INFSCI 1600 Security and Privacy

Fall Semester 2021

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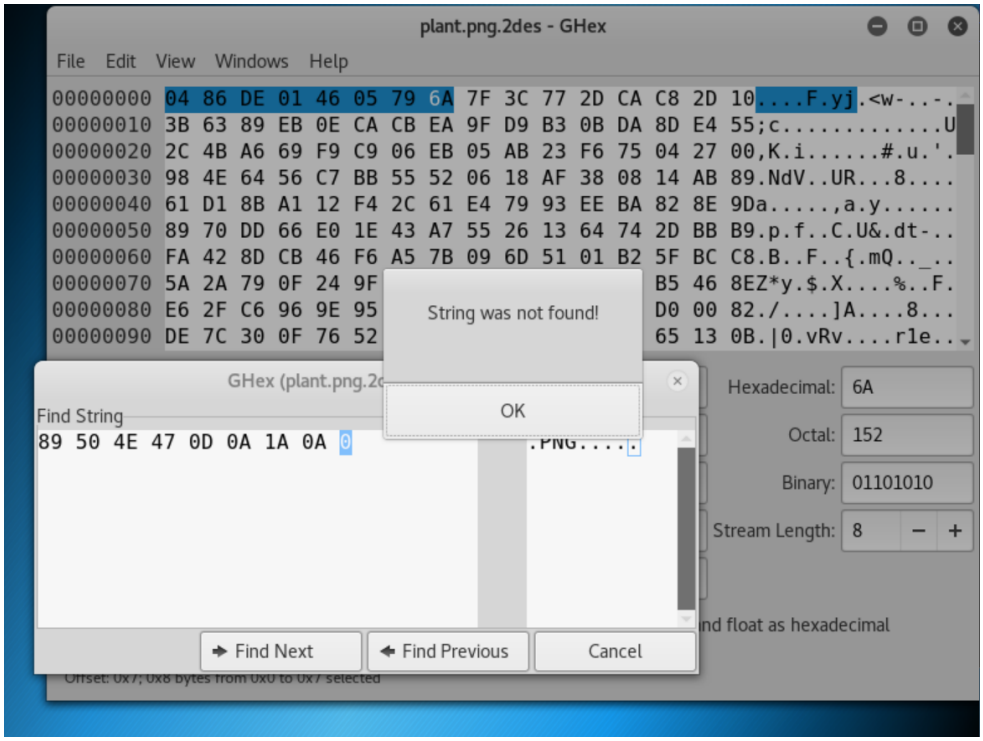
Project 2 - 2DES Meet-in-the-Middle Attack

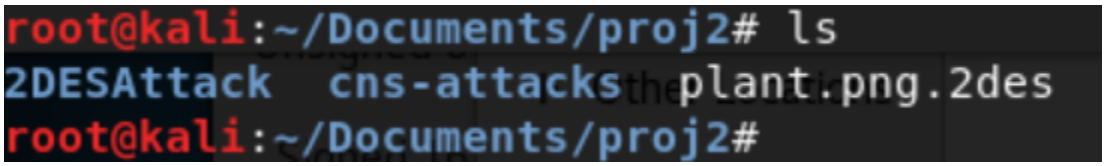
The first step that I did was look at my notes on what I have on project 2. The next step was to download the 2DES png file using file.io to transfer the png file from my host machine to my VM. I then looked up the PNG file signature which turned out to be “89 50 4E 47 0D 0A 1A 0A” and I tried to look for that same hex onto the encrypted PNG file using GHex in figure 1.

(Figure 1: Ghex)



I knew that I would not find it because it was encrypted using 2DES, so the next step was to find out what more information I needed. I wanted to learn more about 2DES and meet-in-the-middle attacks so I googled file signatures, looked at class notes, and websites on what it is I'm doing. I installed a variety of code and then deleted it because I had no idea what it needed and what it wanted me to input. For example, I downloaded a cns-attack on github as shown in figure 2 and 3. The source code here was in another language so I decided to translate it and continue with that code.

(Figure 2)

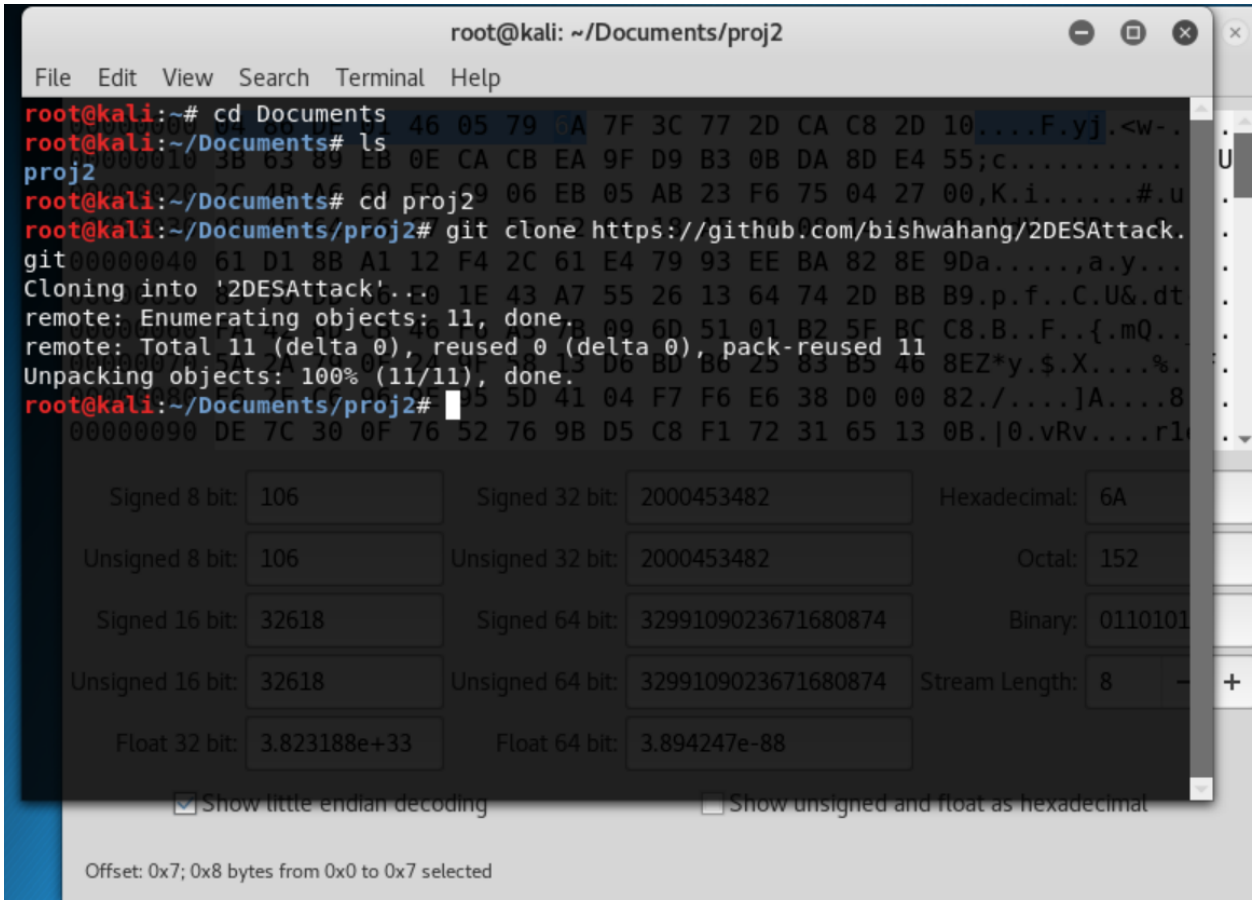


(Figure 3)

```
def main():

    # Exercitiu pentru test des2_enc
    key1 = 'Smerenie'
    key2 = 'Dragoste'
    m1_given = 'Fericiti cei saraci cu duhul, ca'
    c1 = 'cda98e4b247612e5b088a803b4277710f106beccf3d020ffcc577ddd889e2f32'
    # ++> done, TODO: implement des2_enc and des2_dec
    m1 = des2_dec(key1, key2, c1.decode('hex'))

    print 'ciphertext: ' + c1
    print 'plaintext: ' + m1
    print 'plaintext in hexa: ' + m1.encode('hex')
    print 'ciphertext: ' + des2_enc(key1, key2, m1).encode('hex')

    # TODO: run meet-in-the-middle attack for the following plaintext/ciphertext
    m1 = 'Pocainta'
    c1 = '9f98dbd6fe5f785d' # in hex string
    m2 = 'Iertarea'
    c2 = '6e266642ef3069c2'
```

I began to think that this did not work because of the necessary inputs that it required so I went ahead and found another repository that I could understand. I stumbled on a github repository as shown in figure 4 and downloaded it onto my VM.

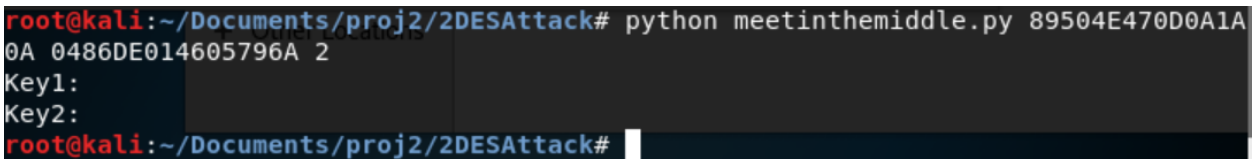
(Figure 4: Github repository)



https://github.com/bishwahang/2DESAttack

At this point I am stuck because when I tried to run the program using the hex signature of both the PNG file and the encrypted file with a key size of 2, it gives me a wrong output. It is shown in figure 5. The reason that I put 2 for the key size length is because it was given to us on one of the lecture slides.

(Figure 5)



After that attempt, I tried to convert those hex signatures into plaintext and then tried it again. I then noticed that if you were to put it into plaintext, the ciphertext would come up encrypted so

that did not make sense. From here, I decided to look at the source code and determine where that display is. I found out that the keys were left blank intentionally and that the code was supposed to find those keys and display it. I had googled what an IV is during a 2DES encryption and to see what it was all about. I found out that it is needed for encryption using a CBC or a cipher block chaining. I then looked at the video that was given to us about project 2 and noted that there are many solutions and that these solutions are created for general purposes. It was also said that we should look into how the code works. This is where I began my research into the source code. All of my input from before was in CBC mode, so I decided to switch it to ECB mode in figure 6. It also came up with nothin for the value of keys 1 and 2. I then went onto Piazza to ask a question about it and followed the instructions to include ".decode('hex')" within the python code as shown in figure 7.

(Figure 6: Change to ECB)

```
#the function handed to us to get the decryption done
def twodes(plain, keyOne, keyTwo):
    cipherOne = des(binascii.unhexlify(keyOne), ECB, "5edcc504", pad=None)
    cipherTwo = des(binascii.unhexlify(keyTwo), ECB, "5edcc504", pad=None)
    return cipherTwo.encrypt(cipherOne.encrypt(plain))
```

(Figure 7: Added ".decode('hex')")

```
# The following is your plaintext/ciphertext pair. We read it from
# stdin:
plaintext = sys.argv[1].decode("hex")
ciphertext = sys.argv[2]
```

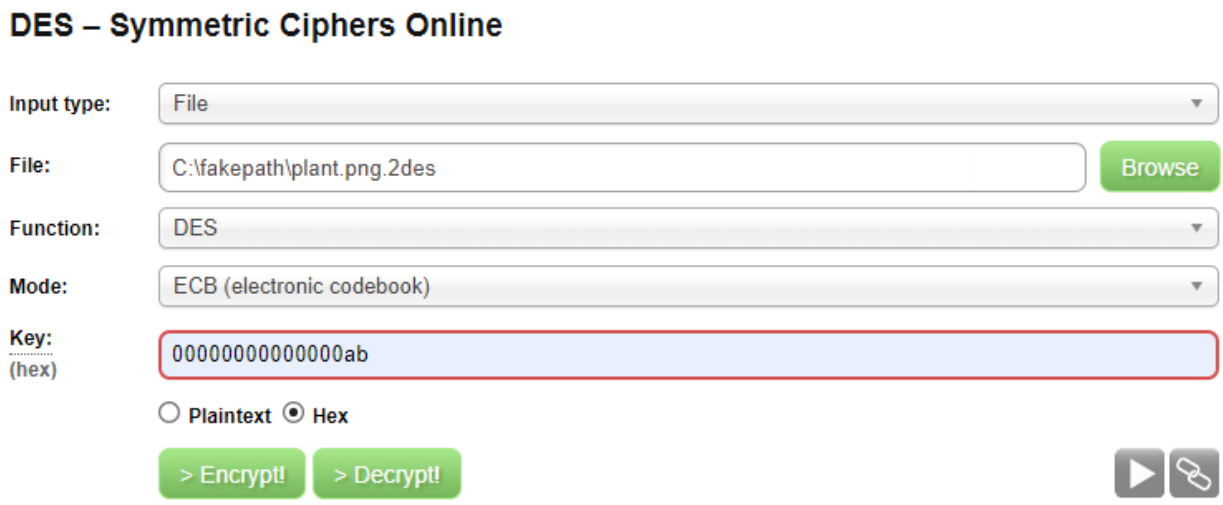
It then gave me an output of both keys in figure 8. Key 1 is 00000000000000ab and Key 2 is 0000000000000012.

(Figure 8: Key 1 and Key 2)

```
root@kali:~/Documents/proj2/2DESAttack# python meetinthemiddle.py 89504e470d0a1a
0a 0486de014605796a 2
Key1:00000000000000ab
Key2:0000000000000012
root@kali:~/Documents/proj2/2DESAttack#
```

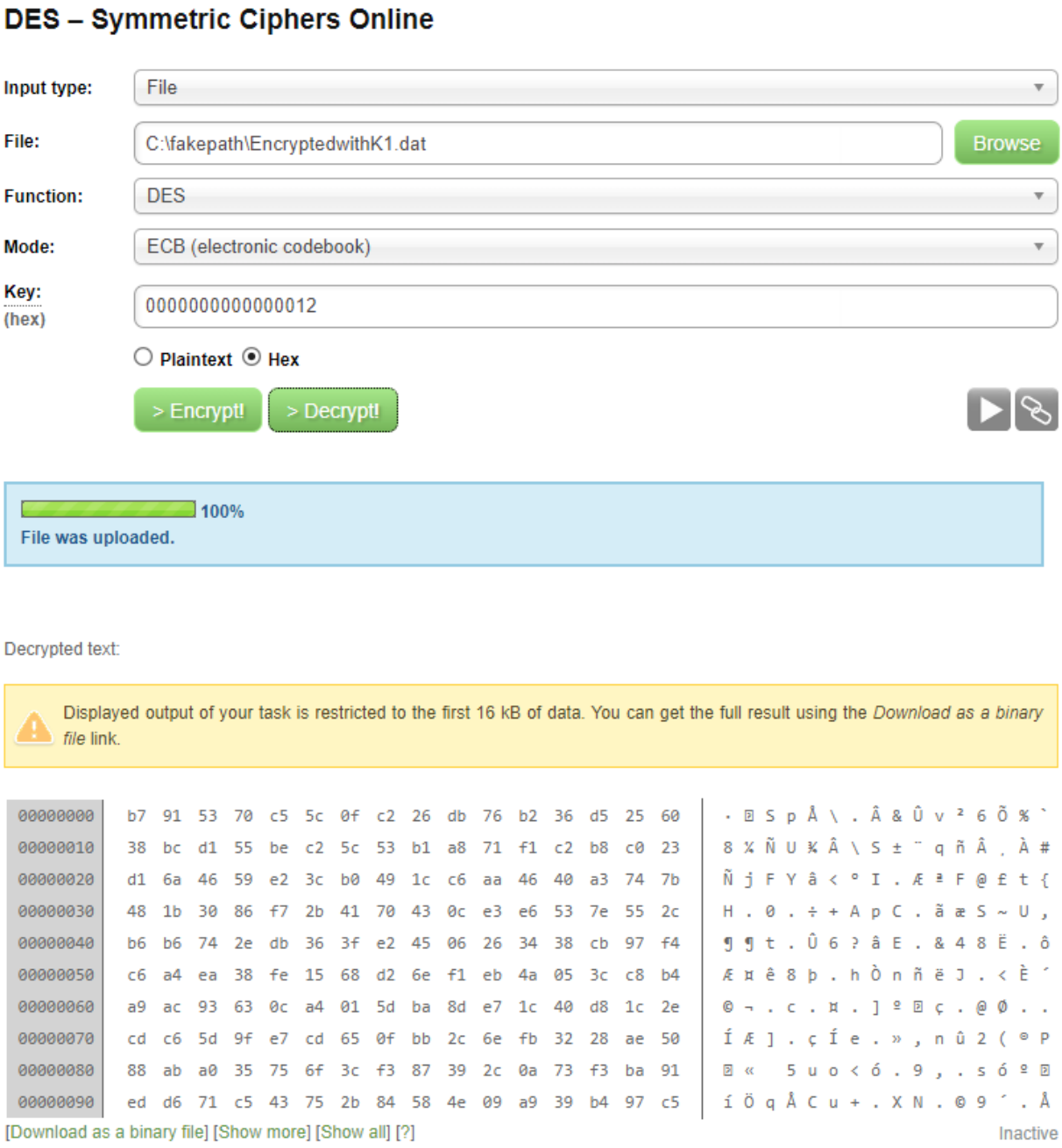
Next step was to figure out what to do with the keys. Now that I got the two keys, next was to decrypt the encrypted png file. I googled a website to find a free decryption tool to use those keys and stumbled upon des.online-domain-tools.com. In the boxes, I inputted the encrypted file and along with the first key because of how 2DES works (figure 9). At first, I inputted the keys as a plaintext and it gave me an error that the plaintext length should be between 1-8 bits long and then I decided to change it to hex because I had used hex code to get those keys.

(Figure 9: des-online-domain-tools.com)



After the first key was used, next up is to decrypt the most recent file that I had gotten from the website. We save that binary file output, in this case I saved it under the name of "EncryptedwithK1" shown in figure 10, and apply key 2 to that file.

(Figure 10: Decrypt with Key 2)



DES – Symmetric Ciphers Online

Input type: File

File: C:\fakepath\EncryptedwithK1.dat Browse

Function: DES

Mode: ECB (electronic codebook)

Key: (hex) 0000000000000012

Plaintext Hex

> Encrypt! > Decrypt!

100%

File was uploaded.

Decrypted text:

Displayed output of your task is restricted to the first 16 kB of data. You can get the full result using the *Download as a binary file* link.

00000000	b7	91	53	70	c5	5c	0f	c2	26	db	76	b2	36	d5	25	60
00000010	38	bc	d1	55	be	c2	5c	53	b1	a8	71	f1	c2	b8	c0	23
00000020	d1	6a	46	59	e2	3c	b0	49	1c	c6	aa	46	40	a3	74	7b
00000030	48	1b	30	86	f7	2b	41	70	43	0c	e3	e6	53	7e	55	2c
00000040	b6	b6	74	2e	db	36	3f	e2	45	06	26	34	38	cb	97	f4
00000050	c6	a4	ea	38	fe	15	68	d2	6e	f1	eb	4a	05	3c	c8	b4
00000060	a9	ac	93	63	0c	a4	01	5d	ba	8d	e7	1c	40	d8	1c	2e
00000070	cd	c6	5d	9f	e7	cd	65	0f	bb	2c	6e	fb	32	28	ae	50
00000080	88	ab	a0	35	75	6f	3c	f3	87	39	2c	0a	73	f3	ba	91
00000090	ed	d6	71	c5	43	75	2b	84	58	4e	09	a9	39	b4	97	c5

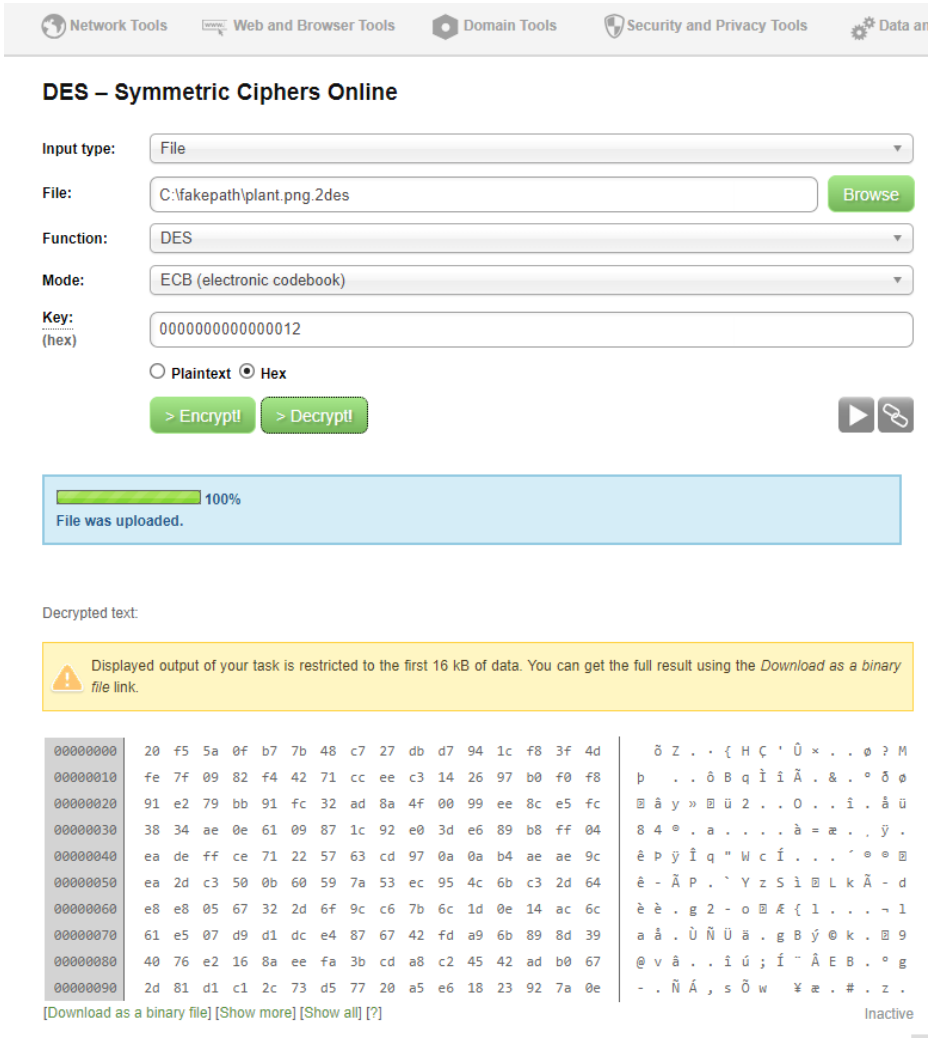
[Download as a binary file] [Show more] [Show all] [?]

Inactive

This again is where I got stuck. I spent some time decrypting the same file over and over again. I tried to find out where my problem was occurring. First, I tried to mess around with my input in the virtual machine. I replaced the lowercase letters in the code to uppercase and that output gave me nothing for the keys. I then went ahead and uninstalled and installed the same

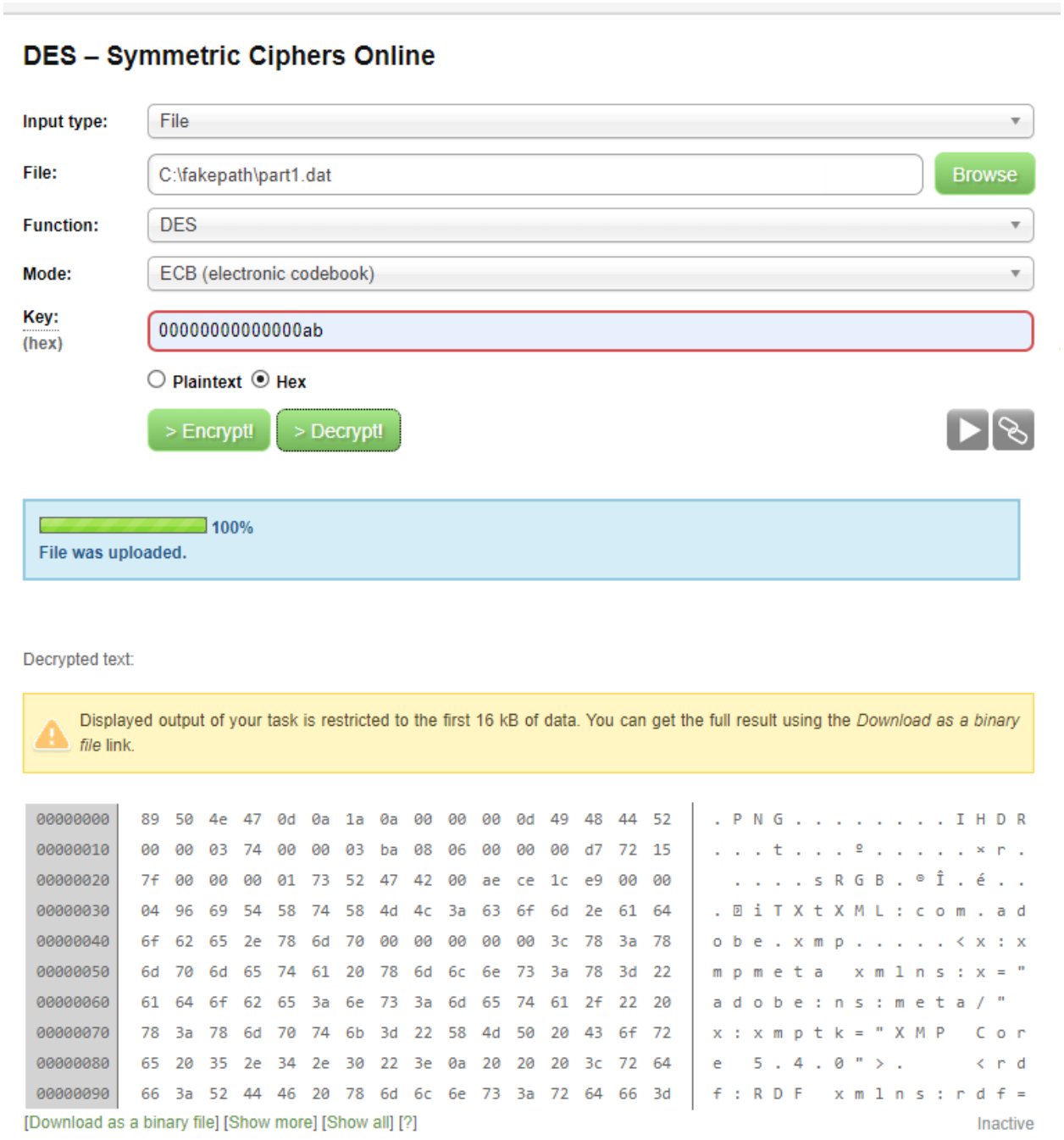
program again to make sure that I did not corrupt anything. When I downloaded the program again, I changed it again from CBC to ECB and added the decode("hex") function as well. I ran the program again and it outputted the same keys again. I then went to research why it was still encrypted. Then it all clicked while I was thinking. If the goal is to decrypt the encrypted file, why would I follow the steps to encrypt the file in the first place. The whole point is to go backwards with the given ciphertext and plaintext. So next, I went to the same online decryption tool but this time used the second key first instead of Key 1 because we are going backwards. Shown in figure 11, is what I inputted in for the boxes.

(Figure 11)



Next, I went ahead and downloaded the binary file of that output with Key 2 and took that binary file and decrypted it with Key 1 as shown in Figure 12.

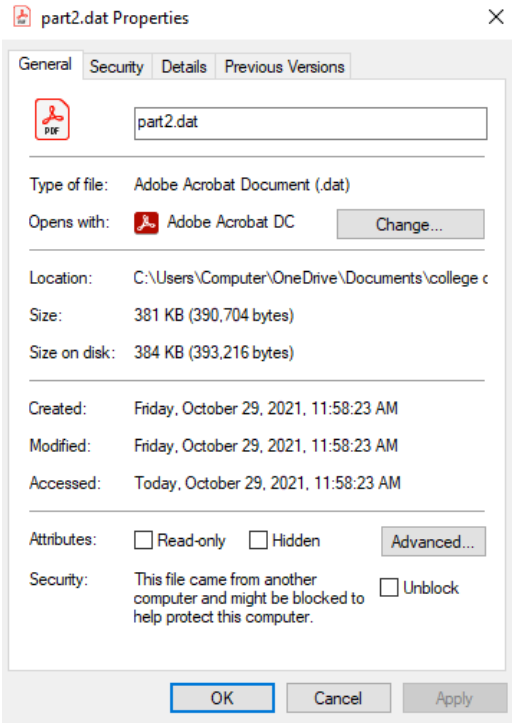
(Figure 12)



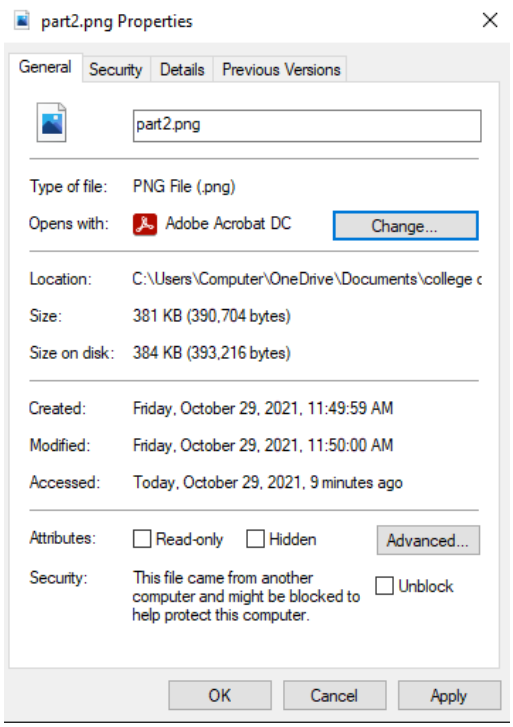
The output here is the decrypted file with both keys and I knew it was normal because of the hex signature of the png file. The PNG file signature matches that of the standard png file. Next step,

I downloaded that binary file and was trying to figure out how to make that png file open as a png file instead of a binary file. The properties on the left, figure 13, are the properties of the decrypted file before I changed it to be a png file. Figure 14 on the right is how I changed it to be a png file. To do that, I changed the file extension to ".png" instead of a ".dat" file and also changed the way the file opens to my default png viewer.

(Figure 13: Pre-changed file)

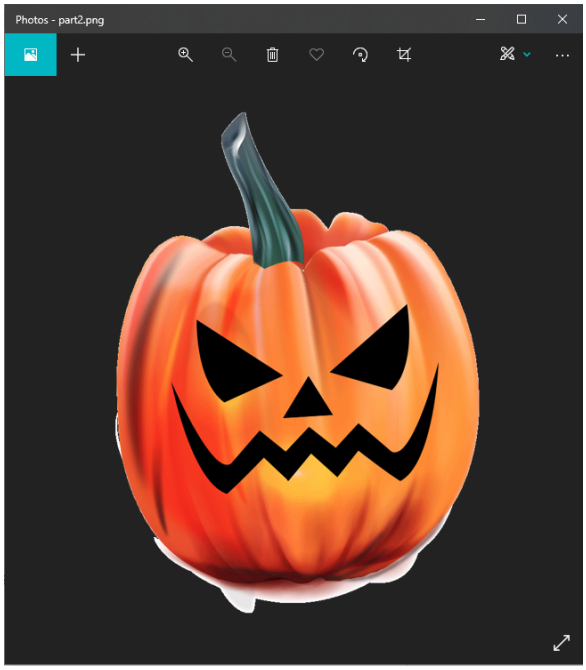


(Figure 14: PNG file)



The last and final step was to open the png file and determine what plant was it and as shown in figure 15, that the plant is a pumpkin.

(Figure 15: Decrypted PNG file)



The overall project took me a great amount of time and thinking. It took me a couple of days to understand what to do and how to do it. I posted a question on Piazza when I did not know what to do next. The process of encrypting and decrypting is what stumped me the most I believe. It took me some time to figure out what I needed to do instead of decrypting it with the first key and then decrypting it with the second key. What also took me some time was looking at the source code and determining what I should change. The source code really stumped me because I had to look at the difference between CBC and ECB, I then had to decide what I should input within the code to make it run. This project has to be one of the hardest projects that I have ever worked on. It required a lot of time to look and understand each part of the process but I'm glad that it finally worked.

Works Cited

https://www.youtube.com/watch?v=_U3dXrJawhg

https://github.com/bishwahang/2DESAttack/blob/ec0063733a6156bf32b45db1a3b287c4ee4d6fcc/meetinthemiddle.py#L102

https://en.wikipedia.org/wiki/Block_cipher_mode_of_operation

https://github.com/yzchen/cns-attacks/blob/master/03-2des-meet-in-the-middle-attack/2des-meet-in-the-middle-attack.py

https://github.com/thomwiggers/des-meet-in-the-middle