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A Comparative Analysis of SHA and MD5 Algorithm

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***Abstract*- This paper is based on the performance analysis of message digest 5 and secure hashing algorithm. These two topics are related with cryptography and cryptography is an extension of cryptology and cryptanalysis. The purpose of this paper is that to compare the time taken to build a hash as well as it also compares the bit rate passes through a hash value. Here we are going to perform a deep analysis for these two algorithms.**

Keywords **Hash, MD5, SHA, Analysis , Cryptography, Message, Cryptology .**

I. INTRODUCTION

Hashing is the topic of cryptography .The cryptography is a way of securing message and data over the internet we know that, data is present on world wide web is double day by day to secure these type of data we are provide a fingerprint for its authenticity .Message Digest is one way where a master fingerprint has been generated for the purpose of providing a message authentication code (hash code) **[4].**

The Data integrity is measured by MD5 by the help of 128 bit message, that message is given by user to create a fingerprint message is of variable length, the main thing is that it is irreversible. The Father of this algorithm is Professor Ronald L. Rivest of MIT **[1].** This algorithm is best for 32 bit and 16 bit machines the comp-ability of this algorithm can be extended to 64 bit machines also but this type of scheme may be quite slow because of its architecture. MD5 is the extension of MD4 algorithm which is quite faster because of its three rounds and MD5 contains four rounds which makes its slower. It's a one way hash function that deals with security features.

As a wide use of internet day by day it is needed that a proper file has been download from peer to peer (P2P) servers/network. Due to present of same name file it is quite difficult to find the original so message digest plays an important role in such type of downloads these type of file may be bound with message authentication code which proves that the source is verified otherwise it shows the warning that verified source not found or vice versa . Both algorithms follows the same concept but with different architecture **[1] [5].**

The SHA Algorithm is a cryptography hash function and used in digital certificate as well as in data integrity. SHA is a fingerprint that specifics the data and was developed by N.I.S.T. as a U.S. Federal Information Processing Standard (FIPS), is intended for use with digital signature applications **[3].**

The message which is less than 264 bits in length Secure Hash Algorithm works with that type of messages. Message digest is the output of SHA and length of these type of messages is 160 bits (32 bits extra than MD5).

II. MESSAGE DIGEST 5 ALGORITHM

This algorithm is based on message length. It requires 8 bit of message length and too fast but also take long message.

// M= (Y0, Y1,……., Yn-1), Message to hash , after padding

// Each Yi is a 32-bit word and N is a multiple of 16

MD5 (M)

//initialize (A,B,C,D) = IV

(A,B,C,D) = (0x67452301,0xefab89 , 0x98badcfe , Ox10325476)

For i=0 to N/16 -1

// Copy block I to X

Xj = Y16i+j for j = 0 to 15

// Copy X to W

Wj = Xσ(j) , for j = 0 to 63

// initialize Q

(Q-4 , Q-3 , Q-2 , Q-1) = (A , D , C , B)

// Rounds 0 , 1 , 2 and 3

Round0(Q , W) Round1(Q , W) Round2(Q , W) Round3(Q , W)

// Each addition is modulo 232

(A , B , C , D)=(Q60 + Q-4 , Q63 + Q-1 , Q62 + Q-1 , Q61 + Q-3)

next i

return A , B , C , D

end MD5

Round0(Q , W)

//steps 0 through 15 for i = 0 to 15

Qi = Qi-1 + ((Qi-4 + F(Qi-1 , Qi-2 , Qi-3) + Wi +Ki) <<< si)

next i

end Round() **[1].**

Step 1:- Padding bits and Append Length

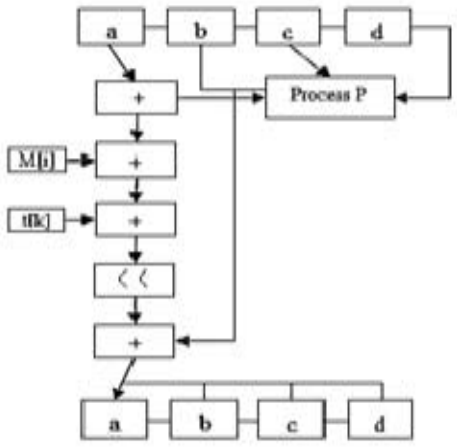
Padding of the bits is compulsory with '0' and '1' first and last respectively until the resulting ≠ bit length which = 448 mod 512,and the last of bit length of the original message as 64-bit integer. The last bit length of the message which is already padded is 512N for a true integer N.

Step 2:-Divide the input into 512-bit blocks
The message which is already padded is now partitioned into N successive 512-bit blocks m1, m2.....mn.

Step 3:- Initialize Channing variables
Initialization of 32-bit number in the form of chaining variables (A,B,C,D) these values are represented in hash only
A = 01 17 2d 43
B = 89 AB CD EF
C = FE DC BA 98
D = 76 54 32 10

Step 4:- Process blocks
The four buffers (A, B, C and D) messages (content) are joined now with the input words, using the four auxiliary functions (W, X, Y and Z).4 rounds are performed and each involves 16 basic operations. The Processing block P is applied to the four buffers (A, B, C and D), by using message word M[i] and constant K[i]. The item "<<<s" denotes a binary left shift by s bits. The four type of IRF(info related functions) that each take as input three 32-bit words and produce same bits of output i.e. 32-bit word. They apply the logical operators ^, v, ! and xor to the input bits.
Q (A, S, D) = AS v not (A) F
W (A, S, D) = AS v S not (F)
E (A, S, D) = A xor S xor F
R (A, S, D) = S xor (A v not (F))
The bits of A, S, and D are totalitarian and balance the each bit of Q (A, S, D) will be totalitarian and balance. The functions (A, S and D) = P, in that they do job in "bitwise parallel" to produce the reliable output from the bits of A, S and D.In such a way that if the be similar bits of D, E and F are autarchic and balanced, then each bit of W (A, S, D), E (A, S, D) and R (A, S, D) will be totalitarian and balance.

Step 5:- Hashed Output
There are 4 rounds performed in message digest 5 (MD5) which is of 128 bits. Fig 1 shows One MD5Operation **[1] [2].**

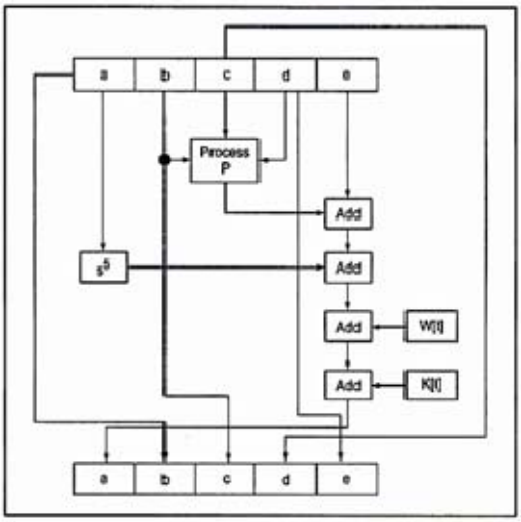


[2].

Fig 1:-One MD5 iteration

III. SECURE HASHING ALGORITHM

Step 1:-Padding
Add Padding to the end of the genuine message length is 64 bits and multiple of 512.
Step2:- Appending length
In this step the excluding length is calculated
Step3:- Divide the Input into 512-bit blocks
In this step we divide the input in the 512 bit blocks
Step4:-Initialize chaining variables
In this step we initializing chaining variables here we initialize 5 chaining variables of 32 bit each=160 bit of total.
Step5:-Process Blocks
1) Copy the chaining variables
2) Divide the 512 into 16 sub blocks
3) Process 4 rounds of 20 steps each **[2].**
The fig 2 shows one SHA iteration.



[2].

Fig 2:-One SHA iteration

IV. PARAMETERS USED FOR MD5 AND SHA ALGORITHM:

A. *Parameters of MD5.*

Below equation shows a single MD5 operation.
1)Default Parameters
a = b + ((a + Process P (b, c, d) + M[i] + t[k]) <<< s) Here:-
a, b, c, d = are Chaining variables
Process P=A non linear operation
M[i] =For M[q x 16 + i], which is the **ith** 32-bit word in the **qth** 512-bit block of the message t[k]=a constant
<<<s =circular-left shift by s bits **[2].**
2) Actual Parameters.
Key Length: 64 bits, 128 bits, 256 bits , 512 bits
Block Size: 128 bits
Cryptanalysis: Resistance Strong against Digital Certificate and very fast on 32 bit machines Security Secure
Rounds: 4
Steps: 16

B. Parameters of SHA.

Below equation shows a single SHA operation.
1) Default Parameters.
abcde(e+process p_s5(a)+W[t]+k[t]),a,s30(b), c, d

Here:-
a, b, c, d, e =chaining variables
Process p =status of logical operations st =<<<
W[t] =derived other 32 bits bytes
K[t]=five additives constants are defined **[2] [3].**
2) Actual Parameters.
Key Length: 128 bits
Block Size: 160 bits
Cryptanalysis: Resistance Strong against Digital Certificate.
Rounds: 4
Total Steps: 20

V. DIFFERENCES AND SIMILARITIES BETWEEN MD5 AND SHA ALGORITHMS:

A. *Differences between MD5 and SHA Algorithms.*

Table 1:- Comparison between MD5 and SHA

Keys For Comparison	MD5	SHA
Security	Less Secure than SHA	High Secure than MD5
Message Digest Length	128 Bits	160 Bits
Attacks required to find out original Message	2^{128} bit operations required to break	2^{160} bit operations required to break
Attacks to try and find two messages producing the same MD	2^{64} bit operations required to break	2^{80} bit operations required to break
Speed	Faster, only 64 iterations	Slower than MD5, Required 80 iterations
Successful attacks so far	Attacks reported to some extents	No such attach report yet

B. *Similarities between MD5 and SHA Algorithms.*

Table 2:-Similarities between MD5 and SHA

Keys For Similarities	MD5	SHA
Padding	✓	✓
Message bit	✓	✓
Members (Hash Family)	✓	✓
Resource Utilization (same)	✓	✓
Fingerprint	✓	✓

VI. RESULTS.

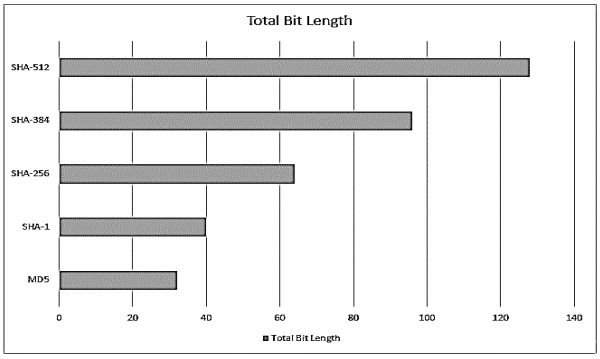


Fig 3: Total Bit Length

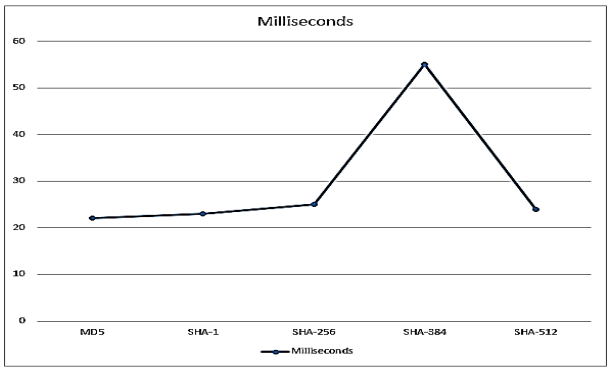


Fig 4**:** Performance chart of hashing algorithms

Table 3:MD5 Execution

Test Strings	MD5
“”	f40decf9ef00e204f9e009e8fcf8121e31
1234567890	f807f1fcf80d030febe008fa1708e1ef31
abcdefghijklmnopqrstuvwxyz	f3fcf3f711e2f4001dfb191cfa17f10b15
abcdefghijklmnopqrstuvwxyz1234567890	1f1d12e001e9f2f70b1bee0f08ef11f332
ABCDEFGHIJKLMNOPQRSTUVWXYZ	131beaee0bf5e307171f1509f711e6ec31
message digest	f91b191d1ce7e3ed121a0f01eaf111f015

Result is based on the instance of MD5.

Table 4 : SHA-1 Execution

Test Strings	SHA-1
“”	cf83e1357eefb8bdf1542850d66d8007d620e4050b5715dc83f4a921d36ce9ce47d0d13c5d85f2b0ff8318d2877eec2f63b931bd47417a81a538327af927da3e
1234567890	12b03226a6d8be9c6e8cd5e55dc6c7920caaa39df14aab92d5e3ea9340d1c8a4d3d0b8e4314f1f6ef131ba4bf1ceb9186ab87c801af0d5c95b1befb8cedae2b9
Abcdefghijklmnopqrstuvwxyz	4dbff86cc2ca1bae1e16468a05cb9881c97f1753bce3619034898faa1aabe429955a1bf8ec483d7421fe3c1646613a59ed5441fb0f321389f77f48a879c7b1f1
abcdefghijklmnopqrstuvwxyz1234567890	3910787b0538d27e648a4e387e989aba8f631456ab99bb96b721b7c5a6891ed36fe70de5fec538339201f531b66b81152d1b80cc463f5104253c37e31be24976
ABCDEFGHIJKLMNOPQRSTUVWXYZ	f9292a765b5826c3e5786d9cf361e677f58ec5e3b5cecfd7a8bf122f5407b157196753f062d109ac7c16b29b0f471f81da9787c8d314e873413edca956027799
message digest	e87034c9a6caef8abbe1aab3ffac96e5a171152fad79e9fbb0aacc45012481d2a44171cef526e9dc7438c6d74b2c1dd95506b7a03cd74f74f967d31966ddb644

Result is based on the instance of SHA-1.

Table 5: SHA-256 Execution

Test Strings	SHA-256
“”	cf83e1357eefb8bdf1542850d66d8007d620e4050b5715dc83f4a921d36ce9ce47d0d13c5d85f2b0ff8318d2877eec
	4d3d0b8e4314f1f6ef131ba4bf1ceb9186ab87c801af0d5c95b1befb8cedae2b9
Abcdefghijklmnopqrstuvwxyz	4dbff86cc2ca1bae1e16468a05cb9881c97f1753bce3619034898faa1aabe429955a1bf8ec483d7421fe3c1646613a59ed5441fb0f321389f77f48a879c7b1f1
abcdefghijklmnopqrstuvwxyz1234567890	3910787b0538d27e648a4e387e989aba8f631456ab99bb96b721b7c5a6891ed36fe70de5fec538339201f531b66b81152d1b80cc463f5104253c37e31be24976
ABCDEFGHIJKLMNOPQRSTUVWXYZ	f9292a765b5826c3e5786d9cf361e677f58ec5e3b5cecfd7a8bf122f5407b157196753f062d109ac7c16b29b0f471f81da9787c8d314e873413edca956027799
message digest	107dbf389d9e9f71a3a95f6c055b9251bc5268c2be16d6c13492ea45b0199f3309e16455ab1e96118e8a905d5597b72038ddb372a89826046de66687bb420e7c

Result is based on the instance of SHA-256.

Table 6: SHA-384 Execution

Test Strings	SHA-384
“”	cf83e1357eefb8bdf1542850d66d8007d620e4050b5715dc83f4a921d36ce9ce47d0d13c5d85f2b0ff8318d2877eec2f63b931bd47417a81a538327af927da3e
1234567890	12b03226a6d8be9c6e8cd5e55dc6c7920caaa39df14aab92d5e3ea9340d1c8a4d3d0b8e4314f1f6ef131ba4bf1ceb9186ab87c801af0d5c95b1befb8cedae2b9
Abcdefghijklmnopqrstuvwxyz	4dbff86cc2ca1bae1e16468a05cb9881c97f1753bce3619034898faa1aabe429955a1bf8ec483d7421fe3c1646613a59ed5441fb0f321389f77f48a879c7b1f1
abcdefghijklmnopqrstuvwxyz1234567890	3910787b0538d27e648a4e387e989aba8f631456ab99bb96b721b7c5a6891ed36fe70de5fec538339201f531b66b81152d1b80cc463f5104253c37e31be24976
ABCDEFGHIJKLMNOPQRSTUVWXYZ	f9292a765b5826c3e5786d9cf361e677f58ec5e3b5cecfd7a8bf122f5407b157196753f062d109ac7c16b29b0f471f81da9787c8d314e873413edca956027799
message digest	107dbf389d9e9f71a3a95f6c055b9251bc5268c2be16d6c13492ea45b0199f3309e16455ab1e96118e8a905d5597b72038ddb372a89826046de66687bb420e7c

Result is based on the instance of SHA-384.

Table 7: SHA-512 Execution

Test Strings	SHA-512
“”	cf83e1357eefb8bdf1542850d66d8007d620e4050b5715dc83f4a921d36ce9ce47d0d13c5d85f2b0ff8318d2877eec2f63b931bd47417a81a538327af927da3e
1234567890	12b03226a6d8be9c6e8cd5e55dc6c7920caaa39df14aab92d5e3ea9340d1c8a4d3d0b8e4314f1f6ef131ba4bf1ceb9186ab87c801af0d5c95b1befb8cedae2b9
abcdefghijklmnopqrstuvwxyz	4dbff86cc2ca1bae1e16468a05cb9881c97f1753bce3619034898faa1aabe429955a1bf8ec483d7421fe3c1646613a59ed5441fb0f321389f77f48a879c7b1f1
abcdefghijklmnopqrstuvwxyz1234567890	3910787b0538d27e648a4e387e989aba8f631456ab99bb96b721b7c5a6891ed36fe70de5fec538339201f531b66b81152d1b80cc463f5104253c37e31be24976
ABCDEFGHIJKLMNOPQRSTUVWXYZ	f9292a765b5826c3e5786d9cf361e677f58ec5e3b5cecfd7a8bf122f5407b157196753f062d109ac7c16b29b0f471f81da9787c8d314e873413edca956027799
message digest	107dbf389d9e9f71a3a95f6c055b9251bc5268c2be16d6c13492ea45b0199f3309e16455ab1e96118e8a905d5597b72038ddb372a89826046de66687bb420e7c

Result is based on the instance of SHA-512.

VII. CONCLUSION

In this paper a new analytical study between MD5 and SHA were present by the help of different parameters like Key Length, Block Size, Cryptanalysis, Rounds, Total Steps .This proves that SHA is more secure than MD5 but on the other hand MD5 is more fast than SHA on 32 bit machines. We also do an execution comparison between MD5 and SHA algorithm.

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