密码学综合设计实验

实验 2：DES 加密解密算法实现

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一、 实验要求

1.实现 Feistel 密码结构（64bit 分组长度）

a) 输入 64bit 明文分组，轮数 Round，轮函数 F，子密钥数组 K

b) 输出 64bit 密文分组

c) 提示：如果是 C 语言实现的话，轮函数用函数指针

2.DES 算法实现

d) 初始置换实现

e) 子密钥生成实现

f) DES 轮函数实现

g) 逆初始置换实现

h) 加密分组实现

i) 解密分组实现

3.附加内容：

j) 自定义轮函数，实现一个基于 Feistel 结构的加密解密自定义算法。

k) 比如自定义轮函数：F(W,K)=(1<<W)+K，即 W 先循环左移 1 位再与 K 异或。

l) 用电码本模式对文件进行加密和解密。

二、 实验原理

1. 所需参数

key：8 个字节共 64 位的工作密钥

data：8 个字节共 64 位的需要被加密或被解密的数据

mode：DES 工作方式，加密或者解密

2. 初始置换

DES 算法使用 64 位的密钥 key 将 64 位的明文输入块变为 64 位的密文输出块，并把输出块分为 L0、R0 两部分，每部分均为 32 位。初始置换规则如下：

```
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
```

3. 轮结构

将 64 比特的轮输入分为 32 比特的左、右两半，分别记为 L 和 R。和 Feistel 网络一样，每轮变换可由以下公式表示：

$$L_i = R_{i-1}$$

$$R_i = L_{i-1} \oplus F(R_{i-1}, K_i)$$

K_i是向第 N 层输入的 48 位的秘钥， F 是以R_{i-1}和K_i为变量的输出 32 位的函数。

4. 函数 F

A. 扩展置换 E

通过扩展置换 E，数据的右半部分 R 从 32 位扩展到 48 位。
扩展置换 E 规则如下：

```
32,01,02,03,04,05,
04,05,06,07,08,09,
08,09,10,11,12,13,
12,13,14,15,16,17,
16,17,18,19,20,21,
20,21,22,23,24,25,
24,25,26,27,28,29,
28,29,30,31,32,01
```

B. S-盒代替

R 扩展置换之后与子秘钥K_i异或以后的结果作为输入块进行 S 盒代替运算，功能是把 48 比特数据变为 32 比特。然后再通过一个 S 盒，产生 32 比特的输出。

代替运算由 8 个不同的代替盒(S 盒)完成。每个 S 盒有 6 位输入，4 位输出。

C. P-盒置换

S-盒代替运算，每一盒得到 4 位，8 盒共得到 32 位输出。这 32 位输出作为 P 盒置换的输入块。

P 盒定义如下：

```
16,07,20,21,
29,12,28,17,
01,15,23,26,
05,18,31,10,
02,08,24,14,
32,27,03,09,
19,13,30,06,
22,11,04,25
```

5. 子密钥的产生

DES 算法由 64 位秘钥产生 16 轮的 48 位子秘钥。在每一轮的迭代过程中，使用不同的子秘钥。

A. 置换选择 1

将 64 位密钥通过缩小选择置换表（PC-1）的变换变成 56 位，然后将置换后的 56 位密钥分为 C0,D0 两半。PC-1 的定义如下：

```
57, 49, 41, 33, 25, 17,  9,
 1, 58, 50, 42, 34, 26, 18,
10,  2, 59, 51, 43, 35, 27,
19, 11,  3, 60, 52, 44, 36,
63, 55, 47, 39, 31, 23, 15,
 7, 62, 54, 46, 38, 30, 22,
14,  6, 61, 53, 45, 37, 29,
21, 13,  5, 28, 20, 12,  4
```

B. 置换选择 2

在第 i 轮分别对C_{i-1}和D_{i-1}进行左循环移位，循环左移每轮移动的位数如下：

每轮移动的位数表

轮	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
位数	1	1	2	2	2	2	2	2	1	2	2	2	2	2	2	1

移位后的结果作为下一轮求子密钥的输入，同时也作为置换选择 2 的输入。通过置换选择 2 产生的 48 比特的K_i，即为本轮的子密钥，作为函数 F 的输入。其中置换选择 2 的定义如下：

```
14, 17, 11, 24,  1,  5,
 3, 28, 15,  6, 21, 10,
23, 19, 12,  4, 26,  8,
16,  7, 27, 20, 13,  2,
41, 52, 31, 37, 47, 55,
30, 40, 51, 45, 33, 48,
44, 49, 39, 56, 34, 53,
46, 42, 50, 36, 29, 32
```

6. 解密

和 Feistel 密码一样，DES 的解密和加密使用同一算法，但子密钥使用的顺序相反。

软件系统设计

实现Feistel密码结构（64bit分组长度）

单独通过一个Feistel函数抽象了Feistel结构

```
def Feistel(ClearTxt,Key,Model):
    #Step 1 is CreateKey
    keylist = createkey(Key)
    print()
    if Model == 1:
        keylist = keylist
    if Model == 2:
        keylist = keylist[::-1] #INVERSEKEY
    #Step 2 is ClearTxt
    text = DES_ECB(ClearTxt,keylist)
    return  text
```

通过不同的加密轮函数和密钥生成结构就可以组合成不同的Feistel密码，通过不同的Key生成函数可以生成不同的子密钥数组

DES算法实现

初始置换实现

Java实现：

```
public int[] IP(int[] BinaryClearTxt){
        int[] IPTABLE = {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};
        if(BinaryClearTxt.length != 64){
            System.out.println("Your key Text lenth is Error!");
        }
        else {
            for (int i = 0;i < IPTABLE.length;i++){
                ret[i] = BinaryClearTxt[IPTABLE[i]-1];
            }
            System.out.print("Source ClearText : ");
            for(int i = 0;i<BinaryClearTxt.length;i++){
                System.out.print(BinaryClearTxt[i]);
            }
        }
        return ret;
    }
```

Python实现：

```
def IP(ClearTxt):
    IPTABLE = [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]
    if len(ClearTxt) != 64:
        print("Your key Text lenth is Error!")
        assert len(ClearTxt) == 64  # if no 64bit error
    else:
        ret = ""
        for i in IPTABLE:
            ret = ret + ClearTxt[i - 1]
        print("Source ClearText : ",ClearTxt)
        print("IP Replace : ",ret)
        return ret
```

子密钥生成实现

Java实现

```
class Key{
    int[] Movetimes = {1, 1, 2, 2, 2, 2, 2, 2, 1, 2, 2, 2, 2, 2, 2, 1};
    int[] PC_1_LTABLE = {57, 49, 41, 33, 25, 17, 9,
            1, 58, 50, 42, 34, 26, 18,
            10, 2, 59, 51, 43, 35, 27,
            19, 11, 3, 60, 52, 44, 36};
    int[] PC_1_RTABLE = {63, 55, 47, 39, 31, 23, 15,
            7, 62, 54, 46, 38, 30, 22,
            14, 6, 61, 53, 45, 37, 29,
            21, 13, 5, 28, 20, 12, 4};
    int[] PC_2_TABLE = {14, 17, 11, 24, 1, 5,
            3, 28, 15, 6, 21, 10,
            23, 19, 12, 4, 26, 8,
            16, 7, 27, 20, 13, 2,
            41, 52, 31, 37, 47, 55,
            30, 40, 51, 45, 33, 48,
            44, 49, 39, 56, 34, 53,
            46, 42, 50, 36, 29, 32};
    public int[] Binarykey = new int[64];
    public int[][] Sonkey = new int[16][48];
    public int len = 0;
    public void set()//(test pass) set Binarykey
    {
        Scanner scan = new Scanner(System.in);
        int[] tmp = new int[64];
        System.out.println("Please input your Key :  ");
        String tmpchar = scan.next();
        HextoBin hexto = new HextoBin();
        hexto.set(tmpchar);
        String str2 = hexto.out();
        for(int i = 0;i < 64;i++){
            Binarykey[i] = str2.charAt(i)-'0';
        }
```

```
    }
    public int[] result(int[] txt,int count){
        int lenth = txt.length;
        int[] tmptxt = new int[lenth];
        if(lenth > 28){
            System.out.println("Your Result length is Error");
        }
        else{
            int tmpnum = 0;
            for(int i = count;i < lenth ;i++){
                tmptxt[tmpnum] = txt[i];
                tmpnum ++;
            }
            for(int i = 0;i < count;i++){
                tmptxt[tmpnum+i] = txt[i];
            }
        }
        return tmptxt;
    }
    public int[][] Main(){
        int lenth = Binarykey.length;
        if(lenth != 64){
            System.out.println("Your  Key lenth is Error");
        }
        String BinarykeyST = "";
        for(int i =0;i < lenth;i++){
            BinarykeyST += Binarykey[i];
        }
        System.out.println("Your  Binary Key is : "+BinarykeyST);
        int[] LO = new int[28];
        int[] RO = new int[28];
        for(int i = 0;i < PC_1_LTABLE.length;i++){
            LO[i] = Binarykey[PC_1_LTABLE[i] - 1];
        }
        for(int i = 0;i < PC_1_LTABLE.length;i++){
            RO[i] = Binarykey[PC_1_RTABLE[i] - 1];
        }
        for(int i = 0;i < 16;i++){
            LO = result(LO,Movetimes[i]);
            RO = result(RO,Movetimes[i]);
            int[] mergedKey = new int[56];
            for(int j = 0;j < 28;j++){
                mergedKey[j] = LO[j];
            }
            for(int j = 28;j < 56;j++){
                mergedKey[j] = RO[j-28];
            }
            int[] tempkey = new int[48];
            for(int j = 0;j < PC_2_TABLE.length;j++){
                tempkey[j] = mergedKey[PC_2_TABLE[j]-1];
            }
            for(int j = 0;j<48;j++){
                Sonkey[i][j] = tempkey[j];
            }
        }
        return Sonkey;
    }
}
```

Python实现

```
def createkey(key):
    Movetimes = [1, 1, 2, 2, 2, 2, 2, 2, 1, 2, 2, 2, 2, 2, 2, 1]
    PC_1_LTABLE = [57, 49, 41, 33, 25, 17, 9,
             1, 58, 50, 42, 34, 26, 18,
             10, 2, 59, 51, 43, 35, 27,
             19, 11, 3, 60, 52, 44, 36]
    PC_1_RTABLE = [63, 55, 47, 39, 31, 23, 15,
             7, 62, 54, 46, 38, 30, 22,
             14, 6, 61, 53, 45, 37, 29,
             21, 13, 5, 28, 20, 12, 4]
    PC_2_TABLE = [14, 17, 11, 24, 1, 5,
                        3, 28, 15, 6, 21, 10,
                        23, 19, 12, 4, 26, 8,
                        16, 7, 27, 20, 13, 2,
                        41, 52, 31, 37, 47, 55,
                        30, 40, 51, 45, 33, 48,
                        44, 49, 39, 56, 34, 53,
                        46, 42, 50, 36, 29, 32]
    if len(key) != 64 :
        print("Your Key lenth is Error!")
        assert len(key) == 64#if no 64bit error
    else:
        L0 = ""
        R0 = ""
        for i in PC_1_LTABLE:
            L0 += key[i - 1]
        for i in PC_1_RTABLE:
            R0 += key[i - 1]
        assert len(L0) == 28 #if no 28bit error
        assert len(R0) == 28
        Sonkey = []
        for i in range(0, 16):
            print("Movetimes : ",i)
            L0 = result(L0, Movetimes[i])
            R0 = result(R0, Movetimes[i])
            print("L0 : ", L0)
            print("R0 : ", R0)
            mergedKey = L0 + R0
            tempkey = ""
            for j in PC_2_TABLE:
                tempkey += mergedKey[j - 1]
            assert len(tempkey) == 48
            print("Your NO.",i," Sonkey :",tempkey)
            Sonkey.append(tempkey)
        return Sonkey
```

DES轮函数实现

Java实现

```
class DES{
    private static String intToHex(int n) {
        StringBuffer s = new StringBuffer();
```

```
        String a;
        char []b =
{'0','1','2','3','4','5','6','7','8','9','A','B','C','D','E','F'};
        while(n != 0){
            s = s.append(b[n%16]);
            n = n/16;
        }
        a = s.reverse().toString();
        return a;
    }
    private static String hexStr =  "0123456789ABCDEF";
    private static String[] binaryArray =
            {"0000","0001","0010","0011",
                    "0100","0101","0110","0111",
                    "1000","1001","1010","1011",
                    "1100","1101","1110","1111"};
    public static String bin2HexStr(byte[] bytes){
        String result = "";
        String hex = "";
        for(int i=0;i<bytes.length;i++){
            //字节高4位
            hex = String.valueOf(hexStr.charAt((bytes[i]&0xF0)>>4));
            //字节低4位
            hex += String.valueOf(hexStr.charAt(bytes[i]&0x0F));
            result +=hex;  //+" "
        }
        return result;
    }
    String ClearTxt = "";
    public int[] BinaryClearTxt = new int[64];
    public int[][] Sonkey = new int[16][48];
    int[] ret = new int[64];
    public int[] IP(int[] BinaryClearTxt){
        int[] IPTABLE = {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};
        if(BinaryClearTxt.length != 64){
            System.out.println("Your key Text lenth is Error!");
        }
        else {
            for (int i = 0;i < IPTABLE.length;i++){
                ret[i] = BinaryClearTxt[IPTABLE[i]-1];
            }
            System.out.print("Source ClearText : ");
            for(int i = 0;i<BinaryClearTxt.length;i++){
                System.out.print(BinaryClearTxt[i]);
            }
        }
        return ret;
    }
    public String expend(String Rn){
        int[] ETABLE = {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 retRn = "";
        for(int i =0;i<ETABLE.length;i++){
            retRn += Rn.charAt(ETABLE[i]-1);
        }
        return retRn;
    }
    public String S_sub(String S_Input){
        int[][] STABLE = {{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}};
        String retstr = "";
        while (S_Input.length()<48){
            S_Input = "0" + S_Input;
        }
        int index = 0;
        for(int i = 0;i < 8;i++){
            int[] Slist = new int[64];
            for(int j = 0;j < 64;j++){
                Slist[j] = STABLE[i][j];
            }
            int row = (S_Input.charAt(index)-'0')*2+(S_Input.charAt(index+5)-
'0');
```

```
            int col = (S_Input.charAt(index+1)-'0')*8 +
(S_Input.charAt(index+2)-'0')*4+(S_Input.charAt(index+3)-'0')*2+
(S_Input.charAt(index+4)-'0');



            String ret_single = Integer.toBinaryString(Slist[row*16+col]);
            while (ret_single.length() < 4){
                ret_single = "0" + ret_single;
            }
            retstr += ret_single;
            index += 6;
        }
        if (retstr.length() != 32){
            System.out.println("Your S_sub retstr lenth is erroe!\n");
        }
        return retstr;
    }
    public String[] P(String Ln,String S_sub_str,String Rn){
        int[] PTABLE = {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};
        String tmp = "";
        for(int i = 0;i < PTABLE.length;i++){
            tmp += S_sub_str.charAt(PTABLE[i]-1);
        }
        String Lnnew = "";
        for(int i = 0;i < tmp.length();i++){
            Lnnew += (tmp.charAt(i) - '0') ^ (Ln.charAt(i) - '0');
        }
        while (Lnnew.length()<32){
            Lnnew = "0" + Lnnew;
        }
        if (Lnnew.length()!=32){
            System.out.println("Your Lnnew lenth is error!\n");
        }
        Ln = Rn;
        Rn = Lnnew;
        String[] strstr = new String[2];
        strstr[0] = Ln;
        strstr[1] = Rn;
        return  strstr;
    }
    public String IP_inverse(String L16,String R16){
        int[] IPINVERSETABLE = {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};
        String tmp = L16 + R16;
        String retstr = "";
        for(int i = 0;i < IPINVERSETABLE.length;i++){
            retstr += tmp.charAt(IPINVERSETABLE[i] - 1);
        }
        if (retstr.length() != 64){
            System.out.println("Your IP_inverse is error!\n");
        }
        return retstr;
```

```
    }
    public void Main(){
        Scanner scan = new Scanner(System.in);
        ClearTxt = scan.next();
        HextoBin hexto = new HextoBin();
        hexto.set(ClearTxt);
        String str2 = hexto.out();
        for(int i = 0;i < 64;i++){
            BinaryClearTxt[i] = str2.charAt(i)-'0';
        }
        BinaryClearTxt = IP(BinaryClearTxt);
        int[] tmpLn = new int[32];
        int[] tmpRn = new int[32];
        String Ln = "";
        String Rn = "";

        for(int i = 0;i <32;i++){
            Ln += BinaryClearTxt[i];
        }
        for(int i = 32;i <64;i++){
            Rn += BinaryClearTxt[i];
        }


        Key Key = new Key();
        Key.set();

        Sonkey = Key.Main();


        for(int i = 0;i <16;i++){
            int[] tmpkey = new int[48];
            for(int j = 0;j < 48;j++){
                tmpkey[j] = Sonkey[i][j];
            }
            while (Rn.length() < 32){
                Rn = "0" + Rn;
            }
            while (Ln.length() < 32){
                Ln = "0" + Ln;
            }
            String Rn_expand = expend(Rn);
            String S_input = "";
            String S_sub_str = "";
            for(int j =0;j<48;j++){
                S_input += ((Rn_expand.charAt(j) - '0') ^ (tmpkey[j]));
            }
            S_sub_str = S_sub(S_input);
            String[] StrStr = new String[2];
            StrStr = P(Ln,S_sub_str,Rn);
            Ln = StrStr[0];
            Rn = StrStr[1];
        }
        String tmpp = "";
        tmpp = Ln;
        Ln = Rn;
        Rn = tmpp;
        String re_text = IP_inverse(Ln,Rn);
```

```
        int tmnum = 0;
        int tmindex = 0;
        int tmmindex = 3;
        String a = "";
        for(int i =0;i <64;i++){
            if(tmindex == 4){
                tmindex = 0;
                a += hexStr.charAt(tmnum);
                tmnum = 0;
                tmmindex = 3;
            }
            tmnum += Math.pow(2,tmmindex) * (re_text.charAt(i) - '0');
            tmmindex --;
            tmindex ++;
            if(i == 63){
                a += hexStr.charAt(tmnum);
            }
        }
        System.out.println("Your DES Result is : "+re_text);
        System.out.println("Your DES Result is : "+tmnum);
        System.out.println("Your DES Result is : "+a);
    }
}
```

Python实现

```
def expend(Rn):
    ETABLE = [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]
    retRn = ""
    for i in ETABLE:
        retRn += Rn[i - 1]
    assert len(retRn) == 48
    return retRn
def S_sub(S_Input):
    STABLE = [(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)]
    S_Input = bin(S_Input)[2:]
    while len(S_Input) < 48:
        S_Input = "0" + S_Input
    index = 0
    retstr = ""
    for Slist in STABLE:
        row = int(S_Input[index] + S_Input[index + 5], base=2)
        col = int(S_Input[index + 1:index + 5], base=2)
        ret_single = bin(Slist[row * 16 + col])[2:]
        while len(ret_single) < 4:
            ret_single = "0" + ret_single
        retstr += ret_single
        index += 6
    assert len(retstr) == 32
    return retstr
def P(Ln, S_sub_str, oldRn):
    PTABLE = [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]
    tmp = ""
    for i in PTABLE:
        tmp += S_sub_str[i - 1]
    LnNew = int(tmp, base=2) ^ int(Ln, base=2)
    LnNew = bin(LnNew)[2:]
    while len(LnNew) < 32:
        LnNew = "0" + LnNew
    assert len(LnNew) == 32
    (Ln, Rn) = (oldRn, LnNew)
    return (Ln, Rn)
def IP_inverse(L16, R16):
    IPINVERSETABLE = [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]
    tmp = L16 + R16
    retstr = ""
    for i in IPINVERSETABLE:
        retstr += tmp[i - 1]
    assert len(retstr) == 64
```

```
    return retstr
def DES_ECB(ClearTxt,Keylist):
    InitKeyCode = IP(ClearTxt)
    Ln = InitKeyCode[0:32]
    Rn = InitKeyCode[32:]
    for key in Keylist:
        while len(Rn) < 32:
            Rn = "0" + Rn
        while len(Ln) < 32:
            Ln = "0" + Ln
        print("Ln : ",Ln)
        print("Rn : ", Rn)
        Rn_expand = expend(Rn)
        print("Rn_expand : ",Rn_expand)
        S_Input = int(Rn_expand, base=2) ^ int(key, base=2)
        print("S_Input : ", S_Input)
        S_sub_str = S_sub(S_Input)
        print("S_sub_str : ", S_sub_str)
        (Ln, Rn) = P(Ln, S_sub_str, Rn)
    (Ln, Rn) = (Rn, Ln)
    re_text = IP_inverse(Ln, Rn)
    return re_text
```

加密分组实现

```
def Encryptmohex(tmplist):
    str_bin = ''.join(tmplist)
    groups = int(len(str_bin) / 64)
    # 生成加密分组
    M = np.zeros((groups, 64))
    index = -8
    for i in range(groups):
        index += 8
        strr = ""
        for j in range(8):
            strr += tmplist[index + j]
        for j in range(64):
            M[i][j] = int(strr[j])
    print("Your List Clear Text: ", tmplist)
    print("Your Binary Clear Text: ", str_bin)
    print("Your Hex Clear Text: ", hex(int(str_bin, base=2)).upper())
    print("Your Clear Text groups: ", groups)
    key_bin = inkey()
    # 打印加密群
    AllCiphertext = ""
    for i in range(groups):
        print("ClearText Group ", i, ": ", end='')
        tmptext = ""
        for j in range(64):
            tmptext += str(int(M[i][j]))
        ciphertext = Feistel(tmptext, key_bin, 1)
        AllCiphertext += ciphertext
        print("Ciphertext: ", ciphertext)
    print("Your Binary Ciphertext: ", AllCiphertext)
    print("Your Hex Ciphertext: ", hex(int(AllCiphertext, base=2)).upper())
```

解密分组实现

主函数同加密分组实现，只需要把密钥取反即可

```
keylist = keylist[::-1] #INVERSEKEY
```

附加内容

用电码本模式对文件进行加密和解密

```
def opentxt():
     f = open('/tmp/test.txt')
     str1 = ""
     while true:
        str1 = f.readline()
     return str1
def Encryptmostr(text):
    lenth = len(text)
    flag = 0
    offset = 0
    # 补位操作
    if (lenth % 8 == 0):
        flag = 0
    else:
        flag = 1
        offset = 8 - lenth % 8
    for i in range(offset):
        text += 'A'
    tmplist = encode(text)
    groups = int(len(tmplist) / 8)
    #对齐8位
    for i in range(len(tmplist)):
        if len(tmplist[i]) != 8:
            tmpp = ""
            for j in range(8 - len(tmplist[i])):
                tmpp += '0'
            tmplist[i] = tmpp + tmplist[i]
    str_bin = ''.join(tmplist)
    #生成加密分组
    M = np.zeros((groups, 64))
    index = -8
    for i in range(groups):
        index += 8
        strr = ""
        for j in range(8):
            for k in tmplist[index+j]:
                strr += k
        for j in range(64):
            M[i][j] = int(strr[j])
    print("Your List Clear Text: ",tmplist)
    print("Your Binary Clear Text: ",str_bin)
    print("Your Hex Clear Text: ", hex(int(str_bin, base=2)).upper())
    print("Your Clear Text offset: ", offset)
    print("Your Clear Text groups: ", groups)
    key_bin = inkey()
    #打印加密群
```

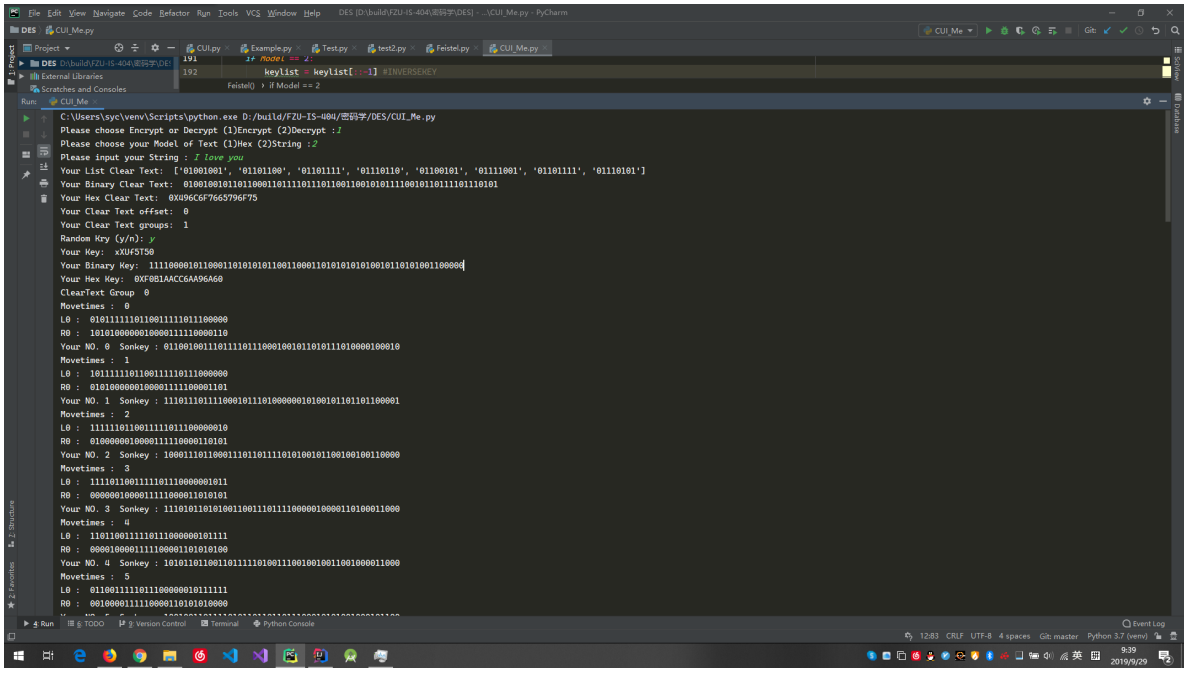
```
    AllCiphertext = ""
    for i in range(groups):
        print("ClearText Group ", i)
        tmptext = ""
        for j in range(64):
            tmptext += str(int(M[i][j]))
        ciphertext = Feistel(tmptext, key_bin, 1)
        AllCiphertext += ciphertext
        print("Ciphertext: ",ciphertext)
    print("Your Binary Ciphertext: ",AllCiphertext)
    print("Your Hex Ciphertext: ", hex(int(AllCiphertext, base=2)).upper())
def encode(s):#字符串转二进制
    tmp = []
    for c in s:
        tmp.append(bin(ord(c)).replace('0b', ''))
    str_bin = ' '.join(tmp)
    for i in range(len(tmp)):
        if len(tmp[i]) != 7:
            tmpp = ""
            for j in range(7-len(tmp[i])):
                tmpp += '0'
            tmp[i] =  tmpp + tmp[i]
    return tmp
def ParityCheck(s):#偶校验
    num = 0
    for i in s:
        if i == '1':
            num = num +1
    if num%2 == 0:
        s += '0'
    else:
        s += '1'
    return s
```

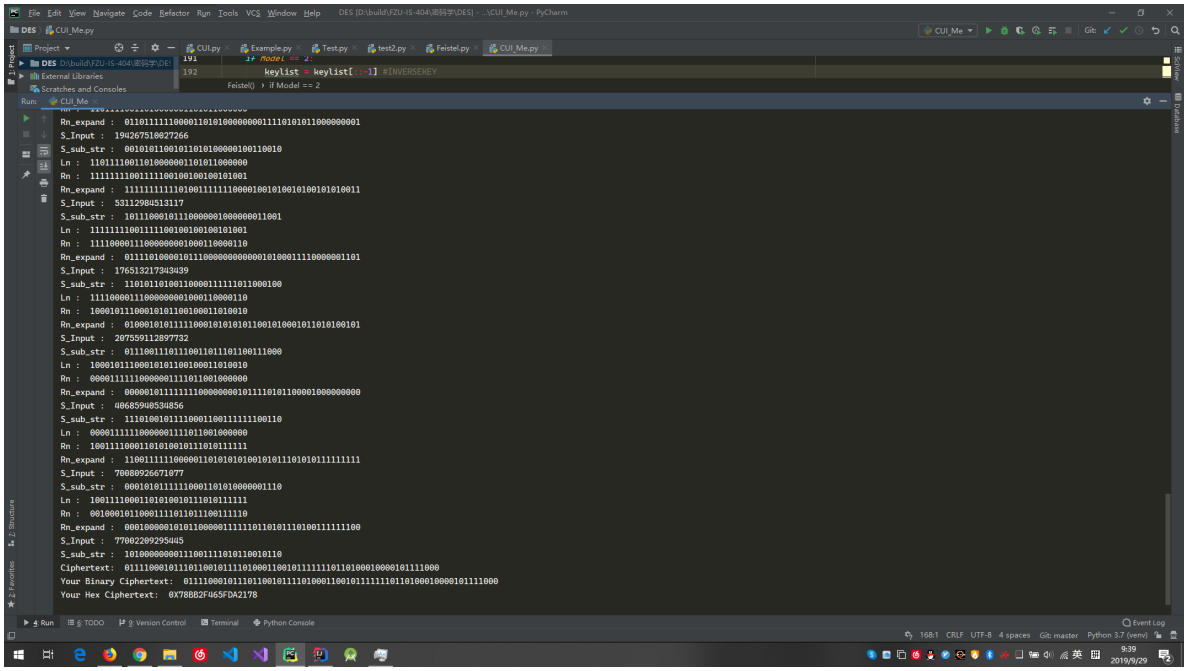
自定义轮函数

F(W,K)=(1<<W)+K, 即W先循环左移1位再与K异或

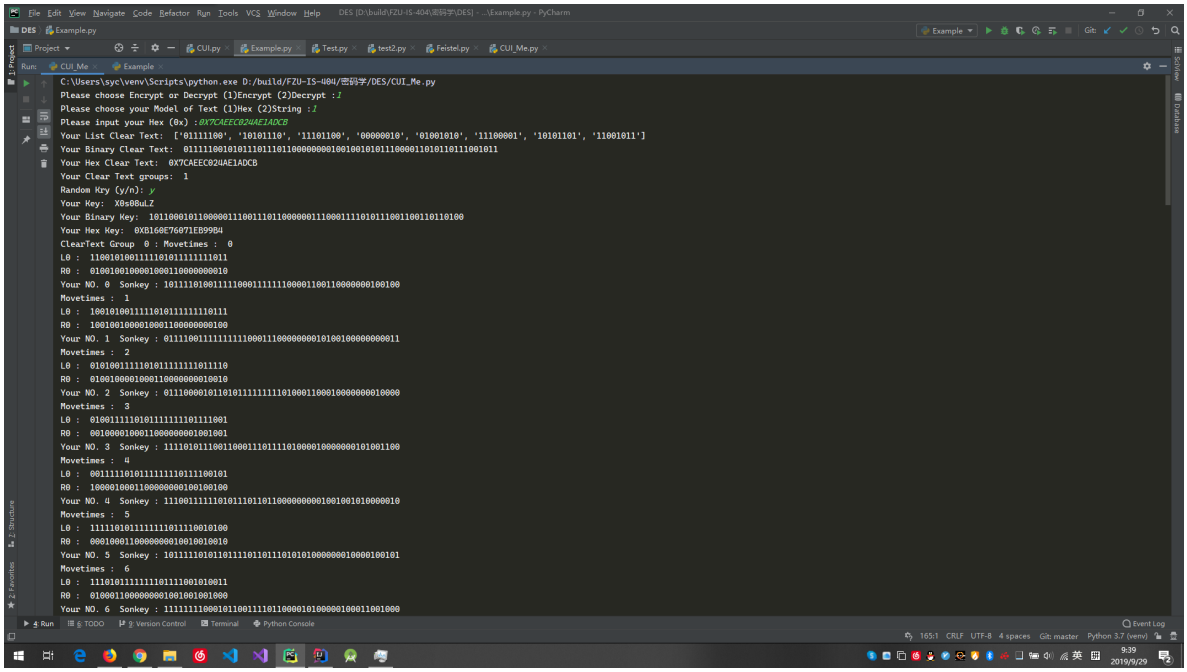
```
def DIYDES(ClearTxt,Key,Model):
    keylist = createkey(Key)
    InitKeyCode = IP(ClearTxt)
    for key in Keylist:
        InitKeyCode = InitKeyCode << 1;
        InitKeyCode = InitKeyCode ^ key
     return InitKeyCode
```

重要的实现细节

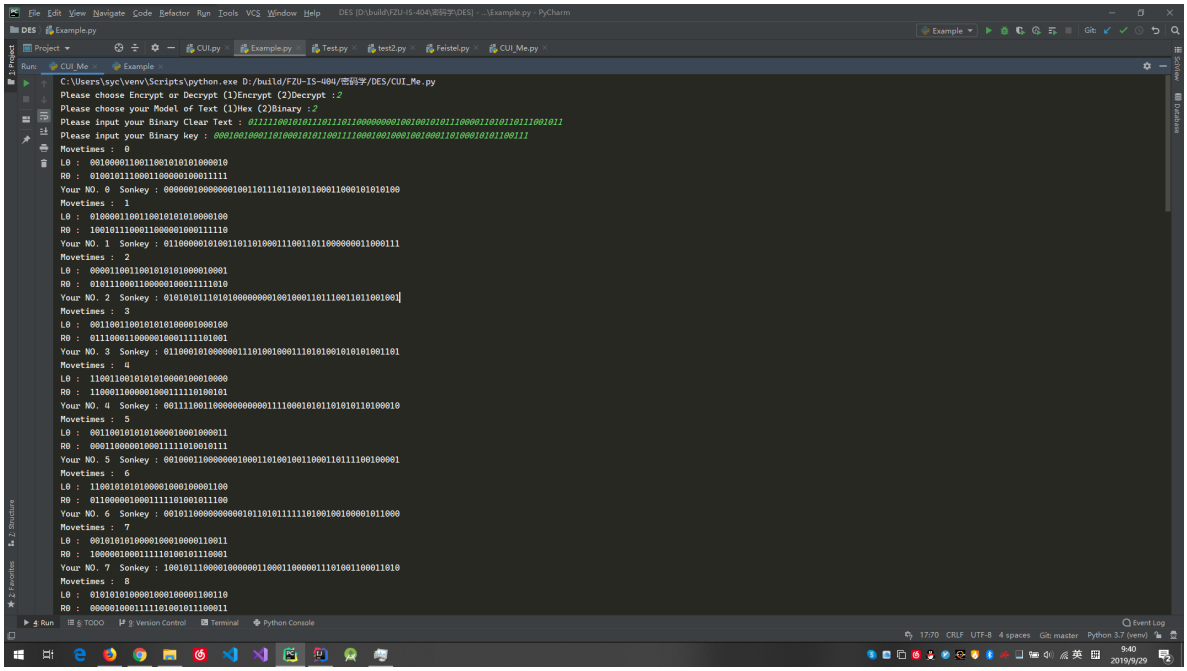
- 随机密钥的生成
    - ```
      if model == "y":
          tmplist = []
          for i in range(8):
              j = random.randint(1,3)
              if j == 1:
                  tmplist.append(chr(random.randint(48, 57)))
              if j == 2:
      ```
      ```

```
                tmplist.append(chr(random.randint(65, 90)))
            if j == 3:
                tmplist.append(chr(random.randint(97, 122)))
        for i in tmplist:
            strr += i
        keylist = encode(strr)
        # 补充奇偶校验位
        for i in range(len(keylist)):
            keylist[i] = ParityCheck(keylist[i])
        key_bin = ''.join(keylist)
        print("Your Key: ", strr)
        print("Your Binary Key: ", key_bin)
        print("Your Hex Key: ", hex(int(key_bin, base=2)).upper())
        return key_bin
```

- 校验位的生成和补位操作
  - ```
    def ParityCheck(s):#偶校验
        num = 0
        for i in s:
            if i == '1':
                num = num +1
        if num%2 == 0:
            s += '0'
        else:
            s += '1'
        return s
     # 补充奇偶校验位
            for i in range(len(keylist)):
                keylist[i] = ParityCheck(keylist[i])
            key_bin = ''.join(keylist)
            print("Your Key: ", strr)
            print("Your Binary Key: ", key_bin)
            print("Your Hex Key: ", hex(int(key_bin, base=2)).upper())
    ```

实现效果

实现文本加密


    ```

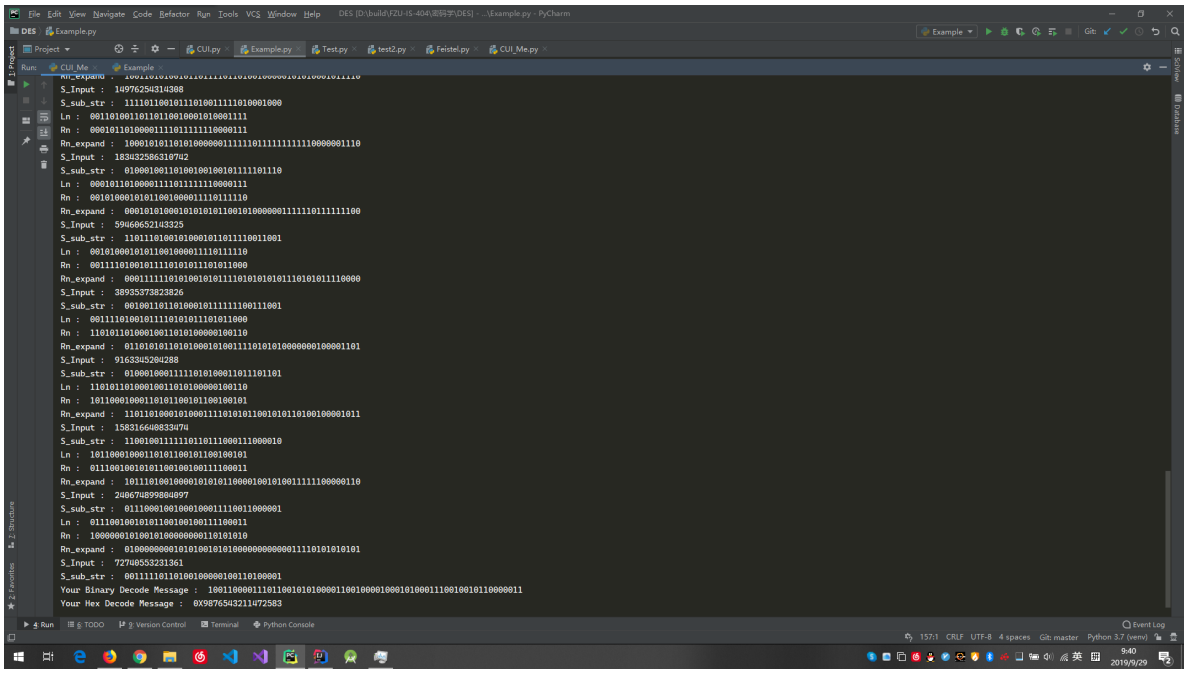


实现十六进制输入加密



实现二进制输入解密





总结

系统亮点

- 实现了完成的Feistel密码结构的分层
- 实现了Key轮加密密钥的类抽象
- 实现了随机密钥的生成方法
- 提供了包括二进制、十六进制、字符串、文本文件在内的多种输入方式
- 提供了自定义轮函数的接口