Technique to Generate Variable Keys with Key Variation with Noise Burst Bit for Achieving Perfect Security in Cryptology towards Optimum Data Transfer

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Abstract

To create dynamic keys which change from session to session or data to data, an idea has been found in literature which has been named as Automatic Variable Key. This technique has been proposed to overcome the problem that arises with a static key. In case of static key, the same key has been used for the entire data communication and if anyhow it has been compromised then the basic requirement of cryptography fails. In this manuscript, we have proposed a few dynamic key generation techniques. In these proposed techniques, the variable keys have been generated based on some existing techniques namely, Computing & Shifting Automatic Variable Key, Alternating & Shifting Automatic Variable Key, Left Shifting Automatic Variable Key by incorporating noise burst bit. During the performance analysis, it has been observed that the auto generated keys are more random in the proposed techniques. The randomness of successive generated keys have been tested with the help of NIST (National Institute of Standards and Technology), a statistical tool and proved that the generated keys are truly random. Lastly, we have commented that these techniques can be used in real-time applications as they provide more security as compared to other existing mechanisms.

Keywords: Randomness, Standard Deviation, Automatic Variable Key, Noise Burst

1. Introduction

Information is an asset that has a specific value so; our aim is to keep that information secretly from attackers and to maintain confidentiality of information. However, attaining the security by a single key in today's era becomes an obsolete idea due to the incredible growth of information technology. As per the fundamental research proposed by Shannon [1-2], perfect security can be achieved if the key is made variable from session to session during data transmission in network security. The cryptographic algorithms rely on increasing the key size to enhance the level of security, it will be an effective way, if keys can be made time variant by changing it from session to session in data communication. Vernum [3-4] proposed that if the generated keys would be changed from session to session during data transmission then it would be impossible to break the keys. Bhunia [5-7] proposed the Automatic Variable Key technique for practical approaches of security in the year 2006. There are many researchers like Goswami [10-17], Banerjee and Dutta *et al.* [8-9] invented more secure techniques based on Automatic Variable Key (AVK) by increasing the randomness, standard deviation and root mean square among the auto generated key sequences. The aim of our techniques is to secure the key from unauthorized persons and to hide the secret keys from others and to generate more

random keys as compared to the existing key generation techniques. The technique of Automatic Variable Key is based on the following procedure:

The initial key K_1 will be exchanged between sender and receiver in a secret mode. Subsequent keys for different data D_{i-1} will be automatically generated between two parties sender and receiver in secret mode like AES.

One technique was proposed by Goswami in 2013 called Computing & Shifting Automatic Variable Key (CSAVK) [14]. In this proposed technique, the key is made variable by an agreement that creates new key for each data. Subsequent keys will be generated as per the following equation:

$$K_i = K'_{i-1} \oplus D'_{i-1} \quad \forall \quad i > 0 \dots \dots \dots (1)$$

Where K'_{i-1} = bit wise right shifted key K_{i-1} , number of shift will be the number of 1's present in K_{i-1} and D'_{i-1} = bit wise left shifted data D_{i-1} , number of shift will be the number of 1's present in D_{i-1} .

In Alternating & Shifting Automatic Variable Key (ASAVK) [15] technique, the key is made variable a procedure that also creates new key for each data.

At first, initial key K_1 is exchanged between sender and receiver and subsequent key K_i (i^{th} stage) is generated by both sender and receiver as follows:

$$K_i = K'_{i-1} \oplus D_{i-1} \quad \forall \quad i > 0 \dots \dots \dots (2)$$

$$K_{i+1} = K_i \oplus D'_{i-1} \quad \forall \quad i > 0 \dots \dots \dots (3)$$

Where K'_{i-1} = block wise shift K_{i-1} , the number of shift will be total length of K_{i-1} divided by 2 and D'_{i-1} = block wise shift D_{i-1} , the number of shift will be total length of D_{i-1} divided by 2.

In Left Shifting Automatic Variable Key (LSAVK) [18] technique, the key is generated as per the following equation:

Subsequent key K_i (i^{th} stage) is generated by both sender and receiver as follows:

$$K'_1 \leftarrow K_0 \oplus D_0 \dots \dots \dots (4)$$

$$K_1 \leftarrow CLS(K'_1) \dots \dots \dots (5)$$

$$K'_2 \leftarrow K_1 \oplus D_1 \dots \dots \dots (6)$$

$$K_2 \leftarrow CLS(K'_2) \dots \dots \dots (7)$$

Where K_0 = Initial key and D_0 = First data set

Where CLS (K'_i) is circular left shift of K'_i by n bits and continue this procedure until dataset $\neq \emptyset$.

We have compared the existing techniques namely, Computing & Shifting Automatic Variable Key with key variation through noise burst bit, Alternating & Shifting Automatic Variable Key with key variation through noise burst bit technique and Left shifting Automatic Variable Key with key variation through noise burst bit and found that these new techniques are more secure than Computing & Shifting Automatic Variable Key technique without key variation noise burst bit, Alternating & Shifting Automatic Variable Key technique without noise burst bit and Left shifting Automatic Variable Key without noise burst bit. In section 2, we have described our new schemes with examples. We have included our experimental results for performance analysis in section 3, section 4 summarizes comparison of the proposed schemes with existing ones followed by randomness verification in section 5. Finally, conclusion is given in section 6.

2. Proposed Scheme

Here, we have proposed new techniques to generate new keys in Automatic Variable Key with key variation through noise burst bit (AVK with NB). The purpose is to yield

new keys with noise burst to enhance security by generating more randomness between two successive keys.

The algorithm of the new technique is as follows:

- Initial key (K_1) and noise burst will be exchanged between sender and receiver.
- Subsequent key (K_i) is generated by both sender and receiver.

At first, noise burst will be read; the bits of noise burst will be read from left to right. If the bit of noise burst is 1 then new key will be generated as per Computing & Shifting Automatic Variable Key (CSAVK) technique as per equation number (1).

No new key will be generated if bit of noise burst is 0, the key will be as same as previously generated keys.

The procedure will be same as in case of Alternating & Shifting Automatic Variable Key (ASAVK) technique. The bits of noise burst will be read from left to right and it is continued till the end of all bits in noise burst. If bit of noise burst is 1, key will be generated as per Alternating & Shifting Automatic Variable Key (ASAVK) technique based on equation number (2-3). If noise burst is 0, key will be as same as previously generated key.

In case of Left Shifting Automatic Variable Key (LSAVK), the procedure will be same. If bit of noise burst is 1 then new key will be generated as per equation number (4-7) otherwise no new key will be generated, the key will be same as previously generated key. This scheme is known as Key Variation with Noise Burst Bit.

Noise Burst is a true random number so if we pass these proposed techniques as mentioned with noise burst bit then we can say that these new techniques are more superior and be capable of producing more randomness between two of successive keys.

In these proposed schemes, we have compared the Computing & Shifting Automatic Variable Key technique, Alternating & Shifting Automatic Variable Key technique and Left Shifting Automatic Variable Key technique with key variation through Noise Burst Bit (KVNBB).

2.1. Example1

Let us assume, initial key $K_1 =$

01100111001111011110001010010000111100010010000010
100110100011001101111000101001000011110001000110001100111001101000001010
011100 and data $D_1 =$

010010100111010101101100011010010111010101110011001000000100001101100001
0 1100101011100110110000101110010001000000111010101110011 with noise
burst=111001010011

110111100010111101001111000100101010101001101010110111100101001000101111
0110011010101101111011100111100010010101010 then the new keys will be
generated as follows:

1st bit of noise burst is 1, so the next will be generated as per Computing & Shifting Automatic Variable Key technique in equation number (1).

$K_2 =$

101111000101010110010011010101010010111010000010101000000100111011111101
00101 011000011110101111100000011100000100011101000110101

2nd bit of noise burst is 1 so the new key will be as follows:

$K_3 =$

110110101010001010110000100100100110000100100110100001100101101001010111
00000 000000011110101001010101000000011001011011000011100

3rd bit of noise burst is 1 so the new will be:

$K_4 =$
111001101011010111000100010000100010111110000111100101011110101011000100
01100 100000001100111101100000110010001011100110100011001
4th bit of noise burst is 0 so the key will be as same as previous key
 $K_5 =$
111001101011010111000100010000100010111110000111100101011110101011000100
01100 100000001100111101100000110010001011100110100011001 and procedure is
continued until noise burst $\neq \emptyset$

2.2. Example2

Let us consider, the initial key $K_1 =$
0110011100111101111000101001000011110001001000
001010011010001100110111100010100100001111000100011000110011100110100000
101001110 and $D_1 =$
010010100111010101101100011010010111010101110011001000000100001101100001
0 1100101011100110110000101110010001000000111010101110011 with noise burst =
11100101001
1110111100010111101001111000100101010100110101011011110010100100010111
101100110101011011111011100111100010010101010.

The new keys will be generated as follows:

1st bit of noise burst is 1, hence the next will be generated as per Alternating & Shifting
Automatic Variable Key technique as per equation number (2-3).

$K_2 =$
100101000101110001100011011110001111100110010101101000101101111100000110
01011 0001001000111110001100000110000000110100111111111
 $K_3 =$
11100100001010000000110000001011100000011100110110101101011101001100011
00111 100101100011001000010100011011000111010000110000110

[Using the noise burst's 2nd bit key K_3 has been generated]

3rd bit of noise burst is 1 so the new key will be generated as per Alternating & Shifting
Automatic Variable Key technique.

$K_4 =$
000011100001110011011000111111101000001100001011110010001111010111000100
01011 111011011010111100111110011110010101111011011001101
 $K_5 =$
0110000001110011101011111101111000101101110101011101001000010101100
00110 110000011100001000111010011101000111000010111101101

[Using noise burst's 4th bit key K_5 has been generated] and procedure is continued until
noise burst $\neq \emptyset$

2.3. Example 3

Let us assume, initial key $K_1 =$
01100111001111011110001010010000111100010010000010
100110100011001101111000101001000011110001000110001100111001101000001010
011100 and $D_1 =$
010010100111010101101100011010010111010101110011001000000100001101100001
01 100101011100110110000101110010001000000111010101110011 with noise burst =
111001010011

110111100010111101001111000100101010101001101010110111100101001000101111
0110011010101101111011100111100010010101010

The new keys will be generated as per equation number (4-7) as follows:

1st bit of noise burst is 1, hence the next will be generated as per Left Shifting Automatic Variable Key technique:

K_2 =
100001000000111010101001010010001001011100110010011011010101101011011101
00110 11101101101010100001001101011111011010111000001001011

2nd bit of noise burst is 1, so the keys will be as:

K_3 =
011101010101111010000101010000110111110010101010110001110001001000000100
10101 001110110100111101011010110110001101011010101001000 and procedure is
continued until dataset $\neq \emptyset$

2.4. Illustration of Computing & Shifting Automatic Variable Key with Key Variation Noise Burst Bit (ASAVK with NB), Alternating & Shifting Automatic Variable Key with Key Variation Noise Burst Bit (ASAVK with NB) and Left Shifting Automatic Variable Key with Key Variation Noise Burst Bit (LSAVK with NB)

Let us consider, sender sends initial key K_1 =

01100111001111011110001010010000111100
010010000010100110100011001101111000101001000011110001000110001100111001
101000001010011100 and data D_1 =

010010100111010101101100011010010111010101110011001000000100
00110110000101100101011100110110000101110010001000000111010101110011 with
noise burst =
111001010011110111100010111101001111000100101010101001101010110111100101
0010001 0111101100110101011011111011100111100010010101010

Then the new key will be generated as per Computing & Shifting Automatic Variable Key technique in Equation number (1) when noise burst bit is 1, next key will be generated as:

1011110001010101100100110101010100101110100000101010000001001110111111
0100101011000011110101111100000011100000100011101000110101 and when noise
burst is 0 then next key will be as same as previously generated key.

In case of Alternating & Shifting Automatic Variable Key technique, the new key will be generated as per Equation (2-3) when bit of noise burst is 1

K_2 =
10010100010111000110001101111000111110011001010110100010110111100000110
01011 000100100011111000110000011000000001101001111111111

K_3 =
111001000010100000001100000010111000000011100110110101101011101001100011
00111 100101100011001000010100011011000111010000110000110 and when noise
burst is 0 then the next key will be as same as previously generated keys.

Let us assume sender sends initial key K_1 =

01100111001111011110001010010000111100010
010000010100110100011001101111000101001000011110001000110001100111001101
000001010011100 and data

D_1 = 01001010011101010110110001101001011101010111001100100000010000110
110000101100101011100110110000101110010001000000111010101110011 with noise
burst = 111

0010100111101111000101111010011110001001010101001101010110111100101001
00010111101100110101011011111011100111100010010101010

Then the new key will be generated as per Left Shifting Automatic Variable Key technique in Equation number (4-7) if the noise burst bit is 1. So the key will be as:

K_2 =

100001000000111010101001010010001001011100110010011011010101101011011101
00110 11101101101010100001001101011111011010111000001001011

2nd bit of noise burst is 1, so the keys will be as:

K_3 =

011101010101111010000101010000110111110010101010110001110001001000000100
10101 001110110100111101011010110110001101011010101001000

3. Performance Analysis

For performance analysis of the proposed techniques, we have taken initial key as K_1 = 011001110011110111100010100100001111000100100000101001101000110011011110
00101001000011110001000110001100111001101000001010011100 and noise burst = 11100101001111011110

001011110100111100010010101010100110101011011110010100100010111101100110
101011011111011100111100010010101010 with the following dataset

Dataset = "Julius Caesar used a cryptosystem in his wars, which is now referred to as Caesar cipher it is an additive cipher with the key set to three, each character in the plaintext is shifted three characters to create cipher text. A brute Force attack on a Hill cipher is extremely difficult because the key is an $m \times m$ matrix, the key matrix in the Hill cipher needs to have a multiplicative inverse, multiplicative inverses are only defined for square matrices".

Using the same initial key and data set pairs with noise burst bit, we have calculated the randomness, average randomness and standard deviation and portrayed these from Figure 1 to 3 respectively. For analysis purpose, we have assumed randomness as a parameter which is a measure of amount of variation between successive keys. For example if K_i = 1010101110110010 and K_{i+1} = 0011101011110011. So the randomness between K_i and K_{i+1} is 5. These results are found more productive and superior among these techniques with noise burst as per literature survey.

Figure 1. Randomness of keys of Computing & Shifting Automatic Variable Key with Key Variation Noise Burst Bit (CSAVK with NB), Alternating & Shifting Automatic Variable Key with Key Variation Noise Burst Bit (ASAVK with NB), Left Shifting Automatic Variable Key with Key Variation Noise Burst Bit (LSAVK with NB)

Figure 2. Comparison of Average Randomness of Computing & Shifting Automatic Variable Key with Key Variation Noise Burst Bit (CSAVK with NB), Alternating & Shifting Automatic Variable Key with Key Variation Noise Burst Bit (ASAVK with NB), Left Shifting Automatic Variable Key with Key Variation Noise Burst Bit (LSAVK with NB)

Figure 3. Comparison of Standard Deviation of Computing & Shifting Automatic Variable Key with Key Variation Noise Burst Bit (CSAVK with NB), Alternating & Shifting Automatic Variable Key with Key Variation Noise Burst Bit (ASAVK with NB), Left Shifting Automatic Variable Key with Key Variation Noise Burst Bit (LSAVK with NB)

4. Comparison

Here, we have proposed 3 new techniques and compared the results of average randomness and standard deviation of Computing & Shifting Automatic Variable Key with key variation through noise burst bit, Alternating & Shifting Automatic Variable Key with key variation through noise burst bit and Left Shifting Automatic Variable Key with key variation through noise burst bit with the existing ones namely, Computing & Shifting Automatic Variable Key, Alternating & Shifting Automatic Variable Key and Left Shifting Automatic Variable Key. The randomness and standard deviation have been calculated by executing those programs and results are portrayed in Figure 4 and 5 respectively.

Figure 4. Comparison of Average Randomness of Computing & Shifting Automatic Variable Key with Key Variation Noise Burst Bit (CSAVK with NB), Alternating & Shifting Automatic Variable Key with Key Variation Noise Burst Bit (ASAVK with NB), Left Shifting Automatic Variable Key with Key Variation Noise Burst Bit (LSAVK with NB), Computing & Shifting Automatic Variable Key (CSAVK), Alternating & Shifting Automatic Variable Key (ASAVK), Left Shifting Automatic Variable Key (LSAVK)

From the graph of Figure 4 and 5, it is found that the superiority of one technique is higher than other technique (*e.g.* ASAVK with NB) and for other cases it is just opposite. From Figure 4, we have found that the Average Randomness of Alternating & Shifting Automatic Variable Key with Noise Burst Bit technique is the highest than the other techniques.

Figure 5. Comparison of Standard Deviation of Computing & Shifting Automatic Variable Key with Key Variation Noise Burst Bit (CSAVK with NB), Alternating & Shifting Automatic Variable Key with Key Variation Noise Burst Bit (ASAVK with NB), Left Shifting Automatic Variable Key with Key Variation Noise Burst Bit (LSAVK with NB), Computing & Shifting Automatic Variable Key (CSAVK), Alternating & Shifting Automatic Variable Key (ASAVK), Left Shifting Automatic Variable Key (LSAVK)

The Standard Deviation of Left Shifting Automatic Variable Key with Noise Burst Bit is the highest as compared to other techniques as shown in Figure 5. Therefore, from the experiment, we have found that the superiority of different techniques may vary from one session to another session.

5. Randomness Verification

We have verified the randomness among the successive keys, generated by all the experiments defined in the previous section, with the help of NIST (National Institute of Standards & Technology) test suite. The NIST test suite is a statistical package containing 15 different tests to determine whether a random key generator is suitable for a particular cryptographic application or not. We have examined the randomness of our successive keys based on the following 4 statistical tests only.

- i) Frequency Test
- ii) Block Frequency Test
- iii) Cumulative Tests
- iv) Runs Test

Each test is based on a calculated test statistic value, which is a function of data. If the test statistic value is S and the critical value is t , then the error probability is $P(S > t \parallel H_0 \text{ is true}) = P(\text{reject } H_0 \mid H_0 \text{ is true})$. Another type of error probability is $P(S \leq t \parallel H_0 \text{ is false}) = P(\text{accept } H_0 \mid H_0 \text{ is false})$, here H_0 = null hypothesis. The test statistic is used to calculate a p-value that summarizes the strength of the evidence against the null hypothesis. For these tests each p-value is the probability that a perfect random number generator would have produced a sequence less random than the sequence that was tested, given the kind of non-randomness assessed by the test. If a p-value for a test is equal to 1, then the sequence appears to have perfectly random. A p-value of zero indicates that the sequence appears to be completely non-random. If the p-value is < 0.01 then it can be inferred that the sequence is non-random otherwise, the sequence is random. The p-values of our experiments have been summarized in Table 1:

Table 1. Statistical Test Results for Computing & Shifting Automatic Variable Key with Key Variation Noise Burst Bit (CSAVK with NB), Alternating & Shifting Automatic Variable Key with Key Variation Noise Burst Bit (ASAVK with NB) and Left shifting Automatic Variable Key with key Variation Noise Burst Bit (LSAVK with NB)

Proposed Techniques	Test	P-Value	Remarks
Computing & Shifting Automatic Variable Key with Noise Burst Bit	Frequency Test	0.213309	Random
	Block Frequency	0.213309	Random
	Cumulative Sum (Forward)	0.534146	Random
	Cumulative Sum (Backward)	0.090936	Random
	Runs Test	0.122325	Random
Alternating & Shifting Automatic Variable Key with Key Variation with	Frequency Test	0.275709	Random
	Block Frequency	0.275709	Random
	Cumulative Sum (Forward)	0.437274	Random
	Cumulative Sum (Backward)	0.739918	Random

Noise Burst Bit	Runs Test	0.090936	Random
Left Shifting Automatic Variable Key with key Variation with Noise Burst Bit	Frequency Test	0.534146	Random
	Block Frequency Test	0.534146	Random
	Cumulative Sum (Forward)	0.090936	Random
	Cumulative sum (Backward)	0.739918	Random
	Runs Test	0.350485	Random

6. Conclusion

In our proposed schemes, we have calculated average randomness and standard deviation of the auto generated successive keys that can be applied in cryptography for security purpose in various applications. The generated keys of Computing & Shifting Automatic Variable Key with key variation through noise burst bit, Alternating & Shifting Automatic Variable Key with key variation through noise burst bit and Left Shifting Automatic Variable Key with key variation through noise burst bit are well established. After analysing the experiments, it is found that the superiority of Alternating & Shifting Automatic Variable Key with key variation through noise burst bit for same dataset is much higher than other compared techniques when we use average randomness as parameter for comparison. But when we use standard deviation as a parameter, Left Shifting Automatic Variable Key with key variation through noise burst bit is much superior to other technique with noise burst. We have tested the generated key sequences in NIST (National Institute of Standards and Technology) statistical tool and we have seen that the key sequences are purely random. Hence, we can conclude that proposed techniques can be applied in cryptographic algorithms such as with RSA, AES, DES for attaining perfect secrecy.

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