Generation of Variable Session Keys Based on Piggybacking Strategy

Manash Pratim Dutta, Subhasish Banerjee, C. T. Bhunia

Abstract— Since the dawn of computer networks, protecting information from unauthorized users becomes like a battle field for the researchers and the attackers. Whenever any new solutions have been designed by the researchers to achieve the confidentiality and integrity towards the shared information, a new problem is always arisen by the attackers who are always ready to find out the loopholes. One of the solutions is to achieve and make difficult for the attacker by changing the keys frequently during the message transmission. In this regard, Automatic Variable Key (AVK) is an alternative approach to fulfill the requirements of such key variations. Therefore, in this article we have analyzed such approaches and given the contributions by proposing a new method to generate the keys which can enhance the security issues by increasing the randomness among the set of auto generated keys.

Keywords— AVK, randomness, security, session keys

I. Introduction

As such computer networks are expanding in exponential order; therefore, it becomes an indispensable part of human life which is used to fulfill all their daily requirements such as e-banking, online shopping, e-trading etc.. Hence, maintaining confidentiality of such shared information becomes an emerging arena of research among the researchers. From the last few decades, many schemes [1-6] have been designed to exchange the information secretly between the authorized entities. But, keeping the keys secret from the attackers is one of the most difficult problems in practical scenario. Whenever none of the attempts goes right in favor of the attackers and almost become tired to search all possible prospects to break the confidentiality then brute force attack may remain as the last hope and most of times get success even. To tackle such problems, one of the vital solutions is to make the key long enough so that attacker cannot try all possible combinations. Due to computing process is not limited anymore; assuring such method may not be further sustainable. In this regard, a famous scientist namely, Vernum [7-10] proposed that difficulty can be added in breaking the long keys if the key changes from session to session or time to time. Therefore,

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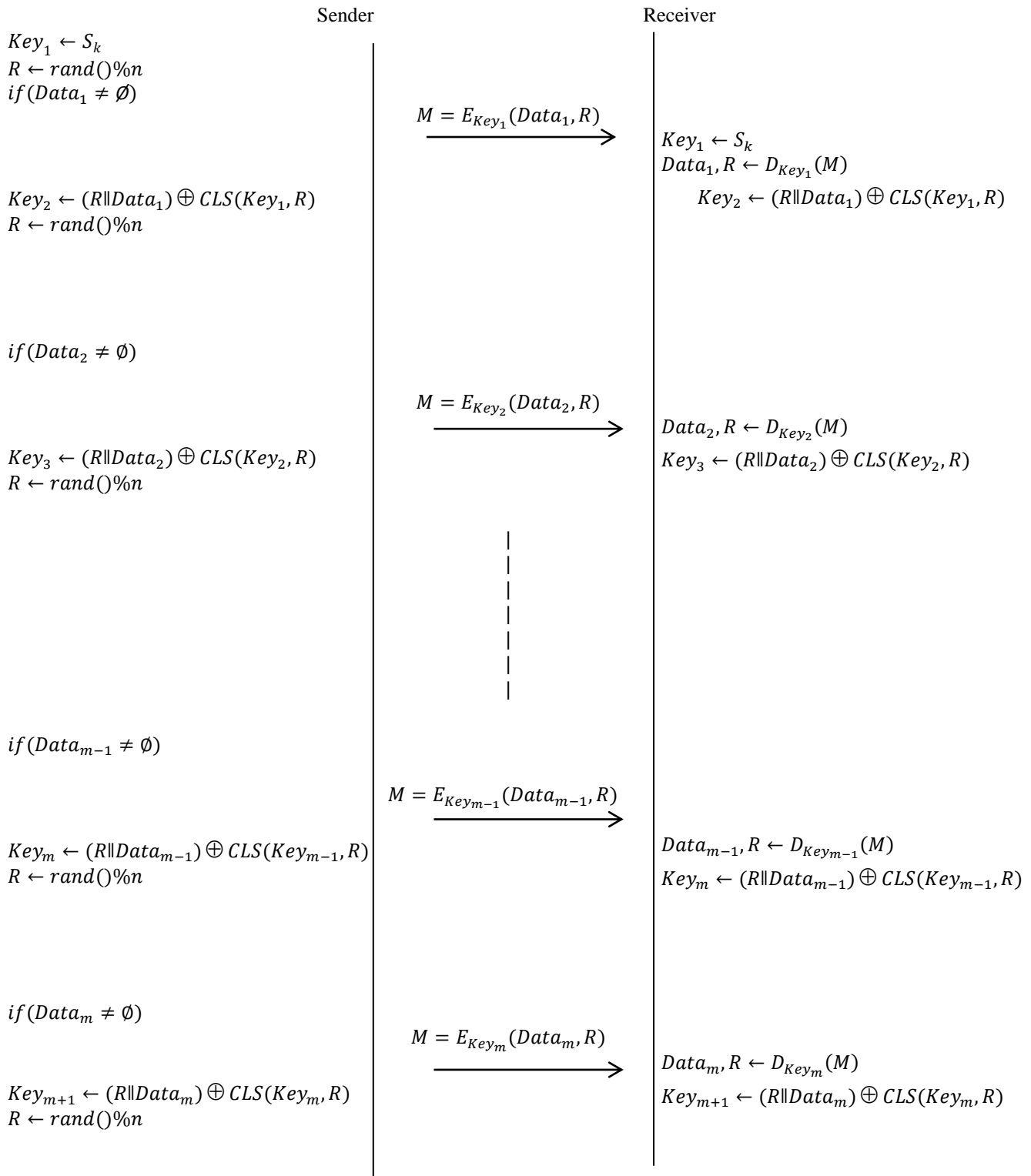National Institute of Technology, Arunachal Pradesh,
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in the year 2006, Bhunia [11-13] introduced the concept of time variant key generation technique which makes the key variable in nature by demonstrating the AVK mechanism. As per the literature survey, the AVK is one of the novel and simplest approaches to achieve the important security requirements such as confidentiality and integrity. After forth, many researchers namely, Chakraborty et al. [14], Goswami et al. [15 - 19], Banerjee et al. [20 - 22] and Dutta et al. [23] have given the contributions in this era and brought many new methods to generate the AVKs to enhance the security than previous existing ones. In this article, we have analyzed the security factors of the existing schemes and proposed a new approach to generate the AVKs based on piggybacking strategy namely, AVKPS. The rest of the article is organized as follows: the proposed scheme has been illustrated in section II, followed by key generation examples in section III. Result analysis of the proposed scheme has been shown in section IV and section V contains the performance comparison of our scheme with the existing schemes. Lastly, we have concluded our paper in section VI.

II. Proposed scheme

In this section, we have proposed our new approach, namely AVKPS to generate the keys for secure data transmission. The following algorithm defines the key generation procedure after establishing the initial key between the sender and receiver. In this scheme, a new random number of bits size $\log_2 n$ is always used to append with each block of message to generate the next key where, n is the size of the key. The complete description of our proposed scheme has been defined below and the graphical representation of the entire method is plotted in Figure 1.

$Key\_Generator$ $(Initial\ key\ of\ n\ bits)$
{
    $K_1 \leftarrow Initial\ Key\ of\ n\ bits$
    $R \leftarrow \text{rand}()\%n$
    $i \leftarrow 1$
    $While\ (Data\ blocks! = \emptyset)$
    {
        $C_i \leftarrow E_{K_i}(D_i, R)$
        $i \leftarrow i + 1$
        $K_i \leftarrow (R||D_{i-1}) \oplus CLS(K_{i-1}, R)$
        $R \leftarrow \text{rand}( )\%n$
    }
}

Where:
$R \leftarrow$ Auto generated random number of bit size $\log_2 n$
$D_i \leftarrow$ i[th] block of data with block size $n - \log_2 n$
$CLS(x, y) \leftarrow$ Circular left shift of x by y bits position
$C_i \leftarrow$ i[th] block of cipher text
$E \leftarrow$ Encryption mechanism

Sender

$Key_1 \leftarrow S_k$
$R \leftarrow rand()\%n$
$if(Data_1 \neq \emptyset)$

$M = E_{Key_1}(Data_1, R)$

$Key_2 \leftarrow (R\|Data_1) \oplus CLS(Key_1, R)$
$R \leftarrow rand()\%n$

$if(Data_2 \neq \emptyset)$

$M = E_{Key_2}(Data_2, R)$

$Key_3 \leftarrow (R\|Data_2) \oplus CLS(Key_2, R)$
$R \leftarrow rand()\%n$

$if(Data_{m-1} \neq \emptyset)$

$M = E_{Key_{m-1}}(Data_{m-1}, R)$

$Key_m \leftarrow (R\|Data_{m-1}) \oplus CLS(Key_{m-1}, R)$
$R \leftarrow rand()\%n$

$if(Data_m \neq \emptyset)$

$M = E_{Key_m}(Data_m, R)$

$Key_{m+1} \leftarrow (R\|Data_m) \oplus CLS(Key_m, R)$
$R \leftarrow rand()\%n$

Receiver

$Key_1 \leftarrow S_k$
$Data_1, R \leftarrow D_{Key_1}(M)$
$Key_2 \leftarrow (R\|Data_1) \oplus CLS(Key_1, R)$

$Data_2, R \leftarrow D_{Key_2}(M)$
$Key_3 \leftarrow (R\|Data_2) \oplus CLS(Key_2, R)$

$Data_{m-1}, R \leftarrow D_{Key_{m-1}}(M)$
$Key_m \leftarrow (R\|Data_{m-1}) \oplus CLS(Key_{m-1}, R)$

$Data_m, R \leftarrow D_{Key_m}(M)$
$Key_{m+1} \leftarrow (R\|Data_m) \oplus CLS(Key_m, R)$

Figure 1. Key generation procedure

III. Key Generation Examples

Here, we have demonstrated the above AVKPS procedure to generate the successive keys based on data set and negotiated initial key between the sender and receiver.

For simplicity, we have considered the key size of 8 bits (i.e. n) and the data set as "11000111" and "PLAIN" respectively. The binary sequence of the data set = "0101000001001100010010010100000101001110" and bit size of the random number, $R = \log_2 n = \log_2 8 = 3$.

Therefore, the block size of the data will be $n - \log_2 n = 8 - 3 = 5$. If the last block of data is not multiple of 5 then extra bits will be appended as parity bits which will be discarded by the receiver. Hence, the 1st block of data, $D_1 = 01010$, 2nd block of data, $D_2 = 00001$ and so on.

First key, $K_1 = 11000111$ and assume the auto generated random number $R = rand( )\%n = 2$. Therefore, generation of 2nd key, K_2 will be $(R||D_1) \oplus CLS(K_1, R) = 2||01010 \oplus CLS(11000111, 2) = 01001010 \oplus 00011111 = 01010101$.

For the third Key K_3, assume that the auto generated random number $R = rand( )\%n = 4$. Hence, 3rd key $K_3 = (R||D_2) \oplus CLS(K_2, R) = 4||00001 \oplus CLS(01001101, 4) = 10001010 \oplus 11010100 = 11011110$.

Similarly, if we assume that the auto generated random number $R= 5$ then, the next key will be computed as $(R||D_3) \oplus CLS(K_3, R) = 5||00110 \oplus CLS(10000000, 5) = 10100110 \oplus 00010000 = 10110110$.

Similarly, the rest of the keys are generated as per the availability of the data set and/or necessity.

IV. Experimental Results

In this part, we have carried out some experiments of our scheme with some real set of data. Here, we have taken the total length of each key as 8 bits only and the block size of individual data set is also restricted to the same size. Where, first 3 bits has been appended as a random number and rest bits are meant for actual message. We have assumed the initial establish key K_0 as 10111011 to perform all the following experiments 1 to 3. To make the experimental result easier to understand, only first 86 auto generated keys are used to define the randomness.

Experiment 1: In this experiment, we have used "*A brute-force attack involves trying every possible key until an intelligible translation of the ciphertext into plaintext is obtained.*" as a data set. The computed value of randomness among the auto generated successive keys is shown in Figure 2.

Experiment 2: "*Frequency analysis is based on the fact that, in any given stretch of written language, certain letters and combinations of letters occur with varying frequencies.*" is considered as the data set for this experiment. The experimental result for randomness is shown in Figure 3.

Experiment 3: The following data set is considered for this experiment and the corresponding generated graph is shown in Figure 3.
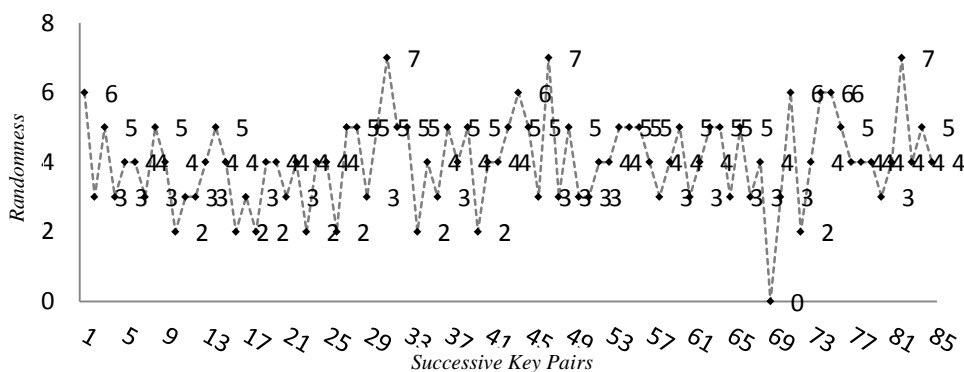"*An encryption scheme is said to be computationally secure if either of the foregoing two criteria are met.*"

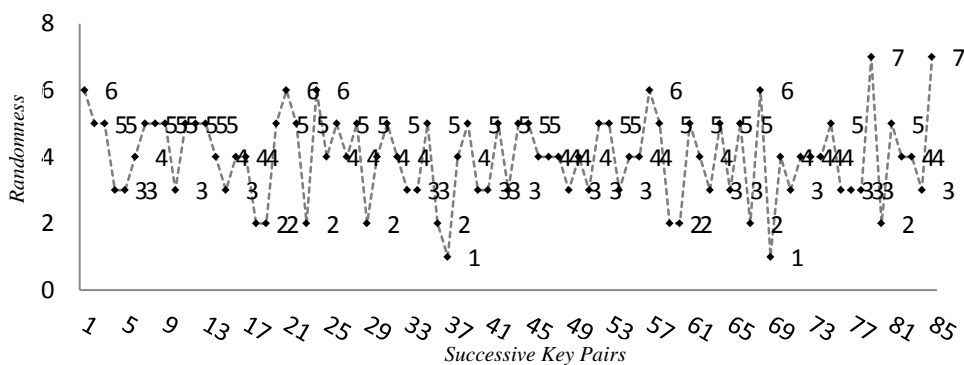Figure 2. Randomness among the successive keys for the experiment 1

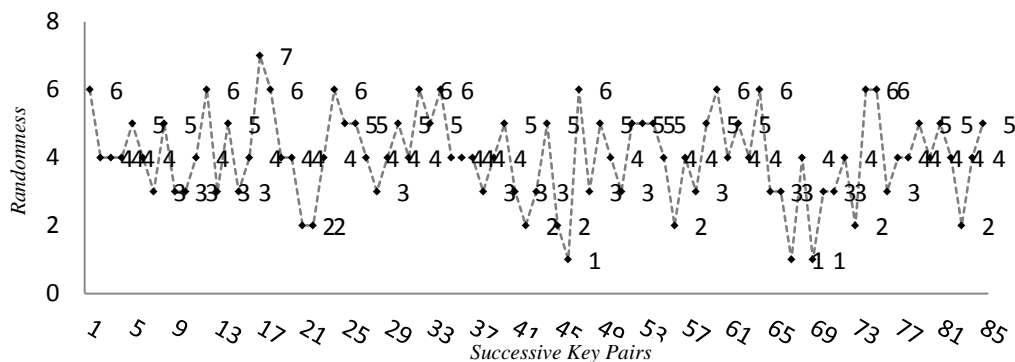Figure 3. Randomness among the successive keys for the experiment 2

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Figure 4. Randomness among the successive keys for the experiment 3

V. Performance Analysis

In this section, we have summarized the effectiveness of our proposed scheme by comparing the average randomness with that of existing related schemes. We have used the same method to compute the average randomness as it is described in the compared schemes. As the generation of keys always depends on initial key and the data set pair, we have taken all the above experiments 1 to 3 into our account for comparison purpose and their corresponding results are depicted from Figure 5 to 7 respectively. The x axis in the graphs indicates the techniques considered for experimental study where as y axis represents the average randomness.
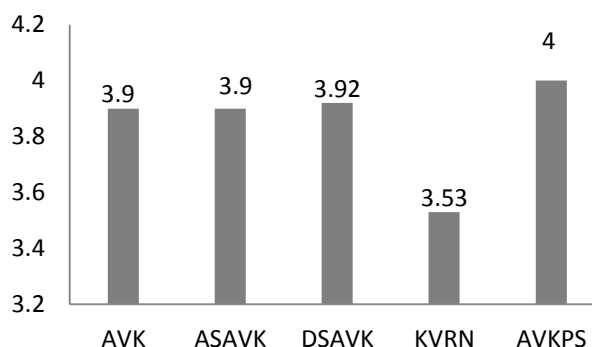
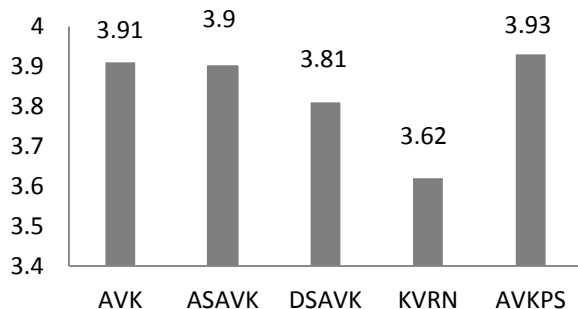

Figure 5: Average randomness comparison of experiment 1

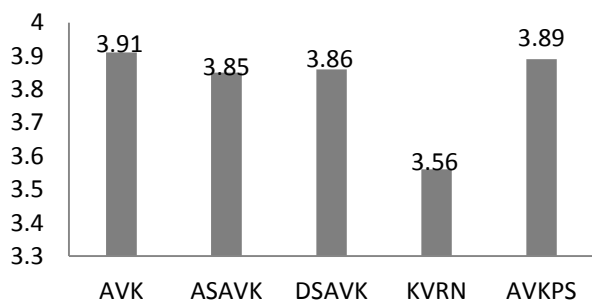
Figure 6: Average randomness comparison of experiment 2

Figure 7: Average randomness comparison of experiment 3

VI. Conclusion

In this article, we have proposed a new and effective key generation procedure to generate the variable session keys to fulfill the essential requirements of the cryptosystem. To prove the effectiveness, we have compared our scheme with the other related schemes. From the comparison graphs depicted in performance analysis section, we can conclude that the new scheme is superior to other schemes in terms of average randomness among the auto generated keys.

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