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CS 370 -Intro to Security-

Programming Project 1

3.1

Cipher 1

Method: -aes-128-cbc

Plaintext: “Hello World”

Ciphertext (hex): 5361 6c74 6564 5f5f 1bbe 4e0a fc63 6f3e 9d33 f9ac bba2 142d 44be 02b3 95c8 88df

Cipher 2

Method: -aes-128-cfb

Plaintext: “Secret Message”

Ciphertext (hex): 5361 6c74 6564 5f5f a9cb 9633 cf68 815c adc8 7d28 5415 227f 57d6 218c b4b5

Cipher 3

Method: -bf-cbc

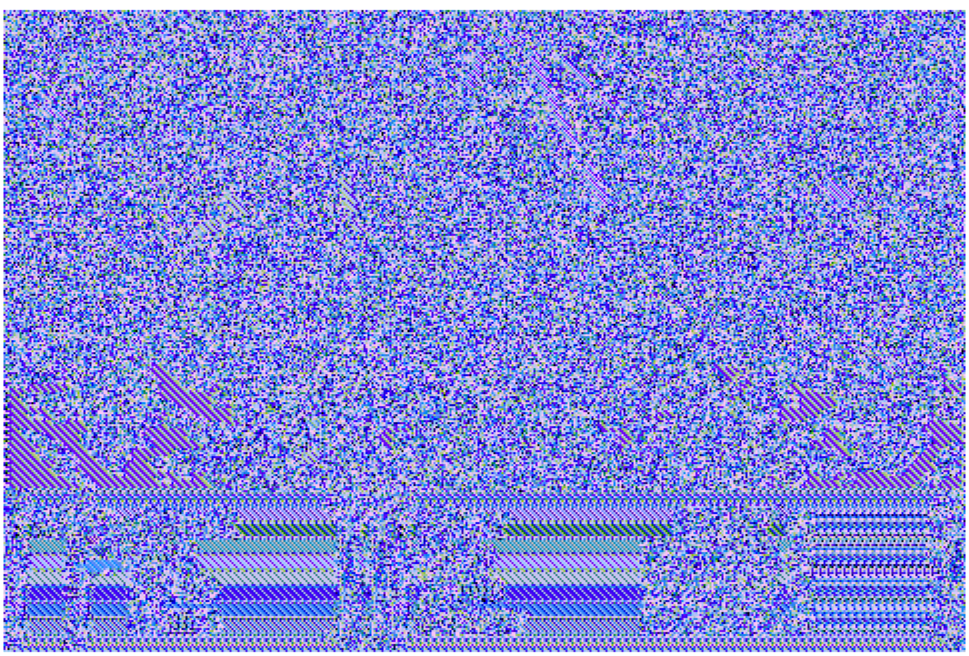
Plaintext: “Cryptography is fun!”

Ciphertext (hex): 5361 6c74 6564 5f5f b0fe f47a 6849 85b2 072e e4de 199e ec5b 8237 9b00 8975 3181 3521 c076 476c 5079

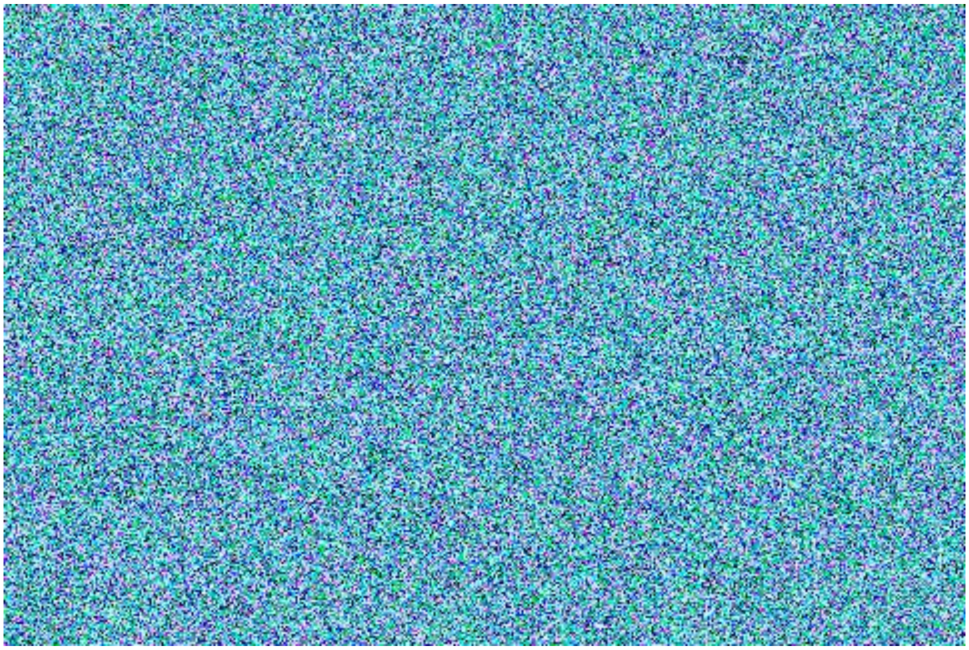
3.2

Original

Encoded with ECB



Encoded with CBC



I should have probably used a simpler picture for this section, but we can still see some patterns and "information leak" with the ECB picture. Toward the bottom where the battle menu is displayed (and the colors are mostly uniform) we can see the outline of the sections between the text. As well, a bit above that, we can also see patches where the clouds are rather uniform in the original picture. This all shows that some of the information of the original picture is still partially recognizable in the encrypted version for ECB.

The CBC version, however, shows none of these patterns, and overall looks like a bunch of random noise.

This demonstrates that CBC produces generally (pseudo)random ciphertexts, while ECB can create patterns in its ciphertexts, making them not truly random.

<u>3.3</u>

Key Used: 1234567890

IV for Run 1 and 2: 0987654321

IV for Run 3: 5555555555

My initial runs to produce encrypt1 and encrypt2 gave different ciphertexts, even though the inputs were the same. This is because I found out OpenSSL v.1.1.1 (the one I have installed) automatically salts encryptions. When I ran them again with the -nosalt flag, the two files were the same. This is because the two encryptions use the same key, IV, and plaintext. Therefore, because of the way CBC works, it gives the same output.

For the third run (with -nosalt used), the ciphertext was different than the first two. This is because, even though it uses the same key, the IV is different. With a different IV, the results of the first cycle will be different.

3.5

Plaintext: “Hello World”

Hash Digest -sha1: 0a4d55a8d778e5022fab701977c5d840bbc486d0

Hash Digest -sha256: a591a6d40bf420404a011733cfb7b190d62c65bf0bcda32b57b277d9ad9f146e

Hash Digest -sha512:
2c74fd17edafd80e8447b0d46741ee243b7eb74dd2149a0ab1b9246fb30382f27e853d8585719e0e67cbda0daa8f51671064615d645ae27acb15bfb1447f459b

3.6

Plaintext: “Hello World”

HMAC-SHA256 Key: bongo

HMAC-SHA256 MAC: bd9e40f6733e868fa502a98109d42871818527d57fa2d5749f70af789b3345af

HMAC-SHA1 Key: key

HMAC-SHA1 MAC: cc24f1acdb06cf429bcf9861b6d708b6ec20a8fa

The answer to if the key needs to be a certain size is yes and no. HMAC uses blocks, so the key needs to be one blocklength in size. However, if the key is larger than a blocklength, then it can be trimmed down to size, and if it is shorter, than it can be padded to the correct length. So, the key should be a certain size, but if it is not, then it can easily be adjusted and keep the security of the hash.

3.7

Plaintext: "The cow jumps over the moon"

Key: bongo

H1-SHA256: aa2f7b095a4e2fb3918fa20b2221544d61632aba9fd9e8afa353eaaefde776db

Binary:
1010101000101111011111011000010010101101001001110001011111011001110010001100011111101
0001000001011001000100010000101010100010011010110000101100011001010101011101010100111
1111011001111010001010111110100011010100111110101010101110111111011110011101101101101
1011011

H2(1 flip)-SHA256: d6708757feafa410bcdd428ae0311c7c4dd3c79970ed0962d166f130d516bf1e

Binary:
1101011001110000100001110101011111111110101011111010010000010000101111001101110101010
0001010001010111000000011000100011100011111000100110111010011110001111001100101111100
0011101101000010010110001011010001011001101111000100110000110101010001011010101111110
0011110

H2(1, 49, 73, and 113 flip)-SHA256:
14727c57d4285b442a51be83c45048ab1d8b9fb6c60cfacc7be35d1d547d6adb

Binary:
0001010001110010011111000101011111010100001010000101101101000100001010100101010001101
1111010000011110001000101000000100100010101011000111011000101110011111101101101100001
1000001100111110101100110001111011111000110101110100011101010101000111110101101010101
1011011

H1-SHA512:
c2e6c46087c682b62e51aa38d30b15146285f7960f45c5531af3967f170cbbb85b0f7aac13f1e4b1eec2e64
0b4e8f28eb1e1f756f30f6bdc4c909fe31fe43229

Binary:
1100001011100110110001000110000010000111110001101000001010110110001011100101010001101
0101000111000110100110000101100010101000101000110001010000101111110111100101100000011
1101000101110001010101001100011010111100111001011001111111000101110000110010111110111
0111000010110110000111101111010101011000001001111110001111001001011000111101110110100
0010111001100100000010110100111010001111001010001110101100011110000111110111010101011
0111100110000111101101011110111000100110010010000100111111110001100011111111110010000
11001000101001

H2(1 flip)-SHA512:
edf3eea01a79eb68531d6a64cc4bf988304c33a340d620f885d1812e3814ca79b64b0499949cd963384b3c
8a2d7c6c20d490da40b2adbd4600b9199e0303ee1f

Binary:
1110110111110011111011101010000000011010011110011110101101101000010100110001110101
0101001100100110011000100101111111001100010000011000001001100001100111010001101000
0011010110001000001111100010000101110100011000000100101110001110000000101001100101
0011110011011011001001011000001001001100110010100100111001101100101100011001110000
1001011001111001000101000101101011111000110110000100000110101001001000011011010010
0000010110010101011011011110101000110000000001011100100011001100111100000001100000
0111110111000011111

H2(1, 49, 73, and 113 flip)-SHA512:
c6948ea468c0b848cccd3cdd48a4acad0ff4dfca8de73bc8674b8d30589b2b3491cc448353a5e41b81b0cfd
f2cccf59f5b8ec4e69bfcb57c54a216533868efcf

Binary:
1100011010010100100011101010010001101000110000000101110000100100011001100110011010
0111100110111010100100010100100101011001010110100001111111101001101111111100101010
0011011110011100111011110010000110011101001011100011010011000000101100010011011001
0101100110100100100011100110001000100100000110101001110100101111001000001101110000
0001101100001100111111011111001011001100110011110101100111110101101110001110110001
0011100110100110111111110010110101011111000101010010100010000101100101001100111000
011010001110111111001111

For the SHA256 H1 and H2(1 flip), I got that they shared 131 bits out of 257. This is approximately 50%, which is what is to be expected from a good algorithm. When one bit is flipped, it should avalanche into about 50% of the total bits flipping in the result.

This trend continued regardless of which bit was flipped, or if multiple bits were flipped. For H2 (four bits flipped), the total shared also came out to about 50% also (123/257). This makes sense, too, as each bit change flips about 50% of the bits in the result. Do this with four bits, and with each 50% flip, some of the previously flipped bits (about 50% of those, or 25% overall) will flip back to being the same. Overall, this will average out to 50% of the bits being different with all the flipping.

The same trend was also seen with the SHA512 hashes, with each HS, when compared to H1, had about 50% different bits.