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CRYPTOGRAPHY AND NETWORK SECURITY
LAB - 4

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Course Code: BCSE309P

Programme: Bachelor of Technology in Computer Science and Engineering with Specialization in Artificial Intelligence and Machine Learning

School: School of Computer Science and Engineering(SCOPE)

Q) Consider a sender and receiver who need to exchange data confidentially using symmetric encryption. Write program that implements DES encryption and decryption using a 64-bit key size and 64-bit block size

Code:

```
def hex2bin(s):
mp = {'0': "0000",
'1': "0001",
'2': "0010",
'3': "0011",
'4': "0100",
'5': "0101",
'6': "0110",
'7': "0111",
'8': "1000",
'9': "1001",
'A': "1010",
'B': "1011",
'C': "1100",
'D': "1101",
'E': "1110",
'F': "1111"}
bin = ""
for i in range(len(s)):
bin = bin + mp[s[i]]
```

```
return bin
def bin2hex(s):
mp = {"0000": '0',
"0001": '1',
"0010": '2',
"0011": '3',
"0100": '4',
"0101": '5',
"0110": '6',
"0111": '7',
"1000": '8',
"1001": '9',
"1010": 'A',
"1011": 'B',
"1100": 'C',
"1101": 'D',
"1110": 'E',
"1111": 'F'}
hex = ""
for i in range(0, len(s), 4):
ch = ""
ch = ch + s[i]
ch = ch + s[i + 1]
ch = ch + s[i + 2]
ch = ch + s[i + 3]
hex = hex + mp[ch]
```

```
return hex
def bin2dec(binary):

binary1 = binary
decimal, i, n = 0, 0, 0
while(binary != 0):
dec = binary % 10
decimal = decimal + dec * pow(2, i)
binary = binary//10
i += 1
return decimal
def dec2bin(num):
res = bin(num).replace("0b", "")
if(len(res) % 4 != 0):
div = len(res) / 4
div = int(div)
counter = (4 * (div + 1)) - len(res)
for i in range(0, counter):
res = '0' + res
return res
def permute(k, arr, n):
permutation = ""
for i in range(0, n):
permutation = permutation + k[arr[i] - 1]
return permutation
```

```
def shift_left(k, nth_shifts):
s = ""
for i in range(nth_shifts):
for j in range(1, len(k)):
s = s + k[j]
s = s + k[0]
k = s
s = ""
return k

def xor(a, b):
ans = ""
for i in range(len(a)):
if a[i] == b[i]:
ans = ans + "0"
else:
ans = ans + "1"
return ans
initial_perm = [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]
```

```
exp_d = [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]

per = [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]

sbox = [[[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]]]
final_perm = [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]


def encrypt(pt, rkb, rk):
pt = hex2bin(pt)
pt = permute(pt, initial_perm, 64)
print("After initial permutation", bin2hex(pt))
left = pt[0:32]
right = pt[32:64]
for i in range(0, 16):
right_expanded = permute(right, exp_d, 48)
xor_x = xor(right_expanded, rkb[i])


sbox_str = ""
for j in range(0, 8):
row = bin2dec(int(xor_x[j * 6] + xor_x[j * 6 + 5]))
```

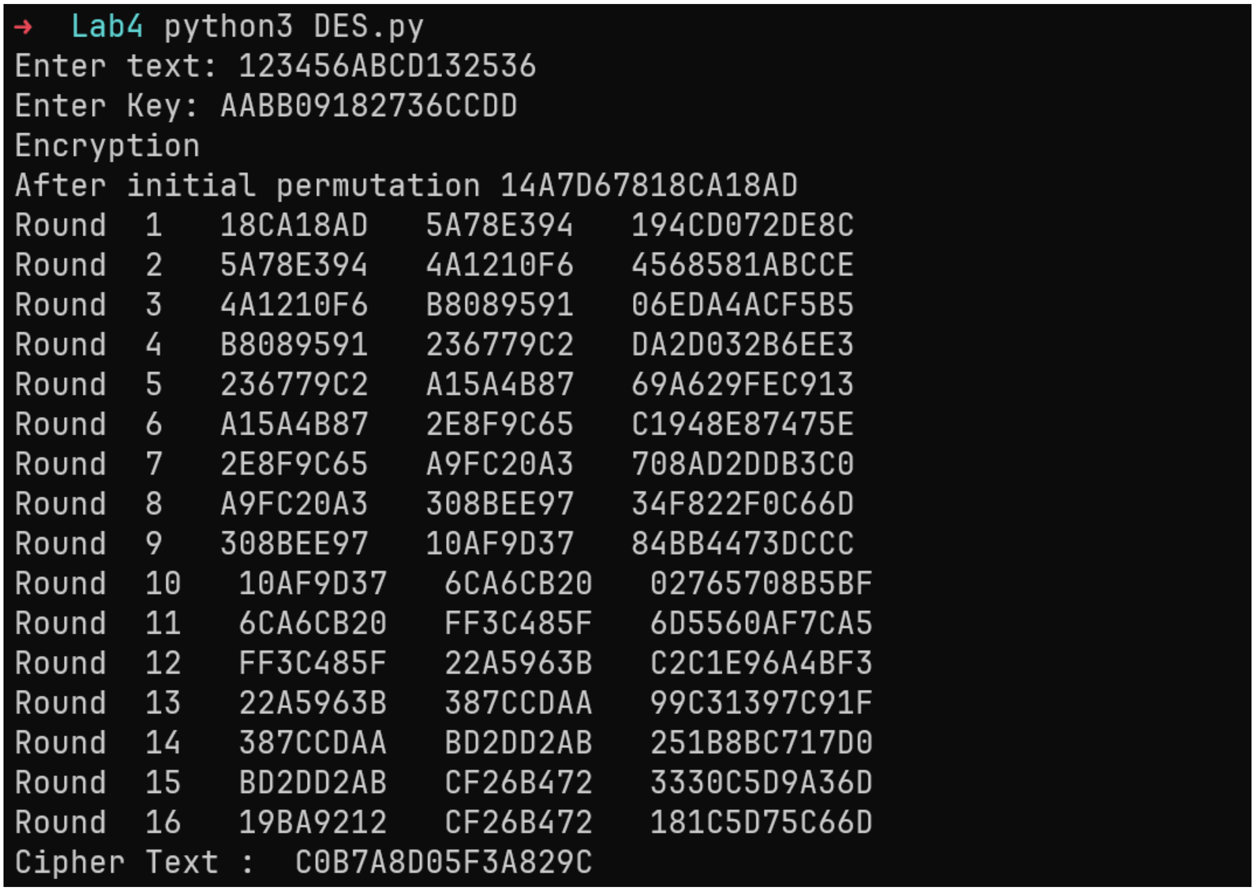
```
col = bin2dec(
int(xor_x[j * 6 + 1] + xor_x[j * 6 + 2] + xor_x[j * 6 + 3] + xor_x[j * 6 + 4]))
val = sbox[j][row][col]
sbox_str = sbox_str + dec2bin(val)

# Straight D-box: After substituting rearranging the bits
sbox_str = permute(sbox_str, per, 32)

# XOR left and sbox_str
result = xor(left, sbox_str)
left = result

# Swapper
if(i != 15):
left, right = right, left
print("Round ", i + 1, " ", bin2hex(left),
" ", bin2hex(right), " ", rk[i])
combine = left + right

cipher_text = permute(combine, final_perm, 64)
return cipher_text


pt = "123456ABCD132536"
key = "AABB09182736CCDD"
key = hex2bin(key)
```

```
keyp = [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]
key = permute(key, keyp, 56)

# Number of bit shifts
shift_table = [1, 1, 2, 2,
2, 2, 2, 2,
1, 2, 2, 2,
2, 2, 2, 1]

key_comp = [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]

left = key[0:28] # rkb for RoundKeys in binary
```

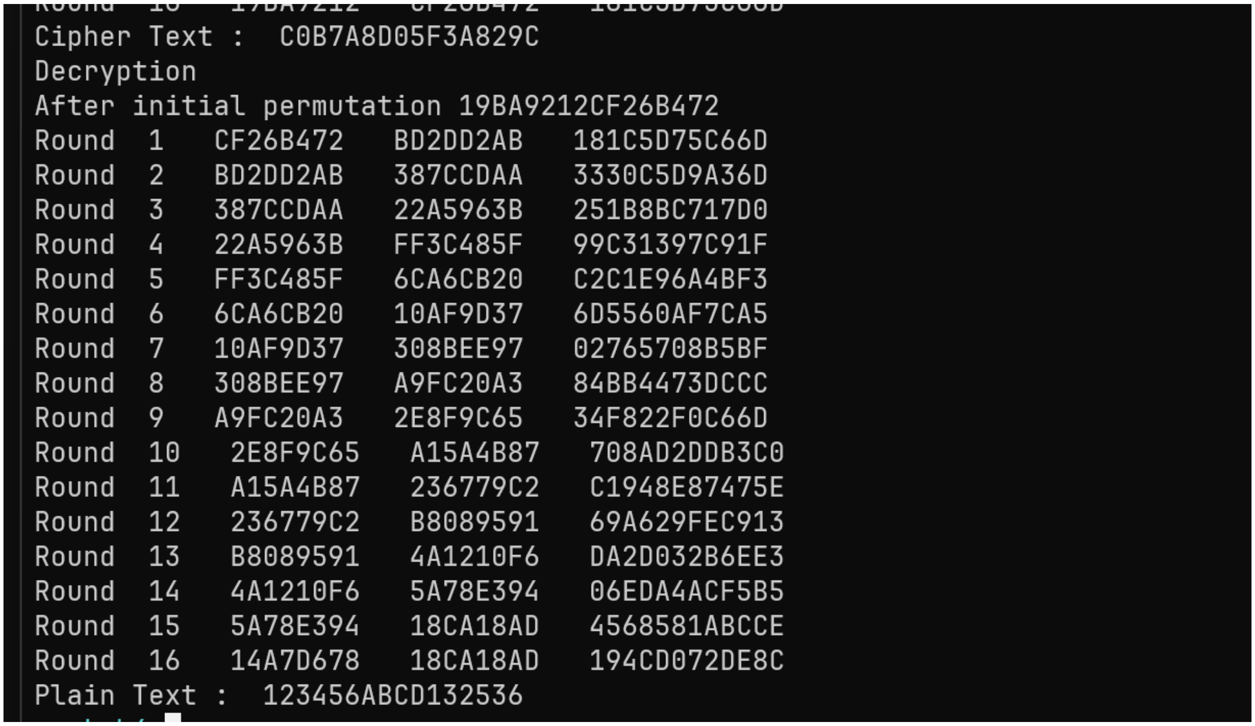
```
right = key[28:56] # rk for RoundKeys in hexadecimal

rkb = []
rk = []
for i in range(0, 16):
# Shifting the bits by nth shifts by checking from shift table
left = shift_left(left, shift_table[i])
right = shift_left(right, shift_table[i])

# Combination of left and right string
combine_str = left + right

# Compression of key from 56 to 48 bits
round_key = permute(combine_str, key_comp, 48)

rkb.append(round_key)
rk.append(bin2hex(round_key))

print("Encryption")
cipher_text = bin2hex(encrypt(pt, rkb, rk))
print("Cipher Text : ", cipher_text)

print("Decryption")
rkb_rev = rkb[::-1]
rk_rev = rk[::-1]
text = bin2hex(encrypt(cipher_text, rkb_rev, rk_rev))
```

print("Plain Text : ", text)

Output Screenshots:



```
➜  Lab4 python3 DES.py
Enter text: 123456ABCD132536
Enter Key: AABB09182736CCDD
Encryption
After initial permutation 14A7D67818CA18AD
Round  1   18CA18AD   5A78E394   194CD072DE8C
Round  2   5A78E394   4A1210F6   4568581ABCCE
Round  3   4A1210F6   B8089591   06EDA4ACF5B5
Round  4   B8089591   236779C2   DA2D032B6EE3
Round  5   236779C2   A15A4B87   69A629FEC913
Round  6   A15A4B87   2E8F9C65   C1948E87475E
Round  7   2E8F9C65   A9FC20A3   708AD2DDB3C0
Round  8   A9FC20A3   308BEE97   34F822F0C66D
Round  9   308BEE97   10AF9D37   84BB4473DCCC
Round  10   10AF9D37   6CA6CB20   02765708B5BF
Round  11   6CA6CB20   FF3C485F   6D5560AF7CA5
Round  12   FF3C485F   22A5963B   C2C1E96A4BF3
Round  13   22A5963B   387CCDAA   99C31397C91F
Round  14   387CCDAA   BD2DD2AB   251B8BC717D0
Round  15   BD2DD2AB   CF26B472   3330C5D9A36D
Round  16   19BA9212   CF26B472   181C5D75C66D
Cipher Text :  C0B7A8D05F3A829C
```



```
Round  16   19BA9212   CF26B472   181C5D75C66D
Cipher Text :  C0B7A8D05F3A829C
Decryption
After initial permutation 19BA9212CF26B472
Round  1   CF26B472   BD2DD2AB   181C5D75C66D
Round  2   BD2DD2AB   387CCDAA   3330C5D9A36D
Round  3   387CCDAA   22A5963B   251B8BC717D0
Round  4   22A5963B   FF3C485F   99C31397C91F
Round  5   FF3C485F   6CA6CB20   C2C1E96A4BF3
Round  6   6CA6CB20   10AF9D37   6D5560AF7CA5
Round  7   10AF9D37   308BEE97   02765708B5BF
Round  8   308BEE97   A9FC20A3   84BB4473DCCC
Round  9   A9FC20A3   2E8F9C65   34F822F0C66D
Round  10   2E8F9C65   A15A4B87   708AD2DDB3C0
Round  11   A15A4B87   236779C2   C1948E87475E
Round  12   236779C2   B8089591   69A629FEC913
Round  13   B8089591   4A1210F6   DA2D032B6EE3
Round  14   4A1210F6   5A78E394   06EDA4ACF5B5
Round  15   5A78E394   18CA18AD   4568581ABCCE
Round  16   14A7D678   18CA18AD   194CD072DE8C
Plain Text :  123456ABCD132536
```

Result:

Thus, the DES algorithm has been successfully executed and verified.