ECE 404 Homework 2

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1. Problem 1: Encrypted Output

d04a94419ec6556c20029c83a277790c5c6380595291ecc23a40b90d60ae5b114dcefad2a37652e
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5e3fde33aab34a81ef30b95855c1917ea1826f0093dfae7a9e6124ac8036677dc75ddb8cc7954
8b5f6b673e2aaa2e74de559d17d4c3597eb793828ce2eba373130b87f4df0f0351aed3d07

2. Problem 1: Decrypted Output

Smartphone devices from the likes of Google, LG, OnePlus, Samsung and Xiaomi are in danger of compromise by cyber criminals after 400 vulnerable code sections were uncovered on Qualcomm's Snapdragon digital signal processor (DSP) chip, which runs on over 40

3. Explanation of the Code

The code I used is shown below:

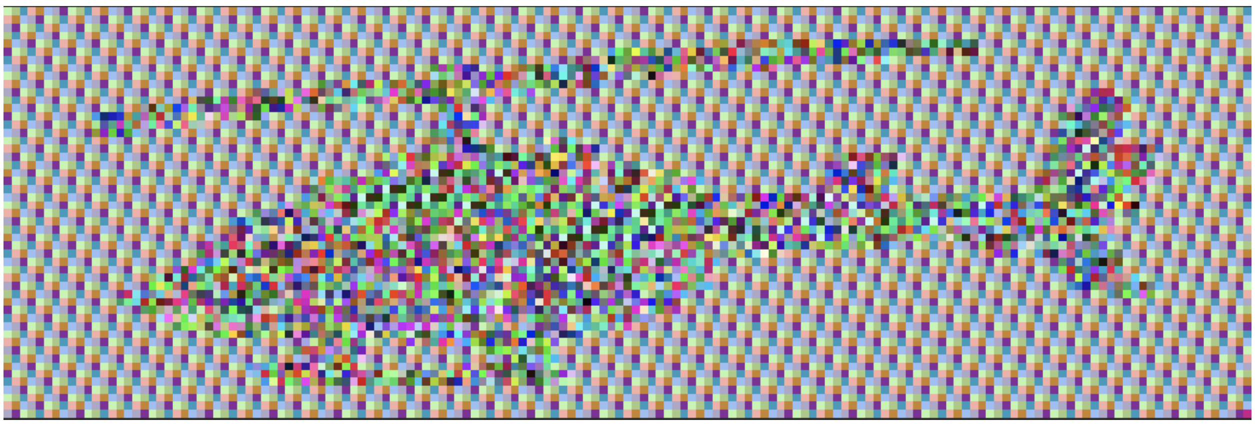
```
def encrypt(plainText,keyStr,cipherText):
    #break the plainText in 64 bit blocks
    bv = BitVector(filename=plainText)
    keyfp = open(keyStr,'r')
    cipherText = open(cipherText,'w')
    key = getEncryptionKey(keyfp)
    keyfp.close()
    roundKeys = extractRoundKeys( key )
    while (bv.more_to_read):
        bvRead = bv.read_bits_from_file( 64 )
        if(bvRead.length() != 64):
            #pad with zeros
            bvRead.pad_from_left(64 - bvRead.length())
        #break 64 bit vector into two 32 bit vectors and perform expansion permutation on r
        if bvRead.length() > 0: #bv.getsize() throws error for some reason
            #16 rounds
            bvHex = bvRead.get_bitvector_in_hex()
            #print("First 64 bit block before round 1:",bvHex)
            [leftHalf, rightHalf] = bvRead.divide_into_two()
            for i in range(16):
                originalRH = rightHalf # needed for the next left half
                #expand rightHalf to 48 bit
                newRH = rightHalf.permute(expansionPermutation)
                #XOR newRH with the roundkey to get new 48 bit
                outXor = newRH ^ roundKeys[i]
                #substitution with 8 s-boxes to get new 32 bit
                sBoxesOutput = substitute(outXor)
                #permutation with pBox
                rightHalf = sBoxesOutput.permute(pBoxPermutation)
                newRH = rightHalf ^ leftHalf
                newLH = originalRH # need og RH
                #swap to create the bitvector for the next round
                #reset bv to all zeros just to be safe
                bvRead.reset(0)
                leftHalf = newLH
                rightHalf = newRH
                #bvRead = newLH + newRH
                bvHex = bvRead.get_bitvector_in_hex()
                #print("First 64 bit block after round 1:",bvHex)
        #write the 64 encrypted block to the cipherText file
        bvRead = rightHalf + leftHalf
        print("64 Bit Block: ",bvRead.get_bitvector_in_hex())
        cipherText.write(bvRead.get_bitvector_in_hex())
    bv.close_file_object()
    cipherText.close()

def decrypt(cipherText,keyStr,plainText):
    #break the plainText in 64 bit blocks
    cipherText = open(cipherText.strip(),'r')
    data = cipherText.read()
    bv = BitVector(hexstring = data)
```

```
    cipherText.close()
    keyfp = open(keyStr,'r')
    plainText = open(plainText,'wb')
    key = getEncryptionKey(keyfp)
    roundKeys = extractRoundKeys( key )
    keyfp.close()
    j = 0
    k = 64
    #round key reverse
    roundKeys.reverse()
    while(k <= bv.length()):
        bvRead = bv[j:k]
        j = j + 64
        k = k + 64
        #print(bv_read)
        if(bvRead.length() != 64):
            #pad with zeros
            bvRead.pad_from_left(64 - bvRead.length())
        #break 64 bit vector into two 32 bit vectors and perform expansion permutation on r
        if bvRead.length() > 0:
            #16 rounds
            [leftHalf, rightHalf] = bvRead.divide_into_two()
            for i in range(16):
                originalRH = rightHalf # needed for the next left half
                #expand rightHalf to 48 bit
                newRH = rightHalf.permute(expansionPermutation)
                #XOR newRH with the roundkey to get new 48 bit
                outXor = newRH ^ roundKeys[i]
                #substitution with 8 s-boxes to get new 32 bit
                sBoxesOutput = substitute(outXor)
                #permutation with pBox
                rightHalf = sBoxesOutput.permute(pBoxPermutation)
                newRH = rightHalf ^ leftHalf
                newLH = originalRH # need og RH
                #swap to create the bitvector for the next round
                #reset bv to all zeros just to be safe
                bvRead.reset(0)
                leftHalf = newLH
                rightHalf = newRH
        #write the decrypted text to the decrypted file
        bvRead = rightHalf + leftHalf
        bvRead.write_to_file(plainText)
```

The code for the first problem depends on two functions(encrypt and decrypt) both of which are essentially the same function when it comes to the encryption logic due to the way a block cipher works. The encrypt functions takes three parameters,which are the file paths of the plainText,the key,and the soon to be created cipherText. To get the encryption key I resued the function that was provided in the example, similarly for the roundkey I resued the code provided. The plainText is converted to a bitvector and looped through in blocks of 64 bits(due to DES requirements). If the block that is read in doesnt have 64 bits the it is padded with zeros(left aligned to not increase the binary value) to make ita 64 bit block. After which the 64 bit block is divided into two halfs. Following which the round function is performed 16 times on the two halves. In the round function I reuse most of the provided code such as the expansion permutation, Sboxes the only new thing was creating the PBoxpermutation. At the end of a round the lefthalf and righthalf of the block is updated with newLH(which is the original righthalf) and the lefthalf is updated by newRH(which is the 32 bit xor result with orginal lefthalf and the output from the sboxes permutation). After the 16 rounds the right and left halves are swapped to create the correct encrypted block, which is then written to the cipherText.

The decryption is very simlar with the main difference being the roundkeys are used in reserve order and the way the cipherText is parsed is different than before. Since the cipherText is a hexstring I used array slicing to break the bitvector into 64 bit blocks. Everything else is the same as encrypt(). Also I wrote comments in the provided code to explain DES step by step.

4. Problem 2: Encrypted Image



5. Explanation of the Code

```
def encrypt(image,keyStr,image_enc):
    #break the image in 64 bit blocks
    bv = BitVector(filename=image)
    keyfp = open(keyStr,'r')
    image_enc = open(image_enc,'wb')
    #copy the header over to image_enc from imagefile
    idx = 0
    print("value of idx", idx)
    while(idx < 3):
        bvRead = bv.read_bits_from_file(8)
        #bvRead.get_bitvector_in_ascii()
        print(bvRead.get_bitvector_in_ascii())
        if(bvRead.get_bitvector_in_ascii() == '\n'):
            idx = idx + 1
        bvRead.write_to_file(image_enc)

    key = getEncryptionKey(keyfp)
    keyfp.close()
    print("value of idx", idx)
    roundKeys = extractRoundKeys( key )

    while (bv.more_to_read):
```

```
        bvRead = bv.read_bits_from_file( 64 )

        if(bvRead.length() != 64):
            #pad with zeros
            bvRead.pad_from_left(64 - bvRead.length())
        #break 64 bit vector into two 32 bit vectors and perform expansion permutation on r
        if bvRead.length() > 0: #bv.getsize() throws error for some reason
            #16 rounds
            #bvHex = bvRead.get_bitvector_in_hex()
            #print("First 64 bit block before round 1:",bvHex)
            [leftHalf, rightHalf] = bvRead.divide_into_two()
            for i in range(16):
                originalRH = rightHalf # needed for the next left half
                #expand rightHalf to 48 bit
                newRH = rightHalf.permute(expansionPermutation)
                #XOR newRH with the roundkey to get new 48 bit
                outXor = newRH ^ roundKeys[i]
                #substitution with 8 s-boxes to get new 32 bit
                sBoxesOutput = substitute(outXor)
                #permutation with pBox
                rightHalf = sBoxesOutput.permute(pBoxPermutation)
                newRH = rightHalf ^ leftHalf
                newLH = originalRH # need og RH
                #swap to create the bitvector for the next round
                #reset bv to all zeros just to be safe
                bvRead.reset(0)
                leftHalf = newLH
                rightHalf = newRH
                #bvRead = newLH + newRH
                #bvHex = bvRead.get_bitvector_in_hex()
                #print("First 64 bit block after round 1:",bvHex)
        #write the 64 encrypted block to the image_enc file
        #[leftHalf, rightHalf] = bvRead.divide_into_two()
        bvRead = rightHalf + leftHalf
        #print("64 Bit Block: ",bvRead.get_bitvector_in_hex())
        bvRead.write_to_file(image_enc)
    bv.close_file_object()
    image_enc.close()
```

The code used to encrypted the image is very similar to the code in problem 1. The main difference is that a ppm file has a header that doesnt need to be encrypted so I read the image file until I found three new line characters. At the same time I rewrote the header in the output file. Following which the remainder of the bitvector(the input image was converted to a bitvector) was read and the DES algorithm was performed on it.Every 64 bit block was encrypted and written to the output file after the header.