p\_box[i] - 1];

    }

    return bin2hex(result);

}

void printValuesOfEachStep(string key, string r\_expanded, string r\_xored, string r\_sbox, string r\_dbox)

{

    cout << "\nRound key in binary";

    cout << "\n-----------------------------------------------------------------------------------------------" << endl;

    for (int i = 0; i < key.length(); ++i)

        cout << key[i] << " ";

    cout << "\n-----------------------------------------------------------------------------------------------" << endl

         << endl;

    cout << "\nafter expansion of P-box, plain text in binary";

    cout << "\n-----------------------------------------------------------------------------------------------" << endl;

    for (int i = 0; i < r\_expanded.length(); ++i)

        cout << r\_expanded[i] << " ";

    cout << "\n-----------------------------------------------------------------------------------------------" << endl

         << endl;

    cout << "\nafter expansion of P-box, plain text in hexadecimal";

    cout << "\n-----------------------------------------------------------------------------------------------" << endl;

    cout << bin2hex(r\_expanded);

    cout << "\n-----------------------------------------------------------------------------------------------" << endl

         << endl;

    cout << "\nafter xor with round key, plain text in binary";

    cout << "\n-----------------------------------------------------------------------------------------------" << endl;

    for (int i = 0; i < r\_xored.length(); ++i)

        cout << r\_xored[i] << " ";

    cout << "\n-----------------------------------------------------------------------------------------------" << endl

         << endl;

    cout << "\nafter xor with round key, plain text in hexadecimal";

    cout << "\n-----------------------------------------------------------------------------------------------" << endl;

    cout << bin2hex(r\_xored);

    cout << "\n-----------------------------------------------------------------------------------------------" << endl

         << endl;

    cout << "\nafter applying S-box, plain text in binary";

    cout << "\n-----------------------------------------------------------------------------------------------" << endl;

    for (int i = 0; i < r\_sbox.length(); ++i)

        cout << r\_sbox[i] << " ";

    cout << "\n-----------------------------------------------------------------------------------------------" << endl

         << endl;

    cout << "\nafter applying S-box, plain text in hexadecimal";

    cout << "\n-----------------------------------------------------------------------------------------------" << endl;

    cout << bin2hex(r\_sbox);

    cout << "\n-----------------------------------------------------------------------------------------------" << endl

         << endl;

    cout << "\nafter straight permutation of D-box, plain text in binary";

    cout << "\n-----------------------------------------------------------------------------------------------" << endl;

    for (int i = 0; i < r\_dbox.length(); ++i)

        cout << r\_dbox[i] << " ";

    cout << "\n-----------------------------------------------------------------------------------------------" << endl

         << endl;

    cout << "\nafter straight permutation of D-box, plain text in hexadecimal";

    cout << "\n-----------------------------------------------------------------------------------------------" << endl;

    cout << bin2hex(r\_dbox);

    cout << "\n-----------------------------------------------------------------------------------------------" << endl

         << endl;

}

string xor\_(string s1, string s2)

{

    s1 = hex2bin(s1);

    s2 = hex2bin(s2);

    string result = "";

    for (int i = 0; i < s1.length(); ++i)

    {

        if (s1[i] == s2[i])

            result += '0';

        else

            result += '1';

    }

    return bin2hex(result);

}

// S-Box

string applySbox(string str)

{

    str = hex2bin(str);

    string result = "";

    int sBox[8][4][16] = {{14, 4, 13, 1, 2, 15, 11, 8, 3, 10, 6, 12, 5, 9, 0, 7,

                           0, 15, 7, 4, 14, 2, 13, 1, 10, 6, 12, 11, 9, 5, 3, 8,

                           4, 1, 14, 8, 13, 6, 2, 11, 15, 12, 9, 7, 3, 10, 5, 0,

                           15, 12, 8, 2, 4, 9, 1, 7, 5, 11, 3, 14, 10, 0, 6, 13},

                          {15, 1, 8, 14, 6, 11, 3, 4, 9, 7, 2, 13, 12, 0, 5, 10,

                           3, 13, 4, 7, 15, 2, 8, 14, 12, 0, 1, 10, 6, 9, 11, 5,

                           0, 14, 7, 11, 10, 4, 13, 1, 5, 8, 12, 6, 9, 3, 2, 15,

                           13, 8, 10, 1, 3, 15, 4, 2, 11, 6, 7, 12, 0, 5, 14, 9},

                          {10, 0, 9, 14, 6, 3, 15, 5, 1, 13, 12, 7, 11, 4, 2, 8,

                           13, 7, 0, 9, 3, 4, 6, 10, 2, 8, 5, 14, 12, 11, 15, 1,

                           13, 6, 4, 9, 8, 15, 3, 0, 11, 1, 2, 12, 5, 10, 14, 7,

                           1, 10, 13, 0, 6, 9, 8, 7, 4, 15, 14, 3, 11, 5, 2, 12},

                          {7, 13, 14, 3, 0, 6, 9, 10, 1, 2, 8, 5, 11, 12, 4, 15,

                           13, 8, 11, 5, 6, 15, 0, 3, 4, 7, 2, 12, 1, 10, 14, 9,

                           10, 6, 9, 0, 12, 11, 7, 13, 15, 1, 3, 14, 5, 2, 8, 4,

                           3, 15, 0, 6, 10, 1, 13, 8, 9, 4, 5, 11, 12, 7, 2, 14},

                          {2, 12, 4, 1, 7, 10, 11, 6, 8, 5, 3, 15, 13, 0, 14, 9,

                           14, 11, 2, 12, 4, 7, 13, 1, 5, 0, 15, 10, 3, 9, 8, 6,

                           4, 2, 1, 11, 10, 13, 7, 8, 15, 9, 12, 5, 6, 3, 0, 14,

                           11, 8, 12, 7, 1, 14, 2, 13, 6, 15, 0, 9, 10, 4, 5, 3},

                          {12, 1, 10, 15, 9, 2, 6, 8, 0, 13, 3, 4, 14, 7, 5, 11,

                           10, 15, 4, 2, 7, 12, 9, 5, 6, 1, 13, 14, 0, 11, 3, 8,

                           9, 14, 15, 5, 2, 8, 12, 3, 7, 0, 4, 10, 1, 13, 11, 6,

                           4, 3, 2, 12, 9, 5, 15, 10, 11, 14, 1, 7, 6, 0, 8, 13},

                          {4, 11, 2, 14, 15, 0, 8, 13, 3, 12, 9, 7, 5, 10, 6, 1,

                           13, 0, 11, 7, 4, 9, 1, 10, 14, 3, 5, 12, 2, 15, 8, 6,

                           1, 4, 11, 13, 12, 3, 7, 14, 10, 15, 6, 8, 0, 5, 9, 2,

                           6, 11, 13, 8, 1, 4, 10, 7, 9, 5, 0, 15, 14, 2, 3, 12},

                          {13, 2, 8, 4, 6, 15, 11, 1, 10, 9, 3, 14, 5, 0, 12, 7,

                           1, 15, 13, 8, 10, 3, 7, 4, 12, 5, 6, 11, 0, 14, 9, 2,

                           7, 11, 4, 1, 9, 12, 14, 2, 0, 6, 10, 13, 15, 3, 5, 8,

                           2, 1, 14, 7, 4, 10, 8, 13, 15, 12, 9, 0, 3, 5, 6, 11}};

    int j = 1;

    for (int i = 0; i < (str.length()); i += 6)

    {

        string s = str.substr(i, 6);

        char prefix = s[0], suffix = s[5];

        string row = "00", col = "";

        row = row + prefix + suffix;

        col = s.substr(1, 4);

        result += int2bin(sBox[i / 6][bin2num(row)][bin2num(col)]);

    }

    return bin2hex(result);

}

string straightD(string str)

{

    str = hex2bin(str);

    string result = "";

    int straight\_d\_box[32] = {16, 7, 20, 21, 29, 12, 28, 17, 1, 15, 23, 26, 5, 18, 31, 10, 2, 8, 24, 14, 32, 27, 3, 9, 19, 13, 30, 6, 22, 11, 4, 25};

    for (int i = 0; i < str.length(); ++i)

    {

        result += str[straight\_d\_box[i] - 1];

    }

    return bin2hex(result);

}

string initialPertmutation(string str)

{

    str = hex2bin(str);

    string permuted = "";

    int initialPerm[64] = {58, 50, 42, 34, 26, 18, 10, 2,

                           60, 52, 44, 36, 28, 20, 12, 4,

                           62, 54, 46, 38, 30, 22, 14, 6,

                           64, 56, 48, 40, 32, 24, 16, 8,

                           57, 49, 41, 33, 25, 17, 9, 1,

                           59, 51, 43, 35, 27, 19, 11, 3,

                           61, 53, 45, 37, 29, 21, 13, 5,

                           63, 55, 47, 39, 31, 23, 15, 7};

    for (int i = 0; i < 64; ++i)

    {

        permuted += str[initialPerm[i] - 1];

    }

    return bin2hex(permuted);

}

string f(string r, string key)

{

    string r\_expanded, r\_xor, r\_sbox, r\_dbox;

    r\_expanded = expansion(r);

    r\_xor = xor\_(r\_expanded, key);

    r\_sbox = applySbox(r\_xor);

    r\_dbox = straightD(r\_sbox);

    // printValuesOfEachStep(hex2bin(key), hex2bin(r\_expanded), hex2bin(r\_xor), hex2bin(r\_sbox), hex2bin(r\_dbox));

    return r\_dbox;

}

pair<string, string> get\_data()

{

    string pt, key;

    cout << "Enter Hexadecimal plain text of 16 charecter long : ";

    cin >> pt;

    if (pt.length() != 16)

    {

        cout << "Length is not 16.Please Enter valid length of text\n"

             << endl;

        exit(1);

    }

    cout << "Enter Hexadecimal Round Key of 12 charecter long : ";

    cin >> key;

    if (key.length() != 12)

    {

        cout << "Length is not 12.Please Enter valid length of Key\n"

             << endl;

        exit(1);

    }

    return make\_pair(pt, key);

}

string finalPermutation(string str)

{

    str = hex2bin(str);

    string result="";

    int finalPerm[64] = {  40, 8, 48, 16, 56, 24, 64, 32,

                           39, 7, 47, 15, 55, 23, 63, 31,

                           38, 6, 46, 14, 54, 22, 62, 30,

                           37, 5, 45, 13, 53, 21, 61, 29,

                           36, 4, 44, 12, 52, 20, 60, 28,

                           35, 3, 43, 11, 51, 19, 59, 27,

                           34, 2, 42, 10, 50, 18, 58, 26,

                           33, 1, 41, 9, 49, 17, 57, 25

                        };

    for(int i = 0 ; i<64 ; ++i)

    {

        result += str[finalPerm[i]-1];

    }

    return bin2hex(result);

}

string mixer(string left0, string right0,string key)

{

    string right1,f\_out;

    f\_out = f(right0,key);

    right1 = xor\_(left0, f\_out);

    return right1;

}

string encryption(string pt, string key)

{

    cout<<"\n\n---------------|\*\*Encryption Process\*\*|---------------------\n"<<endl;

    string left, left0, right, encrypted, pt\_;

    pt\_ = initialPertmutation(pt);

    cout<<"After Intial Permutation: "<<pt\_<<endl;

    left0 = pt\_.substr(0, 8);

    right = pt\_.substr(8, 8);

    for (int i = 0; i < 16; ++i)

    {

        left0 = mixer(left0,right,key);

        //swapper

        if(i<15)

        {

            left = right;

            right = left0;

            left0 = left;

        }

        cout<<"\nRound "<<(i+1)<<"  Left : "<<left0<<"  Right: "<<right<<endl;

    }

    pt\_ = left0 + right;

    encrypted = finalPermutation(pt\_);

    cout<<"\nAfter Final Permutation: "<<encrypted<<endl;

    cout<<"---------------------------------------------------------------------------"<<endl;

    return encrypted;

}

string decryption(string encrypted, string key)

{

    cout<<"\n\n---------------|\*\*Decryption Process\*\*|---------------------\n"<<endl;

    string left, left0, right, encrypted\_,decrypted;

    encrypted\_ = initialPertmutation(encrypted);

    cout<<"After Intial Permutation: "<<encrypted\_<<endl;

    left0 = encrypted\_.substr(0, 8);

    right = encrypted\_.substr(8, 8);

    for (int i = 0; i < 16; ++i)

    {

        left0 = mixer(left0,right,key);

        //swapper

        if(i<15)

        {

            left = right;

            right = left0;

            left0 = left;

        }

        cout<<"\nRound "<<(i+1)<<"  Left : "<<left0<<"  Right: "<<right<<endl;

    }

    encrypted\_ = left0 + right;

    decrypted = finalPermutation(encrypted\_);

    cout<<"\nAfter Final Permutation decrpted Text is : "<<decrypted<<endl;

    cout<<"---------------------------------------------------------------------------"<<endl;

    return decrypted;

}

int main()

{

    string pt, key, encrypted;

    pair<string, string> data = get\_data();

    pt = data.first;

    key = data.second;

    encrypted = encryption(pt,key);

    decryption(encrypted,key);

    return 0;

}

**Input & Output Screenshots:**



