DESIGN OF EVALUATION PROCEDURES FOR LETTER-BASED TECHNIQUES IN TEXT STE GANOGRAPHY METHOD

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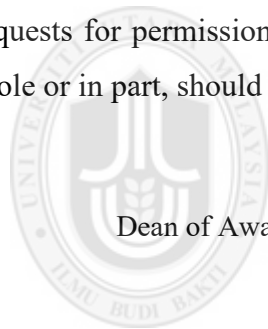
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Abstrak

Steganografi adalah salah satu maklumat kawasan bersembunyi yang meliputi maklumat dalam mana-mana domain sederhana seperti teks, imej, audio dan video. Salah satu kategori steganografi dalam medium teks dipanggil steganografi teks. Ia menyembunyikan mesej tersembunyi dengan menerapkan teks melalui pelbagai kaedah yang digunakan boleh menjadi mendatar beralih, menegak beralih, atau berdasarkan surat struktur teks. Ramai penyelidik menggunakan teknik berdasarkan ciri-untuk menampung mesej tersembunyi berdasarkan keunikan huruf. Oleh itu, kajian ini bertujuan untuk memberi tumpuan kepada jenis tertentu teknik berdasarkan ciri yang merupakan steganografi teks berasaskan huruf. Walau bagaimanapun, masih terdapat isu yang berkaitan dengan kaedah ini yang tentang kewujudan teknik dalam teks ini mudah ditemui oleh pihak luar. Kajian ini menunjukkan bahawa isu ini mungkin berakar dari ketiadaan pengesahan dan pengesahan prosedur semasa pembangunan kaedah steganografi itu. Kajian ini bertujuan untuk mengenal pasti parameter yang sesuai untuk proses pengesahan dan kesahan. Di samping itu, pelbagai parameter yang ada akan digunakan dalam menjalankan penilaian terhadap steganografi teks berasaskan huruf. Hasil kajian menunjukkan bahawa parameter yang terlibat dalam proses pengesahan dan kesahan akan dapat meningkatkan prestasi dan keselamatan teknik.

Kata kunci: Steganografi, Teks steganografi, Steganografi berasaskan Ciri, Steganografi berasaskan huruf, Pengesahan, dan Kesahan
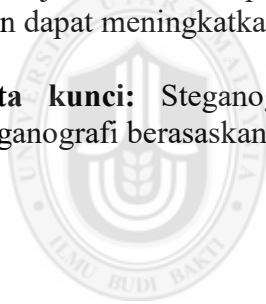
Abstract

Steganography is one of information hiding area that covers the information in any medium domain such as text, image, audio and video. One of steganography categories in the medium of text is called text steganography. It conceals hidden message with embedding the text via various methods such as horizontally shifting, vertically shifting or based on the letter of text structures. Many researchers utilize the feature-based technique to cover hidden message based on uniqueness of letter. Therefore, this study intends to focus on specific type of feature-based technique which is the letter-based text steganography. However, there is still issue relating to this method which the existence of the technique in the text is easily discoverable by attackers. Literature indicated that this issue is probably rooted from the lack of verification and validation procedures during the development of the steganography method. This study aims to identify the suitable parameters for verification and validation process. In addition, the parameters will then be used in conducting evaluation on the letter-based text steganography. The outcome of this study showed that the parameters which involved in verification and validation process will be able to improve the performance and security of the technique.

Keywords: Steganography, Text steganography, Feature-based, Letter-based Verification, and Validation
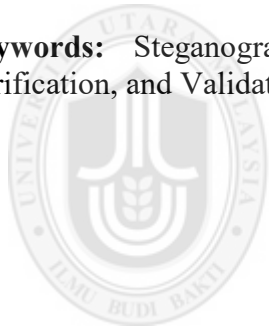
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In the name of Allah, the Beneficent, the Merciful. Alhamdulillah, grateful to Almighty Allah (SWT) for all the blessing He has bestowed upon me, finally this thesis is finally completed.

A lot of thanks to Universiti Utara Malaysia for the supports and the facilities provided. My deepest gratitude and appreciation goes to my respected supervisors, Dr. Massudi Mahmuddin and Dr. Roshidi Din for never ending support, courage and helps along my study to complete this thesis.

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List of Abbreviations

AES	Advanced Encryption Standard
ASCI	American Standard Code for Information Inter-exchange
BMT	Burrows Wheeler Transform
CALP	Chang Alphabet Letter Pattern
CCM	Characteristic Code Mapping
CURVE	Curve Character Subheading
CSS	Cascading Style Sheets
DNA	Deoxyribo-Nucleic Acid
ECR	Encryption with Cover Text and Reordering
FN	False Negative
FP	False Positive
FSM	Finite State Machine
HESM	High Efficient Substitution Method
HTML	Hypertext Markup Language
IM	Instant Message
MTZ	Move to Front
OST	Ontological Semantic Technology
PCFG	Probabilistic Context-Free Grammar
QUAD	Quadruple Categorization
RASAM	Rapid Action Surface to Air Missile
SKT	Secret Key Table
SSCE	Secret Steganography Code for Embedding
SSM	Simple Substitution Method
TN	True Negative
TP	True Positive
VERT	Vertical Straight Line
WSD	Word Sense Disambiguation
XML	Extensible Markup Language

CHAPTER ONE
INTRODUCTION

1.1 Background of Study

The text document has become one of the important medium information until the present time even there are a lot of other medium that had been established. The needs of text documents are still high especially in the domain of business and academic. It is because a lot of important documentation such as appointment letter, certification, report, confidential document and many any other documents are available in text. Therefore, text documents should be a concern for most people due to them are exposed to a lot of risks. For example, the intruders can occasionally temper with information in these documents for their own interests. The text document which is commonly contains confidential information becomes their target in order to discover the secret information which could be used for illegal purposes. Hence, a special technique named steganography is introduced to overcome this problem.

Steganography is best known as an associated knowledge of hiding the messages via medium of data to become invisible and undetectable for human sense. Secure private information is critical point of steganography in applying performance as part of information hiding. The practical idea of steganography has been used since the ancient times (Iyer & Lakhtaria, 2016). The implementation of steganography itself is divided into two categories. The following Figure 1.1 illustrates various categories of steganography and the focus path of this study.
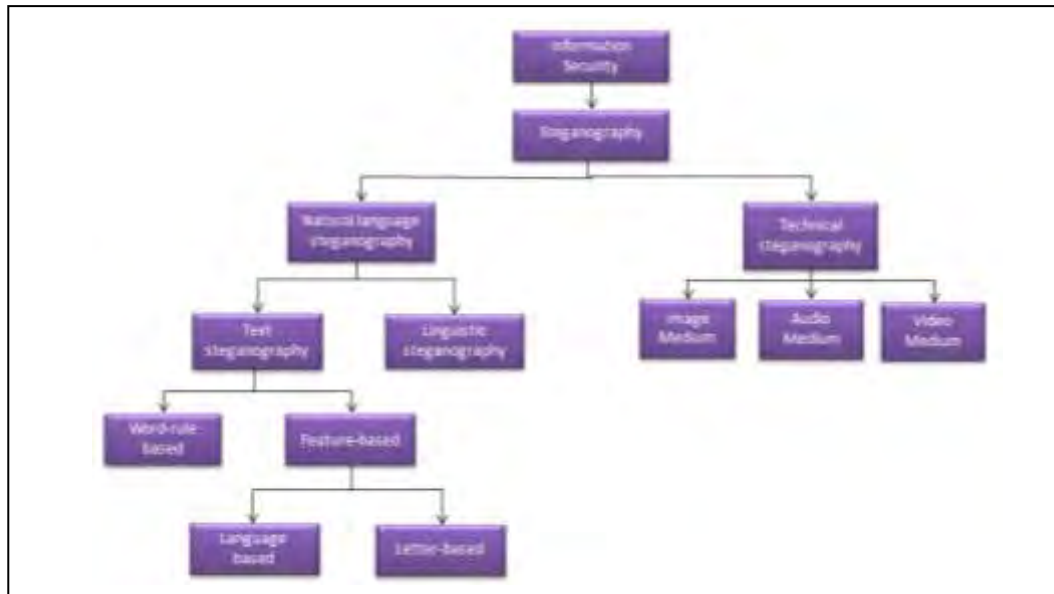
Figure 1.1 Major categories of steganography

Based on Figure 1.1 is showed the steganography that consisted two categories. The first is known as technical steganography which is implemented in other medium (i.e.: non-text) such as images, audios, videos and other digitally invisible codes. Secondly is the natural language steganography whereby the implementation of steganography is done in medium of text. The implementation of natural language steganography involves hiding the hidden message in medium of text so that the third party is unable to discover the existences of message in text. In other words, steganography in medium of text can make the secret information invisible and unnoticed for third party to see or detect, and it is directed to the appropriate receivers to apprehend the information.

However, steganography in text domain is the most challenging method implementation compared to the other domains. The challenges of implementing

steganography in text domain is due to the text file is usually small in size and there for has limited space to hide information (Nasab & Shafei, 2011).

Under the natural language steganography, there are two other sub-categories. The first is linguistic steganography. This type of steganography is dependable with linguistic order of sentence in the text. The second is text steganography that manipulates the component of text such as word, line, space and other component of text in order to hide the message.

This study intends to focus on text steganography category by looking at feature-based method. This method could be able to hide the hidden messages by embedding them in the text based on uniqueness of letter in the text. Furthermore, feature-based consists of two different categories which are language based and letter-based. Language based is the technique of feature-based that only applied in the specific language letter, while letter-based is feature-based technique that can be implemented in any language that use A-Z letter. This study chose the letter-based technique as the domain of study in order to figure out the performance of this technique through measurement process.

1.2 Motivation of Study

There are several reasons why the domain in letter-based technique has been chosen based on the knowledge and application sides.

a. Knowledge Based

Based on knowledge side, this study chooses method in text domain. It because the steganography methods in text domain are the prominent methods than other domain such as image, audio, and video (Nasab & Shafei, 2011). Then, most widely used technique in text steganography is feature-based. It means the feature-based technique is the most commonly used technique and hence more applicable. As for letter-based, it is quite obvious since it is applied in A-Z letter. Therefore, as feature-based category the letter-based is chosen in this study because most of countries in the world used A-Z letter (Bhattacharya et al. 2011; Dulera, Junwal & Dasguptaa, 2011). In term of evaluation of the technique, the measurement approach through verification and validation is quite rarely used in text steganography (Sharma, Upadhyaya, and Agarwal 2013).

b. Application Based

The area of this study is chosen because it able to applied in any field of work and education. Firstly, the development of the method can be applied to e-document that is important in government and education area. Secondly, the idea technique in steganography able to apply for checking documents authentication in business requirement. Thirdly, this study focuses on evaluation processes that use some measurement approach for implementing the domain of study. The measurement skill itself can be used for any field that is relegated with text analysis.

1.3 Problem Formulation

Although there is unique characteristic of letter-based in the process of hiding message in text, apparently there are still critical issues in this technique. Mainly, the critical issue is the existence of text steganography method is easily discovered (Battahcarya et al., 2010). The detectors can discover the hidden messages exist in the text, if they notice the changes of letter in the analyzed text (Dulera, Junwala & Dasguptaa, 2011). Also, the hidden messages which have been embedded will be lost, if the detector changes the text (Odeh, Hani & Elleithy, 2012).The detectors can do so if changes is done to the text such as deleting some letter or words, modifying its content, retyping, and other changes that directly make the hidden message vanish in the text.

According to this issue, there are two problems discovered by previous researchers in letter-based technique which are the lack of effectiveness in developing the text steganography method (Reddy et al., 2014) and low security for covering text in order to hide hidden message (Sun et al., 2010). These two problems can be summarized as lack of performance achievement of text steganography technique. It is also suggested by Sharma, Upadhyaya, and Agarwal (2013) that the text steganography system requires the certain measurement in conducting the verification and validation processes.

However, current researchers in this domain of study commonly conduct verification by verifying the algorithm, model sequence and other component of requirement that will be used for developing their technique (Zhang et al., 2006; Ghosh & Debnath,

2010; Mahato, Yadav & Khan, 2013). On the other hand, many researchers claimed that the validation process were more focusing on validating the total capacity and running time in embedding the hidden message as the proof the improvement of their technique (Alam & Naser, 2013; Kateria et al., 2013; Odeh, Elleite & Faizypour, 2013; Battacharya et al., 2011; Kumar, Chand & Singh, 2014) . There are also some researchers who do not utilize any of the verification and validation processes but instead focusing on developing the technique (Gutub & Fattani, 2007; Sun et al., 2007; Das & Gosh, 2010; Dulera, Junwal & Dasguta, 2011; Odeh et al., 2012; Talip et al., 2012). Hence, in order to improve the current performance and increase the security of letter-based technique, an appropriate evaluation has to be carried out using suitable metrics that takes into consideration both the verification and validation processes. Thus this study, intends to further investigates the suitable perimeters for conducting evaluation that consider both the verification and validation process towards enhancing the overall performances and security of letter-based technique.

1.4 Research Questions

1. What are the parameters that can be used to conduct verification and validation processes on letter-based technique in text steganography?

2. How the performance evaluation that covers both verification and validation does processes being done in letter-based technique of text steganography system?

1.5 Research Objectives

1. To propose suitable parameters for verification and validation processes of letter-based technique in text steganography.

2. To conduct an evaluation on the performance and security of letter-based technique through verification and validation processes.

1.6 Research Scope

This study focuses on the implementation letter-based techniques in steganography text domain. It consists of types of steganography method, types of letter-based technique and some parameters identified.

o **Domain steganography types**

This study considered deliberating the domain on text steganography rather than domain on linguistic steganography

o **Types of letter-based technique**

This study utilized several schemes of letter-based technique in order to embed a hidden message in chosen text through a proposed model of text steganography. The schemes involved are Change Alphabet Letter Pattern (CALP), Curve Character Subheading (CURVE), and Vertical Straight Line (VERT). These schemes were chosen because those schemes represent the idea of embedding process used by single binary bits and the algorithm and have been provided by other researchers (Battacharya et al., 2011; Dulera, ;Junwal & Dasguptaa, 2011).

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o **Evaluation Parameters**

This study uses parameters in verification and validation processes in order to achieve the objectives. The verification processed verifies correctness and size capacity letter-based technique in text domain and validation process is able to establish the accurate model representation of letter-based text steganography design.

1.7 Significance of Study

This study significantly undertakings in proposing the design model of steganography technique in text domain. It is important towards the field of information hiding, specifically in text steganography by providing the parameters that is important to be used in the evaluation process. These evaluation parameters are also helpful in order to measure the implementation of several other techniques in this domain of study. It is also beneficial in figuring out the output of the study so as to improve the development of the technique from its performance and security perspectives.

1.8 Organizing Thesis

This thesis is organized into six main chapters. The first chapter presented the basic idea of steganography area in covering hidden message in text domain by explaining the background of study, problem formulation, research question, research objectives, and research scope of this study. In general, this chapter illustrates the steganography area from various techniques and schemes underneath it. This chapter also detailed out the problem statement that is followed by several research questions

and research objectives to be met. Table 1.1 outlines the phases involved in the research.

Table 1.1

The outline of phase proposed research

Phases of Research	Activity Involved	Deliverable
THEORETICAL	• Review previous and current literature on text steganography	• Summary of literature reviewed • Problem formulation documented
EXPERIMENTAL DESIGN	• Analyzing requirement input • Analyzing the stego key scheme letter-based technique used	• Tabular of appropriate input of experimental design • Stego key formulated.
	• Performance experiments in evaluation measurement	• Algorithm obtained in embedding process. • Prototype of verification and validation model.
OUTPUT	• Verification process • Validation process	• Length of characters and capacity size bits of the datasets. • The performance method based on running time, precision, accuracy and recall rates.

- **Theoretical Study**. In this phase, the natural language steganography which consists of text steganography and some elaboration on linguistic steganography are reviewed. Then, measurement in form of verification and validation are also reviewed to identify the limitation and criteria of method used for improvement. It delivers summarization of literature and documented of problem formulation.

- **Experimental Design.** This phase analyzed the input environment that sends hiding input text or normal input text to integrate the embedding technique

algorithm. It also analyzed what type of algorithms that is suitable with stego key based on letter-based techniques to embed the hidden message. Thus, it is expected that the research deliver"s list of appropriate input of experimental design formulated stego key is obtained. Then, this phase also evaluated performance of the system using parameter of each verification and validation processes to analyze of stego text. These phases can delivered the algorithm that is evaluated through verification and validation processes.

- **Output Environment.** The result of experiment is analyzed from evaluation process environment based parameter matrices. The measurement justified result of verification and validation processes the stego text from embedding process to become output data in this environment. This phase can meet simplify standard measurement in text steganography based on verification and validation processes.

The phases that employed from this research are based on domain, category, algorithm, measurement, and any other requirement of letter-based technique in text steganography. Then, the following the chapter arrange accordingly in this thesis:

The second chapter begins with theoretical of background study in steganography that focuses on natural language steganography. Then, elaborate the category of text steganography and linguistic steganography as comparison of the method. It also discusses about the schemes which had been implemented in previous researcher especially in feature-based (language based and letter-based). This chapter also the evaluation performance that shows the some parameters in verification and validation approach.

The third chapter presents the phases methodology of this study and shows the implementation of scheme as the letter-based technique. This chapter present the discussion of experimental design that involve what are the parameter chosen for schemes of letter-based technique.

The fourth chapter presents the proposed model of design the scheme. This chapter is involved the algorithm design, flow design, logical design, and physical design of the scheme. The schemes of physical design are used as the domain for evaluating process through verification and validation in order to discovering the performance of the technique chosen.

The fifth chapter presents the result of performance the scheme of the technique that is evaluated by some parameters of verification and validation based on experimental design. The verification and validation results are used for comparison purposes.

The last chapter revisits the objectives of this study that related to contribution the steganography in text domain. It also continues with summarizing the main contribution of this study and highlighting the limitation and future work that contribute the significance to steganography community.

CHAPTER TWO
LITERATURE REVIEW

2.1 Introduction

This chapter presents the survey of natural language steganography which focus on text steganography. It also discussed linguistic steganography along with the classification technique in steganography. This chapter also reviews categories of natural language steganography that have been used by previous researchers. The main objective of this chapter is to analyze the classification technique in natural language steganography.

The sections in this chapter will be arranged as follows; section two will review the categorization of general techniques in natural language steganography. This is followed by section three which gives overview of natural language steganography technique. Section four discusses about the application of each steganography technique for text domain. In this section, the letter-based techniques that become the domain in this study also reviewed. Then, the following section discusses the linguistic steganography. Section six summarizes some analysis on previous research about text and linguistic steganography. Additionally, section seven clarifies about common parameters used for verification and validation processes. Finally, section eight summarizes the chapter.

2.2 Background

Nowadays, the state of privacy level in communication is at risk. The existence of intruders in the communication technology enables anyone to easily retrieve information. The irresponsible intruders may disclose the information to uninvolved parties to check or modify it for abusing that information (Amin et al., 2003). Due to the increase interest in private conversations by third parties via the open source system such as the Internet, there is vital need to take additional measures to ensure the right is well protected. One of the solutions in dealing with the issue is through steganography.

Steganography is defined as the art and science of covering hidden message so that the existence of a message is not detected by human vision. It is one of sub-disciplines of information hiding. However, steganography is usually mislabeled with cryptography. Nevertheless both are aimed at protecting valuable information. The fundamental difference between them is steganography relate to hidden information to modify the invisible message. Meanwhile, cryptography is the study of secret writing or cryptograms that involve various methods or in other words, cryptography is a technique of protecting the content messages, whereas steganography conceals the data in existing message (Din, Samsudin & Letkai, 2012). For instance, in steganography, if someone looks at an object that stores secret information, the person would not expected that there is a confidential message in and will not be tempted to decrypt the object.

Steganography derived from a Greek word *Steganos* which means, covered or secret and *Graptos* denotes write or draw. Thus, steganography means literally covered writing that has been used centuries ago even before the term of steganography appears. For example the Greek history narrated about how Demeratus from Xerxes wrote a warning message to the Spartans to obstruct of invasion used wooden base of wax tablet that carved and then covered with a fresh layer of wax (Chang & Clark, 2010). Another example is during World War II, the invisible ink has been used to write the information on a sheet of paper in order to for not to paper falls in the hands of the other party. It will just seem like a plain sheet of paper (Por & Delina, 2008). Based on the examples, the essential advantage of steganography is that no one will suspect the existence of archives that have information hidden in it, especially when it looks like other normal files.

The process of steganography in text domain can analogically be illustrated using Prisoner"s Problem that showed in Figure 2.1 as follow.
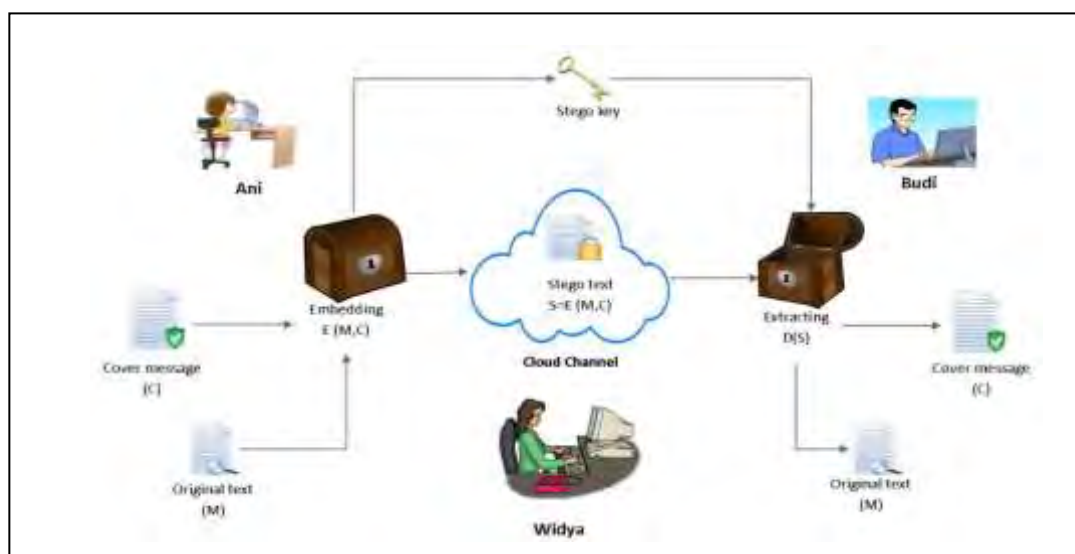
Figure 2.1. A steganography processes on text domain

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The analogy is represented in Figure 2.1 whereby Ani is sending an original text (*M*) along with a cover message (*C*) in order to process embedding known as stego text (*S*) containing a stego key (*K*). Firstly, apply the invertible function *e: {M, C}* → *S*. Ani can plan an original text (*M*) using a stego key (*K*) through *e (M, C) = S*. Hence, *S* as stego object and it is invertible function, Widya will not discover it suspicious thing. Then, Budi will figure out *e - 1(S) = {M, C}* in order to retrieve original text *M* and cover message *C* with a stego key *K* for decoding the process use function. The process of embedding and extracting the information of stego text *S* will be known by Widya that clarify the process steganography is success.

2.3 Domain in Natural Language Steganography

Natural language steganography conceals message in medium of text. It can be divided into two main categories; text steganography and linguistic steganography. Tex;t steganography covers messages which manipulating the component in text such as, word, space, line and any other characters in sentence of text. Whereas, linguistic steganography is covering messages by modifying the information that encoded based on linguistic order (Chang & Clark, 2010). The classification of natural language steganography is presented in Figure 2.2.
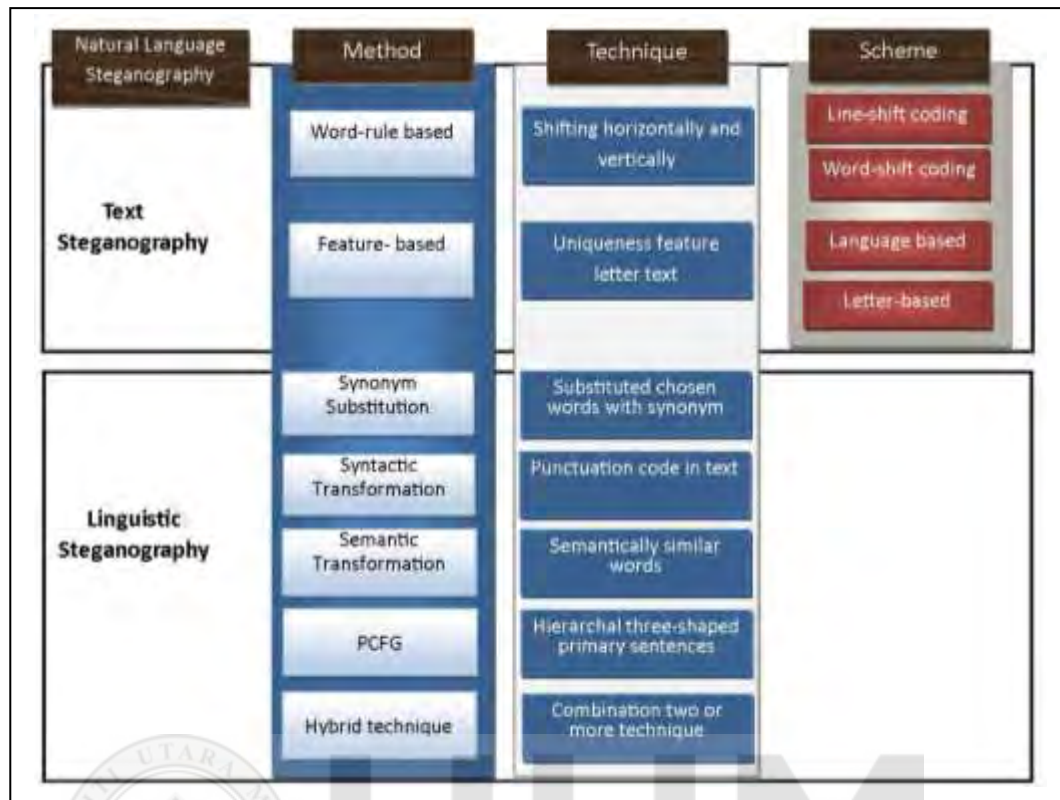
Figure 2.2. Natural language steganography categories

These two categories are classified into rules and technique that the covers message in the text. The steganography technique in text domain is based on Figure 2.2 which is classified by the brief definition of text steganography and also in linguistic steganography. The development of techniques consists of two kind of techniques word-rule based and feature-based. Word-rule based is the technique that embeds the hidden message based on word pattern by shifting in the text. The techniques consist of line-shift coding and word-shift coding. Besides, line-shift coding hides the hidden message with vertically shifting hidden message in text lines. Whereas word-shift coding hides the hidden message with horizontally shifting the hidden message in length between words (Kumar et al., 2014).

Meanwhile, feature-based can define as a technique that altered unique feature characteristic in text based on code word. This technique covers hidden message based on pattern letter or length of the word that conceals and seem nothing changes happen in the text (Nasab & Shafei, 2011). For linguistic steganography, the techniques used for hiding information are such as synonym substitution, syntactic transformation, semantic transformation, probabilistic context-free grammar (PCFG). Synonym substitution constitute a technique that substituted the chosen words with synonym part of text and modification more on focus in grammatical sentences and uninvolved operating structure. Words of language that have a lot of synonyms will obtain more options to hide the information in the text (Chang & Clark, 2010). Then, syntactic transformation known as technique that uses punctuation code in text likes comma (,) stop (.) and etc. to hide information in form binary bits 0 and 1 (Kumar et al., 2014).

Furthermore, semantic transformation is a technique uses two or more semantically similar words with different meaning to translate back and forth that convert to binary bits for hide the hidden message in word (Grothoff et al., 2005). While, probabilistic context-free grammar (PCFG) illustrated the technique in linguistic steganography that hide the information from generative model. It describe structures hierarchal three-shaped primary sentences in given interest domain and also provides distribution of probability on sentences that used to provision decision some task in text (Corazza & Satta, 2007). Finally, technique in linguistic steganography is hybrid techniques that combine two or more method in process to

hide in information in one text. Essentially, the methods are introduced in two categories which are text steganography and linguistic steganography.

2.4 Text Steganography Methods

This section presents text steganography methods which are divided into two parts. First parts presents word-rules based that consist with two techniques, line-shift coding and word-shift coding. Second part presents feature-based in text steganography which is divided into techniques based on unique characteristics that are language based and letter-based.

2.4.1 Word-Rule Based Methods

The implementation of word-rule based technique is divided into two ways of hiding the message. The first technique, line-shift coding can be embedded vertically hidden message to conceal the message in the text. Meanwhile second technique, word-shift coding can embedded horizontally the hidden message to conceal the message in the text.

Table 2.1

Recapitulation word-rules based technique in text steganography

Techniques	Specific Methods	Embedding Techniques	Advantages	Drawbacks
Line-shift coding	Shifting second line (Nasab & Shafei, 2009)	shifted 1/300 inches the second line in each page up and down	High performance	Easy to attack

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	Line-shifted up and down (Sing et al., 2009)	encode of differential and between baseline and two centroids of adjacent lines	Recommended for printing text	Easy to detect and difficult to extract complete text
	Unique shaped (Roy & Manamisti, 2011)	develop the unique shaped in some degree of text shifted vertically	High performance	Low security and Easy attack
Word-shift coding	Word-shift coding (Nasab & Shafei, 2009)	stored the horizontal shifting code in several words that maintains the natural state and can be applied in text file and pictures	Large capacity for hiding text	Easy to detect
	Alteration the length of image word (Roy & Manamisti, 2011)	hidden the secret by shifting horizontally the words and text image can use this method based on alteration the length of images word	Simple and useful for image words	Easy to detect and attack, also consuming much time
	Neighbor difference (Li et al., 2008)	The technique divided the different length of two consecutives to embed the hidden message when 0 bit for unchanged space and 1 bit for changed neighbor difference	Useful for PDF document	Complex development
	Distribution white space (Sing et al.,2009)	justifies the document and not shifted the first and last word on each line of text, then distributed white space used attribute word spacing	High performance	Limited portion capacity
	Encode matrix for	Encode of matrix	Useful in	Limited

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instant message (IM) (Liu et al., 2009)	based on online chat and inferior of encoded shipping adjacent letters for hidden message in plain English text.	internet based	portion capacity and easy redudancy
Integrated inter character (Yang & Kot, 2008)	adjusts all characters and words in document and distributed both of sides randomly	Easy way of hiding messages	Limited portion capacity
Advanced encryption standard (AES) algorithm (Altagani & Barry, 2013)	represents binary form the secret data to accomplish the process and small quantum increasing or decreasing the covers distance depend on the conforming amount bit in secret binary data	Large capacity	Low performance algorithm
Word shift coding in Thai letter (Shampaibon & Dailey, 2008)	replace the cover text in vertical line of font that divided to be four levels; Top level and above level is vertical line above the character and in below of the character names are base line and below level	Useful for Thai letter	Only for Thai letter

Based on Table 2.1 word-rule based technique can develop with other additional techniques. Those techniques have own process of embedding and also have advantage and disadvantage in implementation of this technique. There are several

advantages of word-rule based technique based on Table 2.1. In general, the advantage of word-rule based can be divided in to three categories:

- The technique has high performance in hiding the hidden message like line-shift coding technique using shifting second line (Nasab & Shafei, 2009) and unique shaped technique (Roy & Manamisti, 2009). Then, in word-shift coding also has some technique has good performance like distribution white technique (Sing et al., 2009) and integrated inter character technique has decent performance in the way hiding hidden message (Yang & Kot, 2008).

- The techniques can hide a lot of hidden message in text that embedded in the word-shift coding technique (Nasab & Shafei, 2009).

- The techniques was useful in specific particular based on several condition; recommended for printing text in line-shift up and down (Sing et al., 2009), useful for image in alteration the length image word technique (Roy & Manamisti, 2011), useful for PDF document in technique (Li et al., 2008), encode matrix for Instant Message (IM) that can use in internet based (Liu et al., 2009) and word-shift coding in Thai letter that can use technique steganography in Thai text (Shampaibon & Dailey, 2008).

Meanwhile, some disadvantages have been identified in Table 2.1 about word-rule based text steganography:

- Some of techniques in word-rule based still have low security. The challenges of technique steganography is how to make the hidden message undetected or become invisible, but several technique still has low security that can recognized by other person because the changes of text slightly

visible likes line-shift up and down technique (Sing et al., 2009), word-shift coding (Nasab & Shafei, 2009), and also alteration length of image technique (Roy & Manamisti, 2011). Then, easy destroy means the exitences of hidden message will be lost if any changes is done in the text. This disadvantage existed in technique second shift line (Nasab & Shaefei, 2008) and in unique shape technique (Roy & Manamisti, 2011).

- The performance of algorithm is still complex in implemented the technique like in AES algorithm technique (Altagani & Barry, 2013) and technique neighbor difference (Li et al., 2008). It is opposite with technique that can embed large capacity. Using this technique only can embed few hidden message in text likes technique of distributing white space (Sing et al., 2009) and encode matrix (Liu et al., 2009).

- It takes too long time in developing of system and in process embedding/extracting hidden message in the text. The example of this disadvantage was alteration the length of image word (Roy & Manamisti, 2011).

2.4.2 Feature-Based Methods

Feature-based method alters the feature of letter by manipulating in the shape, size, and position of font in the text. Feature-based technique makes the reader difficult to recognize the hidden information in this text. The technique of feature-based make the reader cannot recognize the secret information in this text (Roy & Manamisti, 2011). Then, due to the characteristic of this technique, feature-based could be used

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by many researchers based on character of language in the world. Based on current effort research about feature-based technique consist of two categories; language based that can use only in certain language and letter based that can use in any language that use A until Z letter. The classifications of feature-based are shown in Table 2.2 as follows.

Table 2.2

Recapitulation feature-based technique in text steganography

Techniques	Specific Methods	Embedding Techniques	Advantage	Drawbacks
Language based				
a. English based	Machine translation (Stutsman et al., 2006)	Translates the transmitted text but allow the source to keep on secret. The sender and receiver used key idea to hide information behind translation-based steganography in natural language translation.	Constant capacity value	Possible error encode algorithm
	Mark up letter (Sui & Luo, 2004)	Markup letter decide the secret bits to recover distance of hidden message. embeds the file with has no unwanted symbols in secret information	Useful hypertext	Low performance and security
	Secret steganography code for embedding (SSCE) (Banerjee, Batacharya & Synal,	Replace vowels and consonant based on grammatical sequence for cover text and then hidden message put in indefinite article for embedded in mapping information from non-particular English language.	Provide to use all letter of English font	Dependable with consonant and vowel words.

	2011)		
	Right-to-Left Remark and Left-to-Right remark (Odeh , Elleithy, & Faezipour, 2013)	hide the information this method convert to binary bits while 00 bits for add nothing, 01 bits for ad Right-to Left Remark (U200F), 10 bits for Left-to-Right Remark (U200E), and 11 bits combination of U200F and U200E	Useful in large capacity and	Low flexibility
	Deoxyribonucleic Acid (DNA) steganography (Reddy et al., 2014)	Represent binary bit 00, C for binary bits 10, G for binary bits 01, and T for binary bits 11. transformed DNA sequence into chipper text using look-up table.	Provide high embedding capacity	Limited method requirement
	Right remark, Left remark, Zero width joiner, and Zero width joiner (Odeh, Elleite, & Faizypour, 2014)	The algorithm used stego key and input carrier for created symbol table and binary representation for hidden bits to embed in the text	Simple equipment to cover data and easy modification	Depending with ASCII and Unicode
	Encryption with Cover Text and Reordering (ECR) (Kataria et al., 2013)	Reorders Eight bit random key with 0 bits describes cover text and 1 bit describes encrypted text.	Useful in large capacity and fast in embed hidden message	Complex requirement
b. Arabic and Persian based	Letter point in novel Arabic (Gutub &	uses binary bits when 1 bits are pointed letter with extension in Arabic character and for unpointed letter hold 0	Capable to embed a lot hidden message based extension	Only the characters with extension

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	Fattani 2007)	bits with extension	of letter.	can embed the stego text.
	Vertical displacement of the point (Odeh et al., 2012)	encode the number bits while the 0 bit encode for letter without the point or dot and 1 bit for encode letter with the point.	Capable to embed large hidden message.	Retyping remove the hidden message.
	Reversed Fatah (Memon, Khowaja & Kazi, 2008)	Uses reversed Fatah to embed the hidden message that had been converted into binary bits.	High invisibility and large capacity.	Retyping remove the hidden message.
	Secret key table encryption (SKT) and Characteristic Code Mapping (CCM) (Talip et al., 2012)	Uses vowel letters to connected consonant of word and designed part of punctuation to hide the information	Clear process embedding and extracting	Low security and performance
c. Chinese based	Rectangular region (Zhang et al., 2006)	Uses simple algorithm that based on content and explores the method based on mathematical expression and automatic generation in Chinese letter.	High robustness and transparency.	Medium letter for embed is limited.
	Simple substitution method (SSM) and high efficient substitution method (HESM)	Changes the traditional form corresponds to 1 bits and the unchanged feature correspond to 0 bits. It given the stego message based on bit what it is 0 bits or 1 bits and extracted the feature if appear in substitution dictionary.	Available embed more form binary bits depending of substitution.	Low security

	(Sun et al., 2010)			
d. Hindi based	Binary string (Ghosh & Debnath, 2010)	Uses longest common subsequence so to hide the message with minimal modification the feature of letter.		
	Specific matra (Changder et al., 2009)	compress the hidden message and translated length of compressed to binary bits containing matra	Large capacity	Retyping remove the hidden message
	Numerical code (Phatak, 2010)	Every letter in this technique encode based on represent four binary bits and has to consider the first letter to decode the information by chipper phrase.	High security, robustness and capacity	Consuming much time
	Finite state machine (FSM) (Das & Ghosh, 2010)	Encode a binary string with the *Finite State Machine* (FSM) to define transition function and transformable symbols in every category. To encode binary 0 bits select next symbol of transformable from same category, otherwise select next symbol of transformable does not same and apply the transformation	Has the standard model transition	Algorithm complex and consuming much time.
	Chain code using *ANOVA* (Alam & Naser, 2013)	translate code into the number signified contour border pixel direction where one pixel to next pixel converts part of the chain and concatenated to form a chain	Large availability letters to embed hidden message	Low security
	Hindi Text using Matraye (Nagarhali,	The vowel and matra add to consonant in Hindi letter, while matra itself ad in bottom and top of the consonant. The	Able to combine with technique linguistic steganography	Has a lot of classification of dividing letters.

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Bakal & Jain, 2016)	bottom matra hide 0 bits and the top matra hide 1 bits.		

Letter based

Change alphabet letter pattern (CALP) (Battacharya et al., 2011)	Hidden message embedded based on binary bits sequence those are; the letter I and j are character in alphabet have pointed are embedded in 0 bits and 1 bits embedded in character a, c and A	this technique can avoid steganalysis	Dependable with number of letter used convert
Curve subheading (CURVE), vertical straight line (VERT), and quadruple characterization (Dulera, Junwal & Dasguptaa, 2011)	Embed the message based on form of letter from the three techniques. Two techniques (CURVE and VERT) convert into 1 and 0 bits, while other technique (Quadraple) converts into 00, 01, 10, and 11.	Applicable to the soft-copy texts as well as hard-copy texts and cannot decode until is not aware about this technique	Easily to detect
Back end interface web page (Mahato, Yadav & Khan., 2013)	Hiding the information based on HTML attributes using binary bit when 1 bits for two sequent attributes of same tags and 0 bits for two sequent attributes of different tags are taken.	large capacity and Easily transmitted internet process and	Available just for HTML based and consuming much time
Compression ratio in Email (Kumar et al., 2014)	adds several random letter before the „@" symbol of email ids to magnify randomness	Large capacity for embedding.	Available for email environment only
Huffman Compression in Email Based (Kumar et al., 2016)	Set the hidden message in four characters before „@" symbol and also embedding the hidden message after „@" symbol in email address.	Can minimize the necessary medium and large hiding capacity.	Available for email environment only
Alphabet Pairing	Arrange with acrros the	Good	Algorithm

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Text (Iyer & Lakhtaria, 2016)	message that consists of 4 parts that have 2 binary bits	performance robustness and large embedding Capacity	Complex and Depending with ASCII.

The advantages and disadvantages of feature-based technique during last decade have been presented in Table 2.2. In feature-based, three advantages in word-rule based also occurred in feature-based technique such as:

- The high performance implementation of technique has some varieties; in English based technique using encryption with cover text and reordering (ECR) technique has fast process embedding (Kataria et al., 2013), High invisibility in Arabic based using reversed fatah technique (Memon, Khowaja & Kazi, 2008), has standard model transition in Hindi based using finite state machine (FSM) technique (Das & Gosh, 2010), and in letter based using Back end interface web page (Mahato, Yadav & Khan, 2013).

- Some of technique in feature-based also can embed hidden text in large capacity likes in category language based; can hide large capacity in English based using Deoxyribonucleic Acid (DNA) steganography technique (Reddy et al., 2014) and in Arabic based with reversed fattah (Memon, Khowaja & Kazi, 2008),vertical displacement technique (Odeh et al., 2012). In Hindi based technique of specific matra (Changder et al., 2009) and chain code technique (Alam & Naser, 2013) also can embed hidden message in large

capacity. The letter based text steganography techniques compression ratio also can embed a lot of hidden message (Kumar et al., 2014; Kumar et al. 2016).

- The advantage feature-based technique is also similar with word-rule based likes useful for category English based using hypertext in markup letter technique (Sui & Luo, 2004) and for Secret Steganography Code for Embedding (SSCE) technique can use all of letter English font be the medium of hidden message (Banerjee, Batacharya & Synal, 2011). Other technique in feature-based also has other advantages in implementation of development technique. Some technique in feature-based has implemented protection in embed the hidden message like high robustness in rectangular region technique in Chinese based (Zhang et al., 2006), numerical code technique in Hindi based (Phatak, 2010) and change alphabet letter pattern technique a recommended to avoid steganalysis (Battacharya et al., 2011).

Furthermore, the disadvantages of feature-based technique based on Table 2.2 can summarize as:

- Easy to detect existence technique of steganography in the text. But during the last decade using feature-based technique only technique Curve subheading, vertical straight line, and quadruple characterization by Dulera, Junwal and Dasguptaa (2011) can be easily to detect. However, easy to attack that can make the hidden

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message removed also existed in several technique likes retyping in Arabic based using reversed fatah technique (Memon, Khowaja & Kazi, 2008) and vertical displacement of the point (Odeh et al., 2012). Similarly, the removed message existed in Hindi based using specific matra technique (Changder et al., 200).

- The certain techniques in feature-based also have certain problem in implementing the algorithm; in English based using machine translation has often error encode algorithm (Stutsman et al., 2006) that similar with FSM technique in Hindi based (Das & Ghosh, 2010), Right-to-Left Remark and Left-to-Right remark is not flexible technique (Odeh , Elleithy, & Faezipour, 2013). Some performance of technique also dependable with requirement of technique if the requirement of technique not exist, the technique could not use; dependable with ASCII in English based technique using remark joiner (Odeh, Elleite, & Faizypour, 2014), dependable with vowel and consonant word in technique SSCE (Banerjee, Batacharya & Synal, 2011). In Arabic based technique using letter point is dependable with extension character (Gutub & Fattani, 2007).

- The time consuming in process embedding or extracting hidden message in the text was also disadvantage in feature-based technique. (Phatak, 2010).

In addition, this study underlined the letter-based as the part of feature-based technique that has a unique process which could be implemented in other language.

Then, among letter-based technique in Table 2.2 this study focuses on three schemes that had similar characteristic in covering the hidden message. Those are CALP (Battacharya et al., 2011), CURVE and VERT (Dulera, Junwal & Dasguptaa, 2011) that embeds the hidden message by converting in the form of single binary bit (0 and 1) as the development for covering the message in the text.

The next section will continue to elaborate the linguistic steganography methods as the comparison of the development of text steganography methods during last decade.

2.5 Linguistic Steganography Methods

Linguistic steganography is covering the secret information concern to language of word and order modification linguistically for encoding the message. This section presents the linguistic steganography that used steganography technique. Most of techniques in linguistic steganography had been used is the synonym substitution. Synonym substitution can be used in any language as long as the language the text of language has synonym word. As the comparison with text steganography method recapitulation linguistic steganography in last decade are presented in Table 2.3.

Table 2.3

Recapitulation linguistic steganography

Techniques	Specific Methods	Embedding Techniques	Advantage	Drawbacks
Synonym substitution	English text (UK and US) (Shahreza & Shahreza, 2008)	Composes hiding program that checks the current word in list the text and concerned data to establish of 0 and 1 bits while US sentence for hide 0 bit and UK sentence for hide 1 bits	Recommended use in printing text electronic.	Low security
	Malay linguistic (Muhammad et al., 2009)	Cover the text in first word and replace it with synonym or not replace it based on value the first bit in ASCII code, whhere 0 bit no replacement word and 1 bit word replaced by recognized synonym word and also repeated in every of ASCII character in secret information.	High invisibility	Consuming much time
	Chinese text (Yuling et al., 2007)	Uses disambiguation role Chinese text, conditional window of sentences, and substation of synonym set were guaranteed.	Simple and effective variants,	Limited Portion capacity

Chinese text using Word Sense Disambiguation (WSD) (Lu et al., 2009)	Combines similarity to discharging Word Sense Disambiguation (WSD) the accuracy level.	Enhanced the anti-attack watermarking ability and high robustness.	Dependable with WSD tools.
Spanish language using Synonym paraphrasing (Munoz et al., 2010)	Uses dictionaries to substitution word-list synonym those are huge synonym dictionary, verb inflection dictionary, and a noun adjective inflection	Obvious capable use in Spanish language	Easy to attack and narrow volume number
English text using context-based (Wang et al., 2013)	Establish the conditional of equivalence demonstrative adjective ubiquitous and definite article in natural texts to embed secret information	Minimalized create the syntax error which suggests the concealment steganography.	incomplete vocabulary and narrow scales dictionaries
English text using *LUNABEL* function (Chand & Orgun, 2006)	Uses target specific classes of content word for substituted and created text that conserves semantic context and syntactic structured real text.	High invisibility and robustness	Complex algorithm
English text using *SemEval lexical* (Chang & Clark, 2010)	Embed with finding possible information to hide and checked the synonym for encode available carrier for generate	High possibility suitable word for substitution.	High maintenance the grammar text

		hidden message form stego text		
	Traditional synonym substitution (Qi et al., 2013)	Uses traditional synonym substitution and coding schedule and then record the embedding to extract hidden message with abandoned the synonym.	Large capacity and recommended avoid steganalysis	Complex algorithm
	English text using mark-insertion (Topkara et al., 2006)	Adjusted the similarity two words with same meaning based on *WordNet* which is English dictionary manages noun, verb, adverb, and adjective in synonym sets.	Achieve almost in maximum cumulative distortion	Dependable with language model algorithm
Semantic Transformation	*Ontological Semantic Technology* (OST) (Hempelmann & Mehra, 2011).	Created text meaning representation to accept abnormally low number text produces and clauses number in relation text semantically light	High security in filtering syntactic correctness	Generate a lot of semantic spam

Table 2.3 depicts the advantages and disadvantages of linguistic steganography during last decade. The advantages of techniques based on Table 2.3 are highlighted as:

- Unlike text steganography, linguistic steganography especially in synonym substitution technique has own implementation performance; high invisibility in technique Malay linguistic

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(Muhammad et al., 2009) and English text using LUNABEL function (Chand & Orgun, 2006), simple variant in Chinese text synonym (Yuling et al., 2007), minimalized create syntax error in English text using context-based (Wang et al., 2013), and in English text using mark-insertion can achieve maximum cumulative distortion (Topkara et al., 2006).

- The traditional synonym substitution technique (Qi et al., 2013) also can hide hidden message in large capacity.

- Linguistic steganography has advantage in specific condition are useful in printing text using synonym substitution (Shahreza & Shareza, 2008). Other technique has this advantage like synonym paraphrasing that is very useful in Spanish language (Munoz et al., 2010).

- Some technique in feature-based has privilege protection in embed the hidden message like high robustness in rectangular region technique in Chinese based (Zhang et al., 2006), numerical code technique in Hindi based (Phatak, 2010) and one of technique recommended in feature-based able to change alphabet letter pattern technique to avoid steganalysis (Battacharya et al., 2011).

Meanwhile, the disadvantages in this technique based on Table 2.3 are:

- Low security also is the issue in linguistic steganography especially in synonym substitution (Shahreza & Shahreza, 2008) and technique

synonym paraphrase in Spanish language is easy to attack (Munoz et al., 2010).

- The obvious issue in implementing of linguistic steganography is only useful in own language because this technique based on linguistic and other limitation of this technique is it has a complex algorithm in English text using LUNABEl function (Chand & Orgun, 2006) and using traditional synonym substitution (Qi et al., 2013). In English text using context-based has incomplete vocabulary (Wang et al., 2013). Then, in semantic transformation technique the performance possible generates a lot of semantic spam.

- The time consuming in process embedding/extracting hidden message in the text was also disadvantage in linguistic steganography technique likes Malay linguistic (Muhammad et al., 2009).

2.6 Discussion of Natural Language Steganography Domain

In this section, the steganography in medium of text is analyzed and discussed. Several graphs, figures, and tables are presented as a way to evaluate performance natural language steganography techniques.
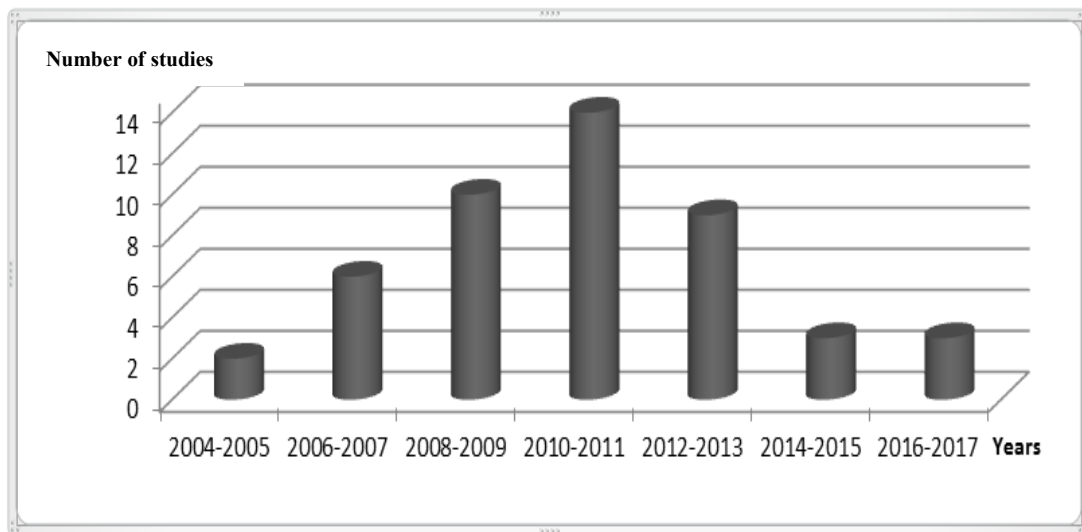
Figure 2.3. Variety of researcher effort about natural language steganography

Figure 2.3 showed a number of studies about steganography in medium of text in recent ten years. Figure 2.3 illustrates the general survey of natural language steganography as one of guidance for the researcher who has conducted the research in this area. Based on Figure 2.3 most of the studies focus on natural language steganography in last decade.
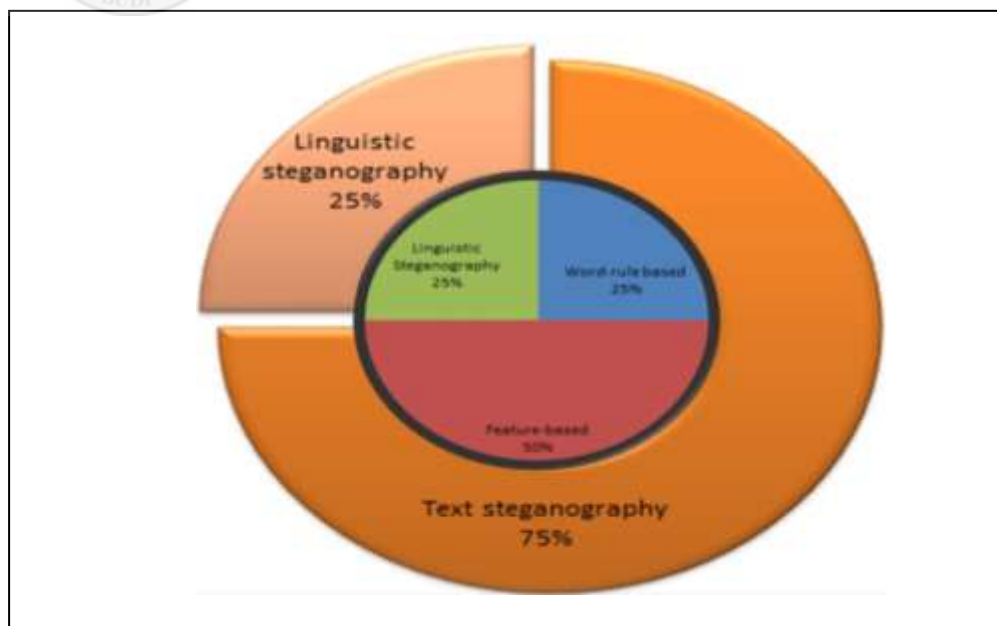
Figure 2.4. Percentage research about text and linguistic steganography

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Figure 2.4 illustrated the percentage of text steganography which are word-rule based and future based. In this figure included the linguistic steganography as the comparison of the technique that had been researched by precious researcher in last ten years. This figure showed feature-based has highest percentage, 50% while word-rule based and linguistic steganography has same percentage 25%.
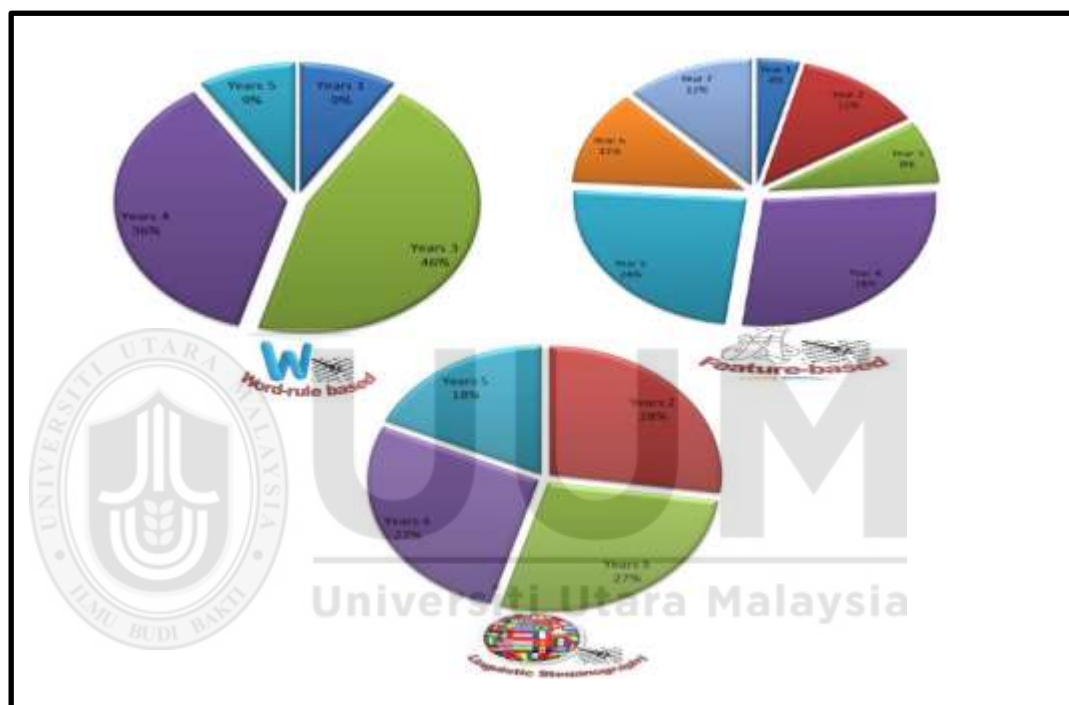
Figure 2.5. Comparison technique of natural language steganography

Figure 2.5 illustrated the comparison of natural language steganography on last ten years that had been studied by previous researchers. This figure compared the graphic two techniques text steganography which are word-rule based, feature-based, and one of technique in linguistic steganography. This figure specifically showed the feature-based in text steganography studied is more than word-rule based and even from linguistic steganography.

Based on the three figures, this study chose the feature-based technique because this technique is widely used by previous researchers. Then, the implementation of this technique could use in language. One of the feature-based is letter-based technique as the domain in this study. Because the letter-based is could be applied in any language that used A-Z letter. Therefore, this study is focusing in letter-based text steganography for measuring the performance of each technique. Then, the evaluation measurement of the proposed method has been done through verification and validation processes.

2.7 Evaluation Parameters

The important thing in order to fulfill essential and specific requirement of methods is the evaluation procedures. The function of evaluation is to predict the quality of requirements that will be used in developing the system. There are two vital procedures in evaluating performance of any method which are verification and validation. In general, verification and validation are determined by selecting relationship between models derived from several producers (Sergeant, 2012). Verification and validation process are used to provide the simpler proofs that a method could achieve better performance in developing system. Based on the last decade, the evaluation performance of the letter-based text steganography through verification and validation processes are shown in Table 2.4.

Table 2.4

The evaluation measurement of feature-based method

Feature-based Technique	Evaluation used		Reviews
Language Based	**Verification**	**Validation**	
Watermarking based on occlusive in Chinese text (Zhang et al., 2006)	Yes	No	*The technique they are used verified the component, Chinese letter, watermarked hosted rectangular and any other component.*
Reversed Fatah in Arabic. (Memon, Khowaja & Kazi, 2008)	Yes	Yes	*They verified the algorithm used in order to embed binary bits. However, only calculation capacity was used for validation measurement based on stego text and hidden message.*
Feature coding Indian language (Ghosh & Debnath, 2010)	Yes	No	*Their study verified model sequence algorithm for embedding binary bits.*
Re-Evaluating Chain Code (Alam & Naser, 2013).	No	Yes	*The technique using ANOVA measured variance, standard deviation and F-measure.*
ECR (Kateria et al., 2013)	No	Yes	*The technique used only validates the capacity ratio and running time overhead this technique.*
Right-to-Left remark and *Left-to-Right* remark (Odeh, Elleite & Faizypour, 2013)	No	Yes	*The study showed the validation of capacity web page for hiding data and total capacity ratio.*
Microsoft Word symbol Steganography (Odeh, Elleite, & Faizypour, 2014)	No	Yes	*The discussion on their study showed the validation of total calculation capacity carrier file, capacity ratio and also the show the comparison total of stego text that had been embedded in some news text.*
Letter-Based	**Verification**	**Validation**	
Change alphabet letter pattern (Battacharya et al., 2011)	No	Yes	*The technique their used were measured validation of technique through correlation-coefficient and Jaro winkler distance.*
Hypertext markup language (Mahato, Yadav & Khan, 2013)	Yes	No	*The obtained technique introducing and verified the technique with converting algorithm into programing language (HTML).*
Email based high Capacity (Kumar, Chand & Singh, 2014)	No	Yes	*The study about this technique only validate the measurement of running time and capacity of the system based on stego text and hidden message.*

Table 2.4 has shown the development of the evaluation in letter-based technique text steganography system. This study simplifies the criteria the measurement which are the group verification or validation because those researchers only mention the parameter used. Therefore, this study classified the measurements which parameter as the verification or validation groups. Based on Table 2.4 most of researchers focus on the either validation or verification measurement and only one technique proposed by previous researchers (Memon, Khowaja & Kazi, 2008) that used verification and validation The next section reviewed about verification and validation processes..

2.7.1 Verification Process

The verification process is determining the input and output variables, when the system due process or stop (Das et al., 2012). Some previous researchers used the measurement of verification and validation process with several reasons. There are two main reasons why verification process is used:

1. Verify the requirement exceptionally important to prevent expense impact and build the framework system (Nazir et al., 2014). Besides that, Ghuman and Lassig (2013) used verification measurement for requirements of system and application in approving correctness evaluation of the system in data source and for checking the model of systems. Moreover, Alves et al. (2013) also identify requirement system using verification process for gathered data in order to observe behavior of system in executed simulation process. Then, Rogovchenko et al. (2013) used verification for formulizing requirement for

identify relationship in fulfill each requirement that can be used through in simulation.

2. Verification can define the implementation of correct model. According Xinhua et al. (2007) that developed model verification for verifying structure of process in each rule for checking possible problem through evaluating matching rules and fact of process. Then, Sergeant (2012) confirmed computerized model verification by determining measurement of program computer is correct to implement. Moreover, Chen et al. (2010) using verification task for applied model perform verified that provided useful insight system to design the system. Furthermore, some researchers used the verification in order to measure their study parameters.

Wu and Yang (2013) proposed verification measurement in order to reestablishment the interval of algorithm. This measurement checked the presence of algorithm through decoding packet-based codes with compressed sensing via density evaluation. The main objective of this verification efficiently implemented the better performance algorithm and lower complexity in process decoding simulation.

Rahmat, Kamel and Yahya (2009) investigated the correctness data in signature of sensor performance. The technique of verification involved four phases of measurement. First, data acquisition is recycled as input device sensor. Second, feature extraction is consideration of extracted the data glove. Third, matching is used to measure the similarity input feature and identity model. Fourth, the decision is to imply the calculation of a decision threshold when matching get similarity.

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Usener et al. (2010) developed the software verification proofs in order to supported computer assessment. This software verification could obtain direct pre-evaluation on prospective error assessment in source code. The verification processes measured the algorithm and logic source code using some transformation rules such as rule for skip, rule for assignments, rule for sequencing, rule for conditionals, rule for while loops. This verification anticipated can prevent time consuming during process assessment in computer support. There some parameter metrics of verification process that had been used shown in Table 2.5 as follows.

Table 2.5

Parameter metrics of verification process

No	Verification Metrics	Source	Review
1	Correctness input data	(Daso & Funnes, 2007; Oberkampf & Roy, 2010).	It determines the accuracy of data input design that used for experimental design. This analysis is very important in order to ensure the availability of the input data that can be used in the technique. The technique verification that can aid in input data is with check consistency in using model cover text, hidden message and stego key.
2	Presence algorithm	Daso & Funnes, 2007; Catal, 2012; Oberkampf & Roy, 2010).	Presence algorithm is ascertains the availability of the obtained technique in order to develop system in process design. In this research, embedding through the stego key used is the algorithm experimental. Thus, verification in algorithm use will be to make construct synchronous encrypting cover text and hidden message in embedding process and decrypting in the embedding process.
3	Loading velocity	(Oberkampf & Roy, 2010)	Loading velocity is used to determine speed of each technique in embedding process the algorithm hidden message and also check of the speed of normal input environment to get normal text. Loading velocity of the text steganography is different based on the stego key technique

			in order to embed hidden message.
4	Examine process evaluation	(Oberkampf & Roy, 2010)	Examine process simulation verification involves type of numerical errors in order to verify the accuracy tools in simulation. These verification measurements will facilitate the process in generating output in form of clear text or stego text in the system.
5	Correctness output data	(Daso & Funnes, 2007; Oberkampf & Roy, 2010; Catal, 2012;)	Correctness output data used to determine the correctness the post process simulation in the system. Thus, the output data have to be similar with the input data in experimental design. It means the hidden message selected that had been embedded should be similar with the hidden message obtained after the stego text had been extracted.
6	Contain letter dataset	(Satir & Iskik, 2012)	Contain letter used in order to determine the total number of character cover text, hidden message and stego text. It used to measure the length character datasets.
7	Capacity size dataset	(Majerjak et al., 2013)	Capacity input datasets used determine the size bit of dataset. In text steganography, it can figure out the total size of cover text and hidden message.

In Table 2.5 showed some of parameter metrics that able to use in verification process. Those are the parameter metrics that can used as tools that measured the system in domain of text. Furthermore, parameter metrics in Table 2.5 could be the options to verify the technique of letter-based on text steganography. This study chooses contain letter dataset and capacity size dataset in order to verify the effectiveness and security performance of the technique. It adjusted with this study that the parameter contain letter dataset are discovered the letter used and letter unused that embedded by hidden message while, the capacity dataset used parameter capacity size bit of the text. With verification metrics, the effectiveness in the system could be verifying the correctness of input data and contain dataset process in evaluating development of model (Oberkampf & Roy, 2010). In text steganography,

examining the contain dataset could be verified by measuring the length of character and capacity of embedding process as process verification approach (Satir & Iskik, 2012). Both of verification able to notice the category effectiveness performance in side capability covers the hidden message and capacity embed text in letter-based technique (Wen, 2009). Meanwhile, in low security of covering hidden message the measuring length of character as the parameter could be used in order to figure it out the availability the stego text that had been embedded with hidden message. It because the common security involves availability in order to ensure the information has been accessed by authorized user (Kaufman, 2009). In text steganography, measuring the availability in security is used to ensure the hidden message properly embedded in the text.

2.7.2 Validation Process

Generally, validation is generating the expected output from testing process that can prevent problem in systems or applications (Ling et al., 2008). There also two main reasons why process of validation is used;

1. In validation measurement process quite similar with verification process, but it has different rules. According to Marincic et al. (2011) that performed validation for design element in structured model is based on verification activities and validate confidence with verification result. Then, Sergeant et al. (2012) defined validation as the substation that model on computerized applicability keeps acceptable range accuracy consistent with the envisioned application of the model in the domain.

2. Validation can guarantee the final system reflect directly encouragement constancy and quality for established requirement in delivering the system (Alves et al., 2013). Then, validation through testing assured representative an expected outcome or result. According Ling et al. (2008) used validation testing functionalities and error point with analyzing input system to check construction system from beginning.

There several parameters matric of validation processes in order to measured system performance are shown in Table 2.6 as follows.

Table 2.6

Parameter metrics of validation process

No	Validation Metrics	Source	Review
1	Running Time	(Daso & Funnes, 2007; Oberkampf & Roy, 2010; Catal, 2012).	The purpose of running time measurement is to measure the speed of the techniques in how consuming time in process embedding hidden message of feature-based technique. The running time is depending on input rate growth of time.
2	Precision rate	(Daso & Funnes, 2007; Oberkampf & Roy, 2010; Catal, 2012).	The purpose of precision rate is to measure accuracy a definite data system that has been predicted. This parameter measurement is based on four possible outcomes (Kohari & Goyal, 2013; Fawcett 2005). These outcomes are: ○ *True positives (TP)* When hidden texts that are correctly embedded as stego text. ○ *True negatives (TN)* When hidden texts that are correctly embedded as non-stego text. ○ *False negatives (FN)* When hidden text that are incorrectly detected as non-stego text. ○ *False positives (FP)* When hidden text that are incorrectly detected as stego text. These are outcomes also use in other parameter measurements. The

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			measurement in considered data system used true positive and false positive numbers for calculates the precision.
3	Accuracy rate	(Daso & Funnes, 2007;Oberkampf & Roy, 2010; Catal, 2012).	The purpose of accuracy value is measured as arrangement closeness between values that get from technique reference and value obtained by alternative technique.
4	Recall rate	(Daso & Funnes, 2007;Oberkampf & Roy, 2010; Catal, 2012).	The purpose of recall rate is to measure prediction model in set of data and calculate the probability of detection or sensitivities in the text. Similar with precision, recall also use number true positive, but it uses false negative for considered data system.
5	F-measure rate	(Daso & Funnes, 2007; Catal, 2012; Fawcett, 2005; Oberkampf & Roy, 2010).	The purpose F-Measure rate is to evaluate the performance of embedding and analyzing text for determines to obtain stego text as the output
6	Correctness output data	(Daso & Funnes, 2007; Oberkampf & Roy, 2010; Catal, 2012)	The accuracy rate is measured as arrangement closeness between values that is generated from technique reference and value obtained by alternative technique.
7	Statistical possibility	(Daso & Funnes, 2007; Oberkampf & Roy, 2010; Catal, 2012)	There are three parameter metrics to measure inside statistical probability those are o Means is to estimate the comparison the computational result with measurement of experimental that considered for prediction accuracy. o Variance is to measure dissemination variable in sample data and delivers the accuracy points of each data. o Standard deviation is to concentrate on average length sample data in each point in order to get original measurement units.

Table 2.6 showed some parameter that can use in validation process. These parameter metrics that had been used by some researchers in the system developed. The parameter metric that has been validating in system is deserved to use after

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developing the technique. This study choose running time which adjusted become embedding time and precision, recall, and accuracy rate that recommended in order to figure performance in term of effectiveness and security.

Furthermore, the previous researchers used parameters metric for validation process in order to measure the system in their domain are:

Arora, Raghunathan, and Jha (2005) evaluated run-time of security program data properties in order to develop framework security assurance towards a wide class of security attack. The run-time security data validated in order to ascertain compilation and execution time in software security for prevent time consuming in memory requirement software. Then, this kind evaluation is useful for enhancing the development of performance system is more accurate and faster.

Cruickshank, Michael, and Shing (2009) used the validation measurement in software safety requirement in order to validate the development of system protection requirement software. The parameter of validation used for software safety requirement was Rapid Action Surface to Air Missile (RASAM) metric for identify the number of software resultant. This parameter determined percentage software to assume as the software system success and percentage software safety requirement to utilize the set similarity of software intensive system.

This study chooses parameters running time, precision, recall, and accuracy rates as the metrics of validation measurements. It is because the effectiveness performance could be validated using precision rate parameter according Moffat and Zobel

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(2008). The precision rate result determines the accurate level of information and system model in the effectiveness performance. Meanwhile, for low security problem the precision rate also recommended as parameter to security development. It is because precision rate determine the accuracy defined data in the model. Furthermore, the other validation could be used are recall and accuracy rates. Because the recall rate determine the security in term of correctness and sensitivity of data chosen, while accuracy rate is the ratio of accurately predicted observations that determine whether it is appropriate or unsuitable arrangement value of model. The value of accuracy rate determines the closeness prediction level of security with the model performance (Daso & Funnes, 2007; Christen & Goiser, 2007).

Therefore, based on above explanation it is important in development of letter-based technique in text steganography through verification and validation processes in order to evaluate the strength of technique on text steganography system.

2.8 Summary

In this chapter is concluded a survey for natural language steganography technique in hiding the information in text medium. This survey has reviewed some published articles about technique in steganography in medium of text.

This chapter presents broad categories natural language steganography method that focused to text steganography consist of web-rule based and feature-based that compared with one of natural language, linguistic steganography. In web-rule consist in two techniques in embed hidden message those are line-shift coding that horizontally and word-shift. The first category is language based that used feature-

based technique based on language text which in used in this world such as English based, Arabic and Persian based, Chinese based, and Indian based. Then, the second category is letter-based that establish the feature-based technique based on any language that A until Z letter. Furthermore, this chapter showed that feature-based the most technique that had been used in area steganography in text medium than can classified into many of languages. Therefore, this study chooses letter-based technique as the domain to evaluate the model of text steganography.

In addition, this chapter also discusses about measurement process verification and validation as standard measurement in order to proof achievement expected result in process in this study. The next chapter will cover the theoretical process of the method and formulization of parameters.
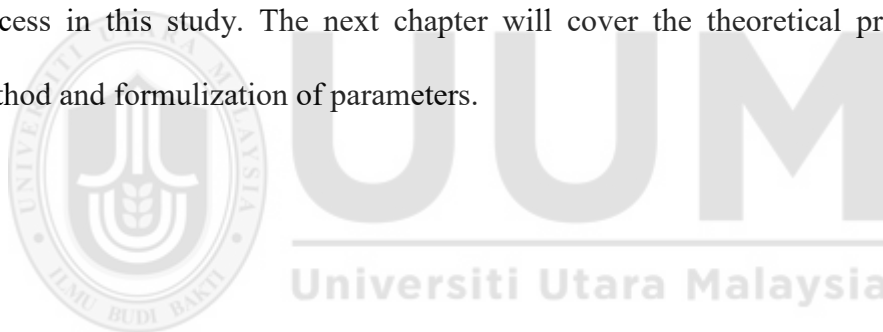
CHAPTER THREE
RESEARCH METHODOLOGY

3.1 Introduction

This chapter presents the phase of research methodology which describes the concept and technique used in order to achieve the objectives of the study. These include problems of conditional text steganography in using the proposed technique and requirement of feature in order to measure the letter-based technique. The main contribution of this research is to evaluate the parameters used for verifying and validating the letter-based technique steganography on text domain. The research design comprises of three phases; theoretical study, experimental design and output environment as shown in Figure 3.1
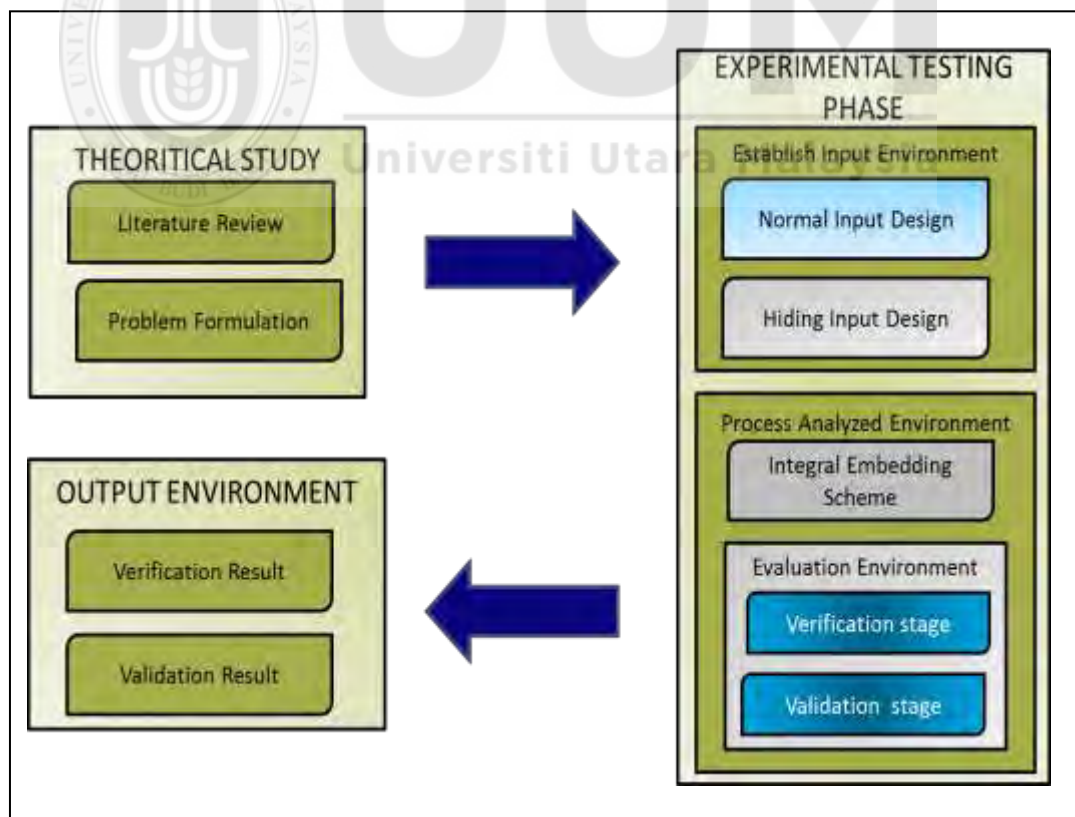
Figure 3.1. The research design

This chapter moves toward the suggestions to discover the problem from the issue and present some activities that will be carried out to achieve the research objectives. Section 3.2 discusses the theoretical study and section 3.3 presents the process of the experimental design and the evaluation procedures. Finally, Section 3.4 discusses the output environment.

3.2 Theoretical Study Phase

Theoretical study phase aims to critically analyze the existing research in this domain area in order to identify the issue that needs further investigation. After analyzing the previous and recent literature, the issues were identified accordingly whereby in the domain of text steganography, the changes that happened in text are easily discoverable. This leads to more fundamental issue that is lack of effectiveness and low security of the technique due to most existing technique do not conduct the process of verification and validation as part of the evaluation phase during the development of the particular technique. These issues were identified during further analysis done on the literature. The next section will describe further the experimental design that has been conducted to achieve the targeted objectives.

3.3 Experimental Testing Phase

This experimental testing phase is developed to further discover the existences of problem that is lack of effectiveness and low security in this technique. This letter-based technique consists of letters from A until Z. This phase is divided into three major activities which are; establishing input environment which consists of normal

input environment and hiding input environment. Next activity is processing the analyzed environment which part of development to integrated embedding algorithm and the evaluation parameters. The final activity of this phase is getting the output environment which defined the evaluation process based on verification and validation result. Figure 3.2 illustrates the activities involved in this phase.
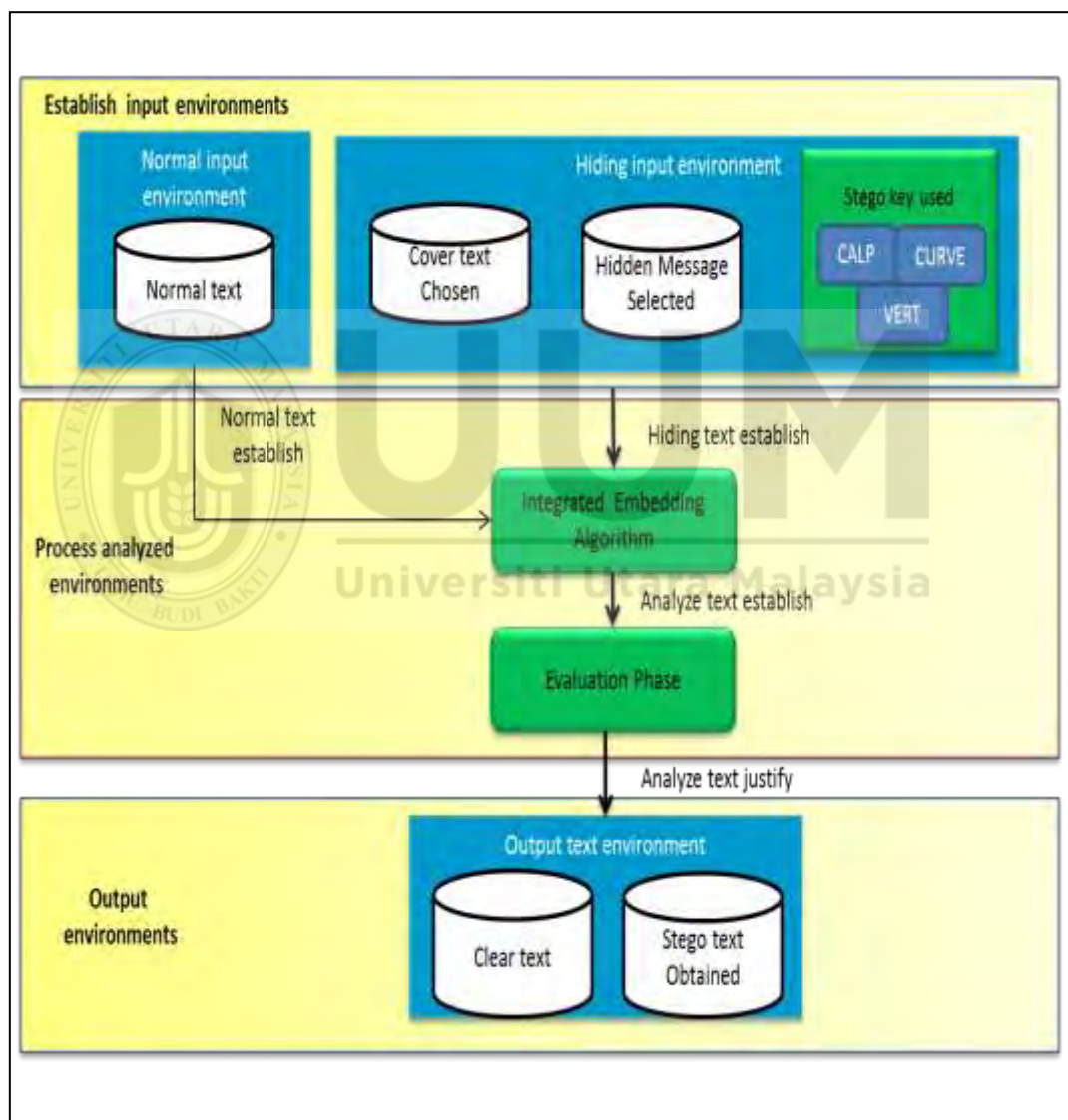
Figure 3.2. Activities involved in experimental testing phase

3.3.1 Establish Input Environments

First sub-activity in this phase is establishing the input environments that are used for designing the input. It has two types of environment which are the normal environment and hiding environment.

Hiding input environment is part of establishing input environment as main input to do the process of text steganography by using letter-based technique. This environment has three components which are cover text chosen, hidden message selected and stego key obtained.

Cover text is the original text that would be embedded in hidden message in process to hide information. Similar with normal text, cover text that was used was taken from *Reuters 21578* (Debola & Sebastiani, 2005). Besides that, it also uses common text paragraph in plain text (.txt) documents. Example on of dataset that is used as cover text is shown in Figure 3.3.

Figure 3.3. Example of cover text from Reuter News 21578 text

The example of the cover text from *Reuter news 21578* becomes the medium for hiding the hidden message. This means that the letter-based technique embedded the hidden message in this example dataset.

The hidden message selected is in the form of binary bits and would be chosen to be embedded in cover text based on each schemes of the technique. In this study, the hidden message has the same format with cover text that is plain text (.txt) documents using *sentences in the language* dataset (Davila, 1999).

```
the boy with the horse is in the park
the girl with the horse is in the park
the boy is in the park with the horse
the girl is in the park with the horse
the boy with the boat is in the park
the girl with the boat is in the park
the boy with the car is in the park
the girl with the car is in the park
the boy with the horse was in the park
the girl with the horse was in the park
the boy was in the park with the horse
the girl was in the park with the horse
the boy with the boat was in the park
the girl with the boat was in the park
the boy with the car was in the park
the girl with the car was in the park
the boy is in the park with the boat
the girl is in the park with the boat
the boy is in the park with the car
the girl is in the park with the car
```

Figure 3.4. Example of hidden message

Meanwhile stego key is a component that enciphers the encrypted embedding algorithm and deciphers the extracted message (Agarwal, 2013). In this research, the categories of technique used are letter-based. This technique used a stego key which is very important in the embedding process. There are three stego keys used in embedding scheme using Java programming language. Those three schemes were

chosen because the implementation of them is based on the same approach. The schemes are relying on the usage of single binary bits in the conversion process while the algorithm and group ID has been provided by previous researcher (Battacharya et al., 2011; Dulera, Junwala & Dasguptaa, 2011; Banerjee, Batacharya & Synal, 2011). The aforementioned schemes were Changing Alphabet Letter Patterns (CALP) (Battacharya et al., 2011), Curve in Character Subheading (CURVES) and Vertical Straight Line (VERT) (Dulera, Junwala & Dasguptaa, 2011).

First, CALP mapping the binary to attempt manipulating English letter sequence of the hidden text through pattern change of several letter of the cover text during embedding process. CALP is using unused symbol of ASCII number system for the pattern. Mapping sequences of this scheme focus on letters *"i"* and *"j"* because of those letter have dot (.) in the letter for embedding 0 bits. Then, for embedding 1 bits *"a", "A",* and *"c"* character will be used.

Secondly, CURVE is a scheme that divides the English letters into two groups based on the shape (i.e. whether a character has a curvature in its shape or not). The CURVE scheme as stego key is based on letter which contain full or partial curvature, meaning every words have curve will be identified as group ID (A) which refers to "*B, C, D, G, J, O, P, Q, R, S, U*" hide 0 bits of a hidden data. Whereas, a letter without any sort of curvature is identified as group ID (B) such as "*A, E, F, H, I, K, L, M, N, T, V, W, X, Y, Z*" hide 1 bits of a hidden data.

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Thirdly, VERT is a scheme that divides English letter into two groups too but based on a straight line in characters as the basis to group each letters. Similar with CURVES, VERT technique divided group letter into two group names. Group ID (A) that does not contain a vertical straight line hide 0 bit of hidden data such as "*A, C, G, H, M, N, O, Q, S, U, V, W, Y, Z*" and Group ID (B) is the letter that has vertical line character hide 1 bit of hidden data such as "*B, D, E, F, I, J, K, L, P, R, T*".

Therefore, these three schemes can be manipulated in English grammar and other multiple languages that use A until Z letter. All these are recent schemes introduced in text steganography which has the different uniqueness and flow algorithm in embedding the hidden message. Therefore, these three schemes becomes the main focus of this study in the effort to support the improvement in the development of letter-based technique in text steganography.

3.3.2 Process Analyzed Environments

The second activity is the main focus in this phase which involved several algorithms based on stego key of letter-based technique. In this section, process analyzed environments will be receiving the normal text environment from normal input established and receive input component established from hiding text environment.

The integration of the embedded scheme is the process of formulation scheme that will be chosen from one of several stego key algorithms. It is to convert the hidden message into binary bits and embed it into cover text to be the stego text. This

process received input text establish from establish environment, and determine the algorithm used based on what kind of stego key has been chosen. The model of integration embedding algorithm is shown in Figure 3.5.
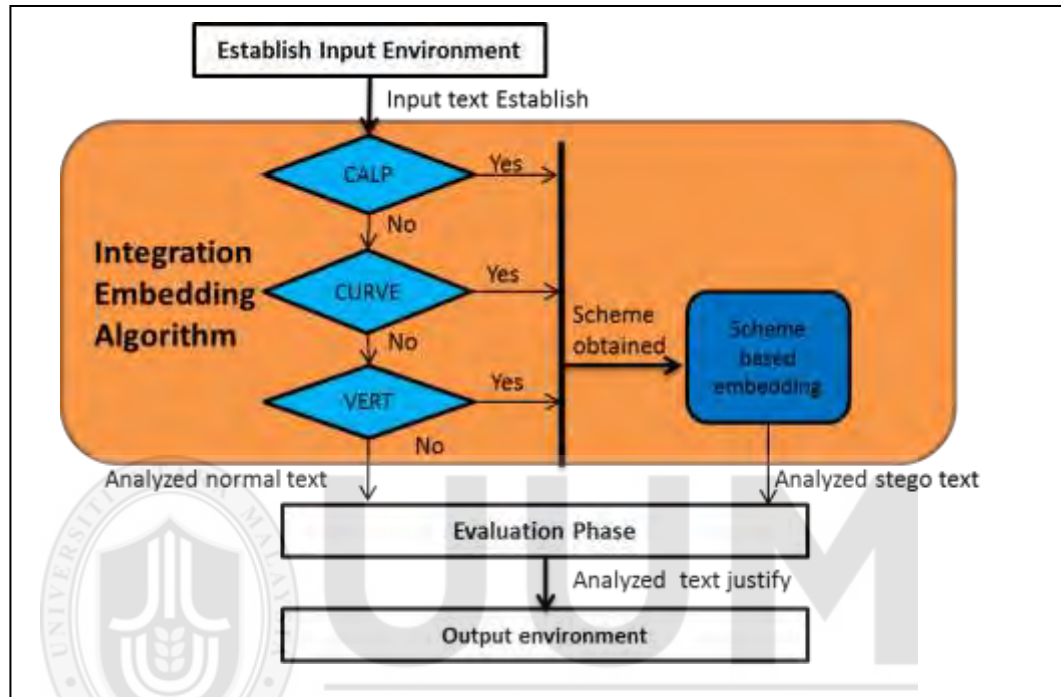
Figure 3.5. Visualize model of the integration embedding scheme

Integration embedding algorithm uses the three of schemes that can be chosen by users. Each scheme has the algorithm in form of pseudo code for embedding the hidden message in process analyzed environment. The following process integration embedding represent the pseudo code of letter-based techniques in each algorithm (Refer to Appendix E for detail source code of three schemes):

1. Pseudo code of embedding CALP

Scheme 1: CALP embedding process

Start

Generate appropriate COVER consisting of "A" or "a" or "c" and "i" or "j".

Let k be the size of the COVER. Copy the contents of the COVER into STEGO.   *(*)*

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For i=1 to k

if (COVER (i) =="a" or , "A" or ,"c") then

go to (MSG(j) =="1")then put STEGO(i)="a" or "A" or "c".   *(**)*

else if(COVER(i) =="i" or ,,j")

go to (MSG(j) =="0")then put STEGO(i)= "i" or "j".   *(***)*

   Insert i into array arr.

   Increment j

   if (j<N) Then false   *(****)*

Else end of if statement

End

There is four functions in develop of this algorithm:

   a. (*): is to generate component that need for CALP technique that will embed in content cover text that will be stego text.

   b. (**) : is to put letter *a, A*, and *c* for convert the hidden message to be 1 bits

   c. (***): is to put letter *i* and *j* for convert hidden message to be 0 bits.

   d. (****):is to put array for adjusting order of list

2. Pseudo code Embedding CURVE

Scheme 2: CURVE embedding process

Start

Generate appropriate COVER consisting of "A, E, F, H, I, K, L, M, N, T, V, W, X, Y, Z" And "B, C, D, G, J, O, P, Q, R, S, U". Let k be the size of the COVER.

Copy the contents of the COVER into STEGO   *(*)*

   For i=1 to k

   If (COVER (i) == "A, E, F, H, I, K, L, M, N, T, V, W, X, Y, Z") then

   go to (MSG (j)== "1') then put STEGO (i)= "A, E, F, H, I, K, L, M, N, T, V, W, X, Y, Z"   *(**)*

else if(COVER(i) == "B, C, D, G, J, O, P, Q, R, S,U")

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go to (MSG(j) =="0")then put STEGO(i)= "B, C, D, G, J, O, P, Q, R, S,U ".   *(***)*

      Insert i into array arr.

      Increment j

      if (j<N) Then false   *(****)*

Else end of if statement

End

There is four functions in develop of algorithm:

    a. (*): is to generate component that need for CURVE technique that will embed in content cover text that will be stego text.

    b. (**) : is to put letter *A, E, F, H, I, K, L, M, N, T, V, W, X, Y, Z* for convert the hidden message to be 1 bits.

    c. (***): is to put letter *B, C, D, G, J, O, P, Q, R, S,U* for convert hidden message to be 0 bits.

    d. (****): is to put array for adjusting order of list.

3. Scheme Embedding VERT

Algorithm 3: VERT embedding process

Start

    Generate appropriate COVER consisting of "B, D, E, F, I, J, K, L, P, R, T" and
    "A, C, G, H,M, N, O, Q, S, U, V, W, X, Y, Z". Let k be the size of the COVER.
    Copy the contents of the COVER into STEGO   *(*)*

      For i=1 to k
      If (COVER (i) == "B, D, E, F, I, J, K, L, P, R, T") then
      go to (MSG (j)== "1') then put STEGO (i)= "B, D, E, F, I, J, K, L, P, R, T"   *(**)*

    else if(COVER(i) == "A, C, G, H,M, N, O, Q, S, U, V, W, X, Y, Z")
    go to (MSG(j) =="0")then put STEGO(i)= "A, C, G, H,M, N, O, Q, S, U, V,
    W, X, Y, Z ".   *(***)*

There is four functions in develop of this algorithm:

a. (*): is to generate component that need for CURVE technique that will embed in content cover text that will be stego text.

b. (**): is to put letter *B, D, E, F, I, J, K, L, P, R, T* for convert the hidden message to be 1 bits.

c. (***): is to put letter *A, C, G, H,M, N, O, Q, S, U, V, W, X, Y, Z* for convert hidden message to be 0 bits.

d. (****): is to put array for adjusting order of list.

3.3.3 Evaluation Phase

The purpose of this phase is to evaluate the performance of letter-based technique. There are two processes in this phase that considered for verification and validation process. Both of processes are the principal in assessing accuracy result in computational condition. Consequently, this process justified the performance of letter-based technique obtained in the system. The design of evaluation performance parameters are showed in Figure 3.6 as follows.
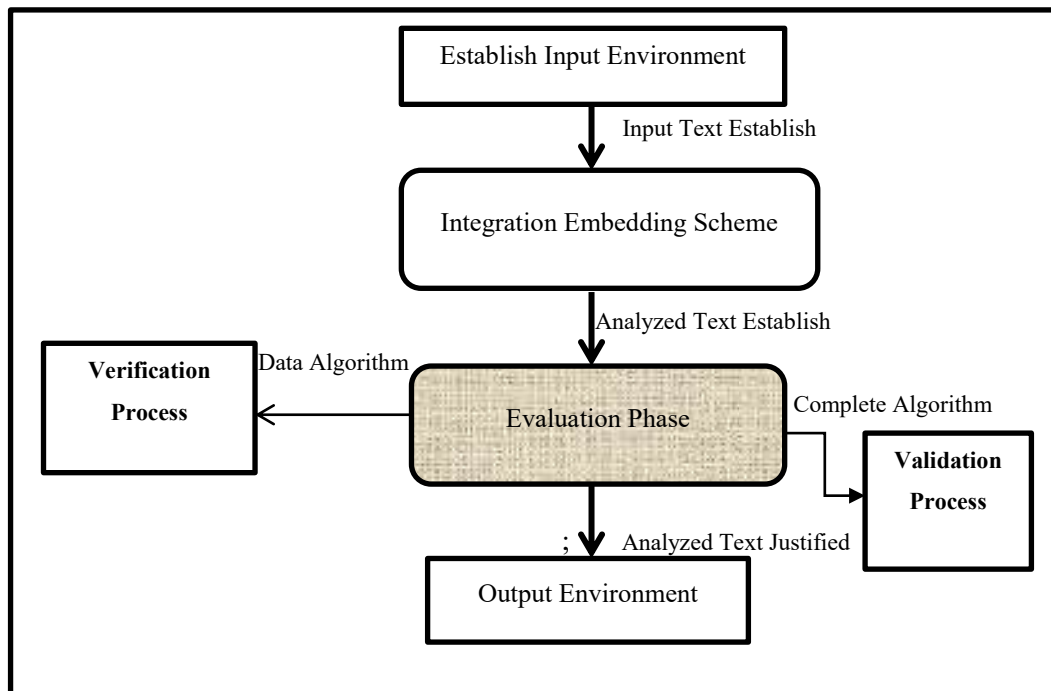
Figure 3.6. Design of Evaluation Procedures

a. Verification Process

Verification process is to determine the correctness in developing the model. In this study the parameters that will be used for verification process are:

a) Character length types of letter used;

   The number characters which are embedded by binary bits of hidden message in stego text.

b) Character length types of letter unused;

   The number characters which are not embedded by binary bits of hidden message in stego text.

c) Bit size types hidden message toward stego text;

   The comparison capacity of size bit among stego text after embedded by hidden message.

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d) Bit size types cover text toward stego text;

The comparison capacity size bit cover text with the stego text.

Those parameters were chosen due to its ability to discover the requirement model of letter-based on text steganography. The verification process aims to verify the effectiveness of the technique by examining the correctness input data contained in the dataset. These parameters are also used for security performance in order to verify the availability the hidden messages are embedded correctly in the text. Furthermore, the bit size types cover text and hidden message toward stego text used in order to notice the effectiveness capacity of text that had been embedded.

b. Validation Process

The validation process aims to determine the accuracy of the model representation by comparing experimental with computational data. The parameters used in this processes are:

a) Embedding time

The number of time of embedding in process generating the stego text

b) Precision rate

Measuring ability of the technique to embed only the exactly stego text. The equation is based on four possible outcomes (Kohari & Goyal, 2013; Fawcett, 2005). These outcomes are;

- *True positives (TP);* when hidden texts that are correctly embedded as stego text.

- *True negatives (TN);* when hidden texts that are correctly embedded as non-stego text.

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- *False negatives (FN);* when hidden text that are incorrectly detected as non-stego text.

- *False positives (FP);* when hidden text that are incorrectly detected as stego text.

The equation of precession rate is;

$$Precision = \frac{TP}{TP+FP} \qquad (3.1)$$

c) Recall rate

Measuring ability of the technique to embed stego text, with the equation as follows

$$Recall = \frac{TP}{TP+FN} \qquad (3.2)$$

d) Accuracy rate

Measuring ability of the technique used to correctly embed the stego text and correctly non-stego text.

$$Accuracy = \frac{TP+TN}{TP+TN+FN+FP} \qquad (3.3)$$

The parameters above are used to measure items such as precision, accuracy and recall in order to discover ability of the method. Therefore, the parameters are able to measure the quality performance of the system (Daso & Funnes, 2007; Oberkampf & Roy, 2010; Catal, 2012). The embedding time used in order to validate the time consuming in process embedding the hidden message. The Precision rate used in order to validate the effectiveness and security performance in determined the accurate level of information can be useful (Moffat & Zobel, 2008). Then, the recall and accuracy rates determine the security in term of correctness and sensitivity of data chosen and suitable arrangement value of model.

3.4 Output Environments

Finally, the output environment obtains the data through input design to get the output data. This environment is generated with verification and validation parameters in letter-based technique in order to obtain the stego text output environment. The stego text output is the final output which is obtained from the embedded hiding input environment. It is then embedded and undergone verification and validation process with letter-based technique based on the stego key. Furthermore, the process of performance evaluation in output environment obtained the result from process verification and validation to determine the performance of the system.

3.5 Summary

This chapter organizes a detail description of the research methodology. The beginning of this chapter illustrated the overview of the research design which is divided into three major phases" namely theoretical study, experimental testing and output environment. Theoretical study phase is the initial stage whereby the activities started from reviewing and analyzing the literatures until the research problem is formulated. Then, the experimental testing phase for establishing input environment and analyzing process environment has been the focus in this chapter.

Whereas establishing input environment has discussed the necessary input components for establishing the system. This study chooses the three schemes under the letter-based technique such as CALP, CURVE and VERT. The choice was due to

the algorithm of those schemes are readily available provided by previous researchers ((Battacharya et al., 2011; Dulera, Junwala & Dasguptaa, 2011).

The process analyzed environment discussed about component data from established input in order to embedding process based on algorithm that used. Subsequently, this process presents evaluation of the research that uses verification and validation processes. Significantly, the output environment displays the result of evaluation after developing and measuring the determined parameters accordingly.

CHAPTER FOUR

MODELING DESIGN OF LETTER-BASED TECHNIQUE

4.1 Introduction

In this chapter, the design of letter-based model is developed before evaluation procedures are applied. The model being developed was based on letter-based technique that would be measured with some identified parameters as mentioned in previous chapter. Therefore, the chapter begins with introducing the stego key scheme and algorithm design. Then, it is followed with flow process, logical design and physical design of letter-based in text steganography.

4.2 Stego Key Scheme

Stego key acts as the principle component of steganography in the process of covering the hidden message. It is an algorithm that enciphers the encrypted embedding algorithm and deciphers the extracted message (Agarwal, 2013). This study utilizes the three stego keys as the schemes for letter-based text steganography. The technique consists of letters that were chosen in cover text that could be embedded by hidden message in the text. Table 4.1 displays the algorithm of the schemes in letter-based text steganography.

Table 4.1

Letter-based technique scheme

Group ID		Stego Key of Letter-based Technique	
ID		**One binary bits**	
	CALP	**CURVE**	**VERT**
A	i, j	B, C, D, G, J,O, P, Q, R, S, U	A, C, G, H, M, N, O, Q, S, U, V,
B	A, a, c	A, E, F, H, I,K, L, M, N,T, V, W, X,Y, Z	B, D, E, F, I,J, K, L, P, R, T

4.3 Algorithm Design of Embedding Technique

Algorithm design is a specific method used to create a formulation process in solving problems that have been identified as the solution based on theories applied for this study. Therefore, this study also presented the algorithm design of the three schemes of letter-based. The stego key schemes as shown in Table 4.1 can be converted into algorithm form. The implementation of the algorithm is shown them in Table 4.2 (Refer to Appendix E for detail source code of the embedding technique).

Table 4.2

Design of algorithm letter-based technique;

Technique	Task	Algorithm
CALP	Task 1	*Start*
		*//**Identify group hidden message character**//*
		Set character hidden message consisting of group
		Group A = "i, j"
		Group B = "A, a, c"
	Task 2	*//**Determine the character 0 bit**//*
		Set int = 0
		For i=0 to s

		If character = "i,j"
		Set group (c=="i.j")
		Set binary.chart (j) = "0"
	Task 3	*//**Determine the character 1 bit**//*
		Set int = 1
		For i=1 to s
		Else if character = "A, a, c"
		Set group (c=="A, a, c")
		Set binary.chart (j) = "1"
	Task 4	*//**Display the stego text**//*
		Then,
		Stego +=c of group
		arr.add(i) j++
		If (j = noOfElement)
		End
CURVE	Task 1	*Start*
		*//**Identify group ;hidden message character**//*
		Set character hidden message consisting of group
		Group A =" B, C, D, G, J,O, P, Q, R, S,U "
		Group B = "A, E, F, H, I,K, L, M, N,T, V, W, X, Y, Z"
	Task 2	*//**Determine the character 0 bit**//*
		Set int = 0
		For i=0 to s
		If character = "B, C, D, G, J,O, P, Q, R, S,U"
		Set group (c==" B, C, D, G, J,O, P, Q, R, S,U")
		Set binary.chart (j) = "0"
	Task 3	*//**Determine the character 1 bit**//*
		Set int = 1
		For i=1 to s
		Else if character = "A, E, F, H, I,K, L, M, N,T, V, W, X, Y, Z"
		Set group (c==" A, E, F, H, I,K, L, M, N,T, V, W, X, Y, Z")

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		Set binary.chart (j) = "1"
	Task 4	*//**Display the stego text**//* *Then,* *Stego +=c of group* *arr.add(i) j++* *If (j = noOfElement)* *End*
VERT	Task 1	*Start* *//**Identify group hidden message character**//* *Set character hidden message consisting of group* *Group A =" A, C, G, H,M, N, O, Q,S, U, V, W,X, Y, Z "* *Group B = "B, D, E, F, I,J, K, L, P, R,T ""*
	Task 2	*//**Determine the character 0 bit**//* *Set int = 0* *For i=0 to s* *If character = "A, C, G, H,M, N, O, Q,S, U, V, W,X, Y, Z"* *Set group (c==" A, C, G, H,M, N, O, Q,S, U, V, W,X, Y, Z") Set binary.chart (j) = "0"*
	Task 3	*//**Determine the character 1 bit**//* *Set int = 1* *For i=1 to s* *Else if character = "B, D, E, F, I,J, K, L, P, R,T"* *Set group (c==" B, D, E, F, I,J, K, L, P, R,T")* *Set binary.chart (j) = "1"*
	Task 4	*//**Display the stego text**//* *Then,* *Stego +=c of group* *arr.add(i) j++* *If (j = noOfElement)* *End*

Based on the algorithms as presented in Table 4.2, the three schemes had two groups ID which consist of group 0 bit and group 1 bit. The phases of the task that involved in the algorithms are:

a. Task 1: to identify the groups of each technique that will be chosen.

b. Task 2: to determining the 0 bit letter for CALP, CURVE and VERT schemes.

c. Task 3: to determining the 1 bit letter for CALP, CURVE and VERT schemes.

d. Task 4: to display the result of embedding process in form of stego text in CALP, CURVE and VERT schemes. Next section of this study is to implement the phases of the development the technique in form of flowchart diagram.

4.4 Flow Design of Embedding Technique

Flow process diagram are used in analyzing, designing, documenting or managing phases of the process. This study represents the letter-based technique in form of flowchart diagram in order to display workflow on how the techniques do the process according to phases. In letter-based technique, the flowchart consists of the integrated embedding and extracting algorithm.

The flow process integrated embedding technique displays on how the process is used to hide the hidden message based on scheme chosen as shown in Figure 4.1.
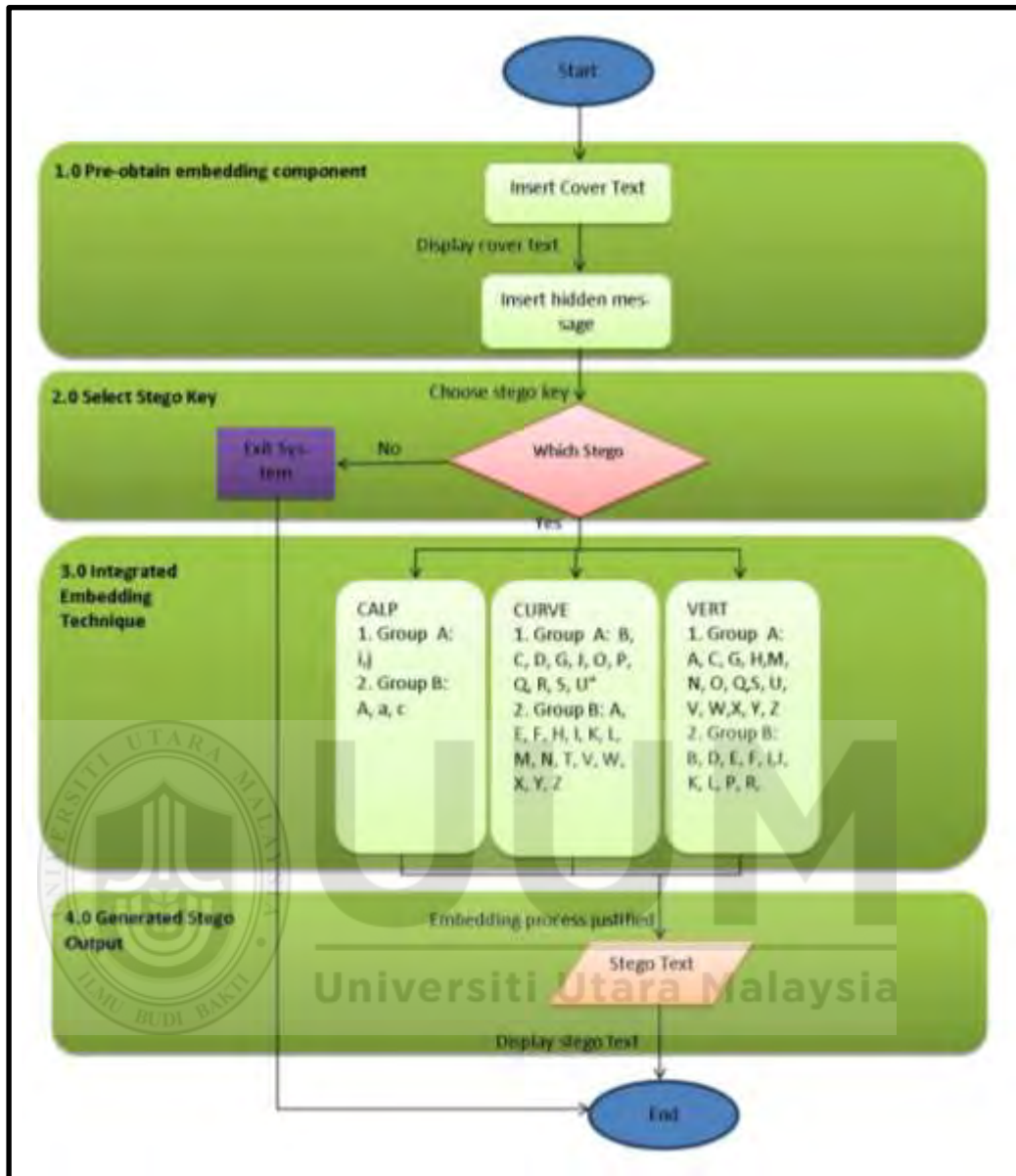
Figure 4.1. Flow process of embedding algorithm in text steganography system

Figure 4.1 illustrates the flow process of embedding letter-based technique starting with insert the cover text and the hidden message. The system has the options of stego key which consist of three schemes. Each stego key chosen generates the stego text that embedded with the hidden message.

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The next is flow process where it involved with extracting hidden message process and display how to discover the hidden message that had been embedded by hidden message based on chosen scheme as shown in Figure 4.2.
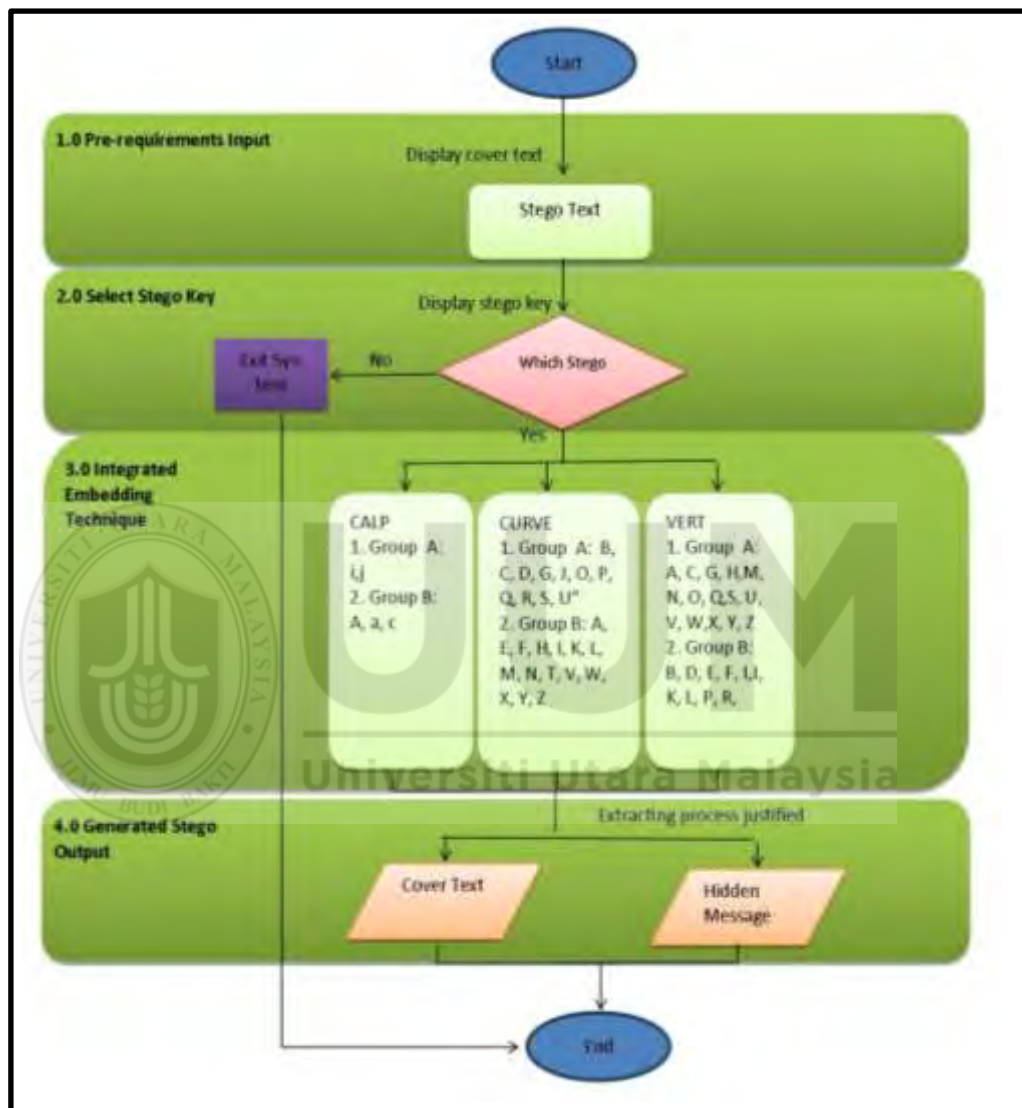
Figure 4.2. Flow process of extracting algorithm in text steganography system

Figure 4.2 illustrates the flow diagram of the process to extract the stego text that discovers the hidden message based on what kind of scheme chosen. It is obvious that the extracted process could be the hidden message that had been embedded in the text.

4.5 Logical Design of Embedding Technique

The model of the letter-based technique begins with logical design as the guidance to develop and implement the technique in form of system. The logical design is a graphical representation of a system showing the system"s process and the flows of data into and out of the process. The first logical design used is use case model, the second is sequence diagram and the third is class diagram

a. Use Case Model

Use case model is the simplest representing of a user's interaction with the system which shows the relationship between the user and the different use cases in which the user is involved. Figure 4.3 below illustrates the requirement in the user of the development the system in form of interface.
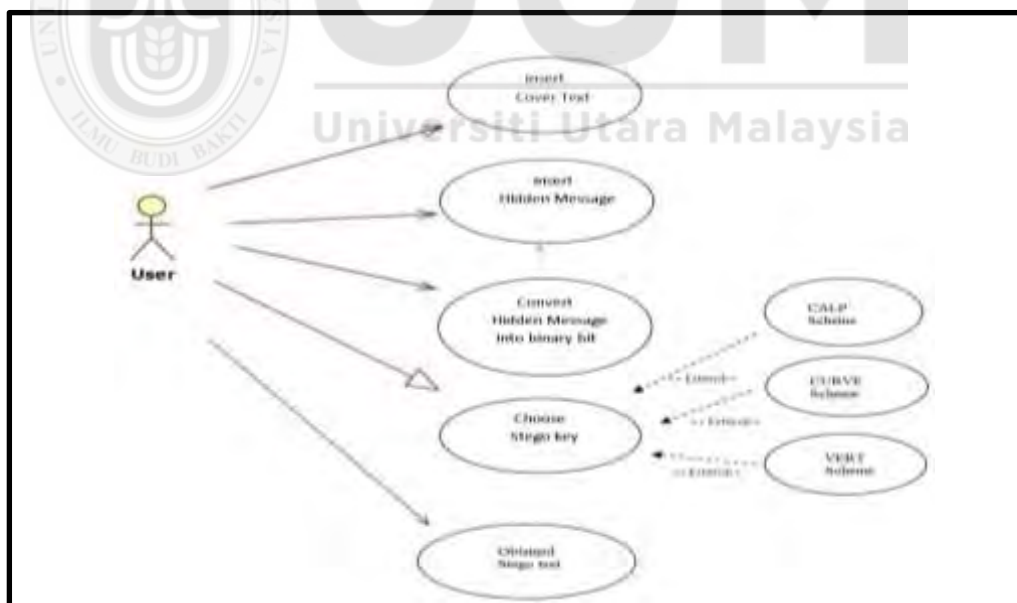
Figure 4.3. Use case diagram of text steganography scheme

Figure 4.3 displays the requirements in letter-based technique in this study. The requirement needs to do insert cover text and hidden message, and then convert

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hidden message into binary bits. The description of use case diagram is shown in Table 4.3 as follows.

Table 4.3

Use case component diagrams in text steganography system

Entity	Description
User	An actor entity that interact with the system to perform the embedding process.
Insert Cover Text	The function is to load the cover text file into the system.
Insert Hidden Message	The function to load the hidden message file into the system
Convert Hidden Message	The function to convert the hidden message in string type into stream bit type.
Choose Stego Key	The function to choose the stego key that can be used for embedding process.
Choose CALP Scheme	The extend function of Choose Stego Key function to select the CALP scheme for embedding process.
Choose CURVE Scheme	The extend function of Choose Stego Key function to select the CURVE scheme for embedding process.
Choose VERT Scheme	The extend function of Choose Stego Key function to select the VERT schemes for embedding process.
Obtained Stego text	The function to embed the hidden message into cover text to get the stego text

b. Sequence Diagram

Sequence Diagram is an interaction diagram that shows how processes operate with one another in order. It is a construct of a message sequence chart.
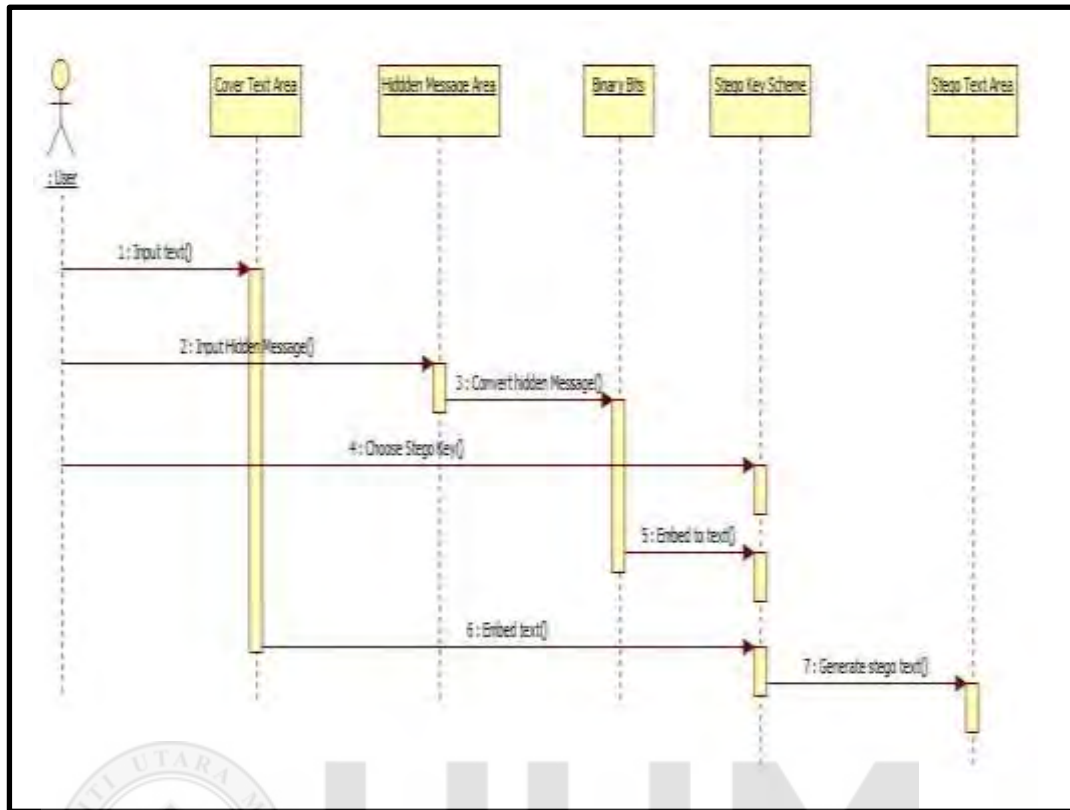
Figure 4.4. Sequence diagram of text steganography system

Figure 4.4 shows the order process to uses the proposed system in cover text area and in the hidden message. The hidden message is converted in binary bits. Furthermore, the user chose the stego key scheme that could generate the stego text in stego text area.

c. **Class Diagram**

Class diagram is a type of static structure diagram that describes the structure of a system and the relationships among objects. Figure 4.5 displays the class diagram of letter-based on text steganography.
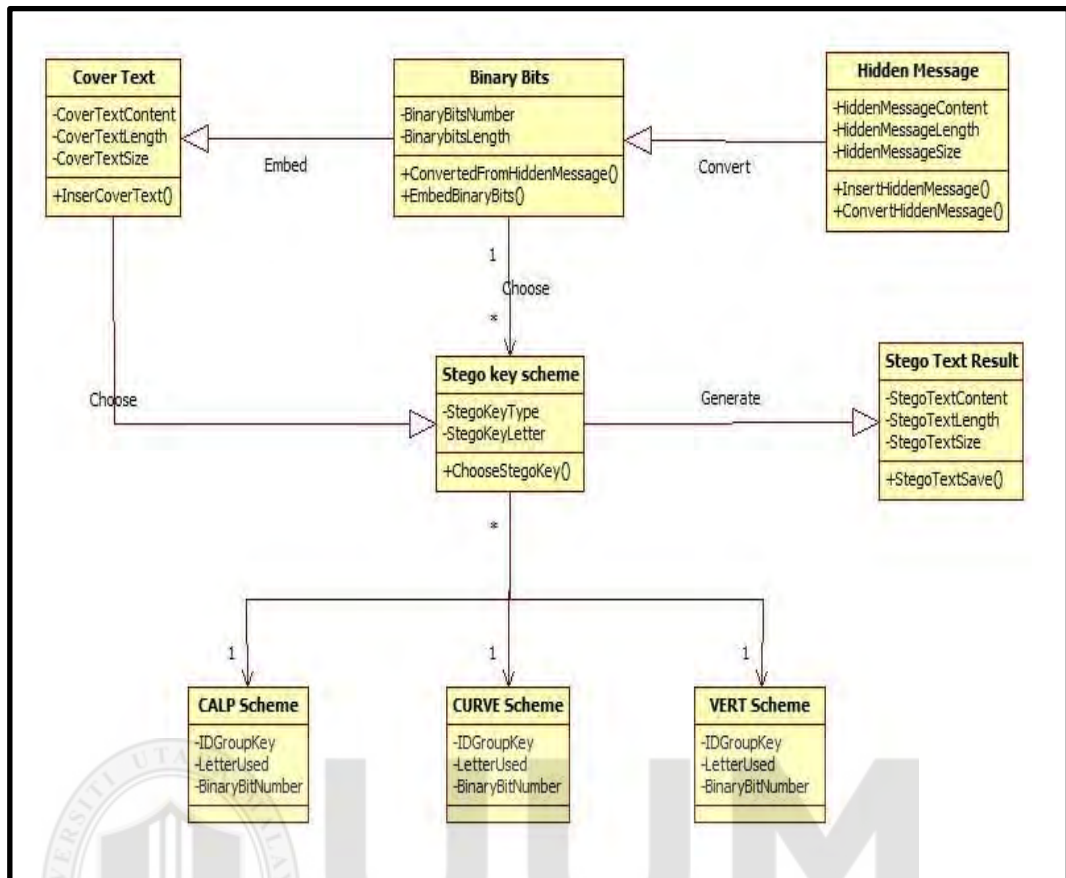
Figure 4.5. Class diagram of text steganography system

Figure 4.5, represents the static view of the embedding part of letter-based text steganography. The attributes and operations of several classes and also the constraints are imposed on embedding of letter-based text steganography.

4.6 Physical Design

The physical design is a graphical representation of a system showing the system‟s internal and external entities as well as the flows of data in and out of these entities. In this section the interface of model letter-based used CALP, CURVE and VERT schemes are shown in Figure 4.6 as follows.

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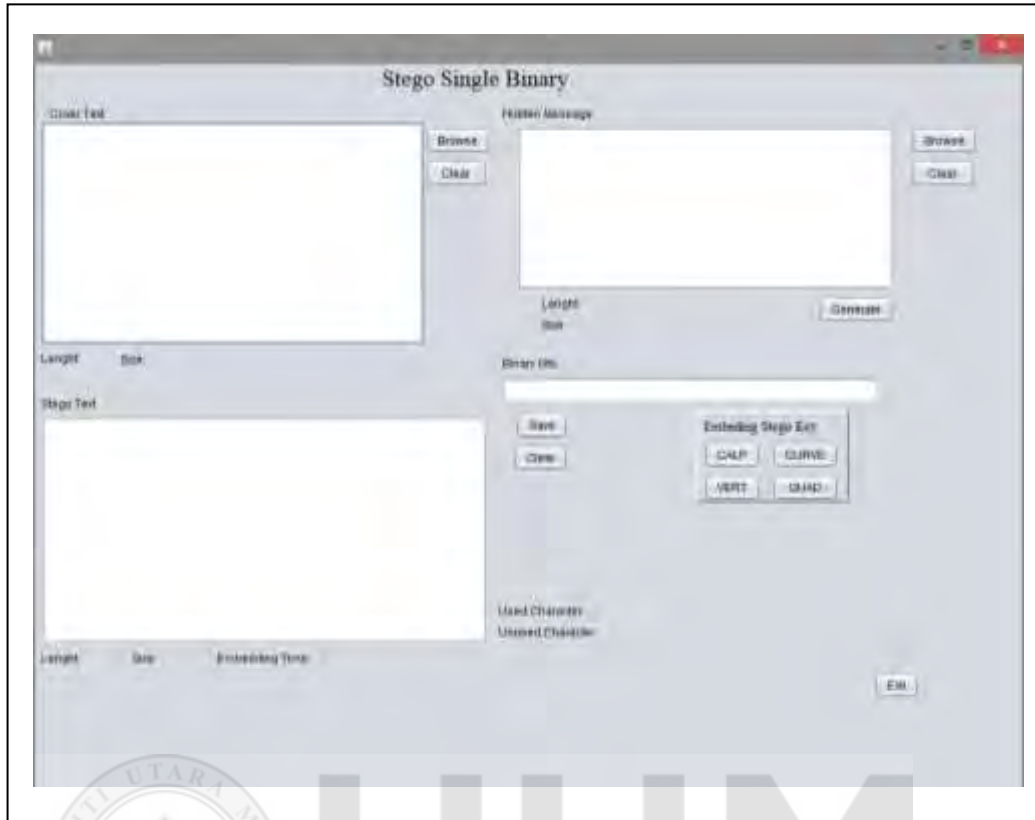
Figure 4.6. Physical design interface system

The interface shown in Figure 4.6 is established using GUI of java programming language. It also shows the user interface that is concerned with how users add information to the system and how the system presents information back to them. Based on the Figure 4.6 the component of the interface is displayed in Table 4.4 as follows.

Table 4.4

The description interface of text steganography model

No.	Component	Description
1	Browse button	The button to insert the covert text file
2	Cover text Area	The area display the cover text be used for embedded hidden message
3	Clear button	The button used to erase all of the content in area of text in

		this interface
4	Length of character	The area show the total amount of character cover text, hidden message, and stego text
5	Size of letter	The area show of capacity size bit of cover text, hidden message and stego text.
6	Hidden message area	The area displays the hidden message content by browse or by typing.
7.	Generate button	The button used in order to convert the hidden message in form of binary bits.
8.	Binary bits area	The area to display the binary bits numbers that have been converted from hidden message
9.	CALP button	The button used in order to embed the binary bits into cover text on A, a, c ,i, j letters
10.	CURVE button	The button used in order to embed the binary into cover text on all letters that divided based on curve form
11.	VERT button	The button used in order to embed the binary into cover text on all letters that divided based on vertical straight line of letter.
12.	Stego text area	The area to show the stego text that is used to show the result of embedding binary bit of hidden message.
13.	Save button	The button used in order to save the result of the stego text in content in form of .txt and .doc
14.	Embedding time	Total time that need in order to generate stego text
15.	Character used	Total letter that embedded with binary bits in stego text
16.	Character unused	Total letter that not chosen as embedded letter in stego text
17.	Exit button	Button that used in order to close the system

Table 4.4 showed the description the tools and information in the letter-based of the model in the interface Figure 4.6. The steps on how to use them are shown in Figure 4.7(a) and 4.7(b) respectively.
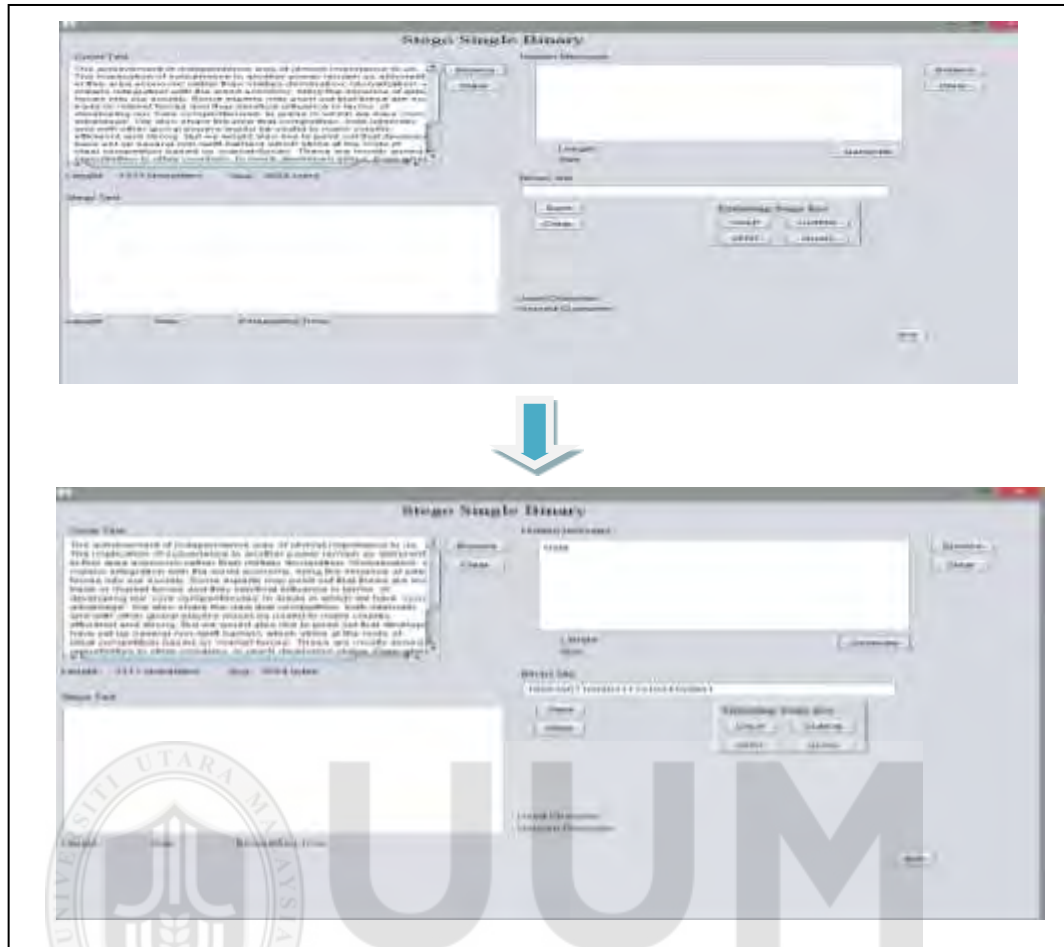
Figure 4.7(a). The step how to load the text on GUI Java language

Based on Figure 4.7(a), the first step begins with browsing button the cover text that load in cover text area. The second step is loading the hidden message and then in third step generates the hidden message in form of binary bits. The length and size of cover text and hidden message is displayed during load the text process. The next step is shown in Figure 4.7(b) as follows.
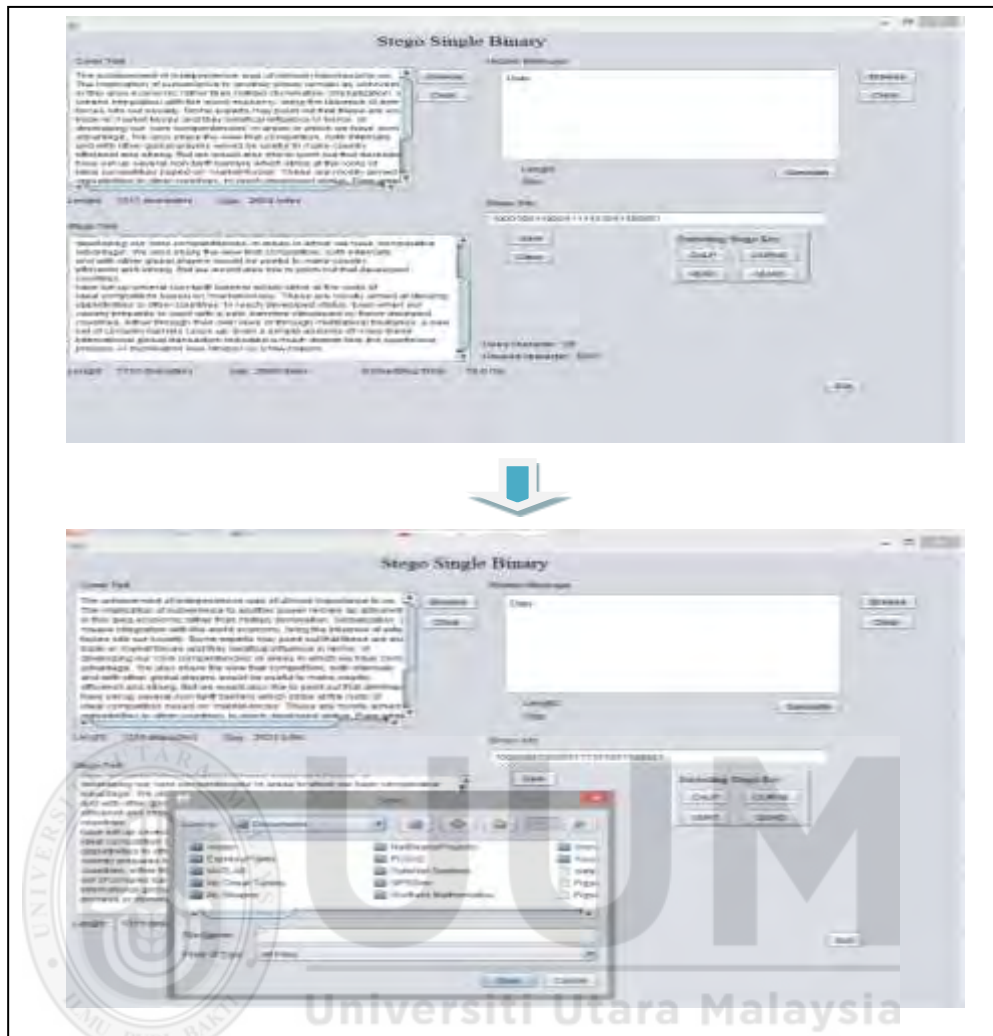
Figure 4.7(b). The step how to generate stego text on GUI Java language

Figure 4.7 (b) is a continuation from Figure 4.7(a), it showed how to embed the
binary bits with a chosen one of embedded stego key then showed in stego text.
Stego text that is obtained automatically shows the letter used, letter unused, and
embedding time. The last step showed with save button the stego text obtained could
be saving in form of files.

4.7 Summary

This chapter detailed the design model of letter-based techniques. The discussion begins with the stego key scheme such as CALP, CURVE and VERT. Then, it continues with the algorithm of three schemes that is used in the model. This chapter discusses the flow process of model in terms of embedding and extracting processes. Then, it is followed with logical design of proposed model in form of use case diagram, sequence diagram and class diagram. Finally, from the logical design, the physical design in form of system in GUI Java language use the three schemes of text steganography system are demonstrated. This design used as domain to evaluate the model with suitable parameters. The implementation of the evaluation procedures will produce results as discuss in the next chapter.
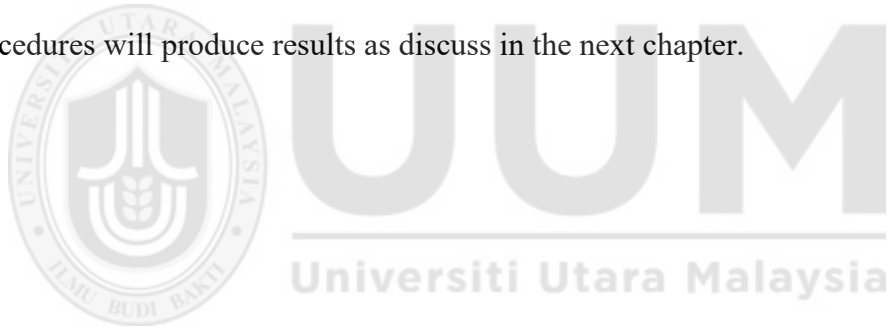
CHAPTER FIVE
EXPERIMENT AND ANALYSIS

5.1 Introduction

This chapter elaborates the analysis and result of evaluation performance on letter-based technique using the selected parameters. The performance analysis covers the verification and validation processes. It is followed by several series of experiments that produces results based on verification and validation processes used for the letter-based technique on text steganography model. The result will be analyzed and discussed in this chapter.

5.2 Verification Process

This section describes the implementation input datasets design that is used in the development of letter-based technique that had been explained in Chapter 3. It involves evaluation which comprises of verification process. The aim of verification process is to verify two categories of plain texts that is used as cover text (*Reuter News 21578)* and hidden message which select *sentence in the language* since this dataset has been verified in some method by Davila (2000) on text domain which is similar to this research domain. The classifications of input datasets are compared based on length of characters of the text and capacity size bit in the text.

5.2.1 Character Length Types

Table 5.1 showed list of total character length input datasets cover text and the hidden message. Twenty cover texts were chosen because *Reuters News 21578* as the input dataset provided 20 kinds of dataset options. Then, 15 hidden messages are involved in this study because *sentence in the language* (Davila, 1999) provided 15 input datasets.

Table 5.1

List of character length of cover text and hidden message

No.	Length of Cover Text (Characters)	Length of Hidden Message (Characters)	No.	Length of Cover Text (Characters	Length of Hidden Message (Characters)
1	1254440	62	1;1	1304117	440
2	1217495	100	12	1323584	480
3	1298721	139	13	1129687	518
4	1321623	177	14	1128671	556
5	1388644	214	15	1258665	593
6	1254765	251	16	1316417	-
7	1256772	287	17	1546911	-
8	1338903	324	18	1258819	-
9	1410117	362	19	1261780	-
10	1371071	401	20	1049566	-

In this experiment one of cover text connected with 15 hidden messages which increase the amount length until the highest length character in hidden message. The position of cover text in view of hidden message was based on *Reuters News 21578* datasets where the highest amount letter cover text is cover text 17 and the lowest is cover text 20.

In this study, the hidden message would be converted in form of binary bits. Then, its binary bits embedded in cover text based on the letter based on the technique chosen that generated to become stego text. The scheme chosen are CALP, CURVE and VERT. Meanwhile, the stego text that had been generated consists of two categories. Those are utilized letter used as the letter chosen which embedded with binary bits and letter unused that are common letter medium of text or do not chose for embed the binary bits. Based on this experiment, embedded process does not influence the total length character. It means that total cover text is similar with the stego text.

5.2.1.1 Experiment A1: Letter Used in Embedding Processes

The first experiment is the character length types in input dataset in order to discover the letter used. Then, CALP becomes the first schemes of letter used for stgeo text after embedded process for cover text with hidden message that showed in Table 5.2 (Refer to Appendix A for detail result of the length of stego text vs letter used of CALP scheme).

Table 5.2

Length of stego text vs letter used of CALP scheme

Hidden Message	Number of Characters Stego Text (ST)									
	ST 1	ST 2	ST 3	ST 4	ST 5	ST 6	ST 7	ST 8	ST 9	ST 10
1	353	353	353	353	353	353	353	353	353	353
2	611	611	611	611	611	611	611	611	611	611
3	870	870	870	870	870	870	870	870	870	870
4	1128	1128	1128	1128	1128	1128	1128	1128	1128	1128
5	1376	1376	1376	1376	1376	1376	1376	1376	1376	1376
6	1672	1672	1672	1672	1672	1672	1672	1672	1672	1672
7	1868	1868	1868	1868	1868	1868	1868	1868	1868	1868
8	2116	2116	2116	2116	2116	2116	2116	2116	2116	2116
9	2374	2374	2374	2374	2374	2374	2374	2374	2374	2374
10	2639	2639	2639	2639	2639	2639	2639	2639	2639	2639
11	2901	2901	2901	2901	2901	2901	2901	2901	2901	2901
12	3170	3170	3170	3170	3170	3170	3170	3170	3170	3170
13	3425	3425	3425	3425	3425	3425	3425	3425	3425	3425
14	3683	3683	3683	3683	3683	3683	3683	3683	3683	3683
15	3931	3931	3931	3931	3931	3931	3931	3931	3931	3931
	ST 11	ST 12	ST 13	ST 14	ST 15	ST 16	ST 17	ST 18	ST 19	ST 20
1	353	353	353	353	353	353	353	353	353	353
2	611	611	611	611	611	611	611	611	611	611
3	870	870	870	870	870	870	870	870	870	870
4	1128	1128	1128	1128	1128	1128	1128	1128	1128	1128
5	1376	1376	1376	1376	1376	1376	1376	1376	1376	1376
6	1672	1672	1672	1672	1672	1672	1672	1672	1672	1672
7	1868	1868	1868	1868	1868	1868	1868	1868	1868	1868
8	2116	2116	2116	2116	2116	2116	2116	2116	2116	2116
9	2374	2374	2374	2374	2374	2374	2374	2374	2374	2374
10	2639	2639	2639	2639	2639	2639	2639	2639	2639	2639
11	2901	2901	2901	2901	2901	2901	2901	2901	2901	2901
12	3170	3170	3170	3170	3170	3170	3170	3170	3170	3170
13	3425	3425	3425	3425	3425	3425	3425	3425	3425	3425
14	3683	3683	3683	3683	3683	3683	3683	3683	3683	3683
15	3931	3931	3931	3931	3931	3931	3931	3931	3931	3931

Table 5.2 showed the total letter used in stego text for CALP scheme toward hidden message. It showed the results of letters used for stego text 1(ST 1) until stego text 20 (ST 20). Based on Table 5.2 every stego text in one hidden message has the same amount length of letter embedded. It showed in hidden message 1 all of ST 1 numbers are 353 and same with other that also same number in the same hidden

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message. This means that all of binary bits are embedded in the obtained stego text.
The second scheme used in this experiment is CURVE. In this particular scheme the
letter used that embeds with binary bits showed in Table 5.3 (Refer to Appendix B
for detail result of the length of stego text vs letter used of CURVE scheme).

Table 5.3

Length of stego text and letter used of CURVE scheme

Hidden Message	Number of Characters Stego Text (ST)									
	ST 1	ST 2	ST 3	ST 4	ST 5	ST 6	ST 7	ST 8	ST 9	ST 10
1	353	353	353	353	353	353	353	353	353	353
2	611	611	611	611	611	611	611	611	611	611
3	870	870	870	870	870	870	870	870	870	870
4	1128	1128	1128	1128	1128	1128	1128	1128	1128	1128
5	1376	1376	1376	1376	1376	1376	1376	1376	1376	1376
6	1672	1672	1672	1672	1672	1672	1672	1672	1672	1672
7	1868	1868	1868	1868	1868	1868	1868	1868	1868	1868
8	2116	2116	2116	2116	2116	2116	2116	2116	2116	2116
9	2374	2374	2374	2374	2374	2374	2374	2374	2374	2374
10	2639	2639	2639	2639	2639	2639	2639	2639	2639	2639
11	2901	2901	2901	2901	2901	2901	2901	2901	2901	2901
12	3170	3170	3170	3170	3170	3170	3170	3170	3170	3170
13	3425	3425	3425	3425	3425	3425	3425	3425	3425	3425
14	3683	3683	3683	3683	3683	3683	3683	3683	3683	3683
15	3931	3931	3931	3931	3931	3931	3931	3931	3931	3931
	ST 11	ST 12	ST 13	ST 14	ST 15	ST 16	ST 17	ST 18	ST 19	ST 20
1	353	353	353	353	353	353	353	353	353	353
2	611	611	611	611	611	611	611	611	611	611
3	870	870	870	870	870	870	870	870	870	870
4	1128	1128	1128	1128	1128	1128	1128	1128	1128	1128
5	1376	1376	1376	1376	1376	1376	1376	1376	1376	1376
6	1672	1672	1672	1672	1672	1672	1672	1672	1672	1672
7	1868	1868	1868	1868	1868	1868	1868	1868	1868	1868
8	2116	2116	2116	2116	2116	2116	2116	2116	2116	2116
9	2374	2374	2374	2374	2374	2374	2374	2374	2374	2374
10	2639	2639	2639	2639	2639	2639	2639	2639	2639	2639
11	2901	2901	2901	2901	2901	2901	2901	2901	2901	2901
12	3170	3170	3170	3170	3170	3170	3170	3170	3170	3170
13	3425	3425	3425	3425	3425	3425	3425	3425	3425	3425
14	3683	3683	3683	3683	3683	3683	3683	3683	3683	3683
15	3931	3931	3931	3931	3931	3931	3931	3931	3931	3931

Table 5.3 shows the total letter used in stego text for CURVE scheme is similar with
letter used in CALP scheme. This means that all of binary bits in CALP and CURVE
are embedded in the cover text. The total letter used in two of scheme are the same,
that is from 353 until 3931 characters of letters used after embedded binary bits.

Then, in Table 5.4 showed the letter used of third scheme which is VERT (Refer to Appendix C for detail result of the length of stego text vs letter used of VERT scheme).

Table 5.4

Length of stego text and letter used of VERT scheme

Hidden Message	Number of Characters Stego Text (ST)									
	ST 1	ST 2	ST 3	ST 4	ST 5	ST 6	ST 7	ST 8	ST 9	ST 10
1	345	346	353	342	344	349	347	347	347	346
2	598	598	603	598	611	611	603	603	602	599
3	853	854	858	852	858	870	859	857	855	857
4	1111	1107	1109	1108	1113	1114	1114	1110	1108	1113
5	1367	1351	1376	1350	1376	1376	1355	1356	1354	1360
6	1672	1599	1601	1601	1603	1610	1604	1602	1600	1605
7	1868	1840	1836	1868	1841	1868	1842	1839	1837	1845
8	2084	2088	2080	2083	2085	2089	2087	2081	2082	2087
9	2338	2345	2333	2336	2337	2345	2342	2334	2336	2337
10	2597	2605	2593	2600	2599	2605	2605	2596	2597	2596
11	2895	2866	2854	2858	2855	2861	2865	2855	2857	2853
12	3121	3132	3118	3125	3170	3129	3130	3120	3119	3119
13	3373	3385	3369	3376	3372	3382	3382	3373	3371	3369
14	3632	3638	3623	3633	3683	3680	3637	3626	3630	3626
15	3879	3879	3869	3880	3873	3881	3883	3872	3873	3870

Hidden Message	ST 11	ST 12	ST 13	ST 14	ST 15	ST 16	ST 17	ST 18	ST 19	ST 20
1	347	343	346	346	345	344	344	342	343	344
2	602	596	603	600	598	601	596	595	601	599
3	858	851	857	857	851	859	850	852	857	854
4	1110	1101	1113	1112	1106	1117	1105	1105	1112	1108
5	1354	1345	1357	1356	1353	1361	1352	1346	1355	1352
6	1603	1593	1600	1601	1601	1609	1600	1592	1603	1600
7	1839	1825	1840	1841	1838	1849	1847	1830	1834	1837
8	2084	2071	2085	2086	2084	2096	2083	2069	2078	2083
9	2337	2326	2339	2342	2340	2351	2335	2324	2323	2336
10	2600	2586	2602	2605	2603	2613	2600	2584	2592	2597
11	2860	2846	2860	2863	2856	2871	2853	2846	2849	2854
12	3124	3110	3128	3128	3121	3141	3115	3112	3113	3123
13	3374	3262	3380	3378	3373	3495	3470	3362	3364	3377
14	3627	3617	3631	3634	3630	3649	3626	3618	3619	3628
15	3931	3860	3877	3878	3875	3894	3870	3863	3869	3876

Table 5.4 showed the letter used for stego text in VERT scheme is different with other scheme. The number of characters used for stego text was different even when using similar hidden message in any cover text. This means that the hidden message

and binary bits are similar but the embedded letters in cover text and the letter used in stego text of VERT scheme is different. This also indicates that in VERT scheme not all the binary bits from hidden message are embedded in cover text. In short, VERT scheme are different in total letters used and more varieties compared to CALP and CURVE scheme.

Regarding the effectiveness of the schemes, CALP and CURVE scheme performs better in embedding process of hidden message in cover text. It because total the binary bits which are converted by hidden message are embedded in cover text. It also impact in security issue in term of availability of information that both of techniques are ensured properly embedded and able to obtain the correct hidden message. Meanwhile, VERT scheme is ascertained has the lack effectiveness in capability of embedding process because not all binary bits embedded in cover text. This influenced the availability aspect in security which certainly discovers the wrong information because total number of binary bits is different with total of letter that had been embedded.

5.2.1.2 Experiment A2: Letter Unused in Embedding Process

In the second experiment, the character length types are processed in order to discover the unused letters. Unused letter is the opposite of letter used, which is the letter that not embedded by binary bits. It means that the number letter unused generally discovered from the total number of character in cover text decreased with number of letter used from the scheme. The letter unused is needed in order to notice how many characters that is not be embedded using the letter-based technique on

text steganography. In accordance with the letter used in these experiments, it begins with CALP scheme, then CURVE scheme and the VERT scheme. The total length of letter unused of stego text used CALP scheme is showed in Table 5.5 (Refer to Appendix A for detail result of the length of stego text vs letter unused of CALP scheme).

Table 5.5

Length of stego text vs letter unused of CALP scheme

Hidden Message	Stego Text (ST) Characters									
	ST 1	ST 2	ST 3	ST 4	ST 5	ST 6	ST 7	ST 8	ST 9	ST 10
1	1254095	1217149	1298378	1321281	1388300	1254416	1256425	1338556	1409770	1370725
2	1253842	1216641	1298118	1321027	1388083	1254154	1256169	1338300	1409515	1370472
3	1253587	1216625	1297863	1320771	1387786	1253895	1255913	1338046	1409262	1370214
4	1253329	1216388	1287612	1320515	1387531	1253651	1255658	1337793	1409009	1369958
5	1253085	1216144	1297365	1320273	1387286	1253389	1255417	1337547	1408763	1369711
6	1252813	1215896	1297120	1320002	1387041	1253155	1255168	1337301	1408517	1369466
7	1252572	1215655	1296885	1319755	1386803	1252897	1254930	1337064	1408280	1369226
8	1252356	1215407	1296641	1319540	1386550	1252676	1254685	1336822	1408045	1368984
9	1252066	1215121	1296388	1319287	1386307	1252420	1254430	1336569	1407781	1368734
10	1251843	1214856	1296128	1319023	1386045	1252160	1254167	1336307	1407520	1368475
11	1251581	1214629	1295867	1318876	1385789	1251904	1253907	1336048	1407260	1368218
12	1251319	1214363	1295603	1318498	1385474	1251636	1253642	1335783	1406998	1367952
13	1251067	1214110	1295352	1318247	1385272	1251383	1253390	1335530	1406746	1367702
14	1250808	1213857	1295098	1317990	1384961	1251135	1253135	1335277	1406487	1367445
15	1250561	1213616	1294852	1317743	1384771	1250884	1252889	1335031	1406244	1367201

Hidden Message	ST 11	ST 12	ST 13	ST 14	ST 15	ST 16	ST 17	ST 18	ST 19	ST 20
1	1303770	1323241	1129341	1128325	1258320	1316073	1546567	1248477	1261437	1049222
2	1303515	1322988	1129084	1128071	1258067	1315816	1546315	1258224	1261179	1048967
3	1303259	1322733	1128830	1127814	1257814	1315558	1546061	1257967	1260923	1048712
4	1303007	1322483	1128574	1127559	1257559	1315300	1545806	1257714	1260668	1048458
5	1302763	1322239	1128330	1127315	1257312	1315056	1545559	1257473	1260425	1048214
6	1302514	1321991	1128087	1127070	1257064	1314808	1545311	1257227	1260177	1047966
7	1302278	1321759	1127847	1126830	1256727	1314568	1545074	1256989	1259946	1047729
8	1302033	1321513	1127602	1126585	1256581	1314321	1544828	1256740	1259702	1047483
9	1301780	1321258	1127348	1126329	1256325	1314066	1544576	1256495	1259448	1047230
10	1301517	1320998	1127085	1126066	1256062	1312804	1544311	1256235	1259188	1046969
11	1301257	1320738	1126827	1125808	1255809	1313546	1544058	1255973	1258931	1046712
12	1300993	1320474	1126559	1125543	1255544	1313276	1543796	1255707	1258667	1046443
13	1300743	1320222	1126307	1125293	1255292	1313022	1543541	1255457	1258416	1046189
14	1300940	1319967	1126056	1125037	1255035	1312768	1543285	1255201	1258161	1045938
15	1300186	1319724	1125810	1124793	1254790	1312523	1543041	1254956	1257911	1045690

Table 5.5 showed the total letter unused in CALP scheme. The total of this number is based on length stego text decreased by letter unused. It seems when the number letter used becomes higher. It is resulted in the decrement of letter unused. The

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second scheme is CURVE has also has similar amount number letter unused with CALP that is showed in Table 5.6 (Refer to Appendix B for detail result of the length of stego text vs letter unused of CURVE scheme).

Table 5.6

Length of stego text vs letter unused of CURVE scheme

Hidden Message	Number Characters of Stego Text (ST)									
	ST 1	ST 2	ST 3	ST 4	ST 5	ST 6	ST 7	ST 8	ST 9	ST 10
1	1254087	1217142	1298368	1321270	1388291	1254412	1256419	1338550	1409764	1370718
2	1253829	1216884	1298110	1321012	1388083	1254154	1256161	1338292	1409506	1370460
3	1253570	1216625	1297851	1320753	1387774	1253895	1255902	1338033	1409247	1370201
4	1253312	1216367	1287593	1320495	1387516	1253637	1255644	1337775	1408989	1369943
5	1253064	1216119	1297345	1320247	1387268	1253389	1255396	1337527	1408741	1369956
6	1252813	1215868	1297094	1319996	1387017	1253138	1255145	1337278	1408490	1369444
7	1252572	1215627	1296853	1319755	1386776	1252897	1254904	1337035	1408249	1369203
8	1252324	1215379	1296605	1319507	1386528	1252649	1254656	1336787	1408001	1368955
9	1252066	1215121	1296347	1319249	1386270	1252391	1254398	1336529	1407743	1368697
10	1251801	1214856	1296082	1318984	1386005	1252126	1254133	1336264	1407478	1368432
11	1251539	1214594	1295820	131872	1385743	1251864	1253871	1336002	1407216	1368170
12	1251270	1214325	1295551	1318453	1385474	1251595	1253602	1335733	1406947	1367901
13	1251015	1214070	1295296	1318198	1386942	1251340	1253347	1335478	1406692	1367646
14	1250757	1213812	1295038	1317940	1384961	1251082	1253089	1335220	1406434	1367388
15	1250509	1213564	1294790	1317692	1384713	1250834	1252841	1334972	1406186	1367140
	ST 11	ST 12	ST 13	ST 14	ST 15	ST 16	ST 17	ST 18	ST 19	ST 20
1	1303764	1323231	1129334	1128318	1258312	1316064	1546558	1248466	1261427	1049213
2	1303506	1322973	1129076	1128060	1258054	1315806	1546300	1258208	1261169	1048955
3	1303257	1322714	1128817	1127801	1257795	1315547	1546041	1257949	1260910	1048696
4	1302989	1322456	1128559	1127543	1257537	1315289	1545783	1257691	1260652	1048438
5	1302741	1322208	1128311	1127295	1257289	1315041	1545535	1257443	1260404	1048190
6	1302490	1321957	1128060	1127044	1257038	1314790	1545284	1257192	1260153	1047939
7	1302249	1321716	1127819	1126803	1256797	1314549	1545043	1256951	1259912	1047698
8	1302001	1321468	1127571	1126555	1256549	1314301	1544795	1256703	1259664	1047450
9	1301743	1321210	1127313	1126297	1256291	1314043	1544537	1256445	1259406	1047192
10	1301478	1320945	1127048	1126032	1256026	1312778	1544272	1256180	1259141	1046927
11	1301216	1320683	1126786	1125770	1255764	1313416	1544010	1255918	1259364	1046665
12	1300947	1320414	1126517	1125501	1255495	1313247	1543741	1255649	1258610	1046396
13	1300692	1320159	1126262	1125246	1255240	1312992	1543486	1255539	1258355	1046141
14	1300434	1319901	1126004	1124988	1254982	1312734	1543228	1255136	1258097	1045883
15	1300186	1319653	1125756	1124740	1254734	1312486	1542980	1254888	1257849	1045635

Table 5.6 showed the number of letter unused is obviously similar with the Table 5.5. It is because CALP and CURVE generated the same letter used, so it automatically obtained the same number of letter unused. The different number of

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letter unused is in VERT (Refer to Appendix C for detail result of the length of stego text vs letter unused of VERT scheme). scheme that is showed in Table 5.7.

Table 5.7

Length of stego text and letter unused of VERT scheme

Hidden Message	Number of Character Stego Text (ST)									
	ST 1	ST 2	ST 3	ST 4	ST 5	ST 6	ST 7	ST 8	ST 9	ST 10
1	1254095	1217149	1298378	1321281	1388300	1254416	1256425	1338556	1409770	1370725
2	1253842	1216641	1298118	1321027	1388083	1254154	1256169	1338300	1409515	1370472
3	1253587	1216625	1297863	1320771	1387786	1253895	1255913	1338046	1409262	1370214
4	1253329	1216388	1287612	1320515	1387531	1253651	1255658	1337793	1409009	1369958
5	1253085	1216144	1297365	1320273	1387286	1253389	1255417	1337547	1408763	1369711
6	1252813	1215896	1297120	1320002	1387041	1253155	1255168	1337301	1408517	1369466
7	1252572	1215655	1296885	1319755	1386803	1252897	1254930	1337064	1408280	1369226
8	1252356	1215407	1296641	1319540	1386550	1252676	1254685	1336822	1408045	1368984
9	1252066	1215121	1296388	1319287	1386307	1252420	1254430	1336569	1407781	1368734
10	1251843	1214856	1296128	1319023	1386045	1252160	1254167	1336307	1407520	1368475
11	1251581	1214629	1295867	131876	1385789	1251904	1253907	1336048	1407260	1368218
12	1251319	1214363	1295603	1318498	1385474	1251636	1253642	1335783	1406998	1367952
13	1251067	1214110	1295352	1318247	1385272	1251383	1253390	1335530	1406746	1367702
14	1250808	1213857	1295098	1317990	1384961	1251135	1253135	1335277	1406487	1367445
15	1250561	1213616	1294852	1317743	1384771	1250884	1252889	1335031	1406244	1367201

Hidden Message	ST 11	ST 12	ST 13	ST 14	ST 15	ST 16	ST 17	ST 18	ST 19	ST 20
1	1303770	1323241	1129341	1128325	1258320	1316073	1546567	1248477	1261437	1049222
2	1303515	1322988	1129084	1128071	1258067	1315816	1546315	1258224	1261179	1048967
3	1303259	1322733	1128830	1127814	1257814	1315558	1546061	1257967	1260923	1048712
4	1303007	1322483	1128574	1127559	1257559	1315300	1545806	1257714	1260668	1048458
5	1302763	1322239	1128330	1127315	1257312	1315056	1545559	1257473	1260425	1048214
6	1302514	1321991	1128087	1127070	1257064	1314808	1545311	1257227	1260177	1047966
7	1302278	1321759	1127847	1126830	1256727	1314568	1545074	1256989	1259946	1047729
8	1302033	1321513	1127602	1126585	1256581	1314321	1544828	1256740	1259702	1047483
9	1301780	1321258	1127348	1126329	1256325	1314066	1544576	1256495	1259448	1047230
10	1301517	1320998	1127085	1126066	1256062	1312804	1544311	1256235	1259188	1046969
11	1301257	1320738	1126827	1125808	1255809	1313546	1544058	1255973	1258931	1046712
12	1300993	1320474	1126559	1125543	1255544	1313276	1543796	1255707	1258667	1046443
13	1300743	1320222	1126307	1125293	1255292	1313022	1543541	1255457	1258416	1046189
14	1300940	1319967	1126056	1125037	1255035	1312768	1543285	1255201	1258161	1045938
15	1300186	1319724	1125810	1124793	1254790	1312523	1543041	1254956	1257911	1045690

Table 5.7 showed the VERT scheme has different number letter unused compared to other schemes. This is because VERT scheme is dependable with letter used and not all binary bits embedded using VERT scheme.

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This letter unused is presented as the comparison for letter used to notice how many letter available in stego text that not embedded by binary bits. Based on letter used only VERT scheme has different number with other schemes which opposite the unused letter. In terms of verification, the capability on process embedded and availability hidden message is suitable as predicted in CALP and CURVE scheme. Meanwhile, problem of lack effectiveness and low security existed that reinforced with result number of letter unused.

5.2.2 Size Bit Types

The input datasets in cover text are investigated using 20 different types of length character as following respectively. The size bits are based one capacity of size bit the datasets. Figure 5.8 illustrated capacity size bit of cover text and hidden message. It is similar to the experiment of length character that provided 20 cover texts and 15 hidden messages. The size bit capacity of cover text was around thousand kb where the highest capacity of cover text 17 with 3093.82 kb and the lowest capacity size bit is cover text 20 with number of bit 2099.13 kb. Meanwhile, to the hidden message is from 0.882 kb until 1.188 kb. The experiment in this section is to evaluate the capacity size bit stego text that had been embedded with hidden message.

Table 5.8

List of size bit of cover text and hidden message

No.	Size bit Cover Text (Kb	Size bit Hidden Message (Kb)	No.	Size bit Cover Text (Kb)	Size bit Hidden Message (Kb)
1	2508.88	0.126	11	2608.24	0.882
2	2434.99	0.202	12	2647.17	0.962
3	2597.44	0.280	13	2259.38	1.038
4	2643.24	0.356	14	2257.34	1.114
5	2777.29	0.430	15	2517.33	1.188
6	2509.53	0.504	16	2632.83	-
7	2513.55	0.576	17	3093.82	-
8	2677.80	0.650	18	2517.64	-
9	2820.23	0.726	19	2523.56	-
10	2742.14	0.804	20	2099.13	-

5.2.2.1 Experiment B1: Size Bit Stego Text toward Hidden Message

The result from experiment in this section showed the size bit of stego text that had been embedded with hidden message. The first scheme that measure the size bit is used CALP scheme, followed by CURVE scheme and the last is VERT scheme. The number of amount of size bit stego text using CALP scheme is shown in Table 5.9 (Refer to Appendix A for detail result of size bit of stego text vs hidden message of CALP scheme).

Table 5.9

Size bit of stego text vs hidden message CALP scheme

Hidden Message	Stego text size bit (kb)									
	ST 1	ST 2	ST 3	ST 4	ST 5	ST 6	ST 7	ST 8	ST 9	ST 10
0.126	2509.58	2435.7	2598.15	2643.95	2777.99	2510.24	2514.25	2678.51	2820.94	2742.85
0.202	2510.1	2436.21	2598.67	2644.47	2778.51	2510.75	2514.77	2679.03	2821.45	2743.37
0.28	2510.62	2436.73	2599.18	2644.99	2779.03	2511.27	2515.53	2679.55	2821.98	2743.88
0.356	2511.14	2437.25	2599.7	2645.5	2779.54	2511.79	2515.8	2680.06	2822.49	2744.4
0.43	2511.63	2437.74	2600.19	2646	2780.04	2512.28	2516.3	2680.56	2822.98	2744.9
0.504	2512.13	2438.25	2600.69	2646.5	2780.54	2512.78	2516.88	2681.06	2823.49	2745.4
0.576	2512.62	2438.73	2601.18	2646.98	2781.02	2513.27	2517.28	2681.54	2823.97	2745.88
0.65	2513.11	2439.22	2601.68	2647.48	2781.52	2513.76	2517.78	2682.04	2824.47	2746.38
0.726	2513.63	2439.74	2602.19	2647.99	2782.03	2514.28	2518.29	2682.56	2824.98	2746.89
0.804	2514.16	2440.27	2602.67	2648.52	2782.56	2514.81	2518.82	2683.09	2825.51	2747.42
0.882	2514.46	2440.79	2603.24	2649.05	2783.09	2515.33	2519.34	2683.61	2826.03	2747.95
0.962	2515.22	2441.33	2603.78	2649.58	2783.63	2515.87	2519.88	2684.14	2826.58	2748.48
1.038	2515.73	2441.84	2604.29	2650.09	2784.14	2516.38	2520.4	2684.65	2827.08	2749
1.114	2516.25	2442.36	2604.81	2650.61	2784.66	2516.89	2520.91	2685.17	2827.6	2749.51
1.188	2516.74	2442.85	2605.31	2651.11	2785.15	2517.39	2521.41	2685.67	2828.09	2750
	ST 11	ST 12	ST 13	ST 14	ST 15	ST 16	ST 17	ST 18	ST 19	ST 20
0.126	2608.94	2647.88	2260.08	2258.05	2518.04	2633.54	3094.53	2518.35	2524.29	2099.87
0.202	2609.47	2648.39	2260.59	2258.57	2518.54	2634.06	3095.05	2518.86	2524.78	2100.35
0.28	2609.98	2648.91	2261.11	2259.08	2519.07	2634.58	3095.56	2519.38	2525.3	2100.87
0.356	2610.49	2649.42	2261.63	2259.6	2519.59	2635.09	3096.08	2519.89	2525.82	2101.39
0.43	2610.99	2649.92	2262.21	2260.1	2520.08	2635.59	3096.58	2520.39	2526.31	2101.89
0.504	2611.49	2650.42	2262.63	2260.6	2520.58	2636.09	3097.08	2520.89	2526.82	2102.39
0.576	2611.97	2650.91	2263.11	2261.08	2521.07	2636.57	3097.56	2521.38	2527.3	2102.87
0.65	2612.47	2651.4	2263.61	2261.58	2521.64	2637.07	3098.06	2521.87	2527.79	2103.37
0.726	2612.98	2651.92	2264.12	2262.09	2522.08	2637.58	3098.57	2522.38	2528.31	2103.88
0.804	2613.51	2652.45	2264.65	2262.62	2522.61	2638.11	3099.1	2522.92	2528.84	2104.41
0.882	2614.04	2652.97	2265.18	2263.15	2523.13	2638.64	3099.63	2523.44	2529.36	2104.94
0.962	2614.58	2653.51	2265.72	2263.68	2523.67	2639.18	3100.16	2523.98	2529.9	2105.47
1.038	2615.09	2654.02	2266.23	2264.19	2524.18	2639.68	3100.84	2524.49	2530.41	2105.98
1.114	2615.5	2654.54	2266.74	2264.71	2524.7	2640.2	3101.19	2525.01	2530.93	2106.5
1.188	2616.1	2655.03	2267.24	2265.21	2525.19	2640.69	3101.68	2525.5	2531.42	2106.99

In Table 5.9 shows the size bit stego text of CALP scheme toward the hidden message. It showed the larger size bit of hidden message influenced generated larger stego text size bit capacity. As the example, stego text 1 (ST 1) begins with 2509.58 kb until reach 2516.74 kb in the last hidden message. Then, for size bit CURVE

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scheme showed in Table 5.10 (Refer to Appendix B for detail result of size bit of stego text vs hidden message of CURVE scheme).

Table 5.10

Size bit of stego text vs hidden message CURVE scheme

Hidden Message	Stego text Size bit (Kb)									
	ST 1	ST 2	ST 3	ST 4	ST 5	ST 6	ST 7	ST 8	ST 9	ST 10
0.126	2509.28	2435.4	2597.83	2643.68	2777.67	2509.92	2513.96	2678.23	2820.6	2742.52
0.202	2509.61	2435.77	2598.23	2644.05	2778	2510.22	2514.28	2678.54	2820.92	2742.81
0.28	2509.96	2436.11	2598.44	2644.36	2778.32	2510.5	2514.62	2678.91	2821.25	2743.14
0.356	2510.25	2436.38	2598.75	2644.69	2778.69	2510.78	2514.95	2679.21	2821.55	2743.5
0.43	2510.55	2436.7	2599.09	2645.02	2779.03	2511.08	2515.24	2679.47	2821.87	2743.85
0.504	2510.86	2436.98	2599.41	2645.36	2779.03	2511.36	2515.56	2679.77	2822.23	2744.16
0.576	2511.12	2437.25	2599.69	2645.69	2779.63	2511.68	2515.82	2680.08	2822.55	2744.52
0.65	2511.47	2437.59	2599.96	2646.02	2779.94	2512	2516.08	2680.44	2822.88	2744.82
0.726	2511.81	2437.9	2600.29	2646.36	2780.31	2512.32	2516.36	2680.76	2823.23	2745.18
0.804	2512.12	2438.21	2600.58	2646.67	2780.71	2512.63	2516.68	2681.06	2823.52	2745.53
0.882	2512.41	2438.53	2600.87	2647.1	2781.06	2512.94	2516.96	2681.41	2823.85	2745.84
0.962	2512.71	2438.89	2601.19	2647.49	2781.42	2513.23	2517.29	2681.7	2824.17	2746.17
1.038	2513.3	2439.23	2601.55	2647.85	2781.76	2513.52	2517.65	2682.21	2824.46	2746.49
1.114	2513.35	2439.54	2601.86	2648.16	2782.07	2513.8	2517.98	2682.41	2824.83	2746.82
1.188	2513.36	2439.88	2602.19	2648.52	2782.43	2514.1	2518.29	2682.7	2825.15	2747.1
	ST 11	ST 12	ST 13	ST 14	ST 15	ST 16	ST 17	ST 18	ST 19	ST 20
0.126	2608.63	2647.54	2259.77	2257.76	2517.72	2633.21	3094.24	2517.8	2523.96	2099.53
0.202	2608.95	2647.88	2260.1	2258.05	2518.01	2633.48	3094.56	2518.38	2524.23	2099.88
0.28	2609.27	2648.24	2260.45	2258.32	2518.32	2633.78	3094.86	2518.73	2524.62	2100.23
0.356	2609.59	2648.56	2260.8	2258.65	2518.62	2634.16	3095.16	2518.91	2524.94	2100.57
0.43	2609.88	2648.89	2261.1	2258.95	2518.93	2634.51	3095.47	2519.33	2525.22	2100.88
0.504	2610.17	2649.24	2261.42	2259.21	2519.21	2634.82	3095.8	2519.69	2525.54	2101.17
0.576	2610.44	2649.56	2261.71	2259.52	2519.5	2635.13	3096.13	2520.04	2525.84	2101.48
0.65	2610.76	2649.88	2262.01	2259.79	2519.8	2635.46	3096.43	2520.37	2526.15	2101.81
0.726	2611.13	2650.18	2262.37	2260.11	2520.12	2635.85	3096.74	2520.75	2526.51	2102.17
0.804	2611.52	2650.59	2262.66	2260.43	2520.47	2636.19	3097.04	2521.08	2526.86	2102.51
0.882	2611.84	2650.78	2262.98	2260.76	2520.75	2636.51	3097.39	2521.41	2527.2	2102.85
0.962	2612.17	2651.13	2263.34	2261.04	2521.1	2636.82	3097.78	2521.7	2527.56	2103.21
1.038	2612.46	2651.42	2263.63	2261.36	2521.44	2637.13	3098.11	2522.01	2527.88	2103.56
1.114	2612.79	2651.71	2263.95	2261.63	2521.76	2637.45	3098.43	2522.36	2528.18	2103.9
1.188	2613.08	2652.04	2264.23	2261.89	2522.1	2637.78	3098.71	2522.68	2528.54	2104.23

Based on Table 5.10 size bit of stego text CURVE also increased if the size hidden message is larger. It showed ST 1 in hidden message 1 the size bit 2509.28kb and in

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the last hidden message 20 reaches 2613.08kb. However, the size bit CURVE was

less then CALP scheme's size bit. For example in ST 1 in CURVE was only started

with 2509.28 kb until 2513.36 while the CALP the highest size bit reach 2516.74 kb.

Finally, the VERT scheme would show different number size bit that shown in Table

5.11 (Refer to Appendix C for detail result of size bit of stego text vs hidden message of

VERT scheme).

Table 5.11

Size bit of stego text vs hidden message VERT scheme

Hidden Message	Stego text Size bit (Kb)									
	ST 1	ST 2	ST 3	ST 4	ST 5	ST 6	ST 7	ST 8	ST 9	ST 10
0.126	2508.97	2435.07	2597.52	2643.35	2777.39	2509.62	2513.64	2677.9	2820.39	2742.23
0.202	2509.06	2435.07	2597.59	2643.39	2777.44	2509.7	2513.64	2677.95	2820.47	2742.32
0.28	2509.09	2435.14	2597.63	2643.43	2777.49	2509.75	2513.64	2677.96	2820.49	2742.37
0.356	2509.16	2435.19	2597.71	2643.46	2777.52	2509.82	2513.72	2678.04	2820.49	2742.38
0.43	2509.23	2435.23	2597.78	2643.51	2777.6	2509.88	2513.79	2678.15	2820.59	2742.4
0.504	2509.3	2435.1	2597.79	2643.53	2777.6	2509.92	2513.82	2678.23	2820.59	2742.46
0.576	2509.31	2435.37	2597.86	2643.58	2777.62	2510	2513.89	2678.3	2820.6	2742.47
0.65	2509.34	2435.41	2597.93	2643.6	2777.62	2510.02	2514	2678.31	2820.6	2742.5
0.726	2509.4	2435.54	2598.06	2643.63	2777.63	2510.08	2514.09	2678.35	2820.6	2742.59
0.804	2509.47	2435.55	2598.1	2643.67	2777.65	2510.14	2514.12	2678.42	2820.63	2742.62
0.882	2509.54	2435.59	2598.2	2643.68	2777.66	2510.21	2514.25	2678.48	2820.72	2742.67
0.962	2509.63	2435.62	2598.25	2643.68	2777.67	2510.29	2514.32	2678.58	2820.77	2742.7
1.038	2509.72	2435.63	2598.32	2643.69	2777.68	2510.41	2514.34	2678.64	2820.87	2742.77
1.114	2509.78	2435.69	2598.37	2643.7	2777.73	2510.49	2514.34	2678.64	2820.91	2742.79
1.188	2509.85	2435.72	2598.45	2643.76	2777.74	2510.58	2514.39	2678.71	2820.91	2742.87
	ST 11	ST 12	ST 13	ST 14	ST 15	ST 16	ST 17	ST 18	ST 19	ST 20
0.126	2608.32	2647.29	2259.48	2257.42	2518.44	2633	3093.93	2517.72	2523.68	2099.22
0.202	2608.35	2647.32	2259.52	2257.5	2518.54	2633.1	3094.01	2517.84	2523.78	2099.24
0.28	2608.41	2647.32	2259.53	2257.62	2518.62	2633.19	3094.09	2517.89	2523.82	2099.25
0.356	2608.5	2647.32	2259.56	2257.72	2518.69	2633.19	3094.16	2517.92	2523.83	2099.25
0.43	2608.57	2647.32	2259.62	2257.78	2518.74	2633.19	3094.23	2518.01	2523.89	2099.31
0.504	2608.66	2647.32	2259.64	2257.89	2518.82	2633.27	3094.23	2518.05	2523.93	2099.38
0.576	2608.72	2647.32	2259.69	2257.97	2518.87	2633.29	3094.23	2518.06	2523.94	2099.44
0.65	2608.83	2647.32	2259.76	2258.05	2518.95	2633.3	3094.25	2518.06	2524.01	2099.5
0.726	2608.85	2647.41	2259.8	2258.09	2519.07	2633.3	3094.33	2518.06	2524.04	2099.51
0.804	2608.86	2647.49	2259.9	2258.21	2519.14	2633.31	3094.4	2518.08	2524.04	2099.51
0.882	2608.87	2647.58	2259.97	2258.26	2519.23	2633.41	3094.46	2518.14	2524.04	2099.57
0.962	2608.93	2647.61	2260.03	2258.37	2519.35	2633.43	3094.46	2518.18	2524.04	2099.62
1.038	2608.98	2647.69	2260.03	2258.48	2519.37	2633.48	3094.46	2518.27	2524.11	2099.63
1.114	2609.02	2647.72	2260.09	2258.55	2519.39	2633.57	3094.53	2518.34	2524.16	2099.64
1.188	2609.1	2647.83	2260.18	2258.67	2519.54	2633.62	3094.61	2518.68	2524.21	2099.64

In Table 5.11 show the VERT scheme also has increased the number of the size bit, but not significant like other schemes. It seems in some stego text of VERT scheme had same number like in stego text 5 in hidden message 5 and 6 with 2777.60 kb or in stego text 16 in hidden message 8 and 9 that also had similar number was 2633.30 kb. It means that the number of size bit of stego text using VERT has less number of capacities compared with CURVE and CALP scheme.

Next section discusses the comparison of stego text with the cover text that had the original size bit capacity.

5.2.2.2 Experiment B2: Size Bit Stego Text toward Cover Text

This result experiment about size bit stego text toward cover text is similar with size bit stego text toward hidden message. However, this experiment compared the size bit between cover text and stego text. It similar with the previous experiment that is discovered number of stego text. It also used the three schemes which are CALP, CURVE, and VERT. The result of experiment used in order to compare the number of size bit stego text that had been discovered with the original capacity of size bit the cover text.

The first scheme that measures the size bit is CALP scheme that comparing the number of stego text and cover text obtained which is showed in Table 5.12 (Refer to Appendix A for detail result of size bit of stego text vs cover text of CALP scheme).

Table 5.12

Size bit of stego text vs cover text CALP scheme

Stego Text	Cover Text (Kb)									
	2508.88	2434.99	2597.44	2643.24	2777.29	2509.53	2513.55	2677.8	2820.23	2742.14
ST 1	2509.58	2435.7	2598.15	2643.95	2777.99	2510.24	2514.25	2678.51	2820.94	2742.85
ST 2	2510.1	2436.21	2598.67	2644.47	2778.51	2510.75	2514.77	2679.03	2821.45	2743.37
ST 3	2510.62	2436.73	2599.18	2644.99	2779.03	2511.27	2515.53	2679.55	2821.98	2743.88
ST 4	2511.14	2437.25	2599.7	2645.5	2779.54	2511.79	2515.8	2680.06	2822.49	2744.4
ST 5	2511.63	2437.74	2600.19	2646	2780.04	2512.28	2516.3	2680.56	2822.98	2744.9
ST 6	2512.13	2438.25	2600.69	2646.5	2780.54	2512.78	2516.88	2681.06	2823.49	2745.4
ST 7	2512.62	2438.73	2601.18	2646.98	2781.02	2513.27	2517.28	2681.54	2823.97	2745.88
ST 8	2513.11	2439.22	2601.68	2647.48	2781.52	2513.76	2517.78	2682.04	2824.47	2746.38
ST 9	2513.63	2439.74	2602.19	2647.99	2782.03	2514.28	2518.29	2682.56	2824.98	2746.89
ST 10	2514.16	2440.27	2602.67	2648.52	2782.56	2514.81	2518.82	2683.09	2825.51	2747.42
ST 11	2514.46	2440.79	2603.24	2649.05	2783.09	2515.33	2519.34	2683.61	2826.03	2747.95
ST 12	2515.22	2441.33	2603.78	2649.58	2783.63	2515.87	2519.88	2684.14	2826.58	2748.48
ST 13	2515.73	2441.84	2604.29	2650.09	2784.14	2516.38	2520.4	2684.65	2827.08	2749
ST 14	2516.25	2442.36	2604.81	2650.61	2784.66	2516.89	2520.91	2685.17	2827.6	2749.51
ST 15	2516.74	2442.85	2605.31	2651.11	2785.15	2517.39	2521.41	2685.67	2828.09	2750
	2608.24	2647.17	2259.38	2257.34	2517.33	2632.83	3093.82	2517.64	2523.56	2099.13
ST 1	2608.94	2647.88	2260.08	2258.05	2518.04	2633.54	3094.53	2518.35	2524.29	2099.87
ST 2	2609.47	2648.39	2260.59	2258.57	2518.54	2634.06	3095.05	2518.86	2524.78	2100.35
ST 3	2609.98	2648.91	2261.11	2259.08	2519.07	2634.58	3095.56	2519.38	2525.3	2100.87
ST 4	2610.49	2649.42	2261.63	2259.6	2519.59	2635.09	3096.08	2519.89	2525.82	2101.39
ST 5	2610.99	2649.92	2262.21	2260.1	2520.08	2635.59	3096.58	2520.39	2526.31	2101.89
ST 6	2611.49	2650.42	2262.63	2260.6	2520.58	2636.09	3097.08	2520.89	2526.82	2102.39
ST 7	2611.97	2650.91	2263.11	2261.08	2521.07	2636.57	3097.56	2521.38	2527.3	2102.87
ST 8	2612.47	2651.4	2263.61	2261.58	2521.64	2637.07	3098.06	2521.87	2527.79	2103.37
ST 9	2612.98	2651.92	2264.12	2262.09	2522.08	2637.58	3098.57	2522.38	2528.31	2103.88
ST 10	2613.51	2652.45	2264.65	2262.62	2522.61	2638.11	3099.1	2522.92	2528.84	2104.41
ST 11	2614.04	2652.97	2265.18	2263.15	2523.13	2638.64	3099.63	2523.44	2529.36	2104.94
ST 12	2614.58	2653.51	2265.72	2263.68	2523.67	2639.18	3100.16	2523.98	2529.9	2105.47
ST 13	2615.09	2654.02	2266.23	2264.19	2524.18	2639.68	3100.84	2524.49	2530.41	2105.98
ST 14	2615.5	2654.54	2266.74	2264.71	2524.7	2640.2	3101.19	2525.01	2530.93	2106.5
ST 15	2616.1	2655.03	2267.24	2265.21	2525.19	2640.69	3101.68	2525.5	2531.42	2106.99

In Table 5.12 shows the same number with Table 5.9. It is because it shows the number value of same stego text, but only compared with cover text for Table 5.12 while the Table 5.9 is comparing with hidden message size bit. However, in Table 5.13 seem increased the stego text from cover text size bit. For example, the cover

text 1 with size bit 2508.88 kb after embedded with the first stego text increased become 2509.58 kb. It means from cover text 1 to stego text 1 after embedded increased 0.7 kb. Then, cover text 2 with size bit 2434.99 kb become 2435.70 kb after embedded as stego text. Next, Table 5.13 the size bit of stego text toward cover text (Refer to Appendix B for detail result of size bit of stego text vs cover text of CURVE scheme).

Table 5.13

Size bit of stego text vs cover text CURVE scheme

Steog Text	Cover Text (Kb)									
	2508.88	2434.99	2597.44	2643.24	2777.29	2509.53	2513.55	2677.8	2820.23	2742.14
ST 1	2509.28	2435.4	2597.83	2643.68	2777.67	2509.92	2513.96	2678.23	2820.6	2742.52
ST 2	2509.61	2435.77	2598.23	2644.05	2778	2510.22	2514.28	2678.54	2820.92	2742.81
ST 3	2509.96	2436.11	2598.44	2644.36	2778.32	2510.5	2514.62	2678.91	2821.25	2743.14
ST 4	2510.25	2436.38	2598.75	2644.69	2778.69	2510.78	2514.95	2679.21	2821.55	2743.5
ST 5	2510.55	2436.7	2599.09	2645.02	2779.03	2511.08	2515.24	2679.47	2821.87	2743.85
ST 6	2510.86	2436.98	2599.41	2645.36	2779.03	2511.36	2515.56	2679.77	2822.23	2744.16
ST 7	2511.12	2437.25	2599.69	2645.69	2779.63	2511.68	2515.82	2680.08	2822.55	2744.52
ST 8	2511.47	2437.59	2599.96	2646.02	2779.94	2512	2516.08	2680.44	2822.88	2744.82
ST 9	2511.81	2437.9	2600.29	2646.36	2780.31	2512.32	2516.36	2680.76	2823.23	2745.18
ST 10	2512.12	2438.21	2600.58	2646.67	2780.71	2512.63	2516.68	2681.06	2823.52	2745.53
ST 11	2512.41	2438.53	2600.87	2647.1	2781.06	2512.94	2516.96	2681.41	2823.85	2745.84
ST 12	2512.71	2438.89	2601.19	2647.49	2781.42	2513.23	2517.29	2681.7	2824.17	2746.17
ST 13	2513.3	2439.23	2601.55	2647.85	2781.76	2513.52	2517.65	2682.21	2824.46	2746.49
ST 14	2513.35	2439.54	2601.86	2648.16	2782.07	2513.8	2517.98	2682.41	2824.83	2746.82
ST 15	2513.36	2439.88	2602.19	2648.52	2782.43	2514.1	2518.29	2682.7	2825.15	2747.1
	2608.24	2647.17	2259.38	2257.34	2517.33	2632.83	3093.82	2517.64	2523.56	2099.13
ST 1	2608.63	2647.54	2259.77	2257.76	2517.72	2633.21	3094.24	2517.8	2523.96	2099.53
ST 2	2608.95	2647.88	2260.1	2258.05	2518.01	2633.48	3094.56	2518.38	2524.23	2099.88
ST 3	2609.27	2648.24	2260.45	2258.32	2518.32	2633.78	3094.86	2518.73	2524.62	2100.23
ST 4	2609.59	2648.56	2260.8	2258.65	2518.62	2634.16	3095.16	2518.91	2524.94	2100.57
ST 5	2609.88	2648.89	2261.1	2258.95	2518.93	2634.51	3095.47	2519.33	2525.22	2100.88
ST 6	2610.17	2649.24	2261.42	2259.21	2519.21	2634.82	3095.8	2519.69	2525.54	2101.17
ST 7	2610.44	2649.56	2261.71	2259.52	2519.5	2635.13	3096.13	2520.04	2525.84	2101.48
ST 8	2610.76	2649.88	2262.01	2259.79	2519.8	2635.46	3096.43	2520.37	2526.15	2101.81
ST 9	2611.13	2650.18	2262.37	2260.11	2520.12	2635.85	3096.74	2520.75	2526.51	2102.17
ST 10	2611.52	2650.59	2262.66	2260.43	2520.47	2636.19	3097.04	2521.08	2526.86	2102.51
ST 11	2611.84	2650.78	2262.98	2260.76	2520.75	2636.51	3097.39	2521.41	2527.2	2102.85
ST 12	2612.17	2651.13	2263.34	2261.04	2521.1	2636.82	3097.78	2521.7	2527.56	2103.21
ST 13	2612.46	2651.42	2263.63	2261.36	2521.44	2637.13	3098.11	2522.01	2527.88	2103.56
ST 14	2612.79	2651.71	2263.95	2261.63	2521.76	2637.45	3098.43	2522.36	2528.18	2103.9
ST 15	2613.08	2652.04	2264.23	2261.89	2522.1	2637.78	3098.71	2522.68	2528.54	2104.23

In Table 5.13 size bit stego text of cover text in CURVE scheme increased less then with stego text in CALP scheme. If a cover text 1 to stego text in CALP increased around 0.70 kb, in CURVE the cover text 1 toward stego text 1 only increased by 0.40 kb which the size bits of cover text 1 is 2508.88 kb and stego text become 2509.28 kb after embedded. Then, for the VERT scheme of size bit stego text shows in Table 5.14 (Refer to Appendix B for detail result of size bit of stego text vs cover text of VERT scheme).

Table 5.14

Size bit of stego text toward cover text VERT scheme

Stego Text	Cover Text (Kb)									
	2508.88	2434.99	2597.44	2643.24	2777.29	2509.53	2513.55	2677.8	2820.23	2742.14
ST 1	2508.97	2435.07	2597.52	2643.35	2777.39	2509.62	2513.64	2677.9	2820.39	2742.23
ST 2	2509.06	2435.07	2597.59	2643.39	2777.44	2509.7	2513.64	2677.95	2820.47	2742.32
ST 3	2509.09	2435.14	2597.63	2643.43	2777.49	2509.75	2513.64	2677.96	2820.49	2742.37
ST 4	2509.16	2435.19	2597.71	2643.46	2777.52	2509.82	2513.72	2678.04	2820.49	2742.38
ST 5	2509.23	2435.23	2597.78	2643.51	2777.6	2509.88	2513.79	2678.15	2820.59	2742.4
ST 6	2509.3	2435.1	2597.79	2643.53	2777.6	2509.92	2513.82	2678.23	2820.59	2742.46
ST 7	2509.31	2435.37	2597.86	2643.58	2777.62	2510	2513.89	2678.3	2820.6	2742.47
ST 8	2509.34	2435.41	2597.93	2643.6	2777.62	2510.02	2514	2678.31	2820.6	2742.5
ST 9	2509.4	2435.54	2598.06	2643.63	2777.63	2510.08	2514.09	2678.35	2820.6	2742.59
ST 10	2509.47	2435.55	2598.1	2643.67	2777.65	2510.14	2514.12	2678.42	2820.63	2742.62
ST 11	2509.54	2435.59	2598.2	2643.68	2777.66	2510.21	2514.25	2678.48	2820.72	2742.67
ST 12	2509.63	2435.62	2598.25	2643.68	2777.67	2510.29	2514.32	2678.58	2820.77	2742.7
ST 13	2509.72	2435.63	2598.32	2643.69	2777.68	2510.41	2514.34	2678.64	2820.87	2742.77
ST 14	2509.78	2435.69	2598.37	2643.7	2777.73	2510.49	2514.34	2678.64	2820.91	2742.79
ST 15	2509.85	2435.72	2598.45	2643.76	2777.74	2510.58	2514.39	2678.71	2820.91	2742.87
	2608.24	2647.17	2259.38	2257.34	2517.33	2632.83	3093.82	2517.64	2523.56	2099.13
ST 1	2608.32	2647.29	2259.48	2257.42	2518.44	2633	3093.93	2517.72	2523.68	2099.22
ST 2	2608.35	2647.32	2259.52	2257.5	2518.54	2633.1	3094.01	2517.84	2523.78	2099.24
ST 3	2608.41	2647.32	2259.53	2257.62	2518.62	2633.19	3094.09	2517.89	2523.82	2099.25
ST 4	2608.5	2647.32	2259.56	2257.72	2518.69	2633.19	3094.16	2517.92	2523.83	2099.25
ST 5	2608.57	2647.32	2259.62	2257.78	2518.74	2633.19	3094.23	2518.01	2523.89	2099.31
ST 6	2608.66	2647.32	2259.64	2257.89	2518.82	2633.27	3094.23	2518.05	2523.93	2099.38
ST 7	2608.72	2647.32	2259.69	2257.97	2518.87	2633.29	3094.23	2518.06	2523.94	2099.44
ST 8	2608.83	2647.32	2259.76	2258.05	2518.95	2633.3	3094.25	2518.06	2524.01	2099.5
ST 9	2608.85	2647.41	2259.8	2258.09	2519.07	2633.3	3094.33	2518.06	2524.04	2099.51
ST 10	2608.86	2647.49	2259.9	2258.21	2519.14	2633.31	3094.4	2518.08	2524.04	2099.51
ST 11	2608.87	2647.58	2259.97	2258.26	2519.23	2633.41	3094.46	2518.14	2524.04	2099.57
ST 12	2608.93	2647.61	2260.03	2258.37	2519.35	2633.43	3094.46	2518.18	2524.04	2099.62
ST 13	2608.98	2647.69	2260.03	2258.48	2519.37	2633.48	3094.46	2518.27	2524.11	2099.63
ST 14	2609.02	2647.72	2260.09	2258.55	2519.39	2633.57	3094.53	2518.34	2524.16	2099.64
ST 15	2609.1	2647.83	2260.18	2258.67	2519.54	2633.62	3094.61	2518.68	2524.21	2099.64

Based on Table 5.14, the stego text size bit in VERT scheme was less than other schemes. It showed only 0.09 kb increased in cover text 1 that 2508.88 kb become 2508.97 kb as stego text 1 after embedded. The comparison of stego text the three schemes will be elaborated in the next section.

5.2.3 Comparison on Size Bit of Stego Text

The purpose of this section is to compare performance the capacity size bit stego text among the three schemes that had been used in this study. In previous section, it is shown in each datasets of one cover text and one hidden message that embedded generated one value of stego text size bit. The comparison of capacity of three schemes is shown in Figure 5.1.
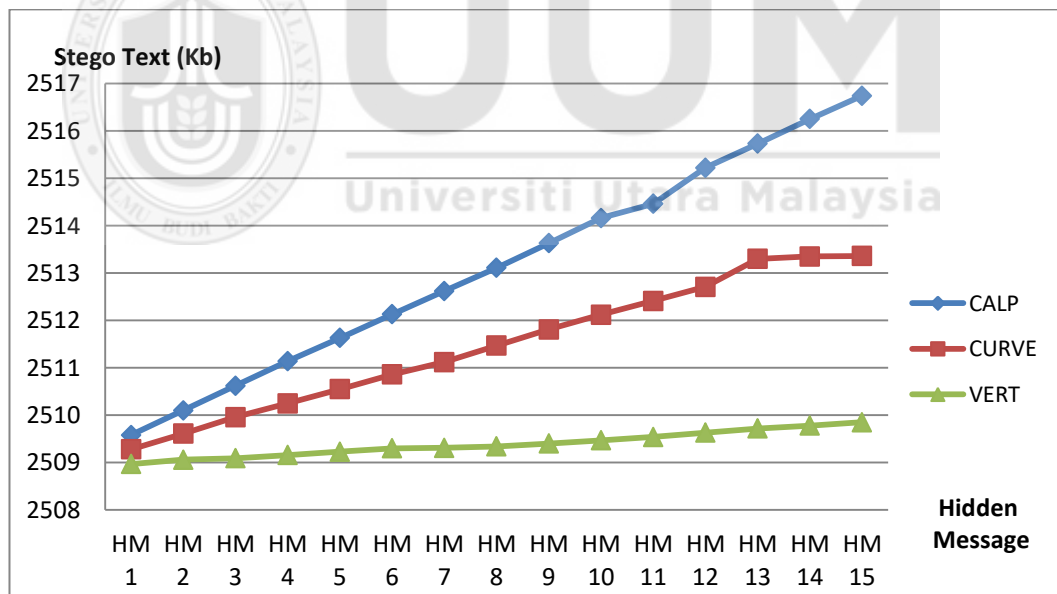
Figure 5.1(a). Stego texts size bit on datasets cover text 1

In order to generate the stego text that could generated 20 graphic size based cover text which consist of 15 hidden messages and 15 value size bit of stego text in one graphic. It has been obtained 20 graphic because this study used 20 datasets of cover

text. Figure 5.1 (a) showed the comparison the size bit of three techniques on datasets in cover text 1 with size bit 2,550.88 kb that showed the CALP scheme has the high capacity size bit of stego text after embedded with hidden message in cover text. The value size bit capacity stable increased even reach the size bit around 2,517 kb when embedded with hidden message 15.

The CURVE scheme a stable increase appears in stego text size bit that embedded with hidden message 1-12 for hidden message 13-15 its value slightly increased value of size bit of stego text. In comparison with CALP scheme, CURVE scheme has a lower value then size bit with CALP scheme. It seem from stego text embedded hidden message 1 that showed CALP slightly higher than CURVE scheme. The difference value is more visible in stego text that embedded with hidden message 15, where the CURVE scheme only reaches around 2,513 kb which is lower value size bit compared to CALP that reach almost 2,517 kb.

VERT scheme has the lowest value size bit compared to the other two techniques. It shows in stego text size that embedded with hidden message 1 that it is slightly lower than other stego size bit with other techniques and the highest value size bit only reached less than 2,510 kb. However, in stego text that embedded with hidden message 7 and 8 the size bit is almost similar value. Another comparison could be showed in other dataset cover text that showed in Figure 5.1(b).
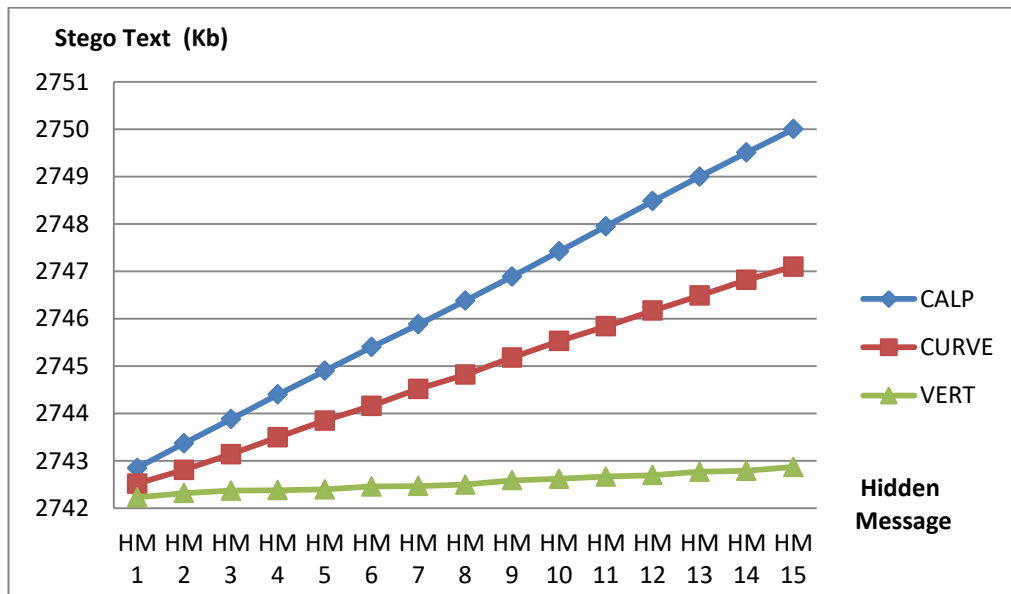
Figure 5.1(b). Stego texts size bit on datasets cover text 10

Figure 5.1(b) almost similar with Figure 5.10(a) where the stego text of size bit of CALP scheme also becomes the highest value than other techniques. The CALP scheme has a higher value from stego text that embedded with hidden message 1 until stego text15 that reach around 2,750 kb which is significantly stable in increasing the value of size bit. The CURVE scheme that has a lower value size bit value than CALP that only reach around 2,747 kb. The lowest value in Figure 5.1(b) is also VERT scheme which the highest size bit of stego text with hidden message that reach around 2,472 kb that even lower than stego text 2 in CALP scheme. Thus, based on the two figure showed that CALP scheme obtained the highest value of stego text size bit, where the lowest size bit of stego text is VERT scheme.

In addition, the comparison of size bit of three techniques used for ensuring effectiveness of technique in term of capacity. Based on the comparison is could verified the cover text and hidden message is effective to use as the dataset. It is due

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to the three schemes are more hidden message and number binary bits, the stego text capacity is also larger. The different is CALP is the largest capacity, while the CURVE is second largest, and the lowest capacity is VERT scheme.

5.3 Validation Process

This section describes the analysis on the evaluation performance after the input datasets have generated the stego text. The validation parameters used for validating the effectiveness and availability part of security in the model of the system.

5.3.1 Experiment C1: Embedding Time Process

The first validation measurement is embedding time that measured how long the hidden message embedded the cover text in order to generated stego text. The embedding time shows how the three schemes are compared generate stego text that shown in Figure 5.2.
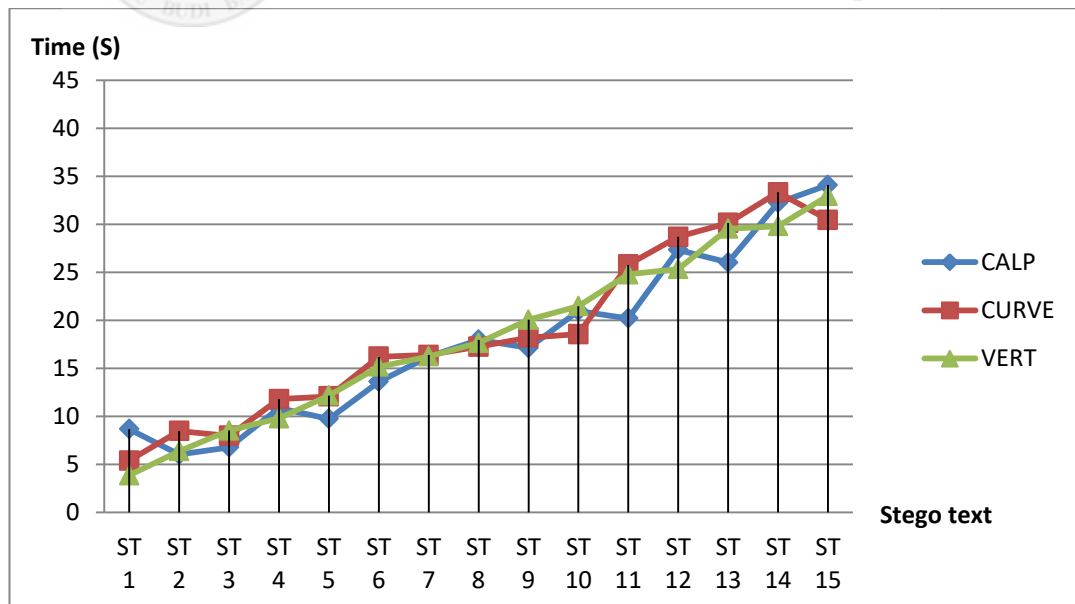
Figure 5.2(a). Embedding time of stego text in datasets cover text 1

Based on the graph, CALP has consuming much time in generated stego text 1 compare to other techniques. It also has the longest time embedded that reaches less than 35 second in last stego text, even though it only has little bit of time different compared to the other schemes. However, the embedding of time CURVE scheme is more random than other schemes. It clearly seen, in this technique stego text 11 until stego text 14 had the longest time than others technique, but it becomes had the fastest time of embedding than other technique. The VERT scheme has the fastest embedding time than others in stego text 1 but it becomes the second fastest scheme in the last stego text. Figure 5.2(b) showed another graphic presentation that of cover text 10.
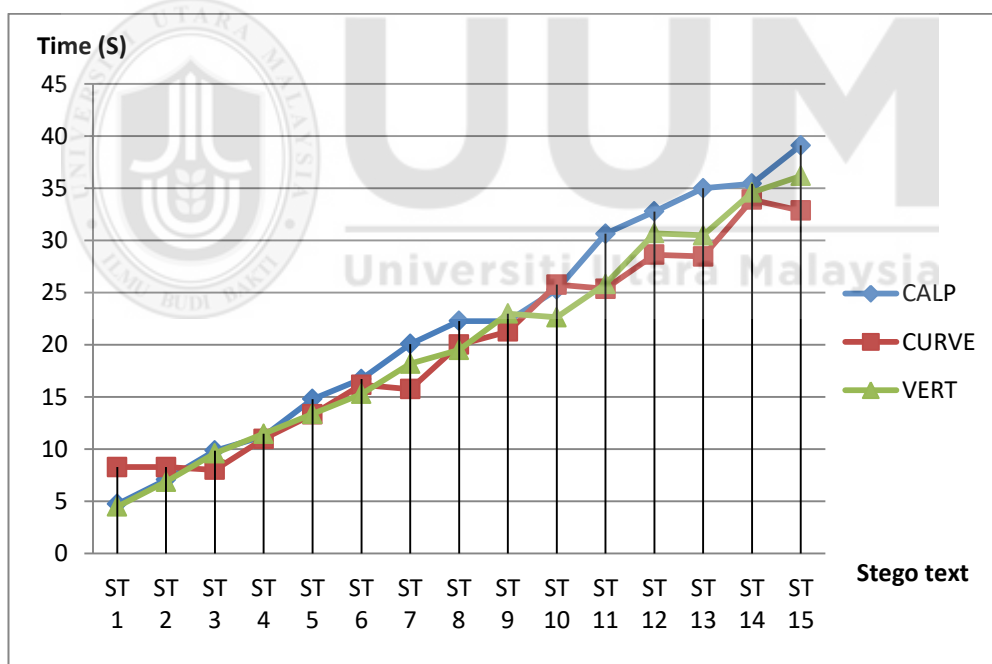
Figure 5.2(b). Embedding time of stego text in datasets cover text 10

From figure 5.2(b) the slowest time of embedding stego text is CURVE scheme in stego text 1. The CALP scheme has becomes longest embedding time from stego text 5 that reach around 15 second until stego text 8 that reach around 23 seconds.

However, The VERT scheme has becomes the highest of embedding time than other scheme in until the last stego text that only need less than 35 seconds, while the other techniques need more than 35 seconds in process embedding the hidden message in the text Figure 5.2(c) below shows another comparison of datasets in cover text 20.
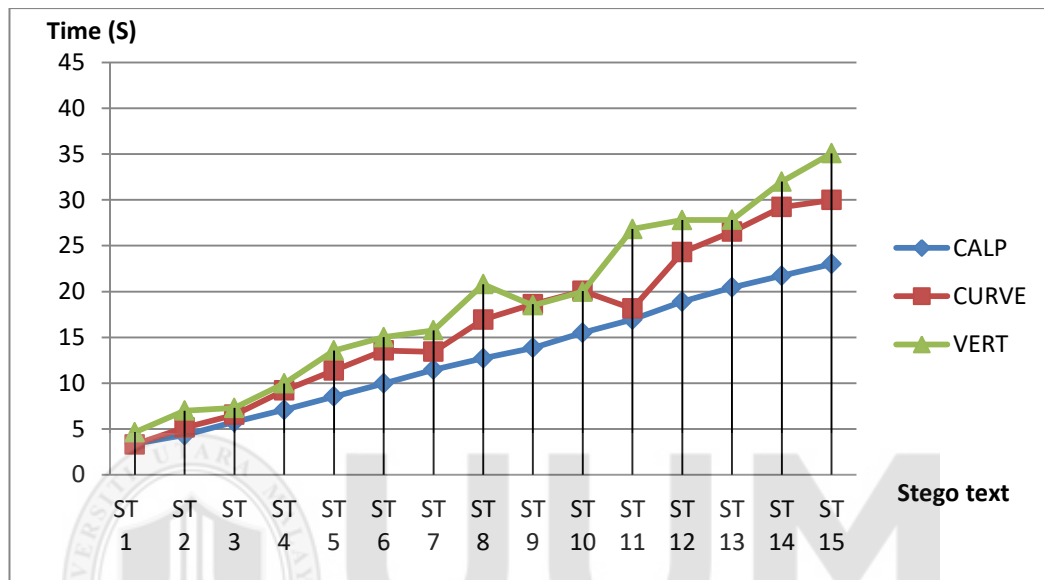
Figure 5.2(c). Embedding time of stego text in datasets cover text 20

In Figure 5.2(c) illustrates the embedding time of stego text in CALP scheme is the fastest than other scheme and quite stable from the beginning until the last stego text. It only needs less than 25 seconds embedding time in last stego text. This followed by CURVE scheme that reaches around 30 seconds embedding time and VERT scheme which around 35 seconds in embedding time in the last stego text respectively. However, even the CALP scheme is the fastest than others schemes, what the scheme chosen will not affect toward proses of embedding technique.

The embedding time is also the side of evaluating effectiveness of the model. Time processing of system determines the effective how many time consumed in order to

implement the model. However, based on the comparison of three figures of embedding time of stego text, it assumed that speed of generated stego text does not depend on the technique used. This is because although all results have shown the random increased the graphic but the hidden message that used is influenced in embedding time. This proved the length and size bit of hidden messages is higher that required take a longer time.

5.3.2 Experiment C2: Precision, Recall and Accuracy Rates

The second validation process that is used in this study is measuring the ability of technique in the model that analyzed to measure the quality performance of system. There are three parameter metrics were investigated that contain 300 files stego text that had been discovered from 20 files of cover text and 15 files of hidden message. The parameter metrics used are precision, recall and accuracy rates. These parameter metrics score are calculated using Equation *(3.1), (3.2),* and *(3.3)* for each method to have a well-defined measurement for the comparison. The detailed information is presented in Appendix D. The result performances of these three parameters are shown in Table 5.15.

Table 5.15

Result of precision, recall, and accuracy on analysed text

Letter-based Technique	Precision	Recall	Accuracy
CALP Scheme	100%	93%	95%
CURVE Scheme	100%	93%	95%
VERT Scheme	98%	23%	62%

In Table 5.15 shows the result of precision, recall, and accuracy rates of analyzed text in the CALP, CURVE, and VERT scheme on 300 analyzed texts. Based on data, the precision result for each scheme as follows; precision rate for CALP and CURVE scheme are 100%, then the VERT scheme is 98%. Its mean the quality of effectiveness performance has relatively accurate level information toward results that is discovered by the model system. The recall rate the results of scheme as follow; CALP and CURVE scheme are reached 93%, while the VERT scheme only reaches 23%.In term of security, its clearly the CALP and CURVE has high level sensitivity of information of data in the system model.

Meanwhile, from the result the recall in VERT scheme is discovered still low security in term of level sensitivity of dat. Finally, for the accuracy rates the CALP and CURVE scheme achieved 95%, which mean has higher security in level closeness prediction and actual value, compare with VERT scheme which is only achieved 62%.

5.4 Summary

This chapter provides a detail of the verification and validation processes result begins with the former process result. The verification performance obtained the length of character and the capacity size bit of stego text of CALP, CURVE and VERT schemes. It is then followed by the results validation performance that consists of an experiment of embedding time process and rates of precision, accuracy and recall. In general, this chapter compares the result of verification and validations performance of the CALP, CURVE and VERT as the chosen scheme of letter-based in text steganography.

CHAPTER SIX
CONCLUSION

6.1 Introduction

This chapter revisits the objectives of this research with related contribution to the letter-based technique in text steganography on text domain. The chapter continues with summaries the major contributions, the value of the research, limitation of study, suggestion and recommendation for future work.

6.2 Revisiting of Research Objective (RO)

This section summarizes the finding the research objective that had been listed in Section 1.4 in of Chapter 1.

6.2.1 RO #1: Parameters used for Verification and Validation Processes

In this study, the description of parameters used is summarized in Section 2.6 of Chapter 2. It illustrates the possible evaluation metric verification and validation in used for designing a model. The previous explanation in Section 2.6 shows general parameter verification process used such as correctness input data, presence of algorithm, loading velocity, examine process simulation, and correctness input data. Then, the proposed general parameter used for validation that is possible to used such as running time, precision rate, recall rate, f-measure rate, accuracy rate.

However, in this study used the letter-based text steganography has different evaluation parameters in order to measure this method. Therefore, this study

proposed some evaluation parameters that adjusted based design of letter-based text steganography that summarized in Section 3.3.3 in Chapter 3. It section showed the parameter metric of verification that used in this study were character length types of letter used and letter unused, as well as bit size types of stego text. The parameters validations that used are embedding time, precision rate, recall rate and accuracy rate. The parameters are used for discovering the problem of lack effectiveness and low security in the technique. However, before implementing the evaluation process, it necessary to design model of letter-based technique that elaborated in Chapter 4.

The design of model begins with scheme and the proposed algorithm of the letter-based technique as summarized in Section 4.2 and Section 4.3 of Chapter 4. Then, flow designs of technique also had been elaborated in Section 4.4. As the model that had been evaluated through verification and validation processes, the logical design based on flow design is elaborated in Section 4.5. As far as the logical design is concerned, it has become the guidance in designing the physical design as the model that evaluates the performance using verification and validation process that is showed in Section 4.6 of Chapter 4.

6.2.2 RO #2: Evaluate The Letter-based Performance

The result of evaluation performance is obtained based on verification and validation in objective 2 in this study. It obtained the result of three schemes through verification and validation than able to compare with each other. Hence the elaboration is available in Chapter 5. Based on verification process of the character length letter used, CALP and CURVE schemes obtained similar that also influenced

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with number of letter unused that summarized in Section 5.2.1. Where are in every hidden message the letter used in each cover text it similar. However, the VERT scheme has different total number of letter used with other schemes and even different in each hidden message that had been embedded in cover text.

The elaboration on the size capacity of the each scheme is found in Section 5.2.2. Based on size bit capacity technique the CALP scheme has the highest number of size bit after it becomes stego text. On the other hand, the lowest size bit capacity after embedded become stego text was VERT scheme. This is summarized in Section 5.2.3 of Chapter 5 that shows a comparison in form of figure in Figure 5.10 in Chapter 5.

Section 5.3.1 compares the embedding time process of each technique. Based on Figure 5.2(a) and Figure 5.2(b) in Section 5.2.3 the embedding time process, the CALP scheme has longest time than other techniques. Meanwhile, in Figure 5.2(c) shows that CALP has become the fastest time in term of the stable than other schemes. This means the embedding time does not depends with the scheme chosen for process embedding.

Next is the experiment in measuring the precision, recall, and accuracy rates in Section 5.3.2. Table 5.15 shows the result of each scheme that showed the CALP and CURVE scheme had same result of precision that achieved 100%, recall reach 93% and accuracy with 95%. Meanwhile, VERT scheme had 98% the precision rates, with recall 23% and the accuracy 62%. Its mean the CALP and CURVE is more

preferable than VERT in term of effectiveness performance and availability of security as the scheme in letter-based on text steganography.

Based on the evaluation the three schemes, it discovered the quality effectiveness of embedding process and security level of schemes. The effectiveness of CALP scheme are has the high capability in order to generate stego text and embed the binary bits from hidden message accurately based on precision rate, but only the capacity of stego text is discovered quite larger than other technique.

In terms of security, CALP scheme has the high sensitivity data based on recall rate and has the high level closeness between prediction and actual values based accuracy rate. Meanwhile, the CURVE scheme also has high capability and able to embed hidden message accurately and the capacity of stego text rather medium compare with the other schemes. However, CURVE scheme has similar high security performance with CALP scheme. Whereas, the VERT scheme has the lack effectiveness in term of capability for embedding hidden message in cover text.

Despite the schemes produce the small capacity of stego text, but the hidden message that embedded in cover text not accurate. The VERT scheme has low security in term of sensitivity of data and quite enough in closeness prediction and actual value rate.

6.3 Research Contributions

The investigate text steganography using letter-based technique. Thus, this would contribute into two parts of contribution such as theoretical contribution and practical contribution.

- o **Theoretical Contribution**

    There are three contributions in this study that have been identified as theoretical contribution such as:

    - ✓ Method of text steganography. It contributes for next researcher in order to distinguish the categories of text steganography or linguistic steganography and description of essential factors in component of methods.

    - ✓ Integrated technique in text steganography. It contributes user who use the algorithm in text steganography.

    - ✓ Provide the evaluation performance based on verification and validation in text steganography. That can be used the evaluation measurement in any text steganography method.

- o **Practical Contribution**

    There are three contributions which could be contributed as practical contribution in application such as:

    - ✓ Government and private industry: Integrated method for secret message in text medium.

✓ Computer forensic: Examining rules from feature extracted of hidden data in text document.

✓ Evaluation standardization: The parameters used in evaluating performance of the system and method through verification and validation

✓ Artificial intelligence application: Pattern recognition of hidden text for data mining.

6.4 Limited of Research Work

It is important to state that there are several limitations of this research work are identified such as;

- Datasets used;

  This work does not apply several datasets. It only depends on *Reuter News 21578* that length character more than one million characters as cover text and *sentences in the language* dataset (Davila, 1999) as datasets of hidden message. For the suggestion, the other input dataset with small number of characters could be the options as datasets.

- Stego key used;

  The stego key used is based on three schemes in letter-based technique chosen such as CALP, CURVE, and VERT that established in form of model using java programing language. It suggested to use other schemes as stego key and could develop in the model in other programming language.

- Evaluation parameters

  The parameters used two stages of evaluation performance those are verification and validation processes which accordance with letter-based technique in the model.

6.5 Future of Research Work

For future work development and expansion of this research, the following are suggested:

- The evaluation performance that measuring the several other components of letter-based method such as integrity, security, effectiveness, robustness and efficiency on text steganography system.

- To integrated new algorithm of letter-based appropriate with characteristic of technique with new process of embedding the hidden message in cover text.

In conclusion, this chapter has discussed and concluded the overall research, the contribution of the research, followed by the limitation of the research. The discussion and recommendations for further development and extension were outlined. It is anticipated the findings of this study are able to provide positive inputs to the future researches and the evaluation efforts in develop letter-based technique of text steganography. Furthermore, it also contributes in other views in evaluation measurement of verification and validation. Hence, this work has achieved the objective research of this study.

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Appendix A

Result Experiment CALP Scheme

1. CALP_Cover Text -1

No.	Cover Text		Hidden Message		Stego Text				
HM	Length (C)	Size (kb)	Length (C)	Size (Kb)	Length (C)	Size(kb)	Embedding Time (s)	Letter Used	Letter Unused
1	1254440	2508.88	62	0.126	1254440	2509.58	8.67	353	1254087
2	1254440	2508.88	100	0.202	1254440	2510.10	6.02	611	1253829
3	1254440	2508.88	139	0.280	1254440	2510.62	6.77	870	1253570
4	1254440	2508.88	177	0.356	1254440	2511.14	10.86	1128	1253312
5	1254440	2508.88	214	0.430	1254440	2511.63	9.75	1376	1253064
6	1254440	2508.88	251	0.504	1254440	2512.13	13.60	1672	1252813
7	1254440	2508.88	287	0.576	1254440	2512.62	16.23	1868	1252572
8	1254440	2508.88	324	0.650	1254440	2513.11	17.97	2116	1252324
9	1254440	2508.88	362	0.726	1254440	2513.63	17.12	2374	1252066
10	1254440	2508.88	401	0.804	1254440	2514.16	20.97	2639	1251801
11	1254440	2508.88	440	0.882	1254440	2514.46	20.20	2901	1251539
12	1254440	2508.88	480	0.962	1254440	2515.22	27.34	3170	1251270
13	1254440	2508.88	518	1.038	1254440	2515.73	26.02	3425	1251015
14	1254440	2508.88	556	1.114	1254440	2516.25	32.24	3683	1250757
15	1254440	2508.88	593	1.188	1254440	2516.74	34.09	3931	1250509

2. CALP_Cover Text 2

No.	Cover Text		Hidden Message		Stego Text				
HM	Length (C)	Size (kb)	Length (C)	Size (Kb)	Length (C)	Size(kb)	Embedding Time (s)	Letter Used	Letter Unused
1	1217495	2434.99	62	0.126	1217495	2435.70	8.74	353	1217142
2	1217495	2434.99	100	0.202	1217495	2436.21	5.59	611	1216884
3	1217495	2434.99	139	0.280	1217495	2436.73	8.03	870	1216625
4	1217495	2434.99	177	0.356	1217495	2437.25	9.11	1128	1216367
5	1217495	2434.99	214	0.430	1217495	2437.74	10.34	1376	1216119
6	1217495	2434.99	251	0.504	1217495	2438.25	11.62	1672	1215868
7	1217495	2434.99	287	0.576	1217495	2438.73	14.77	1868	1215627

8	1217495	2434.99	324	0.650	1217495	2439.22	14.88	2116	1215379
9	1217495	2434.99	362	0.726	1217495	2439.74	15.81	2374	1215121
10	1217495	2434.99	401	0.804	1217495	2440.27	17.52	2639	1214856
11	1217495	2434.99	440	0.882	1217495	2440.79	19.10	2901	1214594
12	1217495	2434.99	480	0.962	1217495	2441.33	22.23	3170	1214325
13	1217495	2434.99	518	1.038	1217495	2441.84	27.08	3425	1214070
14	1217495	2434.99	556	1.114	1217495	2442.36	26.84	3683	1213812
15	1217495	2434.99	593	1.188	1217495	2442.85	34.32	3931	1213564

3. CALP_Cover text 3

No.	Cover Text		Hidden Message			Stego Text			
HM	Length (C)	Size (kb)	Length (C)	Size (Kb)	Length (C)	Size(kb)	Embedding Time (s)	Letter Used	Letter Unused
1	1298721	2597.44	62	0.126	1298721	2598.15	10.50	353	1298368
2	1298721	2597.44	100	0.202	1298721	2598.67	6.06	611	1298110
3	1298721	2597.44	139	0.280	1298721	2599.18	7.09	870	1297851
4	1298721	2597.44	177	0.356	1298721	2599.70	9.82	1128	1287593
5	1298721	2597.44	214	0.430	1298721	2600.19	10.50	1376	1297345
6	1298721	2597.44	251	0.504	1298721	2600.69	11.80	1672	1297094
7	1298721	2597.44	287	0.576	1298721	2601.18	14.40	1868	1296853
8	1298721	2597.44	324	0.650	1298721	2601.68	17.34	2116	1296605
9	1298721	2597.44	362	0.726	1298721	2602.19	19.69	2374	1296347
10	1298721	2597.44	401	0.804	1298721	2602.67	20.14	2639	1296082
11	1298721	2597.44	440	0.882	1298721	2603.24	22.42	2901	1295820
12	1298721	2597.44	480	0.962	1298721	2603.78	24.20	3170	1295551
13	1298721	2597.44	518	1.038	1298721	2604.29	28.46	3425	1295296
14	1298721	2597.44	556	1.114	1298721	2604.81	26.68	3683	1295038
15	1298721	2597.44	593	1.188	1298721	2605.31	32.20	3931	1294790

4. CALP_Cover text 4

No.	Cover Text		Hidden Message			Stego Text			
HM	Length (C)	Size (kb)	Length (C)	Size (Kb)	Length (C)	Size(kb)	Embedding Time (s)	Letter Used	Letter Unused
1	1321623	2643.24	62	0.126	1321623	2643.95	9.81	353	1321270
2	1321623	2643.24	100	0.202	1321623	2644.47	5.51	611	1321012
3	1321623	2643.24	139	0.280	1321623	2644.99	6.57	870	1320753

No.	1321623	2643.24	177	0.356	1321623	2645.50	8.01	1128	1320495
4	1321623	2643.24	177	0.356	1321623	2645.50	8.01	1128	1320495
5	1321623	2643.24	214	0.430	1321623	2646.00	12.67	1376	1320247
16	1321623	2643.24	251	0.504	1321623	2646.50	14.14	1672	1319996
7	1321623	2643.24	287	0.576	1321623	2646.98	13.60	1868	1319755
8	1321623	2643.24	324	0.650	1321623	2647.48	14.88	2116	1319507
9	1321623	2643.24	362	0.726	1321623	2647.99	21.92	2374	1319249
10	1321623	2643.24	401	0.804	1321623	2648.52	24.50	2639	1318984
11	1321623	2643.24	440	0.882	1321623	2649.05	20.89	2901	1318722
12	1321623	2643.24	480	0.962	1321623	2649.58	28.28	3170	1318453
13	1321623	2643.24	518	1.038	1321623	2650.09	30.77	3425	1318198
14	1321623	2643.24	556	1.114	1321623	2650.61	33.37	3683	1317940
15	1321623	2643.24	593	1.188	1298721	2651.11	32.19	3931	1317692

5. CALP_Cover text 5

No.	Cover Text		Hidden Message		Stego Text				
HM	Length (C)	Size (kb)	Length (C)	Size (Kb)	Length (C)	Size(kb)	Embedding Time (s)	Letter Used	Letter Unused
1	1388644	2777.29	62	0.126	1388644	2777.99	4.38	353	1388291
2	1388644	2777.29	100	0.202	1388644	2778.51	5.42	611	1388083
3	1388644	2777.29	139	0.280	1388644	2779.03	7.83	870	1387774
4	1388644	2777.29	177	0.356	1388644	2779.54	12.43	1128	1387516
5	1388644	2777.29	214	0.430	1388644	2780.04	12.76	1376	1387268
6	1388644	2777.29	251	0.504	1388644	2780.54	16.53	1672	1387017
7	1388644	2777.29	287	0.576	1388644	2781.02	17.72	1868	1386776
8	1388644	2777.29	324	0.650	1388644	2781.52	22.30	2116	1386528
9	1388644	2777.29	362	0.726	1388644	2782.03	23.42	2374	1386270
10	1388644	2777.29	401	0.804	1388644	2782.56	24.16	2639	1386005
11	1388644	2777.29	440	0.882	1388644	2783.09	27.67	2901	1385743
12	1388644	2777.29	480	0.962	1388644	2783.63	31.25	3170	1385474
13	1388644	2777.29	518	1.038	1388644	2784.14	28.83	3425	1386942
14	1388644	2777.29	556	1.114	1388644	2784.66	31.97	3683	1384961
15	1388644	2777.29	593	1.188	1388644	2785.15	37.66	3931	1384713

6. CALP_Cover text 6

No.	Cover Text		Hidden Message		Stego Text				
HM	Length (C)	Size (kb)	Length (C)	Size (Kb)	Length (C)	Size(kb)	Embedding Time (s)	Letter Used	Letter Unused
1	1254765	2509.53	62	0.126	1254765	2510.24	9.39	353	1254412
2	1254765	2509.53	100	0.202	1254765	2510.75	7.32	611	1254154
3	1254765	2509.53	139	0.280	1254765	2511.27	10.83	870	1253895
4	1254765	2509.53	177	0.356	1254765	2511.79	14.06	1128	1253637
5	1254765	2509.53	214	0.430	1254765	2512.28	15.70	1376	1253389
6	1254765	2509.53	251	0.504	1254765	2512.78	18.32	1672	1253138
7	1254765	2509.53	287	0.576	1254765	2513.27	21.18	1868	1252897
8	1254765	2509.53	324	0.650	1254765	2513.76	24.26	2116	1252649
9	1254765	2509.53	362	0.726	1254765	2514.28	27.24	2374	1252391
10	1254765	2509.53	401	0.804	1254765	2514.81	28.69	2639	1252126
11	1254765	2509.53	440	0.882	1254765	2515.33	33.19	2901	1251864
12	1254765	2509.53	480	0.962	1254765	2515.87	31.18	3170	1251595
13	1254765	2509.53	518	1.038	1254765	2516.38	39.07	3425	1251340
14	1254765	2509.53	556	1.114	1254765	2516.89	38.93	3683	1251082
15	1254765	2509.53	593	1.188	1254765	2517.39	41.47	3931	1250834

7. CALP_Cover text 7

No.	Cover Text		Hidden Message		Stego Text				
HM	Length (C)	Size (kb)	Length (C)	Size (Kb)	Length (C)	Size(kb)	Embedding Time (s)	Letter Used	Letter Unused
1	1256772	2513.55	62	0.126	125772	2514.25	4.23	353	1256419
2	1256772	2513.55	100	0.202	125772	2514.77	6.47	611	1256161
3	1256772	2513.55	139	0.280	125772	2515.53	8.28	870	1255902
4	1256772	2513.55	177	0.356	125772	2515.80	9.37	1128	1255644
5	1256772	2513.55	214	0.430	125772	2516.30	11.89	1376	1255396
6	1256772	2513.55	251	0.504	125772	2516.88	15.07	1672	1255145
7	1256772	2513.55	287	0.576	125772	2517.28	17.78	1868	1254904
8	1256772	2513.55	324	0.650	125772	2517.78	19.19	2116	1254656
9	1256772	2513.55	362	0.726	125772	2518.29	22.15	2374	1254398
10	1256772	2513.55	401	0.804	125772	2518.82	20.92	2639	1254133
11	1256772	2513.55	440	0.882	125772	2519.34	24.84	2901	1253871
12	1256772	2513.55	480	0.962	125772	2519.88	28.34	3170	1253602
13	1256772	2513.55	518	1.038	125772	2520.40	30.87	3425	1253347

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No.								
14	1256772	2513.55	556	1.114	125772	2520.91	33.29	3683	1253089
15	1256772	2513.55	593	1.188	125772	2521.41	38.20	3931	1252841

8. CALP_Cover text 8

No.	Cover Text		Hidden Message		Stego Text				
HM	Length (C)	Size (kb)	Length (C)	Size (Kb)	Length (C)	Size(kb)	Embedding Time (s)	Letter Used	Letter Unused
1	1338903	2677.80	62	0.126	1338903	2678.51	4.88	353	1338550
2	1338903	2677.80	100	0.202	1338903	2679.03	6.65	611	1338292
3	1338903	2677.80	139	0.280	1338903	2679.55	8.65	870	1338033
4	1338903	2677.80	177	0.356	1338903	2680.06	11.42	1128	1337775
5	1338903	2677.80	214	0.430	1338903	2680.56	14.16	1376	1337527
6	1338903	2677.80	251	0.504	1338903	2681.06	16.86	1672	1337278
7	1338903	2677.80	287	0.576	1338903	2681.54	16.23	1868	1337035
8	1338903	2677.80	324	0.650	1338903	2682.04	19.36	2116	1336787
9	1338903	2677.80	362	0.726	1338903	2682.56	20.74	2374	1336529
10	1338903	2677.80	401	0.804	1338903	2683.09	26.18	2639	1336264
11	1338903	2677.80	440	0.882	1338903	2683.61	27.15	2901	1336002
12	1338903	2677.80	480	0.962	1338903	2684.14	29.82	3170	1335733
13	1338903	2677.80	518	1.038	1338903	2684.65	34.19	3425	1335478
14	1338903	2677.80	556	1.114	1338903	2685.17	35.36	3683	1335220
15	1338903	2677.80	593	1.188	1338903	2685.67	36.07	3931	1334972

9. CALP_Cover Text 9

No.	Cover Text		Hidden Message		Stego Text				
HM	Length (C)	Size (kb)	Length (C)	Size (Kb)	Length (C)	Size(kb)	Embedding Time (s)	Letter Used	Letter Unused
1	1410117	2820.23	62	0.126	1410117	2820.94	10.89	353	1409764
2	1410117	2820.23	100	0.202	1410117	2821.45	6.08	611	1409506
3	1410117	2820.23	139	0.280	1410117	2821.98	8.68	870	1409247
4	1410117	2820.23	177	0.356	1410117	2822.49	10.91	1128	1408989
5	1410117	2820.23	214	0.430	1410117	2822.98	11.45	1376	1408741
6	1410117	2820.23	251	0.504	1410117	2823.49	14.17	1672	1408490
7	1410117	2820.23	287	0.576	1410117	2823.97	19.53	1868	1408249
8	1410117	2820.23	324	0.650	1410117	2824.47	21.56	2116	1408001
9	1410117	2820.23	362	0.726	1410117	2824.98	18.86	2374	1407743

No.								
10	1410117	2820.23	401	0.804	1410117	2825.51	25.95	2639	1407478
11	1410117	2820.23	440	0.882	1410117	2826.03	28.99	2901	1407216
12	1410117	2820.23	480	0.962	1410117	2826.58	33.05	3170	1406947
13	1410117	2820.23	518	1.038	1410117	2827.08	33.75	3425	1406692
14	1410117	2820.23	556	1.114	1410117	2827.60	39.14	3683	1406434
15	1410117	2820.23	593	1.188	1410117	2828.09	41.38	3931	1406186

10. CALP_Cover Text 10

No.	Cover Text		Hidden Message		Stego Text				
HM	Length (C)	Size (kb)	Length (C)	Size (Kb)	Length (C)	Size(kb)	Embedding Time (s)	Letter Used	Letter Unused
1	1371071	2742.14	62	0.126	1371071	2742.85	4.72	353	1370718
2	1371071	2742.14	100	0.202	1371071	2743.37	7.05	611	1370460
3	1371071	2742.14	139	0.280	1371071	2743.88	9.84	870	1370201
4	1371071	2742.14	177	0.356	1371071	2744.40	11.21	1128	1369943
5	1371071	2742.14	214	0.430	1371071	2744.90	14.78	1376	1369956
6	1371071	2742.14	251	0.504	1371071	2745.40	16.70	1672	1369444
7	1371071	2742.14	287	0.576	1371071	2745.88	20.06	1868	1369203
8	1371071	2742.14	324	0.650	1371071	2746.38	22.27	2116	1368955
9	1371071	2742.14	362	0.726	1371071	2746.89	22.25	2374	1368697
10	1371071	2742.14	401	0.804	1371071	2747.42	25.27	2639	1368432
11	1371071	2742.14	440	0.882	1371071	2747.95	30.63	2901	1368170
12	1371071	2742.14	480	0.962	1371071	2748.48	32.76	3170	1367901
13	1371071	2742.14	518	1.038	1371071	2749.00	34.98	3425	1367646
14	1371071	2742.14	556	1.114	1371071	2749.51	35.43	3683	1367388
15	1371071	2742.14	593	1.188	1371071	2750.00	39.09	3931	1367140

11. CALP_Cover Text 11

No.	Cover Text		Hidden Message		Stego Text				
HM	Length (C)	Size (kb)	Length (C)	Size (Kb)	Length (C)	Size(kb)	Embedding Time (s)	Letter Used	Letter Unused
1	1304117	2608.24	62	0.126	1304117	2608.94	9.05	353	1303764
2	1304117	2608.24	100	0.202	1304117	2609.47	6.49	611	1303506
3	1304117	2608.24	139	0.280	1304117	2609.98	8.27	870	1303257
4	1304117	2608.24	177	0.356	1304117	2610.49	11.10	1128	1302989
5	1304117	2608.24	214	0.430	1304117	2610.99	13.45	1376	1302741

6	1304117	2608.24	251	0.504	1304117	2611.49	13.26	1672	1302490
7	1304117	2608.24	287	0.576	1304117	2611.97	16.76	1868	1302249
8	1304117	2608.24	324	0.650	1304117	2612.47	18.64	2116	1302001
9	1304117	2608.24	362	0.726	1304117	2612.98	20.42	2374	1301743
10	1304117	2608.24	401	0.804	1304117	2613.51	20.71	2639	1301478
11	1304117	2608.24	440	0.882	1304117	2614.04	26.03	2901	1301216
12	1304117	2608.24	480	0.962	1304117	2614.58	28.28	3170	1300947
13	1304117	2608.24	518	1.038	1304117	2615.09	29.10	3425	1300692
14	1304117	2608.24	556	1.114	1304117	2615.50	31.31	3683	1300434
15	1304117	2608.24	593	1.188	1304117	2616.10	32.15	3931	1300186

12. CALP_Cover Text 12

No.	Cover Text		Hidden Message		Stego Text				
HM	Length (C)	Size (kb)	Length (C)	Size (Kb)	Length (C)	Size(kb)	Embedding Time (s)	Letter Used	Letter Unused
1	1323584	2647.17	62	0.126	1323584	2647.88	8.42	353	1323231
2	1323584	2647.17	100	0.202	1323584	2648.39	7.44	611	1322973
3	1323584	2647.17	139	0.280	1323584	2648.91	7.29	870	1322714
4	1323584	2647.17	177	0.356	1323584	2649.42	10.65	1128	1322456
5	1323584	2647.17	214	0.430	1323584	2649.92	12.98	1376	1322208
6	1323584	2647.17	251	0.504	1323584	2650.42	13.22	1672	1321957
7	1323584	2647.17	287	0.576	1323584	2650.91	18.86	1868	1321716
8	1323584	2647.17	324	0.650	1323584	2651.40	17.44	2116	1321468
9	1323584	2647.17	362	0.726	1323584	2651.92	17.32	2374	1321210
10	1323584	2647.17	401	0.804	1323584	2652.45	20.51	2639	1320945
11	1323584	2647.17	440	0.882	1323584	2652.97	21.99	2901	1320683
12	1323584	2647.17	480	0.962	1323584	2653.51	23.67	3170	1320414
13	1323584	2647.17	518	1.038	1323584	2654.02	28.09	3425	1320159
14	1323584	2647.17	556	1.114	1323584	2654.54	24.86	3683	1319901
15	1323584	2647.17	593	1.188	1323584	2655.03	32.14	3931	1319653

13. CALP_Cover Text 13

No.	Cover Text		Hidden Message				Stego Text		
HM	Length (C)	Size (kb)	Length (C)	Size (Kb)	Length (C)	Size(kb)	Embedding Time (s)	Letter Used	Letter Unused
1	1129687	2259.38	62	0.126	1129687	2260.08	3.34	353	1129334
2	1129687	2259.38	100	0.202	1129687	2260.59	5.38	611	1129076
3	1129687	2259.38	139	0.280	1129687	2261.11	7.16	870	1128817
4	1129687	2259.38	177	0.356	1129687	2261.63	9.05	1128	1128559
5	1129687	2259.38	214	0.430	1129687	2262.21	10.66	1376	1128311
6	1129687	2259.38	251	0.504	1129687	2262.63	12.06	1672	1128060
7	1129687	2259.38	287	0.576	1129687	2263.11	14.20	1868	1127819
8	1129687	2259.38	324	0.650	1129687	2263.61	13.67	2116	1127571
9	1129687	2259.38	362	0.726	1129687	2264.12	17.10	2374	1127313
10	1129687	2259.38	401	0.804	1129687	2264.65	18.84	2639	1127048
11	1129687	2259.38	440	0.882	1129687	2265.18	20.23	2901	1126786
12	1129687	2259.38	480	0.962	1129687	2265.72	24.99	3170	1126517
13	1129687	2259.38	518	1.038	1129687	2266.23	25.38	3425	1126262
14	1129687	2259.38	556	1.114	1129687	2266.74	28.69	3683	1126004
15	1129687	2259.38	593	1.188	1129687	2267.24	23.85	3931	1125756

14. CALP_Cover Text 14

No.	Cover Text		Hidden Message				Stego Text		
HM	Length (C)	Size (kb)	Length (C)	Size (Kb)	Length (C)	Size(kb)	Embedding Time (s)	Letter Used	Letter Unused
1	1128671	2257.34	62	0.126	1128671	2258.05	3.70	353	1128318
2	1128671	2257.34	100	0.202	1128671	2258.57	5.02	611	1128060
3	1128671	2257.34	139	0.280	1128671	2259.08	7.34	870	1127801
4	1128671	2257.34	177	0.356	1128671	2259.60	8.18	1128	1127543
5	1128671	2257.34	214	0.430	1128671	2260.10	11.10	1376	1127295
6	1128671	2257.34	251	0.504	1128671	2260.60	13.00	1672	1127044
7	1128671	2257.34	287	0.576	1128671	2261.08	15.43	1868	1126803
8	1128671	2257.34	324	0.650	1128671	2261.58	17.04	2116	1126555
9	1128671	2257.34	362	0.726	1128671	2262.09	18.77	2374	1126297
10	1128671	2257.34	401	0.804	1128671	2262.62	18.90	2639	1126032
11	1128671	2257.34	440	0.882	1128671	2263.15	20.90	2901	1125770
12	1128671	2257.34	480	0.962	1128671	2263.68	27.39	3170	1125501
13	1128671	2257.34	518	1.038	1128671	2264.19	24.17	3425	1125246

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No.								
14	1128671	2257.34	556	1.114	1128671	2264.71	26.88	3683	1124988
15	1128671	2257.34	593	1.188	1128671	2265.21	29.35	3931	1124740

15. CALP_Cover Text 15

No.	Cover Text		Hidden Message		Stego Text				
HM	Length (C)	Size (kb)	Length (C)	Size (Kb)	Length (C)	Size(kb)	Embedding Time (s)	Letter Used	Letter Unused
1	1258665	2517.33	62	0.126	1258665	2518.04	8.69	353	1258312
2	1258665	2517.33	100	0.202	1258665	2518.54	6.82	611	1258054
3	1258665	2517.33	139	0.280	1258665	2519.07	7.65	870	1257795
4	1258665	2517.33	177	0.356	1258665	2519.59	9.45	1128	1257537
5	1258665	2517.33	214	0.430	1258665	2520.08	11.16	1376	1257289
6	1258665	2517.33	251	0.504	1258665	2520.58	13.30	1672	1257038
7	1258665	2517.33	287	0.576	1258665	2521.07	14.11	1868	1256797
8	1258665	2517.33	324	0.650	1258665	2521.64	15.95	2116	1256549
9	1258665	2517.33	362	0.726	1258665	2522.08	18.27	2374	1256291
10	1258665	2517.33	401	0.804	1258665	2522.61	19.48	2639	1256026
11	1258665	2517.33	440	0.882	1258665	2523.13	21.49	2901	1255764
12	1258665	2517.33	480	0.962	1258665	2523.67	23.72	3170	1255495
13	1258665	2517.33	518	1.038	1258665	2524.18	25.49	3425	1255240
14	1258665	2517.33	556	1.114	1258665	2524.70	28.20	3683	1254982
15	1258665	2517.33	593	1.188	1258665	2525.19	29.09	3931	1254734

16. CALP_Cover Text 16

No.	Cover Text		Hidden Message		Stego Text				
HM	Length (C)	Size (kb)	Length (C)	Size (Kb)	Length (C)	Size(kb)	Embedding Time (s)	Letter Used	Letter Unused
1	1316417	2632.83	62	0.126	1316417	2633.54	3.53	353	1316064
2	1316417	2632.83	100	0.202	1316417	2634.06	6.04	611	1315806
3	1316417	2632.83	139	0.280	1316417	2634.58	7.92	870	1315547
4	1316417	2632.83	177	0.356	1316417	2635.09	10.09	1128	1315289
5	1316417	2632.83	214	0.430	1316417	2635.59	11.14	1376	1315041
6	1316417	2632.83	251	0.504	1316417	2636.09	13.15	1672	1314790
7	1316417	2632.83	287	0.576	1316417	2636.57	15.65	1868	1314549
8	1316417	2632.83	324	0.650	1316417	2637.07	15.44	2116	1314301
9	1316417	2632.83	362	0.726	1316417	2637.58	17.66	2374	1314043

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10	1316417	2632.83	401	0.804	1316417	2638.11	19.61	2639	1312778
11	1316417	2632.83	440	0.882	1316417	2638.64	21.58	2901	1313416
12	1316417	2632.83	480	0.962	1316417	2639.18	23.19	3170	1313247
13	1316417	2632.83	518	1.038	1316417	2639.68	25.16	3425	1312992
14	1316417	2632.83	556	1.114	1316417	2640.20	26.78	3683	1312734
15	1316417	2632.83	593	1.188	1316417	2640.69	28.78	3931	1312486

17. CALP_Cover Text 17

No.	Cover Text		Hidden Message		Stego Text				
HM	Length (C)	Size (kb)	Length (C)	Size (Kb)	Length (C)	Size(kb)	Embedding Time (s)	Letter Used	Letter Unused
1	1546911	3093.82	62	0.126	1546911	3094.53	4.05	353	1546558
2	1546911	3093.82	100	0.202	1546911	3095.05	6.62	611	1546300
3	1546911	3093.82	139	0.280	1546911	3095.56	8.44	870	1546041
4	1546911	3093.82	177	0.356	1546911	3096.08	10.17	1128	1545783
5	1546911	3093.82	214	0.430	1546911	3096.58	12.30	1376	1545535
6	1546911	3093.82	251	0.504	1546911	3097.08	13.97	1672	1545284
7	1546911	3093.82	287	0.576	1546911	3097.56	16.21	1868	1545043
8	1546911	3093.82	324	0.650	1546911	3098.06	18.27	2116	1544795
9	1546911	3093.82	362	0.726	1546911	3098.57	24.55	2374	1544537
10	1546911	3093.82	401	0.804	1546911	3099.10	22.13	2639	1544272
11	1546911	3093.82	440	0.882	1546911	3099.63	25.07	2901	1544010
12	1546911	3093.82	480	0.962	1546911	3100.16	27.36	3170	1543741
13	1546911	3093.82	518	1.038	1546911	3100.84	32.11	3425	1543486
14	1546911	3093.82	556	1.114	1546911	3101.19	36.28	3683	1543228
15	1546911	3093.82	593	1.188	1546911	3101.68	36.65	3931	1542980

18 CALP_Cover Text 18

No.	Cover Text		Hidden Message		Stego Text				
HM	Length (C)	Size (kb)	Length (C)	Size (Kb)	Length (C)	Size(kb)	Embedding Time (s)	Letter Used	Letter Unused
1	1258819	2517.64	62	0.126	1258819	2518.35	4.56	353	1248466
2	1258819	2517.64	100	0.202	1258819	2518.86	6.97	611	1258208
3	1258819	2517.64	139	0.280	1258819	2519.38	8.60	870	1257949
4	1258819	2517.64	177	0.356	1258819	2519.89	10.22	1128	1257691

No.	Cover Text Length (C)	Size (kb)	Hidden Message Length (C)	Size (Kb)	Stego Text Length (C)	Size(kb)	Embedding Time (s)	Letter Used	Letter Unused
5	1258819	2517.64	214	0.430	1258819	2520.39	12.10	1376	1257443
6	1258819	2517.64	251	0.504	1258819	2520.89	13.61	1672	1257192
7	1258819	2517.64	287	0.576	1258819	2521.38	14.28	1868	1256951
8	1258819	2517.64	324	0.650	1258819	2521.87	18.02	2116	1256703
9	1258819	2517.64	362	0.726	1258819	2522.38	16.90	2374	1256445
10	1258819	2517.64	401	0.804	1258819	2522.92	19.08	2639	1256180
11	1258819	2517.64	440	0.882	1258819	2523.44	22.99	2901	1255918
12	1258819	2517.64	480	0.962	1258819	2523.98	25.04	3170	1255649
13	1258819	2517.64	518	1.038	1258819	2524.49	27.35	3425	1255539
14	1258819	2517.64	556	1.114	1258819	2525.01	29.60	3683	1255136
15	1258819	2517.64	593	1.188	1258819	2525.50	33.66	3931	1254888

19. CALP_Cover Text 19

No.	Cover Text		Hidden Message				Stego Text		
HM	Length (C)	Size (kb)	Length (C)	Size (Kb)	Length (C)	Size(kb)	Embedding Time (s)	Letter Used	Letter Unused
1	1261780	2523.56	62	0.126	1261780	2524.29	3.59	353	1261427
2	1261780	2523.56	100	0.202	1261780	2524.78	4.82	611	1261169
3	1261780	2523.56	139	0.280	1261780	2525.30	7.09	870	1260910
4	1261780	2523.56	177	0.356	1261780	2525.82	8.99	1128	1260652
5	1261780	2523.56	214	0.430	1261780	2526.31	11.54	1376	1260404
6	1261780	2523.56	251	0.504	1261780	2526.82	12.60	1672	1260153
7	1261780	2523.56	287	0.576	1261780	2527.30	15.84	1868	1259912
8	1261780	2523.56	324	0.650	1261780	2527.79	18.53	2116	1259664
9	1261780	2523.56	362	0.726	1261780	2528.31	18.77	2374	1259406
10	1261780	2523.56	401	0.804	1261780	2528.84	22.28	2639	1259141
11	1261780	2523.56	440	0.882	1261780	2529.36	21.63	2901	1259364
12	1261780	2523.56	480	0.962	1261780	2529.90	23.39	3170	1258610
13	1261780	2523.56	518	1.038	1261780	2530.41	23.93	3425	1258355
14	1261780	2523.56	556	1.114	1261780	2530.93	26.14	3683	1258097
15	1261780	2523.56	593	1.188	1261780	2531.42	27.11	3931	1257849

20. CALP_Cover Text 20

No.	Cover Text		Hidden Message		Stego Text				
HM	Length (C)	Size (kb)	Length (C)	Size (Kb)	Length (C)	Size(kb)	Embedding Time (s)	Letter Used	Letter Unused
1	1049566	2099.13	62	0.126	1049566	2099.87	3.38	353	1049213
2	1049566	2099.13	100	0.202	1049566	2100.35	4.32	611	1048955
3	1049566	2099.13	139	0.280	1049566	2100.87	5.75	870	1048696
4	1049566	2099.13	177	0.356	1049566	2101.39	7.09	1128	1048438
5	1049566	2099.13	214	0.430	1049566	2101.89	8.53	1376	1048190
6	1049566	2099.13	251	0.504	1049566	2102.39	9.97	1672	1047939
7	1049566	2099.13	287	0.576	1049566	2102.87	11.46	1868	1047698
8	1049566	2099.13	324	0.650	1049566	2103.37	12.70	2116	1047450
9	1049566	2099.13	362	0.726	1049566	2103.88	13.85	2374	1047192
10	1049566	2099.13	401	0.804	1049566	2104.41	15.51	2639	1046927
11	1049566	2099.13	440	0.882	1049566	2104.94	16.94	2901	1046665
12	1049566	2099.13	480	0.962	1049566	2105.47	18.89	3170	1046396
13	1049566	2099.13	518	1.038	1049566	2105.98	20.44	3425	1046141
14	1049566	2099.13	556	1.114	1049566	2106.50	21.73	3683	1045883
15	1049566	2099.13	593	1.188	1049566	2106.99	23.00	3931	1045635

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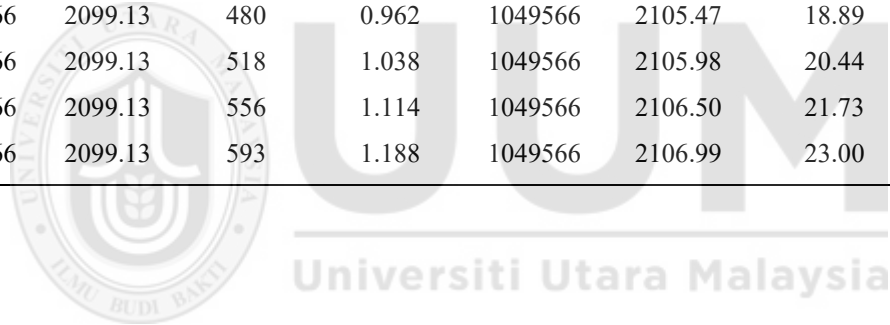
Appendix B

Result Experiment CURVE Scheme

CURVE Technique

    1.   CURVE_Cover Text -1

No.	Cover Text		Hidden Message		Stego Text				
Hm	Length (C)	Size (kb)	Length (C)	Size (Kb)	Length (C)	Size(kb)	Embedding Time (s)	Letter Used	Letter Unused
1	1254440	2508.88	62	0.126	1254440	2509.28	4.41	353	1254087
2	1254440	2508.88	100	0.202	1254440	2509.61	6.70	611	1253829
3	1254440	2508.88	139	0.280	1254440	2509.96	7.73	870	1253570
4	1254440	2508.88	177	0.356	1254440	2510.25	10.20	1128	1253312
5	1254440	2508.88	214	0.430	1254440	2510.55	9.98	1376	1253064
6	1254440	2508.88	251	0.504	1254440	2510.86	12.76	1672	1252813
7	1254440	2508.88	287	0.576	1254440	2511.12	13.84	1868	1252572
8	1254440	2508.88	324	0.650	1254440	2511.47	15.70	2116	1252324
9	1254440	2508.88	362	0.726	1254440	2511.81	16.11	2374	1252066
10	1254440	2508.88	401	0.804	1254440	2512.12	19.38	2639	1251801
11	1254440	2508.88	440	0.882	1254440	2512.41	23.91	2901	1251539
12	1254440	2508.88	480	0.962	1254440	2512.71	23.60	3170	1251270
13	1254440	2508.88	518	1.038	1254440	2513.30	24.01	3425	1251015
14	1254440	2508.88	556	1.114	1254440	2513.35	26.45	3683	1250757
15	1254440	2508.88	593	1.188	1254440	2513.36	27.55	3931	1250509

    2.   CURVE_Cover Text 2

No.	Cover Text		Hidden Message		Stego Text				
HM	Length (C)	Size (kb)	Length (C)	Size (Kb)	Length (C)	Size(kb)	Embedding Time (s)	Letter Used	Letter Unused
1	1217495	2434.99	62	0.126	1217495	2435.40	3.77	353	1217142
2	1217495	2434.99	100	0.202	1217495	2435.77	5.12	611	1216884
3	1217495	2434.99	139	0.280	1217495	2436.11	9.26	870	1216625
4	1217495	2434.99	177	0.356	1217495	2436.38	7.96	1128	1216367
5	1217495	2434.99	214	0.430	1217495	2436.70	12.41	1376	1216119
6	1217495	2434.99	251	0.504	1217495	2436.98	10.12	1672	1215868
7	1217495	2434.99	287	0.576	1217495	2437.25	13.01	1868	1215627

No.								
8	1217495	2434.99	324	0.650	1217495	2437.59	15.13	2116	1215379
9	1217495	2434.99	362	0.726	1217495	2437.90	18.51	2374	1215121
10	1217495	2434.99	401	0.804	1217495	2438.21	20.18	2639	1214856
11	1217495	2434.99	440	0.882	1217495	2438.53	21.69	2901	1214594
12	1217495	2434.99	480	0.962	1217495	2438.89	25.83	3170	1214325
13	1217495	2434.99	518	1.038	1217495	2439.23	27.14	3425	1214070
14	1217495	2434.99	556	1.114	1217495	2439.54	24.96	3683	1213812
15	1217495	2434.99	593	1.188	1217495	2439.88	26.97	3931	1213564

3. CURVE_Cover text 3

No.	Cover Text		Hidden Message				Stego Text		
	Length (C)	Size (kb)	Length (C)	Size (Kb)	Length (C)	Size(kb)	Embedding Time (s)	Letter Used	Letter Unused
1	1298721	2597.44	62	0.126	1298721	2597.83	4.08	353	1298368
2	1298721	2597.44	100	0.202	1298721	2598.23	9.99	611	1298110
3	1298721	2597.44	139	0.280	1298721	2598.44	6.89	870	1297851
4	1298721	2597.44	177	0.356	1298721	2598.75	9.25	1128	1297593
5	1298721	2597.44	214	0.430	1298721	2599.09	11.65	1376	1297345
6	1298721	2597.44	251	0.504	1298721	2599.41	14.50	1672	1297094
7	1298721	2597.44	287	0.576	1298721	2599.69	16.50	1868	1296853
8	1298721	2597.44	324	0.650	1298721	2599.96	21.94	2116	1296605
9	1298721	2597.44	362	0.726	1298721	2600.29	21.02	2374	1296347
10	1298721	2597.44	401	0.804	1298721	2600.58	24.50	2639	1296082
11	1298721	2597.44	440	0.882	1298721	2600.87	26.48	2901	1295820
12	1298721	2597.44	480	0.962	1298721	2601.19	31.49	3170	1295551
13	1298721	2597.44	518	1.038	1298721	2601.55	30.05	3425	1295296
14	1298721	2597.44	556	1.114	1298721	2601.86	36.95	3683	1295038
15	1298721	2597.44	593	1.188	1298721	2602.19	34.02	3931	1294790

4. CURVE_Cover text 4

No.	Cover Text		Hidden Message				Stego Text		
	Length (C)	Size (kb)	Length (C)	Size (Kb)	Length (C)	Size(kb)	Embedding Time (s)	Letter Used	Letter Unused
1	1321623	2643.24	62	0.126	1321623	2643.68	4.57	353	1321270
2	1321623	2643.24	100	0.202	1321623	2644.05	5.71	611	1321012
3	1321623	2643.24	139	0.280	1321623	2644.36	8.23	870	1320753

137

No.	Cover Text		Hidden Message			Stego Text			
	Length (C)	Size (kb)	Length (C)	Size (Kb)	Length (C)	Size(kb)	Embedding Time (s)	Letter Used	Letter Unused
4	1321623	2643.24	177	0.356	1321623	2644.69	11.28	1128	1320495
5	1321623	2643.24	214	0.430	1321623	2645.02	11.22	1376	1320247
6	1321623	2643.24	251	0.504	1321623	2645.36	13.39	1672	1319996
7	1321623	2643.24	287	0.576	1321623	2645.69	16.34	1868	1319755
8	1321623	2643.24	324	0.650	1321623	2646.02	16.32	2116	1319507
9	1321623	2643.24	362	0.726	1321623	2646.36	19.63	2374	1319249
10	1321623	2643.24	401	0.804	1321623	2646.67	21.93	2639	1318984
11	1321623	2643.24	440	0.882	1321623	2647.10	21.41	2901	1318722
12	1321623	2643.24	480	0.962	1321623	2647.49	23.01	3170	1318453
13	1321623	2643.24	518	1.038	1321623	2647.85	27.24	3425	1318198
14	1321623	2643.24	556	1.114	1321623	2648.16	31.58	3683	1317940
15	1321623	2643.24	593	1.188	1298721	2648.52	34.62	3931	1317692

5. CURVE_Cover text 5

No.	Cover Text		Hidden Message			Stego Text			
	Length (C)	Size (kb)	Length (C)	Size (Kb)	Length (C)	Size(kb)	Embedding Time (s)	Letter Used	Letter Unused
1	1388644	2777.29	62	0.126	1388644	2777.67	4.59	353	1388291
2	1388644	2777.29	100	0.202	1388644	2778.00	6.37	611	1388083
3	1388644	2777.29	139	0.280	1388644	2778.32	8.55	870	1387774
4	1388644	2777.29	177	0.356	1388644	2778.69	9.92	1128	1387516
5	1388644	2777.29	214	0.430	1388644	2779.03	11.64	1376	1387268
6	1388644	2777.29	251	0.504	1388644	2779.03	13.98	1672	1387017
7	1388644	2777.29	287	0.576	1388644	2779.63	15.69	1868	1386776
8	1388644	2777.29	324	0.650	1388644	2779.94	17.69	2116	1386528
9	1388644	2777.29	362	0.726	1388644	2780.31	20.89	2374	1386270
10	1388644	2777.29	401	0.804	1388644	2780.71	21.51	2639	1386005
11	1388644	2777.29	440	0.882	1388644	2781.06	23.67	2901	1385743
12	1388644	2777.29	480	0.962	1388644	2781.42	27.25	3170	1385474
13	1388644	2777.29	518	1.038	1388644	2781.76	29.57	3425	1386942
14	1388644	2777.29	556	1.114	1388644	2782.07	30.64	3683	1384961
15	1388644	2777.29	593	1.188	1388644	2782.43	32.58	3931	1384713

6. CURVE_Cover text 6

No.	Cover Text		Hidden Message		Stego Text				
	Length (C)	Size (kb)	Length (C)	Size (Kb)	Length (C)	Size(kb)	Embedding Time (s)	Letter Used	Letter Unused
1	1254765	2509.53	62	0.126	1254765	2509.92	4.07	353	1254412
2	1254765	2509.53	100	0.202	1254765	2510.22	5.55	611	1254154
3	1254765	2509.53	139	0.280	1254765	2510.50	8.70	870	1253895
4	1254765	2509.53	177	0.356	1254765	2510.78	9.97	1128	1253637
5	1254765	2509.53	214	0.430	1254765	2511.08	11.12	1376	1253389
6	1254765	2509.53	251	0.504	1254765	2511.36	12.92	1672	1253138
7	1254765	2509.53	287	0.576	1254765	2511.68	14.31	1868	1252897
8	1254765	2509.53	324	0.650	1254765	2512.00	17.14	2116	1252649
9	1254765	2509.53	362	0.726	1254765	2512.32	18.30	2374	1252391
10	1254765	2509.53	401	0.804	1254765	2512.63	21.86	2639	1252126
11	1254765	2509.53	440	0.882	1254765	2512.94	21.23	2901	1251864
12	1254765	2509.53	480	0.962	1254765	2513.23	23.48	3170	1251595
13	1254765	2509.53	518	1.038	1254765	2513.52	26.35	3425	1251340
14	1254765	2509.53	556	1.114	1254765	2513.80	26.94	3683	1251082
15	1254765	2509.53	593	1.188	1254765	2514.10	29.97	3931	1250834

7. CURVE_Cover text 7

No.	Cover Text		Hidden Message		Stego Text				
Hm	Length (C)	Size (kb)	Length (C)	Size (Kb)	Length (C)	Size(kb)	Embedding Time (s)	Letter Used	Letter Unused
1	1256772	2513.55	62	0.126	125772	2513.96	4.52	353	1256419
2	1256772	2513.55	100	0.202	125772	2514.28	7.85	611	1256161
3	1256772	2513.55	139	0.280	125772	2514.62	8.26	870	1255902
4	1256772	2513.55	177	0.356	125772	2514.95	12.79	1128	1255644
5	1256772	2513.55	214	0.430	125772	2515.24	14.83	1376	1255396
6	1256772	2513.55	251	0.504	125772	2515.56	17.54	1672	1255145
7	1256772	2513.55	287	0.576	125772	2515.82	19.87	1868	1254904
8	1256772	2513.55	324	0.650	125772	2516.08	21.33	2116	1254656
9	1256772	2513.55	362	0.726	125772	2516.36	25.27	2374	1254398
10	1256772	2513.55	401	0.804	125772	2516.68	27.67	2639	1254133
11	1256772	2513.55	440	0.882	125772	2516.96	30.03	2901	1253871
12	1256772	2513.55	480	0.962	125772	2517.29	30.76	3170	1253602
13	1256772	2513.55	518	1.038	125772	2517.65	33.60	3425	1253347

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Hm	Length (C)	Size (kb)	Length (C)	Size (Kb)	Length (C)	Size(kb)	Embedding Time (s)	Letter Used	Letter Unused
14	1256772	2513.55	556	1.114	125772	2517.98	37.22	3683	1253089
15	1256772	2513.55	593	1.188	125772	2518.29	40.23	3931	1252841

8. CURVE_Cover text 8

No.	Cover Text		Hidden Message		Stego Text				
Hm	Length (C)	Size (kb)	Length (C)	Size (Kb)	Length (C)	Size(kb)	Embedding Time (s)	Letter Used	Letter Unused
1	1338903	2677.80	62	0.126	1338903	2678.23	4.14	353	1338550
2	1338903	2677.80	100	0.202	1338903	2678.54	6.76	611	1338292
3	1338903	2677.80	139	0.280	1338903	2678.91	10.38	870	1338033
4	1338903	2677.80	177	0.356	1338903	2679.21	12.60	1128	1337775
5	1338903	2677.80	214	0.430	1338903	2679.47	14.57	1376	1337527
6	1338903	2677.80	251	0.504	1338903	2679.77	16.02	1672	1337278
7	1338903	2677.80	287	0.576	1338903	2680.08	24.76	1868	1337035
8	1338903	2677.80	324	0.650	1338903	2680.44	22.86	2116	1336787
9	1338903	2677.80	362	0.726	1338903	2680.76	24.37	2374	1336529
10	1338903	2677.80	401	0.804	1338903	2681.06	30.23	2639	1336264
11	1338903	2677.80	440	0.882	1338903	2681.41	31.89	2901	1336002
12	1338903	2677.80	480	0.962	1338903	2681.70	27.29	3170	1335733
13	1338903	2677.80	518	1.038	1338903	2682.21	32.77	3425	1335478
14	1338903	2677.80	556	1.114	1338903	2682.41	35.30	3683	1335220
15	1338903	2677.80	593	1.188	1338903	2682.70	36.42	3931	1334972

9. CURVE_Cover Text 9

No.	Cover Text		Hidden Message		Stego Text				
Hm	Length (C)	Size (kb)	Length (C)	Size (Kb)	Length (C)	Size(kb)	Embedding Time (s)	Letter Used	Letter Unused
1	1410117	2820.23	62	0.126	1410117	2820.60	4.91	353	1409764
2	1410117	2820.23	100	0.202	1410117	2820.92	9.08	611	1409506
3	1410117	2820.23	139	0.280	1410117	2821.25	10.70	870	1409247
4	1410117	2820.23	177	0.356	1410117	2821.55	13.62	1128	1408989
5	1410117	2820.23	214	0.430	1410117	2821.87	17.82	1376	1408741
6	1410117	2820.23	251	0.504	1410117	2822.23	20.66	1672	1408490
7	1410117	2820.23	287	0.576	1410117	2822.55	22.09	1868	1408249
8	1410117	2820.23	324	0.650	1410117	2822.88	24.23	2116	1408001
9	1410117	2820.23	362	0.726	1410117	2823.23	27.33	2374	1407743

No.	Cover Text								

10	1410117	2820.23	401	0.804	1410117	2823.52	29.53	2639	1407478
11	1410117	2820.23	440	0.882	1410117	2823.85	33.54	2901	1407216
12	1410117	2820.23	480	0.962	1410117	2824.17	34.89	3170	1406947
13	1410117	2820.23	518	1.038	1410117	2824.46	40.08	3425	1406692
14	1410117	2820.23	556	1.114	1410117	2824.83	40.91	3683	1406434
15	1410117	2820.23	593	1.188	1410117	2825.15	49.92	3931	1406186

10. CURVE_Cover 10

No.	Cover Text		Hidden Message				Stego Text		
Hm	Length (C)	Size (kb)	Length (C)	Size (Kb)	Length (C)	Size(kb)	Embedding Time (s)	Letter Used	Letter Unused
1	1371071	2742.14	62	0.126	1371071	2742.52	8.27	353	1370718
2	1371071	2742.14	100	0.202	1371071	2742.81	8.26	611	1370460
3	1371071	2742.14	139	0.280	1371071	2743.14	8.01	870	1370201
4	1371071	2742.14	177	0.356	1371071	2743.50	10.96	1128	1369943
5	1371071	2742.14	214	0.430	1371071	2743.85	13.31	1376	1369956
6	1371071	2742.14	251	0.504	1371071	2744.16	16.15	1672	1369444
7	1371071	2742.14	287	0.576	1371071	2744.52	15.73	1868	1369203
8	1371071	2742.14	324	0.650	1371071	2744.82	20.00	2116	1368955
9	1371071	2742.14	362	0.726	1371071	2745.18	21.26	2374	1368697
10	1371071	2742.14	401	0.804	1371071	2745.53	25.75	2639	1368432
11	1371071	2742.14	440	0.882	1371071	2745.84	25.36	2901	1368170
12	1371071	2742.14	480	0.962	1371071	2746.17	28.62	3170	1367901
13	1371071	2742.14	518	1.038	1371071	2746.49	28.45	3425	1367646
14	1371071	2742.14	556	1.114	1371071	2746.82	33.89	3683	1367388
15	1371071	2742.14	593	1.188	1371071	2747.10	32.85	3931	1367140

11. CURVE_Cover Text 11

No.	Cover Text		Hidden Message				Stego Text		
Hm	Length (C)	Size (kb)	Length (C)	Size (Kb)	Length (C)	Size(kb)	Embedding Time (s)	Letter Used	Letter Unused
1	1304117	2608.24	62	0.126	1304117	2608.63	4.91	353	1303764
2	1304117	2608.24	100	0.202	1304117	2608.95	6.93	611	1303506
3	1304117	2608.24	139	0.280	1304117	2609.27	8.44	870	1303257

4	1304117	2608.24	177	0.356	1304117	2609.59	11.17	1128	1302989
5	1304117	2608.24	214	0.430	1304117	2609.88	12.37	1376	1302741
6	1304117	2608.24	251	0.504	1304117	2610.17	14.20	1672	1302490
7	1304117	2608.24	287	0.576	1304117	2610.44	15.26	1868	1302249
8	1304117	2608.24	324	0.650	1304117	2610.76	18.36	2116	1302001
9	1304117	2608.24	362	0.726	1304117	2611.13	20.94	2374	1301743
10	1304117	2608.24	401	0.804	1304117	2611.52	24.75	2639	1301478
11	1304117	2608.24	440	0.882	1304117	2611.84	27.94	2901	1301216
12	1304117	2608.24	480	0.962	1304117	2612.17	29.55	3170	1300947
13	1304117	2608.24	518	1.038	1304117	2612.46	29.72	3425	1300692
14	1304117	2608.24	556	1.114	1304117	2612.79	33.99	3683	1300434
15	1304117	2608.24	593	1.188	1304117	2613.08	36.93	3931	1300186

12. CURVE_Cover Text 12

No.	Cover Text		Hidden Message		Stego Text				
Hm	Length (C)	Size (kb)	Length (C)	Size (Kb)	Length (C)	Size(kb)	Embedding Time (s)	Letter Used	Letter Unused
1	1323584	2647.17	62	0.126	1323584	2647.54	5.40	353	1323231
2	1323584	2647.17	100	0.202	1323584	2647.88	8.47	611	1322973
3	1323584	2647.17	139	0.280	1323584	2648.24	7.98	870	1322714
4	1323584	2647.17	177	0.356	1323584	2648.56	11.80	1128	1322456
5	1323584	2647.17	214	0.430	1323584	2648.89	12.07	1376	1322208
6	1323584	2647.17	251	0.504	1323584	2649.24	16.20	1672	1321957
7	1323584	2647.17	287	0.576	1323584	2649.56	16.39	1868	1321716
8	1323584	2647.17	324	0.650	1323584	2649.88	17.25	2116	1321468
9	1323584	2647.17	362	0.726	1323584	2650.18	18.21	2374	1321210
10	1323584	2647.17	401	0.804	1323584	2650.59	18.55	2639	1320945
11	1323584	2647.17	440	0.882	1323584	2650.78	25.81	2901	1320683
12	1323584	2647.17	480	0.962	1323584	2651.13	28.69	3170	1320414
13	1323584	2647.17	518	1.038	1323584	2651.42	30.14	3425	1320159
14	1323584	2647.17	556	1.114	1323584	2651.71	33.32	3683	1319901
15	1323584	2647.17	593	1.188	1323584	2652.04	30.45	3931	1319653

13. CURVE_Cover Text 13

No.	Cover Text		Hidden Message		Stego Text				
Hm	Length (C)	Size (kb)	Length (C)	Size (Kb)	Length (C)	Size(kb)	Embedding Time (s)	Letter Used	Letter Unused

142

1	1129687	2259.38	62	0.126	1129687	2259.77	7.43	353	1129334
2	1129687	2259.38	100	0.202	1129687	2260.10	5.53	611	1129076
3	1129687	2259.38	139	0.280	1129687	2260.45	7.66	870	1128817
4	1129687	2259.38	177	0.356	1129687	2260.80	8.62	1128	1128559
5	1129687	2259.38	214	0.430	1129687	2261.10	8.53	1376	1128311
6	1129687	2259.38	251	0.504	1129687	2261.42	11.67	1672	1128060
7	1129687	2259.38	287	0.576	1129687	2261.71	13.64	1868	1127819
8	1129687	2259.38	324	0.650	1129687	2262.01	13.55	2116	1127571
9	1129687	2259.38	362	0.726	1129687	2262.37	16.37	2374	1127313
10	1129687	2259.38	401	0.804	1129687	2262.66	15.90	2639	1127048
11	1129687	2259.38	440	0.882	1129687	2262.98	17.43	2901	1126786
12	1129687	2259.38	480	0.962	1129687	2263.34	18.51	3170	1126517
13	1129687	2259.38	518	1.038	1129687	2263.63	21.12	3425	1126262
14	1129687	2259.38	556	1.114	1129687	2263.95	22.17	3683	1126004
15	1129687	2259.38	593	1.188	1129687	2264.23	30.31	3931	1125756

14. CURVE_Cover Text 14

No.	Cover Text		Hidden Message				Stego Text		
Hm	Length (C)	Size (kb)	Length (C)	Size (Kb)	Length (C)	Size(kb)	Embedding Time (s)	Letter Used	Letter Unused
1	1128671	2257.34	62	0.126	1128671	2257.76	3.94	353	1128318
2	1128671	2257.34	100	0.202	1128671	2258.05	5.00	611	1128060
3	1128671	2257.34	139	0.280	1128671	2258.32	8.04	870	1127801
4	1128671	2257.34	177	0.356	1128671	2258.65	9.67	1128	1127543
5	1128671	2257.34	214	0.430	1128671	2258.95	11.98	1376	1127295
6	1128671	2257.34	251	0.504	1128671	2259.21	12.93	1672	1127044
7	1128671	2257.34	287	0.576	1128671	2259.52	14.34	1868	1126803
8	1128671	2257.34	324	0.650	1128671	2259.79	16.66	2116	1126555
9	1128671	2257.34	362	0.726	1128671	2260.11	17.04	2374	1126297
10	1128671	2257.34	401	0.804	1128671	2260.43	21.23	2639	1126032
11	1128671	2257.34	440	0.882	1128671	2260.76	17.63	2901	1125770
12	1128671	2257.34	480	0.962	1128671	2261.04	25.92	3170	1125501
13	1128671	2257.34	518	1.038	1128671	2261.36	24.54	3425	1125246
14	1128671	2257.34	556	1.114	1128671	2261.63	27.22	3683	1124988
15	1128671	2257.34	593	1.188	1128671	2261.89	29.72	3931	1124740

15. CURVE_Cover Text 15

No.	Cover Text		Hidden Message				Stego Text		
Hm	Length (C)	Size (kb)	Length (C)	Size (Kb)	Length (C)	Size(kb)	Embedding Time (s)	Letter Used	Letter Unused
1	1258665	2517.33	62	0.126	1258665	2517.72	4.48	353	1258312
2	1258665	2517.33	100	0.202	1258665	2518.01	6.94	611	1258054
3	1258665	2517.33	139	0.280	1258665	2518.32	8.71	870	1257795
4	1258665	2517.33	177	0.356	1258665	2518.62	8.14	1128	1257537
5	1258665	2517.33	214	0.430	1258665	2518.93	11.38	1376	1257289
6	1258665	2517.33	251	0.504	1258665	2519.21	10.87	1672	1257038
7	1258665	2517.33	287	0.576	1258665	2519.50	13.93	1868	1256797
8	1258665	2517.33	324	0.650	1258665	2519.80	16.94	2116	1256549
9	1258665	2517.33	362	0.726	1258665	2520.12	18.83	2374	1256291
10	1258665	2517.33	401	0.804	1258665	2520.47	21.39	2639	1256026
11	1258665	2517.33	440	0.882	1258665	2520.75	23.56	2901	1255764
12	1258665	2517.33	480	0.962	1258665	2521.10	27.37	3170	1255495
13	1258665	2517.33	518	1.038	1258665	2521.44	29.13	3425	1255240
14	1258665	2517.33	556	1.114	1258665	2521.76	30.22	3683	1254982
15	1258665	2517.33	593	1.188	1258665	2522.10	33.48	3931	1254734

16. CURVER_Cover Text 16

No.	Cover Text		Hidden Message				Stego Text		
Hm	Length (C)	Size (kb)	Length (C)	Size (Kb)	Length (C)	Size(kb)	Embedding Time (s)	Letter Used	Letter Unused
1	1316417	2632.83	62	0.126	1316417	2633.21	4.09	353	1316064
2	1316417	2632.83	100	0.202	1316417	2633.48	6.74	611	1315806
3	1316417	2632.83	139	0.280	1316417	2633.78	7.58	870	1315547
4	1316417	2632.83	177	0.356	1316417	2634.16	11.72	1128	1315289
5	1316417	2632.83	214	0.430	1316417	2634.51	10.70	1376	1315041
6	1316417	2632.83	251	0.504	1316417	2634.82	15.08	1672	1314790
7	1316417	2632.83	287	0.576	1316417	2635.13	17.83	1868	1314549
8	1316417	2632.83	324	0.650	1316417	2635.46	19.42	2116	1314301
9	1316417	2632.83	362	0.726	1316417	2635.85	20.47	2374	1314043
10	1316417	2632.83	401	0.804	1316417	2636.19	24.63	2639	1312778
11	1316417	2632.83	440	0.882	1316417	2636.51	23.36	2901	1313416
12	1316417	2632.83	480	0.962	1316417	2636.82	22.33	3170	1313247
13	1316417	2632.83	518	1.038	1316417	2637.13	29.16	3425	1312992

Hm	Cover Text Length (C)	Size (kb)	Hidden Message Length (C)	Size (Kb)	Stego Text Length (C)	Size(kb)	Embedding Time (s)	Letter Used	Letter Unused
14	1316417	2632.83	556	1.114	1316417	2637.45	29.57	3683	1312734
15	1316417	2632.83	593	1.188	1316417	2637.78	27.47	3931	1312486

17. CURVE_Cover Text 17

No.	Cover Text		Hidden Message		Stego Text				
Hm	Length (C)	Size (kb)	Length (C)	Size (Kb)	Length (C)	Size(kb)	Embedding Time (s)	Letter Used	Letter Unused
1	1546911	3093.82	62	0.126	1546911	3094.24	6.28	353	1546558
2	1546911	3093.82	100	0.202	1546911	3094.56	6.78	611	1546300
3	1546911	3093.82	139	0.280	1546911	3094.86	8.32	870	1546041
4	1546911	3093.82	177	0.356	1546911	3095.16	13.08	1128	1545783
5	1546911	3093.82	214	0.430	1546911	3095.47	15.56	1376	1545535
6	1546911	3093.82	251	0.504	1546911	3095.80	17.26	1672	1545284
7	1546911	3093.82	287	0.576	1546911	3096.13	18.51	1868	1545043
8	1546911	3093.82	324	0.650	1546911	3096.43	22.35	2116	1544795
9	1546911	3093.82	362	0.726	1546911	3096.74	25.07	2374	1544537
10	1546911	3093.82	401	0.804	1546911	3097.04	27.31	2639	1544272
11	1546911	3093.82	440	0.882	1546911	3097.39	28.82	2901	1544010
12	1546911	3093.82	480	0.962	1546911	3097.78	34.62	3170	1543741
13	1546911	3093.82	518	1.038	1546911	3098.11	36.05	3425	1543486
14	1546911	3093.82	556	1.114	1546911	3098.43	40.99	3683	1543228
15	1546911	3093.82	593	1.188	1546911	3098.71	43.51	3931	1542980

18 CURVE_Cover Text 18

No.	Cover Text		Hidden Message		Stego Text				
Hm	Length (C)	Size (kb)	Length (C)	Size (Kb)	Length (C)	Size(kb)	Embedding Time (s)	Letter Used	Letter Unused
1	1258819	2517.64	62	0.126	1258819	2517.80	4.14	353	1248466
2	1258819	2517.64	100	0.202	1258819	2518.38	6.39	611	1258208
3	1258819	2517.64	139	0.280	1258819	2518.73	8.77	870	1257949
4	1258819	2517.64	177	0.356	1258819	2518.91	9.83	1128	1257691
5	1258819	2517.64	214	0.430	1258819	2519.33	12.13	1376	1257443
6	1258819	2517.64	251	0.504	1258819	2519.69	14.67	1672	1257192
7	1258819	2517.64	287	0.576	1258819	2520.04	15.99	1868	1256951
8	1258819	2517.64	324	0.650	1258819	2520.37	18.89	2116	1256703
9	1258819	2517.64	362	0.726	1258819	2520.75	19.13	2374	1256445

No.								
10	1258819	2517.64	401	0.804	1258819	2521.08	24.30	2639	1256180
11	1258819	2517.64	440	0.882	1258819	2521.41	23.13	2901	1255918
12	1258819	2517.64	480	0.962	1258819	2521.70	29.13	3170	1255649
13	1258819	2517.64	518	1.038	1258819	2522.01	30.61	3425	1255539
14	1258819	2517.64	556	1.114	1258819	2522.36	31.51	3683	1255136
15	1258819	2517.64	593	1.188	1258819	2522.68	34.90	3931	1254888

19. CURVE_Cover Text 19

No.	Cover Text		Hidden Message		Stego Text				
Hm	Length (C)	Size (kb)	Length (C)	Size (Kb)	Length (C)	Size(kb)	Embedding Time (s)	Letter Used	Letter Unused
1	1261780	2523.56	62	0.126	1261780	2523.96	4.28	353	1261427
2	1261780	2523.56	100	0.202	1261780	2524.23	6.57	611	1261169
3	1261780	2523.56	139	0.280	1261780	2524.62	7.78	870	1260910
4	1261780	2523.56	177	0.356	1261780	2524.94	11.18	1128	1260652
5	1261780	2523.56	214	0.430	1261780	2525.22	13.56	1376	1260404
6	1261780	2523.56	251	0.504	1261780	2525.54	15.04	1672	1260153
7	1261780	2523.56	287	0.576	1261780	2525.84	17.28	1868	1259912
8	1261780	2523.56	324	0.650	1261780	2526.15	18.41	2116	1259664
9	1261780	2523.56	362	0.726	1261780	2526.51	20.55	2374	1259406
10	1261780	2523.56	401	0.804	1261780	2526.86	23.72	2639	1259141
11	1261780	2523.56	440	0.882	1261780	2527.20	26.47	2901	1259364
12	1261780	2523.56	480	0.962	1261780	2527.56	27.94	3170	1258610
13	1261780	2523.56	518	1.038	1261780	2527.88	30.93	3425	1258355
14	1261780	2523.56	556	1.114	1261780	2528.18	32.94	3683	1258097
15	1261780	2523.56	593	1.188	1261780	2528.54	35.18	3931	1257849

20. CURVE_Cover Text 20

No.	Cover Text		Hidden Message		Stego Text				
Hm	Length (C)	Size (kb)	Length (C)	Size (Kb)	Length (C)	Size(kb)	Embedding Time (s)	Letter Used	Letter Unused
1	1049566	2099.13	62	0.126	1049566	2099.53	3.31	353	1049213
2	1049566	2099.13	100	0.202	1049566	2099.88	5.15	611	1048955
3	1049566	2099.13	139	0.280	1049566	2100.23	6.54	870	1048696
4	1049566	2099.13	177	0.356	1049566	2100.57	9.20	1128	1048438

5	1049566	2099.13	214	0.430	1049566	2100.88	11.38	1376	1048190
6	1049566	2099.13	251	0.504	1049566	2101.17	13.57	1672	1047939
7	1049566	2099.13	287	0.576	1049566	2101.48	13.43	1868	1047698
8	1049566	2099.13	324	0.650	1049566	2101.81	16.93	2116	1047450
9	1049566	2099.13	362	0.726	1049566	2102.17	18.62	2374	1047192
10	1049566	2099.13	401	0.804	1049566	2102.51	20.06	2639	1046927
11	1049566	2099.13	440	0.882	1049566	2102.85	18.14	2901	1046665
12	1049566	2099.13	480	0.962	1049566	2103.21	24.30	3170	1046396
13	1049566	2099.13	518	1.038	1049566	2103.56	26.53	3425	1046141
14	1049566	2099.13	556	1.114	1049566	2103.90	29.22	3683	1045883
15	1049566	2099.13	593	1.188	1049566	2104.23	29.98	3931	1045635

Appendix C

Result Experiment VERT Scheme

1. VERT_Cover Text 1

No.	Cover	Text	Hidden	Message			Stego Text		
HM	Length (C)	Size (kb)	Length (C)	Size (Kb)	Length (C)	Size(kb)	Embedding Time (s)	Letter Used	Letter Unused
1	1254440	2508.88	62	0.126	1254440	2508.97	3.86	345	1254095
2	1254440	2508.88	100	0.202	1254440	2509.06	6.38	598	1253842
3	1254440	2508.88	139	0.280	1254440	2509.09	8.53	853	1253587
4	1254440	2508.88	177	0.356	1254440	2509.16	9.80	1111	1253329
5	1254440	2508.88	214	0.430	1254440	2509.23	12.17	1367	1253085
6	1254440	2508.88	251	0.504	1254440	2509.30	15.17	1672	1252813
7	1254440	2508.88	287	0.576	1254440	2509.31	16.24	1868	1252572
8	1254440	2508.88	324	0.650	1254440	2509.34	17.65	2084	1252356
9	1254440	2508.88	362	0.726	1254440	2509.40	20.05	2338	1252066
10	1254440	2508.88	401	0.804	1254440	2509.47	21.47	2597	1251843
11	1254440	2508.88	440	0.882	1254440	2509.54	24.78	2895	1251581
12	1254440	2508.88	480	0.962	1254440	2509.63	25.33	3121	1251319
13	1254440	2508.88	518	1.038	1254440	2509.72	29.53	3373	1251067
14	1254440	2508.88	556	1.114	1254440	2509.78	29.81	3632	1250808
15	1254440	2508.88	593	1.188	1254440	2509.85	32.95	3879	1250561

2. VERT_Cover Text 2

No.	Cover	Text	Hidden	Message			Stego Text		
HM	Length (C)	Size (kb)	Length (C)	Size (Kb)	Length (C)	Size(kb)	Embedding Time (s)	Letter Used	Letter Unused
1	1217495	2434.99	62	0.126	1217495	2435.07	6.66	346	1217149
2	1217495	2434.99	100	0.202	1217495	2435.07	5.56	598	1216641
3	1217495	2434.99	139	0.280	1217495	2435.14	7.33	854	1216625
4	1217495	2434.99	177	0.356	1217495	2435.19	8.38	1107	1216388
5	1217495	2434.99	214	0.430	1217495	2435.23	9.60	1351	1216144
6	1217495	2434.99	251	0.504	1217495	2435.10	12.04	1599	1215896
7	1217495	2434.99	287	0.576	1217495	2435.37	13.84	1840	1215655
8	1217495	2434.99	324	0.650	1217495	2435.41	15.45	2088	1215407

No.	Length (C)	Size (kb)	Length (C)	Size (Kb)	Length (C)	Size(kb)	Embedding Time (s)	Letter Used	Letter Unused
9	1217495	2434.99	362	0.726	1217495	2435.54	21.26	2345	1215121
10	1217495	2434.99	401	0.804	1217495	2435.55	22.97	2605	1214856
11	1217495	2434.99	440	0.882	1217495	2435.59	25.38	2866	1214629
12	1217495	2434.99	480	0.962	1217495	2435.62	24.29	3132	1214363
13	1217495	2434.99	518	1.038	1217495	2435.63	24.73	3385	1214110
14	1217495	2434.99	556	1.114	1217495	2435.69	29.81	3638	1213857
15	1217495	2434.99	593	1.188	1217495	2435.72	31.24	3879	1213616

3. VERT_Cover text 3

No.	Cover Text		Hidden Message		Stego Text				
	Length (C)	Size (kb)	Length (C)	Size (Kb)	Length (C)	Size(kb)	Embedding Time (s)	Letter Used	Letter Unused
1	1298721	2597.44	62	0.126	1298721	2597.52	4.49	353	1298378
2	1298721	2597.44	100	0.202	1298721	2597.59	6.18	603	1298118
3	1298721	2597.44	139	0.280	1298721	2597.63	7.16	858	1297863
4	1298721	2597.44	177	0.356	1298721	2597.71	13.92	1109	1287612
5	1298721	2597.44	214	0.430	1298721	2597.78	13.97	1376	1297365
6	1298721	2597.44	251	0.504	1298721	2597.79	15.92	1601	1297120
7	1298721	2597.44	287	0.576	1298721	2597.86	17.97	1836	1296885
8	1298721	2597.44	324	0.650	1298721	2597.93	22.21	2080	1296641
9	1298721	2597.44	362	0.726	1298721	2598.06	22.67	2333	1296388
10	1298721	2597.44	401	0.804	1298721	2598.10	25.70	2593	1296128
11	1298721	2597.44	440	0.882	1298721	2598.20	22.51	2854	1295867
12	1298721	2597.44	480	0.962	1298721	2598.25	26.70	3118	1295603
13	1298721	2597.44	518	1.038	1298721	2598.32	26.34	3369	1295352
14	1298721	2597.44	556	1.114	1298721	2598.37	31.65	3623	1295098
15	1298721	2597.44	593	1.188	1298721	2598.45	28.35	3869	1294852

4. VERT_Cover text 4

No.	Cover Text		Hidden Message		Stego Text				
HM	Length (C)	Size (kb)	Length (C)	Size (Kb)	Length (C)	Size(kb)	Embedding Time (s)	Letter Used	Letter Unused
1	1321623	2643.24	62	0.126	1321623	2643.35	4.41	342	1321281
2	1321623	2643.24	100	0.202	1321623	2643.39	5.57	598	1321027
3	1321623	2643.24	139	0.280	1321623	2643.43	7.94	852	1320771

4	1321623	2643.24	177	0.356	1321623	2643.46	11.58	1108	1320515
5	1321623	2643.24	214	0.430	1321623	2643.51	13.87	1350	1320273
6	1321623	2643.24	251	0.504	1321623	2643.53	15.24	1601	1320002
7	1321623	2643.24	287	0.576	1321623	2643.58	16.20	1868	1319755
8	1321623	2643.24	324	0.650	1321623	2643.60	19.91	2083	1319540
9	1321623	2643.24	362	0.726	1321623	2643.63	21.55	2336	1319287
10	1321623	2643.24	401	0.804	1321623	2643.67	20.09	2600	1319023
11	1321623	2643.24	440	0.882	1321623	2643.68	25.44	2858	1318765
12	1321623	2643.24	480	0.962	1321623	2643.68	24.73	3125	1318498
13	1321623	2643.24	518	1.038	1321623	2643.69	29.13	3376	1318247
14	1321623	2643.24	556	1.114	1321623	2643.70	30.56	3633	1317990
15	1321623	2643.24	593	1.188	1298721	2643.76	33.11	3880	1317743

5. VERT_Cover text 5

No.	Cover Text		Hidden Message		Stego Text				
HM	Length (C)	Size (kb)	Length (C)	Size (Kb)	Length (C)	Size(kb)	Embedding Time (s)	Letter Used	Letter Unused
1	1388644	2777.29	62	0.126	1388644	2777.39	4.58	344	1388300
2	1388644	2777.29	100	0.202	1388644	2777.44	9.10	611	1388083
3	1388644	2777.29	139	0.280	1388644	2777.49	12.35	858	1387786
4	1388644	2777.29	177	0.356	1388644	2777.52	11.66	1113	1387531
5	1388644	2777.29	214	0.430	1388644	2777.60	14.31	1376	1387286
6	1388644	2777.29	251	0.504	1388644	2777.60	13.96	1603	1387041
7	1388644	2777.29	287	0.576	1388644	2777.62	16.67	1841	1386803
8	1388644	2777.29	324	0.650	1388644	2777.62	18.87	2085	1386550
9	1388644	2777.29	362	0.726	1388644	2777.63	18.35	2337	1386307
10	1388644	2777.29	401	0.804	1388644	2777.65	20.50	2599	1386045
11	1388644	2777.29	440	0.882	1388644	2777.66	23.00	2855	1385789
12	1388644	2777.29	480	0.962	1388644	2777.67	25.54	3170	1385474
13	1388644	2777.29	518	1.038	1388644	2777.68	27.99	3372	1385272
14	1388644	2777.29	556	1.114	1388644	2777.73	31.69	3683	1384961
15	1388644	2777.29	593	1.188	1388644	2777.74	32.86	3873	1384771

6. CURVE_Cover text 6

No.	Cover Text		Hidden Message				Stego Text		
HM	Length (C)	Size (kb)	Length (C)	Size (Kb)	Length (C)	Size(kb)	Embedding Time (s)	Letter Used	Letter Unused
1	1254765	2509.53	62	0.126	1254765	2509.62	4.24	349	1254416
2	1254765	2509.53	100	0.202	1254765	2509.70	5.52	611	1254154
3	1254765	2509.53	139	0.280	1254765	2509.75	7.50	870	1253895
4	1254765	2509.53	177	0.356	1254765	2509.82	10.33	1114	1253651
5	1254765	2509.53	214	0.430	1254765	2509.88	10.74	1376	1253389
6	1254765	2509.53	251	0.504	1254765	2509.92	17.17	1610	1253155
7	1254765	2509.53	287	0.576	1254765	2510.00	18.61	1868	1252897
8	1254765	2509.53	324	0.650	1254765	2510.02	15.03	2089	1252676
9	1254765	2509.53	362	0.726	1254765	2510.08	18.21	2345	1252420
10	1254765	2509.53	401	0.804	1254765	2510.14	19.05	2605	1252160
11	1254765	2509.53	440	0.882	1254765	2510.21	24.37	2861	1251904
12	1254765	2509.53	480	0.962	1254765	2510.29	27.25	3129	1251636
13	1254765	2509.53	518	1.038	1254765	2510.41	30.38	3382	1251383
14	1254765	2509.53	556	1.114	1254765	2510.49	31.84	3680	1251135
15	1254765	2509.53	593	1.188	1254765	2510.58	34.26	3881	1250884

7. VERT_Cover text 7

No.	Cover Text		Hidden Message				Stego Text		
HM	Length (C)	Size (kb)	Length (C)	Size (Kb)	Length (C)	Size(kb)	Embedding Time (s)	Letter Used	Letter Unused
1	1256772	2513.55	62	0.126	125772	2513.64	4.09	347	1256425
2	1256772	2513.55	100	0.202	125772	2513.64	6.38	603	1256169
3	1256772	2513.55	139	0.280	125772	2513.64	7.92	859	1255913
4	1256772	2513.55	177	0.356	125772	2513.72	8.88	1114	1255658
5	1256772	2513.55	214	0.430	125772	2513.79	9.78	1355	1255417
6	1256772	2513.55	251	0.504	125772	2513.82	10.87	1604	1255168
7	1256772	2513.55	287	0.576	125772	2513.89	15.46	1842	1254930
8	1256772	2513.55	324	0.650	125772	2514.00	15.35	2087	1254685
9	1256772	2513.55	362	0.726	125772	2514.09	17.17	2342	1254430
10	1256772	2513.55	401	0.804	125772	2514.12	21.52	2605	1254167
11	1256772	2513.55	440	0.882	125772	2514.25	23.67	2865	1253907
12	1256772	2513.55	480	0.962	125772	2514.32	26.09	3130	1253642

No.	13	1256772	2513.55	518	1.038	125772	2514.34	27.14	3382	1253390
	14	1256772	2513.55	556	1.114	125772	2514.34	26.75	3637	1253135
	15	1256772	2513.55	593	1.188	125772	2514.39	32.11	3883	1252889

8. VERT_Cover text 8

No.	Cover Text		Hidden Message		Stego Text				
HM	Length (C)	Size (kb)	Length (C)	Size (Kb)	Length (C)	Size(kb)	Embedding Time (s)	Letter Used	Letter Unused
1	1338903	2677.80	62	0.126	1338903	2677.90	4.60	347	1338556
2	1338903	2677.80	100	0.202	1338903	2677.95	6.40	603	1338300
3	1338903	2677.80	139	0.280	1338903	2677.96	9.76	857	1338046
4	1338903	2677.80	177	0.356	1338903	2678.04	11.11	1110	1337793
5	1338903	2677.80	214	0.430	1338903	2678.15	13.09	1356	1337547
6	1338903	2677.80	251	0.504	1338903	2678.23	16.24	1602	1337301
7	1338903	2677.80	287	0.576	1338903	2678.30	16.81	1839	1337064
8	1338903	2677.80	324	0.650	1338903	2678.31	19.35	2081	1336822
9	1338903	2677.80	362	0.726	1338903	2678.35	21.39	2334	1336569
10	1338903	2677.80	401	0.804	1338903	2678.42	23.69	2596	1336307
11	1338903	2677.80	440	0.882	1338903	2678.48	23.12	2855	1336048
12	1338903	2677.80	480	0.962	1338903	2678.58	29.24	3120	1335783
13	1338903	2677.80	518	1.038	1338903	2678.64	32.64	3373	1335530
14	1338903	2677.80	556	1.114	1338903	2678.64	35.70	3626	1335277
15	1338903	2677.80	593	1.188	1338903	2678.71	37.92	3872	1335031

9. VERT_Cover TEXT 9

No.	Cover Text		Hidden Message		Stego Text				
HM	Length (C)	Size (kb)	Length (C)	Size (Kb)	Length (C)	Size(kb)	Embedding Time (s)	Letter Used	Letter Unused
1	1410117	2820.23	62	0.126	2820.39	2820.39	5.89	347	1409770
2	1410117	2820.23	100	0.202	2820.47	2820.47	7.61	602	1409515
3	1410117	2820.23	139	0.280	2820.49	2820.49	8.65	855	1409262
4	1410117	2820.23	177	0.356	2820.49	2820.49	11.71	1108	1409009
5	1410117	2820.23	214	0.430	2820.59	2820.59	13.11	1354	1408763
6	1410117	2820.23	251	0.504	2820.59	2820.59	16.00	1600	1408517
7	1410117	2820.23	287	0.576	2820.60	2820.60	17.79	1837	1408280
8	1410117	2820.23	324	0.650	2820.60	2820.60	19.78	2082	1408045

HM	Length (C)	Size (kb)	Length (C)	Size (Kb)	Length (C)	Size(kb)	Embedding Time (s)	Letter Used	Letter Unused
9	1410117	2820.23	362	0.726		2820.60	2820.60	23.98	2336	1407781
10	1410117	2820.23	401	0.804		2820.63	2820.63	26.23	2597	1407520
11	1410117	2820.23	440	0.882		2820.72	2820.72	26.97	2857	1407260
12	1410117	2820.23	480	0.962		2820.77	2820.77	29.62	3119	1406998
13	1410117	2820.23	518	1.038		2820.87	2820.87	32.91	3371	1406746
14	1410117	2820.23	556	1.114		2820.91	2820.91	35.23	3630	1406487
15	1410117	2820.23	593	1.188		2820.91	2820.91	37.35	3873	1406244

10. VERT_Cover 10

No.	Cover Text		Hidden Message		Stego Text				
HM	Length (C)	Size (kb)	Length (C)	Size (Kb)	Length (C)	Size(kb)	Embedding Time (s)	Letter Used	Letter Unused
1	1371071	2742.14	62	0.126	1371071	2742.23	4.47	346	1370725
2	1371071	2742.14	100	0.202	1371071	2742.32	6.85	599	1370472
3	1371071	2742.14	139	0.280	1371071	2742.37	9.58	857	1370214
4	1371071	2742.14	177	0.356	1371071	2742.38	11.46	1113	1369958
5	1371071	2742.14	214	0.430	1371071	2742.40	13.35	1360	1369711
6	1371071	2742.14	251	0.504	1371071	2742.46	15.28	1605	1369466
7	1371071	2742.14	287	0.576	1371071	2742.47	18.17	1845	1369226
8	1371071	2742.14	324	0.650	1371071	2742.50	19.49	2087	1368984
9	1371071	2742.14	362	0.726	1371071	2742.59	22.98	2337	1368734
10	1371071	2742.14	401	0.804	1371071	2742.62	22.62	2596	1368475
11	1371071	2742.14	440	0.882	1371071	2742.67	25.81	2853	1368218
12	1371071	2742.14	480	0.962	1371071	2742.70	30.67	3119	1367952
13	1371071	2742.14	518	1.038	1371071	2742.77	30.47	3369	1367702
14	1371071	2742.14	556	1.114	1371071	2742.79	34.59	3626	1367445
15	1371071	2742.14	593	1.188	1371071	2742.87	36.17	3870	1367201

11. VERT_Cover Text 11

No.	Cover Text		Hidden Message		Stego Text				
HM	Length (C)	Size (kb)	Length (C)	Size (Kb)	Length (C)	Size(kb)	Embedding Time (s)	Letter Used	Letter Unused
1	1304117	2608.24	62	0.126	1304117	2608.32	8.59	347	1303770
2	1304117	2608.24	100	0.202	1304117	2608.35	6.57	602	1303515
3	1304117	2608.24	139	0.280	1304117	2608.41	8.77	858	1303259

HM	Length (C)	Size (kb)	Length (C)	Size (Kb)	Length (C)	Size(kb)	Embedding Time (s)	Letter Used	Letter Unused
4	1304117	2608.24	177	0.356	1304117	2608.50	8.87	1110	1303007
5	1304117	2608.24	214	0.430	1304117	2608.57	10.13	1354	1302763
6	1304117	2608.24	251	0.504	1304117	2608.66	11.52	1603	1302514
7	1304117	2608.24	287	0.576	1304117	2608.72	13.11	1839	1302278
8	1304117	2608.24	324	0.650	1304117	2608.83	15.50	2084	1302033
9	1304117	2608.24	362	0.726	1304117	2608.85	17.36	2337	1301780
10	1304117	2608.24	401	0.804	1304117	2608.86	18.42	2600	1301517
11	1304117	2608.24	440	0.882	1304117	2608.87	19.34	2860	1301257
12	1304117	2608.24	480	0.962	1304117	2608.93	21.36	3124	1300993
13	1304117	2608.24	518	1.038	1304117	2608.98	22.63	3374	1300743
14	1304117	2608.24	556	1.114	1304117	2609.02	23.79	3627	1300940
15	1304117	2608.24	593	1.188	1304117	2609.10	25.76	3931	1300186

12. VERT_Cover Text 12

No.	Cover Text		Hidden Message			Stego Text			
HM	Length (C)	Size (kb)	Length (C)	Size (Kb)	Length (C)	Size(kb)	Embedding Time (s)	Letter Used	Letter Unused
1	1323584	2647.17	62	0.126	1323584	2647.29	3.75	343	1323241
2	1323584	2647.17	100	0.202	1323584	2647.32	5.47	596	1322988
3	1323584	2647.17	139	0.280	1323584	2647.32	6.68	851	1322733
4	1323584	2647.17	177	0.356	1323584	2647.32	9.31	1101	1322483
5	1323584	2647.17	214	0.430	1323584	2647.32	10.27	1345	1322239
6	1323584	2647.17	251	0.504	1323584	2647.32	11.75	1593	1321991
7	1323584	2647.17	287	0.576	1323584	2647.32	13.51	1825	1321759
8	1323584	2647.17	324	0.650	1323584	2647.32	14.77	2071	1321513
9	1323584	2647.17	362	0.726	1323584	2647.41	18.17	2326	1321258
10	1323584	2647.17	401	0.804	1323584	2647.49	19.65	2586	1320998
11	1323584	2647.17	440	0.882	1323584	2647.58	19.92	2846	1320738
12	1323584	2647.17	480	0.962	1323584	2647.61	23.85	3110	1320474
13	1323584	2647.17	518	1.038	1323584	2647.69	24.42	3262	1320222
14	1323584	2647.17	556	1.114	1323584	2647.72	26.61	3617	1319967
15	1323584	2647.17	593	1.188	1323584	2647.83	29.10	3860	1319724

13. VERT_Cover Text 13

No.	Cover	Text	Hidden Message				Stego Text		
HM	Length (C)	Size (kb)	Length (C)	Size (Kb)	Length (C)	Size(kb)	Embedding Time (s)	Letter Used	Letter Unused
1	1129687	2259.38	62	0.126	1129687	2259.48	3.98	346	1129341
2	1129687	2259.38	100	0.202	1129687	2259.52	5.17	603	1129084
3	1129687	2259.38	139	0.280	1129687	2259.53	6.85	857	1128830
4	1129687	2259.38	177	0.356	1129687	2259.56	8.05	1113	1128574
5	1129687	2259.38	214	0.430	1129687	2259.62	9.65	1357	1128330
6	1129687	2259.38	251	0.504	1129687	2259.64	10.90	1600	1128087
7	1129687	2259.38	287	0.576	1129687	2259.69	11.82	1840	1127847
8	1129687	2259.38	324	0.650	1129687	2259.76	13.25	2085	1127602
9	1129687	2259.38	362	0.726	1129687	2259.80	15.97	2339	1127348
10	1129687	2259.38	401	0.804	1129687	2259.90	20.11	2602	1127085
11	1129687	2259.38	440	0.882	1129687	2259.97	18.67	2860	1126827
12	1129687	2259.38	480	0.962	1129687	2260.03	19.80	3128	1126559
13	1129687	2259.38	518	1.038	1129687	2260.03	20.91	3380	1126307
14	1129687	2259.38	556	1.114	1129687	2260.09	23.07	3631	1126056
15	1129687	2259.38	593	1.188	1129687	2260.18	23.96	3877	1125810

14. VERT_Cover Text 14

No.	Cover	Text	Hidden Message				Stego Text		
HM	Length (C)	Size (kb)	Length (C)	Size (Kb)	Length (C)	Size(kb)	Embedding Time (s)	Letter Used	Letter Unused
1	1128671	2257.34	62	0.126	1128671	2257.42	6.28	346	1128325
2	1128671	2257.34	100	0.202	1128671	2257.50	5.44	600	1128071
3	1128671	2257.34	139	0.280	1128671	2257.62	7.08	857	1127814
4	1128671	2257.34	177	0.356	1128671	2257.72	8.52	1112	1127559
5	1128671	2257.34	214	0.430	1128671	2257.78	10.23	1356	1127315
6	1128671	2257.34	251	0.504	1128671	2257.89	11.40	1601	1127070
7	1128671	2257.34	287	0.576	1128671	2257.97	12.87	1841	1126830
8	1128671	2257.34	324	0.650	1128671	2258.05	16.24	2086	1126585
9	1128671	2257.34	362	0.726	1128671	2258.09	18.22	2342	1126329
10	1128671	2257.34	401	0.804	1128671	2258.21	23.19	2605	1126066
11	1128671	2257.34	440	0.882	1128671	2258.26	24.38	2863	1125808
12	1128671	2257.34	480	0.962	1128671	2258.37	28.62	3128	1125543

HM	Length (C)	Size (kb)	Length (C)	Size (Kb)	Length (C)	Size(kb)	Embedding Time (s)	Letter Used	Letter Unused
13	1128671	2257.34	518	1.038	1128671	2258.48	28.02	3378	1125293
14	1128671	2257.34	556	1.114	1128671	2258.55	29.89	3634	1125037
15	1128671	2257.34	593	1.188	1128671	2258.67	28.77	3878	1124793

15. VERT_Cover Text 15

No.	Cover Text		Hidden Message		Stego Text				
HM	Length (C)	Size (kb)	Length (C)	Size (Kb)	Length (C)	Size(kb)	Embedding Time (s)	Letter Used	Letter Unused
1	1258665	2517.33	62	0.126	1258665	2518.44	4.55	345	1258320
2	1258665	2517.33	100	0.202	1258665	2518.54	6.31	598	1258067
3	1258665	2517.33	139	0.280	1258665	2518.62	9.64	851	1257814
4	1258665	2517.33	177	0.356	1258665	2518.69	10.82	1106	1257559
5	1258665	2517.33	214	0.430	1258665	2518.74	14.58	1353	1257312
6	1258665	2517.33	251	0.504	1258665	2518.82	15.50	1601	1257064
7	1258665	2517.33	287	0.576	1258665	2518.87	19.29	1838	1256727
8	1258665	2517.33	324	0.650	1258665	2518.95	20.82	2084	1256581
9	1258665	2517.33	362	0.726	1258665	2519.07	23.71	2340	1256325
10	1258665	2517.33	401	0.804	1258665	2519.14	27.92	2603	1256062
11	1258665	2517.33	440	0.882	1258665	2519.23	25.13	2856	1255809
12	1258665	2517.33	480	0.962	1258665	2519.35	26.24	3121	1255544
13	1258665	2517.33	518	1.038	1258665	2519.37	30.65	3373	1255292
14	1258665	2517.33	556	1.114	1258665	2519.39	29.55	3630	1255035
15	1258665	2517.33	593	1.188	1258665	2519.54	32.11	3875	1254790

16. VERT_Cover Text 16

No.	Cover Text		Hidden Message		Stego Text				
HM	Length (C)	Size (kb)	Length (C)	Size (Kb)	Length (C)	Size(kb)	Embedding Time (s)	Letter Used	Letter Unused
1	1316417	2632.83	62	0.126	1316417	2633.00	4.61	344	1316073
2	1316417	2632.83	100	0.202	1316417	2633.10	6.60	601	1315816
3	1316417	2632.83	139	0.280	1316417	2633.19	9.28	859	1315558
4	1316417	2632.83	177	0.356	1316417	2633.19	13.13	1117	1315300
5	1316417	2632.83	214	0.430	1316417	2633.19	14.97	1361	1315056
6	1316417	2632.83	251	0.504	1316417	2633.27	16.57	1609	1314808
7	1316417	2632.83	287	0.576	1316417	2633.29	17.28	1849	1314568
8	1316417	2632.83	324	0.650	1316417	2633.30	19.00	2096	1314321

HM	Length (C)	Size (kb)	Length (C)	Size (Kb)	Length (C)	Size(kb)	Embedding Time (s)	Letter Used	Letter Unused
9	1316417	2632.83	362	0.726	1316417	2633.30	24.24	2351	1314066
10	1316417	2632.83	401	0.804	1316417	2633.31	24.45	2613	1312804
11	1316417	2632.83	440	0.882	1316417	2633.41	29.97	2871	1313546
12	1316417	2632.83	480	0.962	1316417	2633.43	28.54	3141	1313276
13	1316417	2632.83	518	1.038	1316417	2633.48	32.27	3495	1313022
14	1316417	2632.83	556	1.114	1316417	2633.57	33.05	3649	1312768
15	1316417	2632.83	593	1.188	1316417	2633.62	32.60	3894	1312523

17. VERT_Cover Text 17

No.	Cover Text		Hidden Message		Stego Text				
HM	Length (C)	Size (kb)	Length (C)	Size (Kb)	Length (C)	Size(kb)	Embedding Time (s)	Letter Used	Letter Unused
1	1546911	3093.82	62	0.126	1546911	3093.93	4.36	344	1546567
2	1546911	3093.82	100	0.202	1546911	3094.01	8.52	596	1546315
3	1546911	3093.82	139	0.280	1546911	3094.09	10.72	850	1546061
4	1546911	3093.82	177	0.356	1546911	3094.16	14.66	1105	1545806
5	1546911	3093.82	214	0.430	1546911	3094.23	17.29	1352	1545559
6	1546911	3093.82	251	0.504	1546911	3094.23	18.98	1600	1545311
7	1546911	3093.82	287	0.576	1546911	3094.23	17.28	1847	1545074
8	1546911	3093.82	324	0.650	1546911	3094.25	25.48	2083	1544828
9	1546911	3093.82	362	0.726	1546911	3094.33	28.01	2335	1544576
10	1546911	3093.82	401	0.804	1546911	3094.40	29.74	2600	1544311
11	1546911	3093.82	440	0.882	1546911	3094.46	37.51	2853	1544058
12	1546911	3093.82	480	0.962	1546911	3094.46	35.20	3115	1543796
13	1546911	3093.82	518	1.038	1546911	3094.46	39.64	3470	1543541
14	1546911	3093.82	556	1.114	1546911	3094.53	47.31	3626	1543285
15	1546911	3093.82	593	1.188	1546911	3094.61	40.95	3870	1543041

19 VERT_Cover Text 18

No.	Cover Text		Hidden Message		Stego Text				
HM	Length (C)	Size (kb)	Length (C)	Size (Kb)	Length (C)	Size(kb)	Embedding Time (s)	Letter Used	Letter Unused
1	1258819	2517.64	62	0.126	1258819	2517.72	5.06	342	1248477
2	1258819	2517.64	100	0.202	1258819	2517.84	7.39	595	1258224
3	1258819	2517.64	139	0.280	1258819	2517.89	9.03	852	1257967
4	1258819	2517.64	177	0.356	1258819	2517.92	11.63	1105	1257714

5	1258819	2517.64	214	0.430	1258819	2518.01	14.99	1346	1257473
6	1258819	2517.64	251	0.504	1258819	2518.05	17.49	1592	1257227
7	1258819	2517.64	287	0.576	1258819	2518.06	16.65	1830	1256989
8	1258819	2517.64	324	0.650	1258819	2518.06	20.73	2069	1256740
9	1258819	2517.64	362	0.726	1258819	2518.06	22.56	2324	1256495
10	1258819	2517.64	401	0.804	1258819	2518.08	25.93	2584	1256235
11	1258819	2517.64	440	0.882	1258819	2518.14	27.44	2846	1255973
12	1258819	2517.64	480	0.962	1258819	2518.18	30.59	3112	1255707
13	1258819	2517.64	518	1.038	1258819	2518.27	30.56	3362	1255457
14	1258819	2517.64	556	1.114	1258819	2518.34	33.72	3618	1255201
15	1258819	2517.64	593	1.188	1258819	2518.68	38.28	3863	1254956

18. VERT_Cover Text 19

No.	Cover Text		Hidden Message		Stego Text				
HM	Length (C)	Size (kb)	Length (C)	Size (Kb)	Length (C)	Size(kb)	Embedding Time (s)	Letter Used	Letter Unused
1	1261780	2523.56	62	0.126	1261780	2523.68	4.25	343	1261437
2	1261780	2523.56	100	0.202	1261780	2523.78	6.65	601	1261179
3	1261780	2523.56	139	0.280	1261780	2523.82	6.44	857	1260923
4	1261780	2523.56	177	0.356	1261780	2523.83	8.73	1112	1260668
5	1261780	2523.56	214	0.430	1261780	2523.89	10.75	1355	1260425
6	1261780	2523.56	251	0.504	1261780	2523.93	13.20	1603	1260177
7	1261780	2523.56	287	0.576	1261780	2523.94	14.00	1834	1259946
8	1261780	2523.56	324	0.650	1261780	2524.01	15.54	2078	1259702
9	1261780	2523.56	362	0.726	1261780	2524.04	19.69	2323	1259448
10	1261780	2523.56	401	0.804	1261780	2524.04	24.56	2592	1259188
11	1261780	2523.56	440	0.882	1261780	2524.04	25.24	2849	1258931
12	1261780	2523.56	480	0.962	1261780	2524.04	26.07	3113	1258667
13	1261780	2523.56	518	1.038	1261780	2524.11	35.67	3364	1258416
14	1261780	2523.56	556	1.114	1261780	2524.16	34.15	3619	1258161
15	1261780	2523.56	593	1.188	1261780	2524.21	38.70	3869	1257911

19. VERT_Cover Text 20

No.	Cover Text		Hidden Message		Stego Text				
HM	Length (C)	Size (kb)	Length (C)	Size (Kb)	Length (C)	Size(kb)	Embedding Time (s)	Letter Used	Letter Unused
1	1049566	2099.13	62	0.126	1049566	2099.22	4.64	344	1049222
2	1049566	2099.13	100	0.202	1049566	2099.24	7.00	599	1048967
3	1049566	2099.13	139	0.280	1049566	2099.25	7.30	854	1048712
4	1049566	2099.13	177	0.356	1049566	2099.25	9.96	1108	1048458
5	1049566	2099.13	214	0.430	1049566	2099.31	13.56	1352	1048214
6	1049566	2099.13	251	0.504	1049566	2099.38	15.02	1600	1047966
7	1049566	2099.13	287	0.576	1049566	2099.44	15.77	1837	1047729
8	1049566	2099.13	324	0.650	1049566	2099.50	20.79	2083	1047483
9	1049566	2099.13	362	0.726	1049566	2099.51	18.49	2336	1047230
10	1049566	2099.13	401	0.804	1049566	2099.51	19.98	2597	1046969
11	1049566	2099.13	440	0.882	1049566	2099.57	26.82	2854	1046712
12	1049566	2099.13	480	0.962	1049566	2099.62	27.81	3123	1046443
13	1049566	2099.13	518	1.038	1049566	2099.63	27.82	3377	1046189
14	1049566	2099.13	556	1.114	1049566	2099.64	31.99	3628	1045938
15	1049566	2099.13	593	1.188	1049566	2099.64	35.09	3876	1045690

Appendix D

Performance Evaluation on Analyzed Text

Letter-based Technique	True Positive (TP)	True Negative (TN)	False Negative (FN)	False Positive (FP)
CALP Scheme	185	100	15	0
CURVE Scheme	185	100	15	0
VERT Scheme	46	99	154	1

Appendix E

Source Code the Experiment

- **Script of CALP Scheme**

```
String coverText = CoverText.getText();
 int k = coverText.length();
 int size = (int) coverText.length();
 LengthStego.setText(" " + size + " characters");
 String binary = BinaryText.getText();
 int noOfElement = binary.length();
 int j = 0;
 int used = 0;
for (int i = 0; i < k; i++) {
char c = coverText.charAt(i);
 if (c == 'a' || c == 'A' || c == 'c') {
System.out.println("sas" + j + ": " + binary.charAt(j));
 stego += c;
 coverText = coverText.substring(0, i) + a, A, c +
coverText.substring(i + 1);
 used++;

else if (c == 'i' || c == 'j') {
 if (binary.charAt(j) == '0') {
{coverText = coverText.substring(0, i) + i, j +
coverText.substring(i + 1);
 used++;
 arr.add(i);
 j++;

StegoText.setText(coverText);
endtime = System.currentTimeMillis();
result = (endtime - starttime);
TimeField.setText("" + result + " ms");
Used.setText("Used character : " + used);
Unused.setText("Unused character : " + (size - used));
byte[] bytes = null;
try {
bytes = coverText.getBytes("UTF-16");
SizeStego.setText("size : " + bytes.length);}
catch (UnsupportedEncodingException ex) {
Logger.getLogger(Stegoform.class.getName()).log(Level.SE
VERE, null, ex);
SizeStego.setText("size : " + bytes.length + " bytes");
```

- **Script of CURVE Scheme**

```
String coverText = CoverText.getText();
 int k = coverText.length();
 int size = (int) coverText.length();
 LengthStego.setText(" " + size + " characters");
 String binary = BinaryText.getText();
 int noOfElement = binary.length();
 int j = 0;
 int used = 0;
for (int i = 0; i < k; i++) {
char c = coverText.charAt(i);
 if (c == 'B' || c == 'b' || c == 'C' || c == 'c' || c
== 'D' || c == 'd' || c == 'G' || c == 'g'|| c == 'J' ||
c == 'j' || c == 'O' || c == 'o' || c == 'P' || c == 'p'
|| c == 'Q' || c == 'q'|| c == 'R' || c == 'r' || c ==
'S' ||  c  ==  's'  ||  c  ==  'U'  ||  c  ==  'u')
{System.out.println("sas"    +    j    +    ":    "    +
binary.charAt(j));
stego += c;
if (binary.charAt(j) == '0')
 coverText = coverText.substring(0, i) + B, C, D, G,
J,O, P, Q, R, S,U+ coverText.substring(i + 1);
 used++;

else if (c == 'A' || c == 'a' || c == 'E' || c == 'e' ||
c == 'F' || c == 'f' || c == 'H' || c == 'h' || c == 'I'
 || c == 'J' || c == 'j' || c == 'K' || c == 'k' || c ==
'L' || c == 'l' || c == 'M' || c == 'm'|| c == 'N' || c
== 'n' || c == 'T' || c == 't' || c == 'V' || c == 'v'
|| c == 'W' || c == 'w'|| c == 'Y' || c == 'y' || c ==
'Z' || c == 'z') {
 if (binary.charAt(j) == '1') {
{coverText = coverText.substring(0, i) + A, E, F, H,
I,K, L, M, N,T, V, W, X, Y, Z + coverText.substring(i +
1);
 used++;
 arr.add(i);
 j++;

StegoText.setText(coverText);
endtime = System.currentTimeMillis();
result = (endtime - starttime);
TimeField.setText("" + result + " ms");
Used.setText("Used character : " + used);
Unused.setText("Unused character : " + (size - used));
byte[] bytes = null;
```

```
try {
bytes = coverText.getBytes("UTF-16");
SizeStego.setText("size : " + bytes.length);}
catch (UnsupportedEncodingException ex) {
Logger.getLogger(Stegoform.class.getName()).log(Level.SE
VERE, null, ex);
SizeStego.setText("size : " + bytes.length + " bytes");
```

- **Script of VERT Scheme**

```
String coverText = CoverText.getText();
 int k = coverText.length();
 int size = (int) coverText.length();
 LengthStego.setText(" " + size + " characters");
 String binary = BinaryText.getText();
 int noOfElement = binary.length();
 int j = 0;
 int used = 0;
for (int i = 0; i < k; i++) {
char c = coverText.charAt(i);
 if ('A' || c == 'a' || c == 'C' || c == 'c' || c == 'G'
|| c == 'g' || c == 'H' || c == 'h' || c == 'M'|| c ==
'm' || c == 'N' || c == 'n' || c == 'O' || c == 'o' || c
== 'S'|| c == 's' || c == 'U' || c == 'u' || c == 'V' ||
c == 'v' || c == 'W' || c == 'w'|| c == 'X' || c == 'x'
|| c == 'Y' || c == 'y' || c == 'Z' || c == 'z')
{System.out.println("sas"    +    j    +    ":    "    +
binary.charAt(j));
stego += c;
if (binary.charAt(j) == '0')
 coverText = coverText.substring(0, i) + A, C, G, H,M,
N, O, Q,S, U, V, W,X, Y, Z + coverText.substring(i + 1);
 used++;

else if (== 'B' || c == 'b' || c == 'D' || c == 'd' || c
== 'E' || c == 'e' || c == 'F' || c == 'f'|| c == 'I' ||
c == 'i' || c == 'J' || c == 'j' || c == 'K' || c == 'k'
|| c == 'L'|| c == 'l' || c == 'P' || c == 'p' || c ==
'R' || c == 'r' || c == 'T' || c == 't') {

 if (binary.charAt(j) == '1') {
{coverText = coverText.substring(0, i) + B, D, E, F,
I,J, K, L, P, R,T + coverText.substring(i + 1);
 used++;
```

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```
 arr.add(i);
 j++;

StegoText.setText(coverText);
endtime = System.currentTimeMillis();
result = (endtime - starttime);
TimeField.setText("" + result + " ms");
Used.setText("Used character : " + used);
Unused.setText("Unused character : " + (size - used));
byte[] bytes = null;
try {
bytes = coverText.getBytes("UTF-16");
SizeStego.setText("size : " + bytes.length);}
catch (UnsupportedEncodingException ex) {
Logger.getLogger(Stegoform.class.getName()).log(Level.SE
VERE, null, ex);
SizeStego.setText("size : " + bytes.length + " bytes");
```