SECERET-KEY ENCRYPTION LAB

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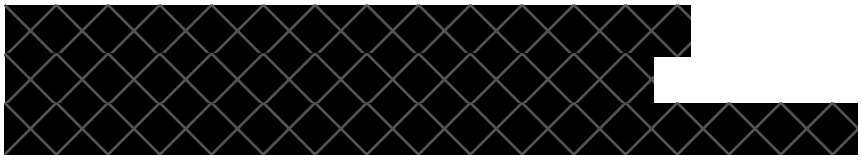
Lab 2
Secret Key Encryption



SECRET-KEY ENCRYPTION LAB

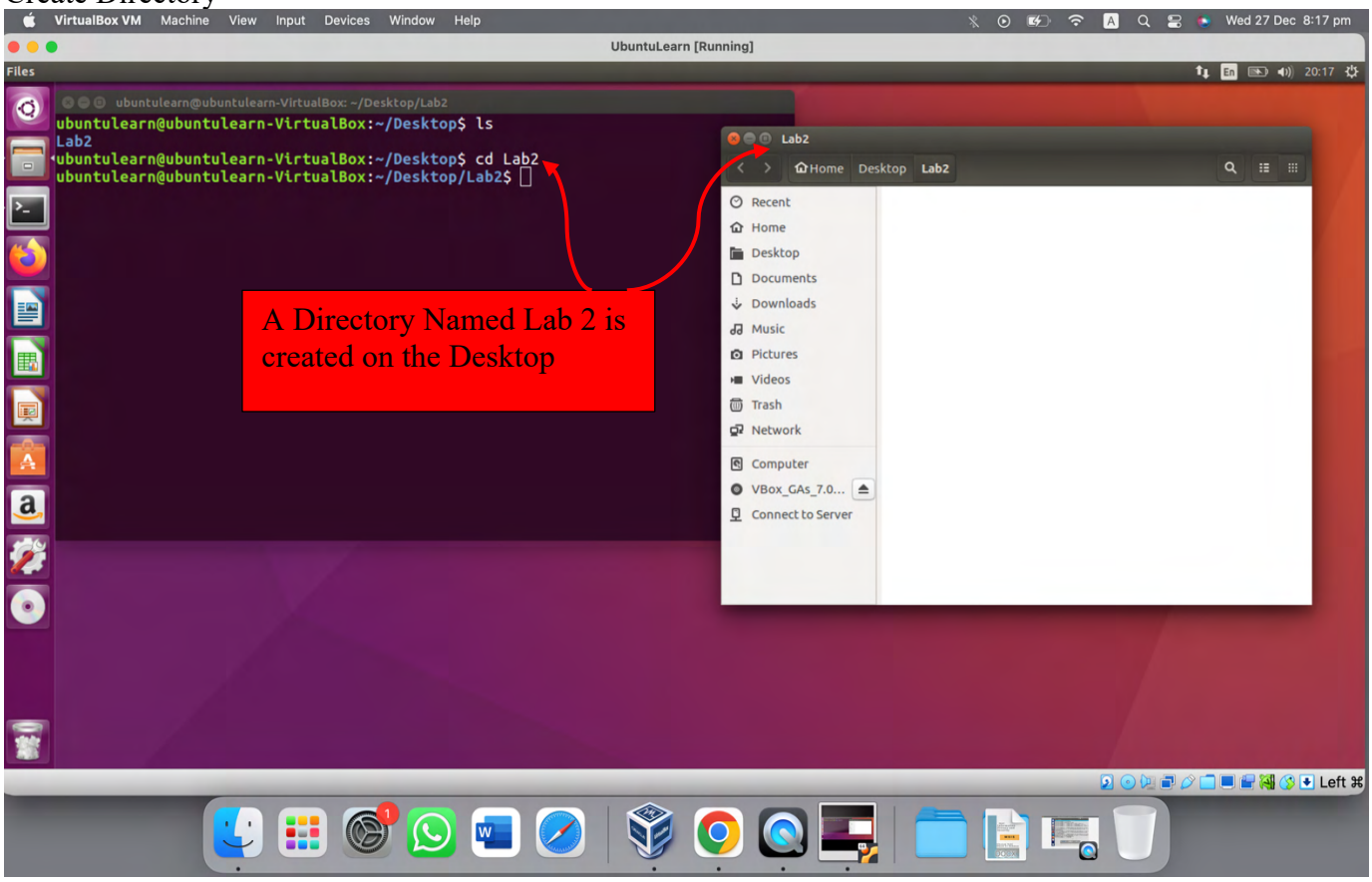
2.1. ENCRYPTION USING DIFFERENT CIPHERS AND MODES

i. AES 128 CBC Task 1

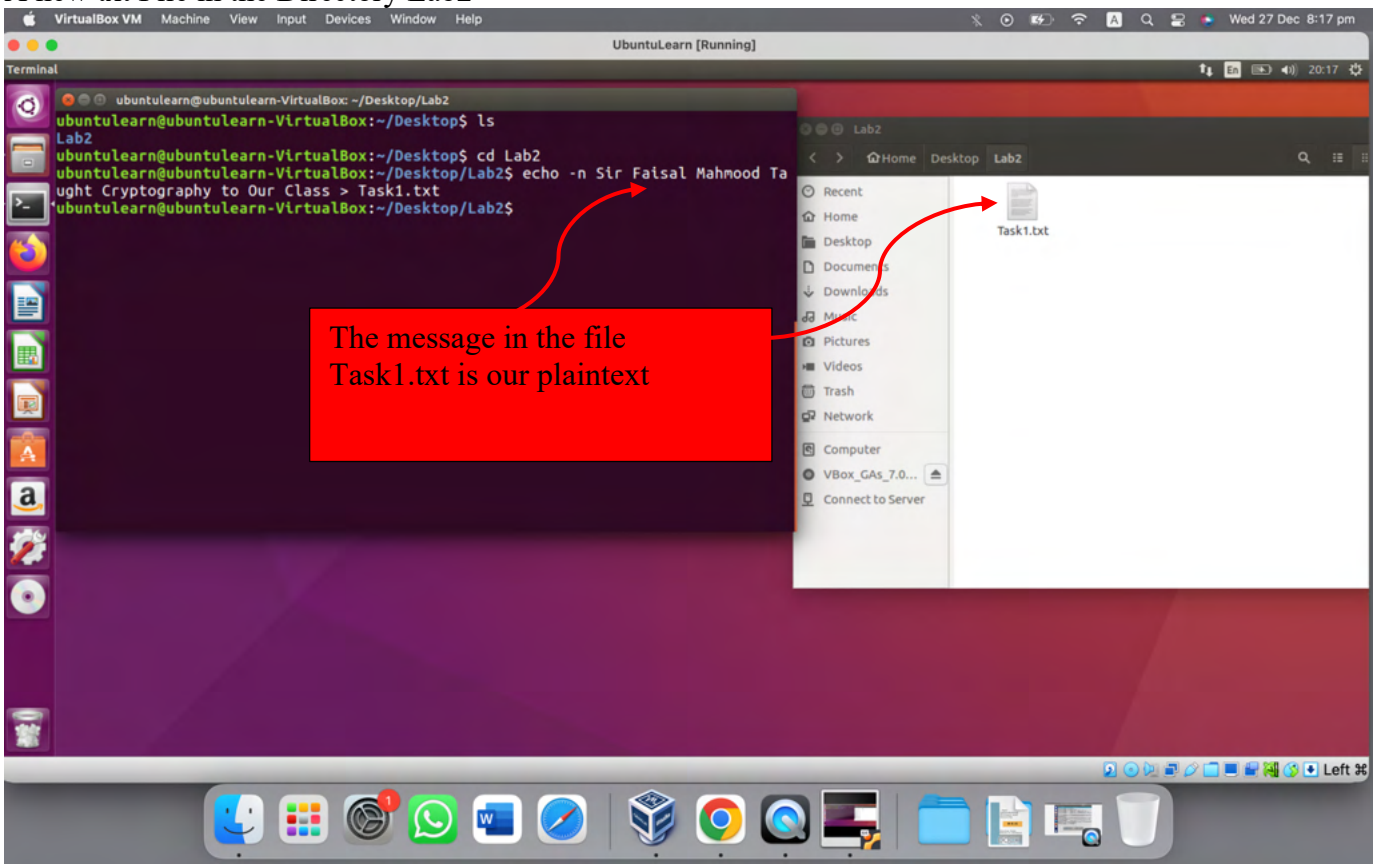
In this mode of encryption, AES Key of 128 bit (16 Bytes) and encryption mode of Cipher Block Channing has been used. They Key value used for the process is: 123a5678b012c456789f12d4567f9d12 and the initial vector (iv) is: 12e4567c12d45d78.

a. Encryption

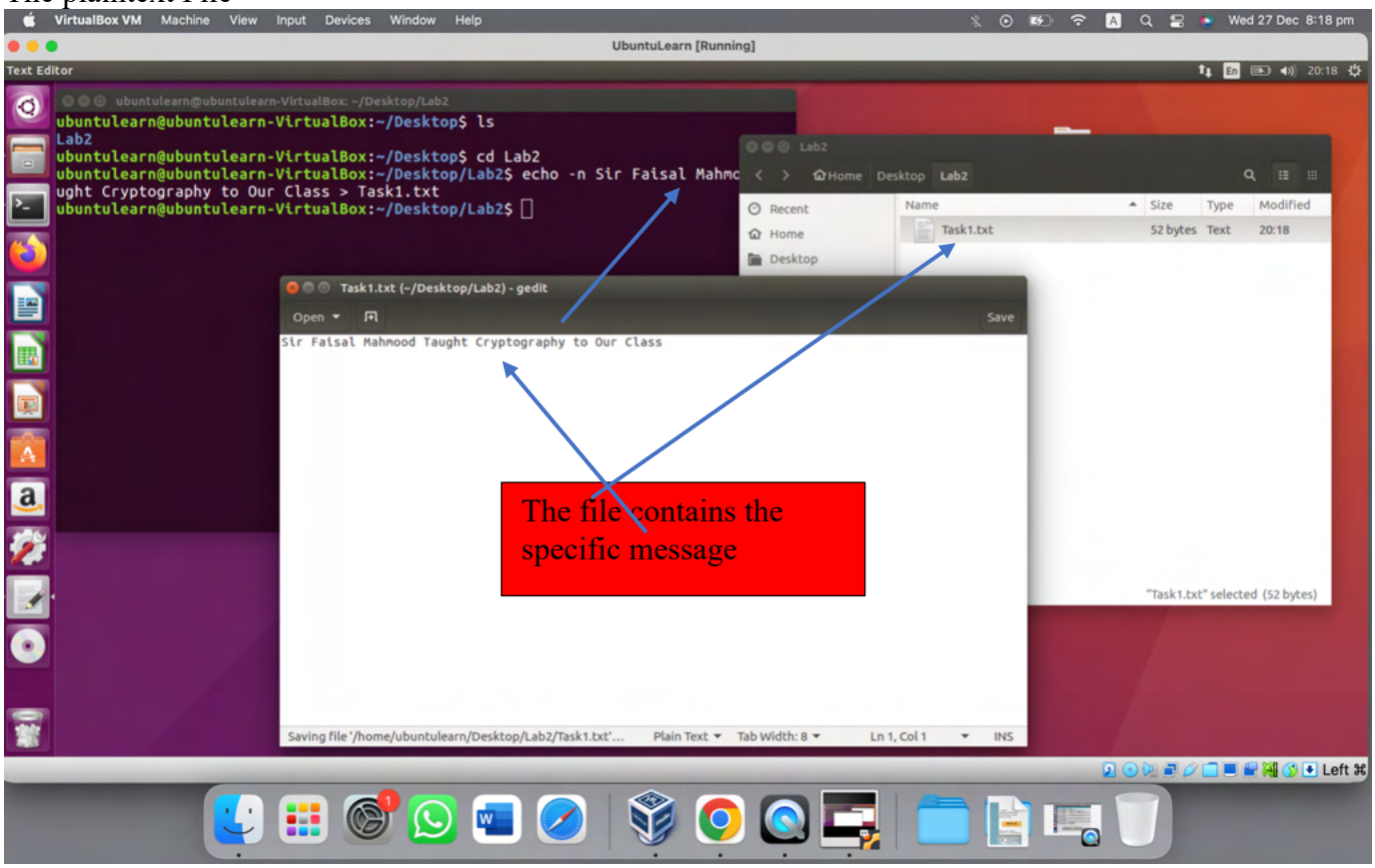
Create Directory



A new txt File in the Directory Lab2



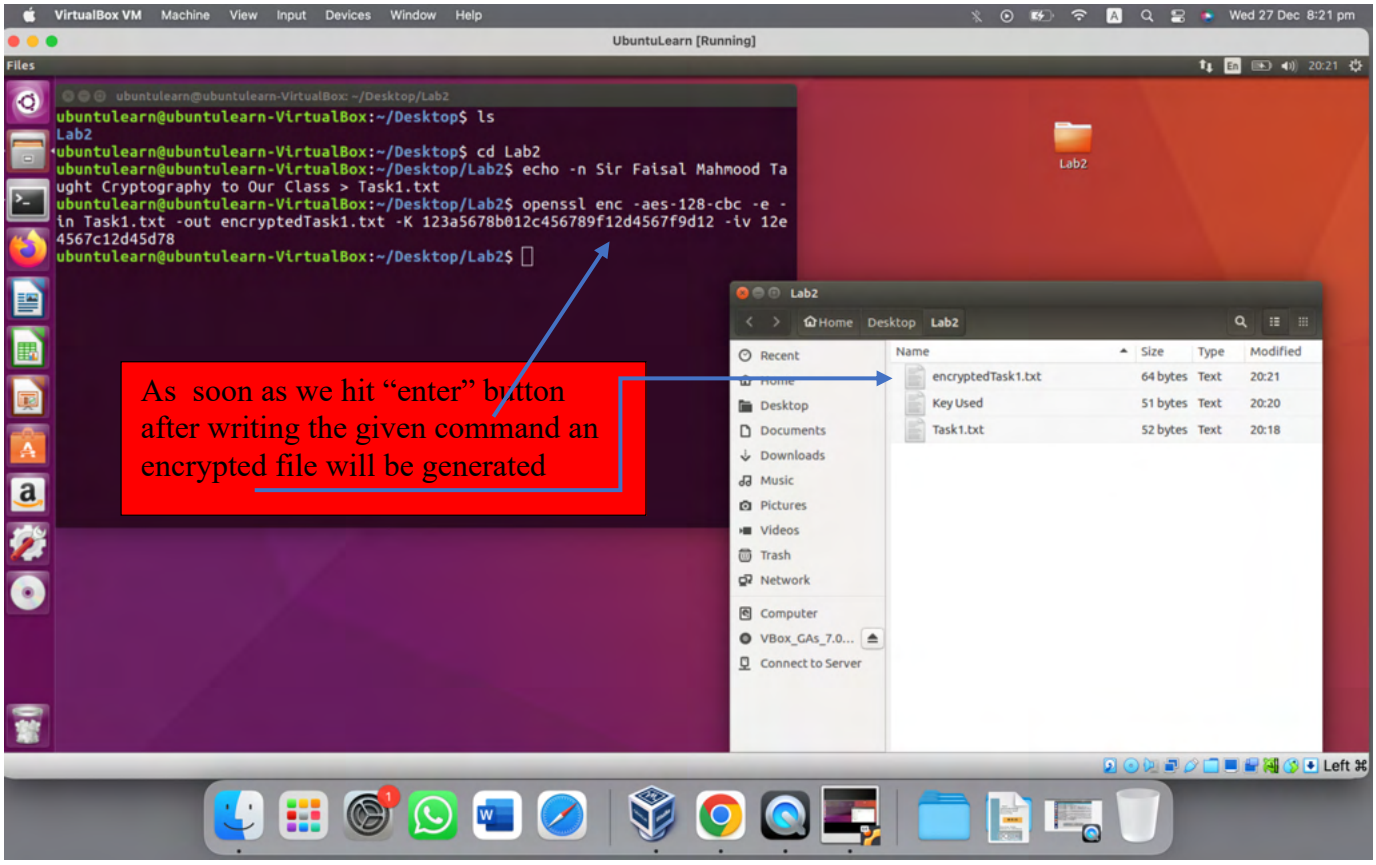
The plaintext File



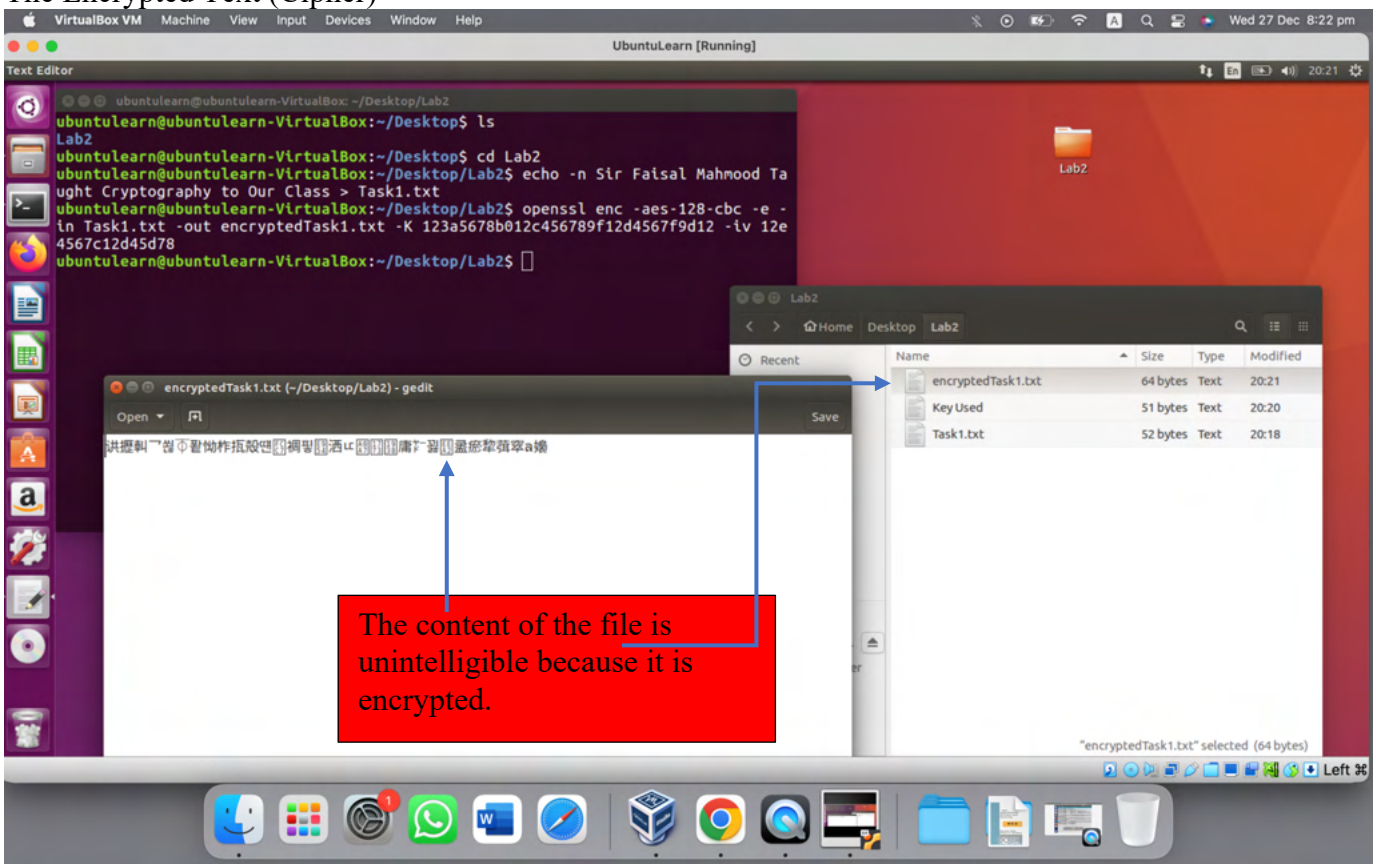
Command to Encrypt

Following command is used to encrypt in CBC mode

openssl enc -aes-128-cbc -e -in Task1.txt -out encryptedTask1.txt -K 123a5678b012c456789f12d4567f9d12 -iv 12e4567c12d45d78



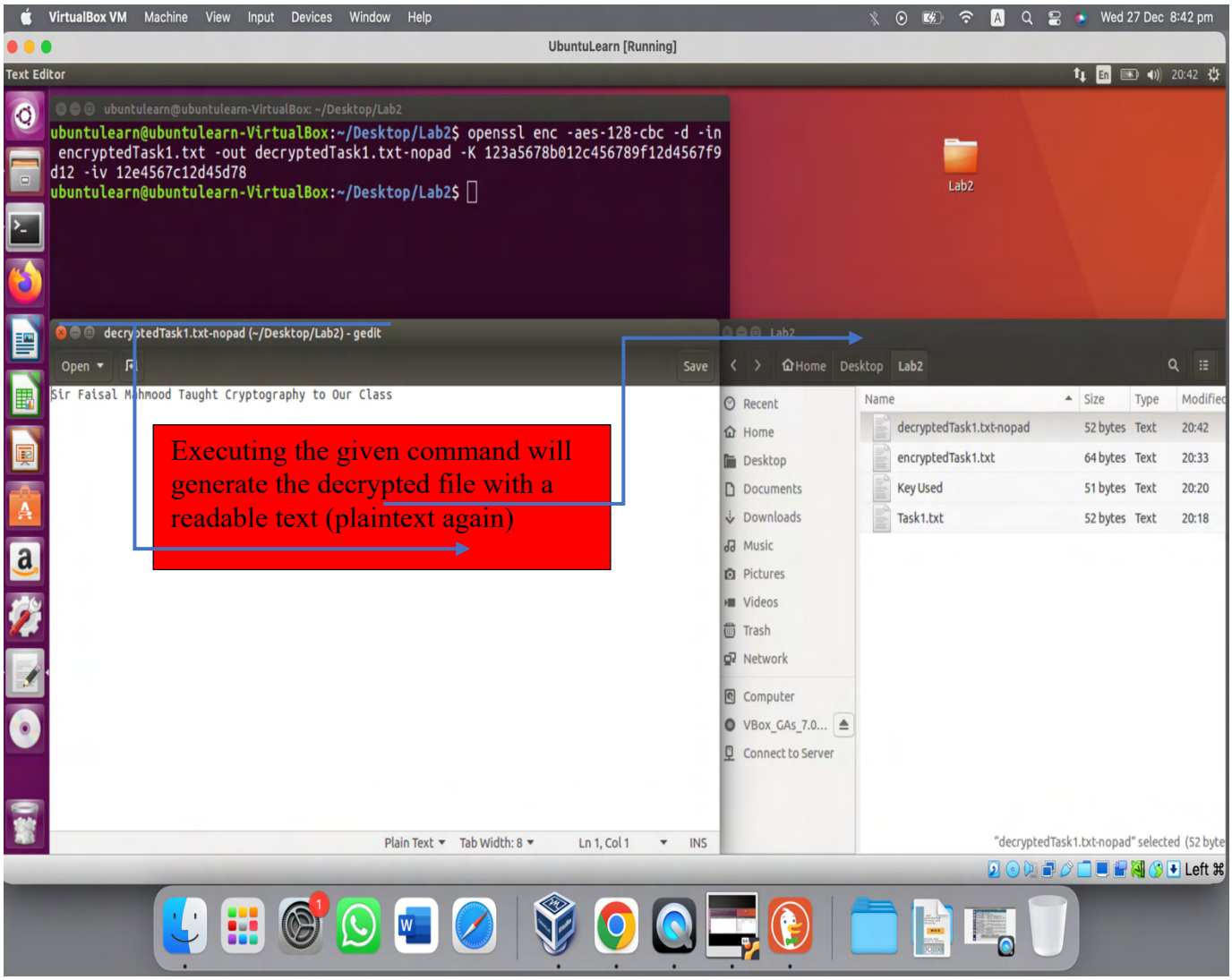
The Encrypted Text (Cipher)



a. Decryption

Following command is used to decrypt in CBC mode

openssl enc -aes-128-cbc -d -in encryptedTask1.txt -out decryptedTask1.txt -K 123a5678b012c456789f12d4567f9d12 -iv 12e4567c12d45d78



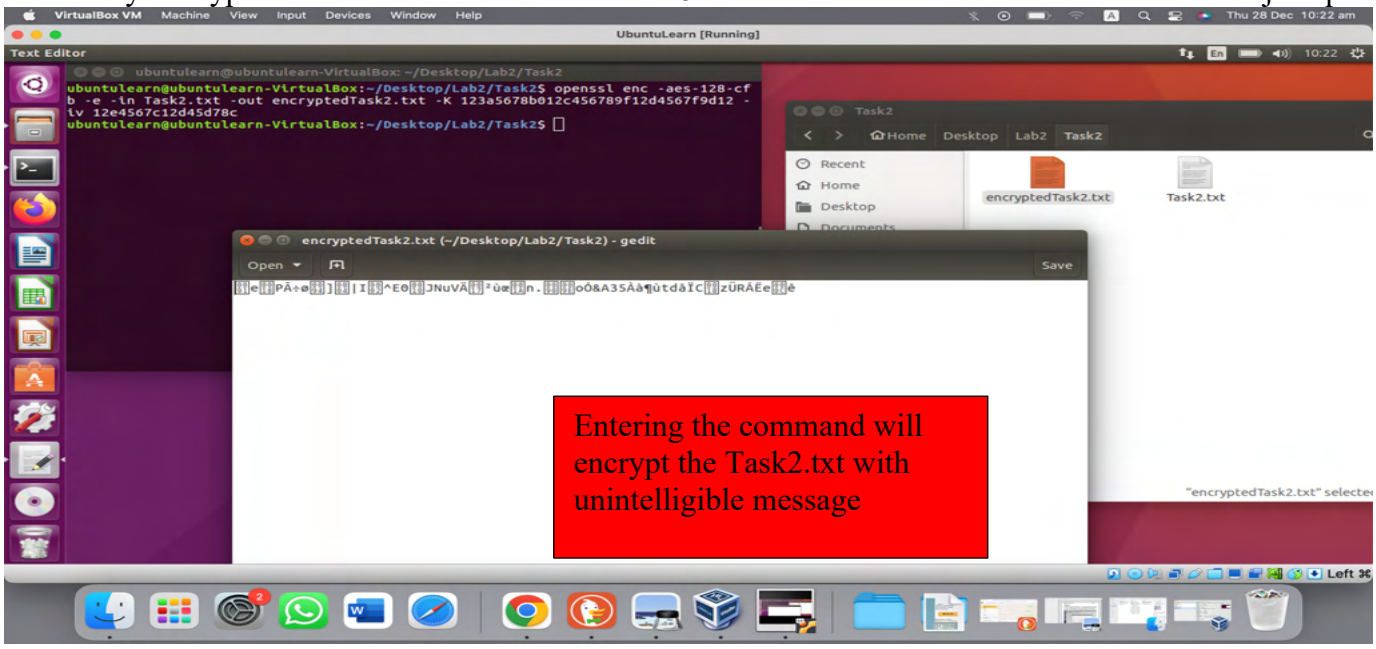
AES-128-CFB Task2

Encryption:

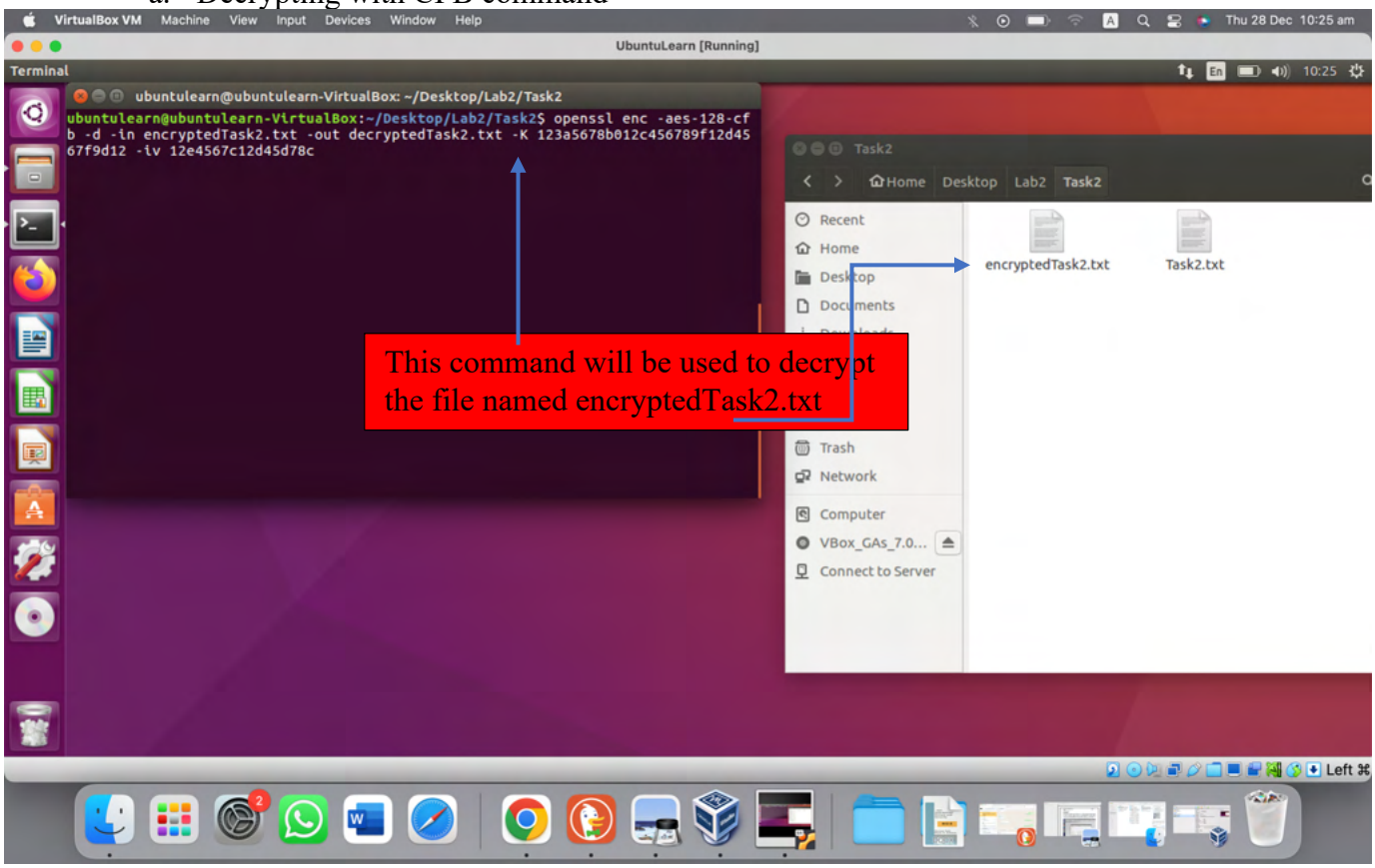
Here we will use Cipher type as AES, Key size = 128 bit (16 bytes), encryption mode as Cipher Feedback (CFB), which is a self-synchronizing stream cipher. Her key value used is 123a5678b012c456789f12d4567f9d12 and initialization vector used is 12e4567c12d45d78. A file Task2.txt with a plaintext will be created in the directory and on running the command for CFB mode we will get the cipher taxt.

Encrypting with CFB command

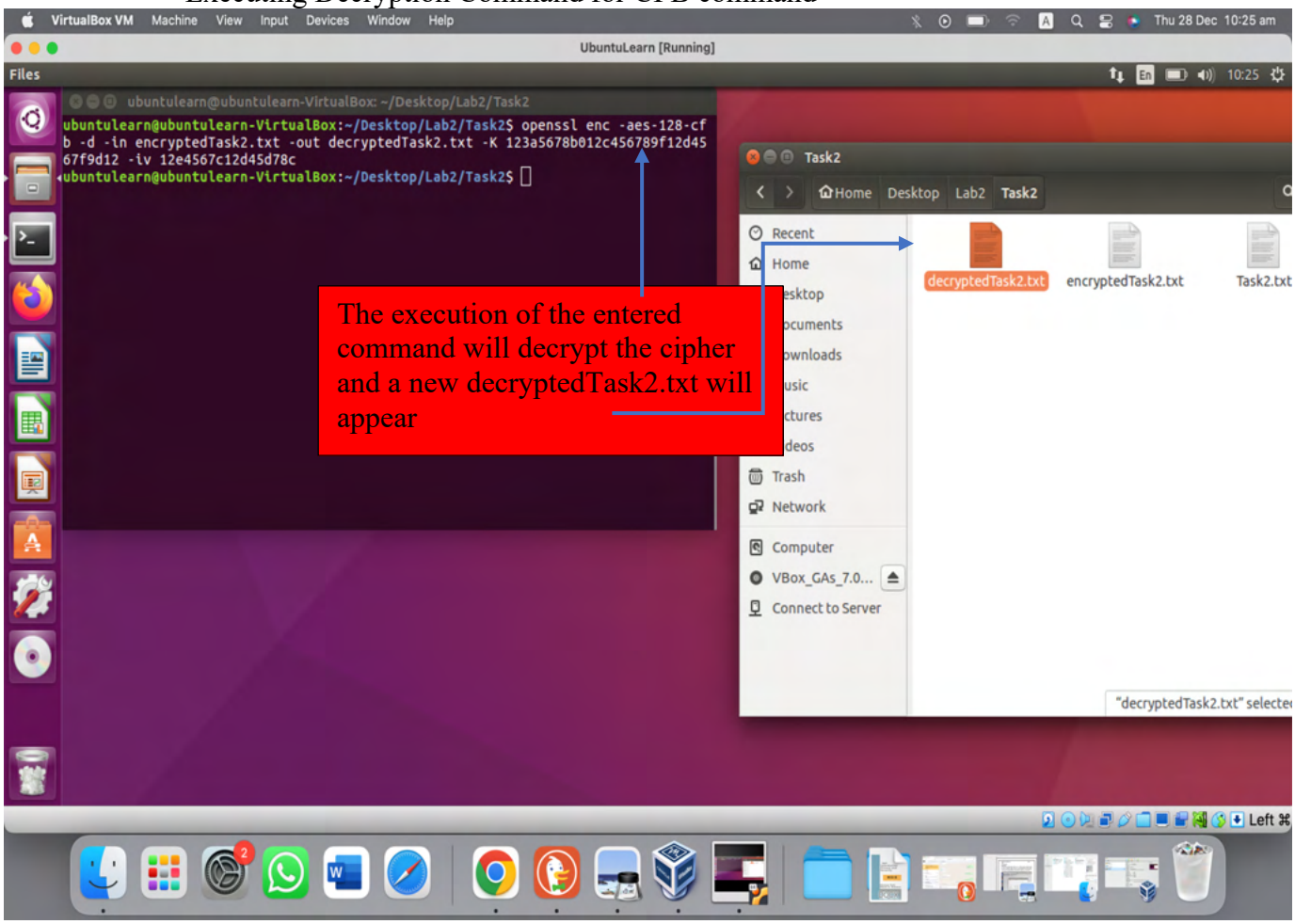
openssl enc -aes-128-cfb -e -in encryptedTask2.txt -out decryptedTask2.txt -K 123a5678b012c456789f12d4567f9d12 -iv 12e4567c12d45d78c



a. Decrypting with CFB command



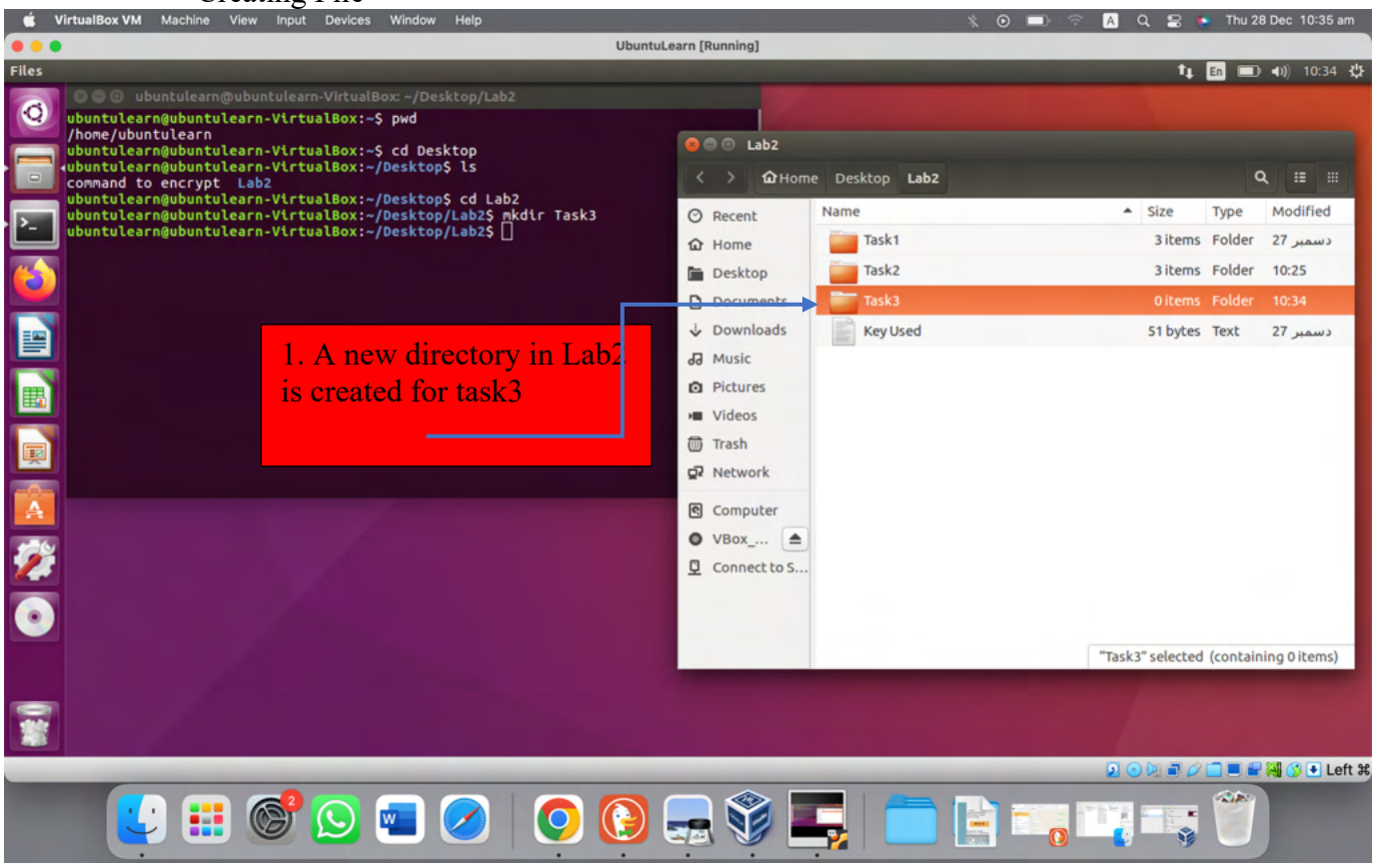
Executing Decryption Command for CFB command

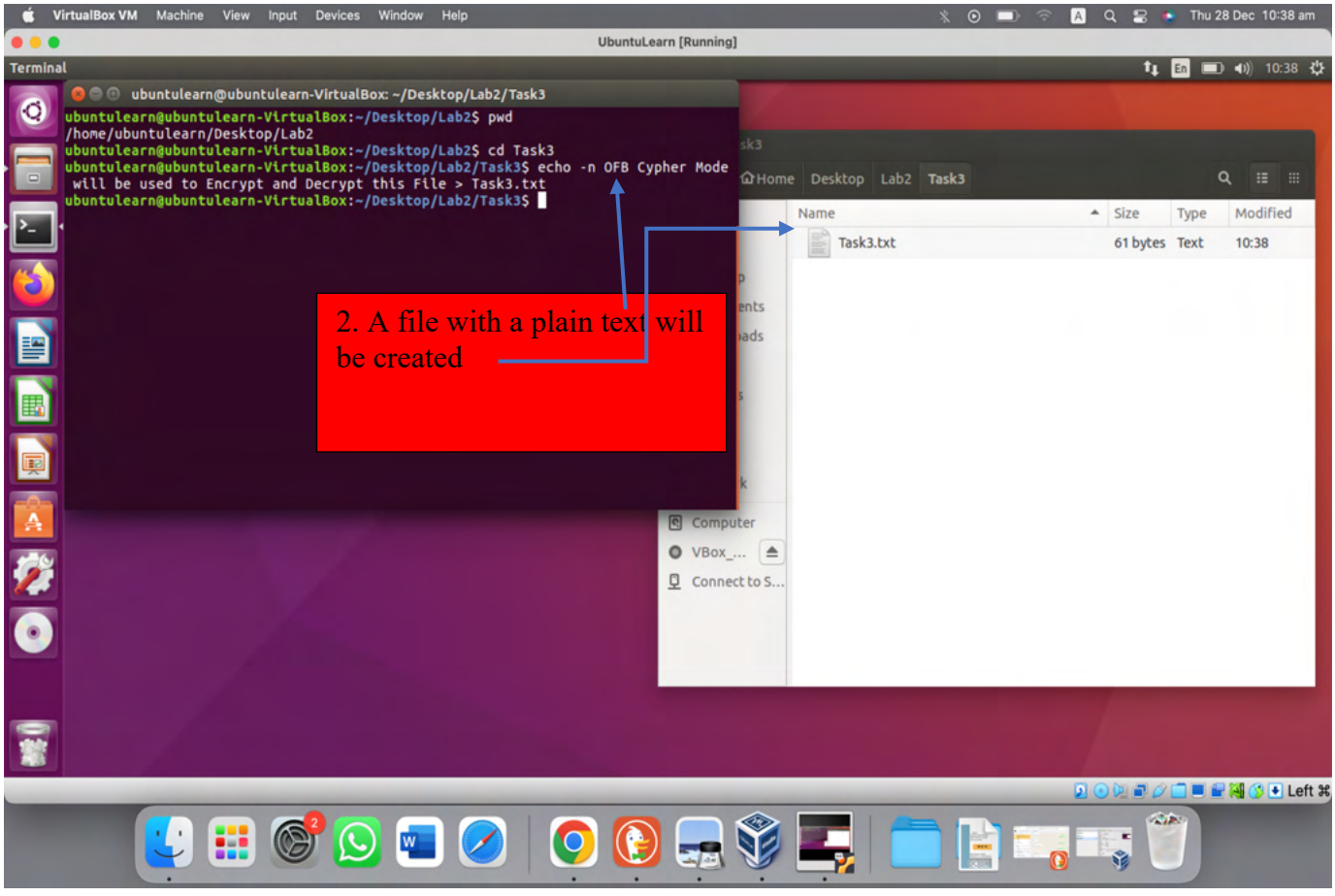


ii. AES-128-OFB Task3

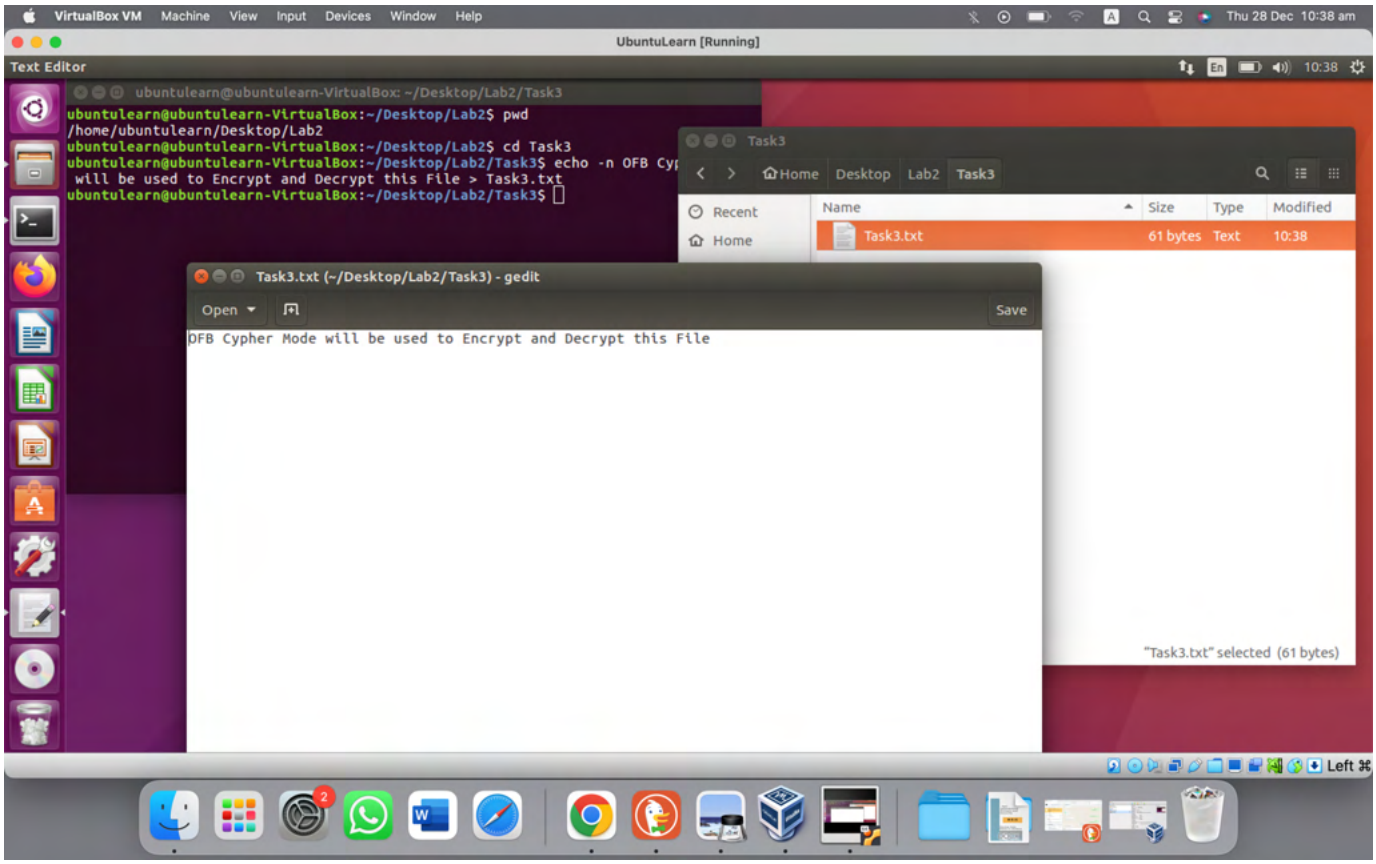
a. Encryption

Creating File



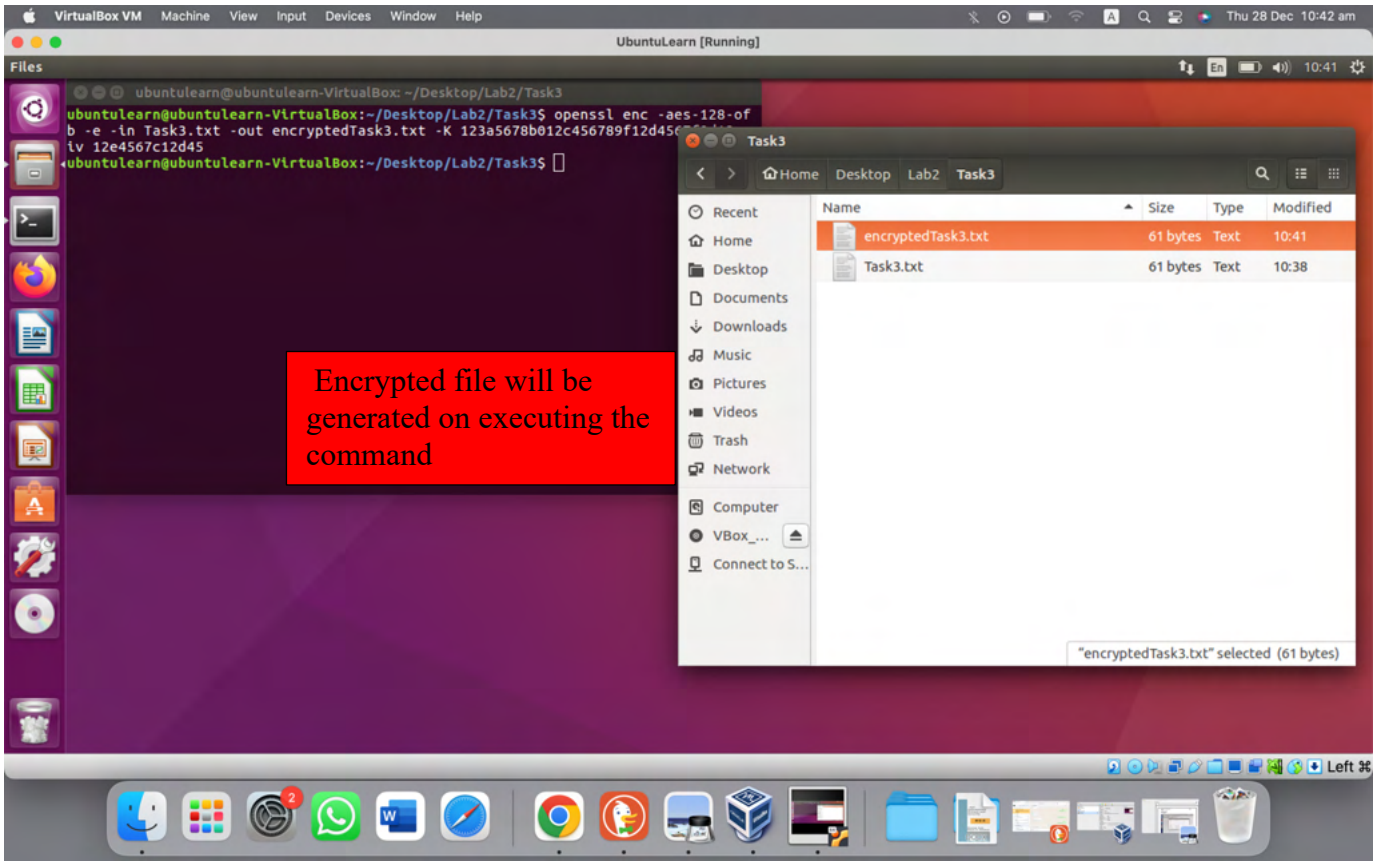


The Plaintext in the .txt File



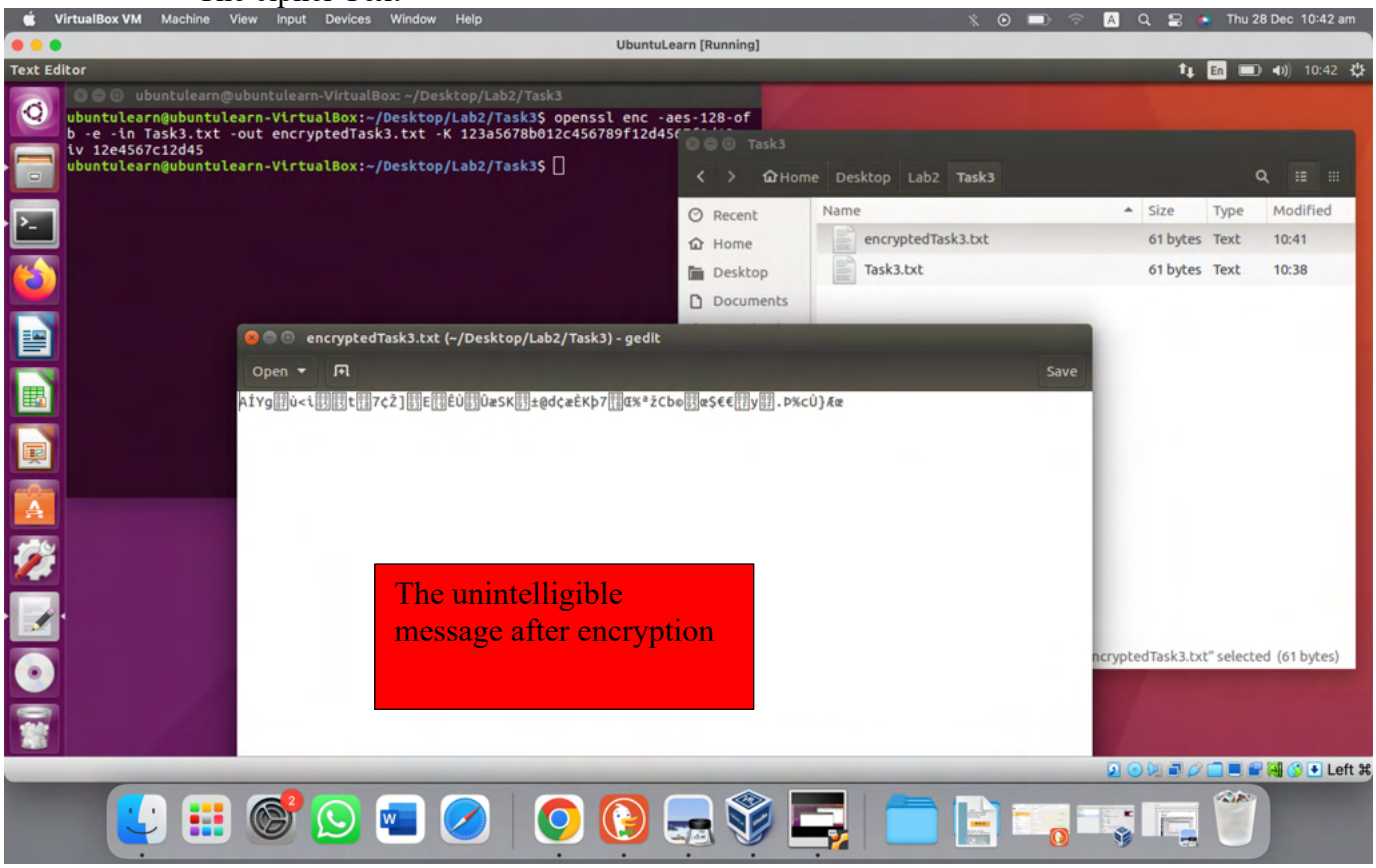
Encrypting the Plaintext

openssl enc -aes-128-cbc -e -in Task3.txt -out encryptedTask3.txt -K 123a5678b012c456789f12d4567f9d12 -iv 12e4567c12d45d78

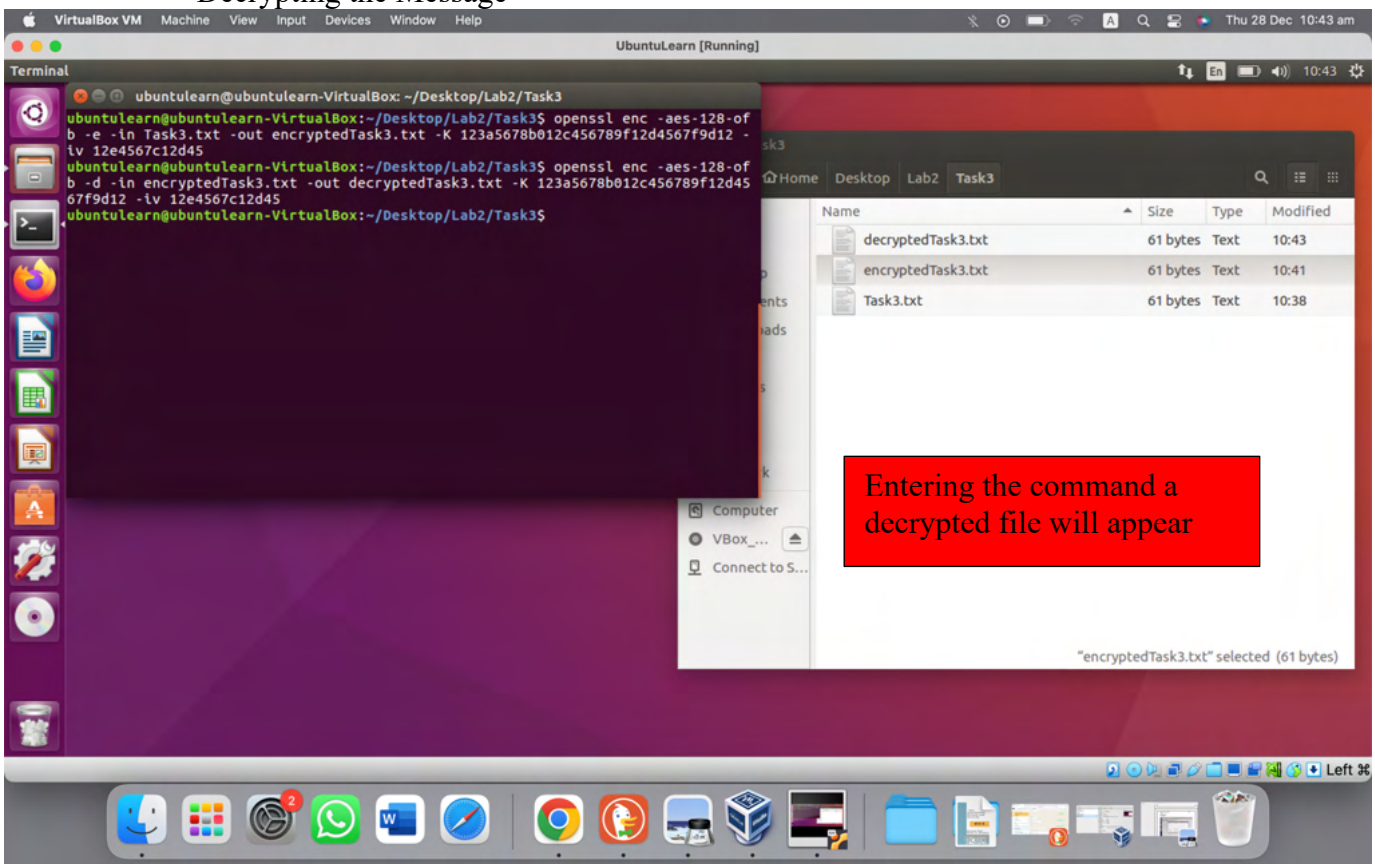


b. Decryption

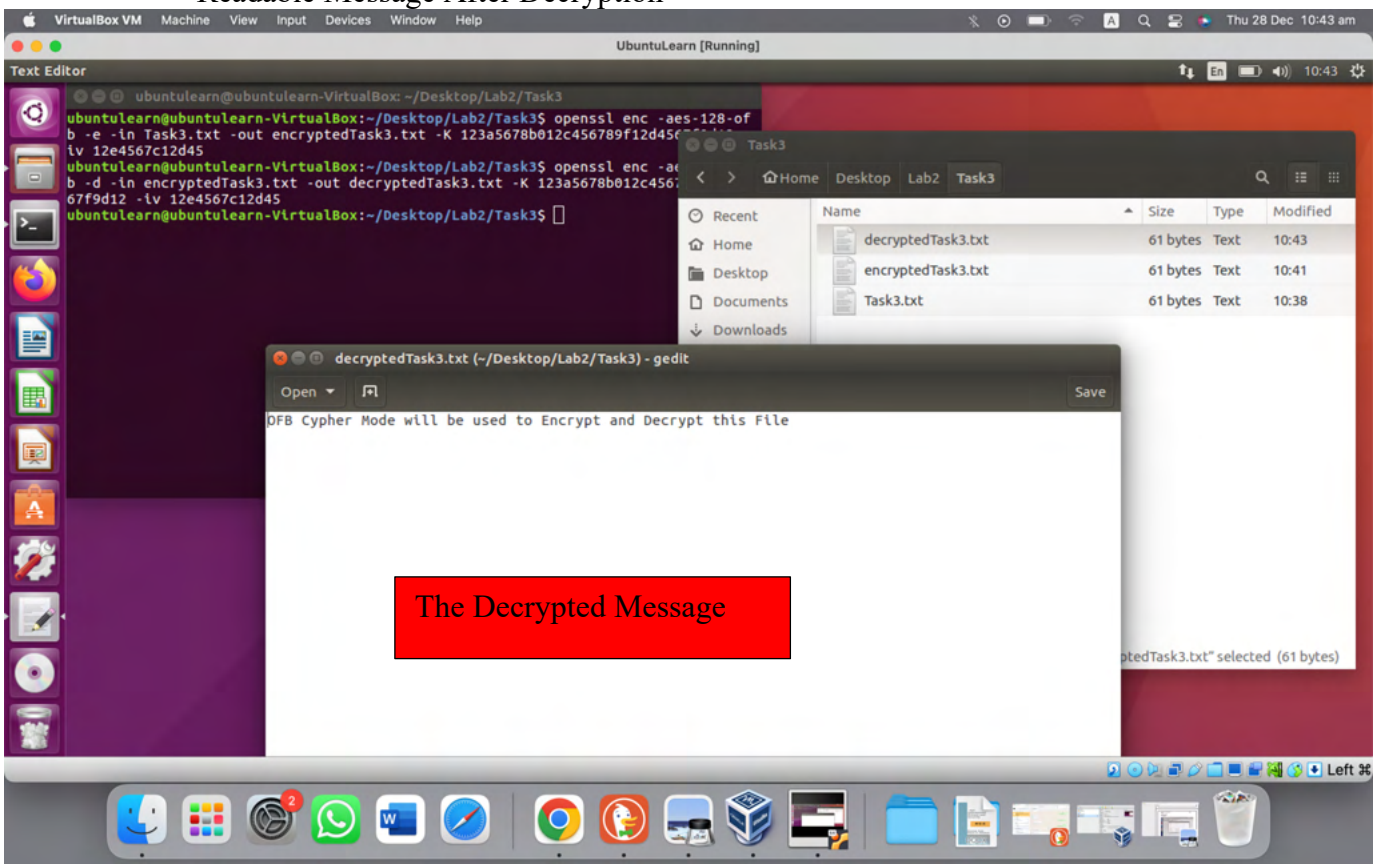
The cipher Text



Decrypting the Message



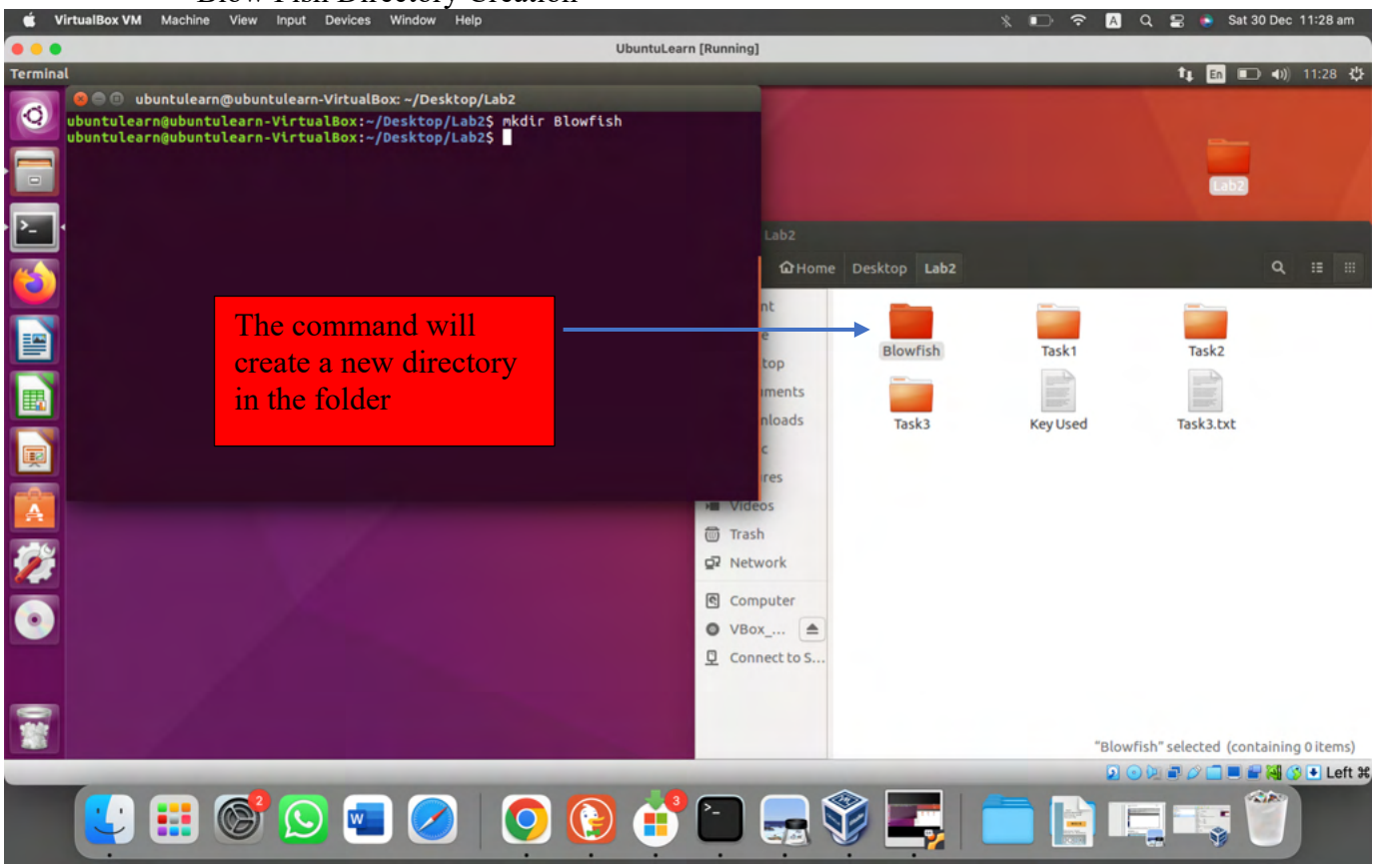
Readable Message After Decryption



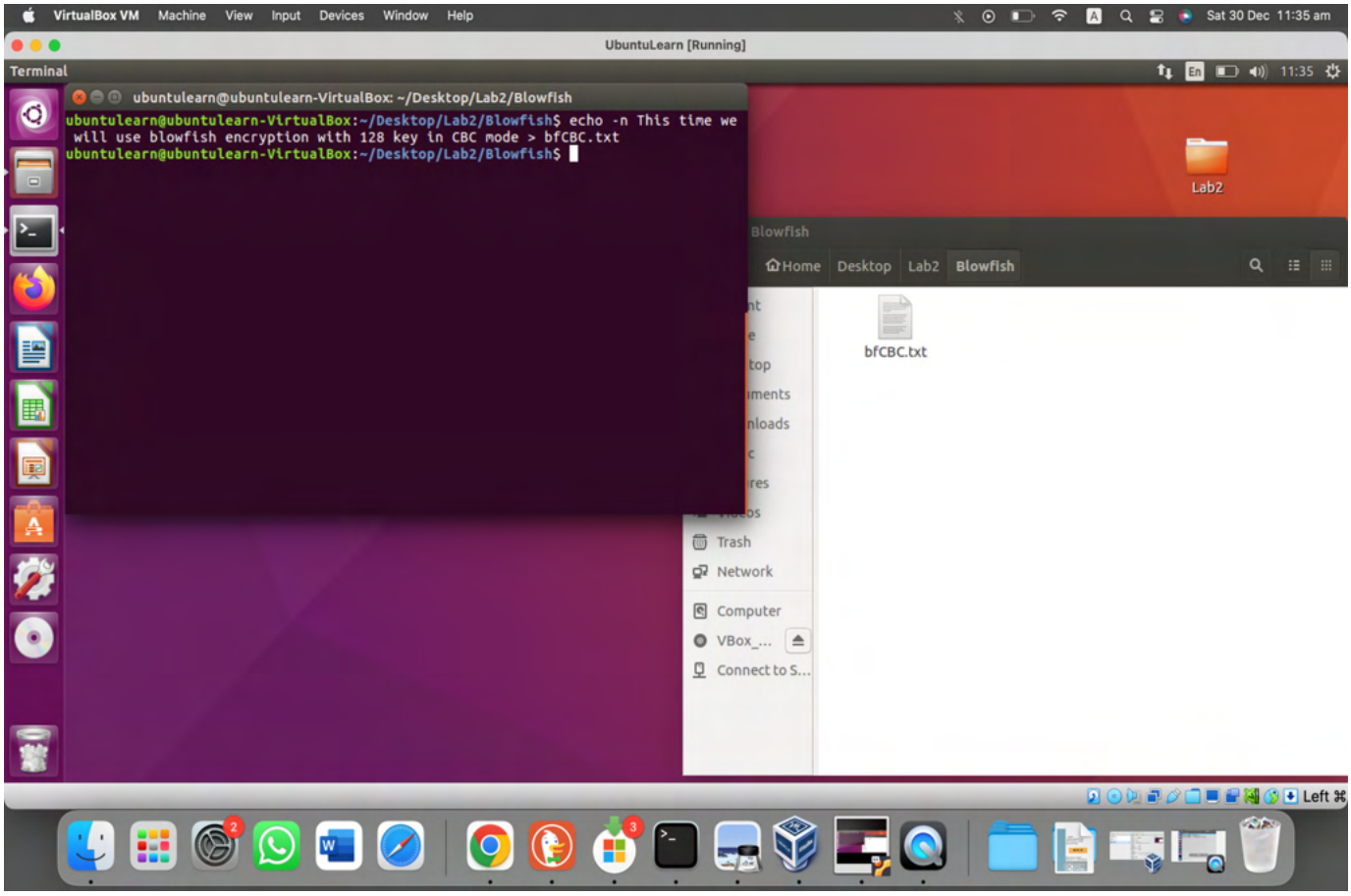
iii. Blow Fish CBC EncryptionTask3

a. Encryption

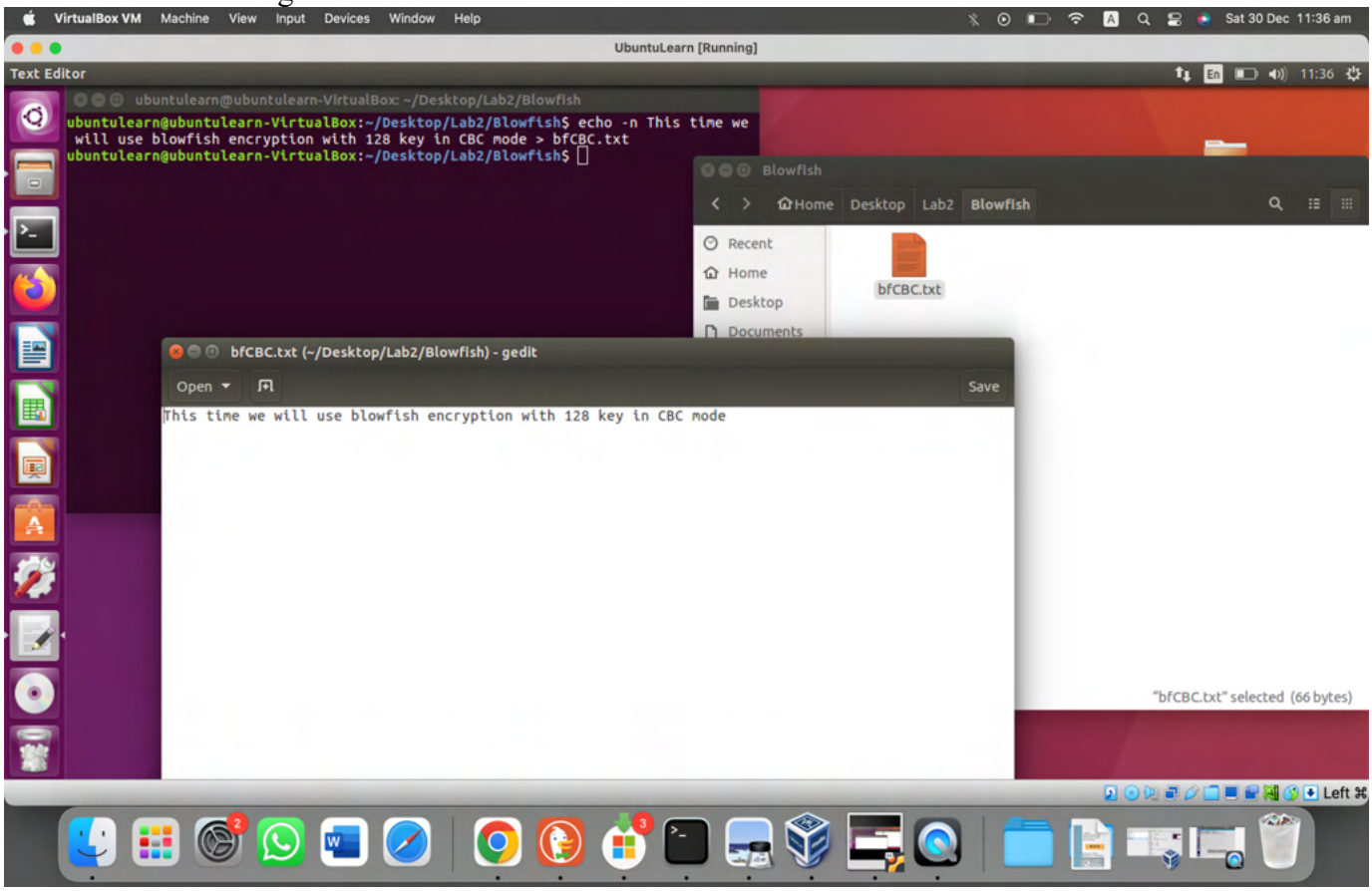
Blow Fish Directory Creation



Blow Fish .txt File Creation



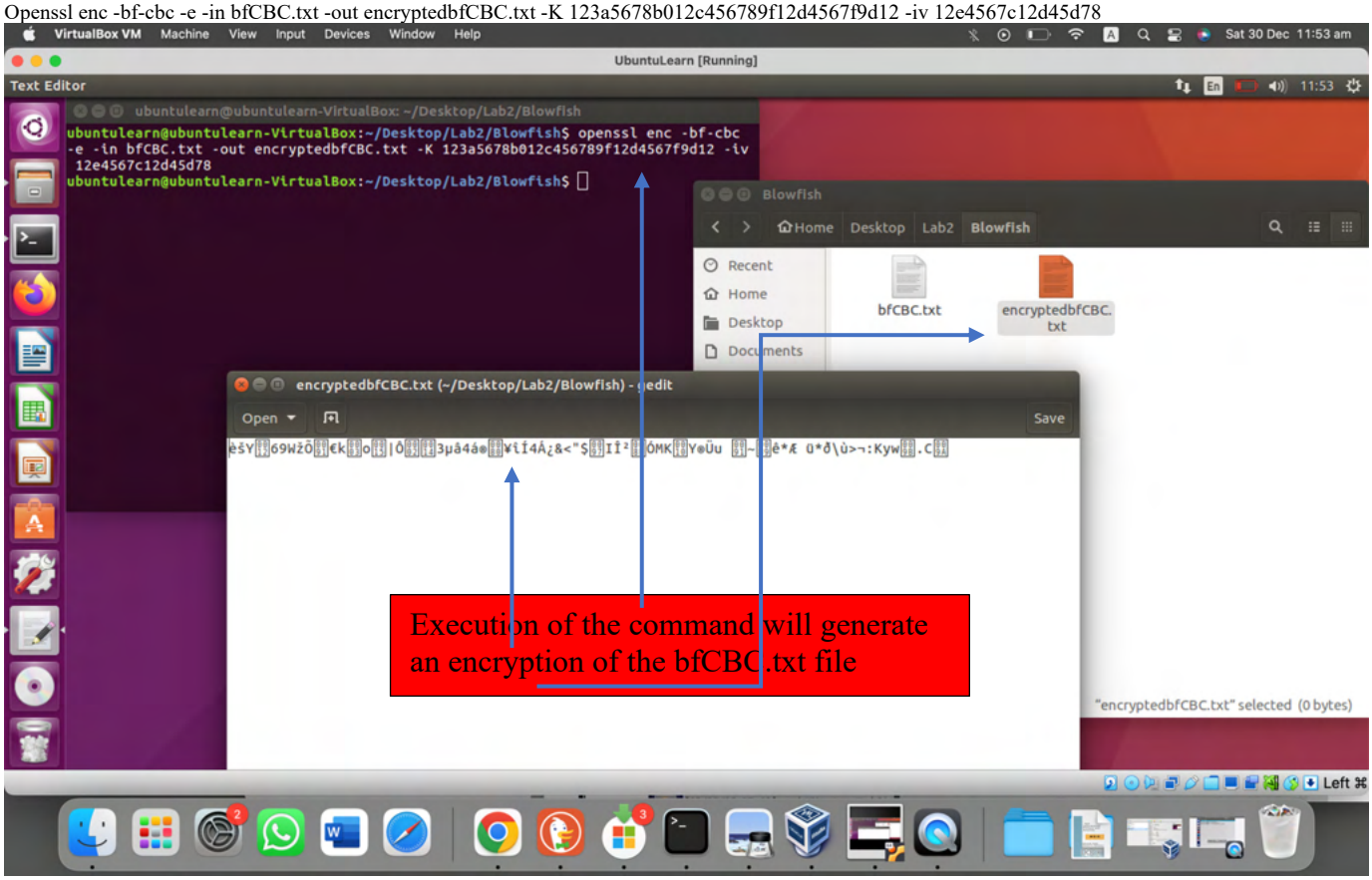
Message in the Blow Fish .txt File



Blow Fish Encryption Command

Following command will be used for Blow Fish encryption:

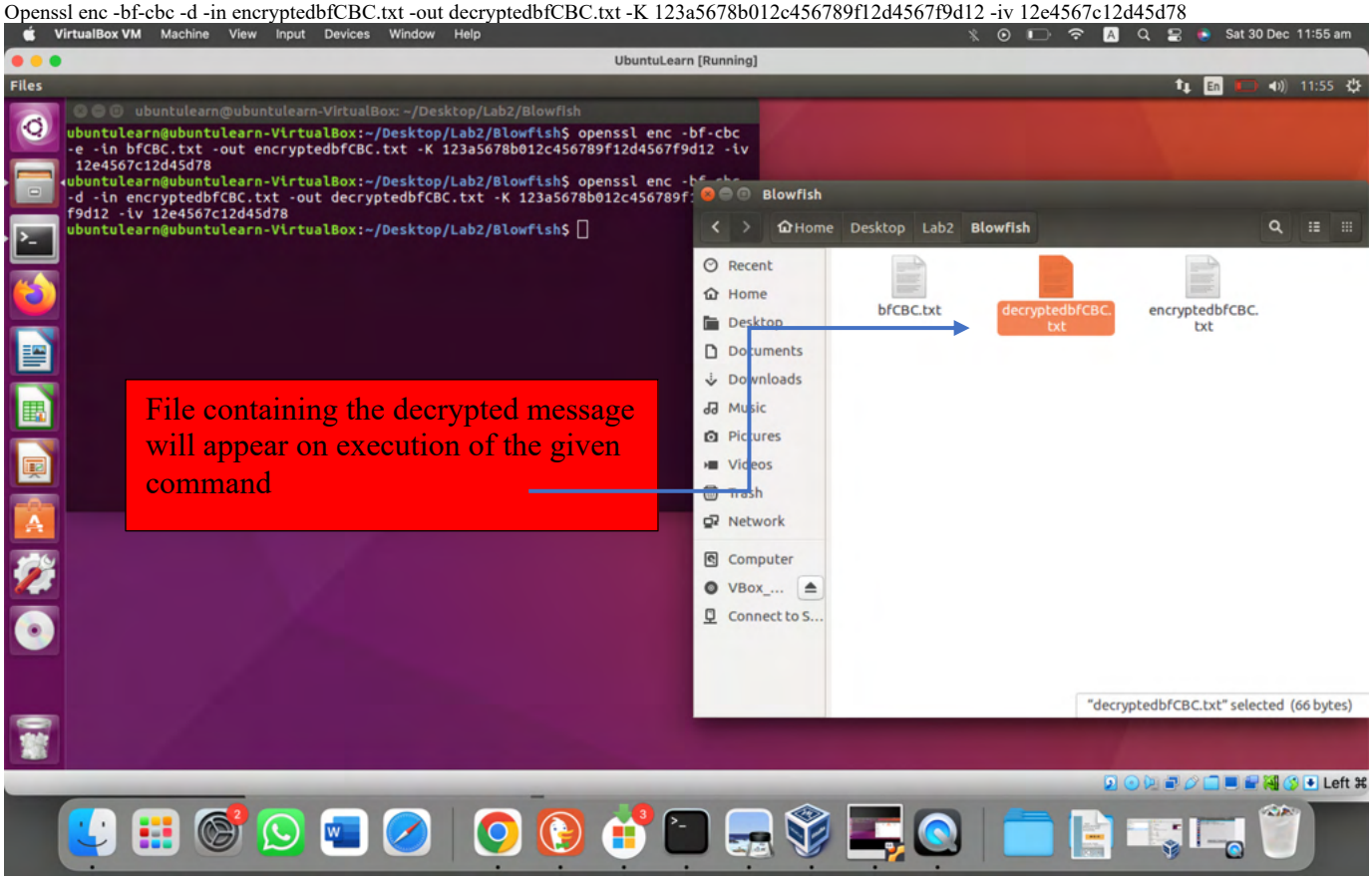
Openssl enc -bf-cbc -e -in bfCBC.txt -out encryptedbfCBC.txt -K 123a5678b012c456789f12d4567f9d12 -iv 12e4567c12d45d78



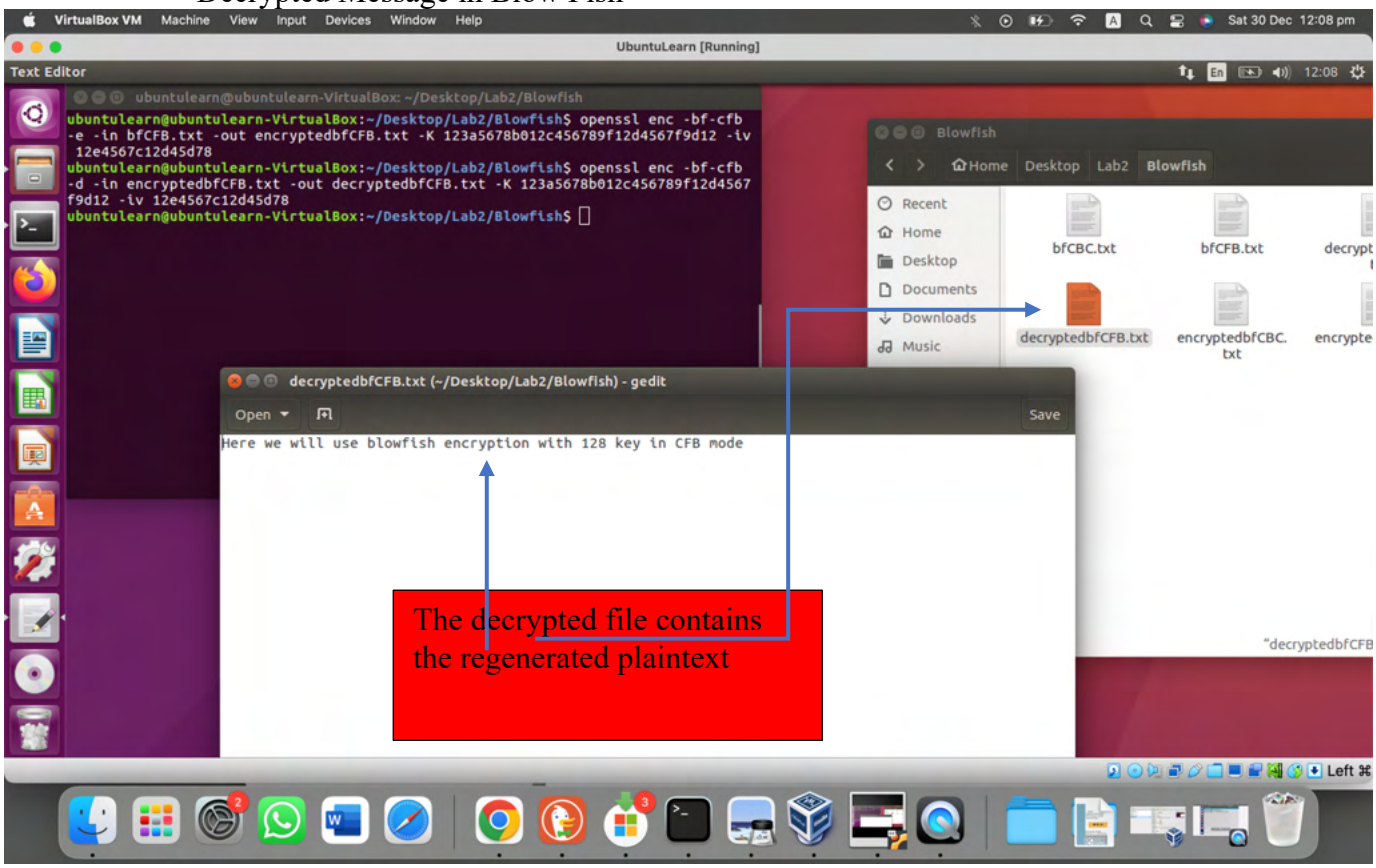
b. Decryption

Command to Decrypt in Blow Fish

Openssl enc -bf-cbc -d -in encryptedbfCBC.txt -out decryptedbfCBC.txt -K 123a5678b012c456789f12d4567f9d12 -iv 12e4567c12d45d78



Decrypted Message in Blow Fish



2.2. ENCRYPTION MODES ECB vs CBC

a. Image Encryption in ECB

Image to be Encrypted

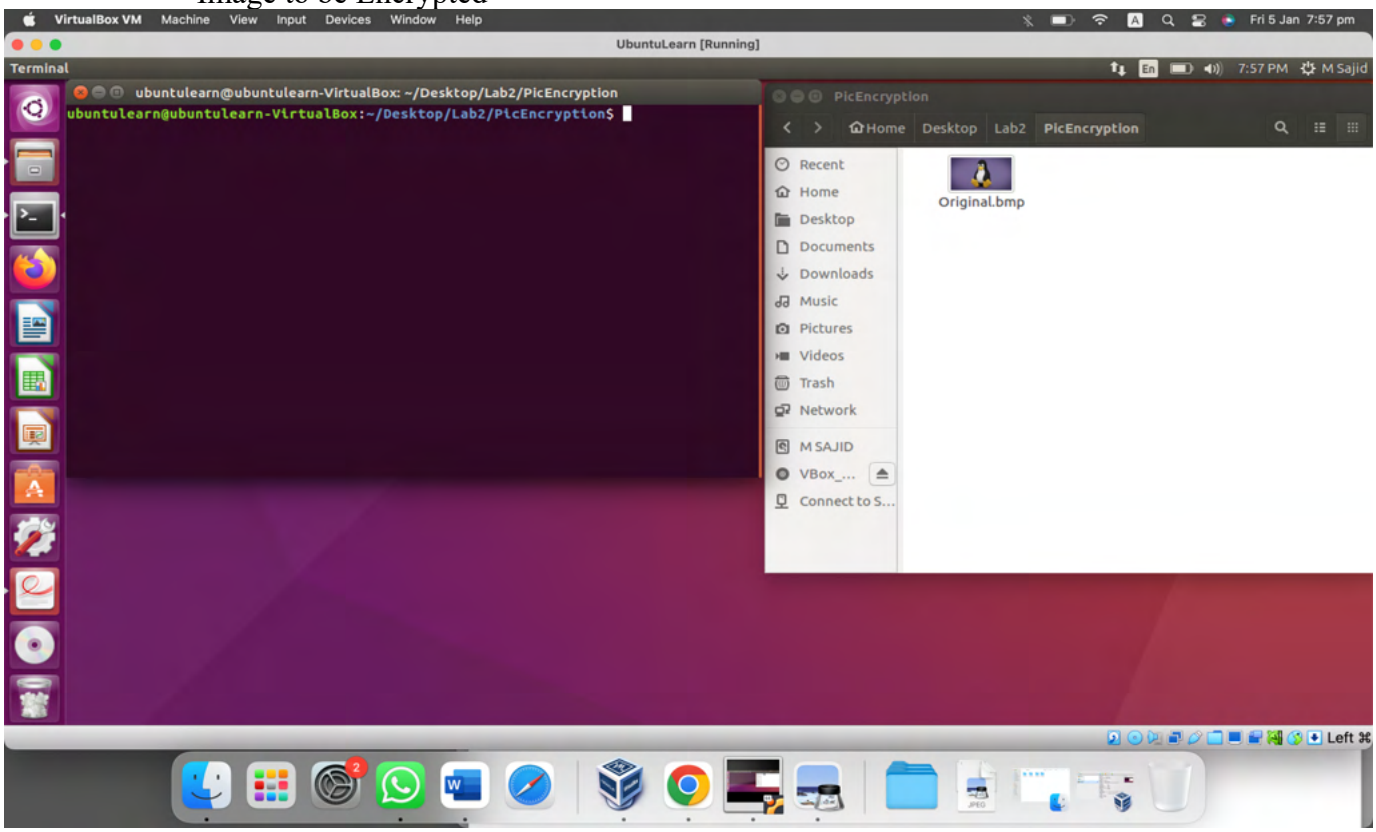
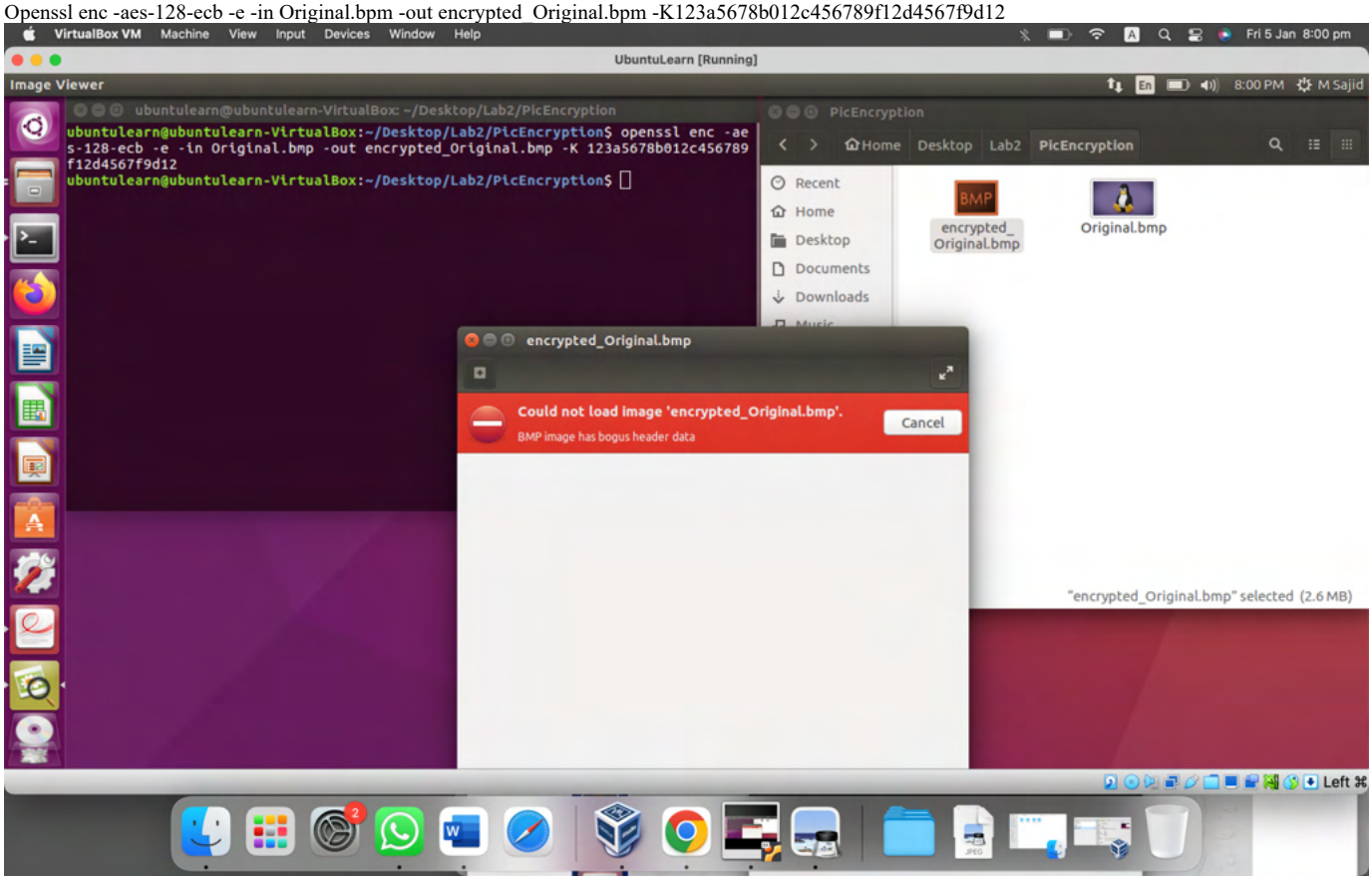


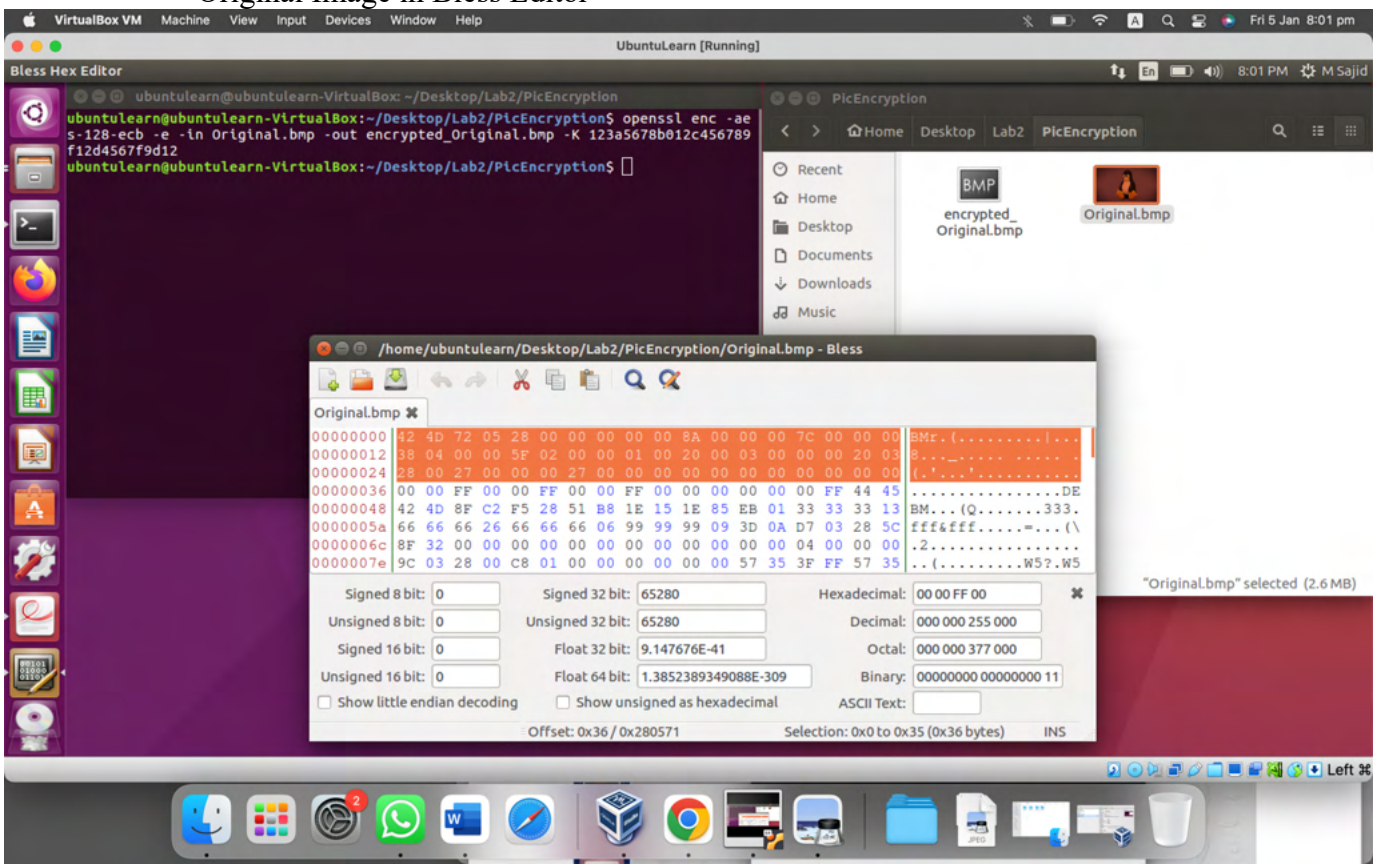
Image Encryption

Following code is used to encrypt the image:

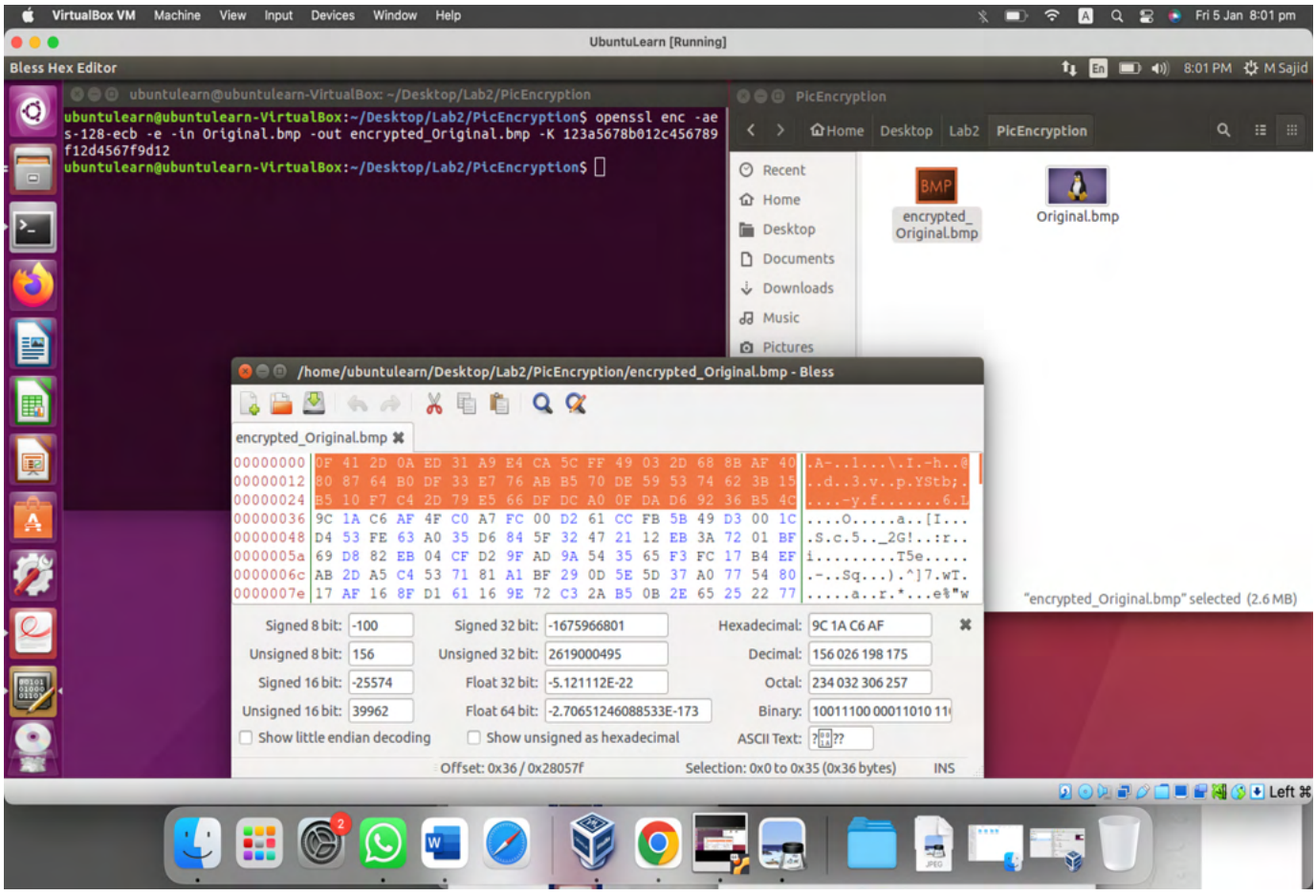
```
Openssl enc -aes-128-ecb -e -in Original.bpm -out encrypted  Original.bpm -K123a5678b012c456789f12d4567f9d12
```



Original Image in Bless Editor

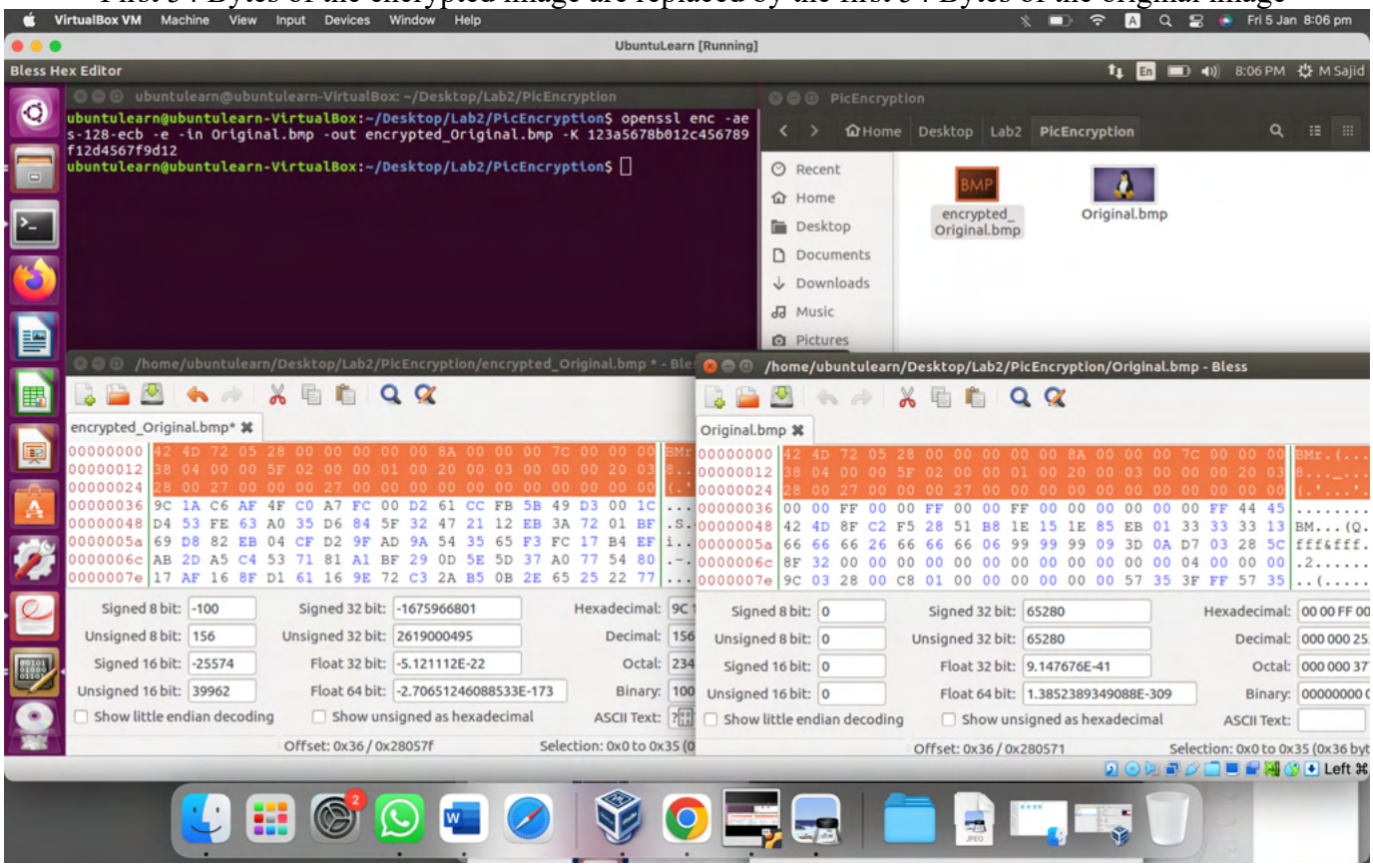


Encrypted Image in Bless Editor

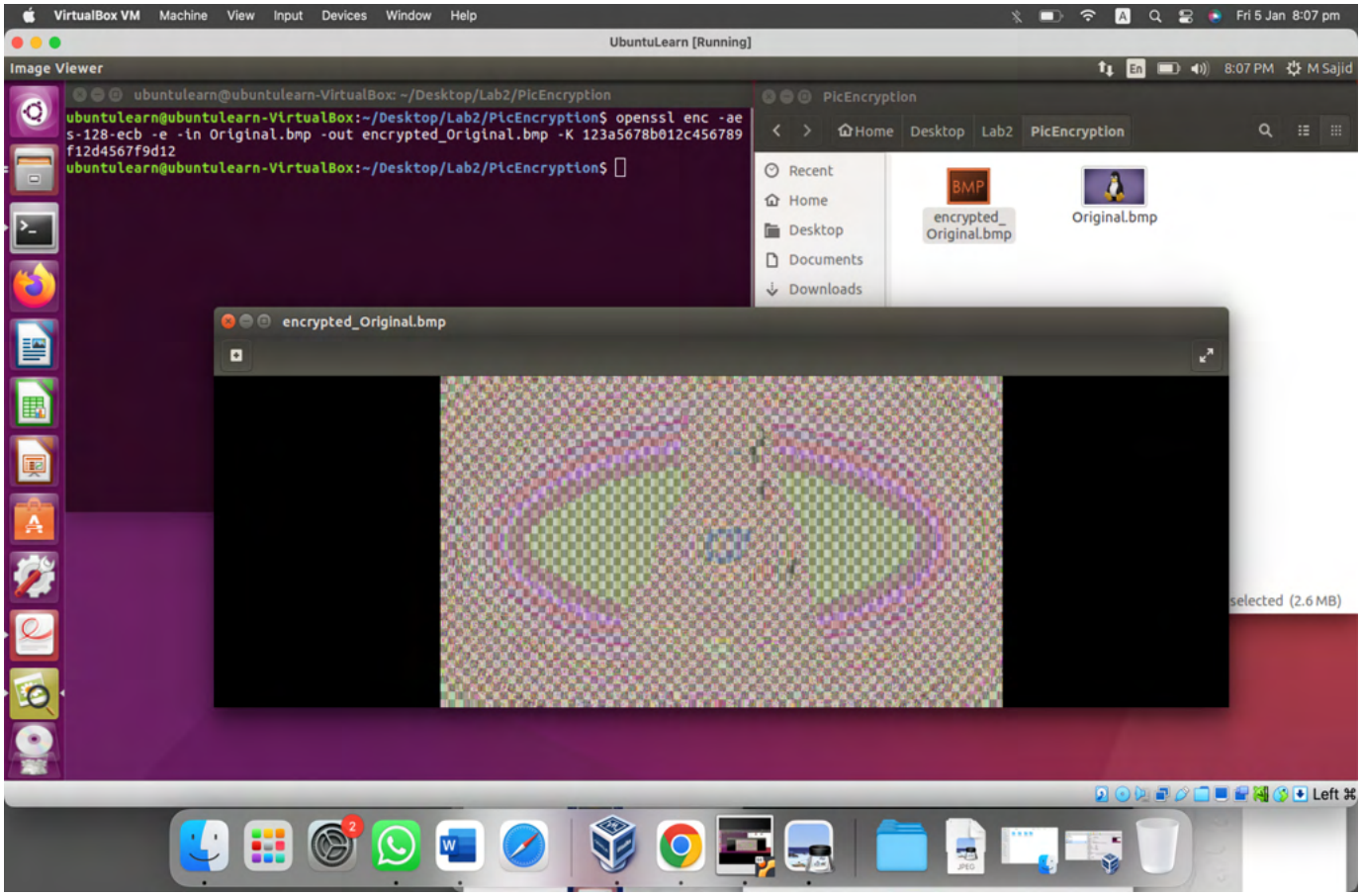


Byte Replacement

First 54 Bytes of the encrypted image are replaced by the first 54 Bytes of the original image

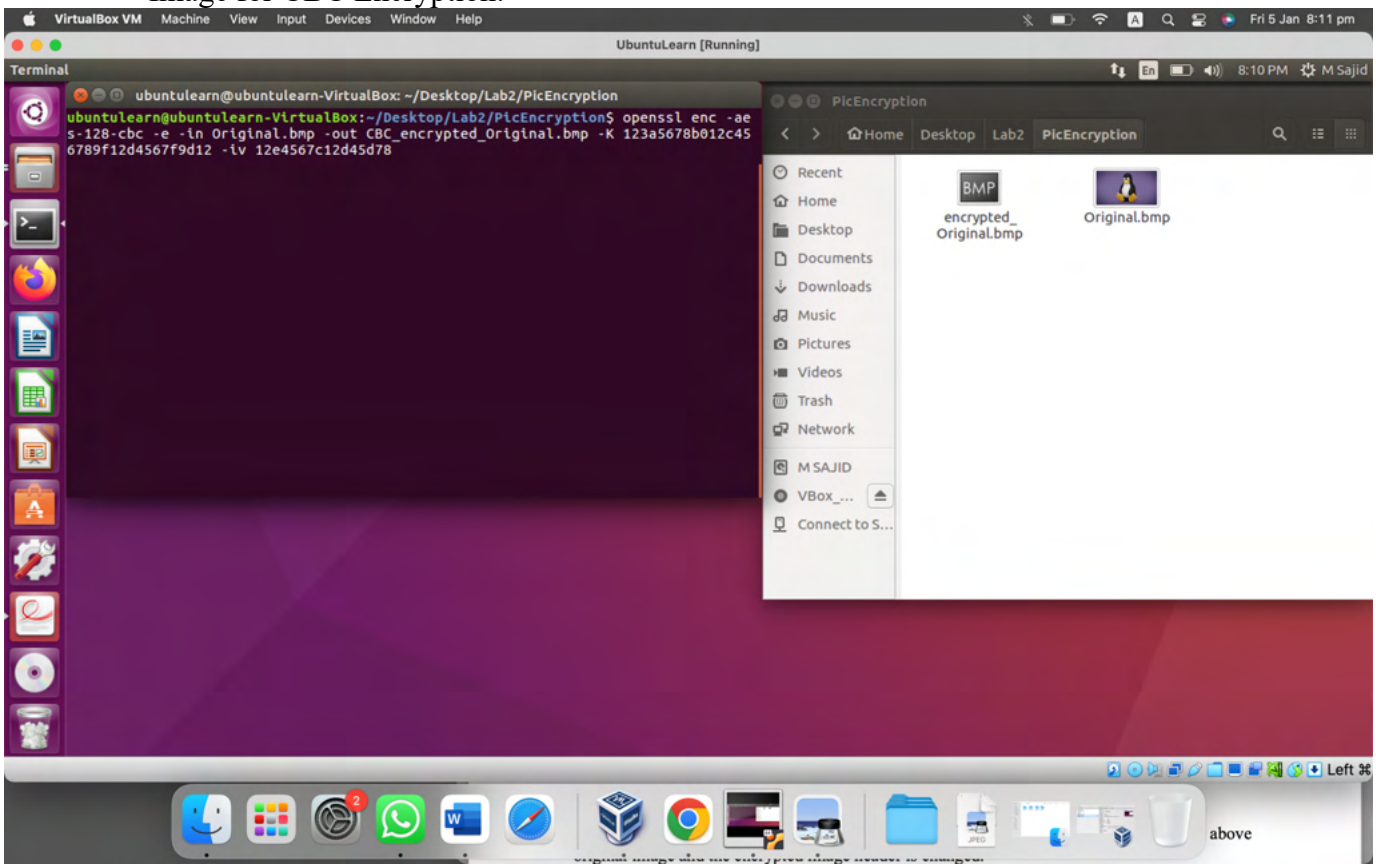


Encrypted Image After Byte Replacement



b. Image Encryption in CBC

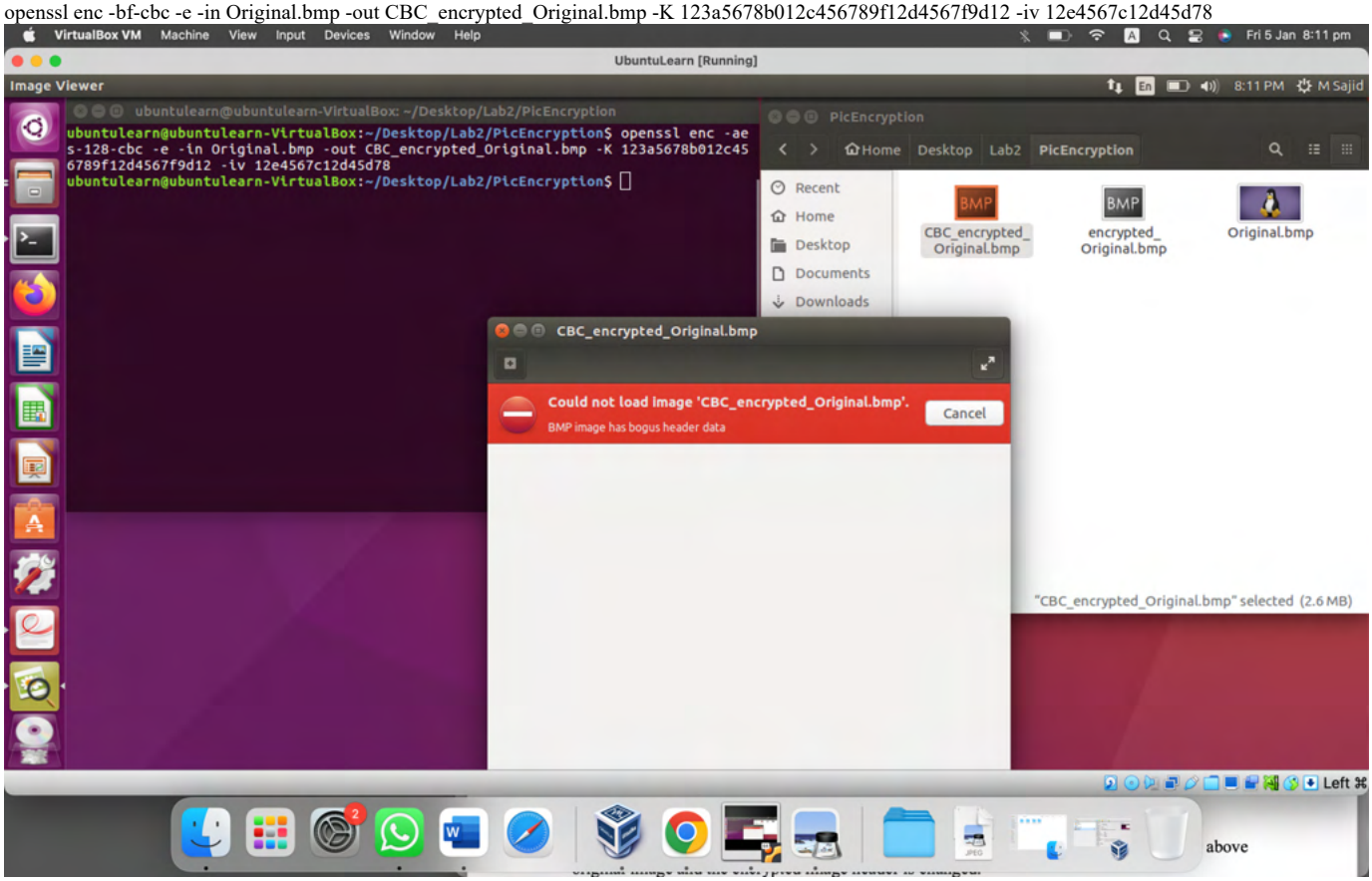
Image for CBC Encryption:



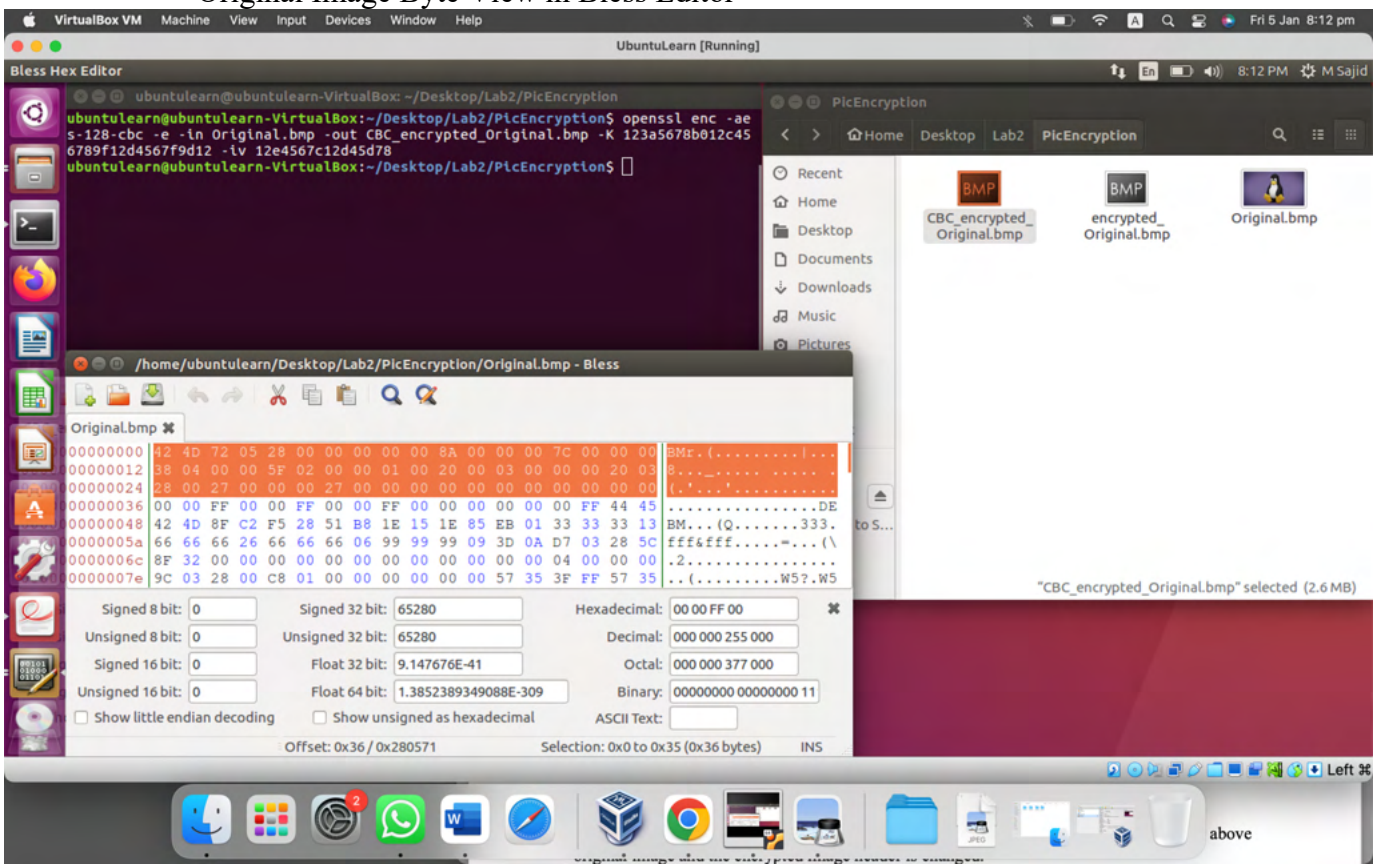
The Code for CBC Encryption

Following code is used for cbc Encryption

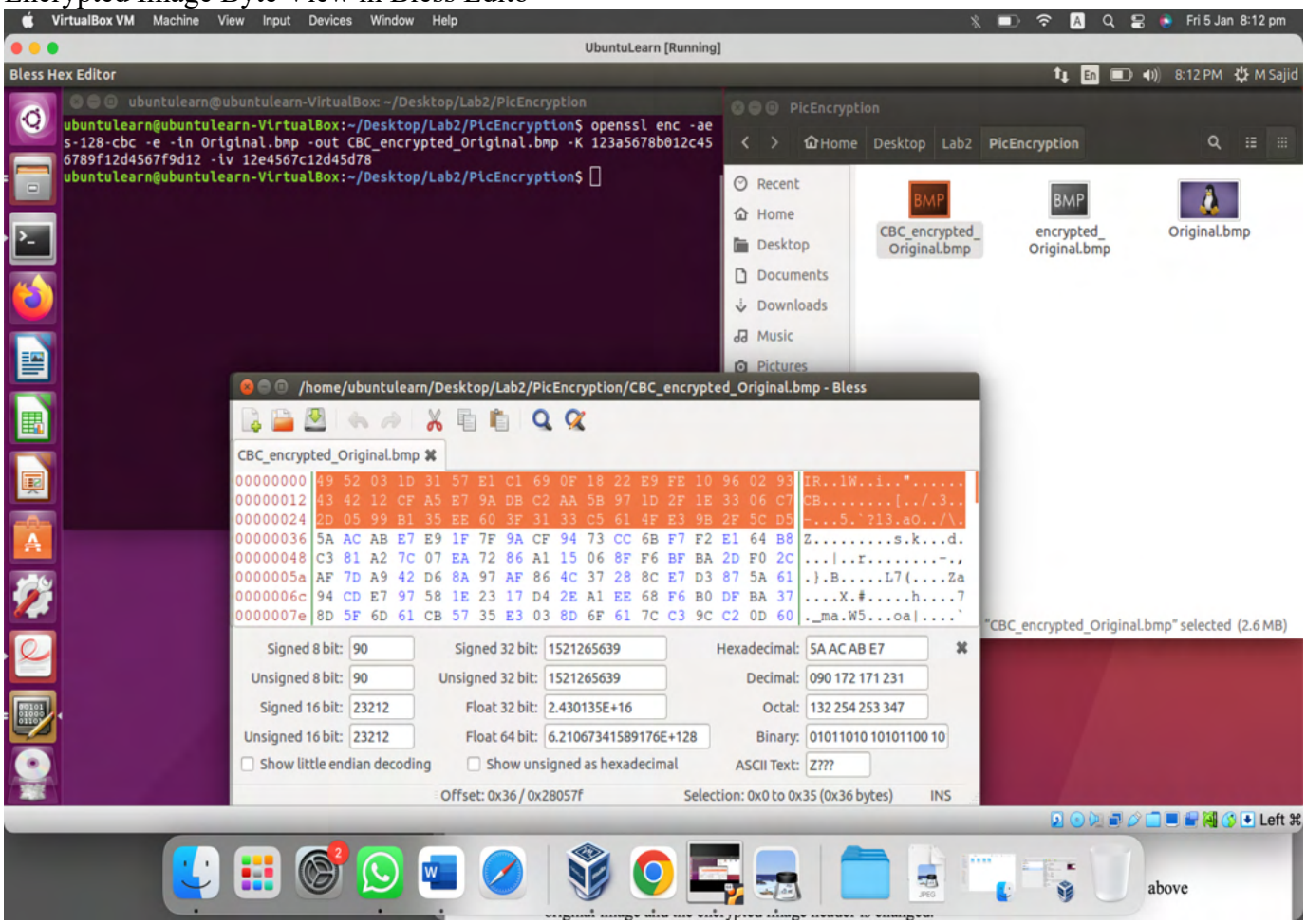
```
openssl enc -bf-cbc -e -in Original.bmp -out CBC_encrypted_Original.bmp -K 123a5678b012c456789f12d4567f9d12 -iv 12e4567c12d45d78
```



Original Image Byte View in Bless Editor



Encrypted Image Byte View in Bless Edito



Byte Replacement

The first 54 byte of the Encrypted Image replaced by the first 54 Bytes of the Original Image

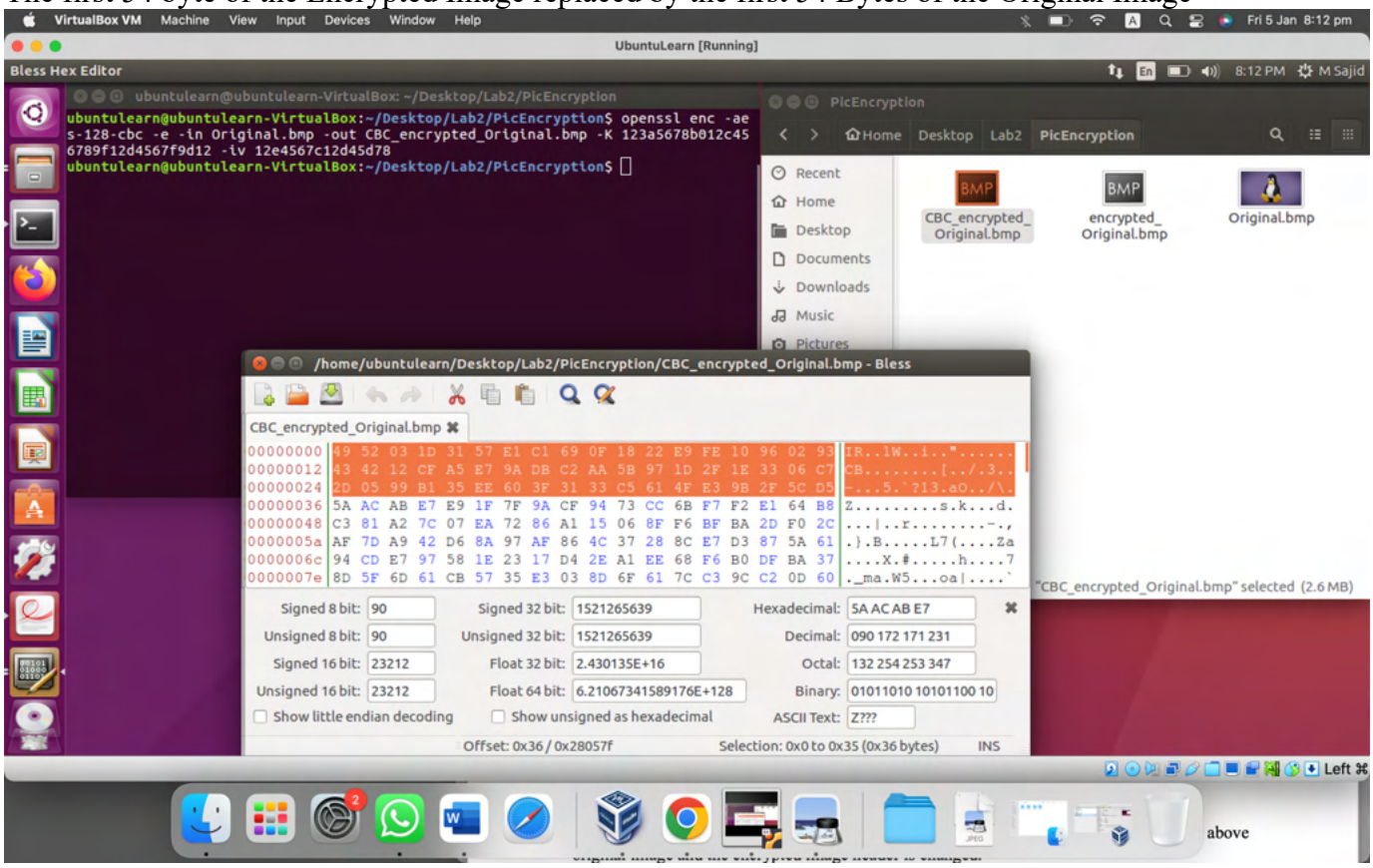
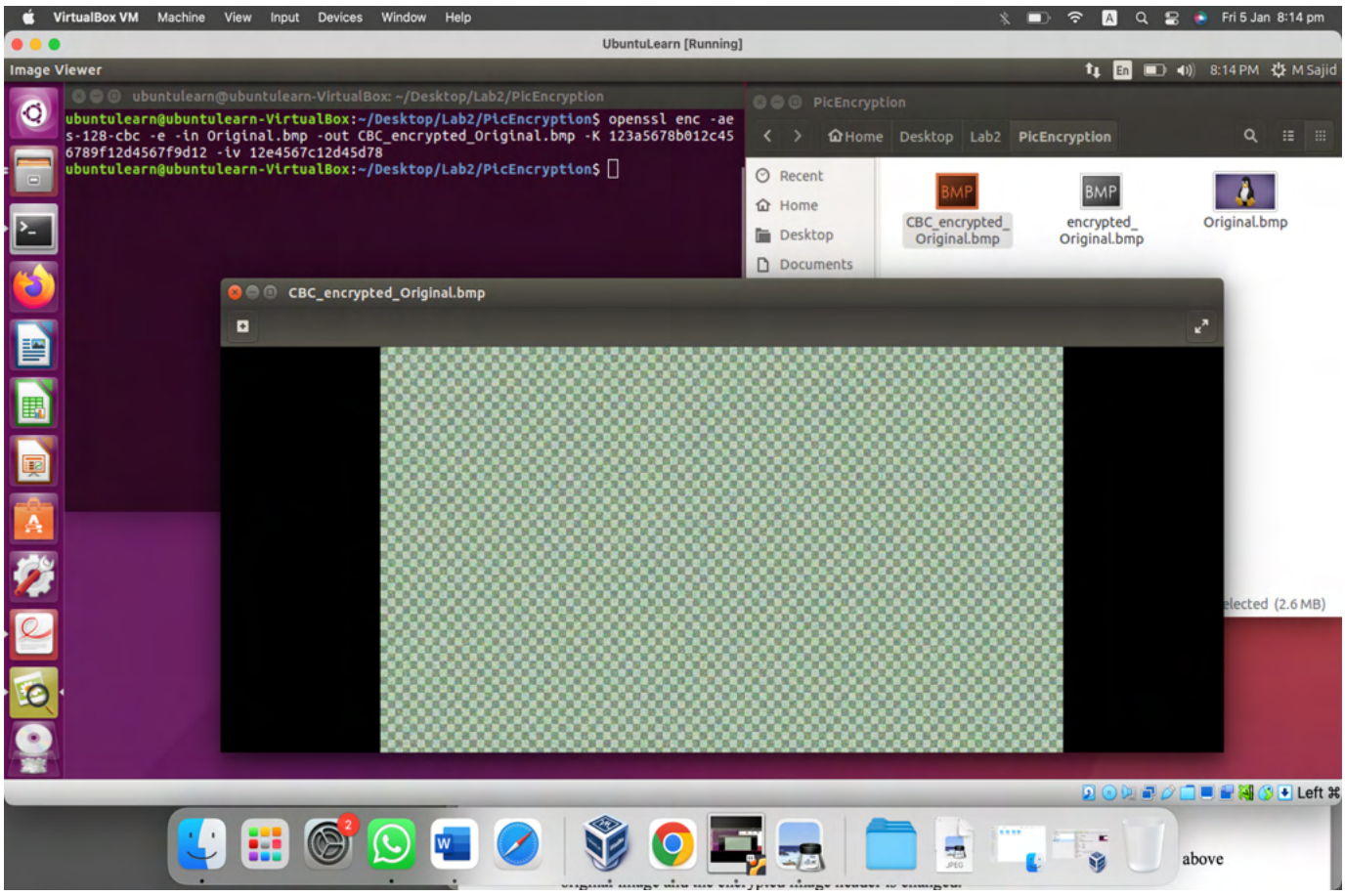


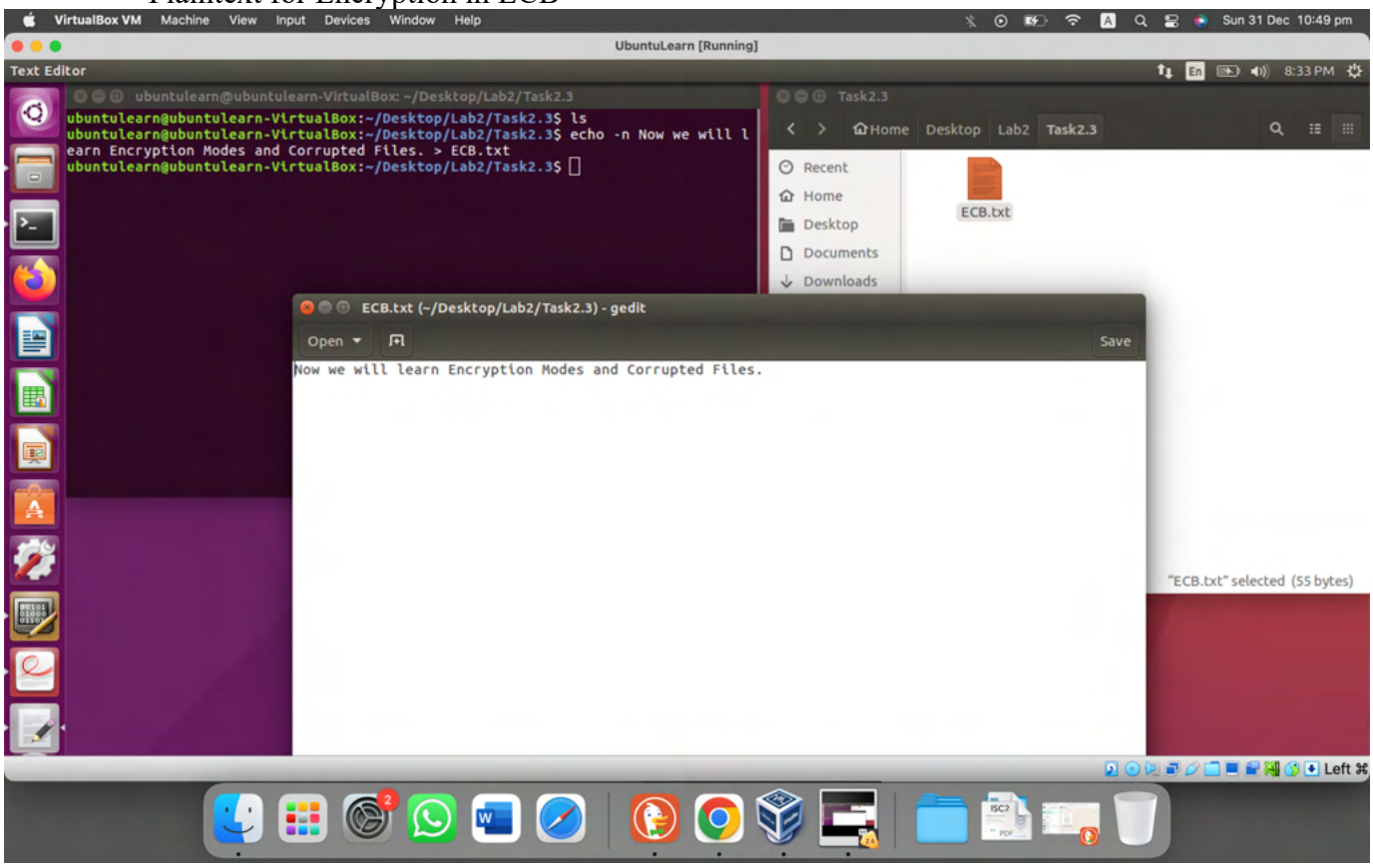
Image After Byte Replacement



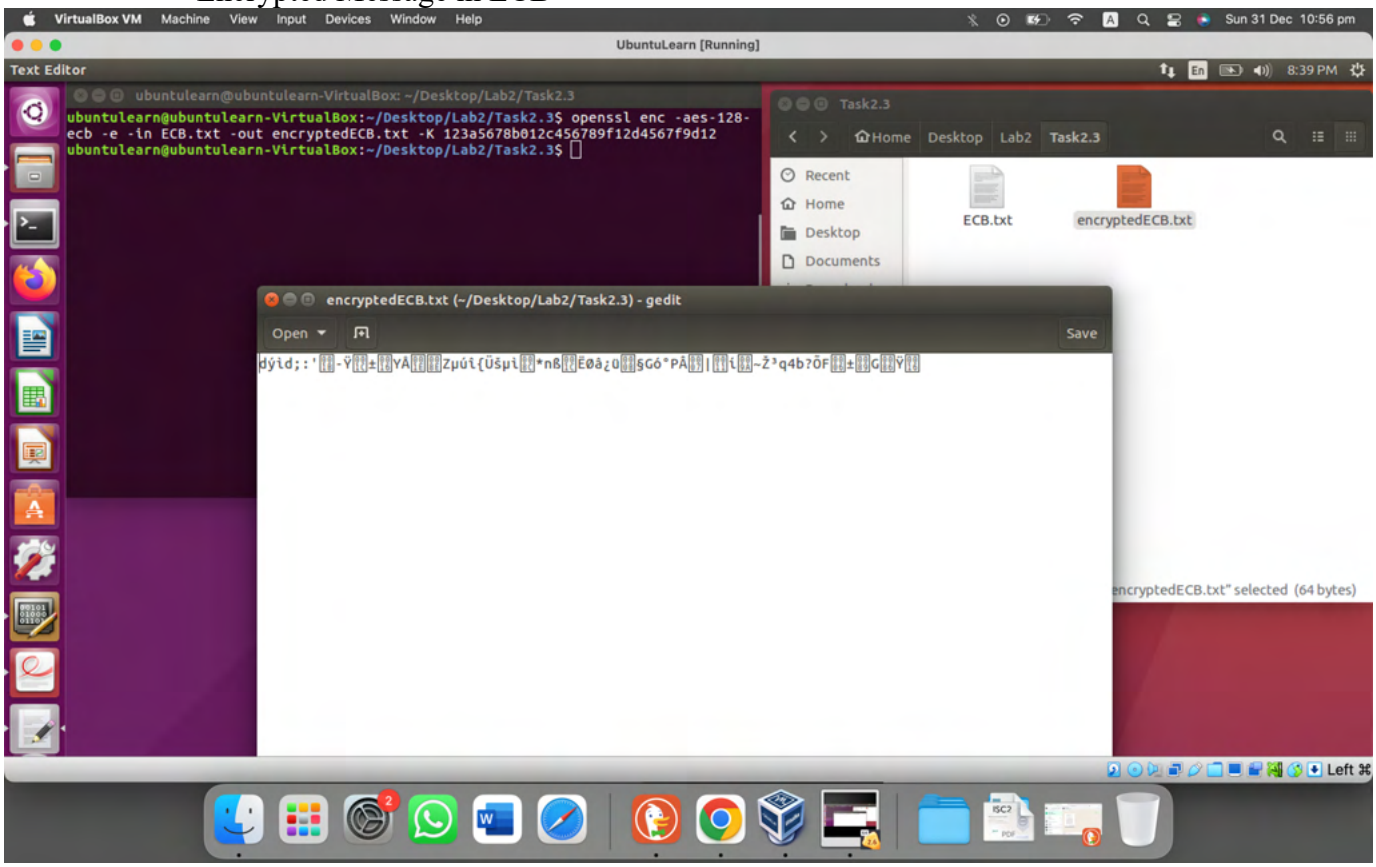
2.3. ENCRYPTION MODES ON CORRUPTED FILES

a. Encryption Mode: ECB

Plaintext for Encryption in ECB

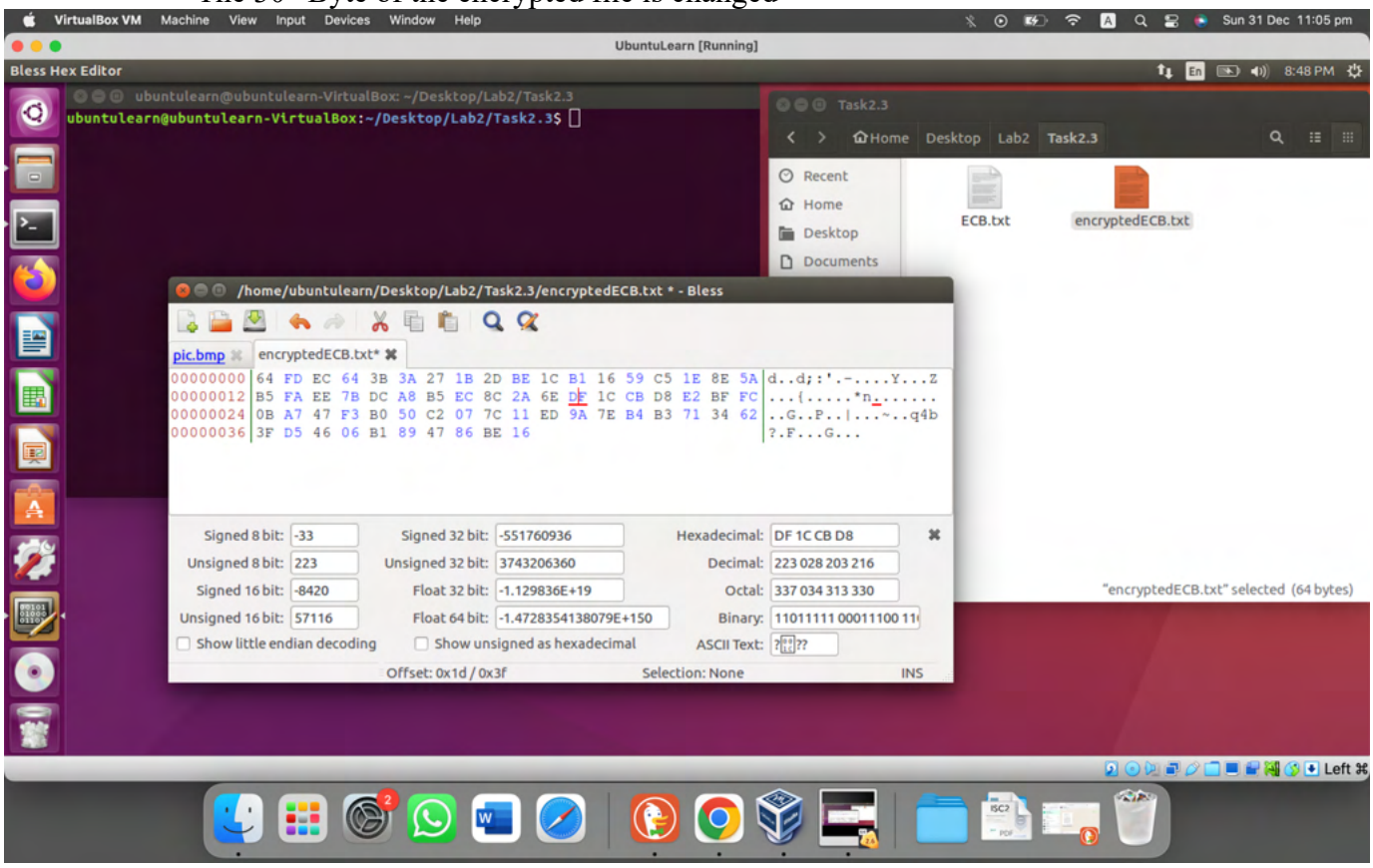


Encrypted Message in ECB

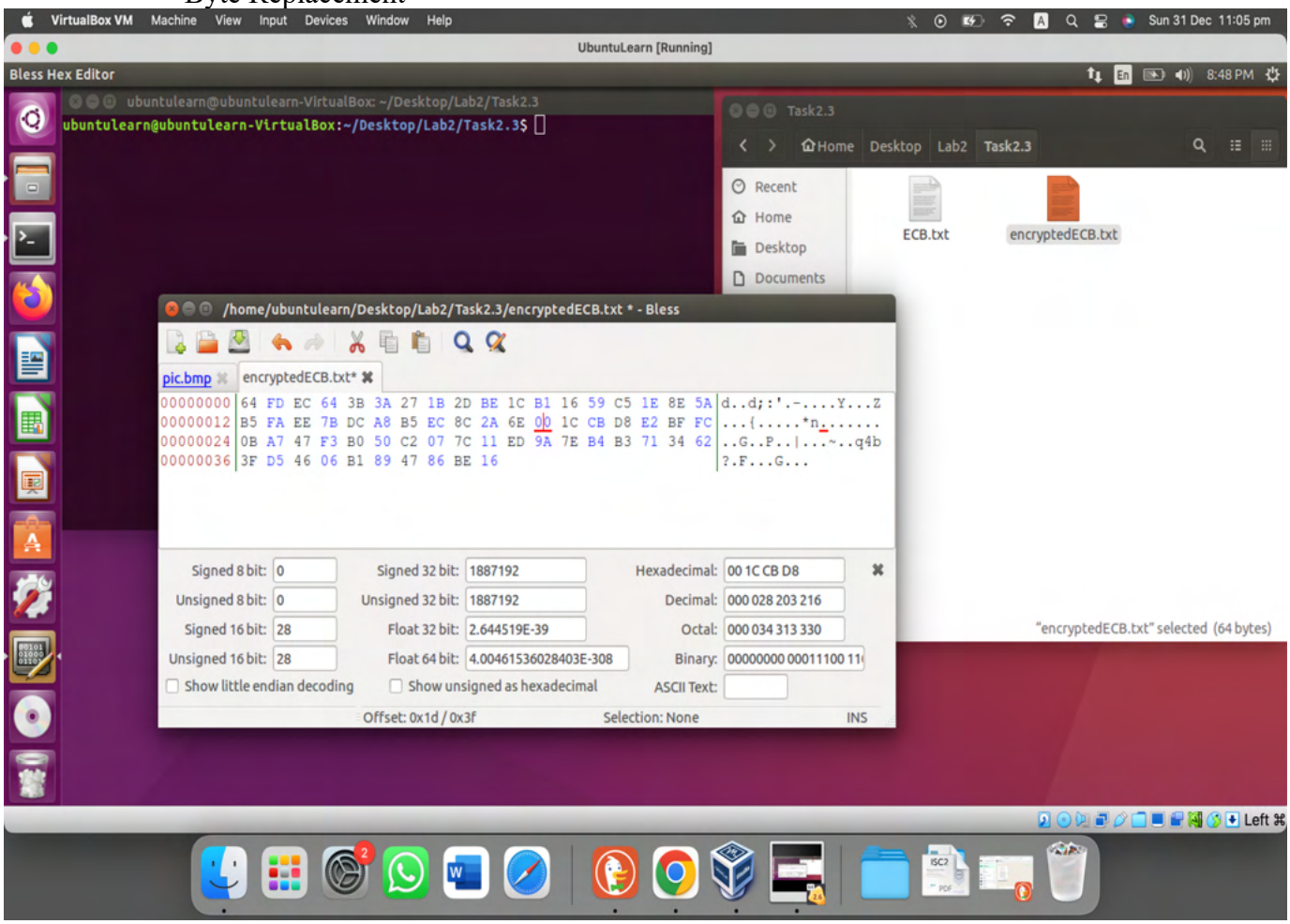


Encrypted Message in Bless Editor

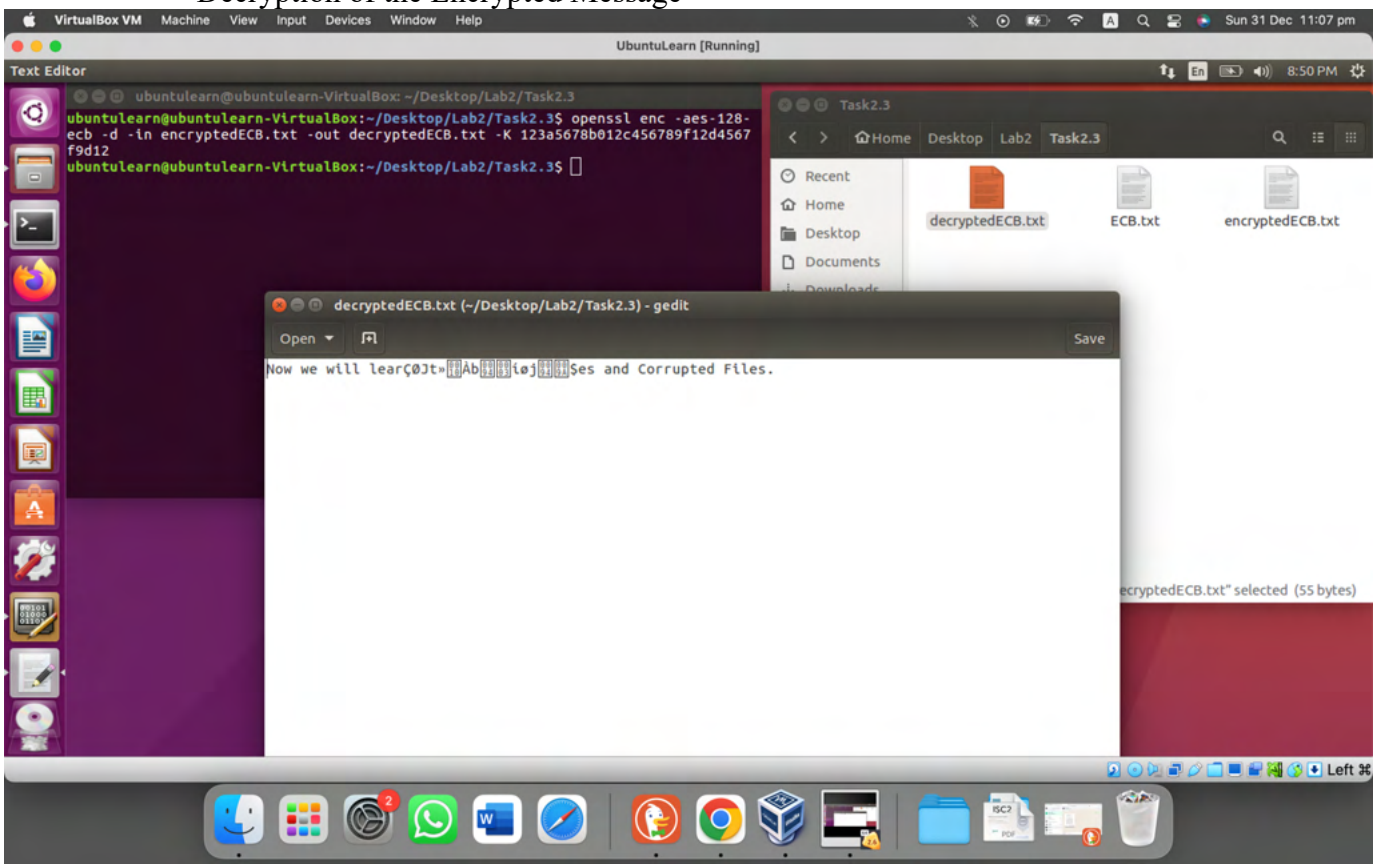
The 30th Byte of the encrypted file is changed



Byte Replacement



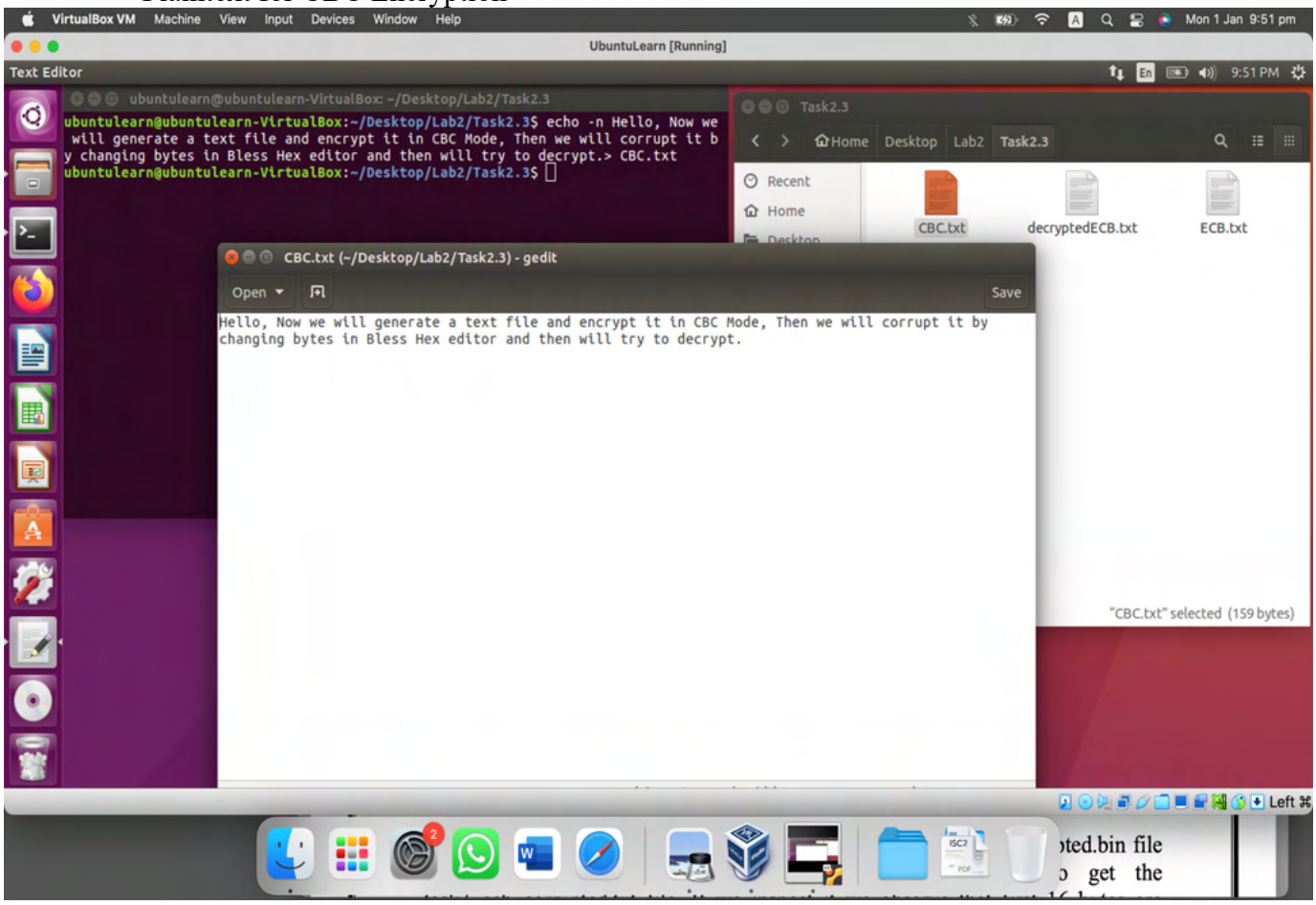
Decryption of the Encrypted Message



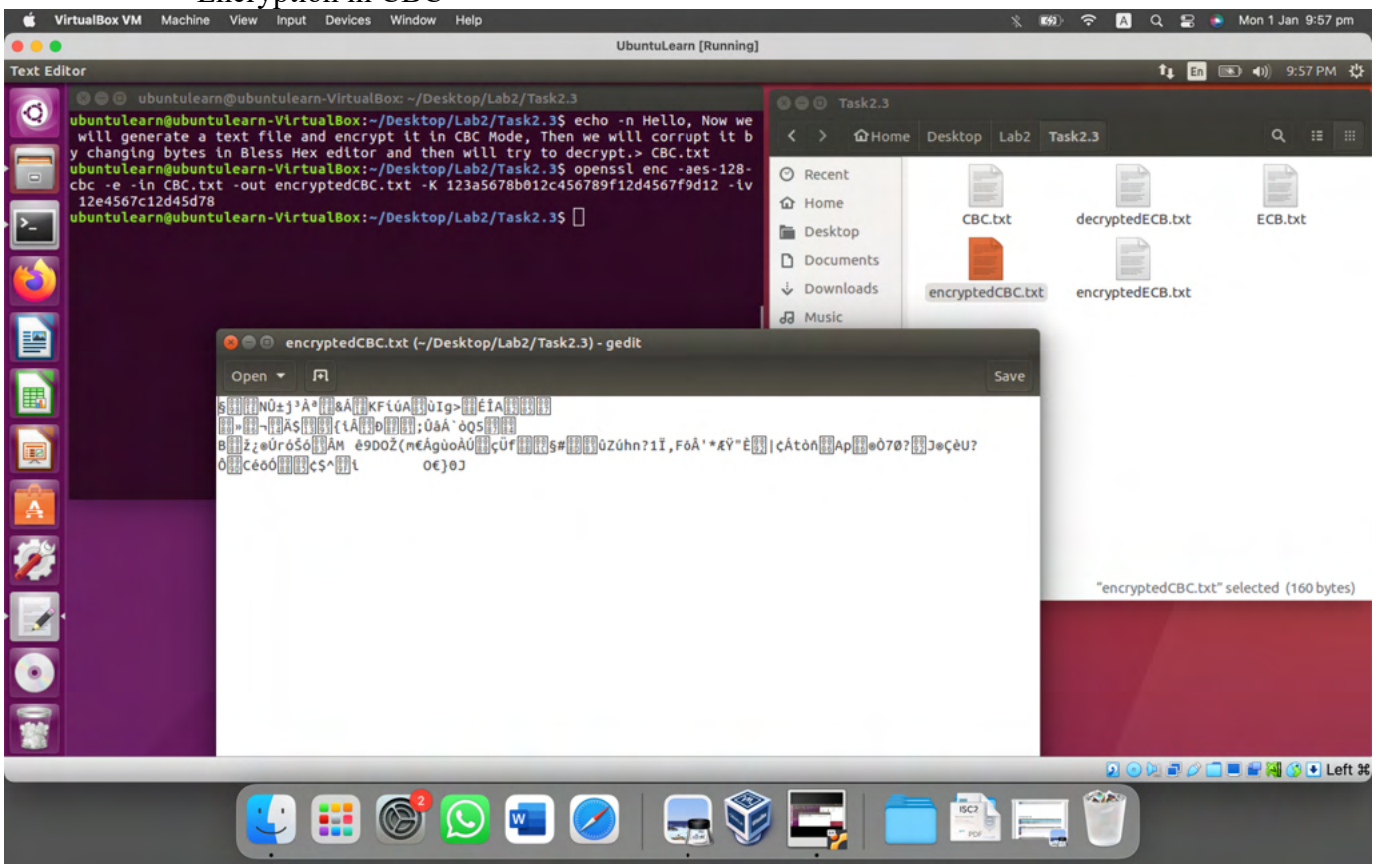
Now we have corrupted the 30th byte of the task3_aes_128_ebc_corrupted.bin file using the hex editor and decrypt the corrupted bin file to get the task3_ecb_corrupted.txt file. If we inspect it we observe that first 16 bytes are recovered, next 16 bytes are corrupted and the rest of the content is also fine (only 2nd block is corrupted because 30th byte is in second block.)

b. Encryption Mode: CBC

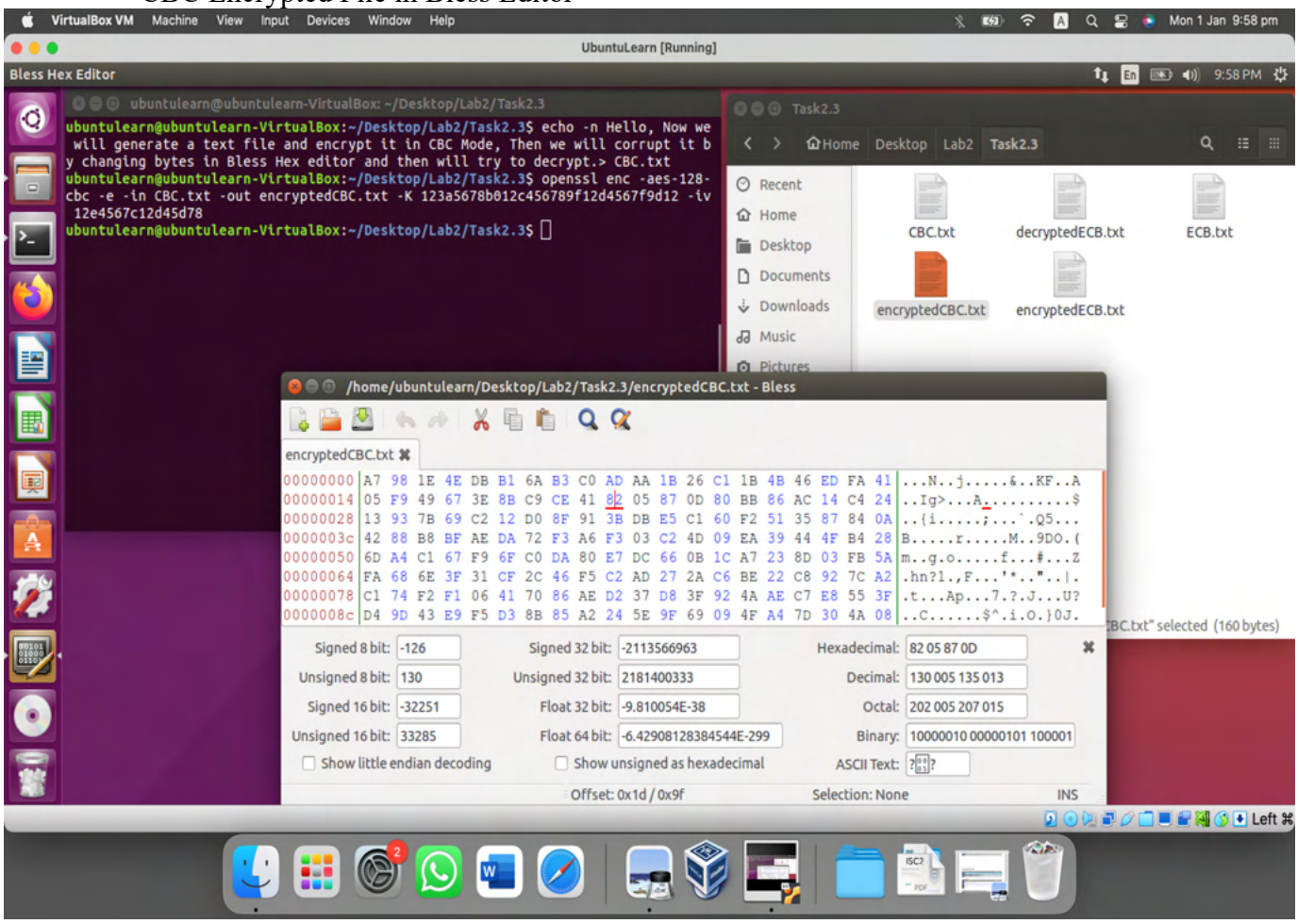
Plaintext for CBC Encryption



Encryption in CBC

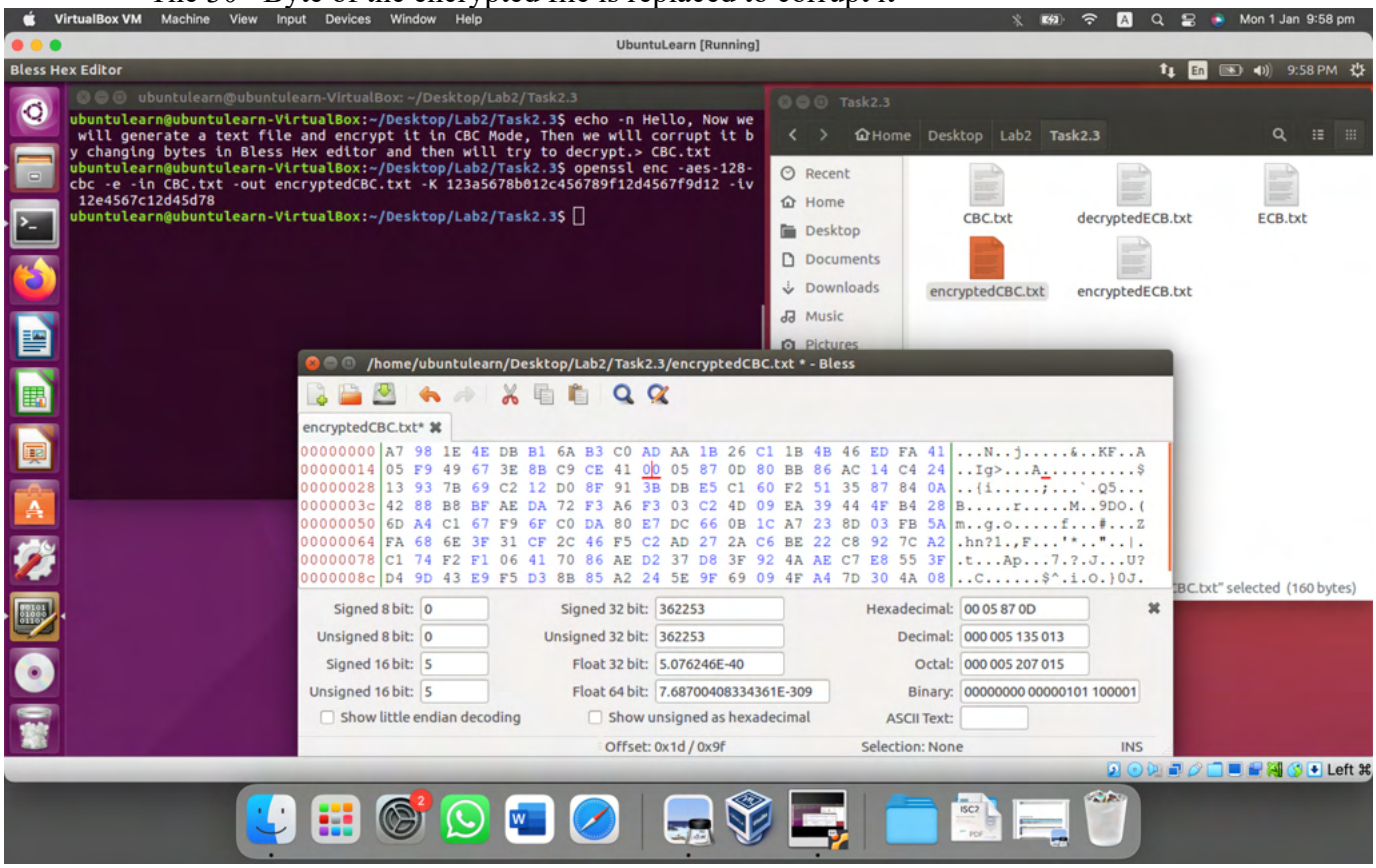


CBC Encrypted File in Bless Editor

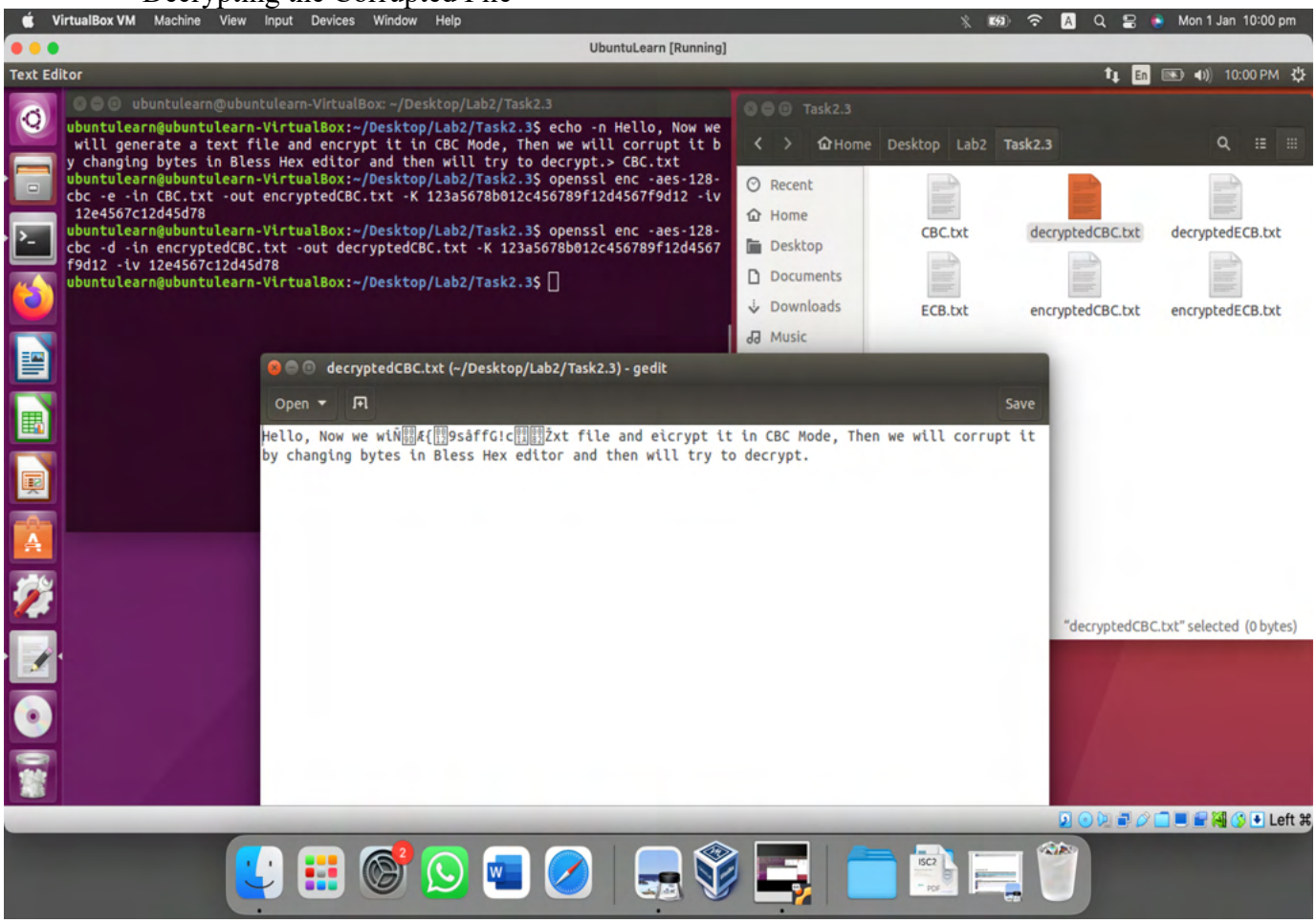


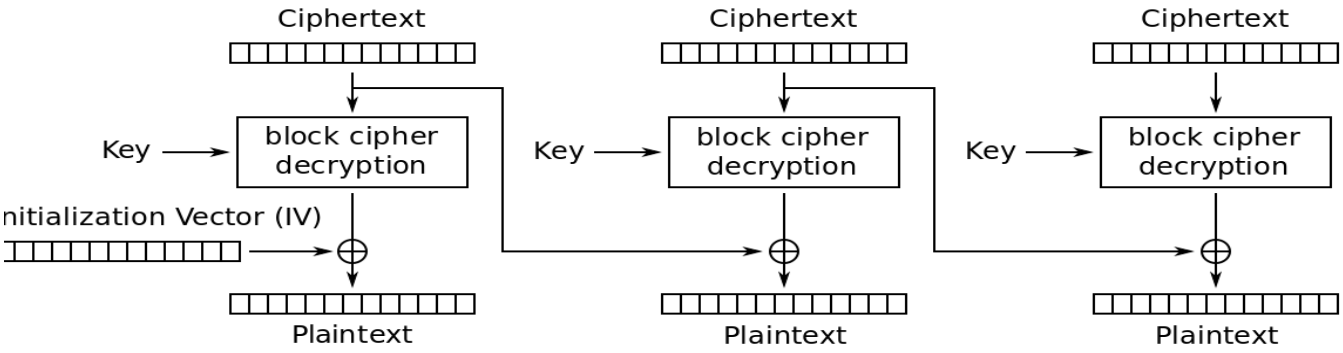
Byte Replacement in Bless Editor

The 30th Byte of the encrypted file is replaced to corrupt it



Decrypting the Corrupted File



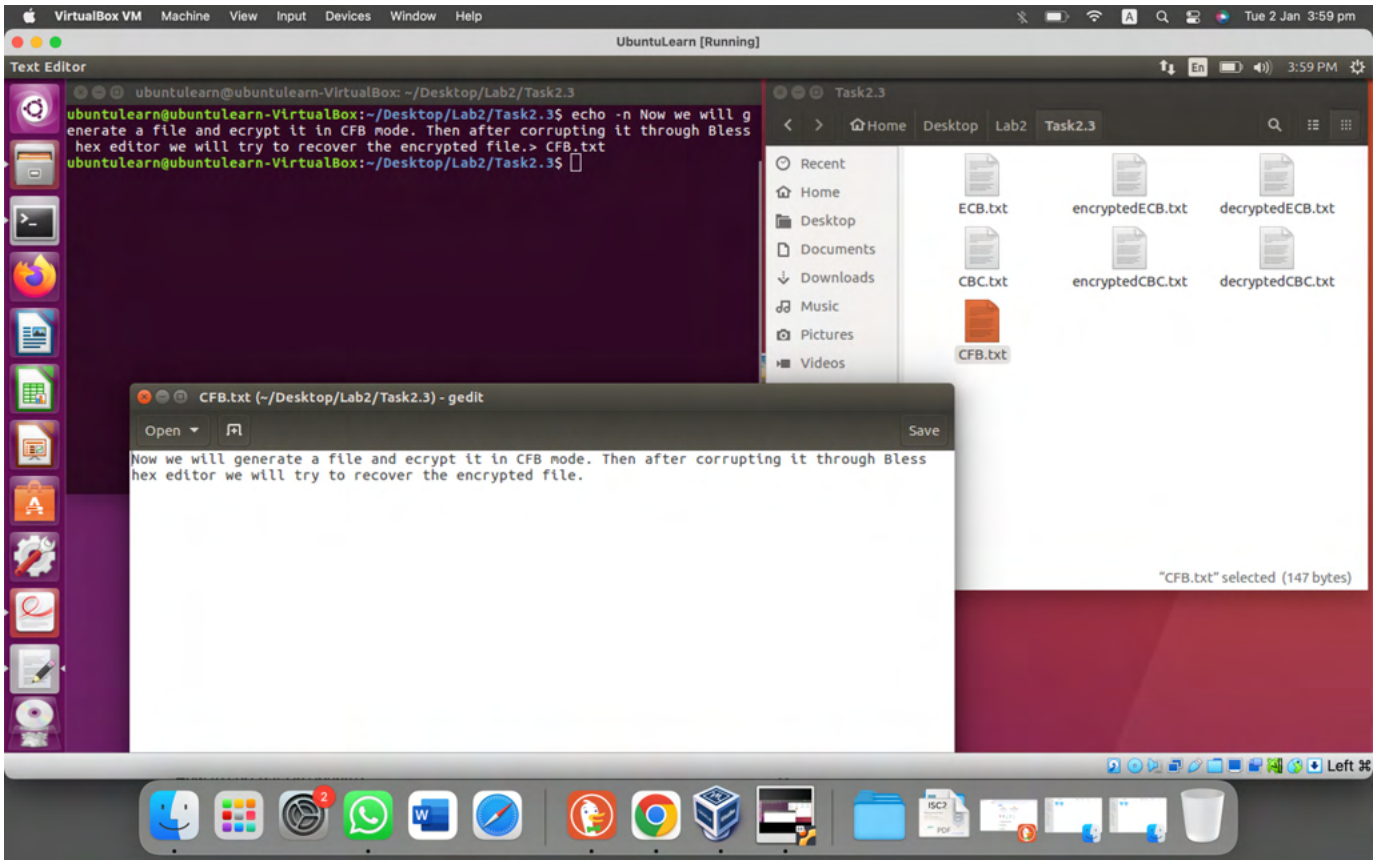


We observe that entire 2nd block is corrupted, 1 byte of third block (46th byte to be precise because it is xored with 30th byte of 2nd block) is corrupted and then rest of the content can be recovered.

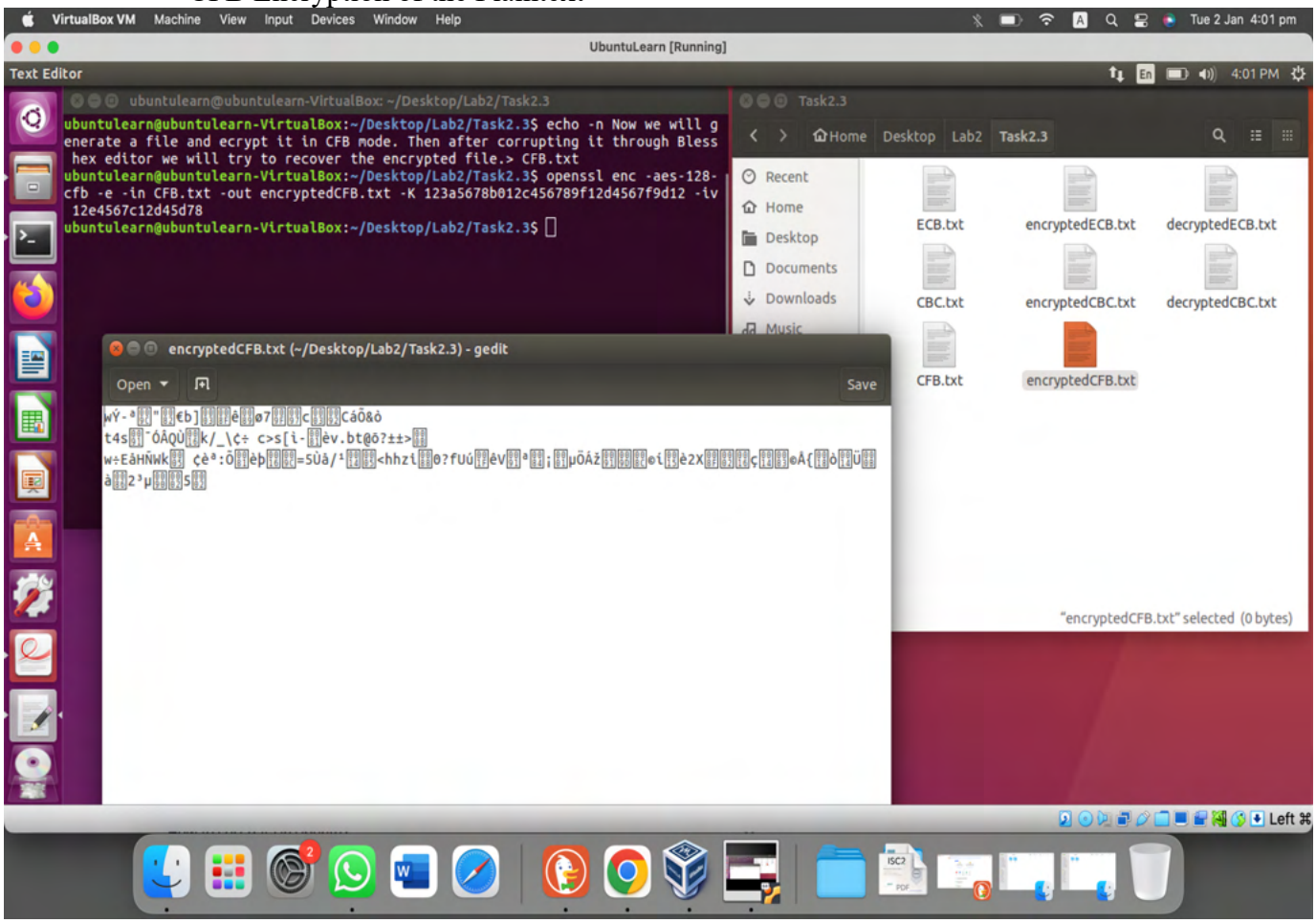
c. Encryption Mode: CFB

A text file is generated to be encrypted in CFB Mode

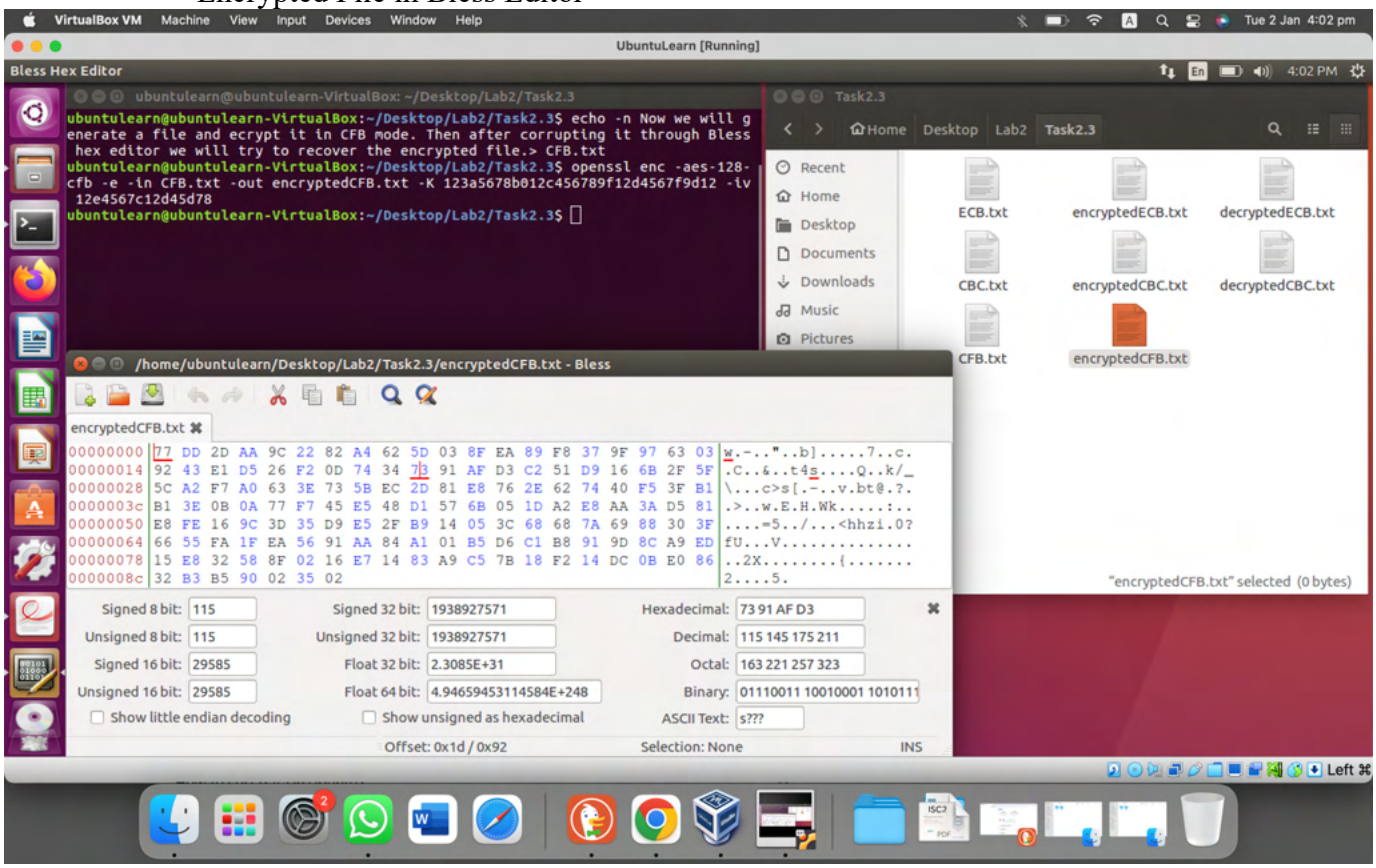
The Plaintext



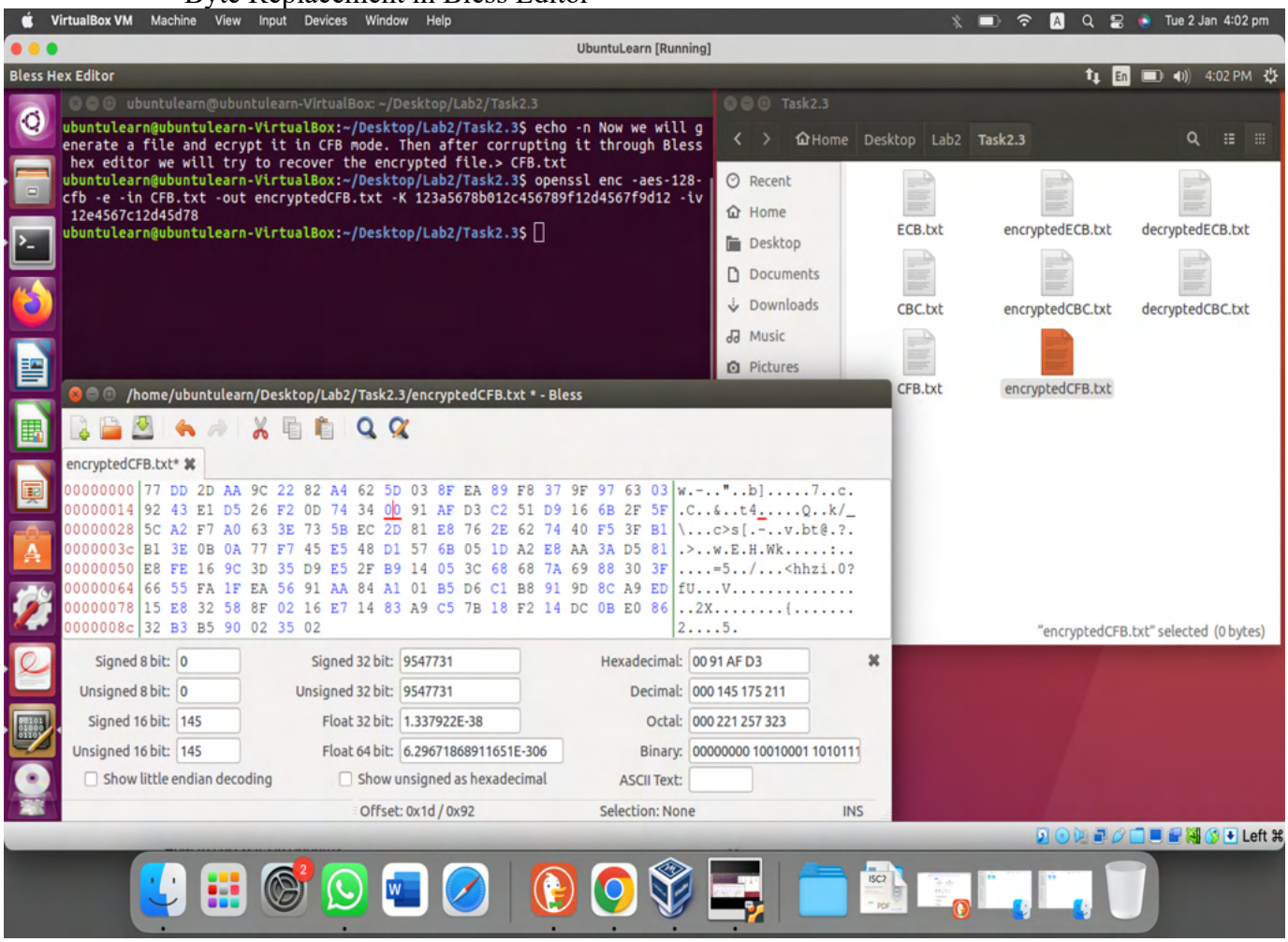
CFB Encryption of the Plaintext



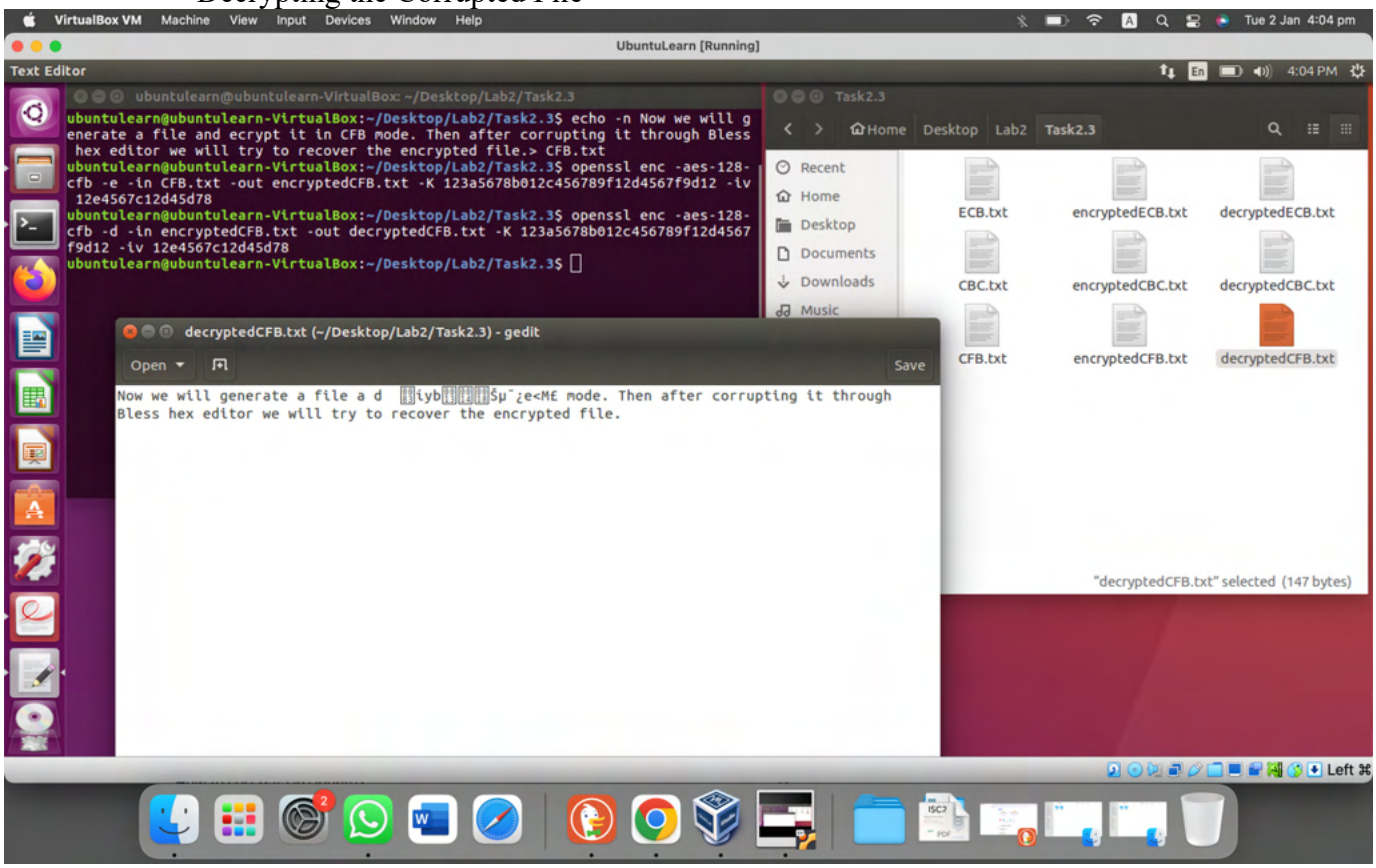
Encrypted File in Bless Editor

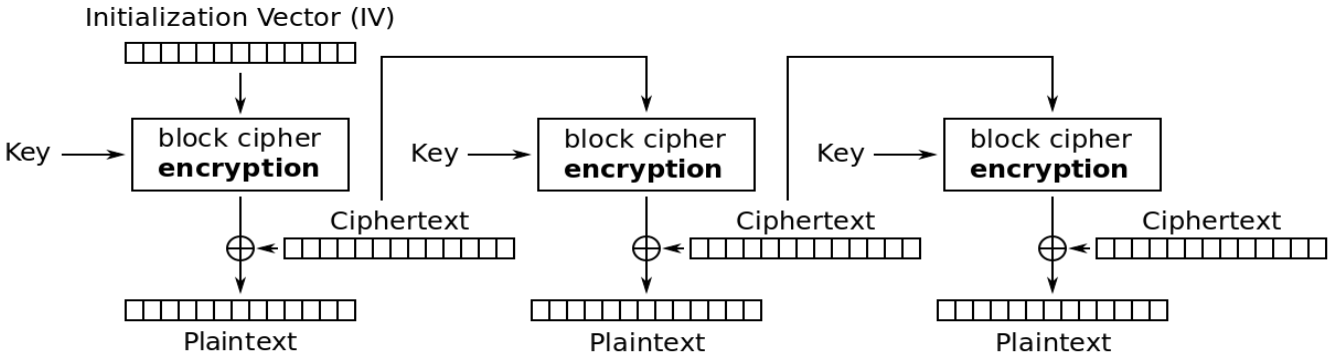


Byte Replacement in Bless Editor



Decrypting the Corrupted File



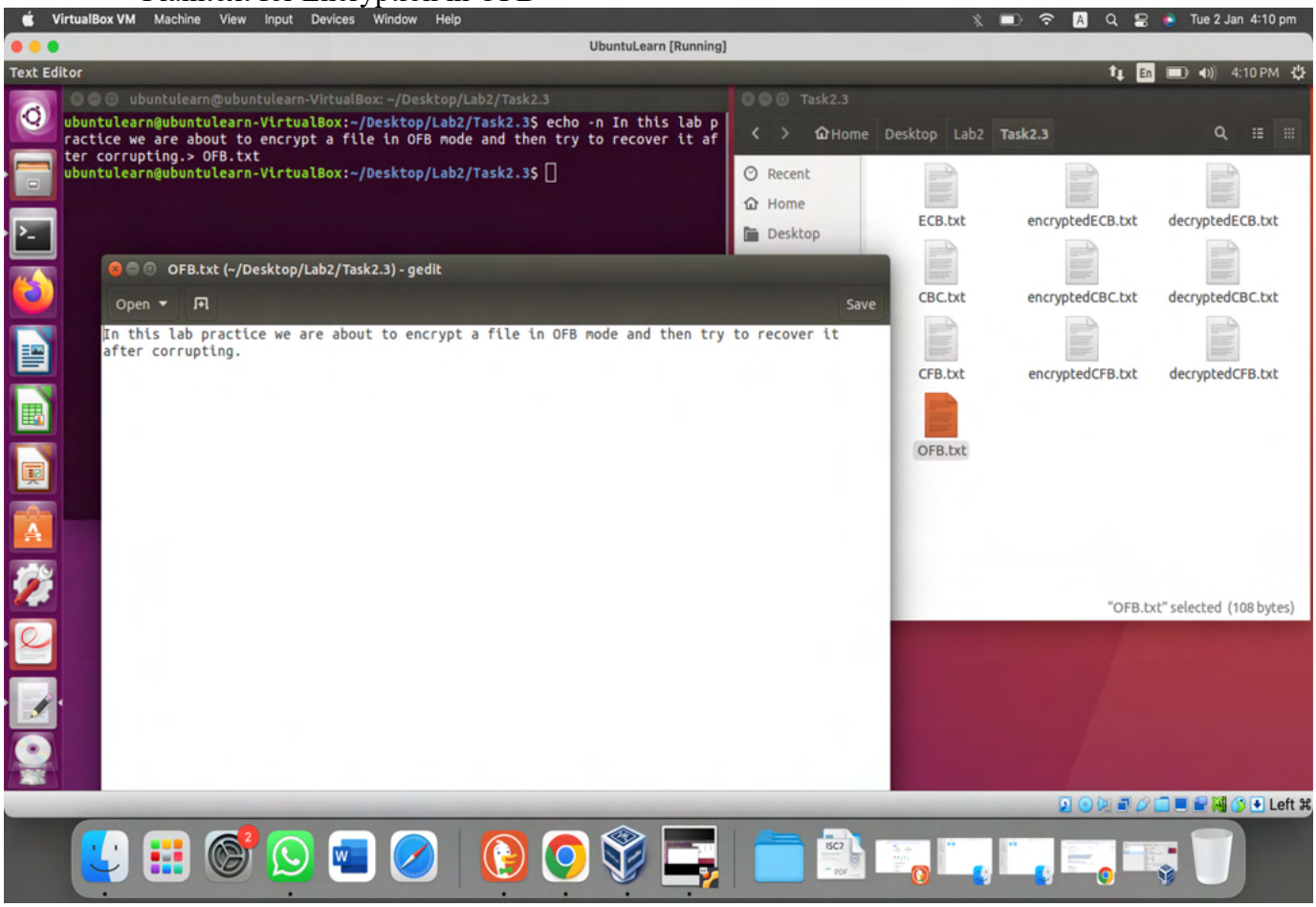


Cipher Feedback (CFB) mode decryption

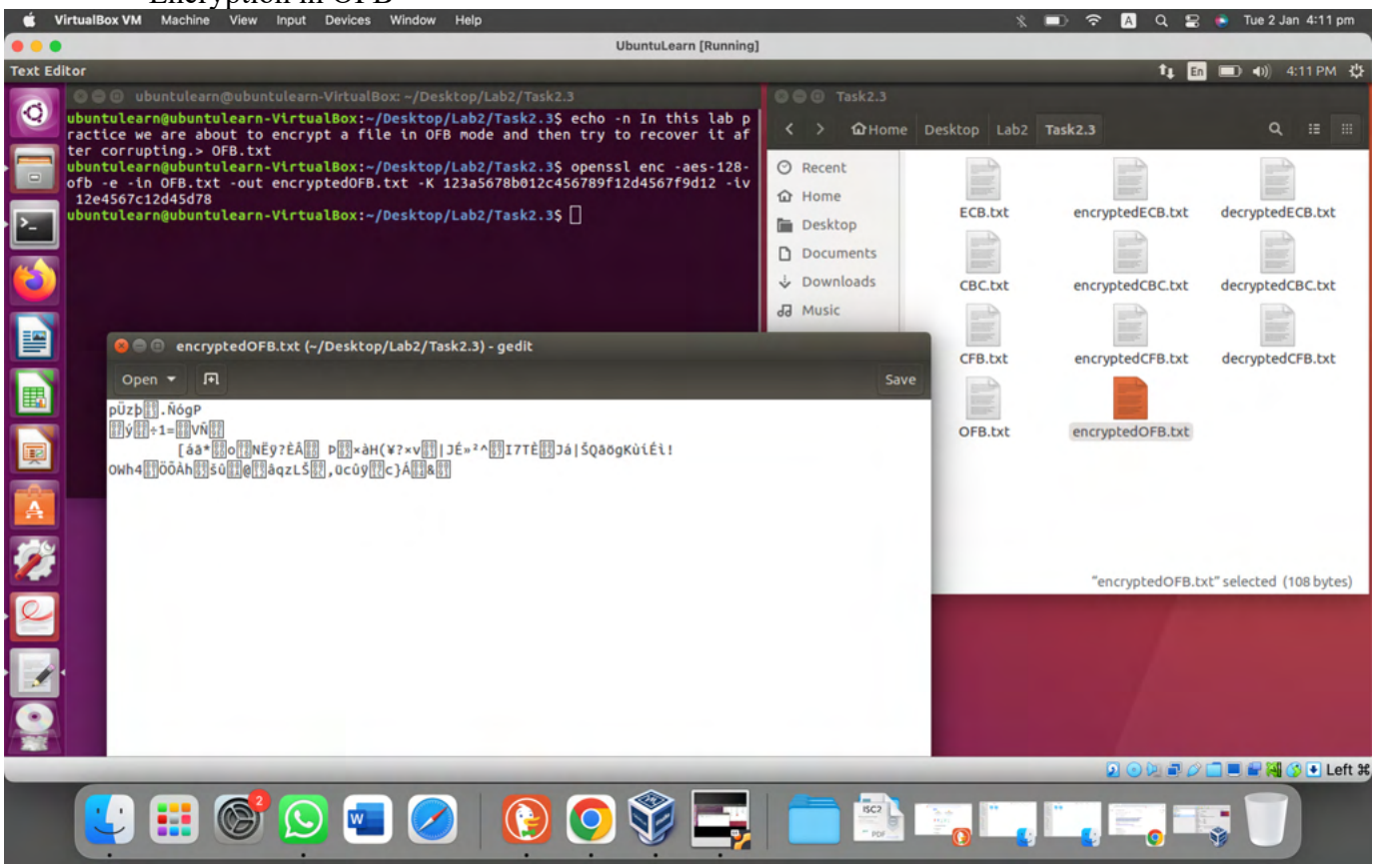
2nd block 1 byte is corrupted, 30th block is completely corrupted. Rest of the content is recovered. (In the decryption diagram above, ciphertext of 1st block is second to be decrypted and then xor is performed with ciphertext of 2nd block, so 1byte of plain text is corrupted, ciphertext of 2nd block is decrypted, so entire plain text of 3rd block is corrupted).

d. Encryption Mode: OFB

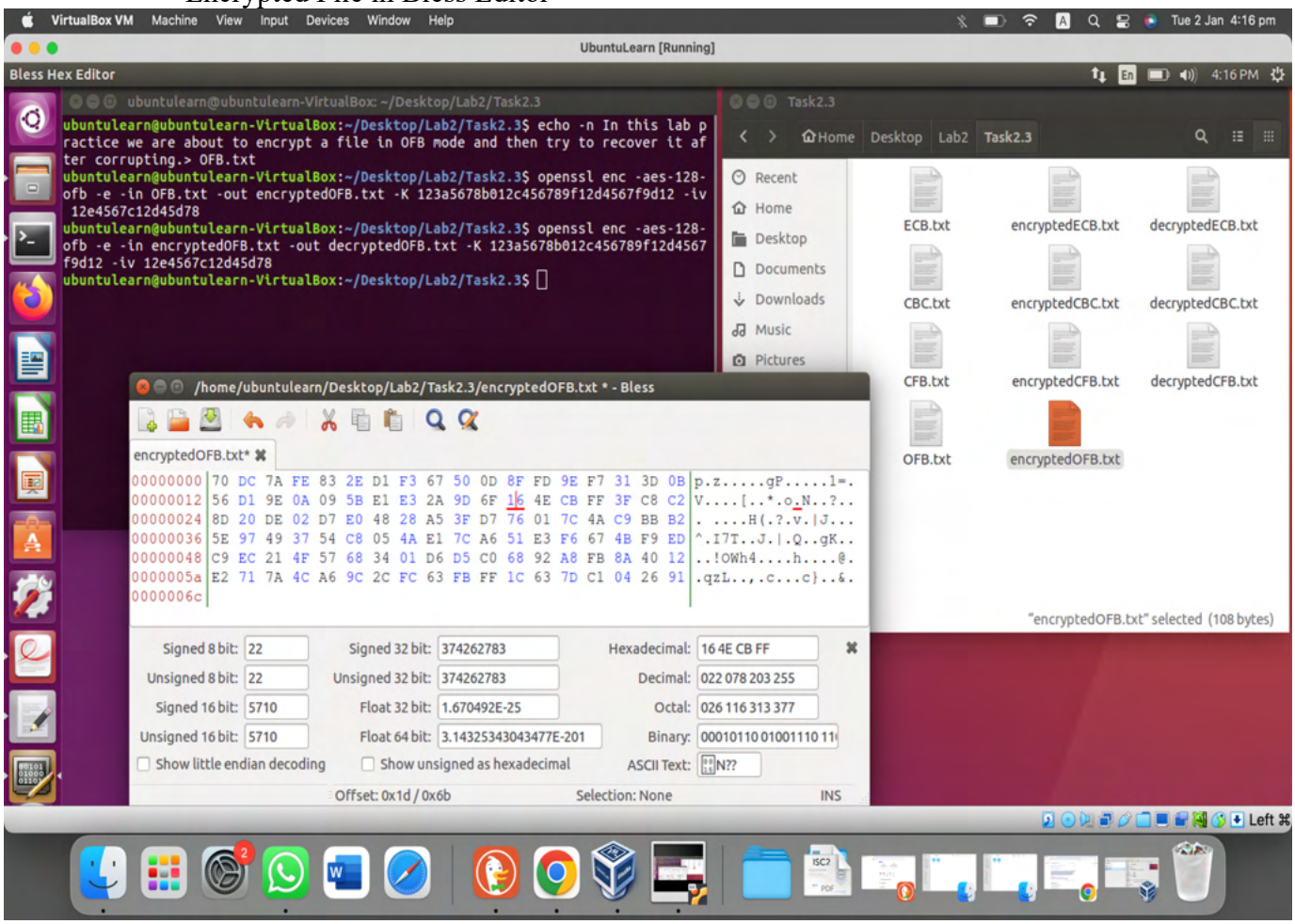
Plaintext for Encryption in OFB



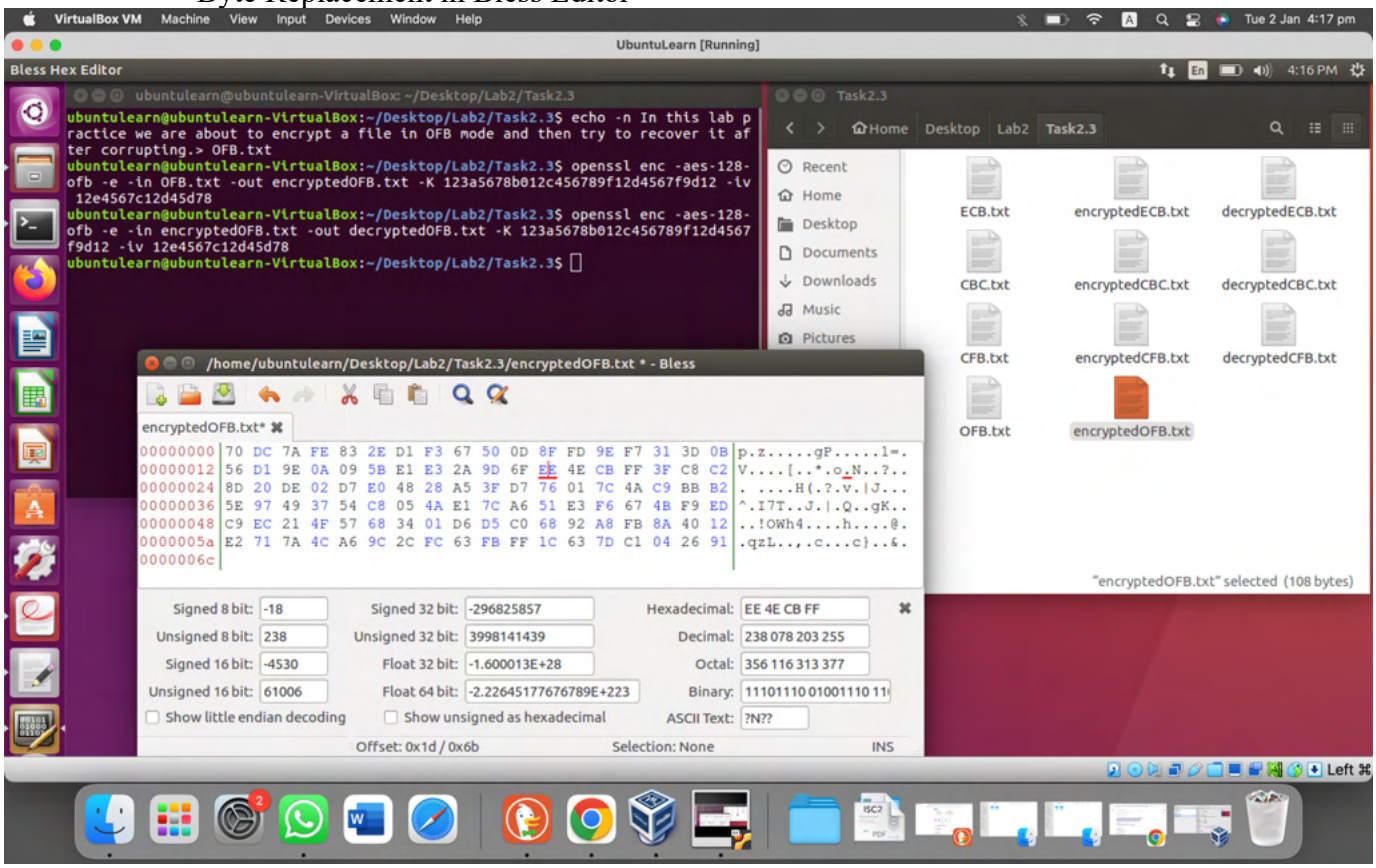
Encryption in OFB



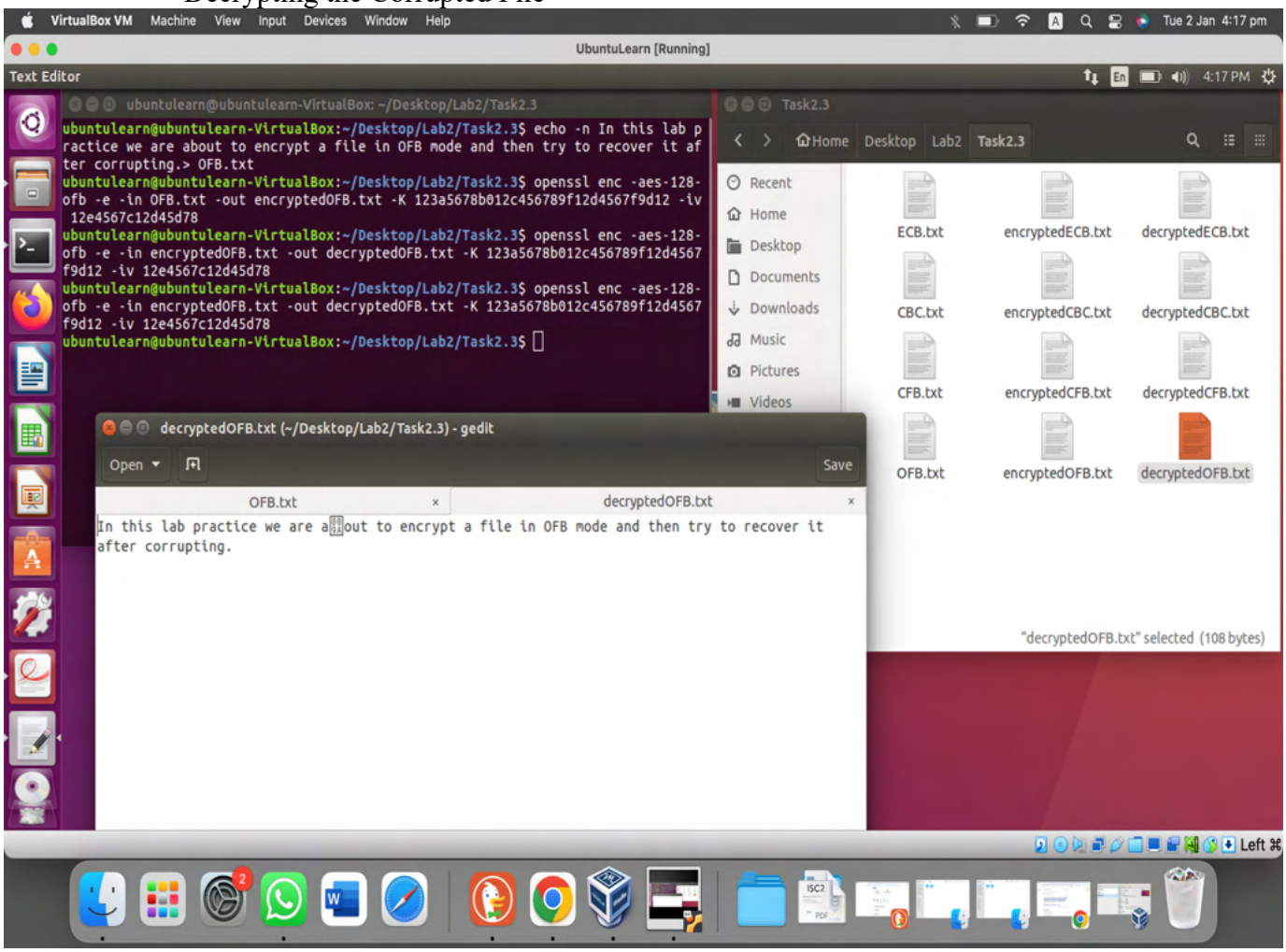
Encrypted File in Bless Editor

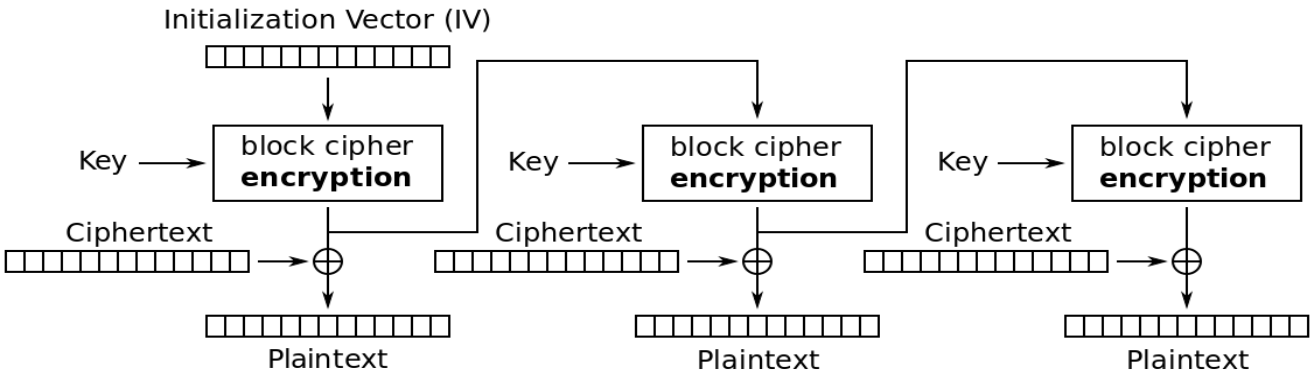


Byte Replacement in Bless Editor



Decrypting the Corrupted File





Output Feedback (OFB) mode decryption

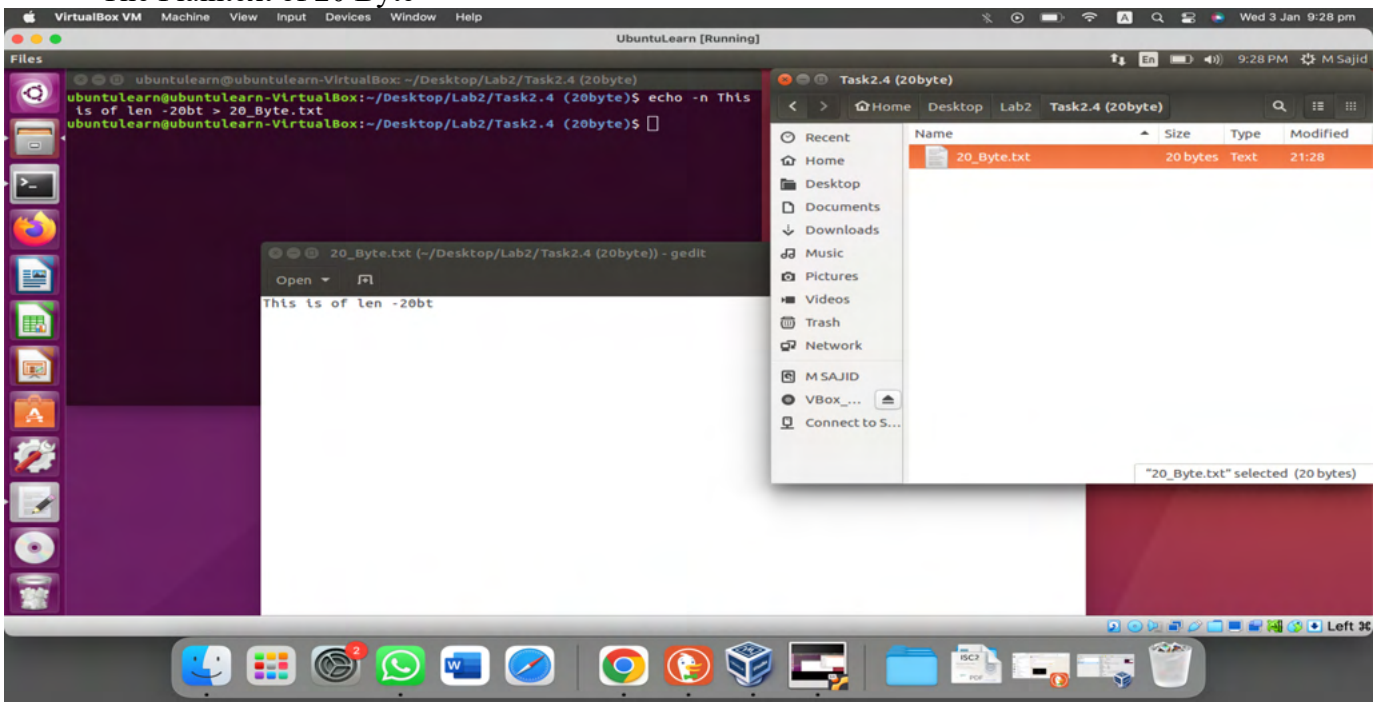
1st block is recovered, **1 byte of second block is corrupted**, Rest of the content is recovered after decryption. (Please observe _ character at 30th byte is corrupted, rest of the content is same as original text)

2.4. PADDING

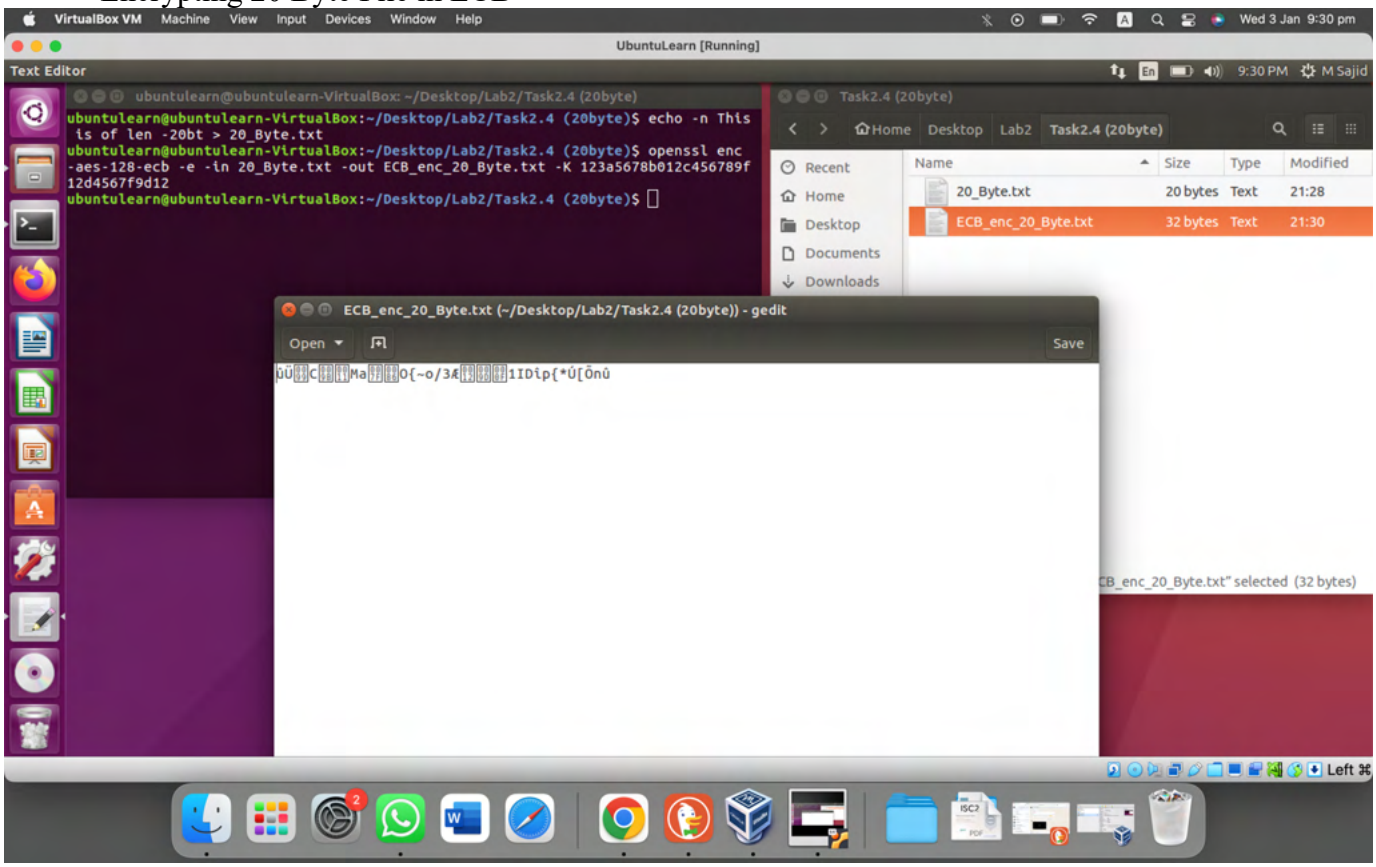
When the size of plaintext is not a multiple of the block size, padding is required. openssl uses PKCS5 standard for its padding. We will experiment to figure out the paddings in the AES encryption for text of length 20 and 32 bytes. In AES-128 each block should be 16 bytes long to encrypt. Any size that is not multiple of 16 is padded accordingly

a. 20 Byte File Encryption

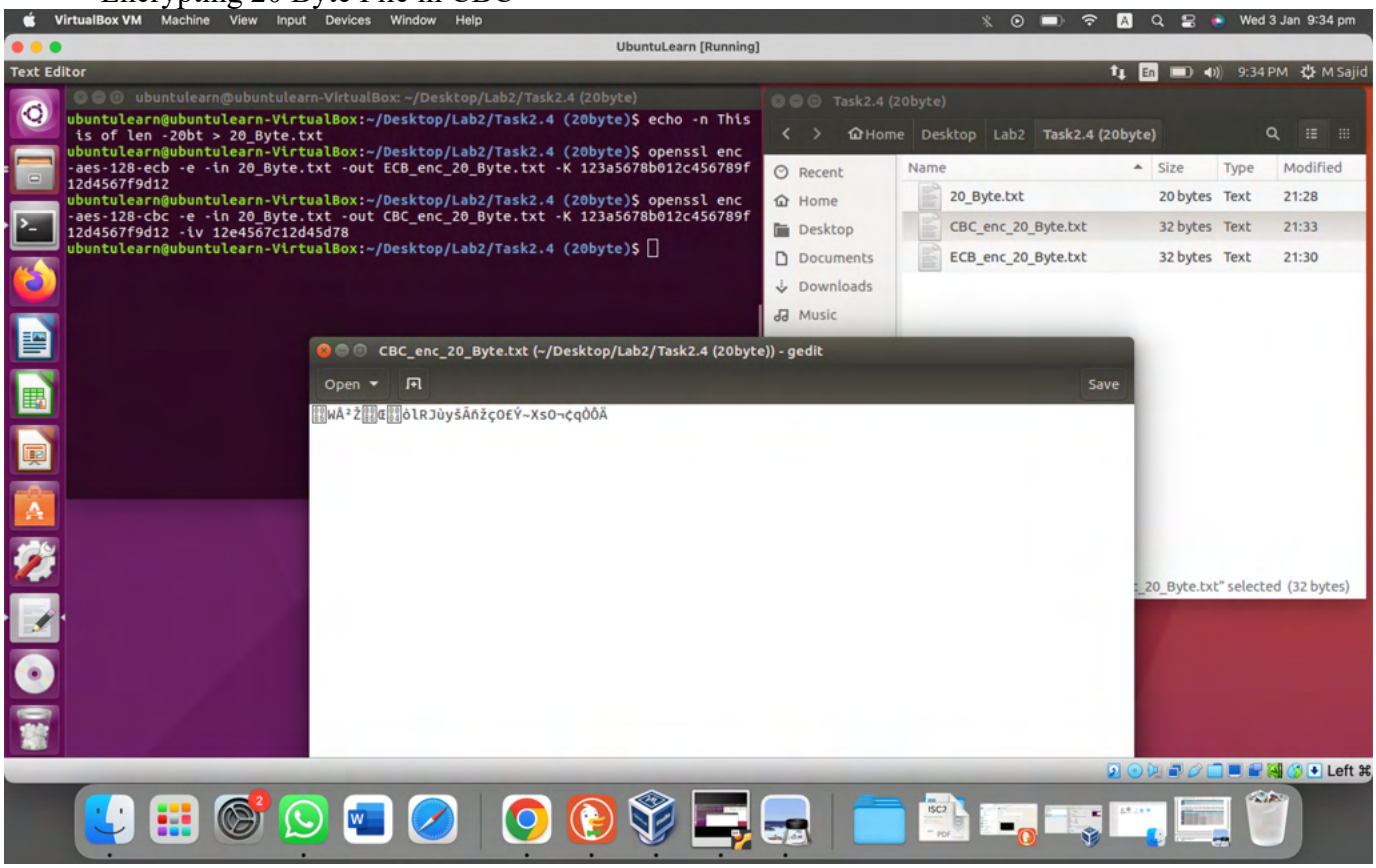
The Plaintext of 20 Byte



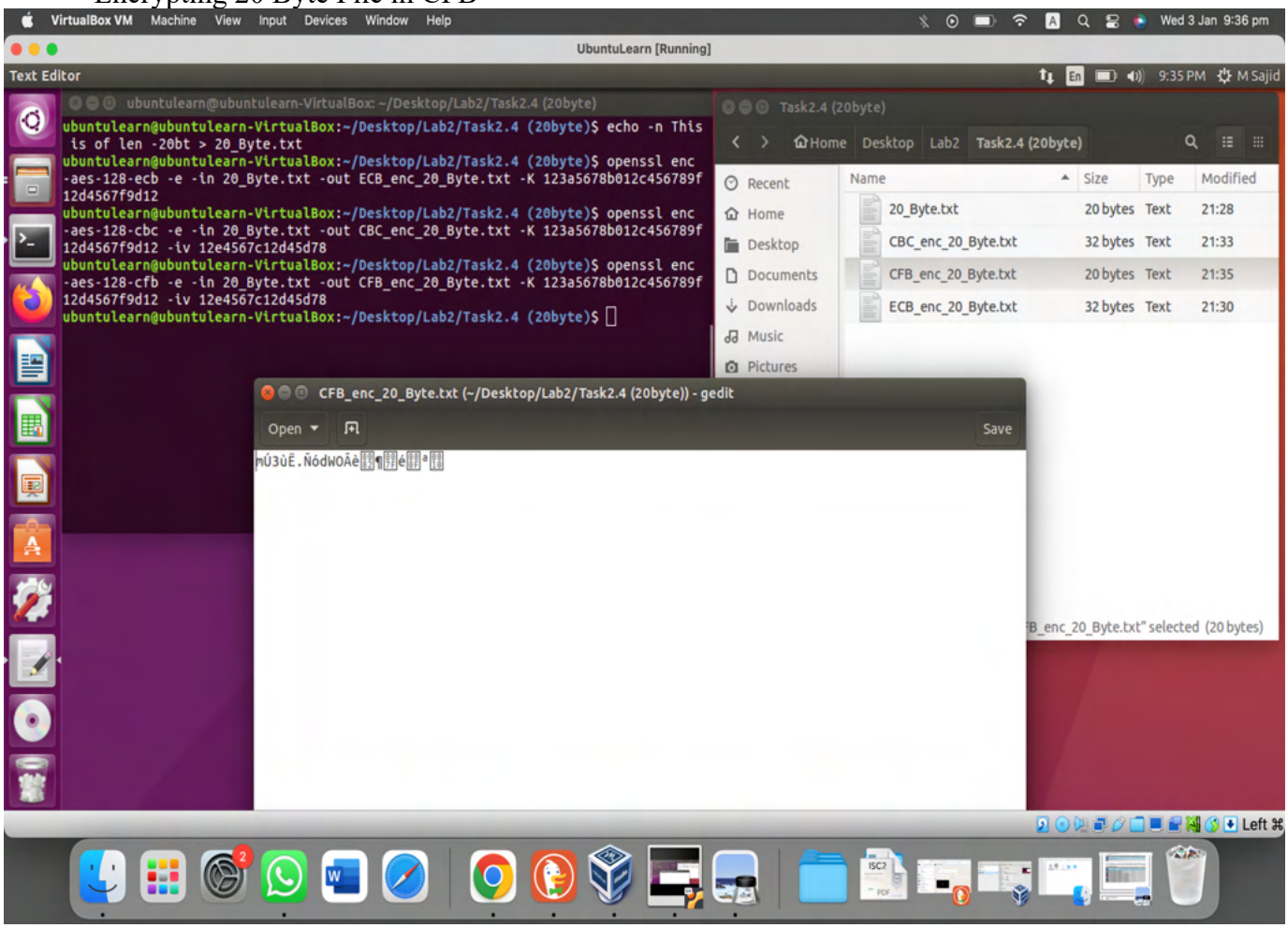
Encrypting 20 Byte File in ECB



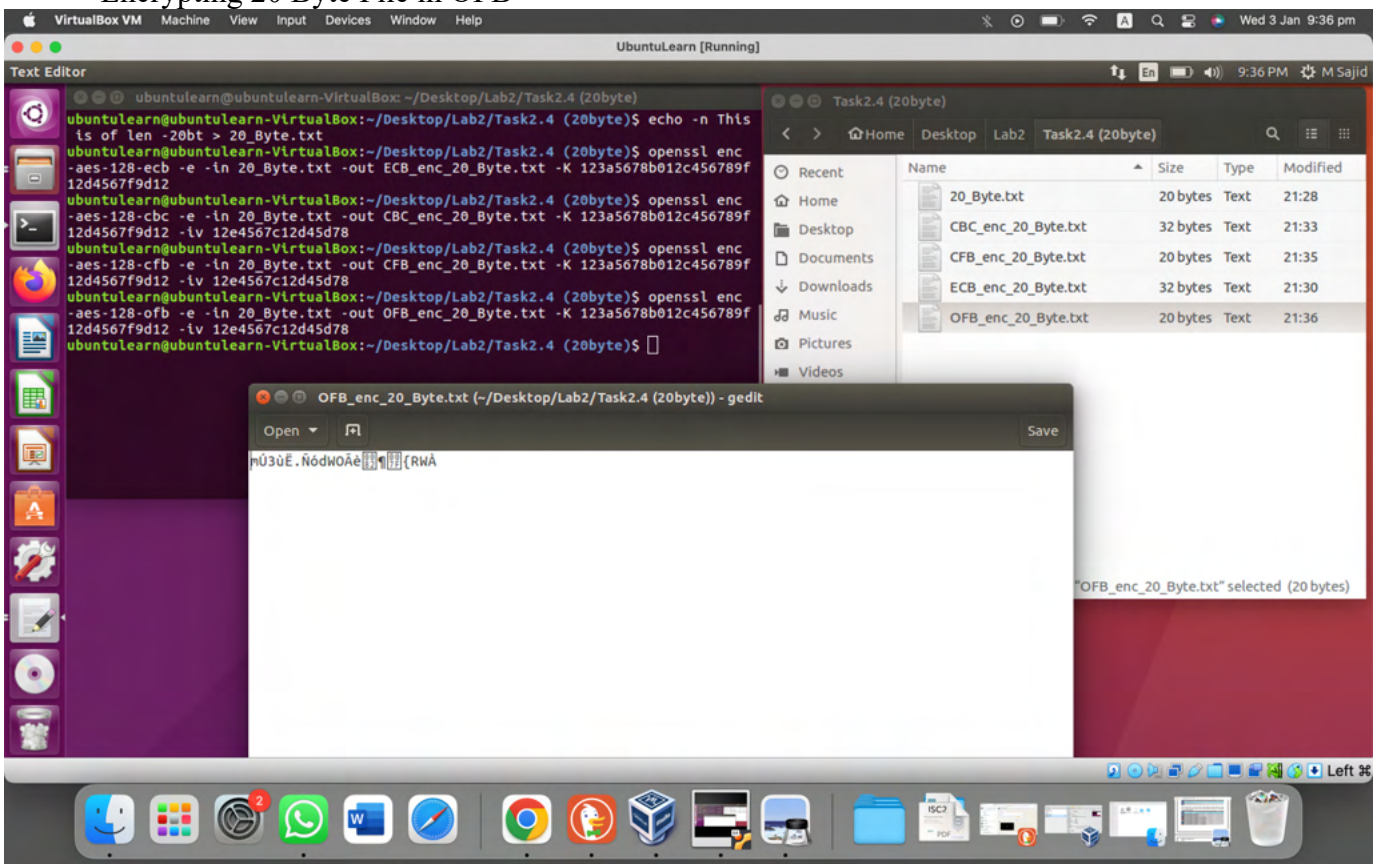
Encrypting 20 Byte File in CBC



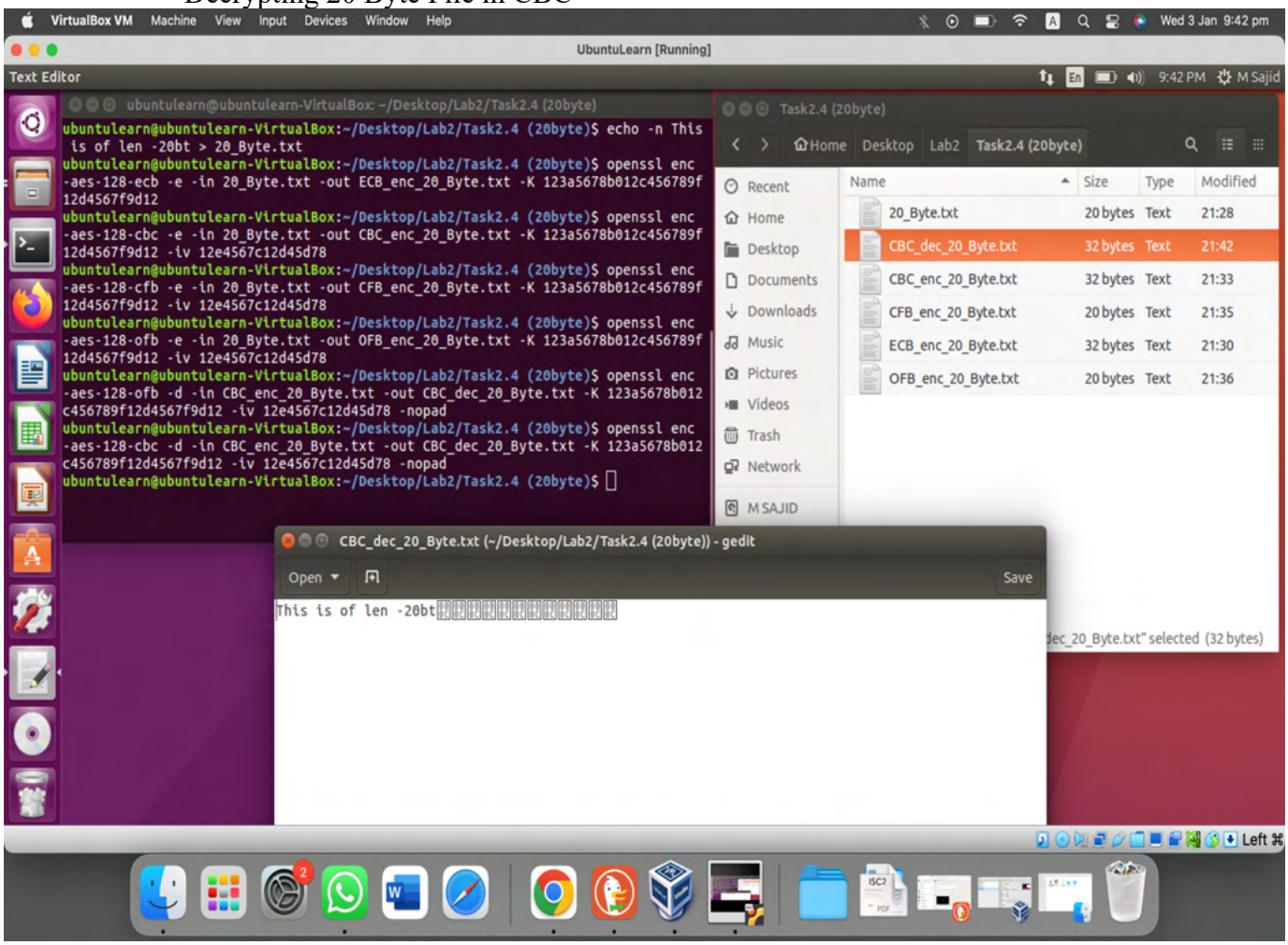
Encrypting 20 Byte File in CFB



Encrypting 20 Byte File in OFB

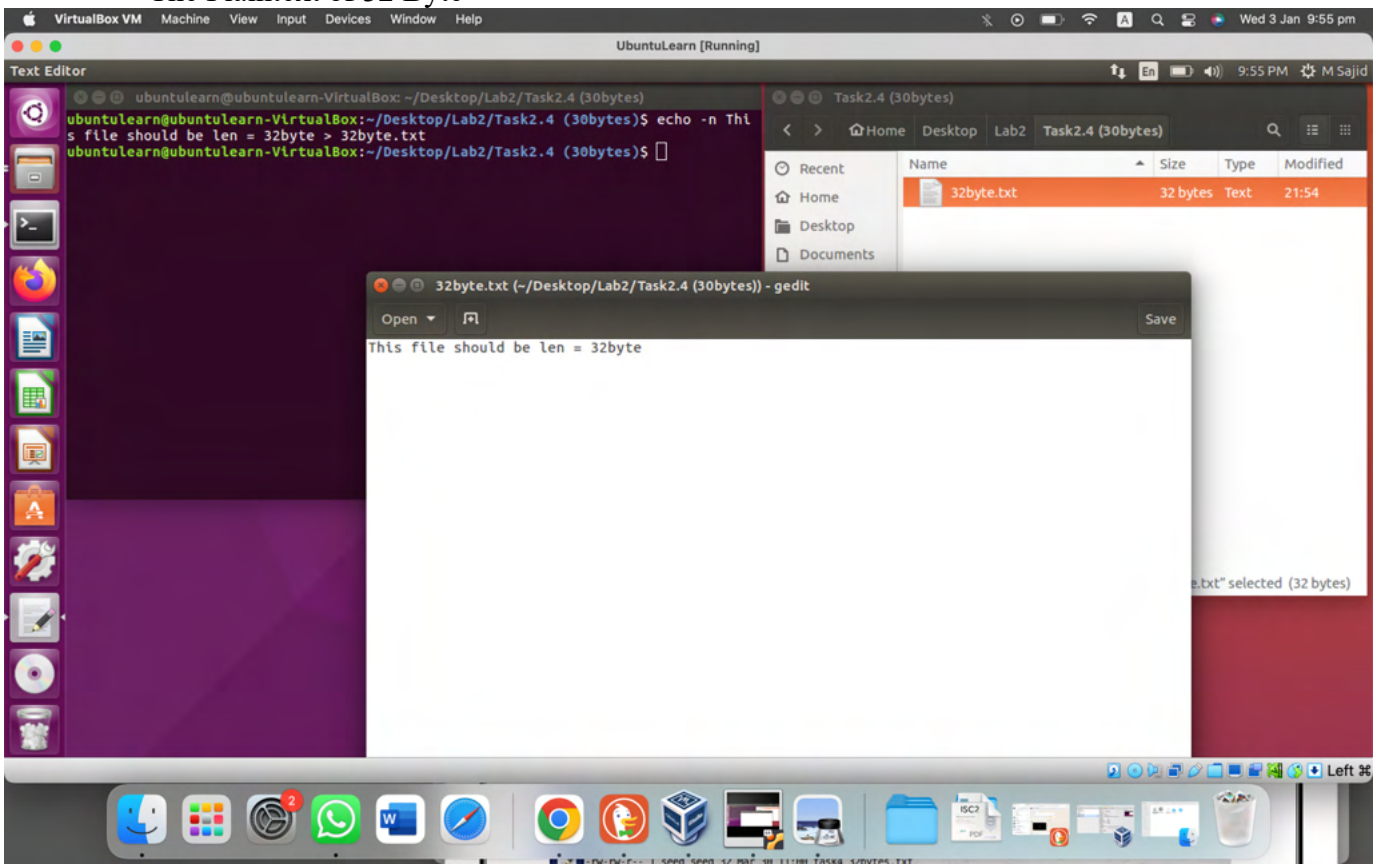


Decrypting 20 Byte File in CBC

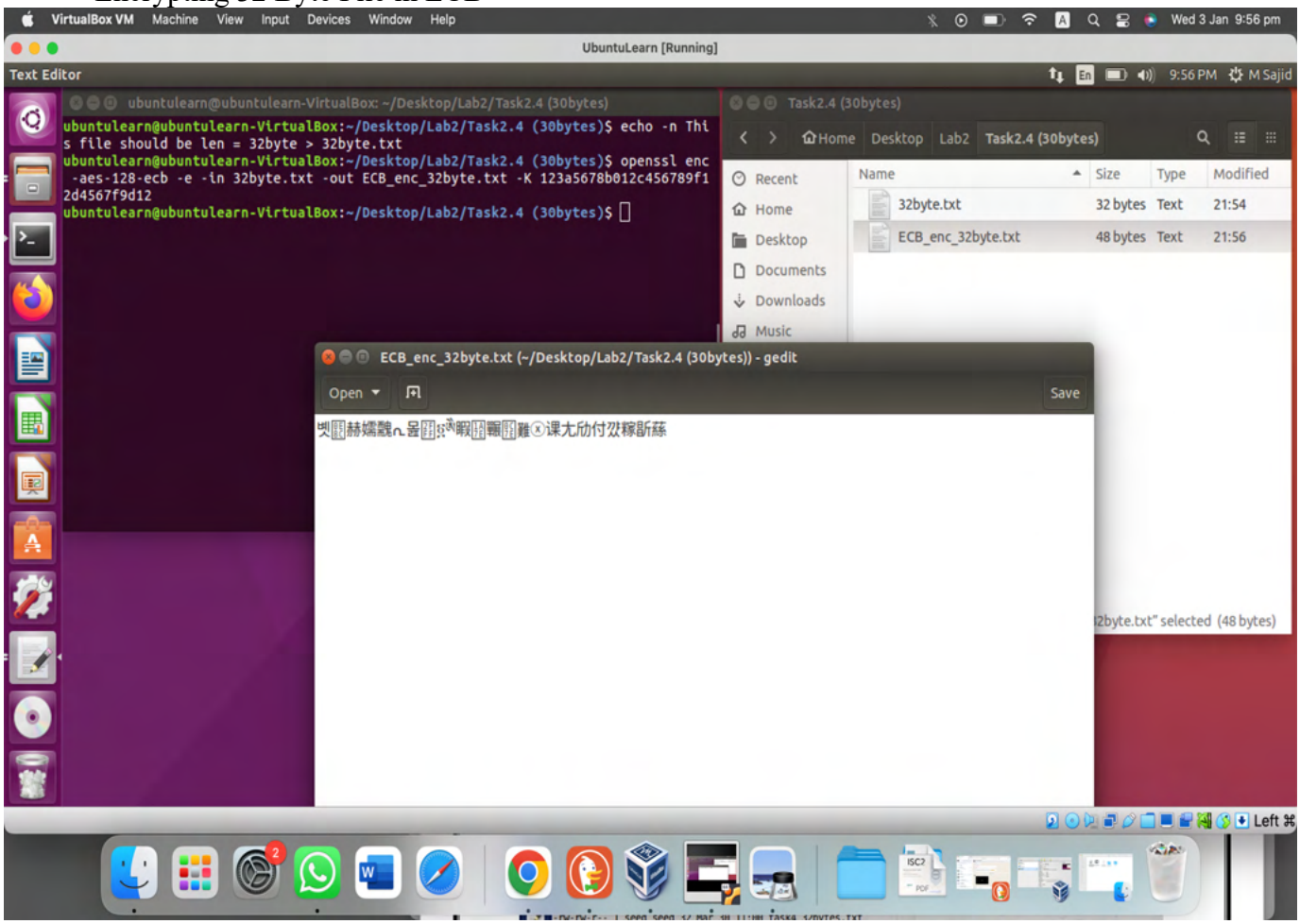


b. 32 Byte File Encryption

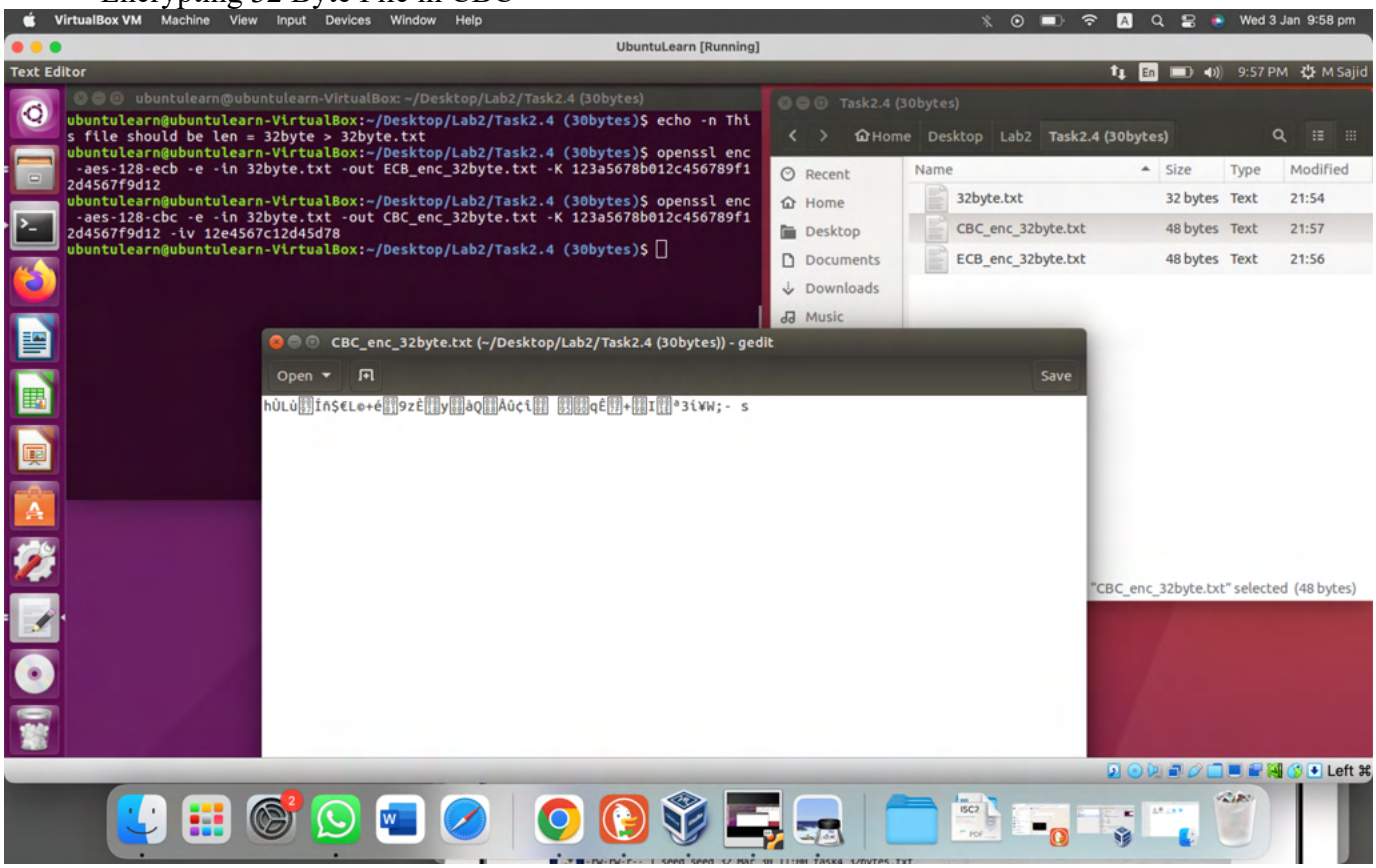
The Plaintext of 32 Byte



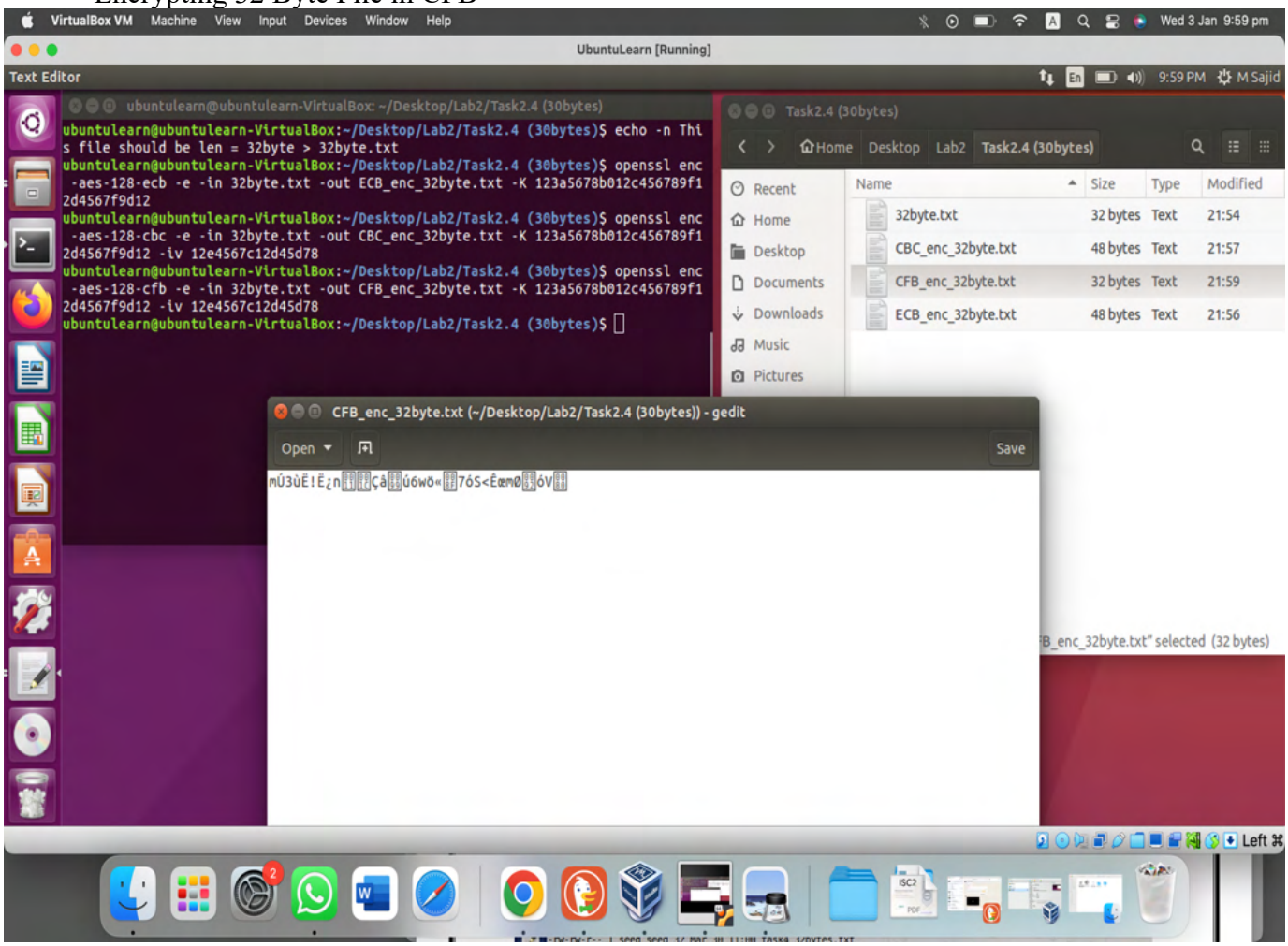
Encrypting 32 Byte File in ECB



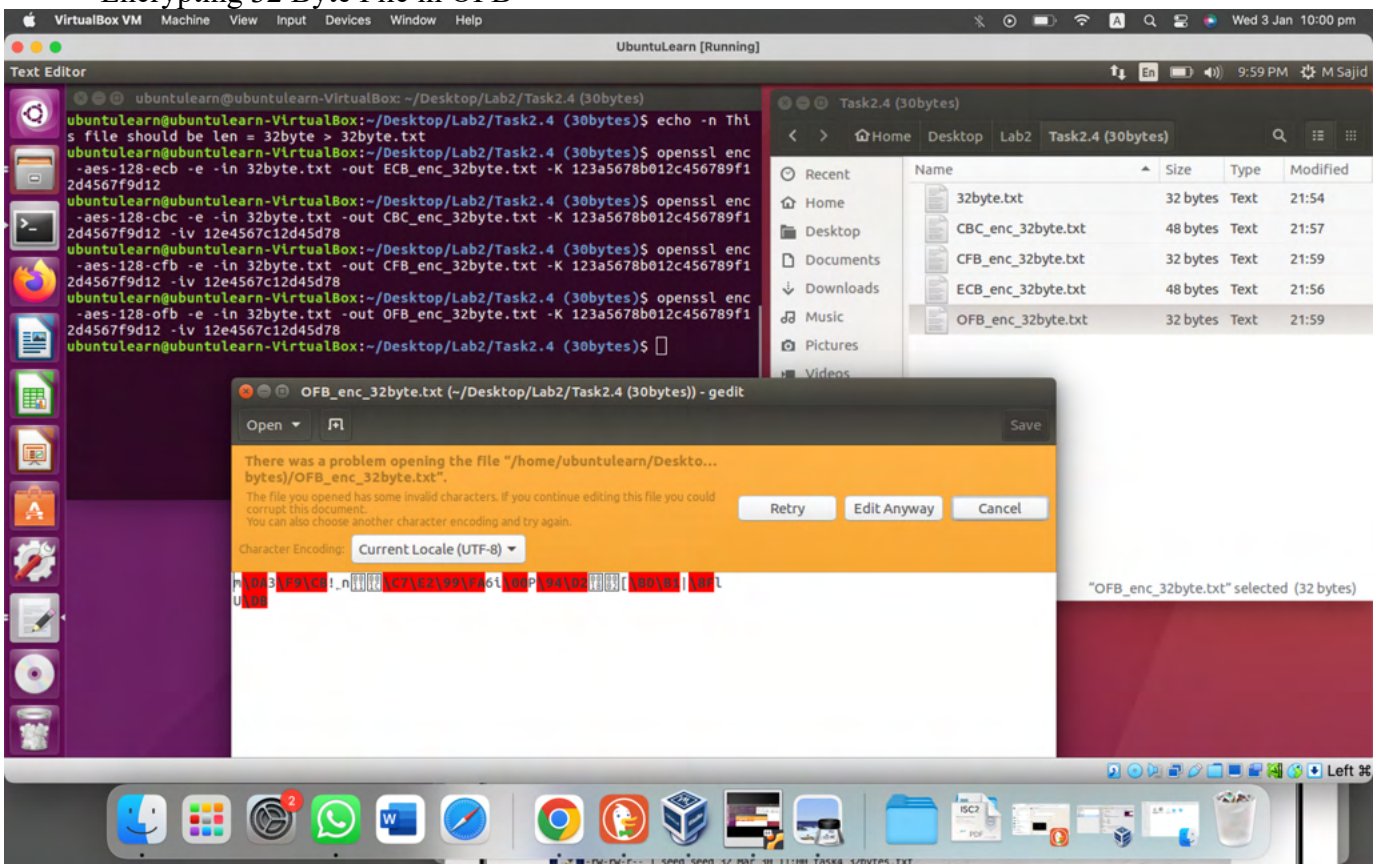
Encrypting 32 Byte File in CBC



Encrypting 32 Byte File in CFB



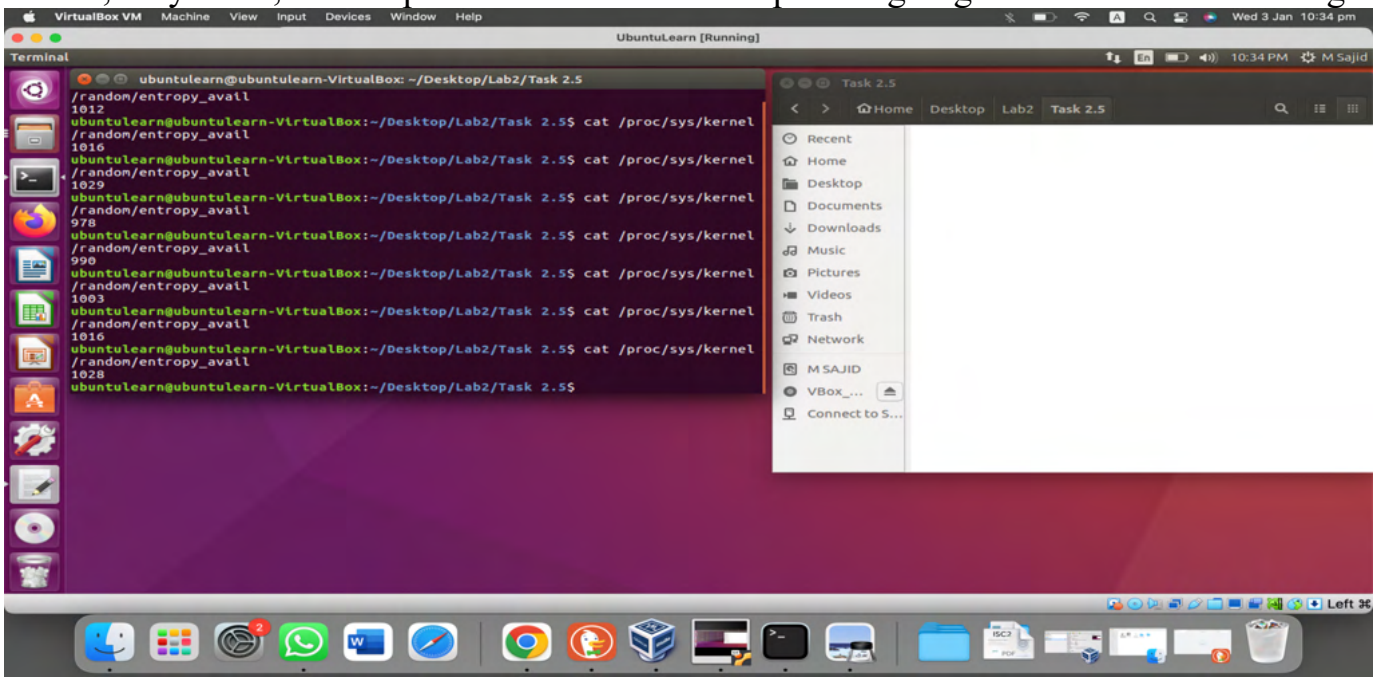
Encrypting 32 Byte File in OFB



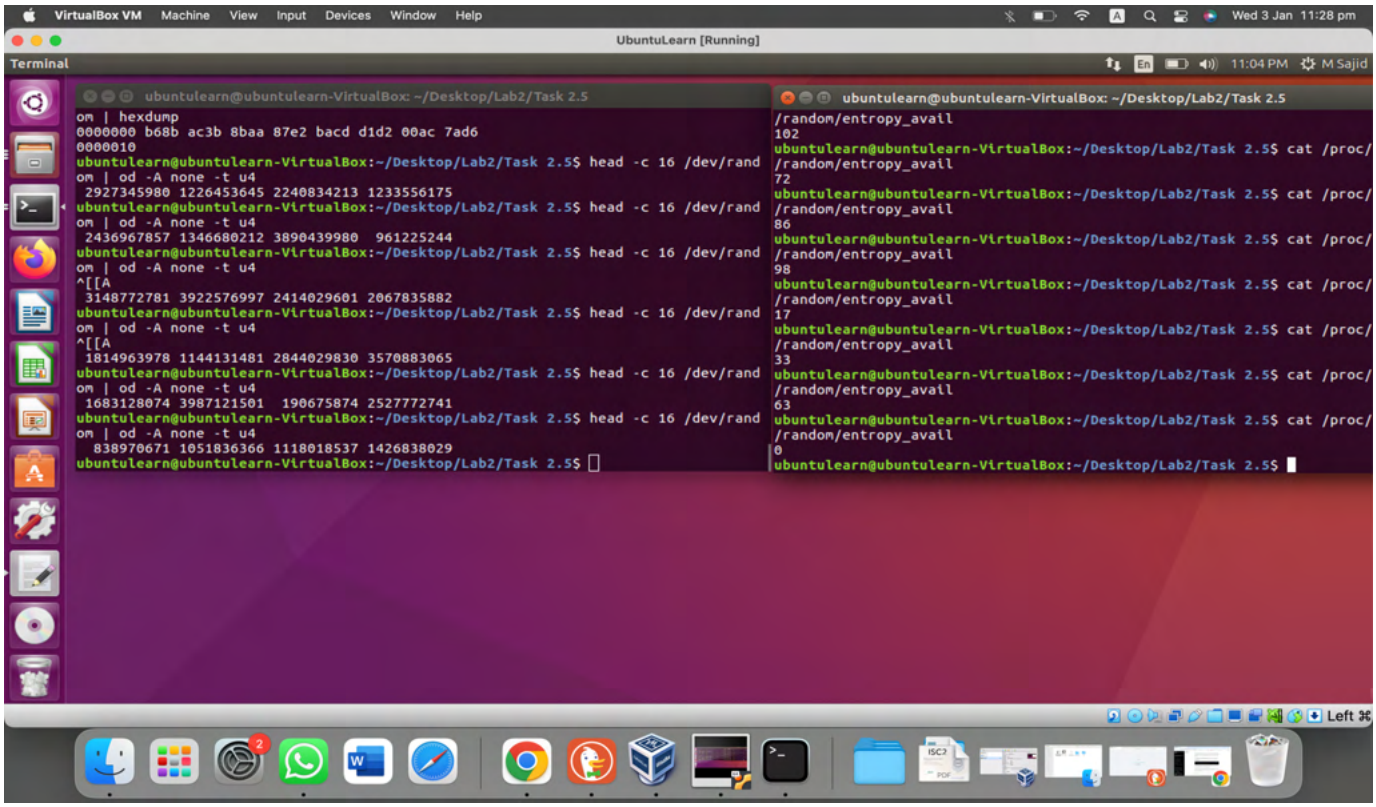
2.5. Pseudo Random Number Generation

a. Measure the Entropy of Kernel

Software might not be good at generating randomness, so it has to resort to physical world to gain the randomness. Some events can be finishing time of block device requests, inter-key press timings, mouse movements etc. Randomness is measured using entropy, It simply means how many bits of random numbers the system currently has. As we keep on moving the mouse and type some command before executing the "cat /proc/sys/kernel/random/entropy_avail" value increases with randomness like moving mouse and giving inputs through keyboard. As the system goes idle with less randomness of mouse, keyboard, interrupts the value also keeps on going down as in the image:

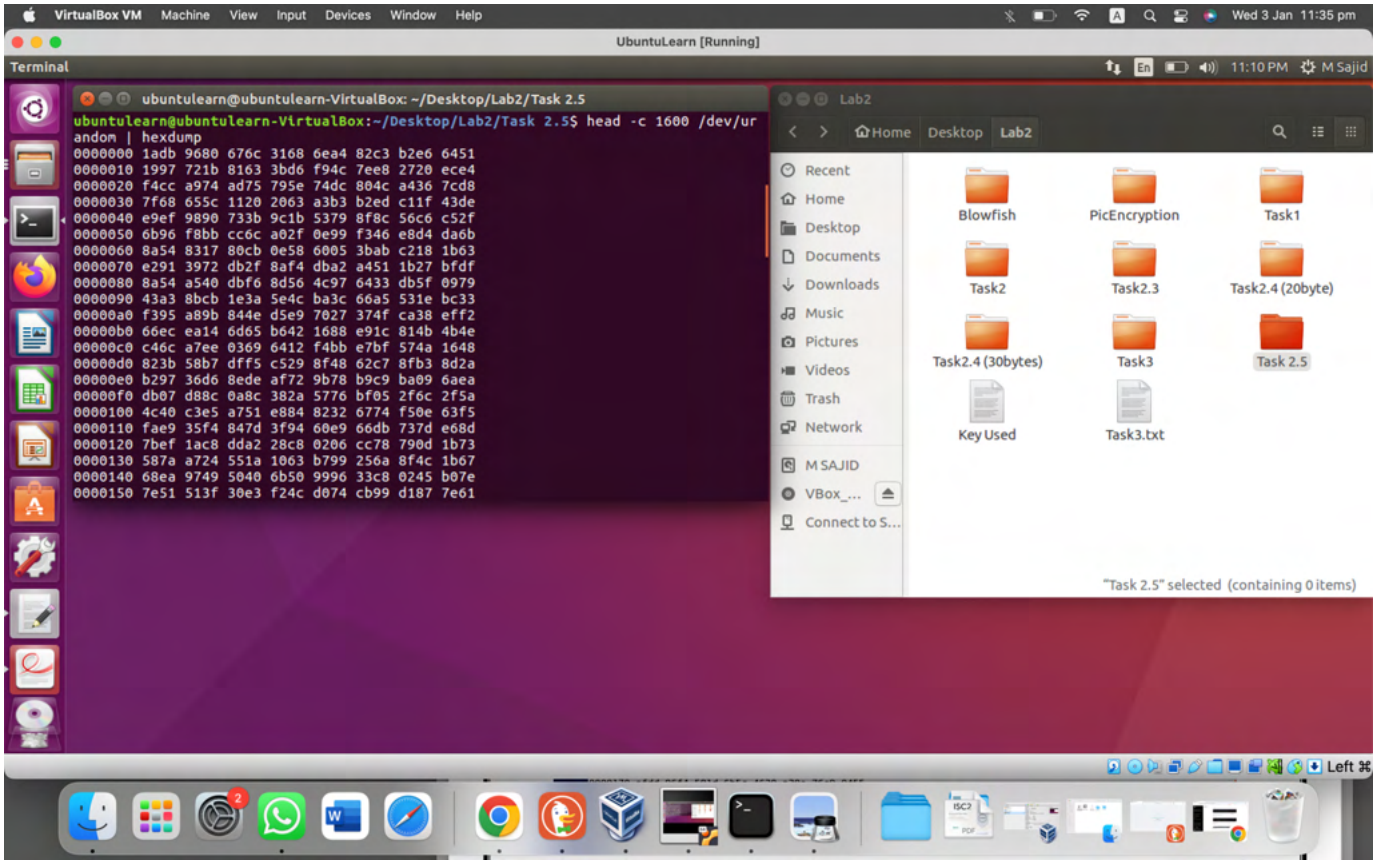


b. Pseudo Random Numbers from /dev/random



c. Get Random Numbers from /dev/urandom

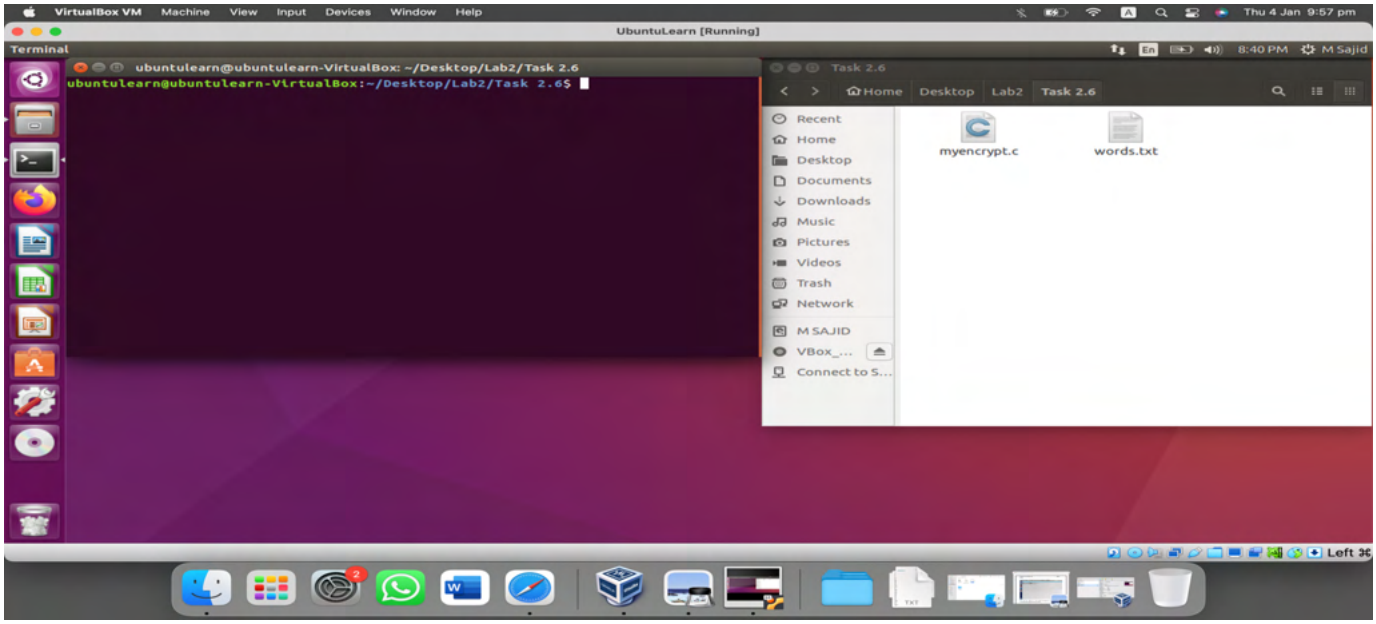
/dev/urandom device doesn't block even if the entropy of the pool runs low. /dev/urandom tries to reseed when new random data is available, It is recommend to use /dev/urandom because /dev/random may lead to denial of service attacks. With /dev/urandom it was not blocked even after running multiple iterations



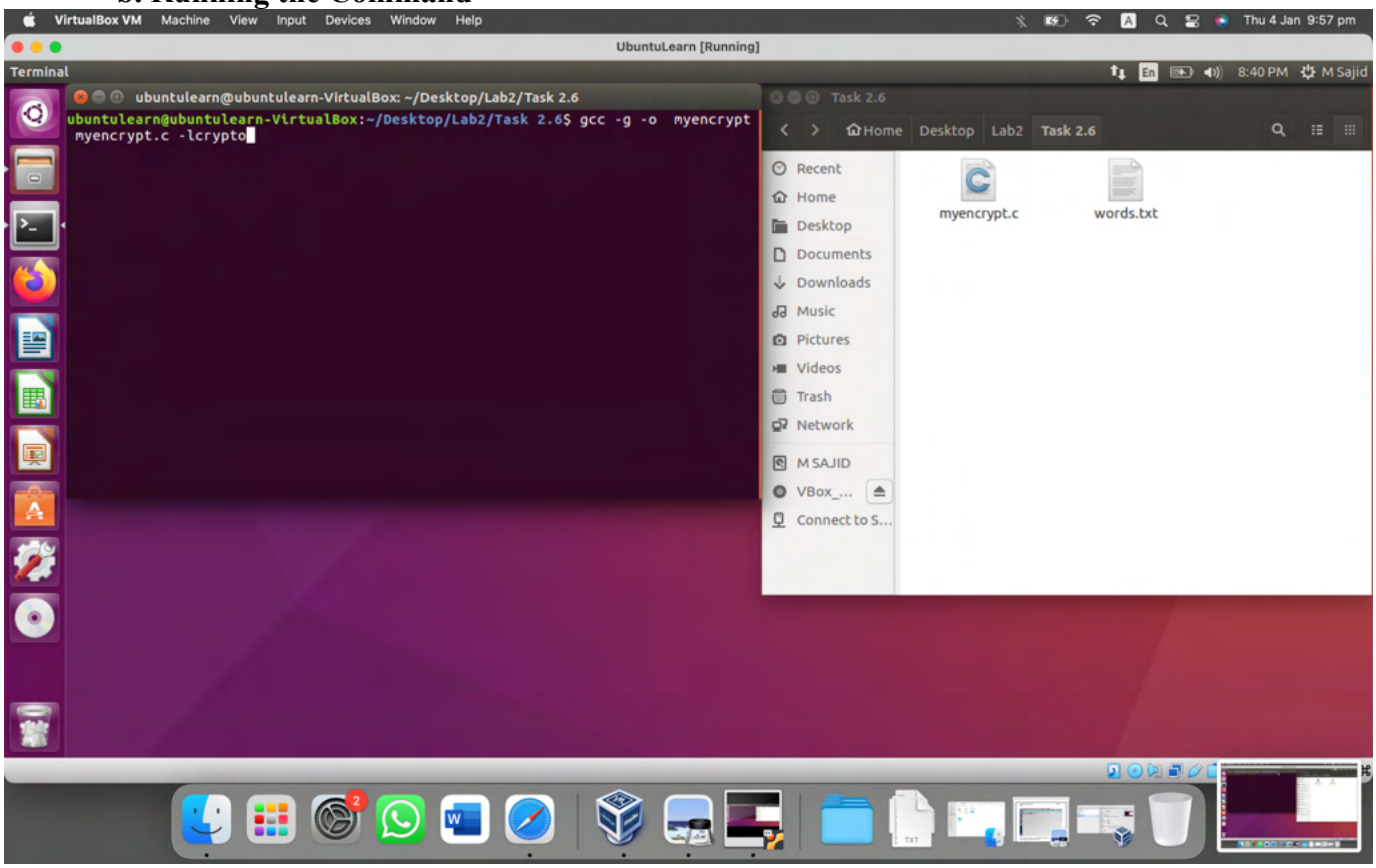
2.6. Programming using the Crypto Library

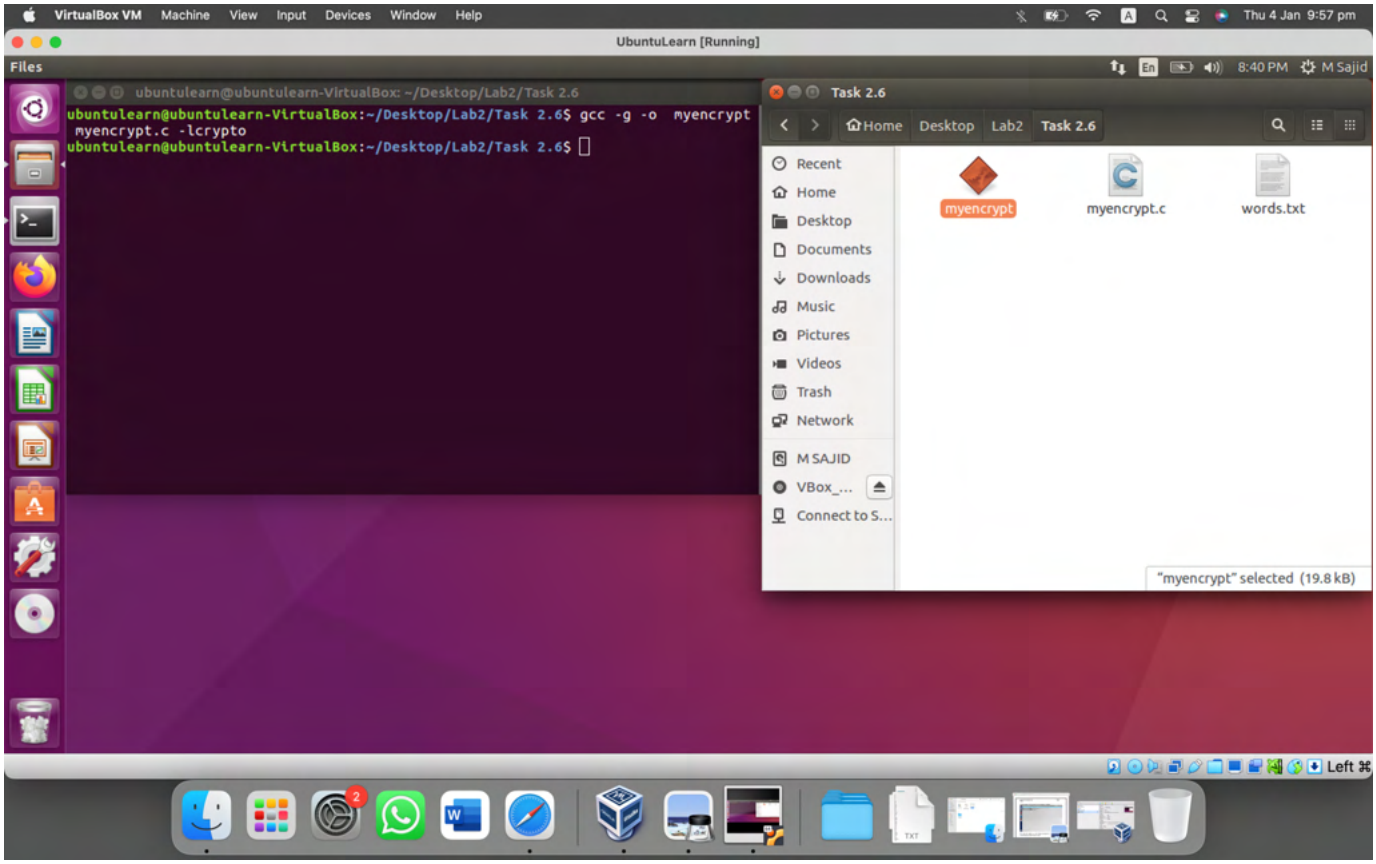
In this task, we are given a plaintext and ciphertext, and we are using aes-128-cbc to generate ciphertext from plaintext. We are told that initialization vectors are zero. (-iv argument in openssl enc command). Another clue is that the key used to encrypt the plain text is an English word shorter than 16 characters. Since the key has less than 16 bytes, space characters are appended to the end of word to form 128 bits. We have to write a program to find this key.

a. The Available Files



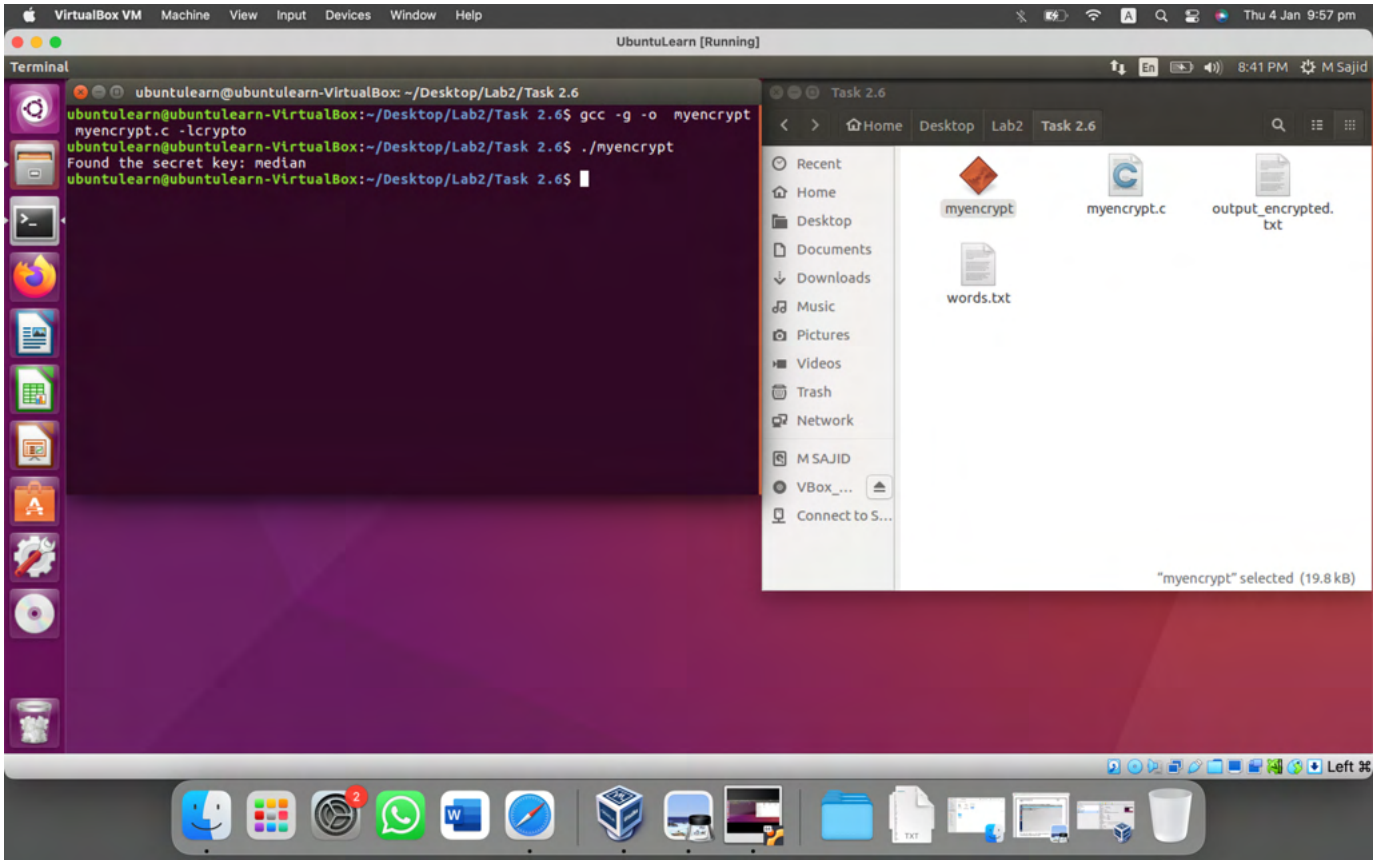
b. Running the Command

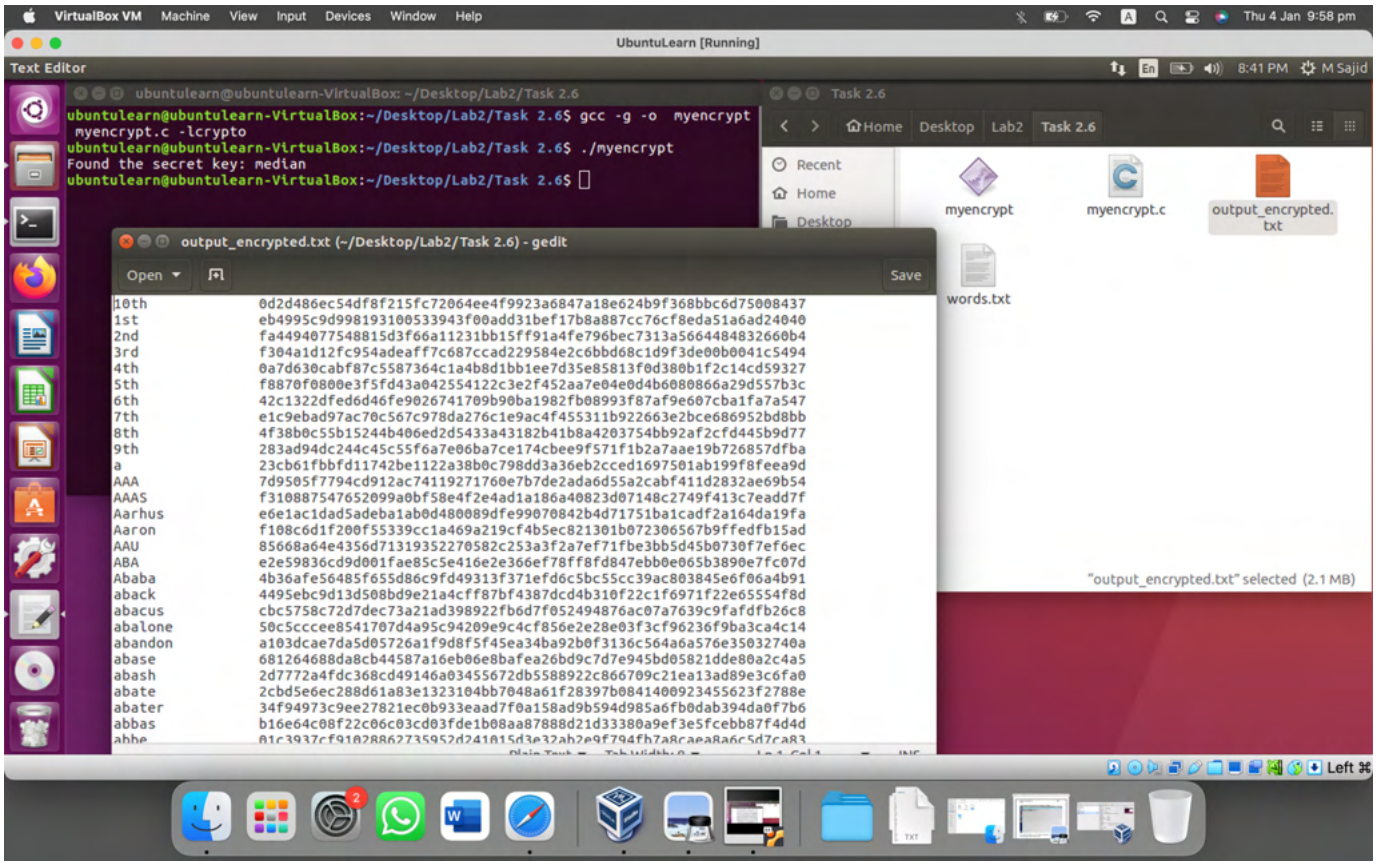




c. Program Output

The secret key in our example is “median”





d. Actual Program:

```
#include<stdio.h>
#include<string.h>
#include<stdlib.h>
#include<openssl/evp.h>
void pad_with_spaces(char* singleword, int len) {
int curlen = strlen(singleword);
while (curlen < len) {
singleword[curlen] = ' ';
curlen++;
}
singleword[len] = '\0';
}
/*One problem I found out is that we need to pass unsigned char *buf (not char
*buf) because
otherwise each character is considered signed and hex digits are mostly printed
as fffff... */
void print_result_output_file(char singleword[], unsigned char *buf, int len,
FILE* outputList) {
for (int i = 0; i < 16; i++) {
fprintf(outputList, "%c", singleword[i]);
}
/* Add a space between key and encrypted string */
fprintf(outputList, "%c", ' ');
for (int i = 0; i < len; i++) {
fprintf(outputList, "%02x", buf[i]);
}
/* Add an end of file for each pair of key and encrypted string */
fprintf(outputList, "%c", '\n');
}
int main() {
int encryptp = 1;
// use aes-128-cbc to generate ciphertext from plaintext
unsigned char key[] = "00112233445566778899aabbccddeeff";
//unsigned char iv[] = "0102030405060708";
unsigned char iv[16] = {0}; //"0000000000000000" ; // "0102030405060708";
/* for (int i = 0; i < 16; i++) {
iv[i] = 0x00;
} */
/* Don't set key or IV right away ; we want to check lengths */
EVP_CIPHER_CTX ctx;
EVP_CIPHER_CTX_init(&ctx);
EVP_CipherInit_ex(&ctx, EVP_aes_128_cbc(), NULL, NULL, NULL, encryptp);
OPENSSL_assert(EVP_CIPHER_CTX_key_length(&ctx) == 16);
OPENSSL_assert(EVP_CIPHER_CTX_iv_length(&ctx) == 16);
FILE *wordsList, *outputList;
wordsList = fopen("words.txt", "r");
outputList = fopen("output_encrypted.txt", "a+");
if (wordsList < 0) {
perror("Error ");
}
char inptext[] = "This is a top secret.";
// printf("Plain string is: %s and length = %d\n", inptext, strlen(inptext));
char
ciphertext[]
=
"8d20e5056a8d24d0462ce74e4904c1b513e10d1df4a2ef2ad4540fae1ca0aaf9";
```

```
// printf("Cipher string is: %s and length = %d\n", ciphertext,
strlen(ciphertext));
FILE* output;
unsigned char singleword[16];
int count = 0;
int templen = 0;
unsigned char outbuf[1024 + EVP_MAX_BLOCK_LENGTH];
// memset(&outbuf, 0, sizeof(outbuf));
int outlen, tmplen;
// printf("Before While Plain string is: %s and length = %d\n", inptext,
strlen(inptext));
while ((fgets(singleword, 16, wordsList) != NULL) ) {
count++;
/* Since the words.txt ends with \n for each line, we replace that '\n' with '\0'
to end that string */
singleword[strlen(singleword)-1] = '\0';
// printf("Len of string is %d\n", strlen(singleword));
if (strlen(singleword) < 16) {
pad_with_spaces(singleword, 16);
}
for(int i = 0; i < strlen(inptext); i++) {
printf("%c ", inptext[i]);
}
// printf("\nBefore EncryptInit String is %s , len of inptext is %d\n",inptext,
strlen(inptext));
EVP_EncryptInit_ex(&ctx, EVP_aes_128_cbc(), NULL, singleword, iv);
// printf("String is %s , len of inptext is %d\n",inptext, strlen(inptext));
// Here I am hardcoding the inptext string. need to debug why when inptext is
given as
// input it is producing outlen as zero
if (!EVP_CipherUpdate(&ctx, outbuf, &outlen, "This is a top secret.", 21)) {
// if (!EVP_EncryptUpdate(&ctx, outbuf, &outlen, inptext, strlen(inptext))) {
/* Error */
EVP_CIPHER_CTX_cleanup(&ctx);
return 0;
}
// printf("Outlen Before final is %d\n", outlen);
/* Clean up any last bytes left in the output buffer */
if (!EVP_CipherFinal_ex(&ctx, outbuf+outlen, &templen)) {
// if (!EVP_EncryptFinal_ex(&ctx, outbuf+outlen, &templen)) {
/* Error */
EVP_CIPHER_CTX_cleanup(&ctx);
return 0;
}
// printf("Outlen is %d\n", outlen);
// printf("templen is %d\n", templen);
outlen += templen;
/* We create double the size of outbuf because for every character
in outbuf we have 2 hexadecimal characters in buf_hex_encrypt */
char buf_hex_encrypt[2*outlen + 1];
char *buf_operate = buf_hex_encrypt;
for (int i = 0; i < outlen; i++) {
buf_operate += sprintf(buf_operate, "%02x",outbuf[i]);
}
/* End the string with \0 value */
*(buf_operate+1) = '\0';
// printf("Key is %s\n", singleword);
// printf("Outlen is %d\n", outlen);
if (strcmp(buf_hex_encrypt, ciphertext) == 0 ) {
printf("Found the secret key: %s\n", singleword);
}
print_result_output_file(singleword, outbuf, outlen, outputList);
```

```
memset(singleword, 0, sizeof(singleword));
}
/* else { }*/
EVP_CIPHER_CTX_cleanup(&ctx);
fclose(wordsList);
fclose(outputList);
// perror("Closed successfully");
return 0;
}
```