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Multi- layered Message Cryption System Using Cryptography, Stegnography Techniques

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Abstract

Cryptography is a method/technique of securing information and communications through use of codes so that only that person for whom the information is intended can understand it and process it. It provides for secure communication in the presence of malicious third-parties—known as adversaries. Thus, preventing unauthorized access to information. The prefix "crypt" means hidden or vault and suffix "graphy" means writing. In Computer Science, Cryptography refers to secure information and communication techniques derived from Mathematical concepts and a set of rule-based calculations called Algorithms, to transform messages in ways that are hard to decipher. These deterministic algorithms are used for cryptographic key generation, digital signing, verification to protect Data Privacy, Web Browsing on the Internet, and confidential communications such as Credit Card transactions and E-mail.

Keywords: Cryptography, Ciphers Techniques, Steganography,CipherText, OneTimePad

Introduction

1. Domain Description

Cryptography: Cryptography is a method/technique of securing information and communications through use of codes so that only that person for whom the information is intended can understand it and process it. It provides for secure communication in the presence of malicious third-parties—known as adversaries. Thus, preventing unauthorized access to information. The prefix "crypt" means hidden or vault and suffix "graphy" means writing. In Computer Science, Cryptography refers to secure information and communication techniques derived from Mathematical concepts and a set of rule-based calculations called Algorithms, to transform messages in ways that are hard to decipher. These deterministic algorithms are used for cryptographic key generation, digital signing, verification to protect Data Privacy, Web Browsing on the Internet, and confidential communications such as Credit Card transactions and E-mail.

2. Cryptography can be two types:-

2.1 Symmetric and Asymmetric. With symmetric cryptography, the same key is used for both encryption and decryption. A sender and a recipient must already have a shared key that is known to both. Key distribution is a tricky problem and was the impetus for developing asymmetric cryptography. With Asymmetric crypto, two different keys are used for encryption and decryption. Every user in an asymmetric cryptosystem has both a public key and a private

key. The private key is kept secret at all times, but the public key may be freely distributed. Data encrypted with a public key may only be decrypted with the corresponding private key. So, sending a message to John requires encrypting that message with John's public key. Only John can decrypt the message, as only John has his private key. Any data encrypted with a private key can only be decrypted with the corresponding public key. Similarly, Jane could digitally sign a message with her private key, and anyone with Jane's public key could decrypt the signed message and verify that it was in fact Jane who sent it. Keeping this in mind, we proceeded in the work of our project paper. Also, to add extra security and protection, we hide the encrypted message inside an image to perceive as 'hidden text'.

3. Background/Review of Related Work

Now-a-days, the Data and Information security is one from the most challenges that face the organizations that need to transfer sensitive or private data online. According to a survey, the number of hackers or online data thief increased rapidly in the last years. The hackers focus on stole the sensitive data such as credit cards numbers and organizations secrets. Thus, the organizations always afraid from the security level of data transferring channels. Cryptography is playing a major role in data protection in applications running in a network environment that used to secure the online transferred data. But the main weakness of Cryptography method is that the hackers can detect the encrypted messages and try to decrypt these messages through many ways such as automatic counters or random tests based on mathematic calculations. So to improve the level of security, Steganography is included as a supportive security method. The main aim of Steganography is to maximize the difficulty of detect the encrypted data that transferred online. Therefore, the encrypted data can be hidden in media file before send this file through online application. The receiver can ex-tract the encrypted data from the media file and decrypt the data using the secret keys. Thus, the hackers will face difficulty to discover encrypted data the transferred online. Steganography is the art of communicating in a way which hides the existence of the communication. Cryptography scrambles a message so it can't be understood; the Steganography hides the message so it can't be seen. So, the combined cryptography and steganography into one system increases the security and confidentiality of it.

Hybrid Cryptography and Steganography are the latest methods that have contributed greatly towards the improvement of security of message transmission. Khider Nassif Jassim (Department of Statistics. Faculty of Management and Economics, Wasit University, Al-Kut, Iraq) and Zico Pratama Putra (School of Electronic Engineering and Computer Science, Queen Mary University of London) proposed a multitasking system for "Improving the cryptography security level using supportive method which is Steganography". [5] "There are four stages represent the methodology of this paper; (1) encrypt the original texts using RSA algorithm, (2) hide the encrypted texts in Image files, (3) extract the encrypted texts from Image files, and (4) decrypt the original texts using decryption key of RSA algorithm".

It is expected to improve the security level of the online transferred textual data. The performance of the final results will be evaluated through compare the Image files quality before and after hide the data in these files. The quality of the original and stego Image files need to be same or near in order to maximize the difficulty of detect that there data hide in these files. [5]

We referred to this project for ideas and motivation and the techniques used were the main inspiration towards the foundation of our Paper Work.

4. Methodology

4.1 Problem Formulation: In this Section, we detail the general structure of three different ciphers focusing on Cryptography. We then describe how to encrypt and decrypt data and finally introduce the encoding and decoding of text into a given image.

4.2 Algorithm Description: Write a suitable Algorithm to Encode and Decode a message into an Image, after Encrypting the input message thrice using separate Cipher techniques. Show the Decryption and Decoding as well to prove accuracy and viability.

5. Design Description:

Cryptography Ciphers used:

1. OneTimePad Cipher
2. Substitution Caesar Cipher
3. Columnar Transposition Cipher

Steganography Process used: Image-based Encoding & Decoding

5.1 OneTimePad Cipher:

One Time Pad algorithm is also known as Vernam Cipher. It is a method of encrypting alphabetic plain text. It is one of the Transposition techniques which convert plain text into cipher text. The relation between the key and plain text, the length of the key should be equal to that of plain text. In this mechanism, we assign a number to each character of the Plain-Text. [3]

eg:- A B C D E F G H I J
0 1 2 3 4 5 6 7 8 9
K L M N O P Q R S T
10 11 12 13 14 15 16 17 18 19
U V W X Y Z
20 21 22 23 24 25
Plain text — H E L L O → 7 4 11 11 14
Key — M O N E Y → 12 14 13 4 24
Plain text + key → 19 18 24 15 38
→ 19 18 24 15 12 (= 38 – 26)
Cipher Text → T S Y P M

5.2 Substitution Caesar Cipher:

This Cipher is one of the earliest & simplest methods of encryption technique. In a Substitution cipher, any character of plain text from the given fixed set of characters is substituted by some

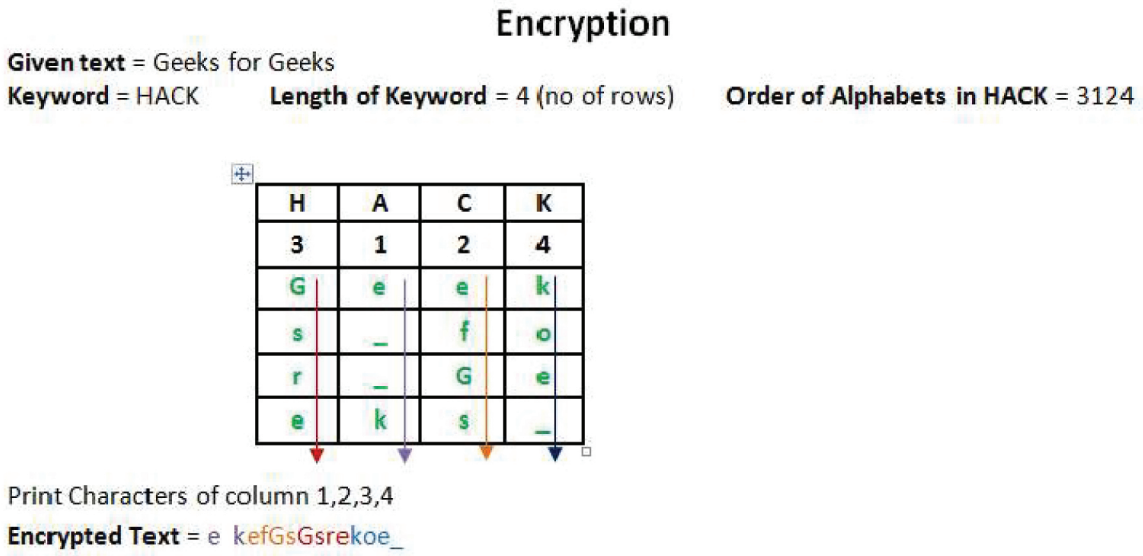
other character from the same set depending on a key. For example, with a shift of 1, A would be replaced by B, B would become C, and so on. [3]

eg:- Plain Text: I am studying Data Encryption
Key: 4

Output: M eq wxyhCmrk Hexe IrgvCtxmsr

5.3 Columnar Transposition Cipher:

A Transposition Cipher is methods of encryption by which the positions held by units of plaintext (which are commonly characters or groups of characters) are shifted according to a regular system, so that the cipher text constitutes a permutation of the plaintext.



In Columnar Transposition Technique, the message is written out in rows of a fixed length, and then read out again column by column, and the columns are chosen in same scrambled order. Both the width of the rows and the permutation of the columns are usually defined by a keyword. [3].

6. Image Based Steganography:

Steganography is the method of hiding secret data in any image/audio/video. In a nutshell, the main motive of steganography is to hide the intended information within any image/audio/video that doesn't appear to be secret just by looking at it.

The idea behind image-based Steganography is very simple. Images are composed of digital data (pixels), which describes what's inside the picture, usually the colors of all the pixels. Since we know every image is made up of pixels and every pixel contains 3-values (red, green, blue).

6.1 Encode the Data:

Every byte of data is converted to its 8-bit binary code using ASCII values. Now pixels are read from left to right in a group of 3 containing a total of 9 values. The first 8-values are used to store binary data. The value is made odd if 1 occurs and even if 0 occurs.

For Example:

Suppose the message to be hidden is ‘ Hi ‘. Since the message is of 3-bytes, therefore, pixels required to encode the data is 3 x 3 = 9. Consider a 4 x 3 image with total 12-pixels, which are sufficient to encode the given data.
[(27, 64, 164), (248, 244, 194), (174, 246, 250), (149, 95, 232),
(188, 156, 169), (71, 167, 127), (132, 173, 97), (113, 69, 206),
(255, 29, 213), (53, 153, 220), (246, 225, 229), (142, 82, 175)]

ASCII value of ‘ H ‘ is 72 whose binary equivalent is 01001000.
Taking first 3-pixels (27, 64, 164), (248, 244, 194), (174, 246, 250) to encode. Now change the pixel to odd for 1 and even for 0. So, the modifies pixels are (26, 63, 164), (248, 243, 194), (174, 246, 250). Since we have to encode more data, therefore, the last value should be even.
Similarly, ‘i‘ can be encoded in this image.
The new image will look like:

[(26, 63, 164), (248, 243, 194), (174, 246, 250), (148, 95, 231),
(188, 155, 168), (70, 167, 126), (132, 173, 97), (112, 69, 206),
(254, 29, 213), (53, 153, 220), (246, 225, 229), (142, 82, 175)]

6.2 Decode the Data:

To decode, three pixels are read at a time, till the last value is odd, which means the message is over. Every 3-pixel contains a binary data, which can be extracted by the same encoding logic. If the value if odd the binary bit is 1 else 0. [4]

7. Implementation

7.1 Main Algorithm:

1. First we import packages One Time Pad.
2. Import package String.
3. Import package Math.
4. Also from PILLOW, we import package Image.
5. Storing all alphabets (lowercase and uppercase) in all letters using string.ascii_letters.
6. Then define the necessary processes in functions:

a) Subencrypt ()
b) Subdecrypt ()
c) transEncrypt ()

d) transDecrypt ()
e) encrypt ()
f) decrypt ()
g) genData ()
h) modPix ()
i) encode_enc ()
j) encodeImg ()
k) decodeImg ()

7. For the body, display a message for the start of user interaction.
8. Assign char value 'Y' to variable 'choice'.
9. Start a while loop with condition being variable 'choice' is equal to 'y' or 'Y'.
10. Display a message for user input for Encrypting or Decrypting. Take integer input in variable 'a'.
11. Start if with condition variable 'a' equals 1(1 denotes Encryption).
12. Accept text to encrypt.
13. Display message to input three keys for encryption as asked.
14. Accept Shift integer value for Substitution cipher key.
15. Accept String value for Transposition cipher key.
16. Accept String value for One Time Pad cipher key.
17. Use function encrypt () with the input text and three keys as parameters.
18. Store it in variable 'code'.
19. Start an if with choice 'ch' from user input, to check the correctness of the encrypted code.
20. Use function decrypt () with the encrypted text 'code' and three keys as parameters.
21. Store it in variable 'decode'.
22. Display the decoded text 'decode' for user verification.
23. Close if.
24. Proceed by encoding the encrypted text 'code' in the image.
25. Use function encode Img(code) to do step 24. The image extension should be provided by user.
26. Display that the Image has been encrypted.
27. Accept 'choice' from user to Continue.
28. Close if.

29. Start elif with condition variable 'a' equals 2 (2 denoted Decryption).
30. Use function decode Img() and store it in variable 'stegoImage'. The image extension should be provided by user.
31. Display message to input three keys for decryption as asked.
32. Accept Shift integer value for Substitution cipher key.
33. Accept String value for Transposition cipher key.
34. Accept String value for OneTimePad cipher key.
35. Use function decrypt () with 'stegoImage' and the keys as parameters.
36. Display the Decoded message obtained from the image.
37. Accept 'choice' from user to Continue.
38. Close elif.
39. Start else.

40. Raise an Exception for wrong 'choice' input.
41. Close while loop.
42. Display a thankful message for using the program.

8. Function Used:

1. def Subencrypt (plain_text,key) : This function accepts a plain text and a key for Substitution Encryption.

A. Input:

1. A String of both lower and upper-case letters, called Plain Text.
2. An Integer denoting the required key.

B. Procedure:

1. Create a list of all the characters.
2. Create a dictionary to store the substitution for all characters.
3. For each character, transform the given character as per the Substitution encrypting rule, i.e, adding Shift key value to Ascii value of the letters present in the text to create Cipher text. Use for loop to carry out this process.
4. Start a for loop to generate Cipher text. Add spaces where necessary using 'join'.
5. Return the new string generated.

2. def Subdecrypt (cipher_text,key) : This function accepts a cipher text and a key for Substitution Decryption.

A. Input:
1. A String of both lower and upper-case letters, called Cipher Text.
2. An Integer denoting the required key.

B. Procedure:

1. Create a list of all the characters.
2. Create a dictionary to store the decryption for all characters.
3. For each character, transform the given character as per the Substitution decrypting rule, i.e, subtracting Shift key value to Ascii value of the letters present in the text to create Plain text. Use for loop to carry out this process.
4. Start a for loop to generate Plain text. Add spaces where necessary using 'join'.
5. Return the new string generated.

3. def transEncrypt (text,key): This function accepts a plain text and a key for Transposition Encryption.

A. **Input:**

1. A String of both lower and upper-case letters, called Plain Text.

2. A String Input value denoting the required key.

B. Procedure:

1. Track key index.
2. Create a string variable to store the transposition for all characters.
3. Calculate column of the matrix (length of the key).
4. Calculate the maximum row of the matrix (ceil value of text length/column length).
5. Add padding character '_' for empty cells of matrix.
6. Create matrix and insert message characters row-wise.
7. Read matrix column-wise using key order.
8. Return the new string generated.

4. def transDecrypt (cipher,key): This function accepts a cipher text and a key for Transposition Decryption.

A. Input:

1. A String of both lower and upper-case letters, called Cipher Text.
2. A String Input value denoting the required key.

B. Procedure:

1. Track key index. Track text indices.
2. Create a string variable to store the decryption for all characters.
3. Calculate column of the matrix (length of the key).
4. Calculate the maximum row of the matrix (ceil value of text length/column length).
5. Convert key into list and sort alphabetically to access each character by its alphabetical position.
6. Create an empty matrix to store deciphered message.
7. Use for loops and arrange the matrix column wise according to permutation order by adding into new matrix.
8. Convert decrypted message matrix into a string.
9. Return the new string generated.

5. def encrypt (text, key1 ,key2 ,key3): This function accepts a plain text and keys for triple Encryption.

A. Input:

1. A String of both lower and upper-case letters, called Plain Text.
2. An Integer Shift value and two String Input values denoting the required keys respectively.

B. Procedure:

1. Use function Subencrypt() with plain text and Integer input key and store it in 'cipher1'.

2. Use function transEncrypt() with 'cipher1' and String input key and store it in 'cipher2'.
3. Use function onetimepad.encrypt( ) from OneTimePad package with 'cipher2' and String Input key as parameters and store it in 'cipher3'.
4. Return 'cipher3', i.e. the triple Encrypted Cipher text.

6. def decrypt (cipher, key1 ,key2 ,key3): This function accepts a Cipher text and keys for triple Decryption.

A. Input:

1. A String of both lower and upper-case letters, called Cipher Text.
2. An Integer Shift value and two String Input values denoting the required keys respectively.

B. Procedure:

1. Use function onetimepad.decrypt( ) from OneTimePad package with cipher text and Integer input key and store it in 'cipher3'.
2. Use function transDecrypt() with 'cipher3' and String input key and store it in 'cipher2'.
3. Use function Subdecrypt() with 'cipher2' and String Input key as parameters and store it in 'cipher1'.
4. Return 'cipher1', i.e. the triple Decrypted Plain text.

7. def genData(data): This function accepts Encrypted Cipher text as data and returns the list of binary codes of given data.

A. Input:

1. A String of both lower and upper-case letters, namely the Encrypted Cipher text as data.

B. Procedure:

1. Create a list to store binary codes of given data.
2. Start a for loop.
3. Transform each character of data into Unicode first,and then format it to binary codes respectively and append them into the list. Use append (format(ord(i), '08b') for this step.
4. Close for loop.
5. Return the list.

8. def modPix(pix,data): This function accepts contents of the image as a sequence object containing pixel values as data and modifies the pixels according to the 8-bit binary data.

A. Input:

1. Pixel values from the Image.
2. A String of both lower and upper-case letters, namely the Encrypted Cipher text as data.

B. Procedure:

1. Convert the data into list of binary codes using function genData() and store it in 'datalist'.
2. Get length of 'datalist'. Access and store the input pixel values.
3. Start a for loop and extract 3-pixels at a time.
4. Start a for loop to change pixel value to odd for 1 and to even for 0.
5. Eighth pixel of every set tells whether to stop or read further. Start a nested if to check. 0 means keep reading, 1 means that message is over.
6. Use topple to keep all changed pixel values together.

9. def encode_enc(new_img, data): This function accepts image and Encrypted Cipher data to encode.

A. Input:

1. Image where data is to be encoded.
2. A String of both lower and upper-case letters, namely the Encrypted Cipher text as data.

B. Procedure:

1. Calculate and store dimensions of the new image.
2. Start a for loop and use modPix() function to modify the pixels.
3. Put new modifies pixel values in the new image using putpixel() function from Image package.

10. def encodeImg(data): This function accepts Encrypted Cipher text as data and encodes the data into the Image.

A. Input:

1. A String of both lower and upper-case letters, namely the Encrypted Cipher text as data.

B. Procedure:

1. Display a message to accept Image name to use with full extension. Store it.
2. Open image using Image.open() from Image package of PILLOW.
3. Copy the image into a new variable, possible 'newimg'.
4. Encode the data using encode_enc() function with 'newimg' and data as the parameters.
5. Accept a new Image name and Extension for the 'newimg'.
6. Save the 'newimg' with the new name and Extension.

11. def decodeImg(): This function decodes the Encrypted data from the Image.

A. Input:

1. Image name and Extension of the Image from where Data can be extracted, is to be provided by user during the execution of this function.

B. Procedure:

1. Display a message to accept Image name to use with full extension. Store it.
2. Open image using Image.open() from Image package of PILLOW, and open it with read 'r' format.
3. Create a string variable to store the data.
4. Extract the pixel values of data and access it using'iter(image.getdata())'.
5. Start a while loop with condition Boolean 'true'.
6. To decode, read three pixels at a time till the last value is odd, which means the message is over. Every 3-pixels contain a binary data, which can be extracted by same encoding logic. If the value is odd, binary bit is 1 else0.
7. Return the data.

Results & Discussion

Encoding (with Viability): Here, an original image has been provided by the user along with three different Cipher keys for respective Ciphers.

Original Image (Nature.jpg)
User provided Keys: 4, Hack, Crypto

Image Encoded with CipherText (Nature1.png)
Keys used: Same as provided by the user

Conclusion

From a technical point of view, Cryptography is the solution to many of the Security Challenges that are present in the Internet. The technology exists to solve most of the problems. However, there are several issues that have obstructed the widespread use of cryptography in the Internet. First of all, cryptography, as a science, faces a difficult problem. Most of the algorithms cannot be proven secure. For this reason, there is suspicion around many of the cryptographic algorithms. Another aspect is related to the intellectual property associated with the algorithms. Most algorithms are patented, and only some companies have licensed them for use.
Finally, Cryptography can be used to harm society. Governments are concerned that encryption will make law enforcement and national security goals more difficult to achieve. For example, terrorists could communicate information over the Internet using encryption that law enforcement agencies could not decrypt. Therefore, some governments, such as the U.S., have regulated the export of software containing encryption algorithms. This is a topic of debate, pitting governments against the right to free speech. For example, U.S. export regulations can prevent the publication of cryptographic research. In one court case, in March 1996, Phil Karn filed suite over whether he could export some source code from [SCHN96]. A District Court ruled that "export controls on encryption software are constitutional under the First Amendment" to the U.S. Constitution.

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