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WebP Image Steganography Using M8PAM for Android Applications

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يقول الله تعالى

بِسۡمِ ٱللَّهِ ٱلرَّحۡمَٰنِ ٱلرَّحِيمِ

لَا تَحْسَبَنَّ الَّذِينَ يَفْرَحُونَ بِمَا أَتَوا وَّيُحِبُّونَ أَن
يُحْمَدُوا بِمَا لَمْ يَفْعَلُوا فَلَا تَحْسَبَنَّهُم بِمَفَازَةٍ مِّنَ
الْعَذَابِ وَلَهُمْ عَذَابٌ أَلِيمٌ

صدقَ الله العَظيم

آل عمران (188)

Dedicated To

My Mother

My father's soul

MY Wife

MY Brothers

My Sisters

My Friends

With Love and gratitude

Mustafa

2017

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Mustafa

2017

Abstract

The spread of using of WebP image format on the Internet, especially on social media and conversation programs, so when sending them repeatedly do not raise doubt, which made it a point of strength in the exploiting this feature by data security field.

In this thesis, an integrated system was proposed to protect secret messages using steganography technique to hiding the secret messages within WebP images format by using the proposed algorithm that named Mod 8 Plus Average Method (M8PAM). The proposed algorithm hides every three bits in one pixel of the cover file according to a proposed algorithm for selection locations.

Three layers are applied to the proposed system; the first layer, to select non-transparent pixels, then apply the proposed algorithm for selection locations that will carry the secret message. The second layer, encrypts every three bits from the secret message by redistributing them using random function. Finally, the third layer, use Rivest, Shamir and Adleman (RSA) method to encrypt the header then add it to the secret message before performing the steganography operations.

To ensure the success of the proposed algorithm, the proposed algorithm was compared with another algorithm that known as mode 16 method audio (M16MA), where the results showed the advantage of the proposed algorithm by using two measures (MSE, PSNR), the average result of MSE equal (0.0147) and PSNR equal (66.457) to the message size equal (4059 Byte) and cover size (31336 Byte). The data hiding rate equal % 66.66.

List of Abbreviations

Abbreviation	***Meaning***
AES	Advanced Encryption Standard
AMD	Advanced Micro Devices
CPU	Central Processing Unit
DVM	Dalvik Virtual Machine
IPC	Inter-Process Communication
JNI	Java Native Interface
JPEG	Joint Photographic Experts Group
Libc	library for the C programming
LSB	Least Significant Bit
M16MA	Mod 16 Method for Audio
M8PAM	Mod 8 Pluse Average Method
MSE	Mean Squared Error
OS	Operating System
OTP	One Time Pad
PNG	Portable Network Graphics
PSNR	Peak Signal-to-Noise Ratio
RAM	Random Access Memory
RGB	Red, Green and Blue
RGBA	Red, Green, Blue and Alpha
RIFF	Resource Interchange File Format
RSA	Rivest, Shamir and Adleman
SGL	Scalable Graphics Library
SHA-1	Secure Hash Algorithm 1
SSL	Secure Sockets Layer
USB	Universal Serial Bus
VGA	Video Graphics Array
WebP	Web Picture
WiFi	Wireless Fidelity
XMP	Extensible Metadata Platform
XML	Extensible Markup Language
XOR	Exclusive OR

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Chapter One

General Introduction

Chapter One

General Introduction

1.1 Introduction

In the last years, the data security become more important issue for the essential and sensitive data, therefore, access to these data by intruders must be restricted and also impossible if necessary, in order to avoid the misuse of this secret data or even to know any information that must remain as a secret. So intruders are willing to exploit any vulnerability to obtain this data whether it belongs to persons, companies, banks, organizations or government institutions. For these reasons, the data security field is more important and that must combine with any other fields which dealing with sensitive and secret data.

There are two techniques that used to provide the data security features; the first technique is the cryptography technique, this technique is most widely used, it's characterized by the conversion of secret data to un-understandable data by encoding it, only the sender and the receiver can decrypt this data by using a shared key. The cryptographers have developed different methods and algorithms for the cryptography technique, because many of the encryption algorithms are broken by using reverse engineering, the field that deals with the methods of analysis of these algorithms is called cryptanalysis, the weakness of the cryptography technique is that encrypted data is suspected if it is observed by intruders. Therefore, there was the need to use another technique. The second technique, the steganography technique, it's characterized by embedding the secret data inside the cover file that can be any type of multimedia files (image, sound, video, etc.) or protocols. In this technique the cover file can be viewed by the intruder, but it is not possible to suspect that there is secret data inside it if the process of the embedding professionally done efficient algorithms, the secret data will restructure the cover file according to a particular algorithm, so that it is possible to retrieve secret data from inside the cover file. The use of steganography technique alone only in any system may not meet the requirement of the data security, for example, secret information was sent to a specific person, and this information was secured using the steganography technique and was embedded in an image. If the computer of the receiver was hacked by an intruder, so the computer was completely controlled by the intruder as well as the files containing the secret data and the application that extracts them, in which case the use of steganography technique alone is not enough. Another example, is that someone wanted to send a secret message to the police and any other person should not discover this message. If this message is not properly secured then it may be attacked by intruders, this secret message will be disclosed and changed to information serving the intruders, and then re-sent with false information. For these reasons, encryption of secret message and data hiding from unauthenticated usage is very important.

1.2 Cryptography Versus Steganography

The design of a system combines the cryptography and steganography techniques as a requirement to provide secure communication and data transmission to ensure that secret data does not fall in hands of intruders. The process of detecting encrypted data is more difficult than unencrypted data that is embedded within a cover file. In this case, the intruder when attempting to extract embedded data will encounter a large problem in understanding this data because it is encoded using one of encryption algorithm, when these two techniques are combined, the system becomes more secure. If the steganography technique fails and the hidden data was extracted, the data is still secured by cryptography technique [Mih12]. There are many difference between the cryptography and steganography [Kha15]:

- Cryptography:

- Known message is passed.
- It alters the structure of the message.
- Key is necessary.
- Used to encode the message.
- In this mostly text are used.
- Attack on Cipher Text is called Cryptoanalysis.
- Output are Cipher text.

- Steganography:

- Unknown message is passed.
- It does not alter the structure of the message.
- Key is optional.
- Used to hide the message.
- Carrier can be any media file like Text, audio, image , video.
- Attack on Stego Object is called Stegoanalysis.
- Output are Stego File.

Algorithm of the combination technique[Kha15]:

- Sender will provide the plain text and a key
- Then an algorithm is used for encryption of the message.
- Then this encrypted message or cipher text is embedded in an image with the help of some algorithm to produce a Stegano Image and key is option in this process.
- Then the Stego image is transmitted for communication.
- Then the receiver will perform the reverse processes. Receiver will first extract the Cipher message form image using extraction algorithm.

- Then receiver will apply decryption algorithm and will provide key to decrypt the cipher text.
- The output will be the original plain text message.

1.3 Android operating system

The Android operating system was designed for mobile devices and tablets, it is one of the most widely used operating systems for smartphones today, the company that founded this operating system (OS) in the 2003 called the Android Incorporated (Inc.). Then in 2005 specifically, Google acquired this operating system and launched it in 2007. This OS based on the Linux kernel, has its own virtual machine and is used to execute its applications. The advantages of the Android OS is the continuous improvement on this OS by google Inc. addition to the higher speed to access to the internet. The Android OS consists of four layers as shown in figure(1.1) [Nar16]:

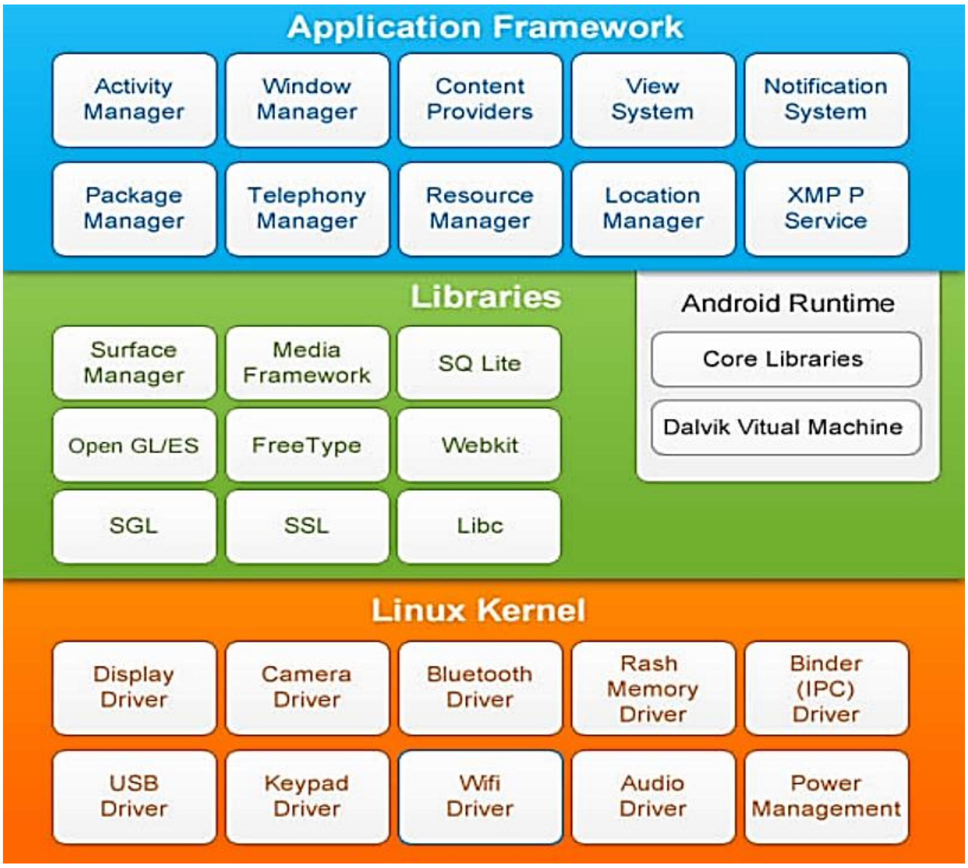


Figure (1. 1) The Android layers.

- **Linux Kernel:** This layer does not provide the ability to interact with developers and users, it provides compatibility between the hardware component and upper layers.
- **Libraries:** Set of libraries that written in the native C/C++ language that support various components (SQLite, OpenGL, Wib Kit, etc.), additionally it provides the **Android Runtime,** it provides the Dalvik Virtual Machine (DVM), that used to execute its applications.
- **Application Framework:** This layer provides services (Activity-Manager, Telephony-Manager, etc.) to developers and is of a higher level for applications in the form of Java.
- **Applications:** it provides the interaction between the device and the user.

Android is a sophisticated Operating System supporting a great number of applications in Smart Phones. Android mainly deals with the apps which are used in real-time[Kas14].

Android Platform Differences[Kas14].

Android is hailed as "the first finish, open, and free portable stage."[Kas14].

- **Complete:** The creators took a thorough methodology when they created the Android stage. They started with a safe working framework and assembled a strong programming structure on top that takes into account rich provision advancement good fortunes.
- **Open:** The Android stage is given through open source permitting. Designers have remarkable access to the handset characteristics when creating provisions.
- **Free:** Android provisions are allowed to create. There are no authorizing or sovereignty charges to create on the stage. No obliged enrolment charges. No obliged testing expenses. No obliged marking or accreditation charges. Android requisitions could be circulated and popularized in a mixed bag of ways.

1.4 Literature Survey

- Thenmozhi and Chandrasekran [The13] presented a novel technique for Image steganography based on DWT, where DWT is used to transform original image (cover image) from spatial domain to frequency domain. Discussed the chaotic system, and its advantages for achieving the encryption of data. Applied the henon mapping (chaos) on the secret image and performed the two dimensional Discrete Wavelet Transform (2-D DWT) on the cover image of size M × N. improved the Image quality by preserving the wavelet coefficients in the low frequency sub band. Experimental results showed that the algorithm has a high capacity and a good invisibility.

- Debiprasad and Kousik [Deb14] proposed an approach of building a secure data hiding technique in digital images using secure LSB technique for image steganography. The proposed technique uses host image files in spatial domain to hide the presence of sensitive information. A 3-3-2 LSB insertion method has been used for image steganography. Experimental results show a substantial improvement in the PSNR and Image value of the proposed technique over the base technique of 3-3-2 LSB insertion.

- Zhiwei [Zhi14] discussed image steganography combined with preprocessing of DES encryption. When transmitting the secret information, firstly, encrypt the information intended to hide by DES encryption was encrypted, and then was written in the image through the LSB steganography. Improved the Encryption algorithm lowest matching performance between the image and the secret information by changing the statistical characteristics of the secret information to enhance the anti-detection of the image steganography. Experimental results showed that the anti-detection robustness of image steganography combined with preprocessing of DES encryption was found much better than the way using LSB steganography algorithms directly.

- Manjula and Ajit [Man15] proposed a method to embed a color secret image (payload) into a color cover image. The proposed technique takes eight bits of secret data at a time and put them in LSB of Red, Green and Blue (RGB) pixel value of the cover image in 2, 3,3 order respectively. Such that out of eight (08) bits of message five (05) bits are inserted in R and G pixel and remaining three (03) bits are inserted in B pixel. This method provides clearly better results compared with 3,3,2 method.

- Mohammed and Atef [Moh16] proposed a novel gray scale steganographic method for information security. It based on the idea of image segmentation to give an improved steganography method for embedding secret message bit in least significant bits of random pixel in a random area within the grayscale cover image. Experimental results show that, the proposed method satisfied most of the security requirements, explained adaptability of grayscale cover image as a host to hide the secret messages and improved the data hiding capacity of host image by utilizing all the pixels.

- Mehdi and Ainuddin [Meh17] proposes a new data hiding method that increases visual quality and payload, as well as maintains steganographic security. The proposed scheme consists of two novel methods of parity-bit pixel value difference (PBPVD) and improved rightmost digit replacement (iRMDR). It partitions the cover image into two non-overlapping pixel blocks. The difference value between pixels in each block is used to determine the selection of PBPVD and iRMDR. According to the experimental results, the iRMDR method attains the best closest stego-pixels for good visual imperceptibility by resolving the region inconsistency problem in the existing method.

1.5 Aim of Thesis

This thesis aims to design and implements steganography system by using proposed algorithm for embedding secret message within WebP image. Main goal of this thesis is to send message secretly such that an unknown person should be not able to extract the hidden message.

The objectives are as follows:

1. To understand how Cryptography and Steganography techniques with proposed algorithm that named Mod 8 Plus Average Method (M8PAM) are implemented.
2. Implements three layers to improve the security of the system.
3. To use new image format that named WebP format also Known as Stickers as a cover file.
4. To explain how the experimental results that used to evaluate the system performance are used.

1.6 Thesis Layout

This thesis was organized into five chapters. Including the first chapter, which is an introduction to the basic concepts of data security as well as operating system Android and the vulnerabilities that facing users in addition to the objectives of this thesis, the rest chapters organized as follows:

1. **Chapter Two:** Entitled ***"Theoretical Background of Data Security"***

   The theoretical basis of the data security was described in this chapter, beside the main two techniques (Steganography, Cryptography) that used in this thesis. This chapter contains a simple explanation of all the concepts mentioned in this thesis.

2. **Chapter Three:** Entitled ***" The Proposed Steganography System"***

   The practical part of this thesis is described in this chapter in detail. This chapter includes the stages of designing the system in successive steps that resulted in the required system. In addition to explain the designed and applied algorithms.

3. **Chapter Four:** Entitled ***" User Interfaces and Experimental Results"***

   The user designed interfaces to perform the functions of the system were presented in this chapter, as well as the experimental results of system performance compared with pre-proposed systems by other researchers.

4. **Chapter Five:** Entitled ***" Conclusions and Future Work"***

   The conclusions of the thesis of the proposed system have been presented in this chapter in summary, in addition to the future work that may be done in the future to develop the proposed system.

Chapter Two

Theoretical Background

Chapter Two

Theoretical Background

2.1 Introduction

Recently, studies on the importance of providing different ways for data security has increased because of increasing attempts of intruding on those data, whether transmitted through the Internet or were stored. In this chapter, the theoretical concepts that related to the data security that represent the thesis work were presented, by explaining all the aspects that have been dealt with by the proposed system.

The following sections are organized as follow: section (2.2) the security issues are presented in details along with the techniques that used in the data security; section (2.3) the network security techniques are presented; finally, some of methods that are used to evaluate the system works are presented in the section (2.4).

2.2 Data Security

The importance of information security have emerged in recent years, due to the spread of computing system in all aspects of life. Therefore, researchers focused in this area on how to keep this information from exposure to theft, loss or change. It has become the field of information security of the most important areas that are being studied and developed, and is defined as "*to provide protection for any automated system that specializes in managing, storing and providing information*" [Wil15].

The properties that must be provided by information security to the information managed by the system, which includes [Wit16]:

- Confidentiality: Information is available only to authorized persons.

- Integrity: Unauthorized changes to the Information is reject.
- Availability: Information must be available all the time to people authorized to access them when needed.

In order for the system to achieve the above properties, some measures must be taken, these measures are classified as follows [Die11]:

- Prevention: Measures taken to protect information from any damage or change.
- Detection: Measures taken to detect the damage in information, how it was damaged and what is causing the damage or change.
- Reaction: Measures taken to repair the damaged information or to restore it to pre-damage or change.

There are many techniques that are developed to achieve data security, the most common techniques are cryptography and steganography [Kha14]. Each technique is applied separately, each with its own weaknesses and strengths, but when the two technologies are combined, the system becomes more powerful. Each technique will be explained in detail in the following section[Hay14];

2.2.1 Steganography

One of the most important data security techniques, which are not limited to being science but goes even further to be the art of embedding of secret data [Hus04]. The term of steganography that derived from two words in Greek "stegano-graphy" which means, "Perform the writing in secret form", steganography is the embed of "the secret data" which can be any form of digital data that represented in the computer system (message, image, sound and etc.) within another digital form for example (image, video and etc.) [Mic12].

The steganography system works as follow, the steganography process consists of two algorithms, the embedding and extraction algorithm also this which represent the processes of the system and the other elements represent the inputs and outputs of the system. The elements of the steganography system are shown in figure (2.1) [Phi08]:

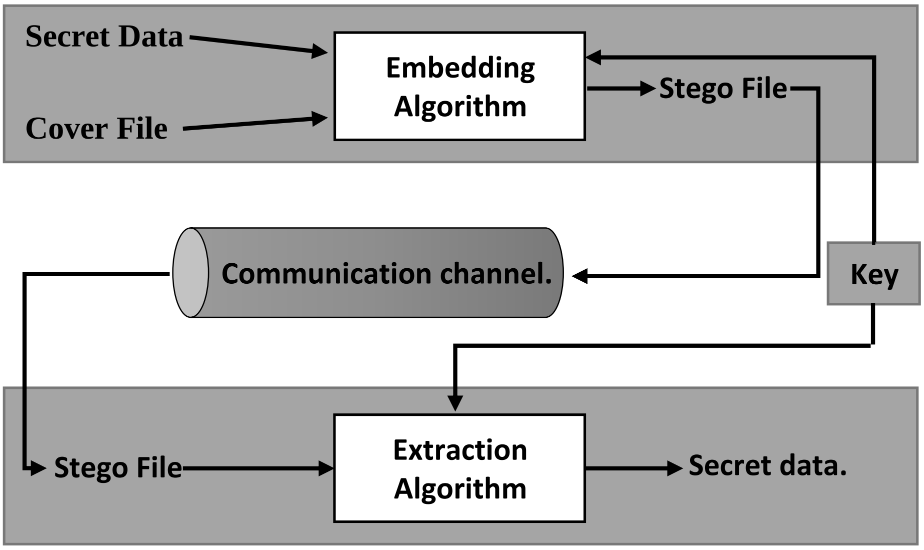


Figure (2. 1) The Steganography System.

I. Secret Data:

Represents any sensitive secret data (message, image, sound, video and etc.), which is converted into a computer format that can be manipulated by the embedding algorithm, which is considered as an input for it.

II.Cover File:

Represents the carrier file that will embed the secret data inside it, it is restructured to produce a stego file.

III. Key:

The key represents an optional element, depending on the type of system proposed by the developer, as fellow[Bre02]:

- Pure system: Is a system that does not require the exchange of any reliable information on the receiving party to extract hidden information, is considered the least safe systems, where it is assumed that only the sender and receiver are aware of the presence of hidden data within the cover file.

- Secret Key system: This key is used in the process of embedding the secret data, and it’s necessary for the process of extracting secret data at the receiver side**.**

- The public key system: In this system, each party has two keys. The first one is public and known for all, and the second is private. The first is used in the embedding process at the sender side and the second is used in the extraction process at the receiver side.

IV. Stego File:

Represent the output of the embedding algorithm and the input of the extraction algorithm, it represents the cover file after the secret data has been hidden inside it.

V.Embedding algorithm:

The embedding algorithm is responsible for performing the process of hiding the secret data within the cover file, it is the most important of the two algorithms. The algorithm must be carefully implemented to ensure that secret data was transmitted to the receiving end without being noticed by intruder, where this point represents the main goal of the steganography system.

VI. Extraction algorithm:

The extraction algorithm becomes easier than the embedding algorithm after it is executed, because it is simply the reverse of the embedding algorithm. The processing of this algorithm takes the resulting file from the embedding process and then extracts the secret data. The secret data must be restricted to the end user.

2.2.2 Cryptography

Cryptography is the conversion of secret data from an understandable formula to another incomprehensible and indistinguishable formula [Tsa05].

The term of cryptography that derived from two words in Greek " kryptos-graphy" which means, "secret writing" [Kav10].

The cryptography system works as follow; the cryptography process consists of two algorithms, the encryption and decryption algorithms they represent the processes of the system and the other elements represent the inputs and outputs of the system. Figure (2.2) shows the cryptography system,

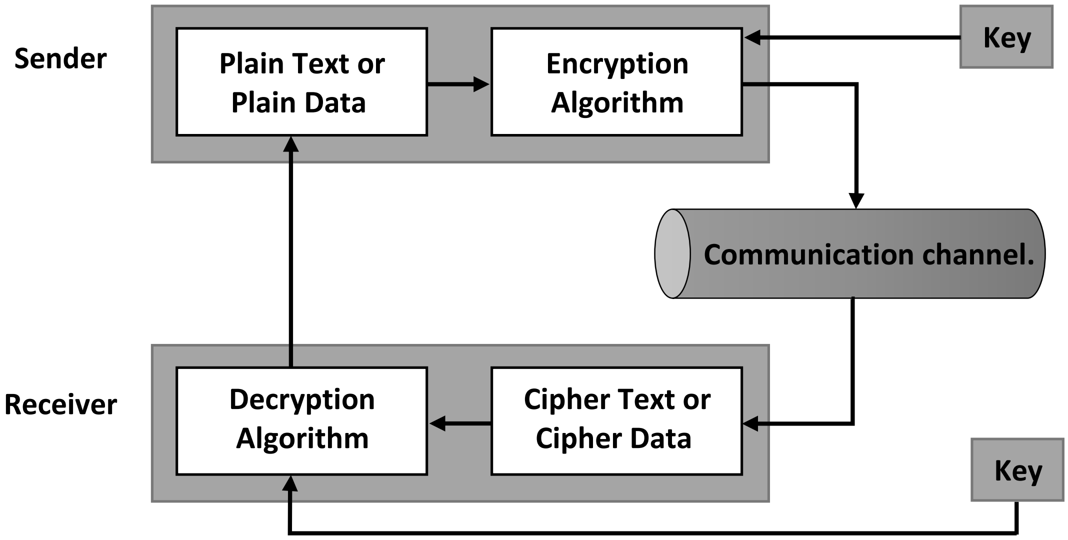


Figure (2. 2) The Cryptography System.

the cryptography elements will be describe in details [Kha15]:

I. Plain Text (Plain Data):

Represents original secret data (message, image, sound, video and etc.), which is converted into a computer format that can be manipulated by the encryption algorithm, which is considered as an input for it.

II.Cipher Text (Cipher Data):

represent the output of the encryption algorithm and the input of the decryption algorithm, it represent the secret file after encrypting it and it’s in a coded format.

III. Key:

The key represents a necessary element in cryptography technique, there are more than one type of key used depending on the type of cryptography system used [Ven10]:

- Secret Key System: This key is used in the process of encrypting the secret data and in the process of decrypting secret data at the receiver side**.**
- Public Key System: In this system, each party has two keys. The first one is public and known for all, and the second is private. The first is used in the encryption process at the sender side. And the second is used in the decryption process at the receiver side.

IV. Encryption algorithm:

The encryption algorithm is responsible for performing the process of encoding the secret data file, the secret data after the encryption process becomes indistinguishable.

V. Decryption algorithm:

The decryption algorithm is used to convert confidential data that has been encrypted using the encryption algorithm from an incomprehensible formula to a comprehensible formula. The processing of this algorithm takes the resulting file from the encryption process that represent the cipher data and then decoding it. The decoding of the secret data must be restricted to the end user.

2.3 Algorithms of Data Security

The algorithms that provide data security in both the steganography and cryptography techniques were initially applied separately, but there was a need to combine the two technologies to provide the integration of their benefits.

There are many different algorithms that have been applied by the two techniques which were explained in detail previously. Two algorithms are presented on each of the techniques that described;

-Steganography: The Least Significant Bit algorithm (LSB) which is one of the most famous algorithms that used in the steganography technique, Mod 16 Method for Audio algorithm (M16MA) which is one of the newest algorithms that is used in the steganography technique.

-Cryptography: The One Time Pad Algorithm (OTP) the most famous algorithms that used in the cryptography technique and Rivest, Shamir, and Adleman algorithm (RSA) that used in the public-key cryptography.

2.3.1 Least Significant Bit (LSB):

It is one of the most common algorithms used in steganography technology because it has many advantages, the simplicity of its implementation of the embedding process is compared to other algorithms, the ability to hide one, two or three bits of secret information inside the carrier medium, when the number of hidden bits increases within the cover media, the capacity of hiding the secret information increases and the cover file becomes more distorted. If a multimedia is used as a cover file in the LSB algorithm, the eye or human hearing cannot distinguish the change in the stego file, because the cover file matches the stego file [Rah14].

After the secret data and the cover file are converted into a stream of bits, the algorithm works in a way that changes the bit less important, in other words, changes the bit of the cover file to the bit of the secret data [Mor05].

For example, suppose the cover file is the 24-bit image as below:

Pixel 1

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

Pixel 2

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

Pixel 3

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

And the secret data bits as below:

1	**0**	**0**	**1**	**1**	**1**	**0**	**1**

Then the cover file (stego file) after the embedding process is:

Pixel 1

1	1	0	0	1	0	0	**1**	1	0	0	0	1	0	0	**0**	0	0	0	1	1	0	0	**0**

Pixel 2

0	0	1	0	0	0	1	**1**	1	0	0	1	0	0	0	**1**	0	1	1	0	0	0	1	**1**

Pixel 3

1	0	1	0	0	0	1	**0**	0	1	0	1	0	0	1	**1**	0	1	0	0	1	0	0	0

The extraction process begins by taking the last bits of the bytes that carry the secret bit and then rearranging them to form the original secret message.

2.3.2 Mod 16 Method algorithm (M16MA):

Is a method designed to hide the secret message within an audio file as cover file, and it is possible that the secret message is any digital format represented by the computer, and are often treated as a bit stream. Embedding positions are selected based on some mathematical function which de-ends on the data value of the digital audio stream. Data embedding is performed by mapping each four bit of the secret message in each of the seed position, based on the remainder of the intensity value when divided by 16 as fellow:

1- Take the remainder of divided the sample value that represents the cover file by 16,

2- The cover sample is subtracted by the remainder value,

3- The result of the subtraction are added to the value of the four bits of the secret message file,

The result of all this processes is the stego file that carry the secret message, figure (2.3) shows the embedding process of the M16MA.

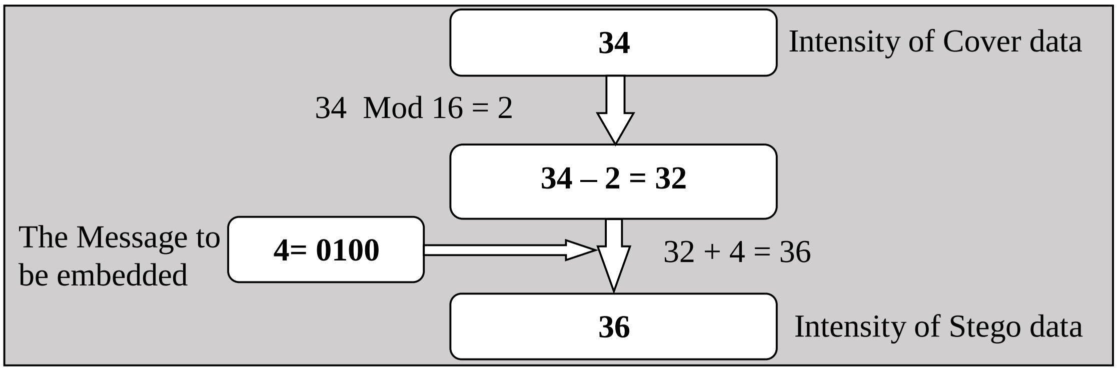


Figure (2.3) the embedding process of the M16MA.

The extraction process begins by selection the locations that have been hidden the secret bits inside it, and then extracting the secret bits by reversing the embedding process, figure (2.4) shows the extraction process of the M16MA [Sou11].

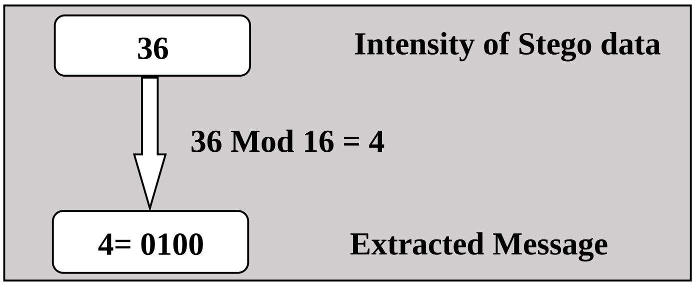


Figure (2.4) the extraction process of the M16MA.

2.3.2 One Time Pad Algorithm (OTP):

One-time pad encryption method was invented in the beginning of the nineteenth century, it was derived from the Vernam encryption method[Nic09]. It's a binary stream encryption, this method produces ciphertext by combining the plaintext and the key, the exclusive OR (XOR) between the key and the plaintext was implemented to produce the ciphertext or between the key and the ciphertext to produce the plaintext, the one-time pad encryption method unbreakable if it met the following conditions[Mil17]:

- Length of the key as the length of the plaintext.

- The key must generate randomly.

- The key must be valid for use only once.

Using exclusive-or, leads to make the one-time pad method more simple and does not consume much computational time, so to develop this method and make it more complex, the changes that have been applied to the method are the addition of the use of the 9’s complement and then the 1’s complement to the algorithm [Sri10]. Algorithm (2.1) shows the implementation of the one-time pad encryption.

Algorithm (2.1) implementation of the one-time pad encryption method.
Goal: Encryption of the plain-text. ***Input:*** The plain-text. ***Output:*** The cipher-text.
Steps:
- Step1: The plaintext
- Step2: Get the sequence number for each letter
- Step3: Apply the 9‟s complement.
- Step4: Convert each digit to the 6 bits and then apply the key with 6 bits.
- Step5: Apply the 1‟s complement
- Step6: Convert the result to the digit
- Step7: Get the letter for sequence number that represent the ciphertext.

Algorithm (2.2) shows the implementation of the one-time pad decryption.

Algorithm (2.2) implementation of the one-time pad decryption method.
Goal: Decryption of the cipher-text. ***Input:*** The cipher-text. ***Output:*** The plain-text.
Steps:
- Step1: The ciphertext
- Step2: Get the sequence number for each letter.

- Step3: Convert each digit to the 6 bits and then apply the key with 6 bits.
- Step4: Apply the 1‟s complement .
- Step5: Convert the result to the digit.
- Step6: Apply the 9‟s complement.
- Step7: Get the letter for sequence number, that represent the plaintext.

2.3.3 Rivest, Shamir, and Adleman algorithm (RSA):

The cryptographic algorithms using the key is divided into two types, cryptosystem by using symmetric-key and cryptosystem by using asymmetric-key. In the first type; one key is used for the encryption process as well as the decryption process and in the second type; one key is used for the encryption process and another key is different from the first one in the decryption process, one of these keys is a public key and the other is a private key [Asw14].

One of the most common asymmetric-key algorithms is an algorithm announced in 1977 by three researchers, Ron Rivest, Adi Shamir and Leonard Adleman, this algorithm named as RSA algorithm based on the names of their discoverers [Asm16].

RSA used for (key exchange, digital signatures and data encryption), the strength of the RSA algorithm comes from its mathematical behavior by determining the following points:

1) The simple calculation processes for large numbers.
2) The difficult processes for finding the prime factor for those numbers.
3) They also deal with numbers consisting of hundreds of digits.

The first step in the RSA algorithm, create the pair keys that represent the public /private key [Ven10]. Algorithm (2.3) shows the processes of the RSA to generate the public /private key.

Algorithm (2.3) the processes of generate the public /private key.
Goal: Generate the public and private keys. ***Input:*** prime numbers. ***Output:*** public and private keys.
Steps:
- Step1: Select p and q that represent the prime numbers.
- Step2: Compute modulus (n).
- Step3: Compute Euler of n.
- Step4: Select e, 1<e< Φ(n), GCD(e, Φ(n))=1. Then the (n,e) represent the public key.
- Step5: Compute integer d. Then the (n,d) represent the private key.

After the pair of keys were generated that represent the public/private keys, the role of encryption/decryption processes comes. Algorithm (2.4) shows the encryption processes of the RSA, while Algorithm (2.5) shows the decryption processes of the RSA.

Algorithm (2.4) implementation of the RSA encryption method.
Goal: Encryption the plain-text. ***Input:*** The plain-text, public-key(e, n). ***Output:*** The cipher-text.
Steps:
- Step1: Enter the plaintext, public-key (e, n)
- Step2: Get the sequence number for each letter
- Step3: Apply RSA encryption equation.

Algorithm (2.5) implementation of the RSA decryption method.
Goal: Decryption the cipher-text.

Input: The cipher-text, private-key(d, n).

Output: The plain-text.

Steps:

- **Step1:** Enter the ciphertext, private -key (e, n)
- **Step2:** Apply RSA decryption equation. Then get the letter for sequence number, that represent the plaintext.

2.4 Cover File (WebP) image format

The cover file is the file that carries the secret data; its different according to the algorithm used in the steganography technique, therefore, a cover file must not be affected by the secret data that is embedded inside it. It also has the capability to embed as much secret data as possible [Cha13]. WebP extension can be used as a cover file, in order to make the web browser more rapid, google has developed a new image format in 2010, so that the size of these images format is small while maintaining image quality, this format is the WebP image format. The WebP image is less size than the jpeg image format by 25-34% and less size than the png image format by 28% [Tre12].

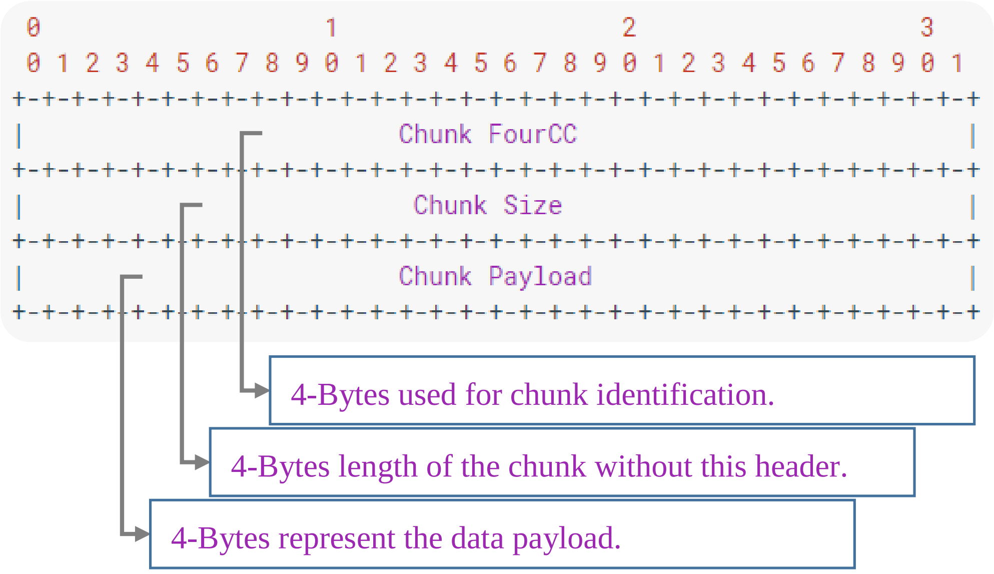
The main purpose of developing the WebP image format, is that 65% of the multimedia that consuming Internet speed is an image, so there is a need to develop image extension with fewer size of traditional images while maintaining image quality. Table (2.1) shows the difference between the WebP image format and the JPEG image format [Mil16].

Table (2.1) the difference between the WebP and the JPEG image formats.

	webp	JPEG
Resolution (pixels)	**16,383 × 16,383**	**65,535 × 65,535**
Data Compression	**lossy / lossless**	**Lossy**
Transparency	**Yes**	**No**
Bit depth	**8/RGB+ 8/Alpha**	**8/RGB**
Colors	**16,777,216**	**16,777,216**

The WebP image format based on the Resource interchange File Format container (RIFF) [Gia12].

It's used two compressions methods; First, the lossy compression that known as VP8 method and Second, the lossless compression that known as WebP method, the WebP image format with Transparency header was presented in the following [Goo10], figure (2.5) shows the RIFF file header, and figure (2.6) shows the WebP file header.



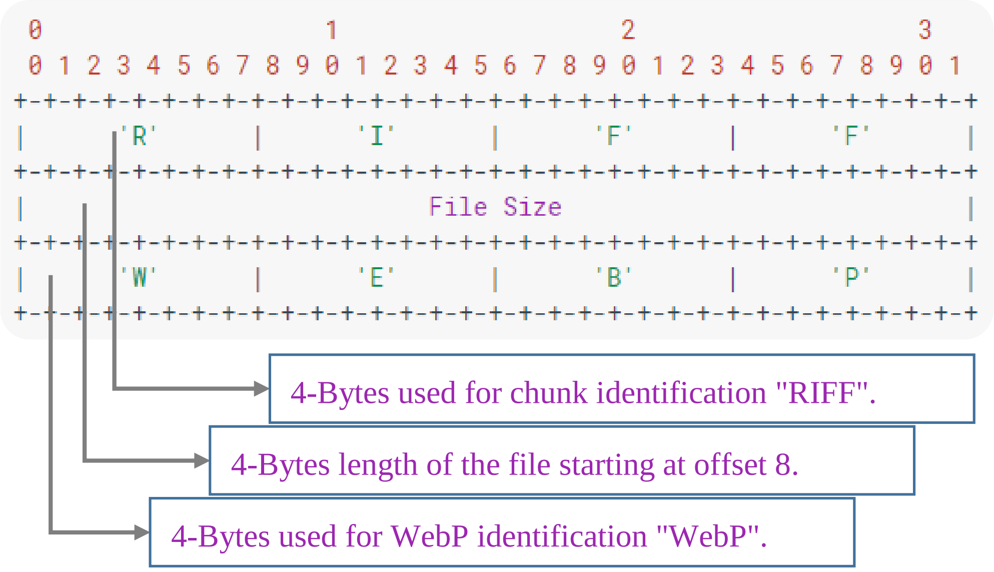
```
 0                   1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                         Chunk FourCC                          |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                          Chunk Size                           |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                         Chunk Payload                         |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

4-Bytes used for chunk identification.

4-Bytes length of the chunk without this header.

4-Bytes represent the data payload.

Figure (2.5) the RIFF file header.



```
 0                   1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|      'R'      |      'I'      |      'F'      |      'F'      |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                           File Size                           |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|      'W'      |      'E'      |      'B'      |      'P'      |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

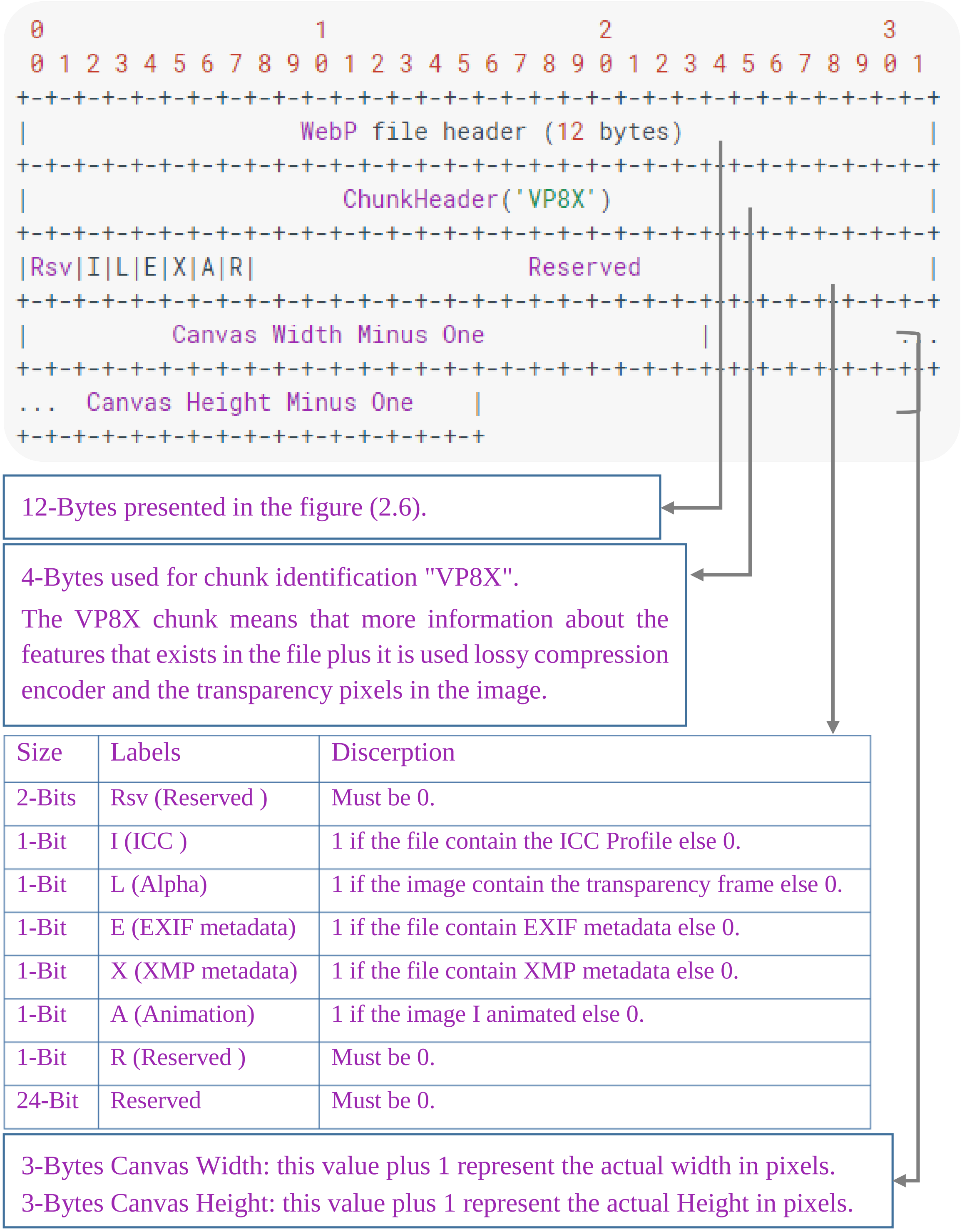
4-Bytes used for chunk identification "RIFF".

4-Bytes length of the file starting at offset 8.

4-Bytes used for WebP identification "WebP".

Figure (2.6) the WebP file header.

The version of the WebP image encoder that is used in this thesis is "VP8X", figure (2.7) shows the WebP file with VP8X header.



```
 0                   1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                   WebP file header (12 bytes)                 |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                      ChunkHeader('VP8X')                      |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|Rsv|I|L|E|X|A|R|                   Reserved                    |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|          Canvas Width Minus One               |             ...
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
...  Canvas Height Minus One    |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

12-Bytes presented in the figure (2.6).

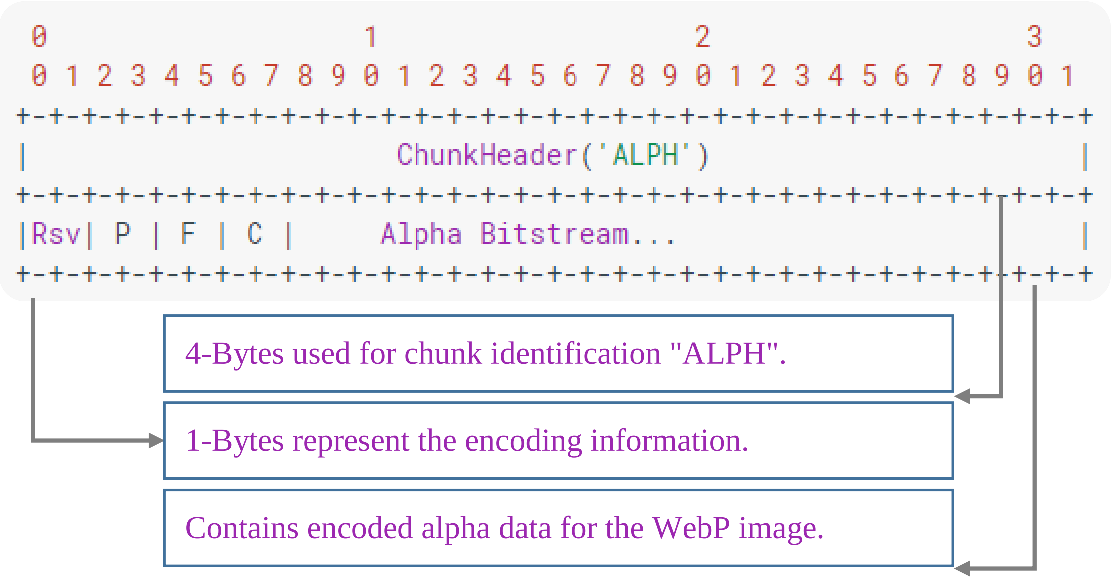
4-Bytes used for chunk identification "VP8X".
The VP8X chunk means that more information about the features that exists in the file plus it is used lossy compression encoder and the transparency pixels in the image.

Size	Labels	Discerption
2-Bits	Rsv (Reserved)	Must be 0.
1-Bit	I (ICC)	1 if the file contain the ICC Profile else 0.
1-Bit	L (Alpha)	1 if the image contain the transparency frame else 0.
1-Bit	E (EXIF metadata)	1 if the file contain EXIF metadata else 0.
1-Bit	X (XMP metadata)	1 if the file contain XMP metadata else 0.
1-Bit	A (Animation)	1 if the image I animated else 0.
1-Bit	R (Reserved)	Must be 0.
24-Bit	Reserved	Must be 0.

3-Bytes Canvas Width: this value plus 1 represent the actual width in pixels.
3-Bytes Canvas Height: this value plus 1 represent the actual Height in pixels.

Figure (2.7) the WebP file with VP8X header.

The WebP image that is used in this thesis with transparency, therefore the Alpha flag must be 1, figure (2.8) shows the Alpha header.



```
 0                   1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                      ChunkHeader('ALPH')                      |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|Rsv| P | F | C |     Alpha Bitstream...                        |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

4-Bytes used for chunk identification "ALPH".

1-Bytes represent the encoding information.

Contains encoded alpha data for the WebP image.

Figure (2.8) the Alpha header.

2.5 Evaluation Tools

In this section, the evaluation method that is used to assess the difference between two image is presented. The first image represent the original image and the second image represent the resulted image from the processes on the orginial image:

- Mean square error (MSE):

The average of the square of the difference between the original pixel and the affected pixel by the number of the pixels [Zho04]:

where $\text{Im}_{\text{original}}$ and $\text{Im}_{\text{affected}}$ be the original and the effected images respectively, sized H×W, MSE is defined as

$$MSE = \frac{1}{H * W} \sum_{x=1}^{W} \sum_{y=1}^{H} (Im_{original}(x,y) - Im_{affected}(x,y))^2 \qquad (2.1)$$

- Peak signal to noise ratio (PSNR):

The amount of noise on the resulting image by computing the following equation [Zai14]:

where Max is the maximum pixel value, PSNR is defined as

$$PSNR = 10\, log_{10} \left(\frac{Max^2}{MSE} \right) \quad (2.2)$$

Chapter Three

The Proposed Steganography System

Chapter Three

The Proposed Steganography System

3.1 Introduction

In this chapter, the design of information security based on steganography technique by using a proposed algorithm that named as Mod 8 Plus Average Method (M8PAM) is designed to hide the secret message inside the newest images format used in the internet, this image format known as a WebP format, also Known as the stickers for chatting applications. The M8PAM algorithm is applied on three layers.

The first layer, to select the locations of the cover file where the secret data will be hidden in it in a non-sequential manner based on a proposed algorithm. This layer can be applied alone. The second layer, recoding the secret data by changing the sequence of secret message bits based on the random sequence generation function. At this layer, the secret data is embedded and extracted using a symmetric key on both sides. The symmetric key affects the seed number that used in the random sequence generation function and this layer can't be applied without the first layer. The third layer is to hide the secret data at the sending end using the public key and to extract the secret data at the receiving end using the private key and this layer can't be applied without the second layer and the first layer.

In this chapter, the proposed steganography system are presented with implementation requirement and the steps taken to the establishment of the proposed steganography system.

3.2 Mod 8 Plus Average Method (M8PAM) Steganography System

The proposed system for information hiding requires perform the embedding and extracting algorithm on the inputs of the system. The block diagram of the proposed steganography system shown in figure (3.1) are:

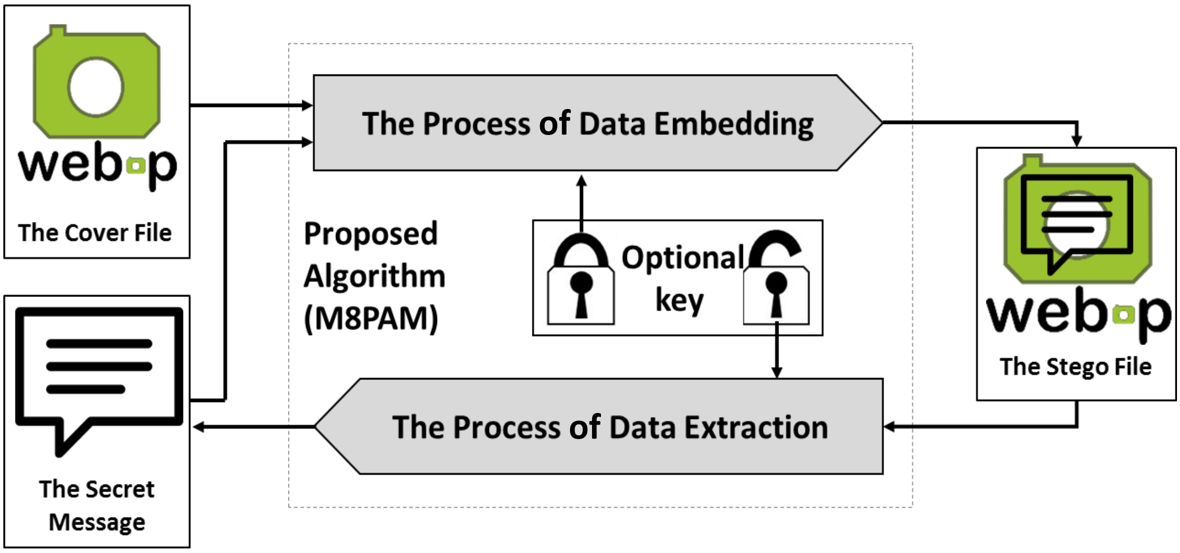

webp
The Cover File
The Secret Message
The Process of Data Embedding
Proposed Algorithm (M8PAM)
Optional key
The Process of Data Extraction
webp
The Stego File

Figure (3. 1) The block diagram of the proposed steganography system.

1) The **proposed algorithm** (M8PAM) works in a bi-direction way, first: the process of data embedding. Second: the process of data extraction.
2) **The secret data** that needed to be protect from falling into the hands of the intruders.
3) **The cover file**, which will carry the secret data, it should be unaffected by the embedding process, as well as must keep its accuracy.
4) **The optional key** for increasing the security of the steganography system, this key maybe represented by symmetric key or maybe represented by the public-private key.
5) **The stego file** that represents the resultant of embedding process.

The secret data, cover file and optional key, if its exist, considered as the inputs for the process of data embedding. The stego file and optional key if it exist in the process of data embedding considered as the inputs for the process of data extraction. Figure (3.2) shows the block diagram of the proposed embedding steganography system.

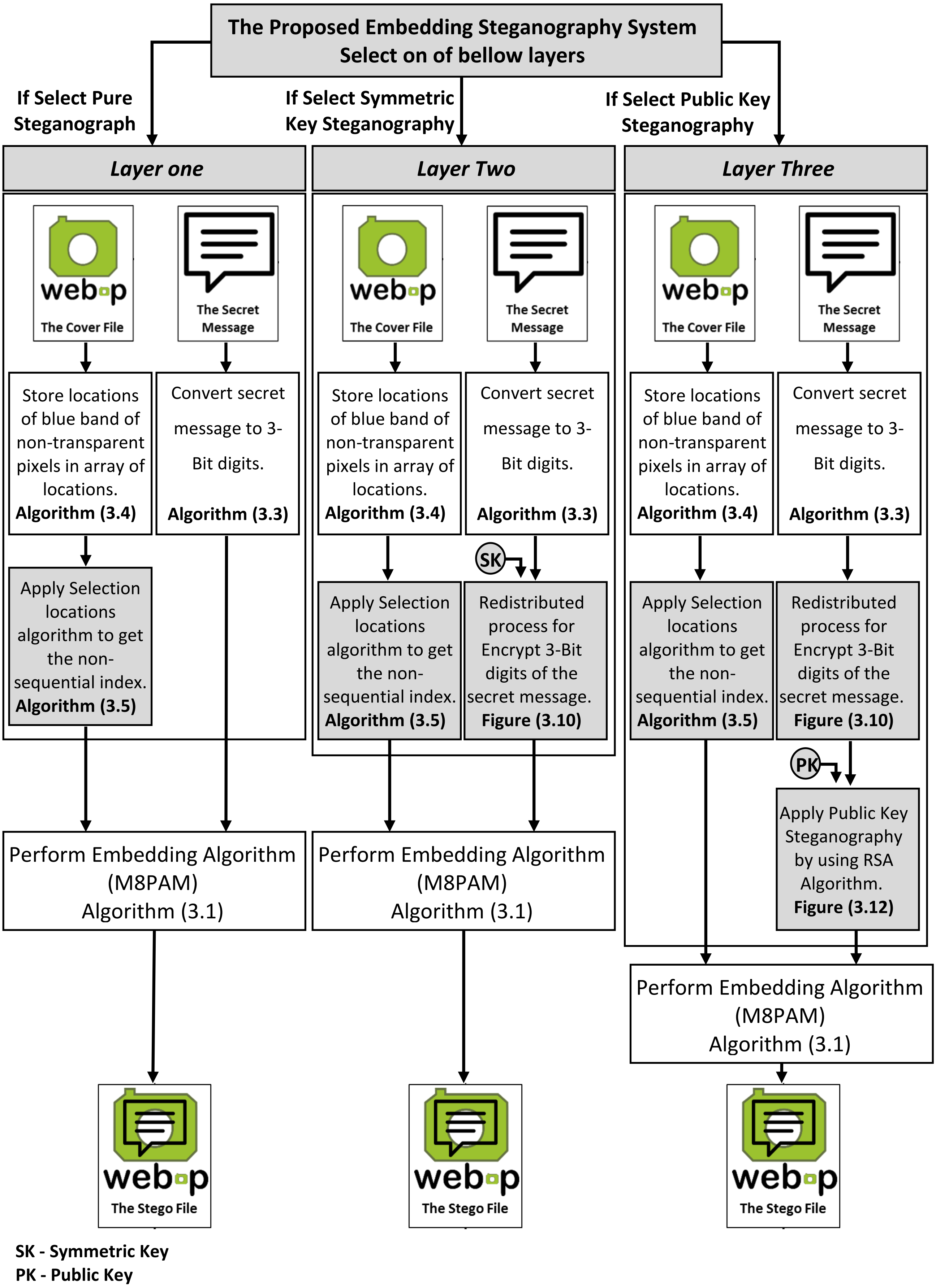

The Proposed Embedding Steganography System
Select on of bellow layers
If Select Pure Steganograph
If Select Symmetric Key Steganography
If Select Public Key Steganography
Layer one
Layer Two
Layer Three
webp
The Cover File
The Secret Message
Store locations of blue band of non-transparent pixels in array of locations. Algorithm (3.4)
Convert secret message to 3-Bit digits. Algorithm (3.3)
Apply Selection locations algorithm to get the non-sequential index. Algorithm (3.5)
SK
Redistributed process for Encrypt 3-Bit digits of the secret message. Figure (3.10)
PK
Apply Public Key Steganography by using RSA Algorithm. Figure (3.12)
Perform Embedding Algorithm (M8PAM) Algorithm (3.1)
The Stego File
SK - Symmetric Key
PK - Public Key

Figure (3. 2) Block diagram of the proposed embedding steganography system.

The processing portion, that relating to the proposed method (M8PAM) in the figure (3.2) represent the proposed method for embedding the secret data that designed in a way to hide every three bits of the secret message in one sample of the cover file according to a proposed algorithm to select the locations of the cover file which will carrying the bits of the secret message, algorithm (3.1) shows the steps of the embedding process.

Algorithm (3.1) implementation of the embedding process.

Goal: embedding the secret message inside the cover file.
Input: The secret message as array of digits (ArrayM), the cover file as array of samples (ArrayC).
Output: Stego File as array of samples (ArraySte).

Steps:

```
- Step1: Initialization the variables to repeat step 2 and 4, Let Loc = 0, Index= 0.
- Step2: For each digit in ArrayM And ArrayC Apply:
        - Ocov = Cov= ArrayC[Loc]
        - IF Cov Negative, Then Sign=-1 Else Sign=1
        - Reminder = Cov Mod 8
        - Cov = Cov – Reminder + ArrayM[Loc]
        - Increment Central Change[Ocover -Cov]
        - IF Sign = -1 Then Cov = Cov * -1
        - Store the result
        - Increment the index of location
        - IF Loc equal Size of ArrayM Then go to step 4
  Else repeat step 2
- Step3: Find the maximum value in Array of Central Change Then get it's index
- Step4: For each digit in ArraySte Adding Central Change Value:
         -ArraySte[Index] = ArraySte[Index] + Max
        -Increment the index of location
        -IF Index equal Size of ArraySte Then go to step5
         Else repeat step4
- Step5: End
```

The value 8 came to allow the possibility of hiding three bits from the secret message in every sample of the cover file, that's because the result of 2 power 3 equal 8, number 3 come to allow hiding three bits but not more. On the other side the extraction process is applied, figure (3.3) shows the Block diagram of the proposed extraction steganography system.

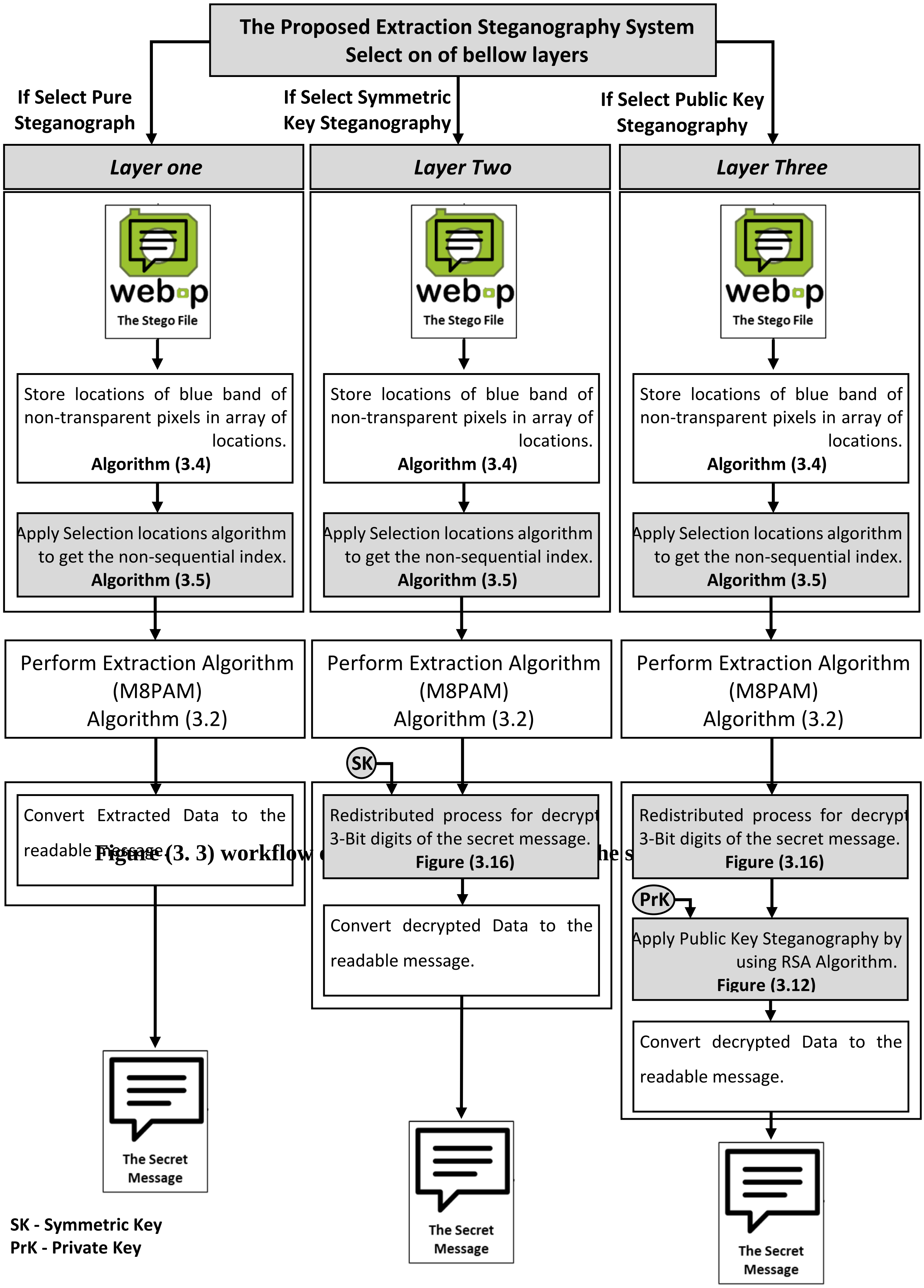

The Proposed Extraction Steganography System
Select on of bellow layers
If Select Pure Steganograph
If Select Symmetric Key Steganography
If Select Public Key Steganography
Layer one
Layer Two
Layer Three
webp
The Stego File
Store locations of blue band of non-transparent pixels in array of locations.
Algorithm (3.4)
Apply Selection locations algorithm to get the non-sequential index.
Algorithm (3.5)
Perform Extraction Algorithm (M8PAM)
Algorithm (3.2)
Convert Extracted Data to the readable message.
SK
Redistributed process for decrypt 3-Bit digits of the secret message.
Figure (3.16)
Convert decrypted Data to the readable message.
PrK
Apply Public Key Steganography by using RSA Algorithm.
Figure (3.12)
The Secret Message
SK - Symmetric Key
PrK - Private Key
Figure (3. 3) workflow

Figure (3. 3) Block diagram of the proposed extraction steganography system.

The processing portion that related to the proposed method (M8PAM) is shown in the figure (3.3), it represents the proposed method for extracting the secret data that designed in a way to extract every three bits from one sample of the cover file, based on remainder quotient resulting from dividing the sample on 8, then subtract the value of the central change from the remainder of division from the sample, after retrieval of all bits of the secret data, it is converted to array of bytes then it translated into the formula of secret data. Algorithm (3.2) shows the implementation of the extraction process.

Algorithm (3.2) implementation of the extraction process.

Goal: extracting the secret message from the cover file.
Input: The Stego file as array of samples (ArraySte).
Output: The secret data as array of the digits (ArrayM).

```
Steps:
- Step1: Initialization the variables to repeat step 2, Let Loc = 0 and Index= 0.
- Step2: Get the Central Change from the embedded Hider.
- Step3: For each digit in ArraySte Apply:
        - IF ArraySte[Loc] Negative
          Then ArraySte[Loc] = ArraySte[Loc] * -1
        - Reminder = ArraySte[Loc]  Mod 8
        - ArrayM[Loc]= Reminder - Central Change
        - Increment the index of location
        - IF Loc equal Size of Message Then go to step 4
          Else repeat step 3
- Step4: End
```

3.3 The Embedding Process

In the previous section, the proposed method was described in details that considered the kernel of the proposed information-hiding system. The proposed system operates in two directions, the first applied at the sending end, which performs the process of embedding the secret message inside the cover file, the embedding processes are applied beside the three layers to achieve the system aims. The second direction at the receiving end is performing the extraction operations, to extract the secret message from the cover file. The embedding process at least requires two parameters to perform the hiding process. These main parameters are as follows:

1- **The secret data** that represents the secret message, at first, this secret message enter to the system, and then the secret message will be converted to bits in order to initialize this secret message for the embedding process. Algorithm (3.3) shows the steps of the process that occur on the secret message with an example.

Algorithm (3.3) the process that occur on the secret message.

Goal: Convert the message to the formula that can use it to embed inside the cover.

Input: The secret message as a string, for example "SOS".

Output: Array of digits, each digit represented as three bits.

Steps:	**Example:**
- Step1: Convert each character to the digit.	**83 | 79 | 83**
- Step2: Convert each digit to the two bytes, to allow the Arabic character.	**0000 0000 | 0101 0011** **0000 0000 | 0100 1111** **0000 0000 | 0101 0011**
- Step3: Convert the array of bytes to the array of bits, and then make sure the size of the array divisible by 3. - **IF** size mod 3 equal 1 Then extend the array by adding two location in the last with 0 value. - **Else IF** size mod 3 equal 2 Then extend the array by adding one location in the last with 0 value.	**0000000001010** **0110000000001** **0011110000000** **001010011**
- Step4: Convert each three bits to one digit and then store them in the array of digits.	**0 | 0 | 0 | 5 | 1 | 4** **0 | 0 | 2 | 3 | 6 | 0** **0 | 1 | 2 | 3**
- Step5: End	

After finished perform the operation on the secret data and produce the new array that represent the stream of secret bits, the new array will be send to the embedding process to hide it.

2- **The cover file** represent the media that carry the secret data. In this thesis the **WebP** image used as the cover media. This format of the image designed for the internet purpose, particularly used in chat applications as stickers and it is supported by **Google** by providing the libraries that deal with this format. This library programmed by native C/C++, so must be linked with the Android APIs and the native C/C++, this link is known as the Java Native Interface **(JNI)**. After initializing the requirement of the system to use this format, the **WebP** image are entered to the system. Algorithm (3.4) shows the steps of the process on the **WebP** to get the embedding locations.

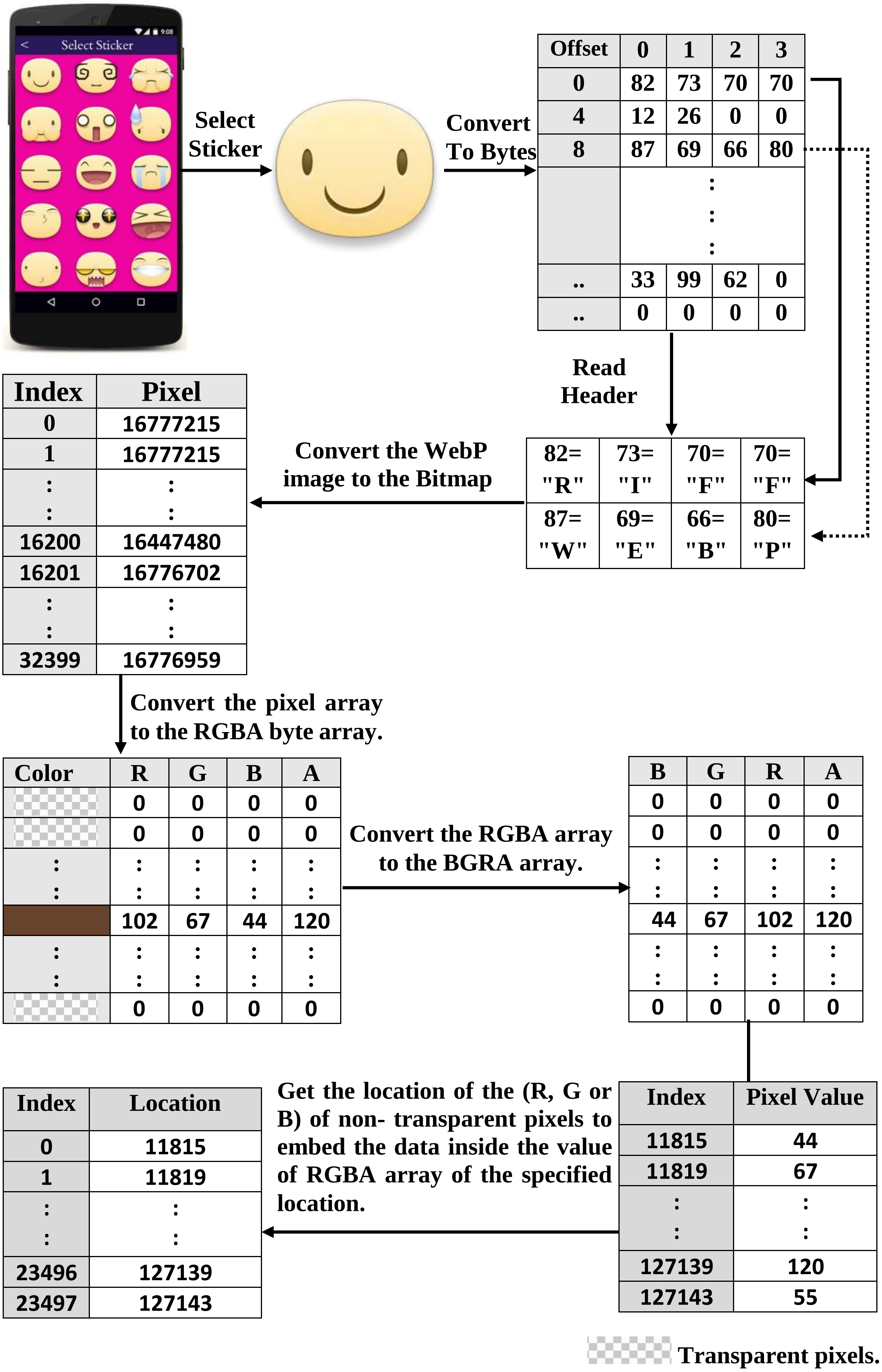
Algorithm (3.4) the process that occur on the cover media.

Goal: Get locations of the image to embed the secret data inside it.
Input: The WebP image from the list.
Output: Array of digits that represent the locations of (R,G or B) of tha non-transparent pixels.

Steps:

```
-Step1: Convert the selected sticker to an array of byte.
-Step2: Check the header of the sticker that were selected.
        - IF array[0-3] equal "RIFF" & array[8-11] equal "WebP"  Then Goto Step3
        - Else Go to Step5.
-Step3: Convert the Array of bytes to the Bitmap As RGBA.
-Step4: Get the location of non-transparent pixels by testing the value of "RGBA".
            – For each pixel in Webp image:
             - IF Alpha band not equal zero Then store location in an array of locations
-Step5: End
```

In practice, the array of locations will not contain the pixels values or even their locations, but one of the three components of the pixels (R, G or B) will be saved its locations, and by upon on the visual and computational results of the embedding process, it will be discussed later. Figure (3.4) shows the workflow of the operation on the **WebP** to get the embedding locations with example.



Select Sticker

Convert To Bytes

Offset	0	1	2	3
0	82	73	70	70
4	12	26	0	0
8	87	69	66	80
		: : :		
..	33	99	62	0
..	0	0	0	0

Read Header

82= "R"	73= "I"	70= "F"	70= "F"
87= "W"	69= "E"	66= "B"	80= "P"

Convert the WebP image to the Bitmap

Index	Pixel
0	16777215
1	16777215
: :	: :
16200	16447480
16201	16776702
: :	: :
32399	16776959

Convert the pixel array to the RGBA byte array.

Color	R	G	B	A
▨	0	0	0	0
▨	0	0	0	0
: :	: :	: :	: :	: :
🟫	102	67	44	120
: :	: :	: :	: :	: :
▨	0	0	0	0

Convert the RGBA array to the BGRA array.

B	G	R	A
0	0	0	0
0	0	0	0
: :	: :	: :	: :
44	67	102	120
: :	: :	: :	: :
0	0	0	0

Index	Pixel Value
11815	44
11819	67
: :	: :
127139	120
127143	55

Get the location of the (R, G or B) of non- transparent pixels to embed the data inside the value of RGBA array of the specified location.

Index	Location
0	11815
1	11819
: :	: :
23496	127139
23497	127143

▨ Transparent pixels.

Figure (3. 4) the workflow of the operation on the WebP.

After describing the main parameters that represent the input for the steganography system in details, these parameters do not represent the only input to the system, but these inputs are the main parameters of the system and that will be worked on continuously to produce the final output. As previously mentioned that the system developed at three layers, each layer requires its parameters, which may be entered by the user or these parameters are created using a specific algorithm, and some of these parameters may be shared between these three layers. The steganography system was improved by adding each layer. Figure (3.5) shows the integration between layers to provide an integrated steganography system.

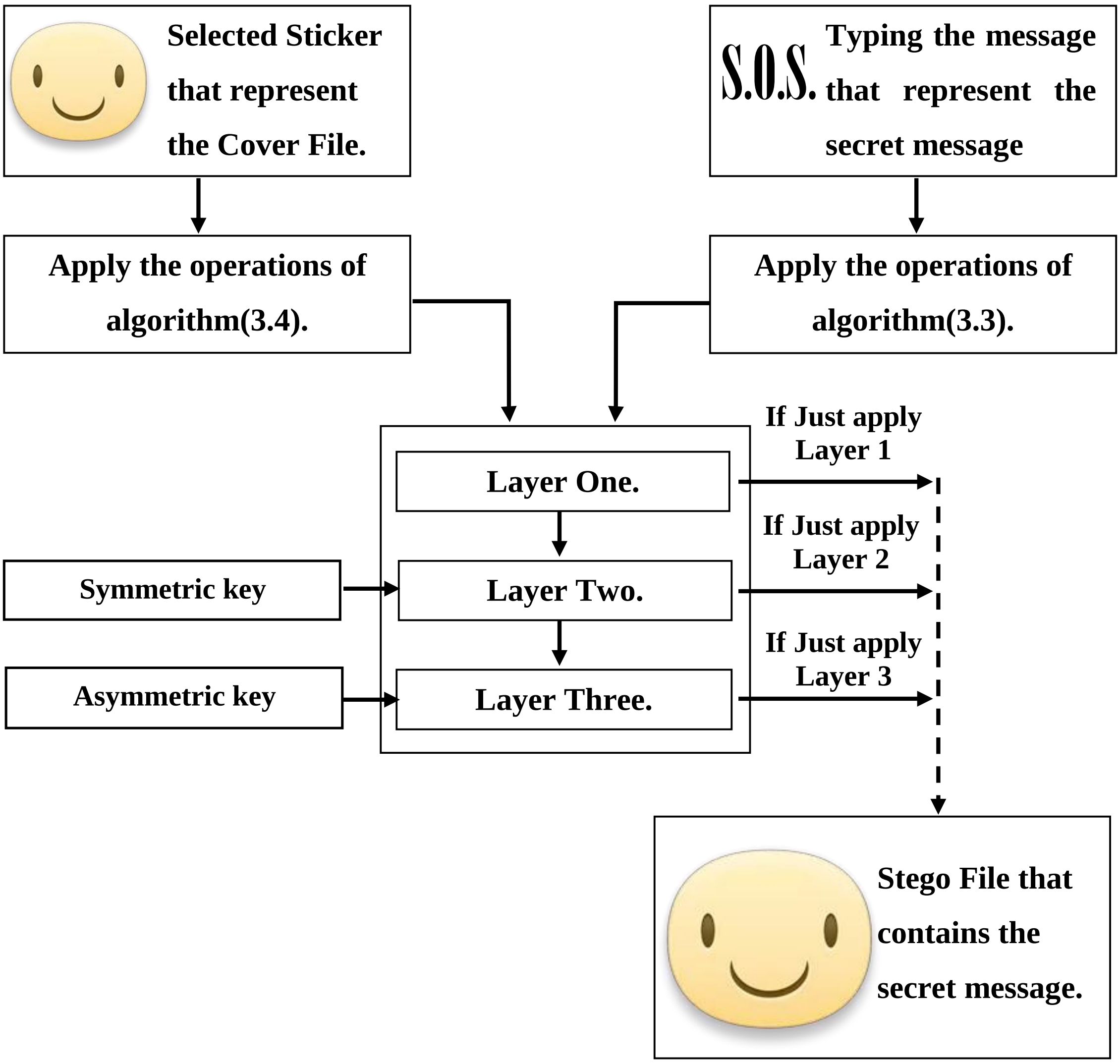
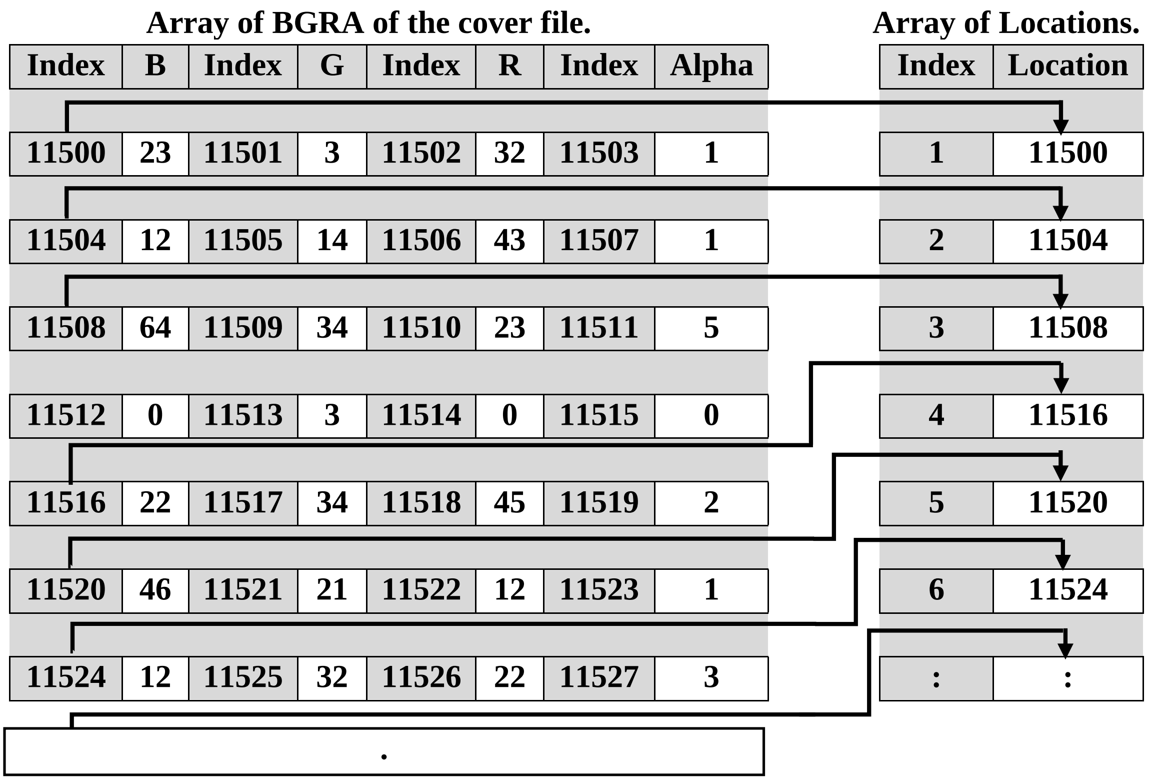

Selected Sticker that represent the Cover File.
S.O.S.
Typing the message that represent the secret message
Apply the operations of algorithm(3.4).
Apply the operations of algorithm(3.3).
Layer One.
Layer Two.
Layer Three.
Symmetric key
Asymmetric key
If Just apply Layer 1
If Just apply Layer 2
If Just apply Layer 3
Stego File that contains the secret message.

Figure (3. 5) The integration between the layers.

i. Layer one

To increase the strength of the proposed system, the embedding process must be applied in a non-traditional way, that could be achieved by applying many layers, in the first layer as mentioned previously, the proposed algorithm will be applied to select the positions of the samples that data will be embed inside the value of the specific position of the cover file. The embedding process do not occur in the sequential positions, the selected positions often non-cascaded, it begins by specifying the non-transparent pixels, then store the location of the value of one of the three component of pixel (R, G or B) in addition to the alpha byte, figure (3.6) shows the example about getting the indexes of the cover file.



Array of BGRA of the cover file.

Index	B	Index	G	Index	R	Index	Alpha
11500	23	11501	3	11502	32	11503	1
11504	12	11505	14	11506	43	11507	1
11508	64	11509	34	11510	23	11511	5
11512	0	11513	3	11514	0	11515	0
11516	22	11517	34	11518	45	11519	2
11520	46	11521	21	11522	12	11523	1
11524	12	11525	32	11526	22	11527	3

.

Array of Locations.

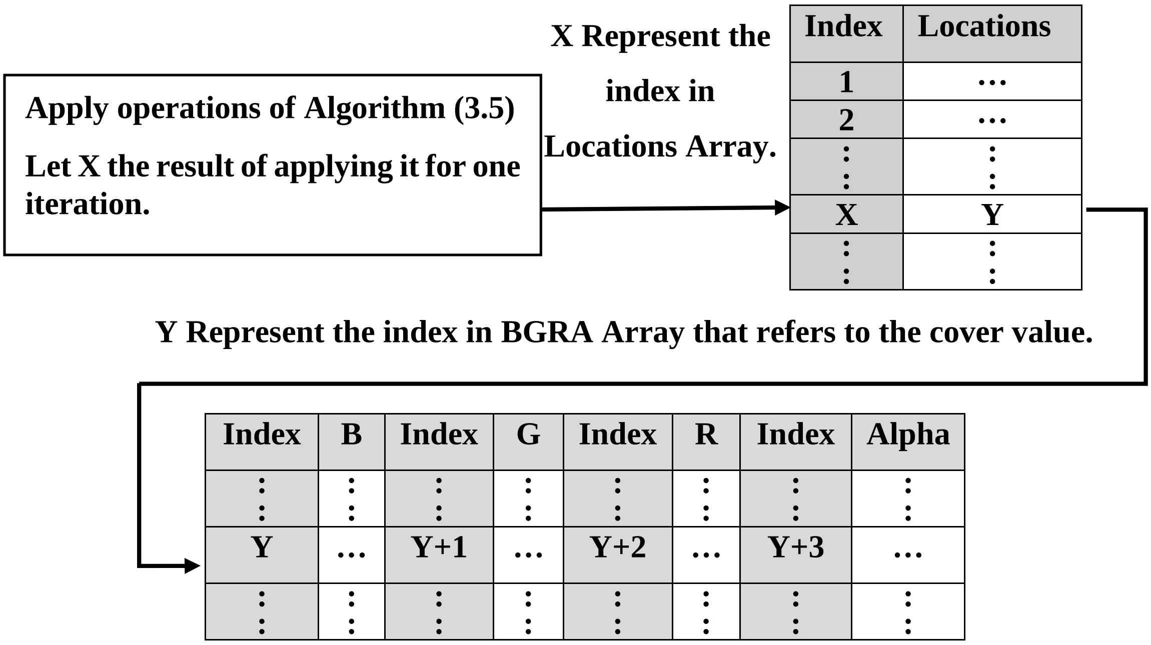
Index	Location
1	11500
2	11504
3	11508
4	11516
5	11520
6	11524
:	:

Figure (3. 6) Example about the getting indexes in the cover file.

After creating array of locations, the proposed algorithm will be applied on it to get the value that represents the location of the value from BGRA array to use it in the embedding process. The proposed algorithm works to determine the location in which the data will be hidden in the cover file, where it makes the mapping to two arrays is as follows:

- The proposed algorithm produces the number at every iteration, suppose X.
- Number X represents the index in the first array, called the array of locations, suppose the value of the specified index X is Y.
- Number Y represents the location of one of the components of the pixel (R,G,B and Alpha) these components are stored in the second array, the selected value represent the carrier of the secret data.

Figure (3.7) shows the relation between the BGRA array, Array of locations and the result of the proposed algorithm.


Apply operations of Algorithm (3.5)
Let X the result of applying it for one iteration.
X Represent the index in Locations Array.
Y Represent the index in BGRA Array that refers to the cover value.

Index	Locations
1	…
2	…
⋮	⋮
X	Y
⋮	⋮

Index	B	Index	G	Index	R	Index	Alpha
⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮
Y	…	Y+1	…	Y+2	…	Y+3	…
⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮

Figure (3. 7) Relation between the BGRA array, Array of locations and the result of the proposed algorithm for selection locations.

Algorithm (3.5) shows the steps of the algorithm of selection locations to get the non-sequential index.

Algorithm (3.5) The steps of the algorithm of selection locations.

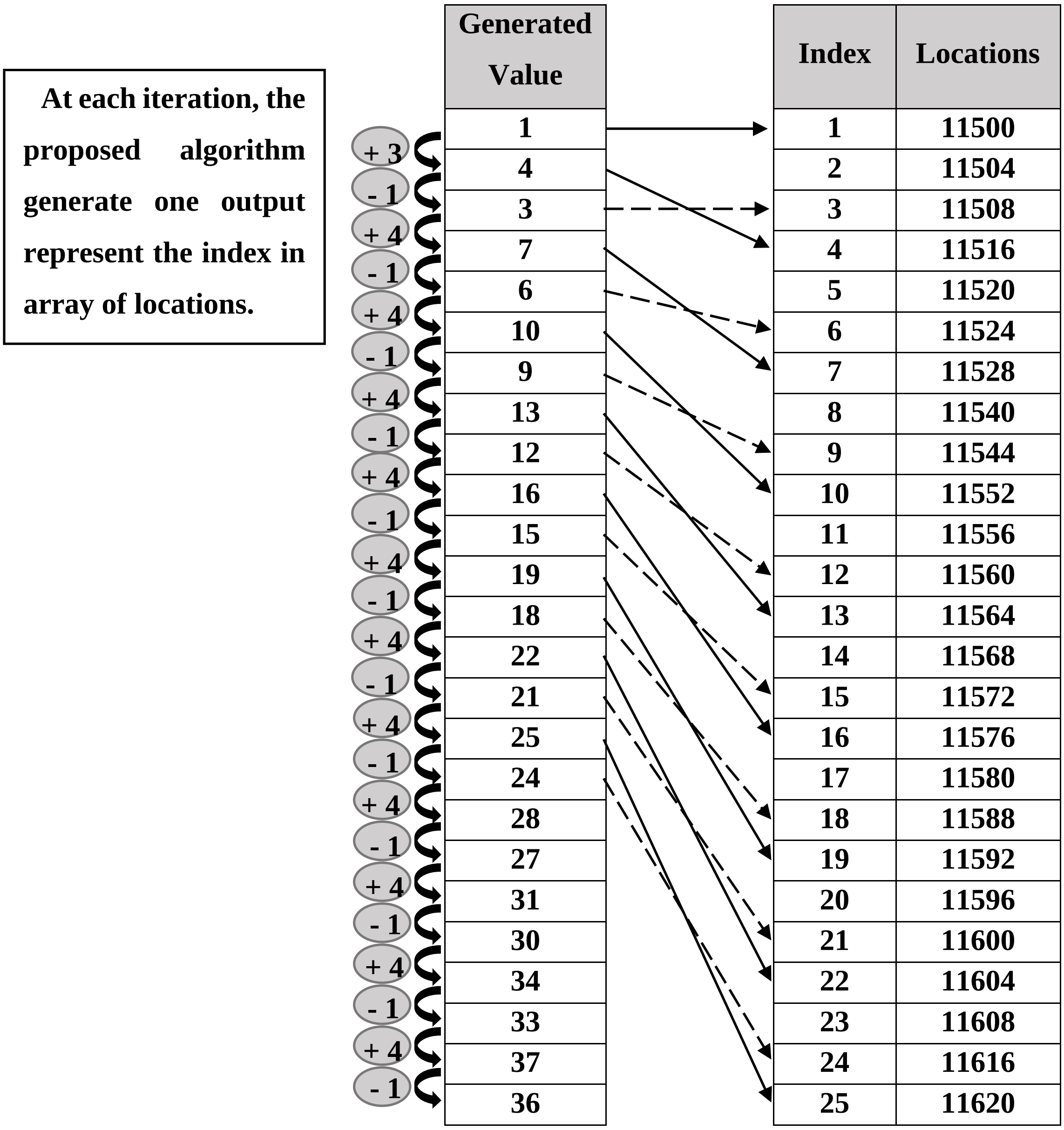
Goal: Generate a non-sequential index for getting value from Array of locations.
Input: the cover file (Webp).
Output: For each iteration, getting the number represent the index in array of locations (Loc).

Steps:

```
    - Step1: initialization , let INDEX=1 and VALUE=3.
```

```
- Step2: For from step2 to step5
        Loc[index]= INDEX, increment index
        INDEX = INDEX + VALUE.
- Step3: IF VALUE mod 3 equal 0 Than set 4 to VALUE.
- Step4: VALUE = VALUE – 3.
- Step5: VALUE = VALUE*(-1).
- Step6: IF INDEX Equal or Greater then cover file   Then  go to Step7
        Else go to Step1
- Step7: End
```

The process of generating a non-sequential index repeated until the entire secret message embedded. Figure (3.8) shows the example about the generating a non-sequential index by using the proposed algorithm.



At each iteration, the proposed algorithm generate one output represent the index in array of locations.

Generated Value
1
4
3
7
6
10
9
13
12
16
15
19
18
22
21
25
24
28
27
31
30
34
33
37
36

Index	Locations
1	11500
2	11504
3	11508
4	11516
5	11520
6	11524
7	11528
8	11540
9	11544
10	11552
11	11556
12	11560
13	11564
14	11568
15	11572
16	11576
17	11580
18	11588
19	11592
20	11596
21	11600
22	11604
23	11608
24	11616
25	11620

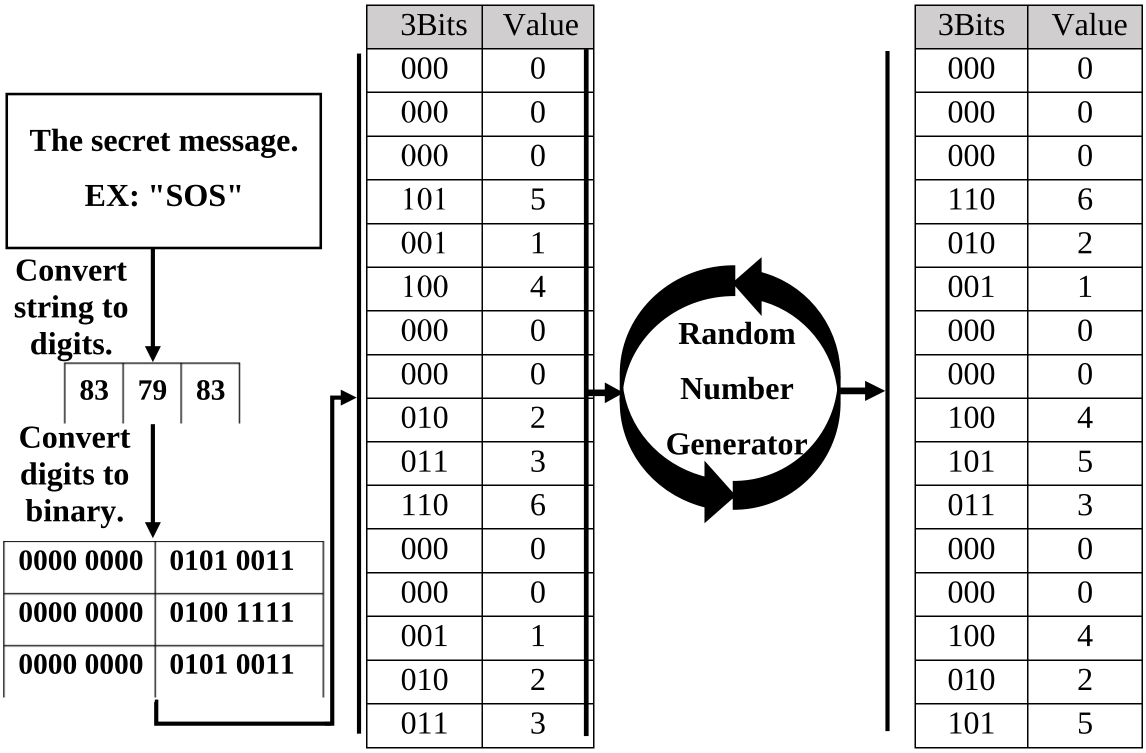
Figure (3. 8) Example about the generating a non-sequential indexes.

ii. Layer Two

Layer two, represents some operations on the secret message, these operations represented in embedding process. In this layer, after converting the secret message to an array of bits, then get every three bits as a digit number then store it in an array of digits as described in algorithm (3.1). It will be improving the system by redistributing the bits of the secret message, the redistribution process occurs for every digit as follows:

- Reconverting every digit to the three bits.
- Distribute these three bits randomly.
- Get the digit from the result of the distribution process.
- And finally; hide the randomized digit.

The redistribution process require the random sorting for these three bits, for producing this random range a special function in the programming language library called "java.util.Random" will be used, this function based on the Linear Congruential Generator (LCG). Figure (3.9) shows in example of redistributed process.



0000 0000	0101 0011
0000 0000	0100 1111
0000 0000	0101 0011

3Bits	Value
000	0
000	0
000	0
101	5
001	1
100	4
000	0
000	0
010	2
011	3
110	6
000	0
000	0
001	1
010	2
011	3

3Bits	Value
000	0
000	0
000	0
110	6
010	2
001	1
000	0
000	0
100	4
101	5
011	3
000	0
000	0
100	4
010	2
101	5

Figure (3. 9) Example of redistributed process.

The Random function, requires two parameters to produce the final result that represents the redistributed value:

1- First parameter, the secret digit value before the redistribution process.
2- Second parameter, the seed number this parameter represents the key of the randomization process.

Each secret digit value with a specific seed number that is sent to the random generation function, which produces redistributed value, on the other side must send the redistributed value with the same seed number to get the original value before redistribution process. The seed number represents the same value resulting from selection locations algorithm that used to generate the positions of the cover values. The seed number is calculated from the sum of the same value with the value of the symmetric key in the system that uses the symmetric key for steganography. Figure (3.10) shows the parameters of the random function with the output of the process.

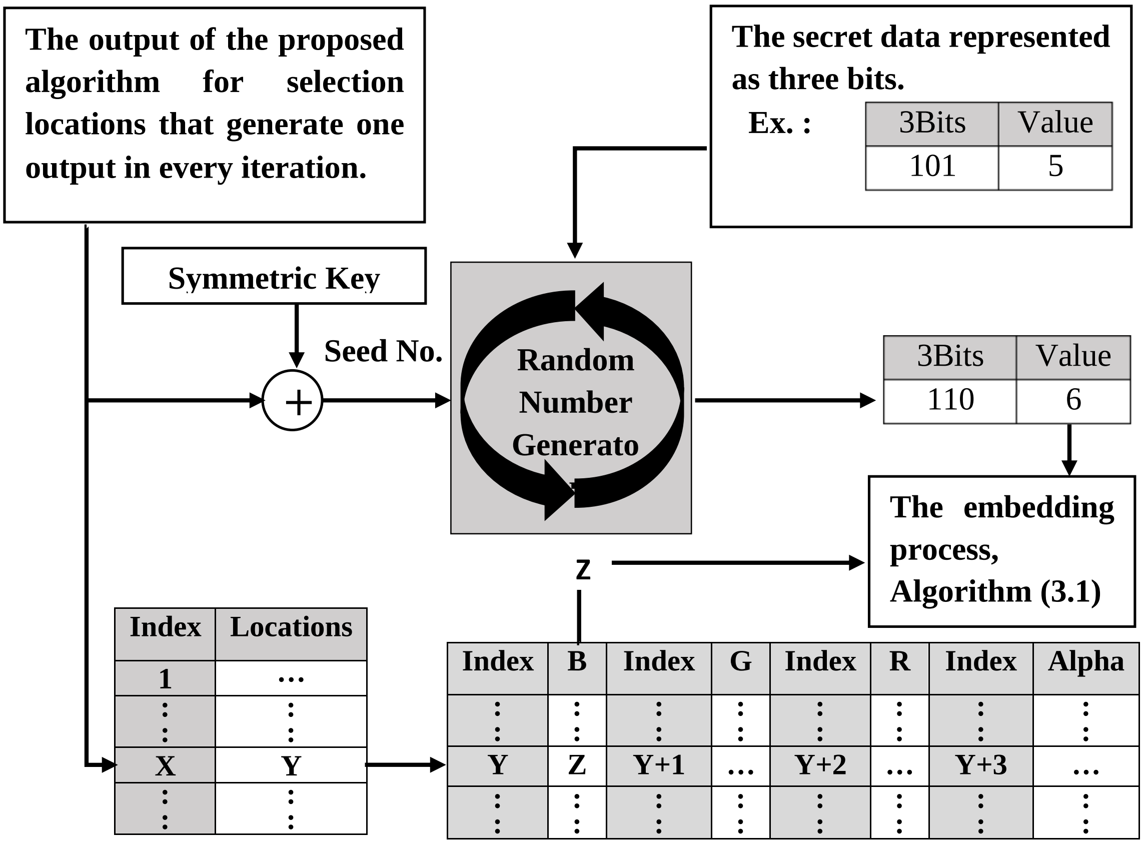
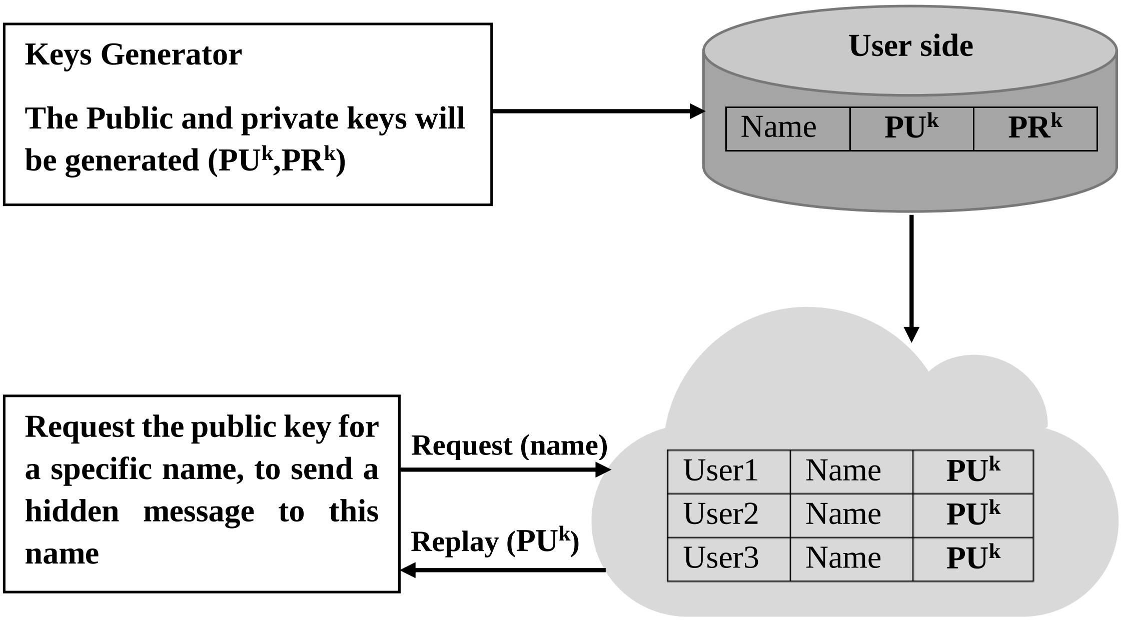

The output of the proposed algorithm for selection locations that generate one output in every iteration.
The secret data represented as three bits.
Ex. :
3Bits
Value
101
5
Symmetric Key
Seed No.
+
Random Number Generato
3Bits
Value
110
6
The embedding process, Algorithm (3.1)
Z
Index
Locations
1
…
X
Y
Index
B
Index
G
Index
R
Index
Alpha
Y
Z
Y+1
…
Y+2
…
Y+3
…

Figure (3. 10)The parameters of the random function and the output of the process.

iii. Layer Three

The first two layers that described previously represent the operations that occur on the cover file to produce a non-sequential location for embedding process and redistributed the secret data bits that represent the cryptography process for the secret message. The need for the data security was increased with increasing the use of the internet, therefore layer three comes for adding one of the network security algorithms to the system, this algorithm is Known as a RSA. The RSA algorithm is used to provide two keys for each user, the public key represent the first key, which is used in the embedding process, and the private key represent the second key, only the user knows this key, so it represent the secret key. At first, the user must register in the system, in the registrations process, a public and private keys will be generating for each user, these keys with the name of the user will be stored, only the user name and the public key will be share on the network. Figure (3.11) shows the workflow of the registration process.



Keys Generator

The Public and private keys will be generated (PU^k,PR^k)

Name	**PU^k**	**PR^k**

Request the public key for a specific name, to send a hidden message to this name

User1	Name	**PU^k**
User2	Name	**PU^k**
User3	Name	**PU^k**

Figure (3. 11) The workflow of the registration process.

After the sender select the name from its list to send the secret message, the following action will occur:

1- The proposed system will retrieve the public key for this user.

2- The system will encrypt the special header then add it to the secret message.

3- Perform the operations of the previous two layers.

Figure (3.12) shows the workflow of the proposed system with the three layers.

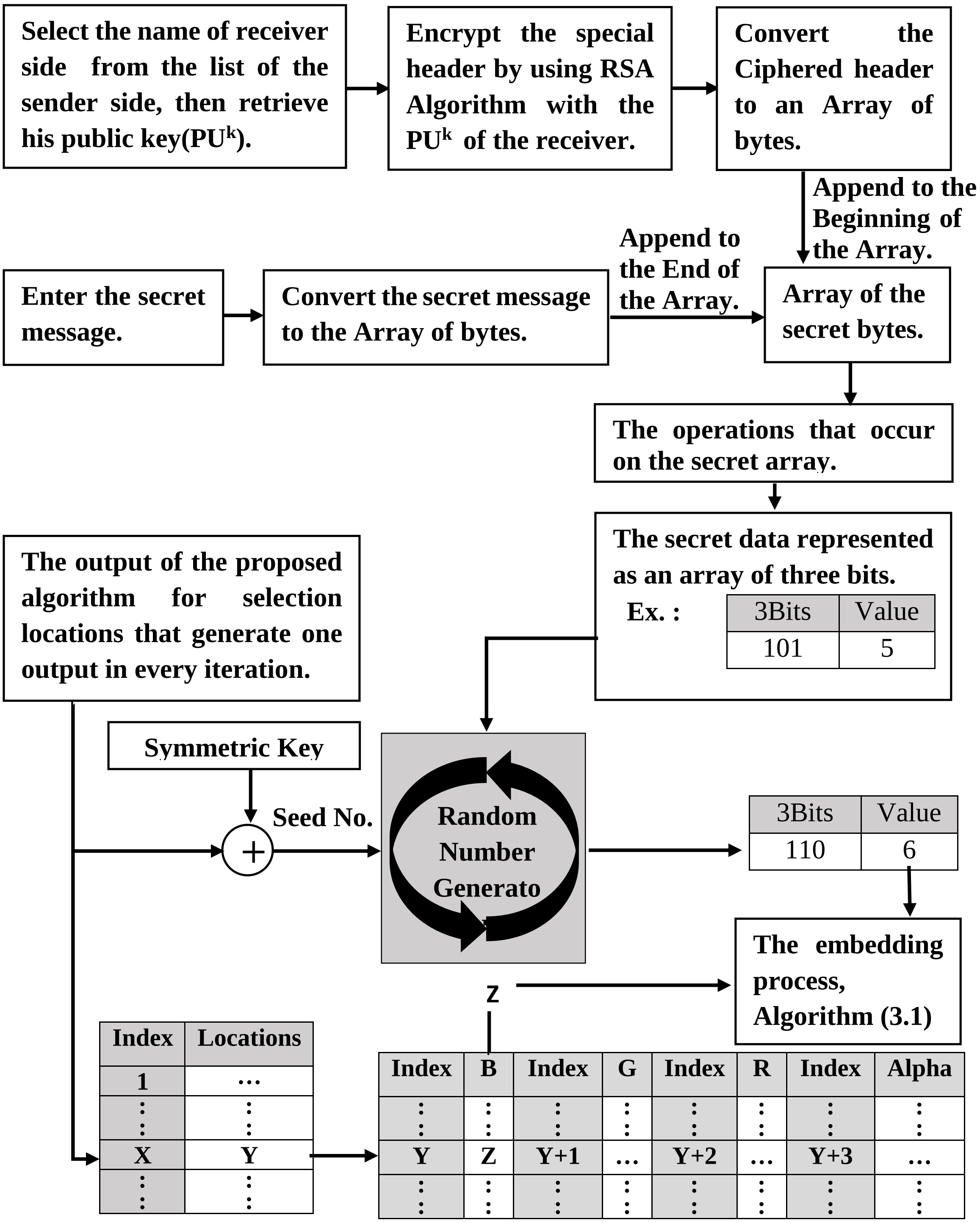

Select the name of receiver side from the list of the sender side, then retrieve his public key(PUk).
Encrypt the special header by using RSA Algorithm with the PUk of the receiver.
Convert the Ciphered header to an Array of bytes.
Append to the Beginning of the Array.
Enter the secret message.
Convert the secret message to the Array of bytes.
Append to the End of the Array.
Array of the secret bytes.
The operations that occur on the secret array.
The secret data represented as an array of three bits.
Ex. :
3Bits
Value
101
5
The output of the proposed algorithm for selection locations that generate one output in every iteration.
Symmetric Key
Seed No.
Random Number Generato
3Bits
Value
110
6
The embedding process, Algorithm (3.1)
Z
Index
Locations
1
…
X
Y
Index
B
Index
G
Index
R
Index
Alpha
Y
Z
Y+1
…
Y+2
…
Y+3
…

Figure (3. 12) The workflow of the proposed system with the three layers.

3.4 The Extraction Process

After the embedding process was applied by the sender on the secret data and the cover file to produce the stego file as a carrier for the secret data, the extraction process is applied by the receiver on the stego file to extract the secret data. The number of layers that are applied in the extraction process depends on the number of layers that have been applied in the embedding process. Figure (3.13) shows the relation between the embedding process and the extraction process, part (a) represents applying layer one in the proposed system, part (b) represent applying layer one and layer two in the proposed system and part (c) in figure (3.13) represents the applying of layer one, layer two and layer three in the proposed system.

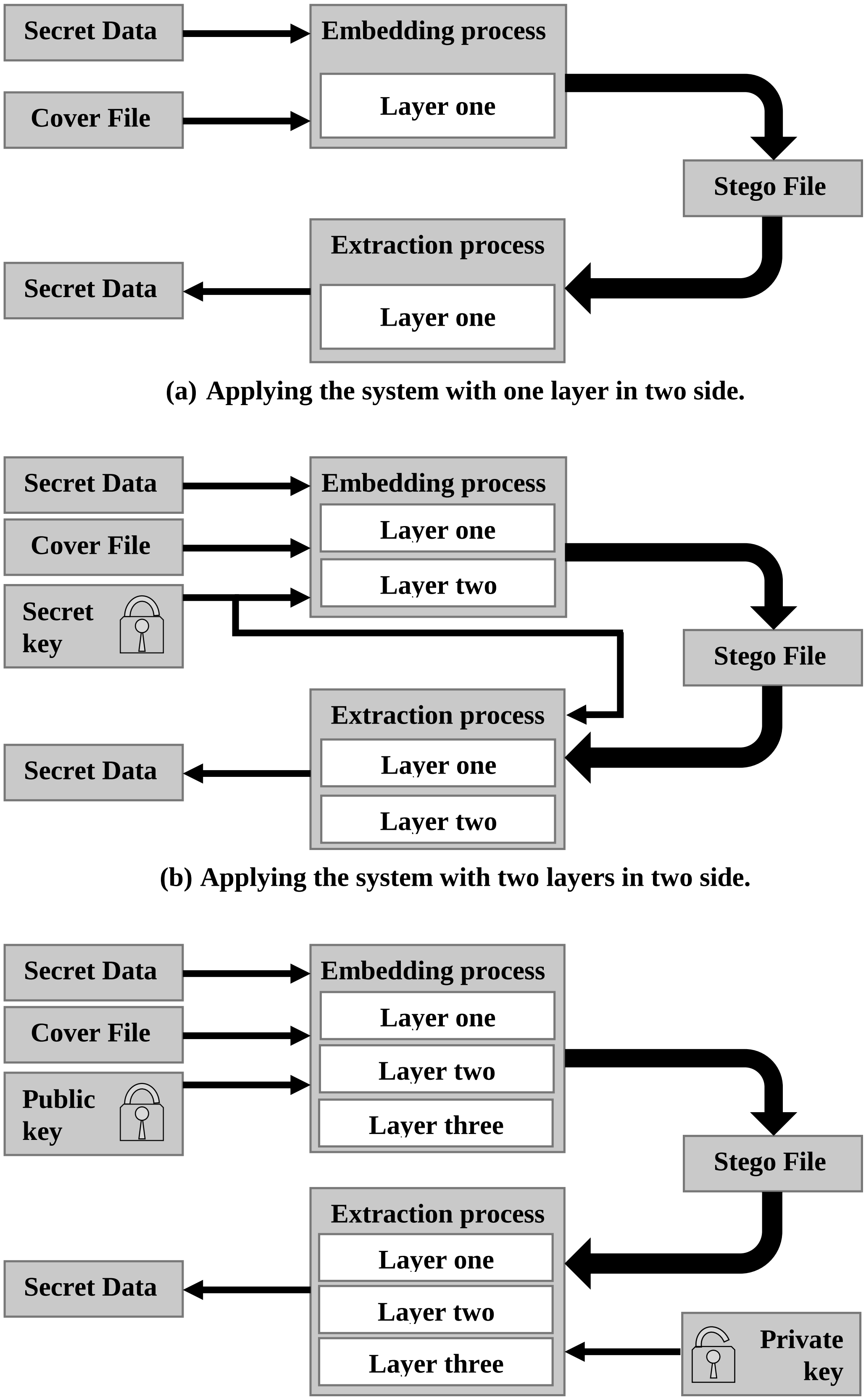
The difference between applying the embedding process and the extraction process are:

1- The algorithm that are applied in the extraction side is the reverse the algorithm that applied in the embedding side.

2- The parameters that entered in the extraction side differs from the parameters that entered in the embedding side. The number of parameters that entering to the extraction process determined by the numbers of layers, the extraction process at least requires one parameter to perform the extraction process, which is the stego file this main parameter that carried the secret data.

The stego file represent the media that carry the secret data, therefore the stego file also as the **WebP** image, algorithm (3.4) and figure(3.4) explained how to deal with this format as well as how to determine the pixels that carry the secret data in the same way that used with the cover file.

Figure (3.14) shows the integration between layers to provide an integrated extraction process.



(a) Applying the system with one layer in two side.

(b) Applying the system with two layers in two side.

(c) Applying the system with three layers in two side.

Figure (3. 13) The relation between the embedding process and the extraction process.

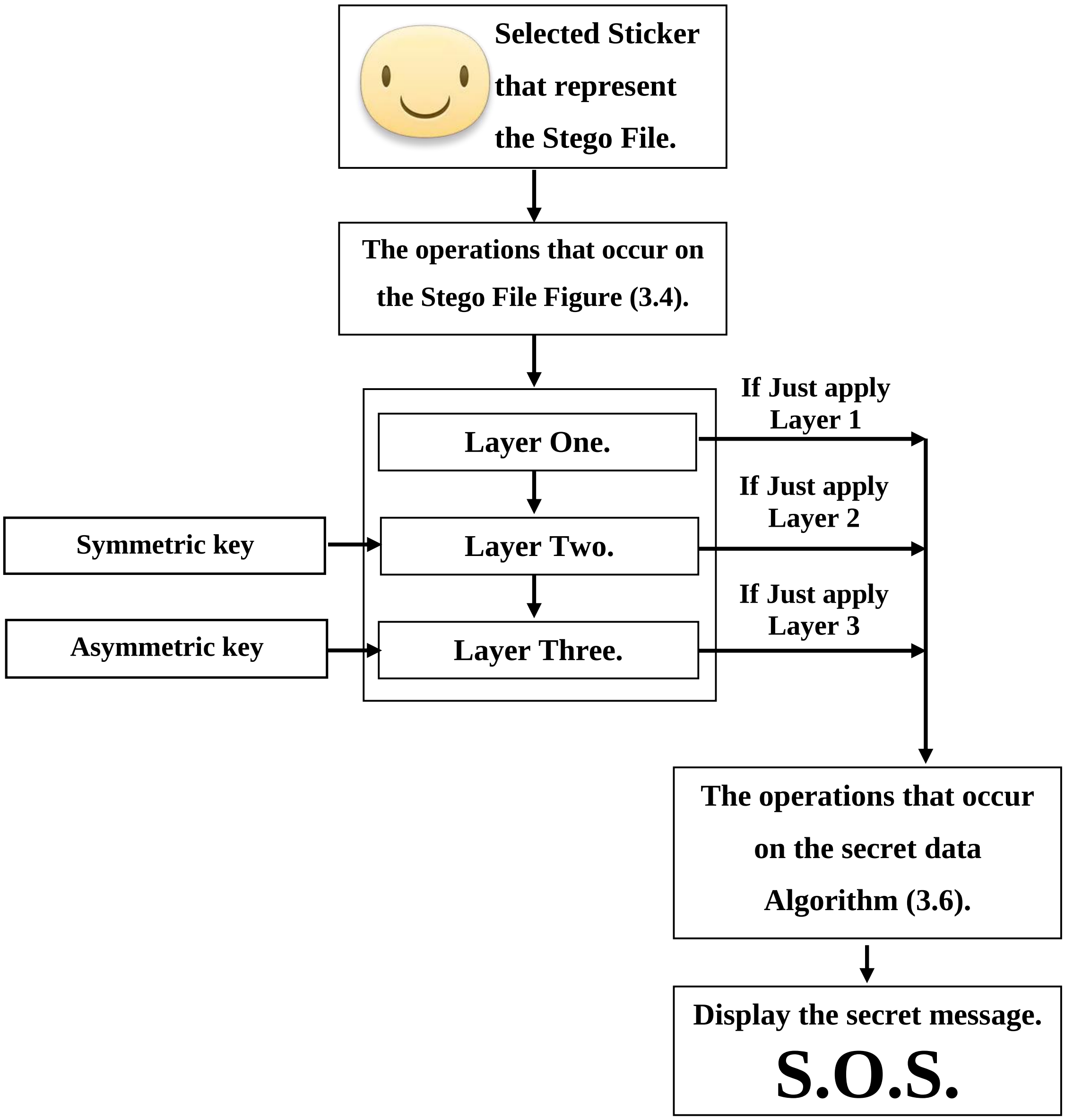

Selected Sticker that represent the Stego File.
The operations that occur on the Stego File Figure (3.4).
Layer One.
Layer Two.
Layer Three.
Symmetric key
Asymmetric key
If Just apply Layer 1
If Just apply Layer 2
If Just apply Layer 3
The operations that occur on the secret data Algorithm (3.6).
Display the secret message.
S.O.S.

Figure (3. 14) the integration between layers to provide an integrated extraction process.

i. Layer one

As described previously the embedding process do not occur in sequential positions, the selected positions depend on the mathematical equation, that specify the non-transparent pixels, then store the location of the value in one of the three component of pixel in addition to the alpha byte. In the extraction process the first layer begins by determine the non-transparent pixels of the stego file then store the location of the value of one from components of pixel (ARGB). Figure (3.8) shows an example about getting indexes of the **WebP** file that represent the cover file before the embedding process and after the extraction process. After creating the array of locations, the proposed algorithm used to generate the positions of this locations that carry the secret data. Algorithm (3.5) and figure (3.7) shows the work of proposed algorithm for selection locations. Figure (3.15) shows the workflow of layer one in the extraction process.

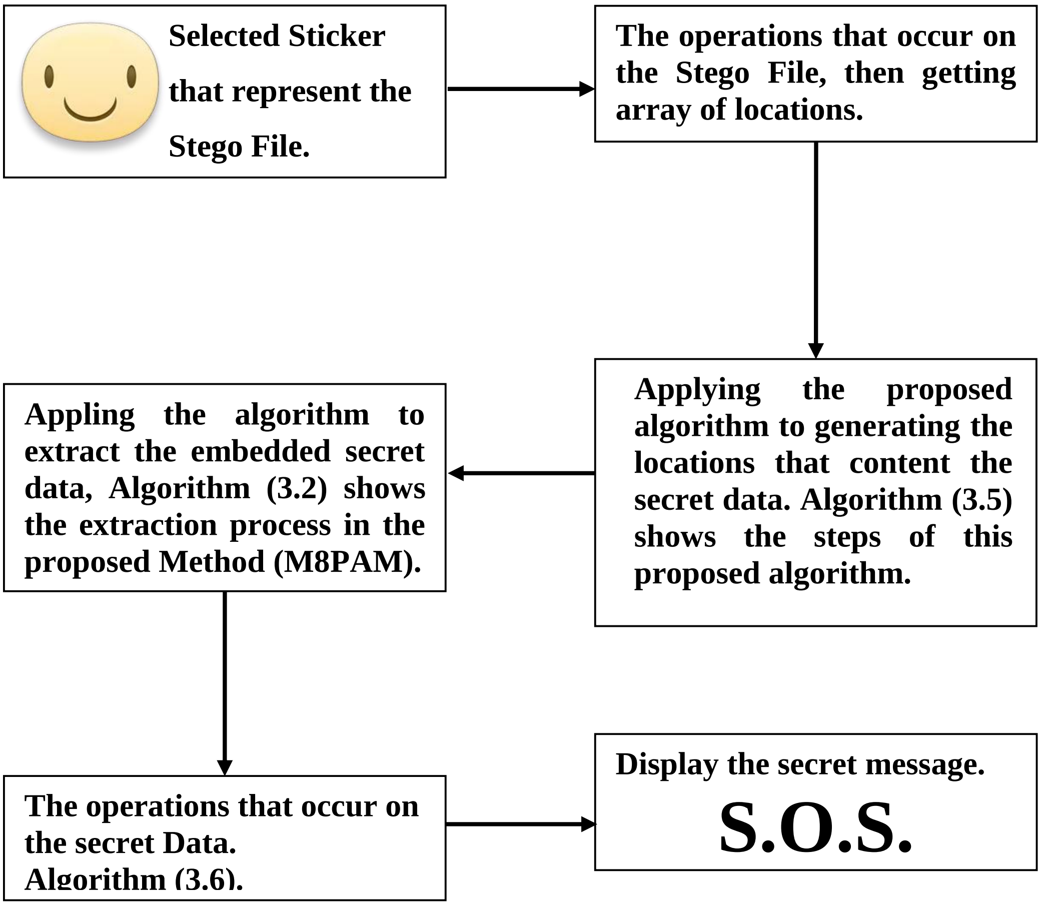

Selected Sticker that represent the Stego File.
The operations that occur on the Stego File, then getting array of locations.
Applying the proposed algorithm to generating the locations that content the secret data. Algorithm (3.5) shows the steps of this proposed algorithm.
Appling the algorithm to extract the embedded secret data, Algorithm (3.2) shows the extraction process in the proposed Method (M8PAM).
The operations that occur on the secret Data. Algorithm (3.6).
Display the secret message.
S.O.S.

Figure (3. 15) the workflow of layer one in the extraction process.

The extracted data represented as the digits, each one of them consists of three bits, so some of the processes applied to retrieve and display the secret message. Algorithm (3.6) shows the operations that occur on the extracted secret data.

Each character represented as a two byte to allow the Arabic character and the emoji in the secret message.

Algorithm (3.6) the operations that occur on the extracted secret data.	
Goal: Convert the extracted secret data to the message. ***Input:*** The extracted secret data. ***Output:*** Secret message.	
Steps:	**Example:**
- Step1: Getting the array of secret data as the digits, each digit Consist of three bits.	**0 0 0 5 1 4** **0 0 2 3 6 0** **0 1 2 3**
- Step2: Convert each digit to three bits.	**000 000 000 101 001 100** **000 000 010 011 110 000** **000 001 010 011**
- Step3: Combine all three bits in one array of bits.	**0 0 0 0 0 0 0 0 0 1 0 1 0 0 1 1 0 0** **0 0 0 0 0 0 0 1 0 0 1 1 1 1 0 0 0 0** **0 0 0 0 0 1 0 1 0 0 1**
- Step4: Convert the array of bits to the array of bytes.	**0000 0000 0101 0011 0000 0000** **0100 1111 0000 0000 0101 0011**
- Step5: Convert each two bytes to a single character and display it.	**"SOS"**
- Step6: End	

ii. Layer two

Layer one of the extraction process applied to generate the locations of the values that content the secret message in the stego file, then extract the secret data. If layer two in the embedding process was applied, the secret data that extracted still unreadable because layer two in the embedding process was applied to redistributed the three bit of the secret data that represented as a digit. After geting the original digits the following action will be occur:

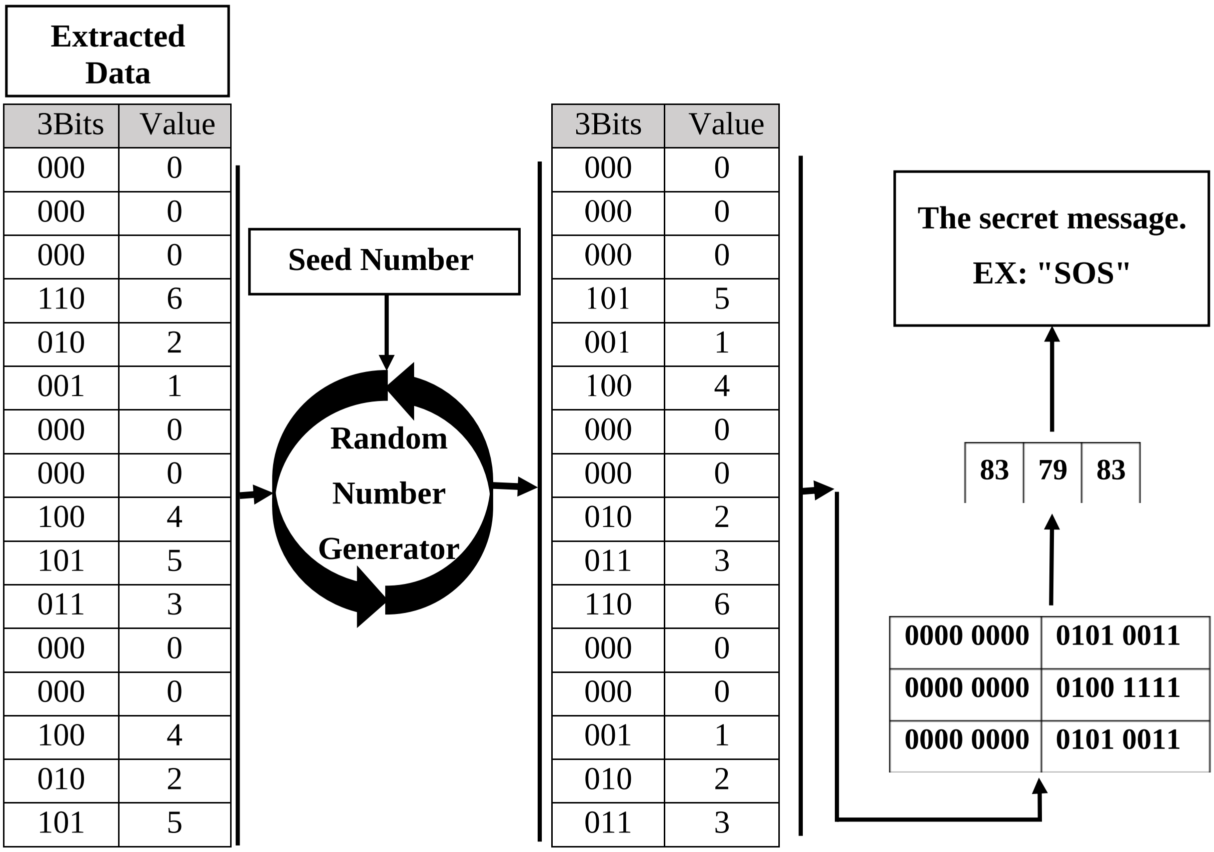
1- Every digit is converted to three bits.

2- Combine all bits as a stream of bits.

3- Convert each sixteen bits to a single character.

4- Display the secret message.

Figure (3.16) shows the example about the regenerate the original digits.



3Bits	Value
000	0
000	0
000	0
110	6
010	2
001	1
000	0
000	0
100	4
101	5
011	3
000	0
000	0
100	4
010	2
101	5

3Bits	Value
000	0
000	0
000	0
101	5
001	1
100	4
000	0
000	0
010	2
011	3
110	6
000	0
000	0
001	1
010	2
011	3

0000 0000	0101 0011
0000 0000	0100 1111
0000 0000	0101 0011

83	79	83

Figure (3. 16) the example about the regenerate the original digits.

layer two of the extraction process is applied to re-generate the original digit, it does this by using the same seed number that used in the embedding process for the specified digit that generated by using the same value that generated by the proposed algorithm for selection locations and the shared symmetric key if it used in the embedding process.

Figure (3.17) shows the parameters of the random function in extraction process.

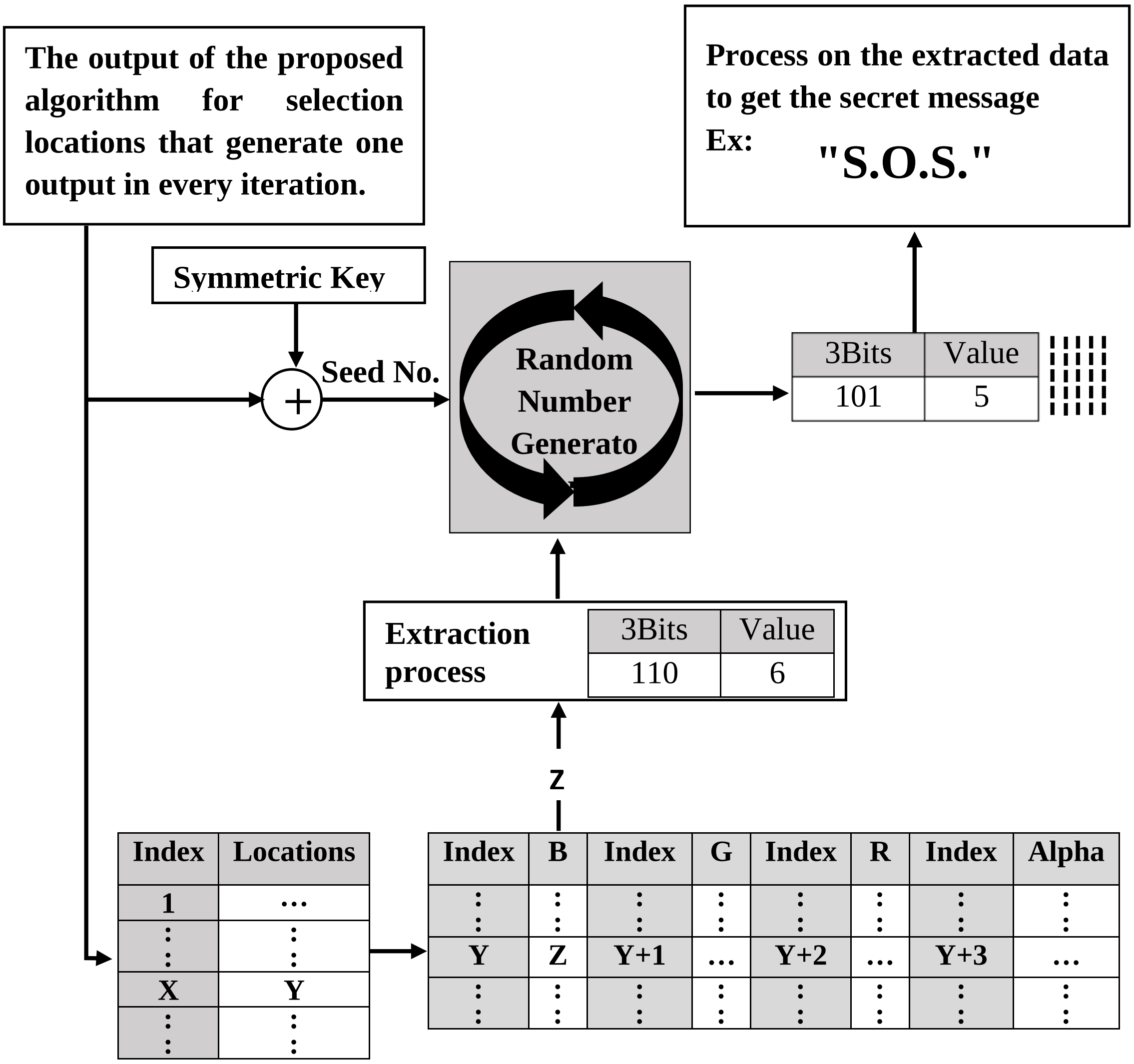
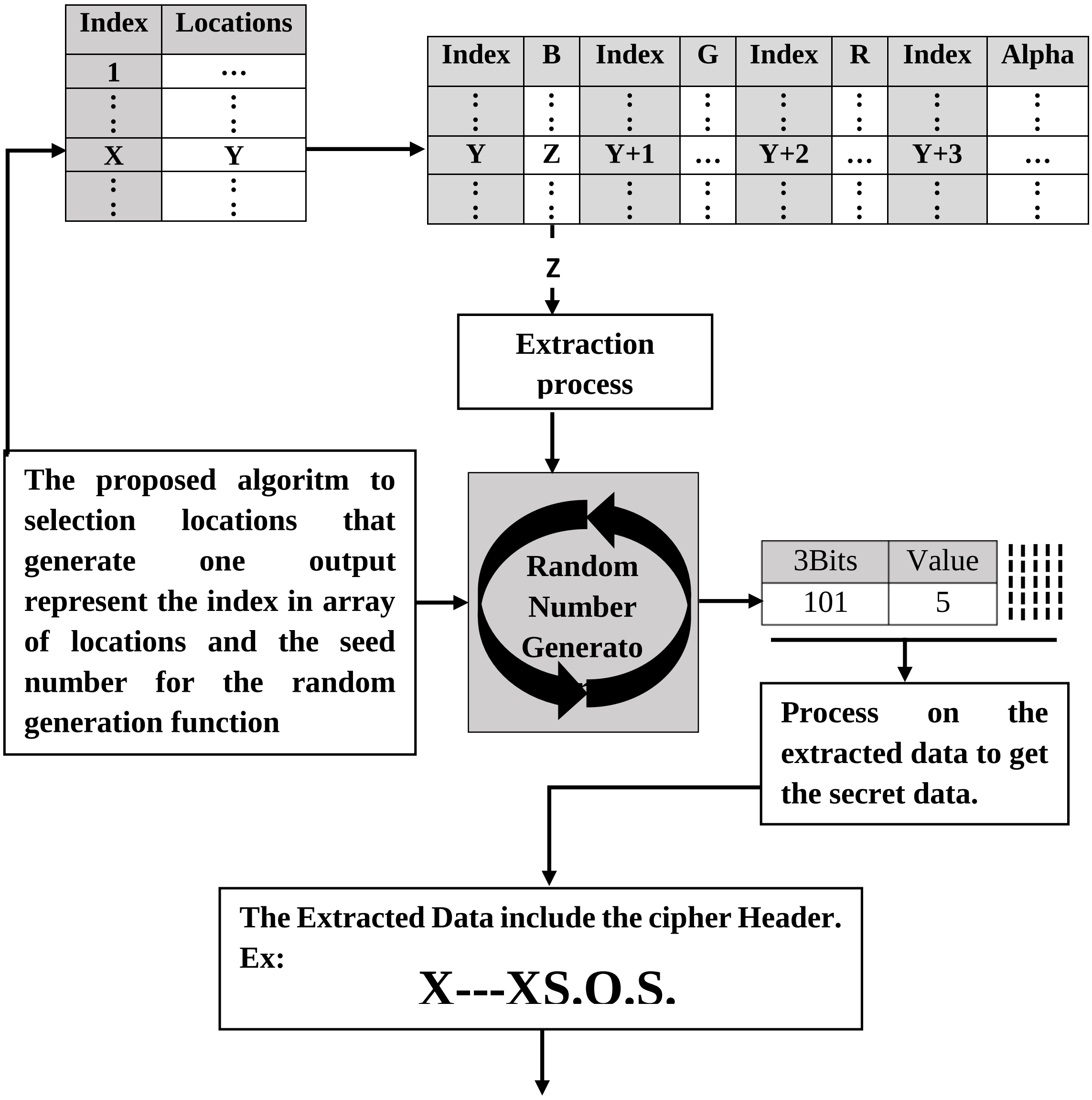

The output of the proposed algorithm for selection locations that generate one output in every iteration.
Process on the extracted data to get the secret message
Ex: "S.O.S."
Symmetric Key
Seed No.
Random Number Generato
3Bits
Value
101
5
Extraction process
3Bits
Value
110
6
Z
Index
Locations
1
X
Y
Index
B
Index
G
Index
R
Index
Alpha
Y
Z
Y+1
Y+2
Y+3

Figure (3. 17) the parameters of the random function in extraction process.

iii. Layer three

layer three was applied in the embedding process to ensure the network security in the process, so layer three is applied to extract the message, it must to be applied a layer three in the extraction process. As mention previously, each user has two keys, one of them is shared to all other user, is known as a public key and the second key it is a secret key which is it known as a private key.

The public key used in the embedding process and the private key is used in the extraction process. The private key stored only with the key owner, when the user receive the sticker that represents the stego file, this sticker entered into the extraction process, to extract the secret message. The secret message will be extracted by using the private key for the recipient. Layer one and layer two are applied at first to extract the secret data that include the header, the secret data still unreadable for the unauthorized users, when the header is decrypted, it is matched with the original header, if it has matched, the user is authorized and otherwise is not authorized to read the secret message. The header and the private key considered as the input to the RSA algorithm, the header represent the ciphertext, the output of the RSA algorithm represents the plaintext that represents the original header. Figure (3.18) shows the workflow of the proposed extraction process with the three layers.



Index	Locations
1	…
⋮	⋮
X	Y
⋮	⋮

Index	B	Index	G	Index	R	Index	Alpha
⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮
Y	Z	Y+1	…	Y+2	…	Y+3	…
⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮

3Bits	Value
101	5

Z
Extraction process
Random Number Generato
The proposed algoritm to selection locations that generate one output represent the index in array of locations and the seed number for the random generation function
Process on the extracted data to get the secret data.
The Extracted Data include the cipher Header.
Ex:
X---XS.O.S.

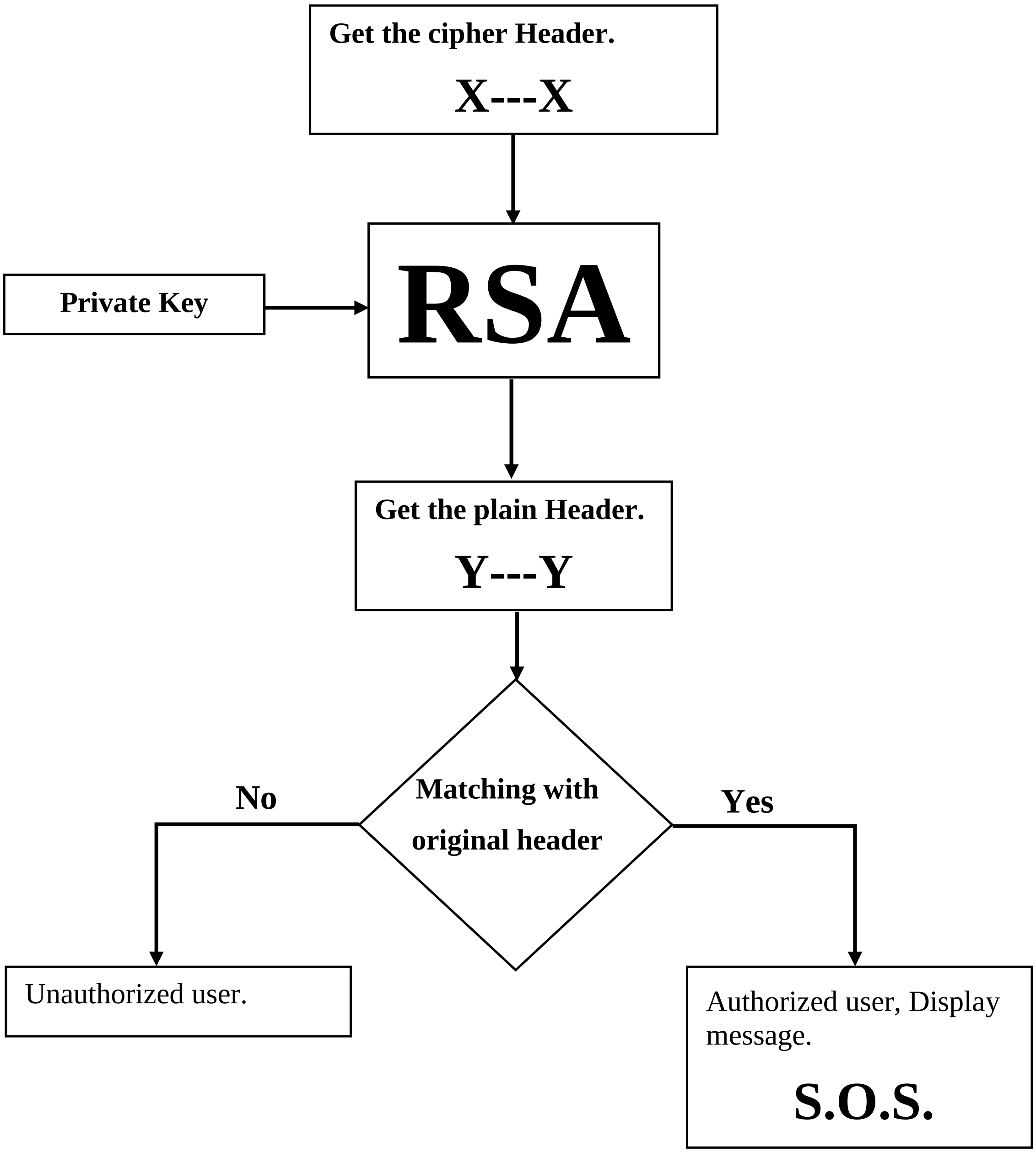


Figure (3. 18) workflow of the proposed extraction process with the three layers.

Chapter Four

User Interfaces and Experimental Results

Chapter Four
User Interfaces and Experimental Results

4.1 Introduction

In this chapter, user interfaces are presented, by explaining all options of the proposed system in details and presenting the three levels of the system by using the user interfaces. Also the system performance and evaluation are discussed, then exploring the effects of the secret message that embedded inside the cover media that represent the WebP image. The system evaluation will discuss the following points:

1- Maximum capacity of the cover file.
2- Determine the central change value (Mode).
3- Selecting the suitable sites to embed the secret message.
4- The proposed system performance (MSE, PSNR).

Many of the known measures have been used in the process of evaluation of the proposed system these measures are used to assess the quality of the proposed system by testing the cover file and the stego file.

The proposed system have been programmed by using the Android studio that used the Java programming language for programming the proposed system operations and algorithms, as well as has been using the native language (C, C++) to deal with the cover file. Also, the user interfaces are designed by using the XML (Extensible Markup Language) inside the Android Studio.

The proposed system has been programmed under the Environment: Laptop Acer aspire V5-551 (CPU: AMD A8-4 CPUs 1.6GHz, RAM: 6 GB and VGA: AMD Radeon HD 3GB), the operating system is Windows 10 Home 64-bit.

4.2 User Interfaces

In this section, the user interfaces are presented in details. All options and implementation of the three levels to achieve the goal of the proposed system in data security are explained, figure (4.1) shows the start activity of the proposed system. The start Activity is activated by clicking on the system icon. Reference was made to each control by it's associated number, then explain this control function by typing its number and then the description.

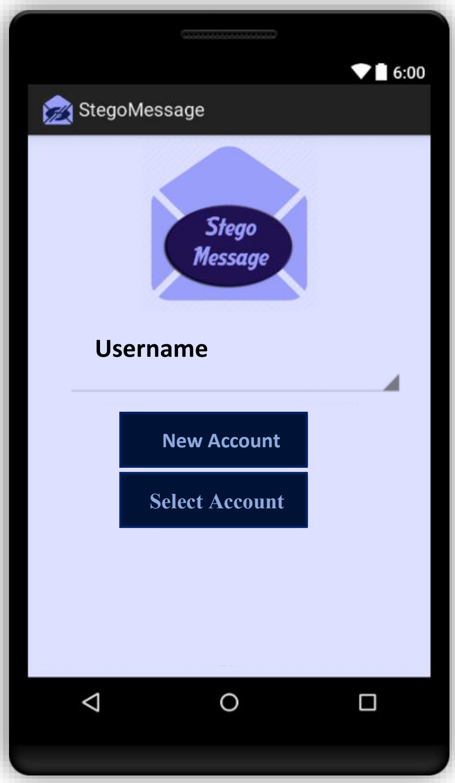


Figure (4. 1) the start activity of the proposed system.

1. ***Username:*** The spinner control that used to select and display the current user, that represent the person whose doing the embedding and extraction processes for the secret data.
2. ***New Account:*** The button control that used to create new user account and add its name to the spinner control. Figure (4.2) shows Create New Account Activity.
3. ***Select Account:*** The button control that used to display the activity that contain the system options. Figure (4.3) shows Select Option Activity.

The start activity represents the first activity that appears to the user when pressed on the icon of the proposed system existence in the collections of the android applications, permit the user to move between the interfaces of the system to allows him to use the functions which provided by the proposed system. Later it is clarified how to reach to another activity via the start activity.

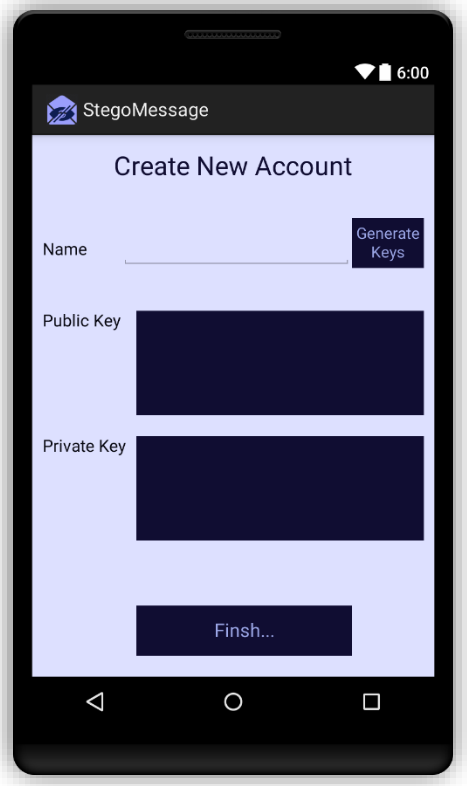
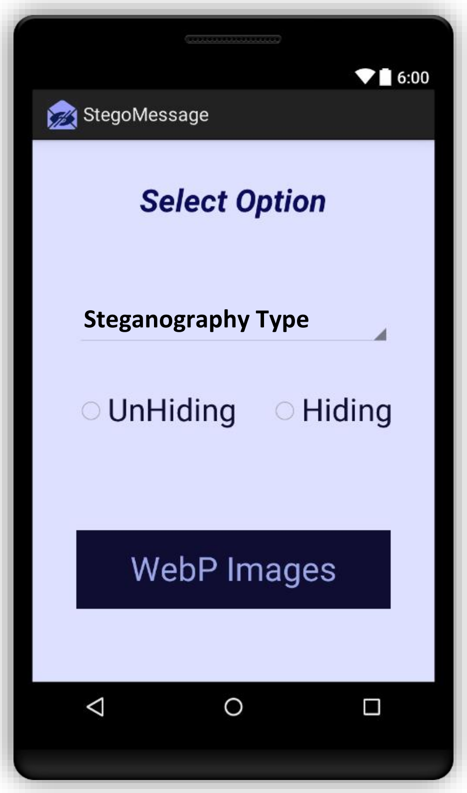

6:00
StegoMessage
Create New Account
Name
Generate Keys
Public Key
Private Key
Finsh...

Figure (4. 2) the new account activity.

1. ***Name:*** The Edit Text control used to enter the name of the new account.
2. ***Generate Keys:*** The button control that used to generating the pair of keys (public and private keys) for the new account.
3. ***Public Key:*** The Edit Text control used to display the generated public key.
4. ***Private Key:*** The Edit Text control used to display the generated private key.
5. ***Finish:*** The button control used to save the user information that entered for the new account, then return to the start activity.



Figure(4. 3) the Select Option Activity.

1. ***Steganography Type:*** The spinner control that used to select the steganography type, figure (4.4) shows the drop down list of steganography types.
2. ***Hiding:*** The Radio button control that used to select the embedding process (hiding), figure (4.5) shows the list of Stickers that used as the cover in the embedding process.
3. ***UnHiding:*** The Radio button control that used to select the extraction process (Un-Hiding), figure (4.10) shows the Data Extraction Activity for Pure Steganography, figure (4.11) shows the Data Extraction Activity for Secret Key Steganography and figure (4.12) shows the Data Extraction Activity for Public Key Steganography.
4. ***WebP Images:*** The button control is used to display the list of stickers activity if the Radio button for Hiding are checked or display the extract data activity if the Radio button for UnHiding are checked.

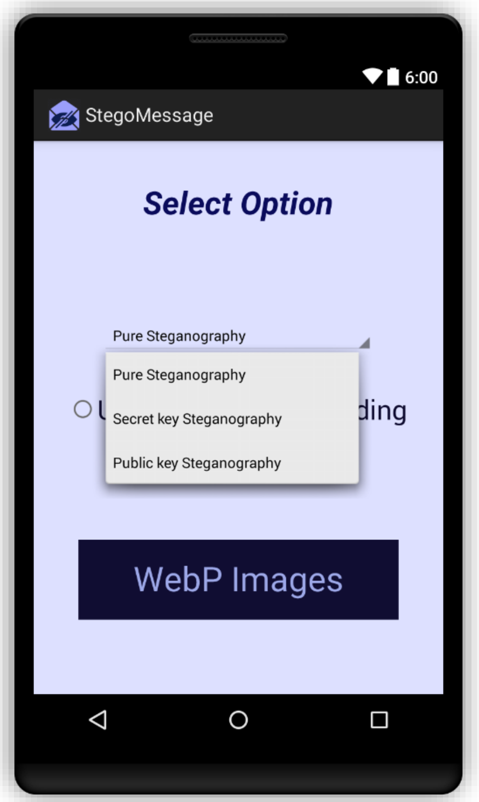
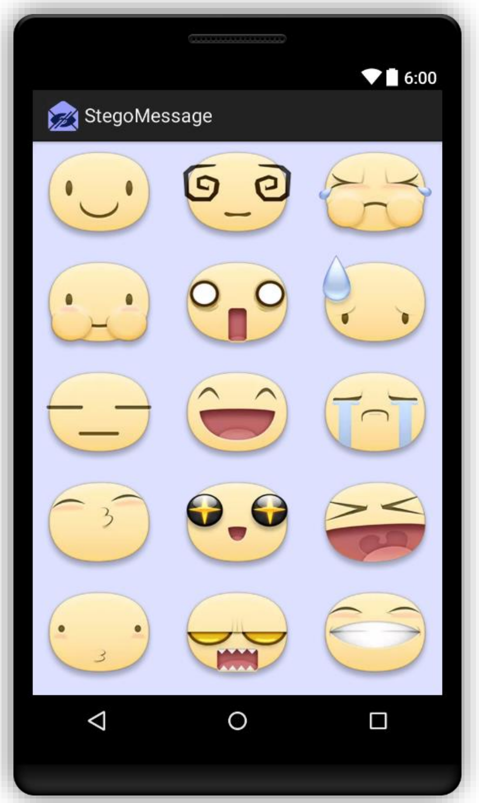


Figure (4. 4) the steganography types.



Figure(4. 5) the list of Stickers.

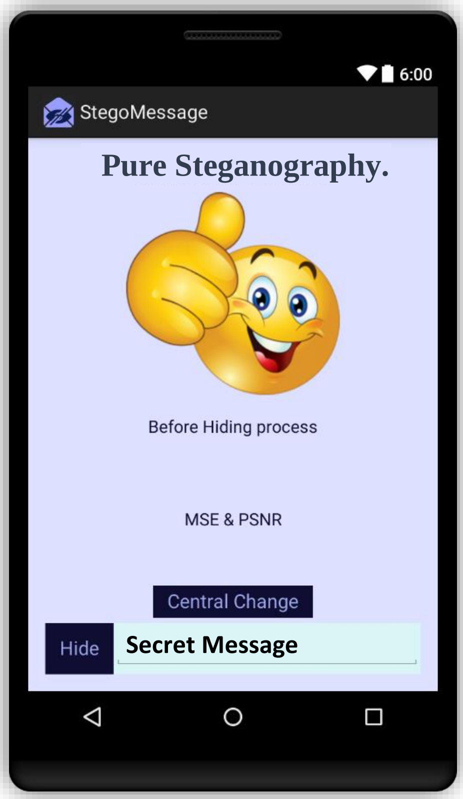
Pressing on the button control that named as ***WebP Images*** in the figure (4.3) and the Radio button control that called hiding is selected. The activity that contains list of stickers that represent the cover media is displayed figure (4. 5). After the stickers activity is displayed, the user can select one of the sticker to embed the secret message inside it, after the sticker are selected, one of three activities will be displayed to embedding process with one of three steganography types that shows in figure (4. 4):

a. ***Pure Steganography:*** Select this type to embed or extract the data without any sharing prior information, this type applied for level one and level two from the proposed system. Figure (4.6) shows the Embedding process activity by using the Pure Steganography.

b. ***Secret key Steganography:*** Select this type to embedding or extracting data with sharing prior information that represent the secret key, which is added to the output of the proposed algorithm for selection location as the seed number in the level two, this type applied for level one and level two from the proposed system. Figure (4.7) shows the Embedding process activity by using the Secret key Steganography.

c. ***Public key Steganography:*** Select this type for embedding the data by using the public key or extracting data by using the private key, this type is applied on level one, level two and level three from the proposed system. Figure (4.8) shows the Embedding process activity by using the Public key Steganography.

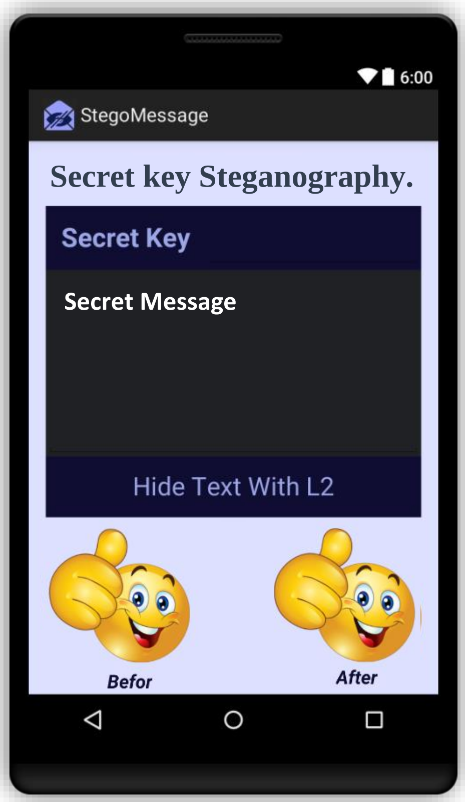
The selected sticker, will be presented in the selected steganography activity.



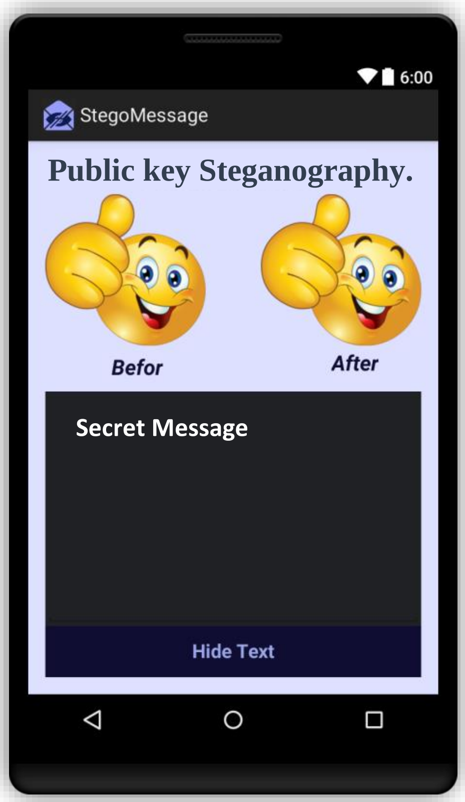
Figure(4. 6) the Embedding activity for the Pure Steganography.

1. ***WebP Sticker:*** The ImageView control used to display the selected stickers before and after the embedding process. Also, when pressing on the sticker that represent stego file, the popup image sharing are displayed to share it by using one of the chatting applications. Figure (4.9) shows image sharing popup.

2. ***Before Hiding Process:*** The TextView control used to notify the user about sticker before and after the embedding process.
3. ***MSE & PSNR:*** The TextView control used to display the amount of the MSE and PSNR for the embedding process.
4. ***Secret Message:*** The Edit Text control used to enter the secret message.
5. ***Hide:*** The button control used to perform the hiding process.



Figure(4. 7) the Embedding activity for the Secret key Steganography.



Figure(4. 8) the Embedding activity for the Public key Steganography.

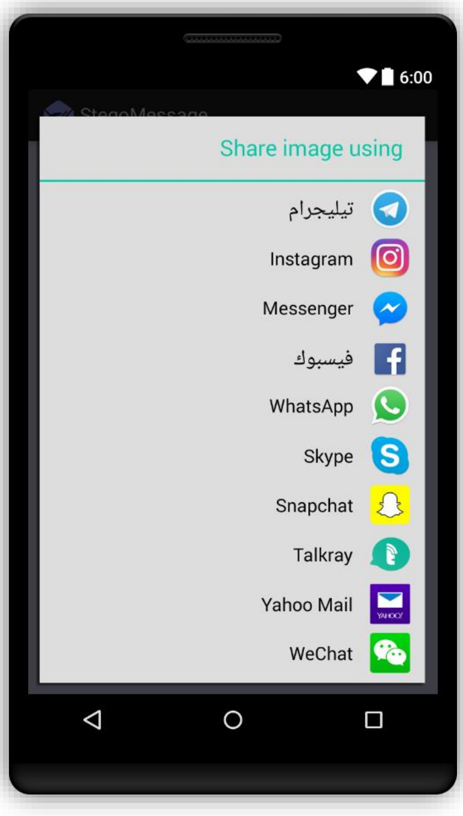
In Figure(4. 7) the controls used to perform the following tasks:

1. ***Secret Key:*** The Edit Text control used to enter the secret key, the secret key must be shared between the embedding side and the extraction side.
2. ***Secret Message:*** The Edit Text control used to enter the secret message.
3. ***Hide Text With L2:*** The button control used to perform the hiding process.
4. ***Before:*** The ImageView control used to display the selected stickers before the embedding process.

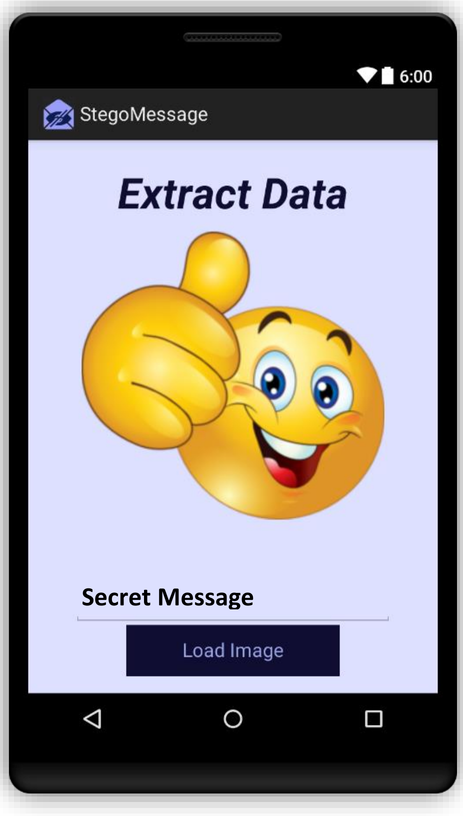
5. ***After:*** The ImageView control used to display the stickers that represent the stego file after the embedding process. Also, when pressing on the sticker, the popup image sharing are displayed to share it by using one of the chatting applications. Figure (4.9) shows image sharing popup.

In Figure(4. 8) the controls used to perform the following tasks:

1. ***Before:*** The ImageView control used to display the selected stickers before the embedding process.
2. ***After:*** The ImageView control used to display the stickers that represent the stego file after the embedding process. Also, when pressing on the sticker, the popup image sharing are displayed to share it by using one of the chatting applications. Figure (4.9) shows image sharing popup.
3. ***Secret Message:*** The Edit Text control used to enter the secret message.
4. ***Hide Text:*** The button control used to perform the hiding process.

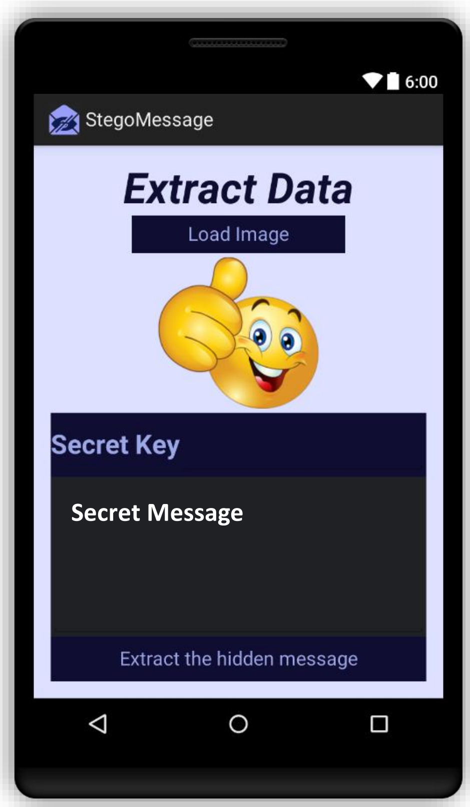


Figure(4. 9) the image sharing popup.



Figure(4. 10) the Extraction Activity for Pure Steganography.

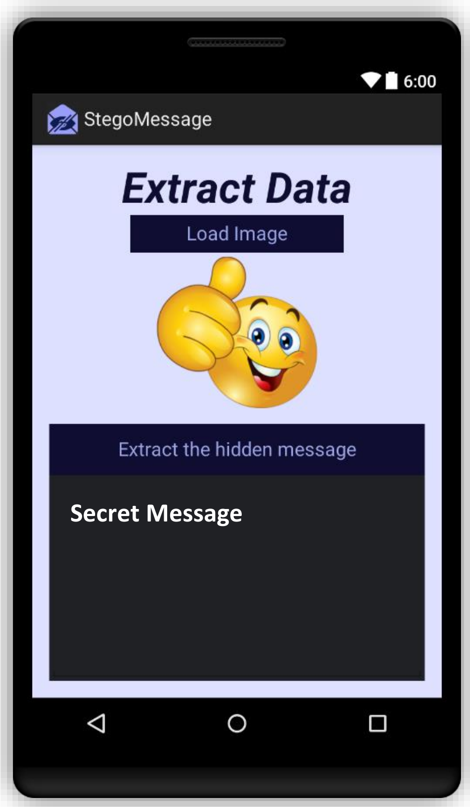
1. ***Load Image:*** The button control used to load sticker from gallery, display sticker, perform the extraction process, display the secret message.
2. ***WebP Sticker:*** The ImageView control used to display the loaded sticker that represent the stego file.
3. ***Secret Message:*** The Edit Text control used to display the extracted secret message.


6:00

StegoMessage

Extract Data

Figure(4. 11)the Extraction Activity for Secret Key Steganography.


6:00

StegoMessage

Extract Data

Figure(4. 12)the Extraction Activity for Public Key Steganography.

In figure (4. 11) the controls used to perform the following tasks:

1. ***Load Image:*** The button control used to load sticker from gallery and display sticker.
2. ***WebP Sticker:*** The ImageView control used to display the loaded sticker that represent the stego file.
3. ***Secret Key:*** The Edit Text control used to enter the secret key.
4. ***Extract the hidden message:*** The button control used perform the extraction process, display the secret message.

5. ***Secret Message:*** The Edit Text control used to display the extracted secret message.

In Figure(4. 12) the controls used to perform the following tasks:

1. ***Load Image:*** The button control used to load sticker from gallery and display sticker.
2. ***WebP Sticker:*** The ImageView control used to display the loaded sticker that represent the stego file.
3. ***Extract the hidden message:*** The button control used to perform the extraction process and display the secret message.
4. ***Secret Message:*** The Edit Text control used to display the extracted secret message.

4.3 The Experimental Results

In this section, the system performance are evaluated by experimental results that will be described. The most important key points that have been discussed in the experimental results, have been classified into the following sections: (4.3.1) the capacity of the cover file, (4.3.2) Determine the central change value, (4.3.3) Selection one of the pixel components (R, G or B) and (4.3.4) The performance of the proposed system.

4.3.1 The capacity of the cover file

The cover file that has been used in the proposed system is the (WebP image that used as the stickers in the chatting applications). After the image are converted to an array of pixels, each pixel is converted into its four components, the embedding process occurs within one of these four components (R, G, B, and Alpha). The Experimental Results are different between all cases, in the following table shows the capacity of the cover file (Sticker) to hide each three bits of the secret message inside one of these components are presented with 12 samples. Table (4.1) shows the samples of the stickers with maximum size of data that allowed to embedded.

Table(4. 1) the samples of the stickers with maximum size of data that allowed to embedded.

Sticker 1	**Size of sticker**	**No. non-transparent pixels**	**Actual locations**	**Size of message in byte**
	4530 Byte	21276 Byte	14183 Byte	5318 Byte
Sticker 1	**Size of sticker**	**No. non-transparent pixels**	**Actual locations**	**Size of message in byte**
	6076 Byte	21929 Byte	14619 Byte	5482 Byte
Sticker 3	**Size of sticker**	**No. non-transparent pixels**	**Actual locations**	**Size of message in byte**
	6768 Byte	23484 Byte	15655 Byte	5870 Byte
Sticker 4	**Size of sticker**	**No. non-transparent pixels**	**Actual locations**	**Size of message in byte**
	7242 Byte	24011 Byte	16007 Byte	6002 Byte
Sticker 5	**Size of sticker**	**No. non-transparent pixels**	**Actual locations**	**Size of message in byte**
	8484 Byte	23565 Byte	15709 Byte	5890 Byte
Sticker 6	**Size of sticker**	**No. non-transparent pixels**	**Actual locations**	**Size of message in byte**
	9854 Byte	42085 Byte	28055 Byte	10520 Byte

Sticker 7	Size of sticker	No. non-transparent pixels	Actual locations	Size of message in byte
	12994 Byte	20742 Byte	13827 Byte	5185 Byte
Sticker 8	**Size of sticker**	**No. non-transparent pixels**	**Actual locations**	**Size of message in byte**
	25948 Byte	148075 Byte	98715 Byte	37018 Byte
Sticker 9	**Size of sticker**	**No. non-transparent pixels**	**Actual locations**	**Size of message in byte**
	31336 Byte	110081 Byte	73387 Byte	27520 Byte
Sticker 10	**Size of sticker**	**No. non-transparent pixels**	**Actual locations**	**Size of message in byte**
	49310 Byte	116350 Byte	77565 Byte	29086 Byte
Sticker 11	**Size of sticker**	**No. non-transparent pixels**	**Actual locations**	**Size of message in byte**
	60546 Byte	125676 Byte	83783 Byte	31418 Byte
Sticker 12	**Size of sticker**	**No. non-transparent pixels**	**Actual locations**	**Size of message in byte**
	73008 Byte	146587 Byte	97723 Byte	36646 Byte

The table above shows the maximum capacity of the secret information that can be hidden in each sample, must notes that the field that referred number of non-transparent pixels, but the field that referred to it as the actual locations represent the locations that generated by the proposed algorithm.

When increasing the size of the sticker, it is not necessary that it means increasing the amount of data that will hide it. For example, the size of the sticker 7 is 12,994 bytes, and is able to hide 2592 characters, while the size of sticker 2 is 6076 bytes, but it is able to hide 2741 characters. This happens, because the proposed system are avoiding the hiding secret information within the transparent pixels, where the amount of the transparent pixels in sticker 7 is greater than the amount of the transparent pixels in the sticker 2.

The hided information inside one of the four components of the pixels and which represents the blue band (b). In the case of selecting two parts of the pixel components to hiding information will increase the maximum capacity by doubling it. For example, the maximum capacity of the secret message for the sticker 12 equal 18323 characters, In this case, the information is hidden just inside the blue part of the pixel, but if choose two parts of the pixel components for example select the blue and alpha(B and A), the maximum capacity of the secret message for the sticker 12 will be increased to 36646 characters.

4.3.2 Determine the central change value

The central change value, represent the most frequent value, which represents the difference between the cover sample before embedding process for a particular location and the stego sample after the embedding process for the same location. This value is added to all locations where there was embedding process, after the addition of the value of the central change, will decrease the number of sites that change their value. Table (4.2) shows the value of central change with its amount of repetition for the secret message with 800 bytes as a size, for the 6 samples.

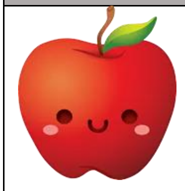
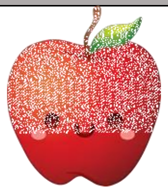
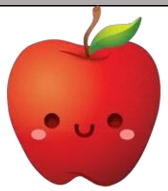
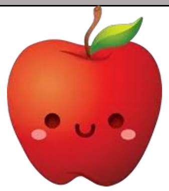
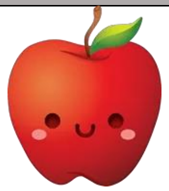
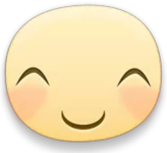
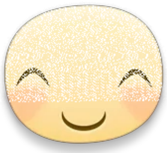
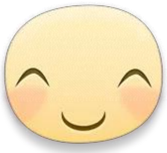
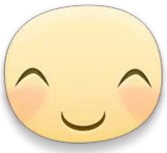
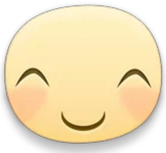
Table(4. 2) the value of central change with its amount of repetition for the secret message.

Sticker No.	Central change value	Amount of repetition	Sticker No.	Central change value	Amount of repetition
Sticker 2	-1	423	Sticker 8	1	604
Sticker 4	2	634	Sticker 10	7	497
Sticker 6	7	548	Sticker 12	7	554

The impact of adding the central changing value an the cover sample is appear after the embedding process, and clearly visible in the case of hiding within the Alpha part, where it appears in the form of gaps if they are not adding value central change. Table (4.3) shows the effect of the adding the central change value for the stego file. The size of the message equal 3825 byte.

A= Alpha, B= Blue and **C= Central Change.**

Table(4. 3)the effect of adding the central change value an the stego file.

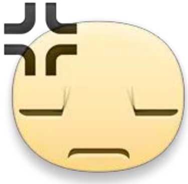
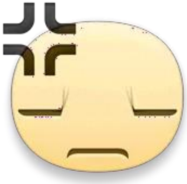
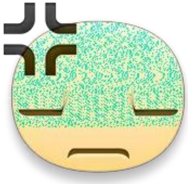
Sticker (Cover file).	Stego file(A).	Stego file (A+C).	Stego file(B).	Stego file (B+C).
				
				

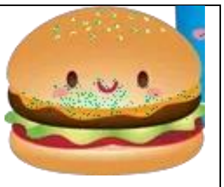
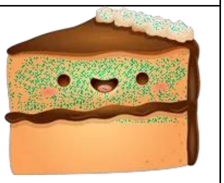
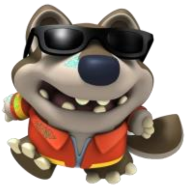
4.3.3 Selection one of the pixel components (R, G or B)

Selected one of the components of the pixels depending on the visual effect, and as a result, it was found that less part that affected the appearance of the sticker in full, is the blue part of the pixel. Table (4.4) shows the effect of the hiding the secret data inside each part of the components of the pixel independently except the alpha part, because it explained in the previous table.

Msize= Message Size, B= Blue, **C= Reed** and **G= Green.**

Table(4. 4) the effect of the hiding the secret data inside (B, G or R).

Sticker (Cover file).	Message size	Stego file(B).	Stego file (G).	Stego file(R).
	4047 byte			

	4047 byte			
	4047 byte			
	28299 byte			

4.3.4 The performance of the proposed system

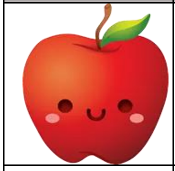
This section, presents the performance of the proposed system by comparing the proposed algorithm with other algorithm that described in section (2.2). Comparison are concentrated on the maximum capacity of secret data that could be hided inside the sticker, in addition to that, the stego file are tested after hiding process using the proposed algorithm and M16MA algorithm, and then display the results using measurements that are described in section (2.3) are displayed the results of measurements in a table comparing. Table (4.5) shows the difference between the maximum capacity of the proposed algorithm and M16MA algorithm.

Table(4. 5) difference between the maximum capacity of the proposed algorithm and the another algorithm.

Sticker	Size of sticker	Algorithm	total locations	Actual locations	maximum capacity
	4530 Byte	**M8PAM**	21276 Byte	14183	5318
		M16MA		2506	1253
	6768 Byte	**M8PAM**	23484 Byte	15655	5870
		M16MA		2765	1382
	8484 Byte	**M8PAM**	23565 Byte	15709	5890
		M16MA		2776	1388
	12994 Byte	**M8PAM**	20742 Byte	13827	5185
		M16MA		2443	1221
	31336 Byte	**M8PAM**	110081Byte	73387	27520
		M16MA		12954	6477
	60546 Byte	**M8PAM**	125676Byte	83783	31418
		M16MA		14788	7394

From the previous table, it shows that the secret data that can be hidden by using the proposed algorithm is equivalent to four times the secret data that can be hidden using M16MA algorithm that used for comparison. Table (4.6) shows the difference between the results of the measures that used to evaluate the system performance of the proposed algorithm and the algorithm that used for comparison. The measures that used as mentioned previously are (MSE and PSNR).

Table(4. 6) the difference between the results of the the proposed algorithm and the algorithm that used for comparison.

Sticker	Size of sticker	Algorithm	Size of Message	MSE	PSNR
	4530 Byte	**M8PAM**	1173 Byte	0.0263	63.931
		M16MA		0.0365	62.5
	6768 Byte	**M8PAM**	1237 Byte	0.0384	62.287
		M16MA		0.0385	62.276
	8484 Byte	**M8PAM**	1343 Byte	0.0369	62.460
		M16MA		0.0442	61.676
	12994 Byte	**M8PAM**	1013 Byte	0.0278	63.690
		M16MA		0.0318	63.106
	31336 Byte	**M8PAM**	4059Byte	0.0147	66.457
		M16MA		0.0155	66.227
	60546 Byte	**M8PAM**	4279Byte	0.0184	65.482
		M16MA		0.0199	65.142

As shown in the table above, the value of the MSE result of using the proposed algorithm is close to zero more than the algorithm used for comparison. Also, the value of the PSNR as a result of the using of the proposed algorithm is greater than the value of the PSNR of the algorithm used for comparison. Table (4.7) shows the results of the measures (MSE and PSNR) that used to evaluate the system performance of the proposed algorithm.

Table(4. 7) the results of the measures (MSE and PSNR) that used to evaluate the system performance of the proposed algorithm.

Sticker	Message 1 250 byte	Message 2 500 byte	Message 3 750 byte	Message 4 1000 byte	Message 5 1250 byte
 25KB	MSE: N/A	MSE: 0.0019	MSE: 0.0028	MSE: 0.0036	MSE: 0.0048
	PSNR: ∞	PSNR: 75.343	PSNR: 73.66	PSNR: 72.567	PSNR: 71.318
 31KB	MSE: N/A	MSE: 0.0018	MSE: 0.0027	MSE: 0.0036	MSE: 0.0046
	PSNR: ∞	PSNR: 75.578	PSNR: 73.817	PSNR: 72.567	PSNR: 71.503
 49KB	MSE: N/A	MSE: 0.0018	MSE: 0.0027	MSE: 0.0035	MSE: 0.0044
	PSNR: ∞	PSNR: 75.578	PSNR: 73.817	PSNR: 73.690	PSNR: 71.696
 60KB	MSE: N/A	MSE: 0.0017	MSE: 0.0026	MSE: 0.0035	MSE: 0.0041
	PSNR: ∞	PSNR: 75.826	PSNR: 73.981	PSNR: 72.690	PSNR: 72.002
 73KB	MSE: N/A	MSE: 0.0016	MSE: 0.0025	MSE: 0.0033	MSE: 0.0041
	PSNR: ∞	PSNR: 76.089	PSNR: 73.151	PSNR: 72.945	PSNR: 72.002

The cover file that used in the proposed system is Webp with lossless compression, therefore the size of the cover file after the embedding process will be increasing, Table (4.8) shows the difference of increased size between the cover file and the stego file.

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Sticker	Size of sticker	Size of Message	Size of Stego file
	6768 Byte	1475 Byte	11,816 bytes
	8484 Byte	1475 Byte	13,914 bytes
	31336 Byte	2943Byte	64684 bytes
	60546 Byte	2943Byte	99,754 bytes

Chapter Five

Conclusions And Suggestion For Future Work

Chapter Five

Conclusions and Suggestion for Future Work

5.1 Conclusions

From this thesis, many important points are observed and concluded. The following are the most important points:

1. Using WebP images (Stickers) as a cover file for secret data, especially the secret messages, is more safer, because this format is used as emoticons and frequently used in conversation applications.
2. Transferring the WebP images, whether they carry secret messages or not, over the Internet is faster than other formats because their sizes are small.
3. It is impossible to distinguish WebP images that containing the secret messages in different sizes with the naked eye, because the dimensions of the WebP images are small.
4. The embedding inside of the alpha channel in the WebP images without adding the central change value, distort the image significantly, as shown in Table (4.3).
5. The retrieved message after extracting from WebP has no distortion.
6. The comparison of the proposed algorithm with M16MA algorithm as shown in table (4.6). The results of the proposed algorithm are better than M16MA algorithms.

5.2 Suggestions for Future Work

For the enhancement of any system, the developer of any system should keep pace with and continuous improvements, the proposed improvements to the system as follows:

1. Develop the system to allow all versions of the WebP images as a cover file.
2. Develop the system in a manner that accepts the embedding of all types of data (Image, Video, Sound, etc.).
3. Develop the system to compatible with the applications of conversation (Viber, WhatsApp, Messenger, etc.).
4. Develop the system in a way that accepts the embedding of secret data on more than one cover file.

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المُلخَص

انتشار استخدام تنسيق صورة WebP على شبكة الإنترنت، وخاصة على برامج وسائل التواصل الاجتماعي وبرامج المحادثة، لذلك عندما ترسل لهم مرارا وتكرارا لا تثير الشك، مما جعلها نقطة قوة لتستغل في مجال أمنية البيانات. في هذه الأطروحة، تم اقتراح نظام لحماية الرسائل السرية باستخدام تقنية اخفاء المعلومات من خلال إخفاء الرسائل السرية داخل تنسيق صورة WebP باستخدام خوارزمية مقترحة و التي سميت M8PAM. تخفي الخوارزمية المقترحة كل ثلاث بتات في بكسل واحدة من الغلاف وفقا لخوارزمية مقترحة لاختيار مواقع الاخفاء في ملف الغطاء .

تم تطبيق ثلاثة مستويات على النظام المقترح؛ المستوى الأول، لتحديد البكسل الغير شفاف، ثم إخفاء البيانات السرية في مواقع محددة في ملف الغطاء باستخدام خوارزمية مقترحة لاختيار مواقع الاخفاء. المستوى الثاني، تشفير كل ثلاث بتات من الرسالة السرية عن طريق إعادة توزيعها باستخدام دالة توليد ارقام عشوائية. وأخيرا المستوى الثالث، استخدام طريقة (RSA) لتشفير مقدمة معينة و اضافتها الى الرسالة السرية قبل تنفيذ عمليات إخفاء البيانات.

للتأكد من ضمان نجاح الخوارزمية المقترحة، تمت مقارنة الخوارزمية المقترحة مع خوارزمية أخرى تدعى (M16MA)، حيث أظهرت النتائج ميزة الخوارزمية المقترحة باستخدام مقياسين مختلفين هما(MSE,PSNR), حيث ان نتيجة تطبيقهما اظهرت ان متوسط MSE يساوي (0.0147) و PSNR يساوي (66.457) مطبقة على بينات سرية يبلغ حجمها (4059 بايت) وحجم الغطاء (31336 بايت). و كذلك ان معدل إخفاء البيانات يساوي 66.66٪.

جمهورية العراق
وزارة التعليم العالي والبحث العلمي
جامعة النهرين
كلية العلوم

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رسالة

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كجزء من متطلبات نيل درجة الماجستير
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مـــن قبـــل

مصطفى باسم محمود
(بكالوريوس علوم حاسبات,2013)

اشراف

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