

SHA-256 PAPER

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Abstract—Define what’s the SHA-256 cryptographic method, what it does and how it works. Experimentation on how long it takes for the method to generate a result for different input sizes.

Index Terms—hash, cryptographic, bit, logic operation

I. INTRODUCTION

In this paper we will talk about the study and experimentation of the SHA-256 hash function, is important to know that SHA-256 isn’t an encryption algorithm, it is a ‘one-way’ cryptographic function. SHA-256 is a member of the SHA-2 family, which was designed by the United States National Security Agency (NSA).

It’s one of the successor hash functions to SHA-1, but is not much complex. The uses of SHA-256 goes from hash tables, integrity verification, challenge handshake authentication to digital signatures, etc.

The fact of being a cryptographic hash functions is their collision resistance: nobody should be able to find two different input values that result in the same hash output.

SHA-256 creates an 256-bit key (from there comes the name), that make it perfect partner-function for AES(Advanced Encryption Standard) and other’s alike.

II. METHODOLOGY

The chosen model is the qualitative one, because it allows us to use experimentation to obtain the necessary data to reach conclusions about the function, we will make distinct experiments around the Java code of the SHA-256 function, once we finish the tests, we will compare then to know the trend of the function with different sizes of input text and the time spent in “digesting” them.

The string list used in the experiments is: [“abc”, “test”, “one after one”, “Heil Hitler”, “today is gonna be a beautiful day”, “I don’t think you trust In my self righteous suicide I cry when angels deserve to die!”].

In the figure 1, is the result of a python code that counts the number of characters which has each string in the previous list, the difference in numbers of characters is important for the test diversity (the presence of uppercase and lowercase letters should not affect the digesting time).

Next is the Java code (figure 2) that is used in the test realization, the code has a string which is digested and comes out in a byte vector, which is manipulated to be transformed into a readable string.

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```
abc
cantidad de caracteres: 3
test
cantidad de caracteres: 4
one after one
cantidad de caracteres: 13
Heil Hitler
cantidad de caracteres: 11
today is gonna be a beautiful day
cantidad de caracteres: 33
I don't think you trust In my self righteous suicide I cry when angels deserve to die!
cantidad de caracteres: 86
```

Fig. 1. Result of the character counter in Python

```
package sha.pqg16;

import java.io.UnsupportedEncodingException;
import java.security.MessageDigest;
import java.security.NoSuchAlgorithmException;

public class SHA256 {

    public static String bytesToHex(byte[] bytes) {
        StringBuffer result = new StringBuffer();
        for (byte b : bytes) result.append(Integer.toHexString((b & 0xFF) | 0x100, 16).substring(1, 3));
        return result.toString();
    }

    public static void main(String[] args) throws NoSuchAlgorithmException, UnsupportedEncodingException {
        MessageDigest md = MessageDigest.getInstance("SHA-256");
        String text = "abc"; // here comes the text to digest
        md.update(text.getBytes("UTF-8")); // Change this to "UTF-16" if needed
        byte[] digest = md.digest(); // here is where the text is digested
        System.out.println(bytesToHex(digest));
    }
}
```

Fig. 2. SHA-256 Java Code

III. EXPERIMENTATION

The algorithm gets the message from the input and processes it to get the bits of it, then adds a number 1 to the end and appends number 0s to make the message a 512 multiple length and finally the length of the message is appended at the end in 64-bit big-endian format. Then, for every 512 bit chunk a series of logical operations (shown in figure 3) are applied to the first 16 words of the chunk to extend the words across the entire 512 bit segment.

$$\begin{aligned} Ch(E, F, G) &= (E \wedge F) \oplus (\neg E \wedge G) \\ Ma(A, B, C) &= (A \wedge B) \oplus (A \wedge C) \oplus (B \wedge C) \\ \Sigma_0(A) &= (A \ggg 2) \oplus (A \ggg 13) \oplus (A \ggg 22) \\ \Sigma_1(E) &= (E \ggg 6) \oplus (E \ggg 11) \oplus (E \ggg 25) \end{aligned}$$

Fig. 3. Logical operations performed to 512 bit chunks

The complexity used to generate the hash code is $O(2^{64})$ because of the size of the word that divides every chunk, which is 64 bits.

Now, we will apply the code to all strings in the already defined list.

```
FUNC:
abc
33 milliseconds
ba781bc9f80f0cf6a41440de5da2223b00361a396177a9cb410ff61f20015ad
BUILD SUCCESSFUL (total time: 0 seconds)
```

Fig. 4. SHA-256 applied to “abc”

```

run:
test
41 milliseconds
9f06d081884c7d659a2f5aa0c55ad015a3bf4f1b2b0b822cd15d6c15b0f00a08
BUILD SUCCESSFUL (total time: 0 seconds)

```

Fig. 5. SHA-256 applied to "test"

```

run:
Heil Hitler
32 milliseconds
b77f184b601cfc6ffab09037da889d3bc2d50a681fef804325d09e2d5940a48
BUILD SUCCESSFUL (total time: 0 seconds)

```

Fig. 6. SHA-256 applied to "Heil Hitler"

```

run:
today is gonna be a beautiful day
32 milliseconds
37b638806c45edea0930004a14bc440088cd16cf434e1e6d52bde8ed205540c0
BUILD SUCCESSFUL (total time: 0 seconds)

```

Fig. 7. SHA-256 applied to "today is gonna be a beautiful day"

```

run:
I don't think you trust In my self righteous suicide I cry when angels deserve to die!
37 milliseconds
825659298b207d408280ca6540999a6e42aa93792f2f2c8aad0962a27ada
BUILD SUCCESSFUL (total time: 0 seconds)

```

Fig. 8. SHA-256 applied to "I don't think you trust In my self righteous suicide I cry when angels deserve to die!"

With the above, we can proceed to the data analysis to obtain results.

IV. RESULTS

With the tests carried out, it is noted that the times to execute or digest the strings, tend to last the same, around 20-40 milliseconds, of course, these times are affected by the processes that are running the system simultaneously, but the effects of those process are usually minimal on the hash.

It is worth mentioning that the size or number of characters in the string does not seem to affect the time to digest, as seen in the tests, due to the SHA-256 process to digest the set of bytes that make up the string.

When seeing the order of the procedure, it coincides with the observed in the times of execution, since the large O is a constant C , there should not be times greater than the same $C = 2^{64}$.

With these results, the utility of the SHA-256 function in the algorithms and computational security processes is seen, since it is a fast, relatively simple function and since it is not an encryption method, the possibility of reaching the original string from of the string passed by the SHA-256 function, it is almost null.

V. DISCUSSION

VI. CONCLUSIONS