

A General Session Based Bit Level Block Encoding Technique Using Symmetric Key Cryptography to Enhance the Security of Network Based Transmission

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ABSTRACT

In this paper a session based symmetric key cryptographic algorithm has been proposed and it is termed as Matrix Based Bit Permutation Technique (MBBPT). MBBPT consider the plain text (i.e. the input file) as a binary bit stream with finite number bits. This input bit stream is divided into manageable-sized blocks with different length. The bits of the each block fit diagonally upward starting from (1 , 1) cell in a left to right trajectory into a square matrix of suitable order n. Then the bits are taken from the square matrix diagonally upward starting from (n , n) cell in a right to left trajectory to form the encrypted binary string and from this encrypted string cipher text is formed. Combination of the values of block length and the no. of blocks of a session generates the session key. For decryption the cipher text is considered as a stream of binary bits. After processing the session key information, this binary string is divided into blocks. The bits of the each block fit diagonally upward starting from (n , n) cell in a right to left trajectory into a square matrix of suitable order n. Then the bits are taken from the square matrix diagonally upward starting from (1 , 1) cell in a left to right trajectory to form the decrypted binary string . Plain text is regenerated from this binary string. Comparison of MBBPT with existing and industrially accepted TDES and AES has been done.

KEYWORDS

Matrix Based Bit Permutation Technique (MBBPT), Cryptography, Symmetric Key, Session Based Key, TDES, AES.

1. INTRODUCTION

The people all over the world are engaged in communication through internet every day. It is very important to secure our essential documents from unauthorized users. Hence network security is looming on the horizon as a potentially massive problem. So network security is the most focused topic among the researchers [1, 2, 3, 4]. Various algorithms have developed in this field but each of them has their own merits and demerits. As a result researchers are working in this field of cryptography to enhance the network based security further.

Based on symmetric key cryptography a new technique has been proposed where the plain text is considered as a stream of binary bits. Bit positions are shuffled to generate the cipher text. A

session key is generated using plain text information. The plain text can be regenerated from the cipher text using the session key information.

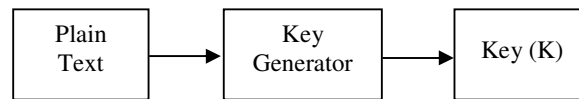
Section 2 of this paper contains the block diagram of the proposed scheme. Section 3 deals with the algorithms of encryption, decryption and key generation. Section 4 explains the proposed technique with an example. Section 5 shows the results and analysis on different files with different sizes and the comparison of the proposed MBBPT with TDES [5], AES [6]. Conclusions are drawn in the section 6.

2. THE SCHEME

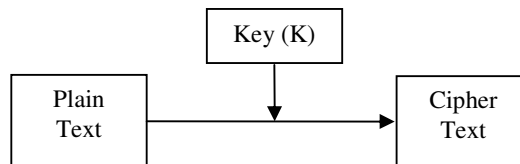
The MBBPT algorithm consists of three major components:

- Key Generation
- Encryption Mechanism
- Decryption Mechanism

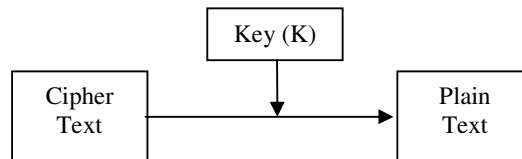
Key Generation:



Encryption Mechanism:



Decryption Mechanism:



3. PROPOSED ALGORITHM

3.1. Encryption Algorithm:

Step 1. The plain text i.e. the input file is considered as a binary bit stream of finite no. of bits.

Step 2. This binary stream breaks into manageable-sized blocks with different lengths like 4 / 16 / 64 / 144 / 256 / 400 / [$(4n)^2$ for $n = 1/2, 1, 2, 3, 4, 5, \dots$] as follows:

First n_1 no. of bits is considered as x_1 no. of blocks with block length y_1 where $n_1 = x_1 * y_1$. Next n_2 no. of bits is considered as x_2 no. of blocks with block length y_2 where $n_2 = x_2 * y_2$ and so on.

Finally n_m no. of bits is considered as x_m no. of blocks with block length $y_m (= 4)$ where $n_m = x_m * y_m$. So no padding is required.

Step 3. Square matrix of order \sqrt{y} is generated for each block of length y . The binary bits of the block from MSB to LSB fit diagonally upward starting from (1 , 1) cell in a left to right trajectory into this square matrix.

Step 4. From the square matrix bits are taken diagonally upward starting from (\sqrt{y} , \sqrt{y}) cell in a right to left trajectory to generate the encrypted block of length y .

Step 5. The cipher text is formed after converting the encrypted binary string into characters.

3.2. Decryption Algorithm:

Step 1. The encrypted file i.e. the cipher text is considered as a stream of binary bits.

Step 2. After processing the session key information, this binary string breaks into manageable-sized blocks.

Step 3. Square matrix of order \sqrt{y} is generated for each block of length y . The binary bits of the block from MSB to LSB fit diagonally upward starting from (\sqrt{y} , \sqrt{y}) cell in a right to left trajectory.

Step 4. The decrypted binary string is generated after taking the bits diagonally upward starting from (1 , 1) cell in a left to right trajectory from the square matrix.

Step 5. The plain text is reformed after converting the decrypted binary string into characters.

3.3. Generation of Session Key:

A session key is generated for one time use in a session of transmission to ensure much more security to MBBPT. This technique divides the input binary bit stream dynamically into 16 portions, each portion is divided again into x no. of blocks with block length y bits. The final (i.e. 16th) portion is divided into x_{16} no. of block with block length 4 bits (i.e. $y_{16} = 4$). So no padding is required. Total length of the input binary string is

$$x_1 * y_1 + x_2 * y_2 + \dots + x_{16} * y_{16}.$$

The values of x and y are generated dynamically. The session key contains the sixteen set of values of x and y respectively.

4. EXAMPLE

To illustrate the MBBPT, let us consider a two letter's word "Go". The ASCII values of "G" and "o" are 71 (01000111) and 111 (01101111) respectively. Corresponding binary bit representation of that word is "0100011101101111". Consider a block with length 16 bits as

0	1	0	0	0	1	1	1	0	1	1	0	1	1	1	1
---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---

Now these bits from MSB to LSB fit diagonally upward starting from (1 , 1) cell in a left to right trajectory into this square matrix of order 4 as follows:

0	0	1	1
1	0	0	1
0	1	0	1
1	1	1	1

The encrypted binary string is formed after taking the bits diagonally upward starting from (4 , 4) cell in a right to left trajectory from above the square matrix as follows:

1	1	1	1	0	1	1	1	0	1	0	0	1	1	0	0
---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---

The equivalent decimal no. of two 8 bit binary numbers 11110111 and 01001100 are 247 and 76 respectively. 247 and 76 are the ASCII values of the characters ÷ (Division Sign) and L (Latin Capital Letter L) respectively. So the word **Go** is encrypted as ÷L.

For decryption, exactly reverse steps of the above are followed.

5. RESULTS AND ANALYSIS

In this section the comparative study between Triple-DES (168bits), AES (128bits) and MBBPT has done on 20 files of 8 different types with file sizes varying from 330 bytes to 62657918 bytes (59.7 MB). Analysis includes comparison of encryption time, decryption time, Character frequencies, Chi-square values, Avalanche and Strict Avalanche effects, Bit Independence. All implementation has been done using JAVA.

5.1. ANALYSIS OF ENCRYPTION & DECRYPTION TIME

Table I & Table II shows the encryption time and decryption time for Triple-DES (168bits), AES (128bits) and proposed MBBPT against the different files. Proposed MBBPT takes very less time to encrypt/decrypt than Triple-DES and little bit more time than AES. Fig. 1(a) and Fig. 1(b) show the graphical representation of encryption time and decryption time against file size in logarithmic scale.

TABLE I

File size v/s encryption time(for Triple-DES, AES and MBBPT algorithms)

Sl. No.	Source File Size (in bytes)	File type	Encryption Time (in seconds)		
			TDES	AES	MBBPT
1	330	Dll	0.001	0.001	0.006
2	528	Txt	0.001	0.001	0.010
3	96317	Txt	0.034	0.004	0.036
4	233071	Rar	0.082	0.011	0.086
5	354304	Exe	0.123	0.017	0.146
6	536387	Zip	0.186	0.023	0.232
7	657408	Doc	0.220	0.031	0.341

8	682496	Dll	0.248	0.031	0.368
9	860713	Pdf	0.289	0.038	0.403
10	988216	Exe	0.331	0.042	0.466
11	1395473	Txt	0.476	0.059	0.518
12	4472320	Doc	1.663	0.192	0.714
13	7820026	Avi	2.626	0.334	1.226
14	9227808	Zip	3.096	0.397	1.338
15	11580416	Dll	4.393	0.544	1.542
16	17486968	Exe	5.906	0.743	3.381
17	20951837	Rar	7.334	0.937	3.568
18	32683952	Pdf	10.971	1.350	4.027
19	44814336	Exe	15.091	1.914	5.992
20	62657918	Avi	21.133	2.689	10.244

TABLE II

File size v/s decryption time (for Triple-DES, AES and MBBPT algorithms)

Sl. No.	Source File Size (in bytes)	File type	Decryption Time (in seconds)		
			TDES	AES	MBBPT
1	330	Dll	0.001	0.001	0.005
2	528	Txt	0.001	0.001	0.009
3	96317	Txt	0.035	0.008	0.031
4	233071	Rar	0.087	0.017	0.072
5	354304	Exe	0.128	0.025	0.132
6	536387	Zip	0.202	0.038	0.218
7	657408	Doc	0.235	0.045	0.333
8	682496	Dll	0.266	0.046	0.348
9	860713	Pdf	0.307	0.060	0.386
10	988216	Exe	0.356	0.070	0.447
11	1395473	Txt	0.530	0.098	0.502
12	4472320	Doc	1.663	0.349	0.706
13	7820026	Avi	2.832	0.557	1.211
14	9227808	Zip	3.377	0.656	1.318
15	11580416	Dll	4.652	0.868	1.526
16	17486968	Exe	6.289	1.220	3.364
17	20951837	Rar	8.052	1.431	3.549
18	32683952	Pdf	11.811	2.274	4.004
19	44814336	Exe	16.253	3.108	5.937
20	62657918	Avi	22.882	4.927	10.168

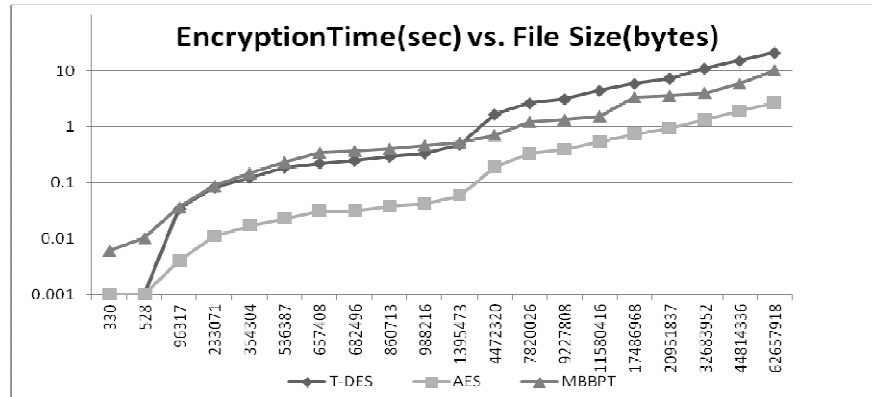


Fig. 1(a). Encryption Time (sec) vs. File Size (bytes) in logarithmic scale

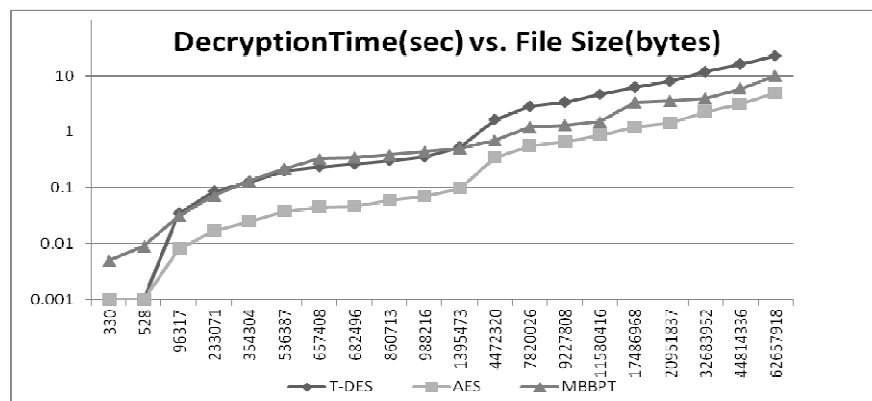


Fig. 1(b). Decryption Time (sec) vs. File Size (bytes) in logarithmic scale

5.2. ANALYSIS OF CHARACTER FREQUENCIES

Analysis of Character frequencies for text file has been performed for T-DES, AES and proposed MBBPT. Fig.2(a) shows the distribution of characters in the plain text. Fig.2(b), 2(c), 2(d) show the characters distribution in cipher text for T-DES, AES and proposed MBBPT. All three algorithms show a distributed spectrum of characters. From the above observation it may be conclude that the proposed MBBPT may obtain very good security.

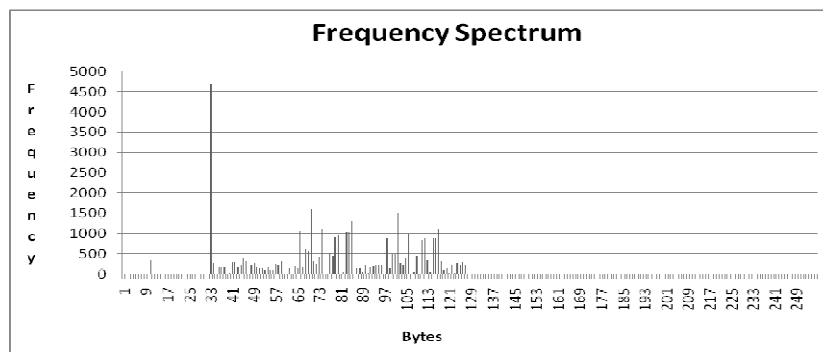


Fig. 2(a). Distribution of characters in source file

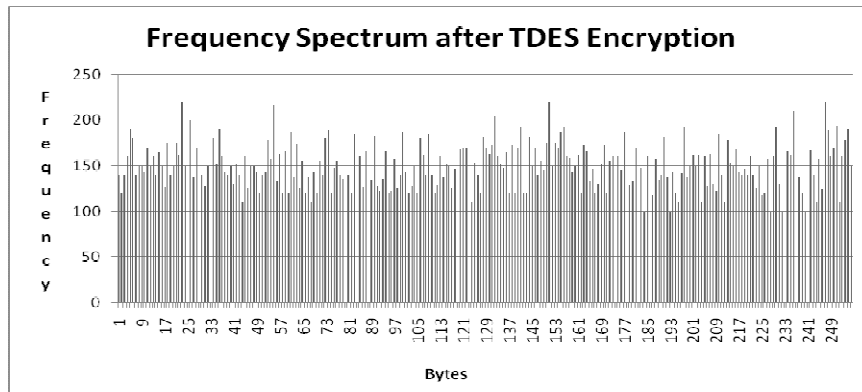


Fig. 2(b): Distribution of characters in TDES

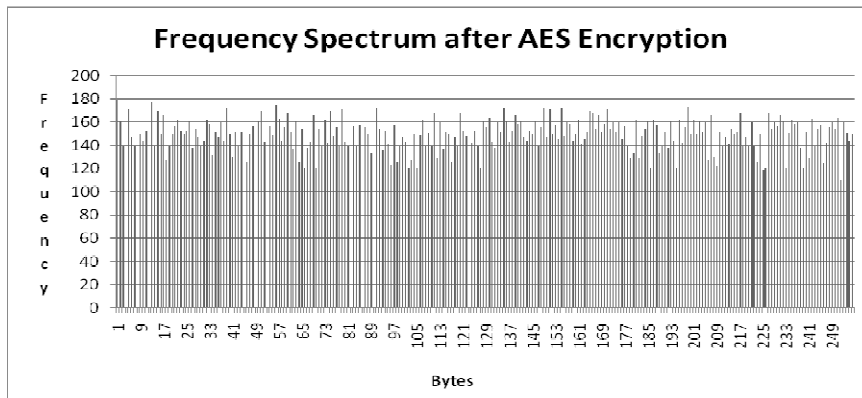


Fig. 2(c). Distribution of characters in AES

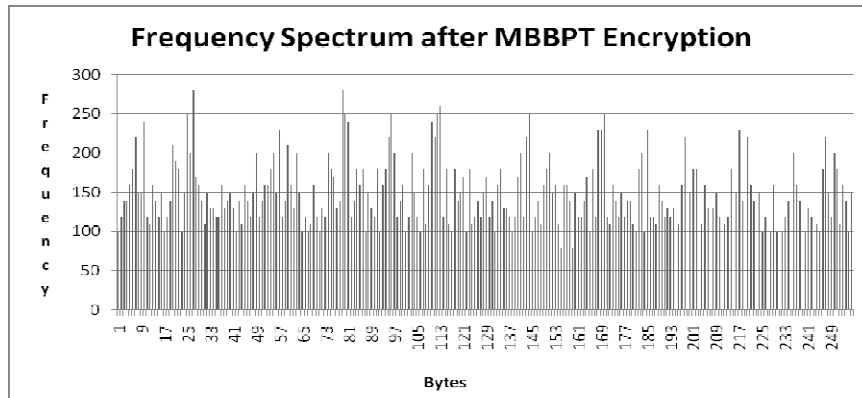


Fig. 2(d). Distribution of characters in MBBPT

5.3. TESTS FOR NON-HOMOGENEITY

The test for goodness of fit (Pearson χ^2) has been performed between the source files and the encrypted files. The large Chi-Square values (compared with tabulated values) may confirm the

high degree of non-homogeneity between the source files and the encrypted files. Table III shows the Chi-Square values for Triple-DES (168bits), AES (128bits) and proposed MBBPT against the different files.

From Table III it may conclude that the Chi-Square values of MBBPT are at par with & sometimes better than that of T-DES and AES. Fig. 3 graphically represents the Chi-Square values on logarithmic scale for T-DES, AES & MBBPT.

Table III

Chi-Square values for Triple-DES, AES and MBBPT algorithms

Sl. No.	Source File Size (bytes)	File type	Chi-Square Values		
			TDES	AES	MBBPT
1	330	dll	922	959	868
2	528	txt	1889	1897	1929
3	96317	txt	23492528	23865067	20843454
4	233071	rar	997	915	958
5	354304	exe	353169	228027	213002
6	536387	zip	3279	3510	3291
7	657408	doc	90750	88706	86657
8	682496	dll	29296	28440	26403
9	860713	pdf	59797	60661	56762
10	988216	exe	240186	245090	254747
11	1395473	txt	5833237390	5545862604	5657405581
12	4472320	doc	102678	102581	99191
13	7820026	avi	1869638	1326136	1139029
14	9227808	zip	37593	37424	36497
15	11580416	dll	28811486	17081530	16614547
16	17486968	exe	8689664	8463203	8096422
17	20951837	rar	25615	24785	26131
18	32683952	pdf	13896909	13893011	14977606
19	44814336	exe	97756312	81405043	76958249
20	62657918	avi	3570872	3571648	3834862

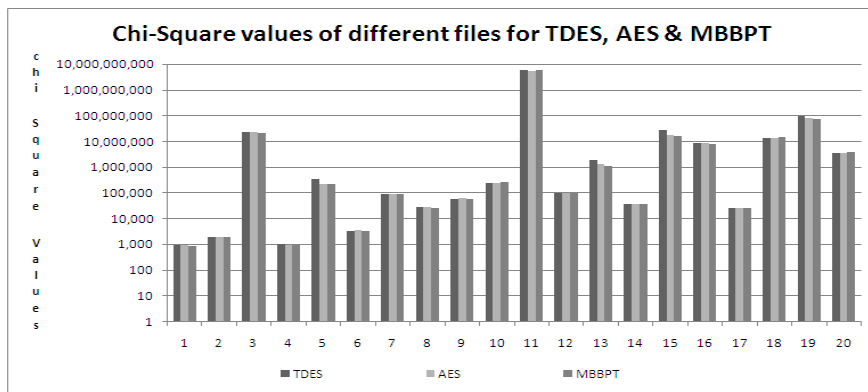


Fig.3 Chi-Square values for TDES, AES & MBBPT in logarithmic scale.

5.4. STUDIES ON AVALANCHE EFFECTS, STRICT AVALANCHE EFFECTS AND BIT INDEPENDENCE CRITERION

Avalanche & Strict Avalanche effects and Bit Independence criterion has been measured by statistical analysis of data. The bit changes among encrypted bytes for a single bit change in the original message sequence for the entire or a relative large number of bytes. The Standard Deviation from the expected values is calculated. The ratio of calculated standard deviation with expected value has been subtracted from 1.0 to get the Avalanche and Strict Avalanche effect on a 0.0 – 1.0 scale. The value closer to 1.0 indicates the better Avalanche & Strict Avalanche effects and the better Bit Independence criterion. Table IV, Table V & Table VI show the Avalanche effects, the Strict Avalanche effects & the Bit Independence criterion respectively. Fig.4(a), Fig.4(b) & Fig.4(c) show the above graphically. In Fig.4(a) & Fig.4(b), the y-axis which represent the Avalanche effects & the Strict Avalanche effects respectively has been scaled from 0.97 – 1.0 for better visual interpretation.

Table IV

Avalanche effects for T-DES, AES and MBBPT algorithms

Sl. No.	Source File Size (in bytes)	File type	Avalanche achieved		
			TDES	AES	MBBPT
1	330	dll	0.99591	0.98904	0.98381
2	528	txt	0.99773	0.99852	0.98542
3	96317	txt	0.99996	0.99997	0.99618
4	233071	rar	0.99994	0.99997	0.99689
5	354304	exe	0.99996	0.99999	0.99592
6	536387	zip	0.99996	0.99994	0.99818
7	657408	doc	0.99996	0.99999	0.99726
8	682496	dll	0.99998	1.00000	0.99847
9	860713	pdf	0.99996	0.99997	0.99816
10	988216	exe	1.00000	0.99998	0.99840
11	1395473	txt	1.00000	1.00000	0.99766
12	4472320	doc	0.99999	0.99997	0.99714
13	7820026	avi	1.00000	0.99999	0.99828
14	9227808	zip	1.00000	1.00000	0.99924
15	11580416	dll	1.00000	0.99999	0.99873
16	17486968	exe	1.00000	0.99999	0.99939
17	20951837	rar	1.00000	1.00000	0.99941
18	32683952	pdf	0.99999	1.00000	0.99958
19	44814336	exe	0.99997	0.99997	0.99948
20	62657918	avi	0.99999	0.99999	0.99964

Table V

Strict Avalanche effect for T-DES, AES & MBBPT algorithms

Sl. No.	Source File Size (in bytes)	File type	Strict Avalanche achieved		
			TDES	AES	MBBPT
1	330	dll	0.98645	0.98505	0.97864
2	528	txt	0.99419	0.99311	0.98806
3	96317	txt	0.99992	0.99987	0.98827
4	233071	rar	0.99986	0.99985	0.99552
5	354304	exe	0.99991	0.99981	0.99648
6	536387	zip	0.99988	0.99985	0.99754
7	657408	doc	0.99989	0.99990	0.99728
8	682496	dll	0.99990	0.99985	0.99816
9	860713	pdf	0.99990	0.99993	0.99841
10	988216	exe	0.99995	0.99995	0.99518
11	1395473	txt	0.99990	0.99996	0.99762
12	4472320	doc	0.99998	0.99995	0.99676
13	7820026	avi	0.99996	0.99996	0.99622
14	9227808	zip	0.99997	0.99998	0.99965
15	11580416	dll	0.99992	0.99998	0.99861
16	17486968	exe	0.99996	0.99997	0.99948
17	20951837	rar	0.99998	0.99996	0.99864
18	32683952	pdf	0.99997	0.99998	0.99929
19	44814336	exe	0.99991	0.99990	0.99904
20	62657918	avi	0.99997	0.99998	0.99933

Table VI

Bit Independence criterion for T-DES, AES & MBBPT algorithms

Sl. No.	Source File Size (in bytes)	File type	Bit Independence achieved		
			TDES	AES	MBBPT
1	330	Dll	0.49180	0.47804	0.42544
2	528	Txt	0.22966	0.23056	0.22602
3	96317	Txt	0.41022	0.41167	0.43706
4	233071	Rar	0.99899	0.99887	0.98665
5	354304	Exe	0.92538	0.92414	0.93618
6	536387	Zip	0.99824	0.99753	0.99621
7	657408	Doc	0.98111	0.98030	0.97588
8	682496	Dll	0.99603	0.99560	0.96852
9	860713	Pdf	0.97073	0.96298	0.96849
10	988216	Exe	0.91480	0.91255	0.93355
11	1395473	Txt	0.25735	0.25464	0.25632
12	4472320	Doc	0.98881	0.98787	0.97428
13	7820026	Avi	0.98857	0.98595	0.97316
14	9227808	Zip	0.99807	0.99817	0.99925
15	11580416	Dll	0.86087	0.86303	0.86211
16	17486968	Exe	0.83078	0.85209	0.85627
17	20951837	Rar	0.99940	0.99937	0.99928

18	32683952	Pdf	0.95803	0.95850	0.95858
19	44814336	Exe	0.70104	0.70688	0.82742
20	62657918	Avi	0.99494	0.99451	0.99776

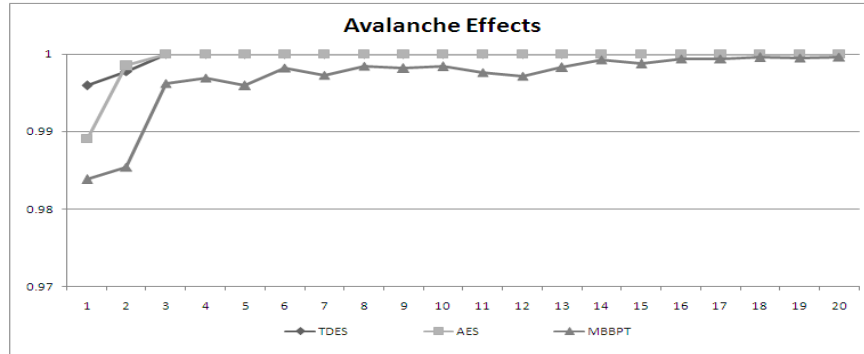


Fig.4(a) Comparison of Avalanche effect between T-DES, AES and MBBPT

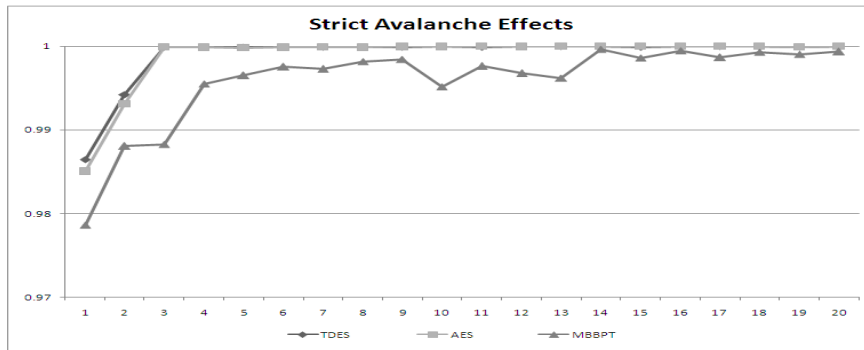


Fig4(b) Comparison of Strict Avalanche effect between TDES, AES and MBBPT

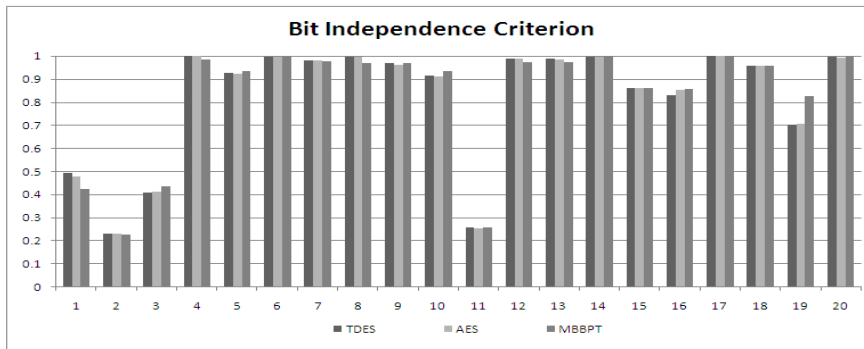


Fig.4(c) Comparison of Bit Independence criterion between TDES, AES and MBBPT

6. CONCLUSION

MBBPT, the proposed technique in this paper is simple and easy to implement. The key varies from session to session for any particular file which may enhance the security features. Results and Analysis section indicates that the MBBPT is comparable with industry accepted standards T-

DES and AES. The performance of MBBPT is significantly better than T-DES algorithm. For large files, MBBPT is at par with AES algorithm. Therefore the proposed technique is applicable to ensure high security in message transmission of any form and is suitable for any sort of file transfer.

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