

**AN ENHANCED BLOWFISH ALGORITHM BASED ON
CYLINDRICAL COORDINATE SYSTEM AND DYNAMIC
PERMUTATION BOX**

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Abstrak

Algoritma Blowfish (BA) adalah sifer blok simetri yang menggunakan rangkaian *Feistel* untuk melakukan fungsi penyulitan dan penyahsulitan yang mudah. Kunci BA adalah pelbagai dari bit 32 ke 448 untuk memastikan tahap keselamatan yang tinggi. Walau bagaimanapun, kotak penggantian (Kotak-S) dalam BA mengambil peratus ruang memori yang tinggi dan mempunyai masalah keselamatan, terutamanya dalam kerambangtarikan output bagi teks dan fail imej yang mempunyai rentetan besar dan mempunyai bait yang serupa. Dengan demikian, objektif kajian ini adalah untuk mempertingkatkan BA bagi mengatasi masalah ini. Kajian ini melibatkan tiga fasa; reka bentuk algoritma, pelaksanaan, dan penilaian. Dalam fasa reka bentuk, Kotak-S 3D dinamik, Kotak Pilih Atur (Kotak-P) dinamik, dan Fungsi Feistel (Fungsi-F) direkabentuk. Pembaikan ini melibatkan integrasi sistem koordinat silinder (CCS) dan Kotak-P dinamik. BA yang dipertingkatkan dikenali sebagai algoritma Ramlan Ashwak Faudziah (RAF). Fasa pelaksanaan melibatkan pengembangan kunci, penyulitan data, dan penyahsulitan data. Fasa penilaian meliputi mengukur algoritma dari segi memori dan keselamatan. Dari segi memori, keputusan menunjukkan RAF menggunakan 256 bait, iaitu kurang daripada BA (4096 bait). Dari segi kerambangtarikan pada teks dan fail imej yang mempunyai rentetan besar dan mempunyai bait yang serupa, kadar purata kerambangtarikan untuk 188 ujian statistik memperolehi nilai lebih daripada 96%. Ini bermakna RAF mempunyai kerambangtarikan tinggi yang menunjukkan bahawa ianya lebih terjamin. Dengan demikian, keputusan ini menunjukkan bahawa algoritma RAF yang mengintegrasikan CCS dan dinamik Kotak-P adalah satu pendekatan berkesan yang dapat mengurangkan ingatan dan mengukuhkan keselamatan.

Kata kunci: Sistem Koordinat Silinder, Kotak-S dinamik, Kotak-P dinamik, Algoritma Blowfish

Abstract

The Blowfish Algorithm (BA) is a symmetric block cipher that uses Feistel network to iterate simple encryption and decryption functions. BA key varies from 32 to 448 bits to ensure a high level of security. However, the substitution box (S-Box) in BA occupies a high percentage of memory and has problems in security, specifically in randomness of output with text and image files that have large strings of identical bytes. Thus, the objective of this research is to enhance the BA to overcome these problems. The research involved three phases, algorithm design, implementation, and evaluation. In the design phase, a dynamic 3D S-Box, a dynamic permutation box (P-Box), and a Feistel Function (F-Function) were improved. The improvement involved integrating Cylindrical Coordinate System (CCS) and dynamic P-Box. The enhanced BA is known as Ramlan Ashwak Faudziah (RAF) algorithm. The implementation phase involved performing key expansion, data encryption, and data decryption. The evaluation phase involved measuring the algorithm in terms of memory and security. In terms of memory, the results showed that the RAF occupied 256 bytes, which is less than the BA (4096 bytes). In terms of randomness of text and image files that have large strings of identical bytes, the average rate of randomness for 188 statistical tests obtained values of more than 96%. This means that the RAF has high randomness indicating that it is more secured. Thus, the results showed that the RAF algorithm that integrates the CCS and dynamic P-Box serves as an effective approach that can consume less memory and strengthen security.

Keywords: Cylindrical Coordinate System, Dynamic 3D S-Box, Dynamic P-box, Blowfish Algorithm.

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Table of Contents

Permission to Use	i
Abstrak	Error! Bookmark not defined.
Abstract	Error! Bookmark not defined.
Acknowledgement	iv
Table of Contents.....	v
List of Tables.....	x
List of Figures.....	xii
List of Appendices	xv
List of Publications	xvi
List of Abbreviations	xviii
CHAPTER ONE INTRUDUCTION.....	1
1.1 Background	1
1.2 Problem Statement	3
1.3 Research Questions	7
1.4 Research Objectives	7
1.4 Scope of Research.....	8
1.5 Contribution of the Study.....	8
1.6 Organization of the Thesis	9
CHAPTER TWO LITERATURE REVIEW.....	11
2.1 Basic Concepts of Cryptography	11
2.1.1 Mode of Operation.....	12
2.1.1.1 Electronic Codebook (ECB) Mode	13
2.1.1.2 Cipher Block Chaining (CBC) Mode	14
2.1.2 Cryptographic Security Requirements.....	16
2.1.2.1 Permutation Box (P-Box).....	17
2.1.2.2 Substitution Box (S-Box)	18
2.1.2.3 Dynamic P-Box and Dynamic S-Box	20
2.2 Basic Concepts of Coordinate Systems and Transformations	22
2.2.1 Coordinate Systems	22
2.2.1.1 Cartesian Coordinate System	24
2.2.1.2 Spherical Coordinate System	25

2.2.1.3 Cylinder Coordinate System	26
2.2.2 Coordinate Transformations	29
2.2.2.1 Transformation of Cartesian coordinate system.....	30
2.2.2.2 Transformation of Polar Coordinates by a Rotation.....	31
2.2.2.3 Transformation of Cylindrical Coordinate System	32
2.2.3 Relations among Coordinate Systems	32
2.3 Past Related Works	33
2.3.1 Pre-eSTREAM Cryptography Algorithms	33
2.3.2 Pre-AES Cryptography Algorithms.....	39
2.3.3 Blowfish Algorithm	47
2.3.3.1 Related Works on BA.....	53
2.3.3.1.1 Security Enhancement	53
2.3.3.1.2 Performance Enhancement	55
2.3.4 3D Block Cipher	58
2.3.5 Dynamic S-Box.....	59
2.3.6 Secret Key Generation	62
2.3.7 Dynamic P-Box.....	63
2.3.8 Evaluation of Block Cipher	65
2.3.8.1 Randomness Test.....	65
2.3.8.1.1 NIST Framework.....	68
2.3.8.1.2 Test Package	69
2.3.8.2 Correlation Coefficient.....	70
2.3.8.3 Security of S-Box	71
2.3.8.3.1 Avalanche Criterion.....	73
2.3.8.3.2 Strict Avalanche criterion.....	76
2.3.8.3.3 Bit Independence Criterion.....	78
2.3.8.4 Cryptanalysis	79
2.3.8.4.1 Linear Cryptanalysis.....	80
2.3.8.4.2 Differential Cryptanalysis.....	81
2.3.8.5 Computational Efficiency.....	82
2.4 Summary	83

CHAPTER THREE RESEARCH METHODOLOGY.....	84
3.1 Introduction.....	84
3.2 Phase 1 RAF Design	85
3.2.1 Dynamic 3D S-Box.....	85
3.2.1.1 Generation of Random SKs.....	90
3.2.1.2 Define Transformations of the Right Cylinder.....	92
3.2.1.3 Byte Permutation	96
3.2.1.3.1 Byte Relocation	96
3.2.1.3.2 Byte Transformation.....	100
3.2.2 Dynamic P-Box.....	102
3.2.3 Designing a New F-Function.....	103
3.2.4 Comparison the basic information between BA and RAF	107
3.3 Phase 2 RAF Implementation	108
3.3.1 Key Expansion.....	108
3.3.2 Perform Data Encryption and Data Decryption.....	108
3.4 Phase 3 RAF Verification	111
3.4.1 Stage 1 Verification of 3D S-Box.....	111
3.4.2 Stage 2 Verification of RAF Output	114
3.4.2.1 Part 1 Evaluation of RAF Output Using NIST Statistical Tests .	114
3.4.2.2 Part 2 Evaluation of RAF Output Using Avalanche Text and Correlation Coefficient.....	120
3.4.2.3 Part 3 Evaluation of RAF Resistance to Cryptanalysis.....	121
3.4.2.4 Part 4 Evaluation of Computational Efficiency of RAF	121
3.4.3 Stage 3 Comparison of RAF with other cryptographic algorithms	122
3.5 Summary	122
CHAPTER FOUR RESULTS	123
4.1 Introduction.....	123
4.2 Phase 1 RAF Design	123
4.2.1 Dynamic 3D S-Box.....	123
4.2.1.1 Random Secret Keys	123
4.2.1.2 Algorithms of Byte Relocation and Byte Transformation	124
4.2.2 Dynamic P-Box.....	127

4.2.2.1 Algorithm of Dynamic P-Box	127
4.2.2.2 Dynamic P-Box Values	128
4.2.3 Cylindrical Coordinate System with Dynamic Permutation Box Function	128
4.3 Phase 2 RAF Implementation	138
4.3.1 Key Expansion	138
4.3.2 Data Encryption and Data Decryption	139
4.3 Summary	140
 CHAPTER FIVE EXPERIMENTAL RESULTS OF DYNAMIC 3D S-BOX.141	
5.1 Introduction	141
5.2 Results of Dynamic 3D S-Box Evaluation with 3 Criteria	141
5.2.1 AVAL Empirical Results	141
5.2.2 Empirical Results of SAC	146
5.2.3 Empirical Results of BIC	150
5.3 Results of Correlation Coefficient on dynamic 3D S-Box in RAF	154
5.3.1 Empirical Results of Uncorrelated Random Eks	154
5.3.2 Empirical Results of Correlated Eks	157
5.4 Summary	161
 CHAPTER SIX EXPERIMENTAL RESULTS OF RAF.....162	
6.1 Introduction	162
6.2 Results of RAF Outputs Using NIST	162
6.2.1 Empirical Results on Cipher Block Chaining Mode	162
6.2.2 Empirical Results on Random Plaintext/Random 128-bit keys	165
6.2.3 Empirical Results on Image Files	167
6.2.4 Empirical Results of Text Files	171
6.2.5 Empirical Results of Video Files	173
6.3 Results of RAF Output Using Avalanche Text and Correlation Coefficient	176
6.3.1 Empirical Results on Avalanche Text	176
6.3.2 Empirical Results and Analysis on Correlation Coefficient	190
6.4 Cryptanalysis	193
6.4.1 Differential and Linear Attacks	193

6.4.2 Short Attack	194
6.5 Computation Efficiency	195
6.5.1 RAF.....	195
6.5.2 Blowfish Algorithm (BA)	197
6.6 Results of Comparison on RAF with other Cryptographic Algorithms.....	198
6.7 Summary	204
CHAPTER SEVEN CONCLUSION.....	205
7.1 General Discussion	205
7.2 Research achievement.....	206
7.3 Contributions.....	207
7.4 Limitation.....	210
7.5 Recommendations for Future Work.....	210
REFERENCES.....	211

List of Tables

Table 2.1 Comparison the basic information of the most popular block cipher algorithms.....	45
Table 2.2 Comparison made between previous studies on S-Box in BA.....	53
Table 2.3 Comparisons of Pervious Studies on BA.....	55
Table 2.4 Comparison of Speeds of the Popular Algorithms	58
Table 2.5 NIST statistical test.....	66
Table 2.6 Minimum requirements of NIST statistical test	67
Table 2.7 Evaluation Procedure for a Single Binary Sequence	68
Table 2.8 Class of the algorithms and number of operations	83
Table 3.1 Five Sets of SKs	91
Table 3.2 Eight Transformations of the Right Cylinder.....	93
Table 5.1 k_{AVAL} (i) values for the S-boxes (first random 128-bit E_k).....	142
Table 5.2 ϵ_A , Max, and Min values of k_{AVAL} (ten random 128-bit E_k).....	143
Table 5.3 ϵ_A , Max, and Min values of k_{AVAL} (Low entropy ones E_k).....	145
Table 5.4 ϵ_A , Max, and Min values of k_{AVAL} (Low entropy zeroes E_k)	145
Table 5.5 k_{SAC} (i, j) with random E_k of the first S-box in BA	146
Table 5.6 SAC of dynamic 3D S-Box in RAF	147
Table 5.7 ϵ_S , max, and min of k_{SAC} with random 128-bit E_k s	148
Table 5.8 ϵ_S , Max, and Min values of k_{SAC} with Low entropy ones E_k	149
Table 5.9 ϵ_S , Max, and Min values of k_{SAC} with Low entropy zeroes E_k	150
Table 5.10 BIC values with random 128-bit E_k s.....	151
Table 5.11 BIC values with Low entropy ones E_k	152
Table 5.12 BIC values with Low entropy zeroes E_k	153
Table 5.13 ϵ_{AVAL} , ϵ_{SAC} , and ϵ_{BIC} values	153
Table 5.14 Correlation Coefficient of 3D S-boxes (Random plaintext & uncorrelated E_k s) .	155
Table 5.15 Correlation Coefficient of dynamic 3D S-Boxes (Low entropy zeroes & uncorrelated E_k s)	156
Table 5.16 Correlation Coefficient of dynamic 3D S-Boxes (Low entropy ones & uncorrelated E_k s)	156
Table 5.17 Correlation Coefficient of dynamic 3D S-Boxes (Random plaintext & correlated E_k s)	158
Table 5.18 Correlation Coefficient of dynamic 3D S-Boxes (Low entropy zeroes & correlated E_k s)	159

Table 5.19 Correlation Coefficient of dynamic 3D S-Boxes (Low entropy ones & correlated Eks)	160
Table 6.1 Avalanche text for both algorithms in the first round.....	177
Table 6.2 Avalanche text for both algorithms in the second round	180
Table 6.3 Avalanche text for both algorithms in the third round.....	183
Table 6.4 Avalanche text for both algorithms in the ciphertext	186
Table 6.5 Correlation Coefficient between plaintext and ciphertext in both algorithms.....	192
Table 6.6 Summary of the Computation Efficiency of RAF and BA.	198
Table 6.7 Comparison Randomness of RAF with finalist of AES	204

List of Figures

Figure 2.1. ECB mode.....	14
Figure 2.2. CBC mode	16
Figure 2.3(a). Cartesian coordinate system for xy-plane	25
Figure 2.3(b). Cartesian coordinate system for xyz-space.....	25
Figure 2.4. Spherical coordinate system	26
Figure 2.5(a). Right Cylinder.....	27
Figure 2.5(b). Oblique Cylinder	27
Figure 2.6. Cylindrical Coordinate System	28
Figure 2.7. Level surfaces for the coordinate ρ	28
Figure 2.8. Level surfaces for the angle coordinate	29
Figure 2.9. Change in coordinates by a rotation	31
Figure 2.10. Relationship among the three coordinate systems.....	33
Figure 2.11. Stream Cipher	34
Figure 2.12. Encryption process in BA	50
Figure 2.13. F-Function architecture.....	51
Figure 3.1. Overview of the research process.....	84
Figure 3.2. Right cylinder.....	86
Figure 3.3. Cross-Section of the right cylinder.....	87
Figure 3.4. Representation of the right cylinder in 3D array	88
Figure 3.5. (a-d) Quarters in the first section with Byte Relocation for (a) with D_0 , (b) with D_1 , (c) with D_2 , and (d) with D_3	98
Figure 3.7. D_0 process for the first section (a before D_0 process, b after D_0 process).....	99
Figure 3.8. Rotation of a circle ($\phi_0 = \pi/4$).....	100
Figure 3.9. Rotation of the first section ($\phi_0 = \pi/4$)	101
Figure 3.10. Translation of the first section ($\rho_0 = 2$)	101
Figure 3.11. Flowchart of the dynamic P-Box.....	102
Figure 3.12. F-Function (CCSDPB)	104
Figure 3.13. Flowchart of F-Function (CCSDPB).....	105
Figure 3.14. Data Encryption RAF.....	109
Figure 3.15. Data decryption RAF Architecture.....	110
Figure 3.16. 3D S-Box verification flow.....	112
Figure 3.17. Flow analysis of correlation coefficient of 3D S-Box in RAF.....	113
Figure 3.18. NIST experimental flow	120

Figure 3.19. Experimental flow on avalanche text	121
Figure 4.1. Random secret keys in round 0	123
Input: dynamic 3D S-Box from key expansion part.	125
Figure 4.2. Dynamic 3D S-Box from key expansion part	125
Figure 4.3. Dynamic 3D S-Box after BR (D0) in round 0	125
Figure 4.4. Dynamic 3D S-Box from BT (T8) in round 0.....	126
Figure 4.5. Dynamic 3D S-Box from BT (T4) in round 0.....	126
Figure 4.6. Dynamic 3D S-Box from BT (T6) in round 0.....	127
Figure 4.7. Dynamic P-Box in round 0	128
Figure 4.8. Output of CCSDPB Function and Ciphertext in round 0	128
Figure 4.9. Dynamic 3D S-BOX of after apply Relocate BR (D1) in round 1.....	129
Figure 4.10. Random secret keys in round 1	129
Figure 4.11. Dynamic 3D S-Box from BT (T8) in round 1.....	130
Figure 4.12. Dynamic 3D S-Box from BT (T4) in round 1.....	130
Figure 4.13. Dynamic 3D S-Box from BT (T6) in round 1.....	131
Figure 4.14. Dynamic P-Box in round 1	131
Figure 4.15. Output of CCSDPB function and ciphertext in round 1	131
Figure 4.16. Dynamic 3D S-Box of after apply Relocate BR (D2) in round 2.....	132
Figure 4.17. Random secret keys in round 2	132
Figure 4.18. Dynamic 3D S-Box from BT (T8) in round 2.....	133
Figure 4.19. Dynamic 3D S-Box from BT (T4) in round 2.....	133
Figure 4.20. Dynamic 3D S-Box from BT (T6) in round 2.....	134
Figure 4.21. Dynamic P-Box in round 2	134
Figure 4.23. Dynamic 3D S-Box of after apply Relocate BR (D3) in round 3.....	135
Figure 4.24. Random secret keys in round 3	135
Figure 4.26. Dynamic 3D S-Box from BT (T4) in round 3.....	136
Figure 4.27. Dynamic 3D S-Box from BT (T6) in round 3.....	137
Figure 4.28. Dynamic P-Box in round 3	137
Figure 4.29. Output of CCSDPB function and ciphertext in round 3	137
Figure 4.30. Output of key expansion part	139
Figure 4.31. Data encryption and data decryption	140
Figure 6.1. Results of Cipher Block Chaining Mode for Round 2 in BA	163
Figure 6.2. Results of Cipher Block Chaining Mode for Round 4 in BA	163
Figure 6.3. Results of Cipher Block Chaining Mode for Round 2 in RAF	164
Figure 6.4. Results of Cipher Block Chaining Mode for Round 4 in RAF	164

Figure 6.5. Results of Random Plaintext/Random128-bit keys for Round 2 in BA	165
Figure 6.6. Results of Random Plaintext/Random128-bit keys for Round 4 in BA	166
Figure 6.7. Results of Random Plaintext/Random128-bit keys for Round 2 in RAF	166
Figure 6.8. Results of Random Plaintext/Random128-bit keys for round 4 in RAF	167
Figure 6.9. Results of image files for Round 2 in BA.....	168
Figure 6.10. Results of image files for Round 4 in BA.....	168
Figure 6.11. Results of image files for Round 2 in RAF.....	169
Figure 6.12. Results of image files for Round 4 in RAF.....	169
Figure 6.13. Results of text files for Round 2 in BA	171
Figure 6.14. Results of text files for Round 4 in BA	171
Figure 6.15. Results of text files for Round 2 in RAF	172
Figure 6.16. Results of text files for Round 4 in RAF	172
Figure 6.17. Results of video files for Round 2 in BA.....	174
Figure 6.18. Results of video files for Round 4 in BA.....	174
Figure 6.19. Results of video files for Round 2 in RAF.....	175
Figure 6.20. Results of video files for Round 4 in RAF.....	175
Figure 6.21. Results of the avalanche text of both algorithms for the first round.....	189
Figure 6.22. Results of the avalanche text of both algorithms for the second round	189
Figure 6.23. Results of the avalanche text of both algorithms for the third round	189
Figure 6.24. Results of the avalanche text of both algorithms for the ciphertext	190
Figure 6.25. Results of correlation of both algorithms.....	191
Figure 6.26. Results of Low Density Plaintext for Round 1 in RAF	199
Figure 6.27. Results of Low Density Plaintext for Round 2 in RAF	199
Figure 6.28. Results of Low Density Plaintext for Round 3 in RAF	200
Figure 6.29. Results of Low Density Plaintext for Round 4 in RAF	200
Figure 6.30. Results of Low Density Plaintext for Round 5 in RAF	201
Figure 6.31. Results of Low Density Plaintext for Round 6 in RAF	201
Figure 6.32. Results of Low Density Plaintext for Round 7 in RAF	202
Figure 6.33. Results of Low Density Plaintext for Round 8 in RAF	202
Figure 6.34. Results of Low Density Plaintext for Round 9 in RAF	203
Figure 6.35. Results of Low Density Plaintext for Round 10 in RAF	203

List of Appendices

Appendix A NIST STATISTICAL TESTS.....	225
Appendix B LAST SIX ROUNDS OF RAF.....	228
Appendix C RESULTS OF NIST STATISTICAL TESTS	240
Appendix D COMPUTATION EFFICIENCY OF RAF AND BA.....	263

List of Publications

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List of Abbreviations

RSA	Rivest – Shamir - Adleman
AES	Advance Encryption Standard
BA	Blowfish Algorithm
DES	Data Encryption Standard
3DES	Triple Data Encryption Standard
IDEA	International Data Encryption Algorithm
RC5	Rivest Cipher 5
RC4	Rivest Cipher 4
S-Box	Substitution box
P-Box	Permutation box
CCS	Cylindrical Coordinate System
CCSDPB	Cylindrical Coordinate System and Dynamic Permutation Box
RAF	Ramlan – Ashwak - Faudziah
3D	Three Dimensional
2D	Two Dimensional
XOR	Exclusive OR
SPN	Substitution - Permutation Network
NIST	National Institute of Standard and Technology
ECB	Electronic Codebook Mode
CBC	Cipher Block Chaining Mode
CFB	Cipher Feedback Mode
OFB	Output Feedback Mode
CTR	Counter Mode
DSDP	Key-Dependent S-Box and Key-Dependent P-Boxes
VMS-AES	Variable Mapping Substitution - Advance Encryption Standard
SK	Secret Key
LFSR	Linear Feedback Shift Register
PN	Pseudo Number
SKs	Secret Keys
Eks	Encryption keys
P-value	Probability value
AVAL	Avalanche Criterion
SAC	Strict Avalanche Criterion
BIC	Bit Independence Criterion
KP	Known Plaintext
LC	Linear Cryptanalysis
BR	Byte Relocation
BT	Byte Transformation
PRT	Partial Round Test
FRT	Full Round Test
BBS	Blum-Blum-Shub

CHAPTER ONE

INTRUDUCTION

1.1 Background

The advancements in technologies have changed the way people communicate with each other. Technologies have accelerated communications, resulting in an exponential information exchange, especially in digital landscape. Hence, it allows people, regardless of the places they are at and the time zone they are in to communicate and transfer information extensively in a borderless manner. In this kind of situation, the protection of transmitted data is very important. This is because in such landscape, the possibility of data theft is high, and eventually results in data loss. More importantly, the attacked data could be manipulated by the attackers for undesirable purposes (Verma, Agarwal, Dafouti, & Tyagi, 2011).

In order to ensure that transmitted data are safe, cryptography has been popularly used Rolf (2005). Cryptography techniques encrypt and hide information. This means that the original information will not be tampered and the information can only be accessed in pieces and not as a whole (Menezes, Van Oorschot, & Vanstone, 1997).

Existing popular cryptographic algorithms on block cipher include DES, RC2, IDEA, CAST, Rijndael, Twofish, RC6, MARS, Serpent, and Blowfish. The limitations of these algorithms except Blowfish are not highly secured and slow.

As mentioned, one of the popular cryptographic algorithms is the Blowfish Algorithm (BA). BA is a symmetric-key block cipher, designed in 1993 by Bruce Schneier and

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