Steganography in SMS by Sudoku Puzzle

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Abstract

Sudoku puzzle is a logical game which has recently got very popular. Every day various mass media print these puzzles. As a result these puzzles are a suitable alternative for hidden data transfer. SMS (short message service) is one of the popular mobile-phone services. In this service people can write short messages and send it to each other through mobile phones. In this paper a method has been presented for Steganography (hiding data) in Sudoku puzzles and through SMS. In this method after hiding data in a Sudoku puzzle, the puzzle is sent in a way that it does not attract any attention. Steganography algorithm is based on order of place of numbers 1 through 9 in one of the specified row or column of the puzzle. In this algorithm after solving the Sudoku puzzle, one extracts hidden data in accordance with order of numbers 1 through 9 in one of the certain row or column which is equivalent with hidden data.

1. Introduction

With the expanding use of mobile phones and the development of mobile telecommunications, mobile phone companies decided to add additional features to their mobile phones in order to attract more customers. One of the first services that were provided on the mobile phone was the SMS.

The SMS (Short Message Service) is the transfer and exchange of short text messages between mobile phones. The SMS is defined based on GSM digital mobile phones. According to the GSM03.40 standard [1], the length of the exchanged message is 160 characters at most, which are saved in 140 bytes depending to how information is saved according to the standards. SMS has the following advantages:

- Exchanging SMS messages while making telephone calls;
- Communicating when the network is busy;
- Sending offline SMS messages;

Today, the issue of information security is increasingly important, esp. in establishing wireless communications in which there is the possibility of disclosure of confidential and personal information during exchange of information between various systems.

One of the important branches in information security is the issue of exchanging hidden information. To this end, various methods such as Cryptography and Steganography have been used.

The Steganography method is one of the methods that have received attention in recent years. In implementation of this method, the main goal is to hide information in the cover of another medium, so that other persons will not notice the hidden information. This is a major distinction of this and the other methods of hidden exchange of information because, in the coding method for example, individuals notice information by seeing encoded information, yet they cannot comprehend the information. However, in Steganography, individuals do not notice the existence of any information in the sources.

Most Steganography works have been carried out on pictures , videos , text , music and sound [2].

Considering the wide use of the mobile phone and exchange of a large number of SMS messages on the mobile phone an appropriate option for establishing hidden communications would be Steganography in SMS messages. As we know, only one other work has been reported in the area of hiding information in SMS which we will indicate in the next section.

In this paper, for hiding data in the SMS messages, we use a new method based on the Sudoku puzzle.

Popular Sudoku puzzle—also known as Number Place—is a logic-based placement puzzle. The aim of the puzzle is to enter a numerical digit from 1 through 9 in each cell of a 9×9 grid made up of 3×3 subgrids

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(called “regions”), starting with various digits given in some cells (the “givens”); each row, column, and region must contain only one instance of each numeral. Completing the puzzle requires patience and logical ability [3]. An example of Sudoku is available in [4].

In our Steganography method, the data are hidden in the Sudoku puzzle by permuting the numbers 1 to 9 in a row or column. In third section, details of this method will be dealt with.

This Steganography method can be considered as a text Steganography method. As we now, there is no similar method for hiding data in games, but the method which is technically similar to our method is Deogol [5].

The way of using our method for hiding data in SMS and its implementation is explained in the third section. This method could help ordinary people use Steganography method. In the final section the conclusion will be made after investigating and studying some advantages of this method.

2. Related works

In this section first we review a previous work on the text Steganography which is similar to our Steganography method. After that we explain the only reported work on hiding information in SMS.

2.1. Text Steganography

As the use of text and hidden communication goes back to antiquity, we have witnessed to Steganography of information in texts since past.

Although many work performed in text Steganography, there is no method which is using games for Steganography. Also most of text Steganography works are performed on electronic text and cannot applied to printed texts.

However, the only work reported on text Steganography which is similar to our Steganography algorithm is [5]. A summary of the work performed by it is as follows:

HTML (HyperText Markup Language), is the coding language used to create hypertext documents for the World Wide Web. HTML includes a series of text "tags" that describe how a Web page is formatted. Every tag is known with a private name that has special members of its own. The attributes constitute one of the elements of any object. Each attribute is applied for activating an attribute of the object to which it is attributed [6].

One of the features of HTML documents is the insensitivity of such documents to the order of the tag members. Therefore, one can hide information in HTML documents using this feature.

To extract information from the document, the order of the tag members is compared with the sorted state of the members and the hidden data is thus extracted.

Despite the advantages of this method, such as no change of the document size, very little information can be hidden in this method.

We will provide a full description of our proposed method in next section. However, main differences of our method with this method are:

1. This method is based on HTML webpages, but our proposed method is non-digital.
2. In this method, the capacity of webpage for hiding data is depended on the numbers of tag’s members, but our method capacity for hiding data is fixed.

2.2. Steganography in SMS

As we know, the only reported work on hiding data in SMS is "Stealth Steganography in SMS" [7]. In this method, the information is hidden in the SMS picture message. This method is as follows:

After converting the picture into the black and white and a suitable format for the mobile phone, the picture is divided into 3×3 blocks. The possibility of Steganography in each block of the picture is considered. If the result is positive, one bit of information is hidden in the picture by maximally changing one block cell. For increase the security, the information is encoded by a password.

Extracting algorithm is the reverse of hiding algorithm. After extracting hidden information from the SMS picture message, the information is removed from the picture by using Morphological methods and the picture message is saved without any data on the recipient’s mobile phone (See Figure 1).

A) Original picture B) Stegano picture C) Stealth picture

Figure 1. Hiding "Iran" message in an SMS picture message [7]

We will provide a full description of our proposed method in section 3. However, the main benefits of our method in compare with this method are:

The maximum size of data that can undergo Steganography in an SMS picture is 27 bytes and it depends to the image used for hiding data. Since each SMS picture message is sent as four SMS message,

therefore we can consider that each SMS can hide about 7 bytes.

But our new method always can hide 18 bits in each SMS. Because it is a fixed amount, and also there is no need to send four SMS messages together and only need to send one SMS, therefore this method is better. Also using the above algorithm need a special program to hide data in a picture and convert it to SMS picture message, but our method can be implementing without any special program, because in our method the user can hide the data in a Sudoku puzzle manually and then enter it to mobile phone as a simple SMS message. In addition, some mobile phones are not supporting SMS picture message, but all mobile phones supporting SMS text messages. In general, our new method is more applicable than above method.

3. Our method

In this paper we present a new method for text Steganography in SMS text messages using Sudoku puzzles. First, the Steganography method is described and then we will explain the way of using this method for establishing hidden communications trough SMS.

3.1. Steganography in Sudoku puzzle

In this part a method has been presented for hiding data in a Sudoku puzzle. As we said earlier, in a 9×9 Sudoku puzzle each of the numbers 1 through 9 appears in each row or column just once and there is no repetitious number in any row or column. As a result of this characteristic we can arrange the numbers of each row or column in 9! permutations. Of course, when a row or column is set, we won't be able to set the other rows or columns as we wish, because they must observe the regulation of non-repetitiousness of the numbers lying in each row or column.

In our proposed method, these 9! permutations are mapped with 18 bits in a way (9! is equal to 362880 so we can map each permutation to 18 bits). As a result at first we change our data, which can be maximum 18 bits, to its equivalent number. Then from this number we create the permutation which is equal to the computed number. This change is as follows:

For changing number k to a permutation of n numbers, suppose that k=q×n+r. In this equation, that is to say, r is the remainder and q is quotient resulting from division of k by n.

Now we place $r+1^{st}$ biggest number among n number(s) as the last digit and make the permutation which is equal with number q using n-1 remainder number on a recursive basis. To change a permutation from n number we act as follows:

Suppose that the last digit of permutation $a_1a_2\ldots a_n$, that is to say, a_s, is in place of $r+1^{st}$ in terms of bigness. Furthermore suppose that the number equal with $a_1a_2\ldots a_{n-1}$ is equal to q. This way the number equal with this permutation is equal to k=q×n+r.

For hiding the information, we place the numbers, in accordance with the desired permutation, in a row or column of a 9×9 Sudoku puzzle. In view of this, we solve the Sudoku puzzle in which we want to hide data. Then we replace a certain row or column of this Sudoku puzzle in accordance with the permutation 1 through 9 which created above. To do this replacement, for each number which we replaced in one cell of that row or column (for example 5 instead of 2), we will also replace these two numbers in all cells of the puzzle. Now that we have done the numbers replacement, we will also apply this replacement on the original unsolved puzzle. As a result, the concerned Sudoku puzzle is designed and put at our disposal. When we choose the original Sudoku puzzle we must note that the puzzle has a unique answer.

Now the Sudoku puzzle is sent to the receiver through an SMS. The method of sending the puzzle through SMS will be described in the succeeding subsection. The concerned person solves the puzzle after receiving the puzzle. To solve the puzzle quickly, the person can use a special software for solving the Sudoku puzzle. During implementation of this project we designed the software required for this work. After solving the puzzle, the numbers of specified row or column of the puzzle are computed. These numbers are given to decoder software and the decoder software will extract and display the coded data (maximum 18 bits) in accordance with order of numbers 1 through 9 and during a process conversely to coding stage.

Although here we have used a special software programs for solving the puzzle, permuting numbers in puzzles and as a whole for coding and decoding data; we can also do all these operations through manual computations (in accordance with the above-mentioned method) without having to use a software.

Furthermore a two-digit number is considered as a key. The first number of the key displays row and the second number indicates a column of the puzzle in which the data has been hidden. Of course one of these two digits must be 0. Number 0 indicates the fact that no data has been hidden in that row or column. For example number 50 means that the data is hidden in the 5^{th} row or number 07 indicates the fact that the data has been hidden in the 7^{th} column.

3.2. Steganography in SMS

After we have hidden the data in a Sudoku puzzle in accordance with the algorithm expressed in section 3.1, we send the puzzle for the concerned person.

As we mentioned in the introduction, an SMS can send up to 160 characters. Since a 9×9 Sudoku puzzle has 81 cells, we can send a Sudoku puzzle through an SMS. Although we can write numbers of the puzzle respectively (of course we can consider 0 for blank cells or place a space); this causes the SMS to attract attentions because the text of sent message does not have an ordinary appearance. So here we use the following format to send Sudoku puzzle through SMS:

In this format the 9×9 Sudoku puzzle is divided to 3×3 blocks and between each block we place lines. In fact we place a colon (:) sign after each 3 numbers, and a row which has 9 equal signs (=) and 2 colon signs (:) in 4^{th} and 8^{th} positions after each 3 rows. We place number 0 for blank cells. By counting the "Enter" sign at the end of each row, the total of 51 more characters are required for formatting the puzzle. To send the key used in the Steganography algorithm, we add the following sentence to the beginning of SMS:

"Solve the Sudoku no. xy"

In the above sentence, xy is a two digit number and in fact it is the stenography key. By counting the "Enter" sign at the end of line, this sentence is composed of 25 characters. Therefore as a whole the final SMS is composed of 157 characters. Because an SMS has a capacity of maximum 160 characters, as a result we can send this message easily through one SMS (See Figure 2).

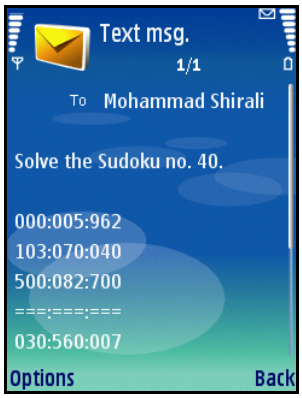

Figure 2. Sending a Sudoku puzzle containing hidden data by an SMS message

Each day billions of SMS are exchanged throughout the world. Therefore hiding data in SMS attracts less attention and it is unlikely to identify the messages containing hidden data.

Stenography method is a rather new method. Sudoku puzzles have recently got very popular. As a result using this method attracts less attention and fewer hackers will attack it.

Solving Sudoku puzzle is a simple activity and our method does not need a very sophisticated algorithm. On the other hand using SMS is very easy, so the most people can use it easily.

The cost of using SMS service is very low especially in comparison with services such as WAP (Wireless Application Protocol) and consequently using this method is more economical.

There are other similar games such as Kakuro (Cross Sums) which can be used for Steganography.

4. Conclusion

In this paper a method is presented for Stenography in SMS using Sudoku puzzle. In this method a permutation of 1 through 9 which is equivalent with hidden data is placed in one of the rows or columns of Sudoku puzzle. Then that puzzle is sent on an unsolved format through an SMS. After receiving the SMS, the receiver solves the puzzle and calculates the arrangement of numbers 1 through 9 from the row or column specified by the received key for extraction of hidden data from the puzzle.

Due to using simple SMS and because of not having to use any software, this method can be executed on all mobile phones even old mobile phones. Also we can use this method in other devices such as PDAs and Pocket PCs.

We can hide more data using bigger Sudoku puzzles such as 16×16 or 25×25 Sudoku puzzle.

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