CSS 322 – QUIZ 3 ANSWERS

First name: ______________________ Last name: ______________________

ID: ______________________ Total Marks: __________
out of 10

Question 1 [3 marks]

Assume you have designed a 4-bit block cipher that produces the following Ciphertext when used with a key *K*:

P	**C**	**P**	**C**	**P**	**C**	**P**	**C**
0000	0101	0100	0010	1000	1110	1100	1000
0001	1001	0101	0111	1001	1011	1101	0100
0010	1101	0110	0000	1010	1100	1110	0011
0011	1111	0111	1010	1011	0001	1111	0110

If you use your cipher in the Counter mode of operation (with initial value of 0), what is the plaintext for the ciphertext C = 011001001010 and key *K*.

Answer

Counter mode encrypts the counter value, and then XORs the result with the ciphertext block to get the original plaintext.

E(0000) = 0101

E(0001) = 1001

E(0010) = 1101

P_1 = C_1 XOR E(0000)
= 0110 XOR 0101
= 0011

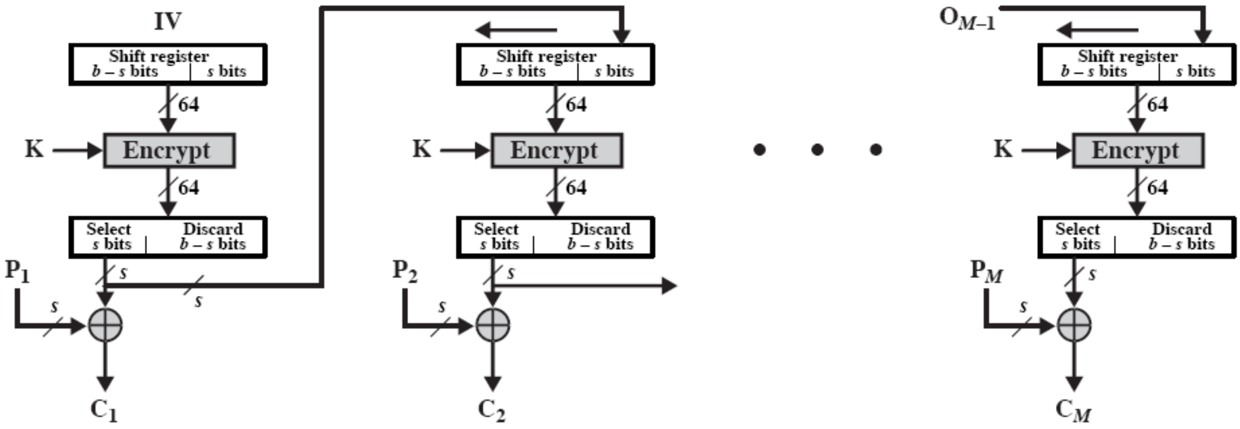
P_2 = C_2 XOR E(0001)
= 0100 XOR 1001
= 1101

P_3 = C_3 XOR E(0010)
= 1010 XOR 1101
= 0111

Therefore the plaintext is: 0011 1101 0111

Question 2 [3 marks]

The following diagram shows the encryption phase of the Output Feedback Mode of operation for 64-bit block ciphers.



Assume you are using a modified Output Feedback Mode that operates on 4-bit block ciphers and it is used with the encryption algorithm designed in Question 2. The plaintext blocks are 2-bits. What is the ciphertext for the plaintext P = 01101011 encrypted using key *K*? The Initialisation Vector is 0000.

Answer

IV		=	0000
Output of Encrypt		=	0101
C_1	= P_1 XOR 01	=	00
V		=	0001
Output of Encrypt		=	1001
C_2	= P_2 XOR 10	=	00
V		=	0110
Output of Encrypt		=	0000
C_3	= P_3 XOR 00	=	10
V		=	1000
Output of Encrypt		=	1110
C_4	= P_4 XOR 11	=	00

Ciphertext = 00001000

Question 3 [4 marks]

Assume you designed your own encryption algorithm, *A*, which uses 4-bit blocks and 2-bit keys. The ciphertext for a *selection* of plaintext and keys for the algorithm, *A*, are given below.

	Key			
Plaintext	**00**	**01**	**10**	**11**
0001	1101	0111	1101	0110
0101	0000	0110	0111	1010
0111	0101	1101	1111	0011
1000	0111	1000	1100	1101

To increase the strength of your algorithm, *A*, against brute-force attack, you apply the algorithm twice using a 4-bit key, *K*. The first two bits of *K* are used as a key into *A* to encrypt the plaintext to produce output *X*, and the second two bits of *K* are used as a key into *A* to encrypt *X* to produce the ciphertext. You call this new algorithm *Double-A*.

An attacker has discovered a pair of (plaintext, ciphertext) for *Double-A*:

(0101, 1101)

a) Use the meet-in-the-middle attack to determine the most likely key *K* used to produce this ciphertext.

b) A limitation of the meet-in-the-middle attack is the amount of memory needed. Explain why, and give the approximate amount of memory needed to perform the attack on Double-DES (which uses two 56-bit keys)?

Answer

a)

Encrypting 0101 with a key K_1, will produce one of four possible values:

K_1 = 00: X = 0000

K_1 = 01: X = 0110

K_1 = 10: X = 0111

K_1 = 11: X = 1010

Decrypting 1101 with a key K_2, will produce one of four possible values:

K_2 = 00: X = 0001

K_2 = 01: X = 0111

K_2 = 10: X = 0001

K_2 = 11: X = 1000

Since X = 0111 matches in both encryption and decryption then the key is: K_1 = 10, K_2 = 01, therefore K = 1001.

b)

With the meet-in-the-middle attack, the plaintext is encrypted with every possible key to produce 2^k values of X, each n-bits in length. Each value of X needs to be stored in memory for the next phase (decrypting the ciphertext and comparing against the values of X). For Double-DES this requires approximately 576,000 Terabytes of memory:

2^{56} values of X, where X is 64 bits (or 8 bytes) = 576460752303423488 bytes (approx 5.8 x 10^{17})