
Title: Attacking Classic Crypto Systems

Omar faruk

Reg No: 2019831055

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Task – 1: AES encryption using different modes

1 INTRODUCTION

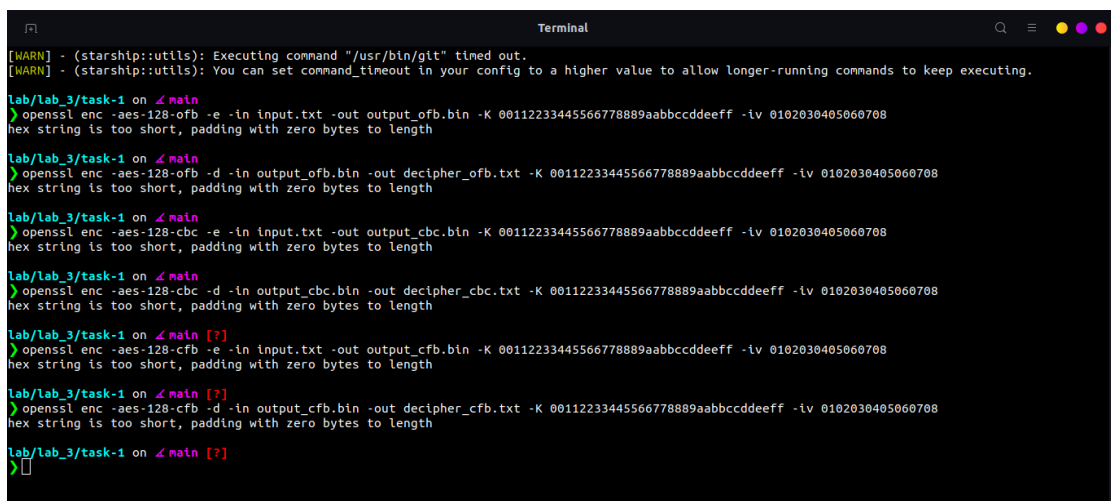
In this project, we explore various encryption algorithms and modes, focusing on AES (Advanced Encryption Standard), a widely used symmetric encryption algorithm. Specifically, we investigate three different modes of AES encryption: CBC (Cipher Block Chaining), CFB (Cipher Feedback), and OFB (Output Feedback).

2 OBJECTIVE

1. To understand the concept of AES encryption.
2. To explore different modes of AES encryption.
3. To implement encryption and decryption using OpenSSL.

3 IMPLEMENTATION

- AES-128-CBC Mode:
openssl enc -aes-128-cbc -e -in input.txt -out output_cbc.bin
-K 00112233445566778889aabbccddeeff -iv 0102030405060708
- AES-128-CFB Mode:
openssl enc -aes-128-cfb -e -in input.txt -out output_cfb.bin
-K 00112233445566778889aabbccddeeff -iv 0102030405060708
- AES-128-OFB Mode:
openssl enc -aes-128-ofb -e -in input.txt -out output_ofb.bin
-K 00112233445566778889aabbccddeeff -iv 0102030405060708



```
lab/lab_3/task-1 on main
> openssl enc -aes-128-ofb -e -in input.txt -out output_ofb.bin -K 00112233445566778889aabbccddeeff -iv 0102030405060708
hex string is too short, padding with zero bytes to length

lab/lab_3/task-1 on main
> openssl enc -aes-128-ofb -d -in output_ofb.bin -out decipher_ofb.txt -K 00112233445566778889aabbccddeeff -iv 0102030405060708
hex string is too short, padding with zero bytes to length

lab/lab_3/task-1 on main
> openssl enc -aes-128-cbc -e -in input.txt -out output_cbc.bin -K 00112233445566778889aabbccddeeff -iv 0102030405060708
hex string is too short, padding with zero bytes to length

lab/lab_3/task-1 on main
> openssl enc -aes-128-cbc -d -in output_cbc.bin -out decipher_cbc.txt -K 00112233445566778889aabbccddeeff -iv 0102030405060708
hex string is too short, padding with zero bytes to length

lab/lab_3/task-1 on main [?]
> openssl enc -aes-128-cfb -e -in input.txt -out output_cfb.bin -K 00112233445566778889aabbccddeeff -iv 0102030405060708
hex string is too short, padding with zero bytes to length

lab/lab_3/task-1 on main [?]
> openssl enc -aes-128-cfb -d -in output_cfb.bin -out decipher_cfb.txt -K 00112233445566778889aabbccddeeff -iv 0102030405060708
hex string is too short, padding with zero bytes to length

lab/lab_3/task-1 on main [?]
>
```

Figure 3.1: command for encryption and decryption

Task – 2: Encryption mode - ECB vs CBC

Encrypting using the ECB and CBC-

- Using OpenSSL with ECB mode:
openssl enc -aes-128-ecb -e -in original.bmp -out
encrypted_ecb.bmp -K 00112233445566778889aabbccddeeff
- Using OpenSSL with CBC mode:
openssl enc -aes-128-cbc -e -in original.bmp -out
encrypted_cbc.bmp -K 00112233445566778889aabbccddeeff -iv
0102030405060708

OBSERVATION

The ECB encrypted image might exhibit patterns or repetition, especially if the image contains repetitive patterns. This is because ECB mode encrypts identical plaintext blocks into identical ciphertext blocks, which can expose patterns in the image.

On the other hand, the CBC encrypted image is less likely to exhibit such patterns because each block of plaintext is XORed with the previous ciphertext block before encryption, adding randomness to the encryption process.

Task – 4: Padding

EXPERIMENTAL PROCEDURE

The plaintext file plaintext.txt was encrypted using OpenSSL with ECB, CBC, CFB, and OFB modes.

- ECB Mode:

```
openssl enc -aes-128-ecb -e -in plaintext.txt -out  
encrypted_ecb.txt -K 00112233445566778889aabbccddeeff
```
- CBC Mode:

```
openssl enc -aes-128-cbc -e -in plaintext.txt -out  
encrypted_cbc.txt -K 00112233445566778889aabbccddeeff -iv  
0102030405060708
```
- CFB Mode:

```
openssl enc -aes-128-cfb -e -in plaintext.txt -out  
encrypted_cfb.txt -K 00112233445566778889aabbccddeeff -iv  
0102030405060708
```
- OFB Mode:

```
openssl enc -aes-128-ofb -e -in plaintext.txt -out  
encrypted_ofb.txt -K 00112233445566778889aabbccddeeff -iv  
0102030405060708
```

Table 3.1: Padding Requirements for Different Encryption Modes

Encryption Mode	Padding Required	Explanation
ECB	No	ECB mode operates on fixed-size blocks and does not require padding. Each block is encrypted independently, making padding unnecessary.
CBC	Yes	CBC mode requires padding because it operates in chained blocks and the final block may not always be full. Padding ensures that the plaintext is a multiple of the block size.
CFB	No	CFB mode does not require padding because it operates on a block-by-block basis, where each block is used to encrypt the next block of plaintext. Padding is not needed as the plaintext is processed in units equal to the block size.
OFB	No	Similar to CFB mode, OFB mode does not require padding because it generates a keystream independent of the plaintext size. Each block of the plaintext is XORed with the corresponding block of the keystream.

Task – 5: Generating message digest

Table 3.2: Hash Values Generated Using Different Algorithms

Command	Hash Value
openssl dgst -md5 message.txt > md5_hash.txt	MD5(plaintext.txt)= c0cf81e6fc699c60b687b63b249ae3af
openssl dgst -sha1 message.txt > sha1_hash.txt	SHA1(plaintext.txt)= 32814bf55a3f3a2ee3492961df59dc0593bd9f3b
openssl dgst -sha256 message.txt > sha256_hash.txt	SHA256(plaintext.txt)= 7f1c437c78909095f6b7d36e7f98c86172a a9586e49a6a13f1a0f26f5f4824fd

Task – 6: Keyed hash and HMAC

Table 3.3: HMAC Values Generated Using Different Algorithms

Algorithm	Command	HMAC
HMAC-MD5	openssl dgst -md5 -hmac "key" message.txt	e48d2535b84d3c8b3b3c6d5fc6f367ee
HMAC-SHA256	openssl dgst -sha256 -hmac "long_secret_key" message.txt	db3c2d70c1c3688d5d19b7734d96c1b6b1e6b7228e0325e00030df628cb285f3
HMAC-SHA1	openssl dgst -sha1 -hmac "12345678901234567890" message.txt	5e30192fc7c49d57a9611a3a3d9cfb27be1f9243

```
lab/lab_3/task-6 on ↵ main [?]  
> openssl dgst -md5 -hmac "key" plaintext.txt  
HMAC-MD5(plaintext.txt)= 104d787d7cd67f5d45d0f23a5e459703  
  
lab/lab_3/task-6 on ↵ main [?]  
> openssl dgst -sha256 -hmac "long_secret_key" plaintext.txt  
HMAC-SHA256(plaintext.txt)= 1449dbeed67de5d2967f776b654ef1bdf2403d8a4e38671364bf  
7eade67b68fb  
  
lab/lab_3/task-6 on ↵ main [?]  
> openssl dgst -sha1 -hmac "12345678901234567890" plaintext.txt  
HMAC-SHA1(plaintext.txt)= af74085dfef5ff7aede41536de7d7cc9b373f811  
  
lab/lab_3/task-6 on ↵ main [?]  
> 
```

Figure 3.2: Commands

Task – 7: Keyed hash and HMAC

Table 3.4: HMAC Values Generated Using Different Algorithms

Algorithm	Command	HMAC
MD5(H1)	openssl dgst -md5 plaintext.txt	c0cf81e6fc699c60b687b63b249ae 3af
SHA256(H1)	openssl dgst -sha256 plaintext.txt	7f1c437c78909095f6b7d36e7f98c8 6172aa9586e49a6a13f1a0f26f5f48 24fd
MD5(H2)	openssl dgst -md5 plaintext.txt	2ca248db83121b9dbee0e2681929 8736
SHA256(H2)	openssl dgst -sha256 plaintext.txt	770e5e38708c501aa919bf41f894c 51823c032a370e7f33a654bab7d8 5299e3f

OBSERVATION

If the hash values H1 and H2 are not the same before and after the bit flipping, it indicates that even a small change in the input data can lead to a significant difference

in the resulting hash values.

Listing 1: number of same bits counting

```
#include <iostream>
#include <string>
#include <bitset>
using namespace std;
int countSameBits(const string& hash1, const string& hash2) {
    int count = 0;
    for (size_t i = 0; i < hash1.length(); ++i) {
        bitset<8> bits1(hash1[i]);
        bitset<8> bits2(hash2[i]);
        count += (bits1 ^ bits2).count();
    }
    return count;
}

int main() {
    string H1 = "c0cf81e6fc699c60b687b63b249ae3af";
    string H2 = "2ca248db83121b9dbee0e26819298736";

    int sameBitsCount = countSameBits(H1, H2);

    cout << "Number of same bits between H1 and H2: " <<
        sameBitsCount << endl;

    return 0;
}
```

Output:Number of same bits between H1 and H2: 85