Egyptian Informatics Journal 21 (2020) 83–90

Contents lists available at ScienceDirect

Egyptian Informatics Journal

journal homepage: www.sciencedirect.com

A novel crypto technique based ciphertext shifting

Farah R. Shareef

Designation, Affiliation, Ministry of Education, Iraq

ARTICLE INFO

Article history:
Received 18 February 2019
Revised 14 June 2019
Accepted 12 November 2019
Available online 20 November 2019

Keywords:
Cryptography
Ciphertext
Shifting algorithm
HMAC
AES

ABSTRACT

One of the significant issues in information security areas is a hidden exchange of data. There are several techniques for this purpose such as cryptography, steganography, etc. Generally, in cryptography, the secret message content is scrambled. In another hand in steganography, the secret message is embedded inside the cover medium. In this paper, a new crypto technique-based ciphertext shifting algorithm has been designed to improve the security for our previous work that combining cryptographic and steganographic. The improvement in the security of the secret message is done by changing the ciphertext value. The proposed shifting algorithm is used to rearranges the location of each character of ciphertext based on key value, in which the final ciphertext length is equivalent to encryption value but it different in value. The key strength of this method is two side one is trick the attacker from notice any change in ciphertext which is the same length as the original, so when used the common cryptanalysis will not get anything due to the original ciphertext has been changed. The second key strength of this method is that the shifting value is variable and dependent on key length. This method is inspected to be a very strong technique that can prevent common cryptography attacks such as a dictionary or brute-force attacks, etc.

1. Introduction

Cryptography is the technology that uses the mathematical algorithms to encrypt and decrypt information to keep messages secure by modifying plaintext form (intelligible data) to ciphertext form (unintelligible data). The cryptography allows store the sensitive data or transfer it across unsafe networks (like the Internet) to ensure that it cannot be identified by anyone except the desired receiver. Steganography is the technology of hiding a message within another message while not drawing any suspicion there is any secret information exist, while only the intended recipient can decode it and got the original message [1].

Any cryptosystem involves Key, plaintext, ciphertext, and the encryption/decryption algorithm. Plaintext is the data or message that are is normally in a readable form (not encrypted). The encryption is the method of transforming the plaintext into ciphertext by using the key. The ciphertext outcome from the encryption process by making use of the encryption key on the plaintext. In another hand, the decryption is the method of retrieving the original plaintext back from the ciphertext form. The Key is employed information to control the cryptosystem, and it just is known by both receiver & sender [2,3]. While the cryptography is highly effective for securing information; the cryptanalysts may possibly success to break the ciphertext by investigating the contents of ciphertext to return the plaintext [4]. The cryptographic systems are usually categorized to a three independent dimensions, that are: Type of Operation on Plaintext, which it took place on plaintext to convert plaintext to ciphertext, the second method is "Number of Used Keys that is dependent on key utilized to be symmetric once single key used and be asymmetric when several keys (public and private key) used, the third method is "The Way where the plaintext is processed" in which the stream cipher runs on every plaintext element continually, and generates one element at a time, since it goes along [2].

In another hand, the steganography techniques are also classified into three types, "Pure Steganography", that is an approach basically uses the steganography approach simply without merging other methods. It is functioning on hiding information inside cover carrier; the second type is "Secret Key Steganography" which

E-mail address: sabahaliraq@gmail.com

Peer review under responsibility of Faculty of Computers and Information, Cairo University.

Production and hosting by Elsevier

https://doi.org/10.1016/j.eij.2019.11.002

utilizes the hybrid of the secret key cryptography approach and the steganography approach. The strategy of this type is to encrypt the information by the secret key approach and then conceal the encrypted data inside cover carrier; the third type is the "Public Key Steganography", which is the hybrid steganography approach with the public key cryptography. The strategy of this type is to encrypt the secret information by using the public key method and then conceal the encrypted information inside the cover carrier [5].

In this paper, we focused on strengthening the cryptosystem side of Secret Key Steganography approach. As in our previous works in [6] where combined text steganography with AES-HMAC cryptography, we designed a new method to increase the cryptographic strength (the cryptographic strength is measured according to the time and resources which are needing to retrieve the plaintext) via changed the value of ciphertext by used shifting algorithm that rearranged the ciphertext characters depending on key value. The result is very strong cryptography, where the ciphertext that generated is very difficult to decipher without possession of the right decoding tool.

2. Previous works

In this part, we take into consideration some previous works that can assist the improvement of the proposed system and compared the effects when using the proposed method as an encryption method than slandered methods.

For hybrid cryptography and steganography technique, we have relied on our previous strategy in [6], which based on hybrid cryptography based on AES- HMAC method. The HMAC (keyed-hash message authentication code) represents a \ method utilized to calculate the combination of MAC and hash function type SHA256 with a secret cryptographic key. In another hand, we utilized AES (Advanced Encryption Standard) type AES-256. Then HMAC. The proposed method has advantages of improving security rather than common standard encryption methods. In this work, we used HMAC as an encryption method and we then applied the proposed shifting algorithm on the ciphertext resultant from the HMAC method.

For text steganography strategy we have investigated some techniques concern uses of Arabic text to hiding data. The choice is to select some good techniques in hiding, from [7], [8] and [9].

The first selected stego method is MSCUKAT (Maximizing Steganography Capacity Using "Kashida" in Arabic Text). This work is done by Gutub and Al-Nazer [7], in 2010. This method is utilized as an extension character "Kashida" to hide the secret data within an Arabic text message. Their work succeeds to maximize the capacity within Arabic text cover via increased the "Kashida" within the cover which leads to a reduction in file size, without effect on the accuracy of visibility when compared than other "Kashida" methods.

The second selected text steganographic method is "Modified Fatha" that is our previous steganographic method in [8], that is based on the previous work "Reverse Fatha" that done by Mujtaba and Asadullah in 2016 [10]. This method based on hiding a secret message in the text by utilized "Fatha" which is a short vowel, diagonal stroke that is written above the consonant which precedes it in pronunciation). The modified "Fatha" is same symbol "Fatha" that is in the same direction of original Fatha but it is oriented some degree than original one, thus it very similar to original one and it hard to detect any difference, thus, it will not give any suspicious from the observer.

The Third selected text steganographic method is "Blood Group" that is our previous novel approach for text steganography called "Blood Group" [9], this approach is based on the behavior of blood group to distribute "Kashida" in order to hide secret data. This method has superiority over other previous methods in many aspects involves time complexity, hiding capacity, similarity, visibility, and robustness.

3. Theoretical background

There are different techniques is used to give information security either by using encryption or steganography or hybrid between these techniques. AES approach, which is also called Rijndael, is a type of symmetric-key block cipher [11]. In contrast to the DES method, AES technique is a nonFeistel cipher which encrypts and decrypts an information block of 128bits, by using 10, 12, or 14 rounds. The size of the key can be 128bits, 192bits, or 256bits, and the number of rounds is depending upon the key size since it enables the secret key to be extended to produce subkey for every round [12]. In AES technique, the input and output sequences are in the same length. Regarding the AES technique, the mixing column, substitution byte, key adding steps and shift rows are carried out in each encryption round to encrypt the message, however, the Mixing Column step does not involve in the last round. During the decryption, the 4 steps are used in a reverse way. As well, the inverse of mixing column step does not involve in the latest round of the decryption [4].

HMAC is an algorithm for cryptographic authentication, the "Keyed-Hash Message Authentication Code," highly utilized in combination with the SHA256 cryptography. The operation is when sender and receiver sharing a message m they also share secret key k. In sender side, the sender device (such as a computer) has s = HMAC (k; m) and added (s) to (m). In another side, the receiver computes have s0 = HMAC (k; m) and then it verifies that s0 = s. In theory, any third party will never know k and as a result, cannot compute s. So, the receiver can infer that message m actually came from the sender [13]. As described in our work in [6], we had used AES-256 and then HMAC SHA-256, a two-step Encrypt then MAC which requires additional keys and additional overhead. The approach action takes the keys and the secret message string, in addition to an optional nonsecret payload then return back then authenticated encrypted string in addition prepended to the nonsecret data with a 256bit keys randomly produced. Furthermore, it has a helper method that utilized a string password for keys creation.

4. The proposed approaches

Based on key concept pointed in [6], that intended to design a highly secure method to protects the secret message by combined two techniques: text steganography and AES-HMAC to get a hybrid method that can combine the many advantages from these two techniques. The main goal of the proposed system is improving the security of the crypto side by using a shifting algorithm. The ciphertext generated from AES-HMAC will be passed to shifting algorithm to rearrange ciphertext and generate shifting ciphertext and then it will be passed to stego part. Fig. 1 illustrated the proposed crypto-stego system structure.

The process (shown in Fig. 1) is done by passing the secret message to the encryption process that used AES 256bit algorithm, after putting crypto key it will be generated ciphertext then the ciphertext characters will be shifting via shifting algorithm which changes the string value to another based on algorithm, after that the message will be embedded within stego cover through the encoding process by select one of three stego method and then got the final result which is stego message

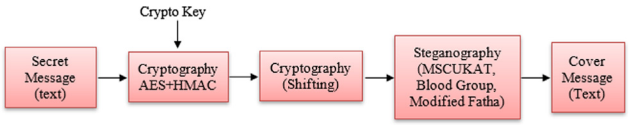


Fig. 1. Crypto-Stego system Structure.

Shifting algorithm

```
Input     Encrypted Message (Ciphertext)
Output    Encrypted Message (Shifted Ciphertext)
Step 1    Start.
Step 2    Define a fixed length Key string
Step 3    Find a total of ASCII values of characters in the key string.
Step 4    Find the length of the key string
Step 5    Right circular shift total (from step 2) by number of bits equal to the length (from step 3)
Step 6    The final value in step 4 is shifts value.
Step 7    Take the last digit of shift value.
Step 8    For the characters at odd places in the input string, take the character on the right side (circular shift) after a number of shifts equal to last digit value in step 6.
Step 9    For the characters at even places in the input string, take the character on the left side (circular shift) after a number of shifts equal to last digit value in step 6.
Step 10   Increment shift value by the number of current characters to be encrypted.
Step 11   Follow steps 6–9 till the end of the string is reached.
Step 12   Store position of each space and number of spaces at the end of the string.
Step 13   End.
```

The decryption process will be run in opposite to encryption/shifting process, the user should be entering crypto key, then the process will be first rearranged the ciphertext to its actual value then decrypt ciphertext to get the original secret message, the decryption algorithm is in follows:

Decryption algorithm

```
Input     Encrypted shifted Secret Message.
Output    Secret Message.
Step 1    Start.
Step 2    Define a fixed length Key string (It should be the same as used for Encryption).
Step 3    The last character in the string is a number of spaces. From the end of the string, remove characters equal to a number of spaces.
Step 4    Put the spaces at the correct location from trimmed characters in step 7.
Step 5    Find a total of ASCII values of characters in the key string.
Step 6    Find the length of the key string
Step 7    Right circular shift total (from step 2) by number of bits equal to the length (from step 3)
Step 8    The final value in step 6 is shifts value.
Step 9    Take the last digit of shift value.
Step 10   For the characters at odd places in the input string, take the character on the left side (circular shift) after a number of shifts equal to last digit value in step 8.
Step 11   For the characters at even places in the input string, take the character on the right side (circular shift) after a number of shifts equal to last digit value in step 8.
Step 12   Increment shift value by the number of current characters to be encrypted.
Step 13   Follow steps 8–11 till the end of the string is reached.
Step 14   Get Ciphertext value
Step 15   Get Key value
Step 16   Decrypt ciphertext by Rijndael algorithm
Step 17   End.
```

The algorithm can be explained in the following example: Let Key String is "Baghdad2018", and the Secret message= "I love Iraq", then the total of ASCII values of characters in key string = 874, as explained in Table 1.

So, the right circular shift total by a number of bits equal to the length (Shift bits in 874 to the right side by 11), Shifting Binary value of 741(001101101010) to right will get the new binary value which is (011011010100) and it corresponding to (1748). The last digit value (L) is 8, so the shifting result can be explained in Table 2.

The de-shifting process is run in opposite, The shifted string is "A lpth nlhi", and the Key String used in the encryption process is "Baghdad2018"; The number of spaces = 2 and the position of space is 1,6, and the Total of ASCII values of characters in key string = 874, and the length of key string is11; thus, the Right circular shift total by number of bits equal to length: Shift bits in 874 to right side by 11 (New value = 1748), so the last digit is 8. The De-shifting process result is shown in Table 3.

Table 1
Calculating the ASCII values of characters in the key string.

Char	ASCII
B	66
a	97
g	103
h	104
d	100
a	97
D	104
2	50
0	48
1	49
8	56
Total	874

Binary value of 874 = 001101101010.
Length of key string = 11.

Table 2
Shifting result for a secret message.

Encrypted Character	Last digit	Shift value	Position	Character
A	8	1748	Even	I
	9	1749	Odd	(Space)
l	0	1750	even	l
p	1	1751	odd	o
t	2	1752	even	v
h	3	1753	odd	e
	4	1754	even	(Space)
n	5	1755	odd	I
l	6	1756	even	r
h	7	1757	odd	a
i	8	1758	even	q

Table 3
De-shifting result in a shifted secret message.

Decrypted character	Last digit	Shift value	Position	Encrypted Character
I	8	1748	Even	A
	9	1749	Odd	(Space)
L	0	1750	Even	L
o	1	1751	odd	p
v	2	1752	even	t
e	3	1753	odd	h
	4	1754	even	(Space)
I	5	1755	odd	n
r	6	1756	even	l
a	7	1757	odd	h
q	8	1758	even	i

As shown in Table 3, the de-shifted process will return the original secret message which is I love Iraq. The process can be applied also with ciphertext generated from cryptography, in that case, we shifted characters as described in previous, with a condition that the generated shifted ciphertext must be the same length as original ciphertext were the program continue generated ciphertext and shifted cipher text until condition achieved. After that the generated shifted ciphertext has been embedded within the cover message by using the required stego method. Fig. 2 shows the GUI of software and the example of the process.

5. Results

In this section, we test the proposed approaches with five secret messages (three English one Arabic and one Persian) with a different size, and we used two Arabic text messages as stego covers. Table 2 shows the cover and secret messages information.:

At first, we have tested the time required for encryption and decryption for both the new proposed method (AES-HMAC + SHIFTING) and (AES-HMAC) to figured out the speed of each method. We have tested the time of encryption for five types of secret message (which has different languages and sizes as shown in Table 4). The testing results are shown in Table 5.

As shown from Table 5, the time required to encrypt a secret message by a new method (AES-HMAC + SHIFTING) is more than the previous method (AES-HMAC), this because the time required to check the length of original ciphertext and shifted ciphertext in order to achieve the condition of symmetrical character length. It also required more time as the secret message be larger. However, the encryption time of proposed method (AES-HMAC + SHIFTING) is relatively fast and it close to our previous method (AES-HMAC), so it can be no concern.

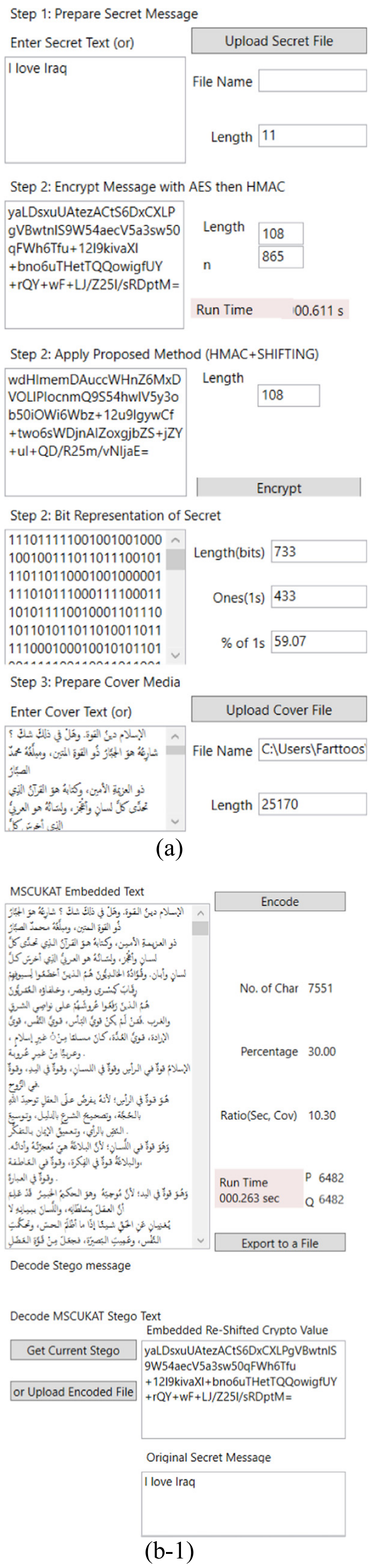
In second part we have tested the embedding of new method by used three stego method of our previous work which is (MSCUKAT, Blood Groupe and Modified Fatha) and compared it with the previous method in order to determine their bit size prior to encryption, bit size after encryption, cover text size which is needed for embedding and time required for embedding process.

There are many equations can be used in the analysis the main aspects for the proposed system, which are [7]:

1- Percentage Capacity: to give the percentage of cover media that has been used to hide the encrypted secret message.

$$\text{Percentage Capacity} = \text{Real Used of Cover}\ (\text{After Encrypt} + \text{Compression}) * 100/\text{Length of cover} \qquad (1)$$

2- Hiding Capacity: to give the percentage of real use of cover (bytes) that has been used to hide the encrypted secret message(bits).



Step 1: Prepare Secret Message

Enter Secret Text (or)

I love Iraq

File Name

Length 11

Step 2: Encrypt Message with AES then HMAC

yaLDsxuUAtezACtS6DxCXLP
gVBwtnIS9W54aecV5a3sw50
qFWh6Tfu+12l9kivaXI
+bno6uTHetTQQowigfUY
+rQY+wF+LJ/Z25I/sRDptM=

Length 108

n 865

Run Time 00.611 s

Step 2: Apply Proposed Method (HMAC+SHIFTING)

wdHImemDAuccWHnZ6MxD
VOLIPlocnmQ9S54hwlV5y3o
b50iOWi6Wbz+12u9lgywCf
+two6sWDjnAlZoxgjbZS+jZY
+ul+QD/R25m/vNljaE=

Length 108

Step 2: Bit Representation of Secret

```
11101111001001001000
10010011101101110010
11011011000100100000
11101011100011110001
10101111001000110111
10110101101101001101
11100010001001010110
```

Length(bits) 733

Ones(1s) 433

% of 1s 59.07

Step 3: Prepare Cover Media

Enter Cover Text (or)

الإسلام دينُ القوة. وهَلْ في ذلكَ شكٌ ؟
شارِعُهُ هوَ الجبَّارُ ذُو القوةِ المتين، ومبلِّغُهُ محمدٌ
الصبَّارُ
ذو العزيمةِ الأمين، وكتابُهُ هوَ القرآنُ الذِي
تحدَّى كلَّ لسانٍ وأعْجَزَ، ولسَانُهُ هو العربيُّ
الذِي أخرسَ كلَّ

File Name C:\Users\Farttoos

Length 25170

(a)

MSCUKAT Embedded Text

الإسلام دينُ القوة. وهَلْ في ذلكَ شكٌ ؟ شارِعُهُ هوَ الجبَّارُ
ذُو القوةِ المتين، ومبلِّغُهُ محمدٌ الصبَّارُ
ذو العزيمةِ الأمين، وكتابُهُ هوَ القرآنُ الذِي تحدَّى كلَّ
لسانٍ وأعْجَزَ، ولسَانُهُ هو العربيُّ الذِي أخرسَ كلَّ
لسانٍ وأبانَ. وقُوَّادُهُ الخالدُونَ هُمُ الذينَ أخضعُوا لسيوفِهِمْ
رِقابَ كِسْرى وقيصر، وخلفاؤهُ المُعْرِقُونَ
هُمُ الذينَ رَفَعُوا عُرُوشَهُمْ على نواصِي الشرقِ
والغرب .فمَنْ لمْ يكنْ قويَّ البأسِ، قويَّ النّفسِ، قويَّ
الإرادة، قويَّ العُدّة، كانَ مسلمًا مِنْ○ غيرِ إسلام ،
وعربيًا مِنْ غيرِ عُروبة .
الإسلامُ قوةٌ في الرأسِ وقوةٌ في اللسانِ، وقوةٌ في اليدِ، وقوةٌ
في الرُّوح.
هُوَ قوةٌ في الرأسِ؛ لأنهُ يفرضُ علَى العقلِ توحيدَ اللهِ
بالحُجّة، وتصحيحَ الشرعِ بالدليل، وتوسيعَ
النَّصِّ بالرأي، وتعميقَ الإيمانِ بالتفكُّر .
وَهُوَ قوةٌ في اللِّسانِ؛ لأنَّ البلاغةَ هيَ مُعجزتُهُ وأداتُه.
والبلاغةُ قوةٌ في الفِكرة، وقوةٌ في العاطفة،
وقوةٌ في العبارة .
وَهُوَ قوةٌ في اليدِ؛ لأنَّ مُوجِّهَهُ وهوَ الحكيمُ الخبيرُ قدْ علِمَ
أنَّ العقلَ بسلطانِه، واللِّسانَ ببيانِهِ لا
يُغنيانِ عَنِ الحقِّ شيئًا إذَا ما أظلَمَ الحِسّ، وتحكَّمتِ
النَّفْس، وعَمِيَتِ البَصيرة، فجعَلَ مِنْ قوّةِ العَضَلِ

No. of Char 7551

Percentage 30.00

Ratio(Sec, Cov) 10.30

Run Time 000.263 sec

P 6482

Q 6482

Decode Stego message

Decode MSCUKAT Stego Text

Embedded Re-Shifted Crypto Value

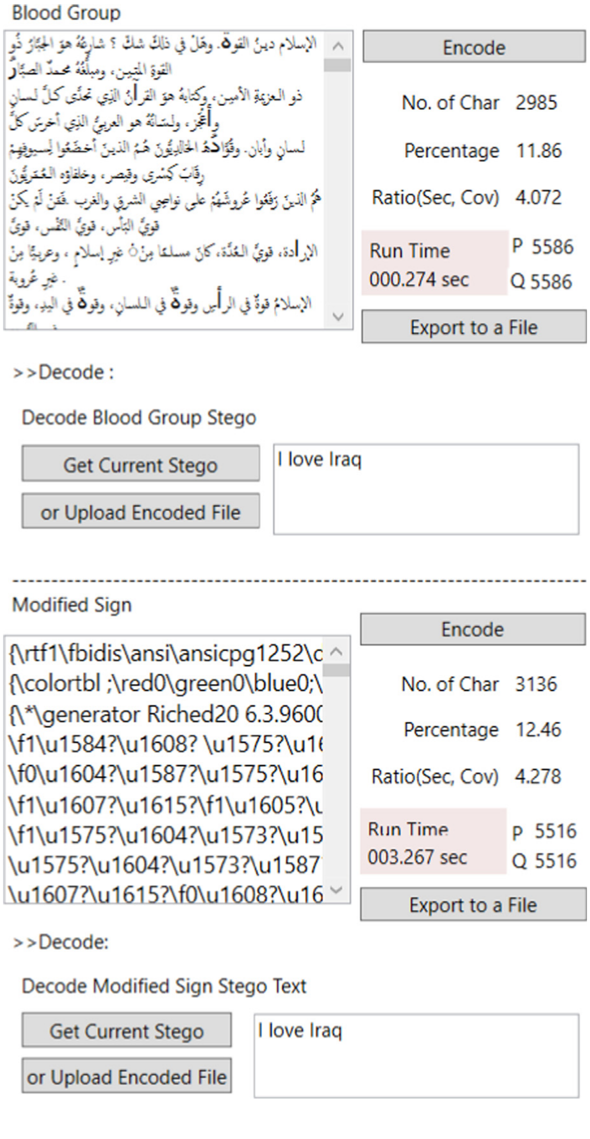
yaLDsxuUAtezACtS6DxCXLPgVBwtnIS
9W54aecV5a3sw50qFWh6Tfu
+12l9kivaXI+bno6uTHetTQQowigfUY
+rQY+wF+LJ/Z25I/sRDptM=

Original Secret Message

I love Iraq

(b-1)

Fig. 2. Crypto-Stego Process. (a) Added secret message and applying HMAC encryption and shifting process. (b-1) Text steganography type MSCUKAT, Upper, embedded the encrypted/shifted message in the cover message, lower is the decoded results (b-2) Text steganography types Blood Group & Modified sign.



Blood Group

الإسلام دينُ القوة. وهَلْ في ذلكَ شكٌ ؟ شارعُهُ هوَ الجبَّارُ ذُو
القوةِ المتِين، ومبلِّغُهُ محمدٌ الصبَّارُ
ذو العزيمةِ الأمين، وكتابهُ هوَ القرآنُ الذِي تحدَّى كلَّ لسانٍ
وأعجز، ولسَانُهُ هو العربيُّ الذِي أخرسَ كلَّ
لسانٍ وأبان. وقوَّادُهُ الخالِدُونَ هُمُ الذينَ أخضَعُوا لسيوفِهِمْ
رِقَابَ كِسْرى وقيصر، وخلفاؤه المُعمّرُون
هُمُ الذينَ رَفَعُوا عُروشَهُمْ على نواحِي الشرقِ والغرب .فمَنْ لَمْ يكنْ
قويَّ البأس، قويَّ النَّفس، قويّ
الإرادة، قويَّ العُدَّة، كانَ مسلمًا مِنْ غيرِ إسلامٍ ، وعربيًّا مِنْ
غيرِ عُروبة .
الإسلامُ قوةٌ في الرأسِ وقوةٌ في اللسانِ، وقوةٌ في اليدِ، وقوةٌ

No. of Char 2985

Percentage 11.86

Ratio(Sec, Cov) 4.072

Run Time 000.274 sec P 5586 Q 5586

>>Decode :

Decode Blood Group Stego

I love Iraq

Modified Sign

```
{\rtf1\fbidis\ansi\ansicpg1252\c
{\colortbl ;\red0\green0\blue0;\
{\*\generator Riched20 6.3.9600
\f1\u1584?\u1608? \u1575?\u16
\f0\u1604?\u1587?\u1575?\u16
\f1\u1607?\u1615?\f1\u1605?\u
\f1\u1575?\u1604?\u1573?\u15
\u1575?\u1604?\u1573?\u1587
\u1607?\u1615?\f0\u1608?\u16
```

No. of Char 3136

Percentage 12.46

Ratio(Sec, Cov) 4.278

Run Time 003.267 sec P 5516 Q 5516

>>Decode:

Decode Modified Sign Stego Text

I love Iraq

(b-2)

Fig. 2 (*continued*)

$$\text{Hiding Capacity} = \text{Sec ret (bits)/Real Used of Cover (bytes)} \quad (2)$$

3- Ratio (secret/cover): It helps to know the ratio between a number of encrypted secret bits to be hidden in a number of characters in the cover media that are enough to hide such encrypted secret bits.

$$\text{Ratio (sec, cov)} = \text{real used of cover/secret(bits)} \quad (3)$$

Table 4
The information for secret messages, cover, and key.

Secret/Cover/Key	Language	Characters Number	Length of the Secret Message (in a bit)
Secret message (s1)	English	28	240
Secret message (s2)	English	346	1856
Secret message (s3)	Persian	966	4568
Secret message (s4)	Arabic	1340	7920
Secret message (s5)	English	3212	13,032
Cover Message (C1)	Arabic	187,782	–
Cover Message (C2)	Arabic	258,107	–
Encryption Key	English	Baghdad2018	–

Table 5
The Time Required for Encryption with (AES-HMAC) and time required for the proposed method (AES-HMAC + SHIFTING).

Secret Message	Time Required for Encryption (sec)	
	(AES-HMAC)	(AES-HMAC) +SHIFTING
Secret message (s1)	0.672	01.413
Secret message (s2)	0.683	01.215
Secret message (s3)	0.865	01.938
Secret message (s4)	0.697	01.590
Secret message (s5)	0.538	01.067

The testing results are shown in Table 6–8.

1. Result when using secret message (S1) with cover (C1)
2. Result when using secret message (S2) with cover (C1)
3. Result when using small secret message (S3) with cover (C1).
4. Result when using small secret message (S4) with cover (C1).
5. Result when using small secret message (S5) with cover (C1).
6. Result when using secret message (S1) with cover (C2)
7. Result when using secret message (S2) with cover (C2)
8. Result when using small secret message (S3) with cover (C2).
9. Result when using small secret message (S4) with cover (C2).
10. Result when using small secret message (S5) with cover (C2).

As shown from applying text steganographic which is results details in tables (6–15). The number of characters of cover message needs for embedding encrypted secret message (i.e. cover size) that generated by used (AES-HMAC + SHIFTING) is same or very close to previous method (AES-HMAC) for all three stego methods (MSCUKAT, blood Group and Modified Fatha) where the cover percentage capacity and hiding capacity are relatively the same for all secret messages. This is due to that the new method modified the AES-HMAC ciphertext and the length of output is the same as the input. For embedding time, the new method is relatively slower than the previous one, this is related to shifting process and

Table 6
The real used of characters, hiding capacity and time for the secret message (S1) with cover (C1).

Time(sec)	Ratio (sec, cov.)	Cover percentage Capacity	Hiding capacity	No. of char (real used)	Encryption Method	Stego Method
0.016	15.61	1.99	6.40	3746	(AES-HMAC) + SHIFTING	MSCUKAT
0.018	15.61	1.99	6.40	3746	(AES-HMAC)	
0.029	20.383	2.61	4.90	4892	(AES-HMAC) + SHIFTING	Blood Group
0.021	20.383	2.61	4.90	4892	(AES-HMAC)	
289.979	18.888	2.41	5.29	4533	(AES-HMAC) + SHIFTING	Modified Fatha
283.460	18.888	2.41	5.29	4533	(AES-HMAC)	

Table 7
The real used of characters, hiding capacity and time for the secret message (S2) with cover (C1).

Time(sec)	Ratio (sec, cov.)	Cover percentage Capacity	Hiding capacity	No. of char (real used)	Encryption Method	Stego Method
0.023	7.26	7.18	13.77	13,478	(AES-HMAC) + SHIFTING	MSCUKAT
0.022	7.28	7.19	13.73	13,509	(AES-HMAC)	
0.031	9.426	9.32	10.60	17,494	(AES-HMAC) + SHIFTING	Blood Group
0.035	9.445	9.33	10.58	17,529	(AES-HMAC)	
283.713	8.801	8.70	11.36	16,334	(AES-HMAC) + SHIFTING	Modified Fatha
274.633	8.817	8.71	11.34	16,365	(AES-HMAC)	

Table 8
The real used of characters, hiding capacity and time for the secret message (S3) with cover (C1).

Time(sec)	Ratio (sec, cov.)	Cover percentage Capacity	Hiding capacity	No. of char (real used)	Encryption Method	Stego Method
0.054	11.34	27.59	8.820	51,790	(AES-HMAC) + SHIFTING	MSCUKAT
0.056	11.33	27.56	8.825	51,758	(AES-HMAC)	
0.091	14.705	35.77	6.8004	67,172	(AES-HMAC) + SHIFTING	Blood Group
0.091	14.700	35.76	6.802	67,149	(AES-HMAC)	
287.078	13.745	33.44	7.275	62,785	(AES-HMAC) + SHIFTING	Modified Fatha
266.934	13.738	33.42	7.278	62,757	(AES-HMAC)	

Table 9
The real used of characters, hiding capacity and time for the secret message (S4) with cover (C1).

Time(sec)	Ratio (sec, cov.)	Cover percentage Capacity	Hiding capacity	No. of char (real used)	Encryption Method	Stego Method
0.076	9.16	38.64	10.481	75,562	(AES-HMAC) + SHIFTING	MSCUKAT
0.080	9.17	38.69	10.902	72,646	(AES-HMAC)	
0.133	11.884	50.12	8.414	94,124	(AES-HMAC) + SHIFTING	Blood Group
0.114	11.900	50.19	8.403	94,250	(AES-HMAC)	
897.900	11.106	46.84	9.003	87,963	(AES-HMAC) + SHIFTING	Modified Fatha
275.237	11.122	46.91	8.99	88,089	(AES-HMAC)	

Table 10
The real used of characters, hiding capacity and time for the secret message (S5).

Time(sec)	Ratio (sec, cov.)	Cover percentage Capacity	Hiding capacity	No. of char (real used)	Encryption Method	Stego Method
0.091	7.39	51.27	13.53	96,277	(AES-HMAC) + SHIFTING	MSCUKAT
0.095	7.38	51.21	13.55	96,158	(AES-HMAC)	
0.141	9.583	66.51	10.43	124,885	(AES-HMAC) + SHIFTING	Blood Group
0.157	9.571	66.42	10.44	124,729	(AES-HMAC)	
322.797	8.957	62.16	11.16	116,722	(AES-HMAC) + SHIFTING	Modified Fatha
308.238	8.947	62.09	11.17	116,595	(AES-HMAC)	

Table 11
The real used of characters, hiding capacity and time for the secret message (S1) with cover (C2).

Time(sec)	Ratio (sec, cov.)	Cover percentage Capacity	Hiding capacity	No. of char (real used)	Encryption Method	Stego Method
0.024	15.19	1.41	6.58	3646	(AES-HMAC) + SHIFTING	MSCUKAT
0.021	15.19	1.41	6.58	3646	(AES-HMAC)	
0.030	19.329	1.80	5.17	4639	(AES-HMAC) + SHIFTING	Blood Group
0.028	19.329	1.80	5.17	4639	(AES-HMAC)	
512.699	21.729	2.02	4.602	5215	(AES-HMAC) + SHIFTING	Modified Fatha
490.830	21.729	2.02	4.602	5215	(AES-HMAC)	

comparing length strategy (the strategy that makes encryption repeated until the length of encryption text is equal to shifting one). However, the encryption time for both are very fast and it not exceed 2 s (Tables 9–14).

- **Time required after Encryption ((AES-HMAC) &(AES-HMAC + SHIFTING)) and steganography for 5-secret messages and 2-covers**

For Table 15, the overall time needed for encryption and decoding of proposed method (AES-HMAC + SHIFTING) is very close to the previous method (AES-HMAC) for all three stego methods (MSCUKAT, blood Group and Modified Fatha). In addition, the proposed method is run fast and no increases in cover size, thus, this method can be used to have strong encryption with relatively same processing time and embedding size which is the big advantage offer improvement to our previous method (Table 16).

Table 12
The real used of characters, hiding capacity and time for the secret message (S2) with cover (C2).

Time(sec)	Ratio (sec, cov.)	Cover percentage Capacity	Hiding capacity	No. of char (real used)	Encryption Method	Stego Method
0.028	7.08	5.09	14.119	13,145	(AES-HMAC) + SHIFTING	MSCUKAT
0.036	7.11	5.11	14.062	13,198	(AES-HMAC)	
0.039	8.922	6.42	11.208	16,559	(AES-HMAC) + SHIFTING	Blood Group
0.034	8.958	6.44	11.163	16,626	(AES-HMAC)	
491.556	9.968	7.17	10.032	18,500	(AES-HMAC) + SHIFTING	Modified Fatha
484.882	10.008	7.2	9.991	18,575	(AES-HMAC)	

Table 13
The real used of characters, hiding capacity and time for the secret message (S3) with cover (C2).

Time(sec)	Ratio (sec, cov.)	Cover percentage Capacity	Hiding capacity	No. of char (real used)	Encryption Method	Stego Method
0.077	11.1	19.65	9.005	50,723	(AES-HMAC) + SHIFTING	MSCUKAT
0.097	11.1	19.65	9.005	50,723	(AES-HMAC)	
0.095	13.991	24.76	7.147	63,909	(AES-HMAC) + SHIFTING	Blood Group
0.131	13.991	24.76	7.147	63,909	(AES-HMAC)	
543.786	15.577	27.57	6.419	71,155	(AES-HMAC) + SHIFTING	Modified Fatha
593.592	15.577	27.57	6.149	71,155	(AES-HMAC)	

Table 14
The real used of characters, hiding capacity and time for the secret message (S4) with cover (C2).

Time(sec)	Ratio (sec, cov.)	Cover percentage Capacity	Hiding capacity	No. of char (real used)	Encryption Method	Stego Method
0.096	9	27.61	11.113	71,264	(AES-HMAC) + SHIFTING	MSCUKAT
0.114	9	27.61	11.113	71,264	(AES-HMAC)	
0.127	11.328	34.76	8.827	89,721	(AES-HMAC) + SHIFTING	Blood Group
0.138	11.328	34.76	8.827	89,721	(AES-HMAC)	
538.06	12.619	38.72	7.924	99,942	(AES-HMAC) + SHIFTING	Modified Fatha
523.809	12.619	38.72	7.924	99,942	(AES-HMAC)	

Table 15
The real used of characters, hiding capacity and time for the secret message (S5) with cover (C2).

Time(sec)	Ratio (sec, cov.)	Cover percentage Capacity	Hiding capacity	No. of char (real used)	Encryption Method	Stego Method
0.099	7.24	36.57	13.806	94,387	(AES-HMAC) + SHIFTING	MSCUKAT
0.109	7.24	36.57	13.806	94,387	(AES-HMAC)	
0.182	9.123	46.07	10.96	118,897	(AES-HMAC) + SHIFTING	Blood Group
0.178	9.123	46.07	10.96	118,897	(AES-HMAC)	
561.468	10.161	51.3	9.842	132,412	(AES-HMAC) + SHIFTING	Modified Fatha
549.54	10.161	51.3	9.842	132,412	(AES-HMAC)	

Table 16
The real used of characters, hiding capacity and time for the secret message (S5) with cover (C2).

Secret messages	Covers	AES-HMAC	(AES-HMAC) + SHIFTING
S1	C1	0.018 ~ 283.460	0.016 ~ 289.979
	C2	0.021 ~ 490.830	0.024 ~ 512.699
S2	C1	0.022 ~ 274.633	0.023 ~ 283.713
	C2	0.036 ~ 484.882	0.028 ~ 491.556
S3	C1	0.056 ~ 266.934	0.54 ~ 287.078
	C2	0.097 ~ 593.592	0.77 ~ 543.786
S4	C1	0.080 ~ 275.237	0.076 ~ 897.900
	C2	0.114 ~ 523.809	0.096 ~ 538.060
S5	C1	0.095 ~ 308.238	0.091 ~ 322.797
	C2	0.109 ~ 549.540	0.099 ~ 561.468

6. Conclusions

In this work, we have proposed a new crypto method that used AES-HMAC algorithm then shifting the ciphertext by used shifting algorithm in order to be embedded within the cover text so that the attacker cannot crack it by used cryptanalysis. For cryptography, we have been used AES256-HMAC algorithm bit then applied a shifting algorithm. The ciphertext generated has passed to shifting algorithm to rearrange ciphertext and generate shifting chipper. The shifted cipher then passes to stego part. several conclusions can be attracted to this work; the mainly important points are:

1. The crypto-stego combination techniques satisfy the requirements such as high security and robustness between sender and receiver.
2. The main advantage of this system is that the method used a combination of AES256-HMAC then shifting the ciphertext by used shifting algorithm which is very secure and the stego techniques which are very hard to detect.
3. Because of the key length is (256bits) and the number of cycles (14) it takes a long time for attacker malware to do a dictionary attack. Furthermore, the use of shifting algorithm that shifting the ciphertext to different characters it makes impossible for the attacker to decrypt message because it needs to rearrange to its original ciphertext.
4. This new method can be run at the low computational requirement, but it will be fast as the computer be stronger. In this work, the test is done by a relatively lower level laptop which

has a Core i3 CPU of speed (1.8GH) and it has (4 GB) of RAM. The encryption process that used combination of AES-HMAC encryption and shifting has need more time which needs (0.016–289.979) second for short message and about (0.023–283.713) second for medium message, and (0.091–322.797) for large message while for previous method it required (0.018–283.460), (0.022–274.633), and (0.095–308.238) respectively, but it still relatively lower in time.

REFERENCES

[1] Al-Gailani MF. ''Advanced Cryptographic System: Design, Architecture and FPGA Implementation'', Ph.D. Thesis, School of Electrical, Electronic and Computer Engineering, Newcastle University, England, United Kingdom, 2012, pp.

[2] Babu KR, Kumar SU, Babu AV. A survey on cryptography and steganography methods for information security. Int J Comput Appl 2010;12(2):13–7.

[3] Madhuravani B, Bhaskara RP, Lalith SRP. ''Steganography Techniques: Study & Comparative Analysis'', International Journal of Advanced Scientific and Technical Research Issue 4 Vol.2, ISSN 2249-9954, 2014.

[4] Rabah K. Theory and implementation of data encryption standard a review. Inf Technol J 2005;4(4):307–25. doi: https://doi.org/10.3923/itj.2005.307.325.

[5] Saleh ME, Aly AA, Omara FA. Data security using cryptography and steganography techniques. Int J Adv Comput Sci Appl (IJACSA) 2016;7(6):390–7.

[6] Malalla S, Shareef FR. Improving hiding security of arabic text steganography by hybrid aes cryptography and text steganography. Int J Eng Res Appl 2016;6(6):60–9.

[7] Gutub AA, Al-Nazer AA. High Capacity Steganography Tool for Arabic Text Using ''Kashida''. The ISC Int'l J Inf Secur 2010;2(2):107–18.

[8] Malalla S, Shareef FR. A new modified fatha method for arabic text steganography hybrid with aes encryption. IOSR 2016;18(5):37–45.

[9] Malalla S, Shareef FR. Novel approach for arabic text steganography based on the ''bloodgroup'' text hiding method. Eng Technol Appl Sci Res 2017;7(2):1482–5.

[10] Mujtaba SM, Asadullah S. A Novel Text Steganography Technique to Arabic Language Using Reverse Fatha''. PJETS 2011;1(2):106–13.

[11] Alanazi HO, Zaidan BB, Zaidan AA, Jalab HA, Shabbir M, Al-Nabhani Y. New comparative study between DES, 3DES, and AES''''. J Comput 2010;2(3):152–7.

[12] Mushtaq MF, Jamel S, Disina AH, Pindar ZA, Shakir NSA, Deris MM. A Survey on the Cryptographic Encryption Algorithms''. Int J Adv Comput Sci Appl (IJACSA) 2017;8(11):333–44.

[13] Beringer L, Petcher A, Ye KQ, Appel AW. Verified Correctness and Security of OpenSSL HMAC'', 24th Usenix Security Symposium, August 2015, pp.1–15.