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Ciphertext Cryptanalysis Using DES Functionality In Spartan3Upto 4 Round.

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Abstract — *in this paper, we present an approach for the cryptanalysis of four rounded Data Encryption Standard (DES). It can be achieved by Encryption algorithms which are used to prevent unauthorized access of data. Cryptography is a science of keeping data transfer secure, so that eavesdroppers (or attackers) cannot decipher the transmitted message. The results indicate that the proposed approach is efficient in finding missing key bits of the data encryption standard Algorithm.*

Keywords — *Encryption; Key; Modalism; S-boxes.*

I. INTRODUCTION

Cryptography includes two basic components: Encryption algorithm and Keys. If sender and recipient use the same key then it is known as symmetrical or private key cryptography. It is always suitable for long data streams. Such system is difficult to use in practice because the sender and receiver must know the key. It also requires sending the keys over a secure channel from sender to recipient The question is that if secure channel already exist then transmit the data over the same channel. On the other hand, if different keys are used by sender and recipient then it is known as asymmetrical or public key cryptography. The key used for encryption is called the public key and the key used for decryption is called the private key. Such technique is used for short data streams and also requires more time to encrypt the data. To encrypt a message, a public key can be used by anyone, but the owner having private key can only decrypt it. There is no need for a secure communication channel for the transmission of the encryption key. Asymmetric algorithms are slower than symmetric algorithms and asymmetric algorithms cannot be applied to variable-length streams of data.

II. CRYPTOGRAPHY TECHNIQUES

There are two techniques used for data encryption and decryption, which are:

2.1 Symmetric Cryptography

If sender and recipient use the same key then it is known as symmetrical or private key cryptography. It is always suitable for long data streams. Such system is difficult to use in practice because the sender and receiver must know the key. It also requires sending the keys over a secure channel from sender to recipient. There are two methods that are used in symmetric key cryptography: block and stream.

The block method divides a large data set into blocks (based on predefined size or the key size), encrypts each block separately and finally combines blocks to produce encrypted data.

The stream method encrypts the data as a stream of bits without separating the data into blocks. The stream of bits from the data is encrypted sequentially using some of the results from the previous bit until all the bits in the data are encrypted as a whole.

2.2 Asymmetric Cryptography

If sender and recipient use different keys then it is known as asymmetrical or public key cryptography. The key used for encryption is called the public key and the key used for decryption is called the private key. Such technique is used for short data streams and also requires more time to encrypt the data. Asymmetric encryption techniques are almost 1000 times slower than symmetric techniques, because they require more computational processing power. To get the benefits of both methods, a hybrid technique is usually used. In this technique, asymmetric encryption is used to exchange the secret key; symmetric encryption is then used to transfer data between sender and receiver.

III. ALGORITHM

DES works on bits, or binary numbers--the 0s and 1s common to digital computers. Each group of four bits makes up a hexadecimal, or base 16, number. Binary "0001" is equal to the hexadecimal number "1", binary

"1000" is equal to the hexadecimal number "8", "1001" is equal to the hexadecimal number "9", "1010" is equal to the hexadecimal number "A", and "1111" is equal to the hexadecimal number "F".

DES works by encrypting groups of 64 message bits, which is the same as 16 hexadecimal numbers. To do the encryption, DES uses "keys" where apparently 16 hexadecimal numbers long, or apparently 64 bits long are also. However, every 8th key bit is ignored in the DES algorithm, so that the effective key size is 56 bits. But, in any case, 64 bits (16 hexadecimal digits) is the round number upon which DES is organized.

For example, if we take the plaintext message "8787878787878787", and encrypt it with the DES key "0E329232EA6D0D73", we end up with the cipher text "0000000000000000". If the cipher text is decrypted with the same secret DES key "0E329232EA6D0D73", the result is the original plaintext "8787878787878787".

This example is neat and orderly because our plaintext was exactly 64 bits long. The same would be true if the plaintext happened to be a multiple of 64 bits. But most messages will not fall into this category. They will not be an exact multiple of 64 bits (that is, an exact multiple of 16 hexadecimal numbers).

For example, take the message "Your lips are smoother than Vaseline". This plaintext message is 38 bytes (76 hexadecimal digits) long. So this message must be padded with some extra bytes at the tail end for the encryption. Once the encrypted message has been decrypted, these extra bytes are thrown away. There are, of course, different padding schemes--different ways to add extra bytes. Here we will just add 0s at the end, so that the total message is a multiple of 8 bytes (or 16 hexadecimal digits, or 64 bits).

The plaintext message "Your lips are smoother than vaseline" is, in hexadecimal,

"596F7572206C6970 732061726520736D 6F6F746865722074 68616E2076617365 6C696E650D0A".

(Note here that the first 72 hexadecimal digits represent the English message, while "0D" is hexadecimal for Carriage Return, and "0A" is hexadecimal for Line Feed, showing that the message file has terminated.) We then pad this message with some 0s on the end, to get a total of 80 hexadecimal digits:

"596F7572206C6970 732061726520736D 6F6F746865722074 68616E2076617365 6C696E650D0A0000".

If we then encrypt this plaintext message 64 bits (16 hexadecimal digits) at a time, using the same DES key "0E329232EA6D0D73" as before, we get the ciphertext:

"C0999FDDE378D7ED 727DA00BCA5A84EE 47F269A4D6438190 9DD52F78F5358499 828AC9B453E0E653".

This is the secret code that can be transmitted or stored. Decrypting the ciphertext restores the original message "Your lips are smoother than vaseline". (Think how much better off Bill Clinton would be today, if Monica Lewinsky had used encryption on her Pentagon computer!)

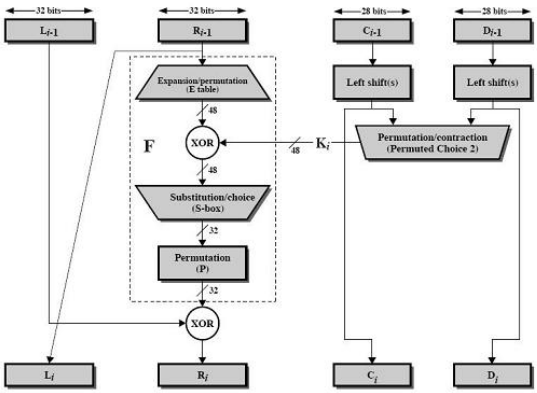


Fig. 1. Single Round of DES Algorithm [7]

The general depiction of DES encryption algorithm which consists of initial permutation of the 64 bit plain text and then goes through 4 rounds, where each round consists permutation and substitution of the text bit and the inputted key bit, and at last goes through an inverse initial permutation to get the 64 bit cipher text.
Steps for Algorithm
Step 1: Create 4 sub-keys, each of which is 48-
bits long. The 64-bit key is permuted according to the following table, PC-1. Since the first entry in the table is "57", this means that the 57th bit of the original key K becomes the first bit of the permuted key K+. The 49th bit of the original key becomesthesecond bit of the permuted key. The 4th bit of the original key is the last bit of the permuted key. Note only 56 bits of the original key appear in the permuted key. Example: From the original 64-bit key
K =1111111111111110000000000000000001010101 01010101001010101010101
we get the 56-bit permutation
K+=00110011110000110011001111000011001111000011001100110011
Next, split this key into left and right halves, C0 and D0, where each half has 28 bits. Example: From the permuted key K+, we get
C0 = 0011001111000011001100111100
D0 = 0011001111000011001100110011

Table 1: PC-1

57	49	41	33	25	17	9
1	58	50	42	34	26	18
10	2	59	51	43	35	27
19	11	3	60	52	44	36
63	55	47	39	31	23	15
7	62	54	46	38	30	22
14	6	61	53	45	37	29
21	13	5	28	20	12	4

With C0 and D0 defined, we now create sixteen blocks Cn andDn, 1<=n<=4. Each pair of blocks Cnand Dn is formed from the previous pair Cn-1 and Dn-1, respectively, for n = 1, 2, … 4, using the schedule of "left shifts" of the previous block. To do a left shift, move each bit one place to the left, except for the first bit, which is cycled to the end of the block. This means, for example, C3 and D3 are obtained from C2 and D2, respectively, by two left shifts, and C4 and D4 are obtained from C3 and D3, respectively, by one left shift. In all cases, by a single left shift is meant a rotation of the bits one place to the left, so that after one left shift the bits in the 28 positions are the bits that were previously in positions 2, 3,..., 28, 1. Example: From original pair C0 and D0 we obtain:

C0 = 0011001111000011001100111100
D0 = 0011001111000011001100110011
C1 = 1110000110011001010101011111
D1 = 0110011110000110011001100110

We now form the keys Kn, for 1<=n<=4, by applying the following permutation table to each of the concatenated pairs CnDn. Each pair has 56 bits, but PC-2 only uses 48 of these.

Table 2: PC-2

14	17	11	24	1	5
3	28	15	6	21	10
23	19	12	4	26	8
16	7	27	20	13	2
41	52	31	37	47	55
30	40	51	45	33	48
44	49	39	56	34	53
46	42	50	36	29	32

Therefore, the first bit of Kn is the 14th bit of CnDn, the second bit the 17th, and so on, ending with the 48th bit ofKn being the 32th bit of CnDn
Step 2: Encode each 64-bit block of data

There is an initial permutation IP of the 64 bits of the message data M. This rearranges the bits according to the following table, where the entries in the table show the new arrangement of the bits from their initial order.

Table 3: IP

58	50	42	34	26	18	10	2
60	52	44	36	28	20	12	4
62	54	46	38	30	22	14	6
64	56	48	40	32	24	168	
57	49	41	33	25	17	9	1
59	51	43	35	27	19	11	3
61	53	45	37	29	21	13	5
63	55	47	39	31	23	15	7

The 58th bit of M becomes the first bit of IP. The 50th bit of M becomes the second bit of IP. The 7th bit of M is the last bit of IP. Example: Applying the initial permutation to the block of text M, given previously, we get
M = 0000 00010010 00110100 01010110 01111000 10011010101111001101111011111
IP=11001100000000000110011001111111111110000 10101010111100001010101O
Here the 58th bit of M is "1", which becomes the first bit of IP. The 50th bit of M is "1", which becomes the second bit of IP. The 7th bit of M is "0", which becomes the last bit of IP. Next divide the permuted block IP into a left half L0 of 32 bits, and a right half R0 of 32 bits.
Example: From IP, we get L0 and R0
L0 = 11001100000000000110011001111111
R0 = 11110000101010101111000010101010
We now proceed through 4 iterations, for 1<=n<=4, using a function f which operates on two blocks--a data block of 32 bits and a key Kn of 48 bits--to produce a block of 32 bits. Let + denote XOR addition, (bit-by-bit addition modulo 2). Then for n going from 1 to 4 we calculate Ln = Rn-1 Rn = Ln-1 + f(Rn-1,Kn)n This results in a final block, for n = 4, of L4R4. That is, in each iteration, we take the right 32 bits of the previous result and make them the left 32 bits of the current step. For the right 32 bits in the current step, we XOR the left 32 bits of the previous step with the calculation f . Example: For n = 1, we have
K1=000110110000001011101111111111000111000001110010
L1 = R0 = 1111 0000 1010 1010 1111 0000 1010 1010
R1 = L0 + f(R0,K1) It remains to explain how the function f works. To calculate f, we first expand each block Rn-1 from 32 bits to 48 bits. This is done by using a selection table that repeats some of the
bits in Rn-1 We'll call the use of this selection table the function E. Thus E(Rn-1) has a 32 bit input block, and a 48 bit output block. Thus the first three bits of E(Rn-1) are the bits in positions 32, 1 and 2 of Rn-1 while the last 2 bits of E(Rn-1) are the bits in positions 32 and 1.Example: We calculate
E(R0) from R0 as follows:
R0 = 1111 0000101010101111000010101010
E(R0)=011110100001010101010101011110100001
010101010101
(Note that each block of 4 original bits has been expanded to a block of 6 output bits.) Next in the f calculation, we XOR the output E(Rn-1) with the key Kn: Kn + E(Rn-1). Example: For K1 , E(R0), we have
K1=000110110000001011101111111111100011 1000001110010
(R0)=011110100001010101010101011110100001 010101 010101
K1+E(R0)=100101010001100001010101011101101000010111000111
To this point we have expanded Rn-1 from 32 bits to 48 bits, using the selection table, and XORed the result withn the key Kn . We now have 48 bits, or eight groups of six bits. We now do something strange with each group of six bits: we use them as addresses in tables called "S boxes". Each group of six bits will give us an address in a different S box. Located at that address will be a 4 bit number. This 4 bit number will replace the original 6 bits. The net result is that the eight groups of 6 bits are transformed into eight groups of 4 bits (the 4-bit outputs from the S boxes) for 32 bits total. Write the previous result, which is 48 bits, in the form:
Kn + E(Rn-1) =B1B2B3B4B5B6B7B8,
where each Bi is a group of six bits. We now calculateS1(B1)S2(B2)S3(B3)S4(B4)S5(B5)S6 (B6)S7(B7)S8(B8) where Si(Bi) refers to the output of the i-th S box. To repeat, each of the
functions S1, S2,..., S8, takes a 6-bit block as input and yields a 4-bit block as output. The table to determine S1 is shown and explained below: If S1 is the function defined in this table and B is a block of 6 bits, then S1(B) is determined as follows: The first and last bits of B represent in base 2 a number in the decimal range 0 to 3 (or binary 00 to 11). Let that number be i. The middle 4 bits of B represent in base 2 a number in the decimal range 0 to 15 (binary 0000 to 1111). Let that number be j. Look up in the table the number in the i-th row and j-th column. It is a number in the range 0 to 15 and is uniquely represented by a 4 bit block. That block is the output S1(B) of S1 for the input B. For example, for input block B = 011101 the first bit is "0" and the last bit "1" giving 01 as the row. This is row 1. The middle four bits are "1110". This is the binary equivalent of

decimal 13, so the column is column number 13. In row 1, column 13 appears 5. This determines the output; 5 is binary 0011, so that the output is 0101. Hence S1(011101) = 0011. Example: For the first round, we obtain as the output of the eight S boxes: K1+E(R0)=100101010001100001010101011101101000010111000111 S1(B1)S2(B2)S3(B3)S4(B4)S5(B5)S6(B6)S7(B7)S8(B8)=010111001000 00101011 010110010111
The final stage in the calculation of f is to do a permutation P of the S-box output to obtain the final value of f: f = P(S1(B1)S2(B2)...S8(B8)) P yields a 32-bit output from a 32-bit input by permuting the bits of the input block. Example: From the output of the eight Sboxes:
S1(B1)S2(B2)S3(B3)S4(B4)S5(B5)S6(B6)S7(B7)
S8(B8) = 010111001000 00101011 01011001 0111
we get f = 0010 00110100101010100100110111011
R1=L0+f(R0,K1)= 11001100000000000110011001
111 1111+ 00100011010010101010100110111011
= 11101111010010100110010101000100

In the next round, we will have L2 = R1, which is
the block we just calculated, and then we must calculate R2 =L1 + f(R1, K2), and so on for 4 rounds. At the end of the sixteenth round we have the blocks L4 and R4. We then reverse the order of the two blocks into the 64-bit block R16L16 and apply a final permutation IP-1 as defined by thefollowing table:

Table 4: IP^ (-1)

40	8	48	16	56	24	64	32
39	7	47	15	55	23	63	31
38	6	46	14	54	22	62	30
37	5	45	13	53	21	61	29
36	4	44	12	52	20	60	28
35	3	43	11	51	19	59	27
34	2	42	10	50	18	58	26
33	1	41	9	49	17	57	25

That is, the output of the algorithm has bit 40 of the pre output block asf

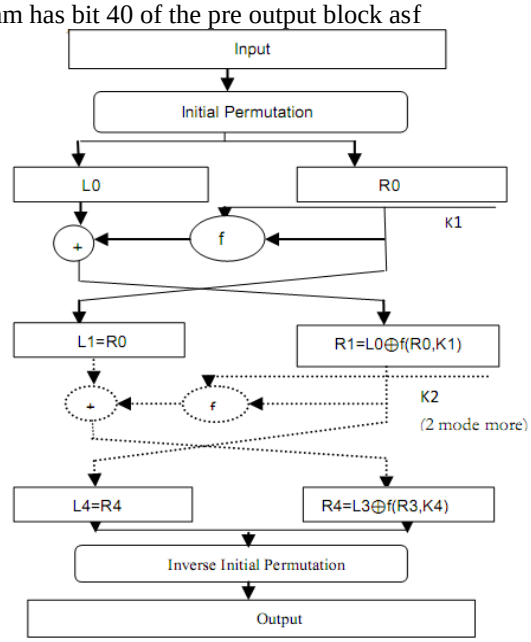
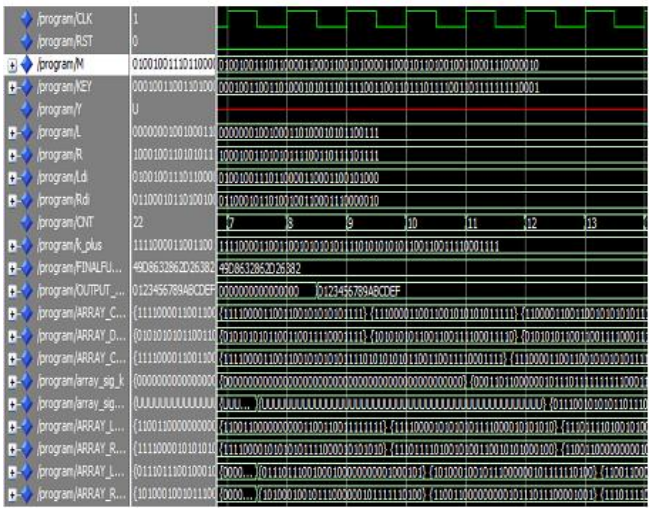


Fig.2 DES Fiestel Digram

its first bit, bit 8 as its second bit, and so on, until bit 25 of the pre-output block is the last bit of the output.



Example: If we process all 4 blocks using the method defined previously, we get, on the 4th round,
L4 = 10100010010111000000101111110100
R4= 01110111001000100000000001000101
We reverse the order of these two blocks and apply the final permutation to
R4L4= 01110111001000100000000001000101 10100010010111000000101111110100
IP-1= 01001001110110000110001100101000 01000101101001001100011100000010 this in hexadecimal format is 49D8632862D26382. This is the encrypted form of
M = 0123456789ABCDEF: namely,
C = 49D8632862D26382.
Decryption is simply the inverse of encryption, following the same steps as above, but reversing the order in which the sub-keys are applied.

IV. CONCLUSION AND FUTURE WORKS

In this paper, for the cryptanalysis of Data Encryption Standard is presented. It shows that it is an effective approach for cryptanalysis of four-rounded DES. The cost function used in this paper is generic and can be used for the cryptanalysis of other block ciphers In the future, we will use this approach on sixteen-rounded DES as well as on other block ciphers such as Advanced Encryption Standard algorithm (AES). We will also try to improve the fitness function.

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