Practical Assignment 2

Network Security

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Github link:
https://github.com/Harirai/Network-Security-18075921/tree/master/Practical%20Assignment-2

```
import matplotlib.pyplot as plt



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

# Binary to decimal conversion
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

# Decimal to binary conversion
def dec2bin(num):
	res = bin(num).replace("0b", "")
	if(len(res)%4 != 0):
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            div = len(res) / 4
            div = int(div)
            counter =(4 * (div + 1)) - len(res)
            for i in range(0, counter):
                res = '0' + res
    return res

# Permute function to rearrange the bits
def permute(k, arr, n):
    permutation = ""
    for i in range(0, n):
        permutation = permutation + k[arr[i] - 1]
    return permutation

# shifting the bits towards left by nth shifts
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

# calculating xow of two strings of binary number a and b
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

# Table of Position of 64 bits at initial level: Initial Permutation Table
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]
```

```
# Expansion D-box Table
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 ]

# Straight Permutation Table
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 ]

# S-box Table
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 ]],
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```
                    [ [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 Permutation Table
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):
    ciphers=[]
    pt = hex2bin(pt)


    pt = permute(pt, initial_perm, 64)

    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 = ""
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        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)


        sbox_str = permute(sbox_str, per, 32)


        result = xor(left, sbox_str)
        left = result

        # Swapper
        if(i != 15):
            left, right = right, left

        ciphers.append(left+right)

    combine = left + right

    cipher_text = permute(combine, final_perm, 64)
    return [cipher_text,ciphers]

pt0='1434D6ABC2132B3A'
pt=['1435D6ABC2132B3A','A434D6ABC2132B3A','1434D6ABC2132B3B','1434D6ABC2132D3
A','143436ABC2132B3A','1434D64BC2132B3A']
key = "AABB09362781DDCC"

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)

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]
right = key[28:56]

rkb = []
rk = []
for i in range(0, 16):
	left = shift_left(left, shift_table[i])
	right = shift_left(right, shift_table[i])
	combine_str = left + right
	round_key = permute(combine_str, key_comp, 48)

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

_, parent_ciphers= encrypt(pt0, rkb, rk)
matrix=[]
for i in range(5):
  _ , ciphers = encrypt(pt[i], rkb, rk)
  matrix.append(ciphers)
matrix =[[row[i] for row in matrix] for i in range(len(matrix[0]))]
print(len(matrix),len(matrix[0]))
print(len(parent_ciphers))

hamming_distances=[]

def calc_hamming_dist(str1,str2):
  count=0
  for i in range(len(str1)):
    if(str1[i]!=str2[i]):
      count+=1
  return count
```

```
for i in range(16):
  tmp=[]
  for j in range(5):
    hd=calc_hamming_dist(matrix[i][j] , parent_ciphers[i])
    tmp.append(hd)
  hamming_distances.append(tmp)
print(hamming_distances)

mean_hamming_distances=[]
for i in hamming_distances:
  mean_hamming_distances.append(sum(i)/len(i))

# plt.plot(mean_hamming_distances)

plt.boxplot(hamming_distances)
plt.title('Avalanche Effect on DES Rounds')
plt.xlabel('DES Rounds')
plt.ylabel('Hamming Distance')
plt.ylim(1,50)
plt.show()
plt.show()

pt0='123456ABCD132536'
pt=['223456BBCD132556','325456ADCD13E536','614453ABCD232536','729456ABCA932531','
924456CBCD138536','923456AECD132537']
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)

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]
right = key[28:56]

rkb = []
rk = []
for i in range(0, 16):
        left = shift_left(left, shift_table[i])
        right = shift_left(right, shift_table[i])
        combine_str = left + right
        round_key = permute(combine_str, key_comp, 48)

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

_, parent_ciphers= encrypt(pt0, rkb, rk)
matrix=[]
for i in range(5):
  _ , ciphers = encrypt(pt[i], rkb, rk)
  matrix.append(ciphers)
matrix =[[row[i] for row in matrix] for i in range(len(matrix[0]))]
print(len(matrix),len(matrix[0]))
print(len(parent_ciphers))

hamming_distances=[]

def calc_hamming_dist(str1,str2):
  count=0
  for i in range(len(str1)):
    if(str1[i]!=str2[i]):
      count+=1
  return count
```

```
for i in range(16):
  tmp=[]
  for j in range(5):
    hd=calc_hamming_dist(matrix[i][j] , parent_ciphers[i])
    tmp.append(hd)
  hamming_distances.append(tmp)
print(hamming_distances)

mean_hamming_distances=[]
for i in hamming_distances:
  mean_hamming_distances.append(sum(i)/len(i))

plt.boxplot(hamming_distances)
plt.title('Avalanche Effect on DES Rounds')
plt.xlabel('DES Rounds')
plt.ylabel('Hamming Distance')
plt.ylim(1,50)
plt.show()

pt0='123456ABCD132536'
pt=['223456BBCD132556','325456ADCD13E536','614453ABCD232536','729456ABCA932531','
924456CBCD138536','923456AECD132537']
key = "ADBCA9189736CCAE"
keys=["BACD09188736CCEE","FABC09188736CCEE","CEBC09188736CCEE","ADBC191887
36CCEE","CDBC09188736CCEE"]
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)

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]
right = key[28:56]

rkb = []
rk = []
for i in range(0, 16):
        left = shift_left(left, shift_table[i])
        right = shift_left(right, shift_table[i])
        combine_str = left + right
        round_key = permute(combine_str, key_comp, 48)

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

_, parent_ciphers= encrypt(pt0, rkb, rk)
matrix=[]
for i in range(5):
  _ , ciphers = encrypt(pt[i], rkb, rk)
  matrix.append(ciphers)
matrix =[[row[i] for row in matrix] for i in range(len(matrix[0]))]
print(len(matrix),len(matrix[0]))
print(len(parent_ciphers))

hamming_distances=[]

def calc_hamming_dist(str1,str2):
  count=0
  for i in range(len(str1)):
    if(str1[i]!=str2[i]):
      count+=1
  return count
```

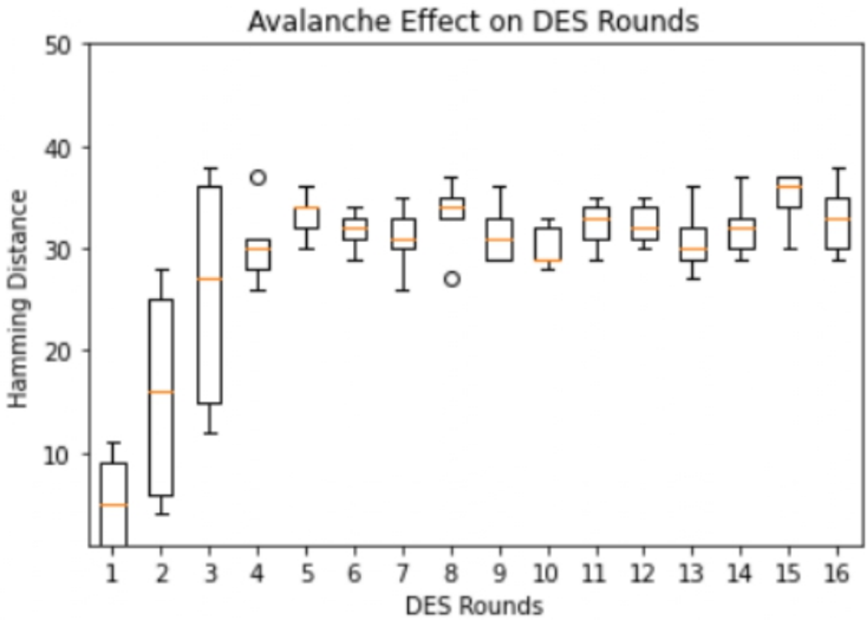
```
for i in range(16):
  tmp=[]
  for j in range(5):
    hd=calc_hamming_dist(matrix[i][j] , parent_ciphers[i])
    tmp.append(hd)
  hamming_distances.append(tmp)
print(hamming_distances)

mean_hamming_distances=[]
for i in hamming_distances:
  mean_hamming_distances.append(sum(i)/len(i))

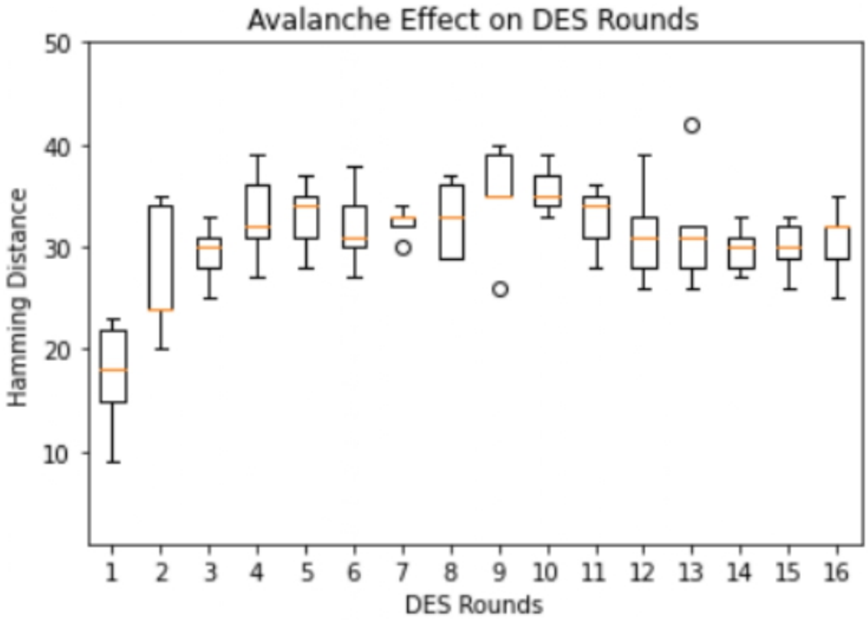
plt.boxplot(hamming_distances)
plt.title('Avalanche Effect on DES rounds')
plt.xlabel('DES rounds')
plt.ylabel('Hamming distance')
plt.ylim(1,50)
plt.show()
```

SCREENSHOT

- **5 Different Plain Text**



- **5 Different Hamming Distances**



- **5 Different Secret Keys**