

A Novel Approach of Secret Hiding in Webpage by Bit Grouping Technology

Xiaoming Zhang, Guoqing Zhao, Pengfei Niu

Department of Computer, Beijing Institute of Petro-chemical Technology, Beijing, China

Email: {zhangxiaoming, zhaoguoqing, niupengfei}@bipt.edu.cn

Abstract—Web pages are used popularly and frequently today because the message in the pages can be fast spreading all over the world in real-time. A kind of new approach is constructed for the webpage information hiding. The hiding data is composed of the length of secret, the checksum and the secret data. The secret message is required for modification using forward transform technology before hiding. A kind of grouping 5-bit scheme and algorithm are proposed to convert the hiding data into some invisible characters. It can hide 10 bits in each end tag of page line. In the extracting process, the message is recomposed as the coupling relationship. The hiding process and algorithms are stated in detail. The experiments are implemented with some well-known homepages of portal websites. The results show that the new approach can not only keep the hiding effects, but also increase the hiding capacity largely. It will be suitable for large-scale message transmission through the Internet.

Index Terms—Webpage, Information hiding, Invisible character, Capacity, Algorithm, Network Security

I. INTRODUCTION

Webpage information hiding (WIH) is a kind of technology to hide important message into the web pages. Owing to the global distribution of webpage in real time, the secret message can be transmitted and spread quickly without any other channels. Meanwhile, if some watermarks are embedded into the web pages, these pages can be protected by temper-proof technology. Both of the sides become important study contents of webpage information security.

There exist several approaches for WIH to aim at the HTML documents. Firstly, the tag-based hiding is used as the popular approach of WIH. There are three typical methods including insensitiveness of upper and lower case letters [1], order of tag attributes [2-3] and white space inserting [4] among the tag-based hiding scheme. All the methods are based on HTML specifications and web browsing effects. By changing the page letters as its upper or lower cases, Zhao [1] proposed a PCA-based approach to embed small image watermarks into web pages. Moreover, Sun [5] used m-sequence to generate the watermark and embed them into the tags of the source code

of web pages. It can decrease the time consuming in embedding and extracting operation stages. However, the different letter cases throughout the page can be identified easily as a strange page.

For the method of order of tag attributes, it has good transparence in source code. The more the number of attributes increases, the bigger the hiding capacity becomes. However, with the cascade style (CSS) technique popularly used in webpage creation, many tag's attributes are only defined in CSS. Because there leaves a few attributes for the initial webpage, the hiding effect by attribute order method is not satisfied in many cases. Owing to the specification of CSS, Sun [6] applied some class selectors of CSS in hiding algorithm. The living Class Selectors of some objects are caught and repeatedly imported to embed information. It has preferable imperceptibility, good ability to contradict with detection and auto filtration.

The space inserting method is easily realized in the end tag. One can not quickly identify the white space among the lots of webpage lines. The method can be presented as bit inserting idea since each inserting can show the state of bit 1. The hiding capacity relies on the number of page lines with end tag.

There exist several creative algorithms in WIH, such as table-based hiding [7-8] and Flash-based hiding [9]. Many web pages have table styles to present information in normalization. Zhang [7] proposed a new approach for WIH by table specification with parity of the consecutive line or row values. The approach has good transparent performance in source code checking. The approach was updated to increase the capacity by multiple table hiding [8]. On the other hand, multimedia information-based hiding approach is still attractive for WIH based on the existed multimedia hiding algorithms. Most of web pages present multimedia information including images, audios, videos and animations except the text message. These messages can be applied for information hiding, especially the popular logo information in the homepage. Through analyzing the data format in Flash developing environment, Zhang [9] successfully created a kind of method for flash information hiding by the Flash logo.

Meanwhile, Xie [10] proposed a novel method by means of the composition of tag, attribute and quotes. Because the representation formats of the tag attribute values can form 8 kinds within the commonly writing

Corresponding author: Xiaoming Zhang.

habits of people, it could be derived from this phenomenon that the 8 formats of the tag attributes could represent 8 values. It can increase the hiding capacity, and will not increase the size of cover-webpage. Similarly, Yang [11] adopted the tag attribute with single quotes and double quotes to represent the two hiding bit, 0 and 1. Besides, Ren [12-13] proposed ideas of tag dictionary and method integration. With more tag composition, the hiding capacity can be enlarged.

A new kind of approach by inserting invisible characters is proposed here for WIH. Through the bit separation and composition algorithm, the secret message with any character can be embedded into the webpage. Because the inserting information is not bit information but special characters, the hiding capacity increases largely. Next, the hiding idea will be stated firstly. Then, the new algorithm is presented with flow chart and process description. The experiments are carried out for the ordinary portal homepage, while several typical attacks on the hiding algorithm are designed and tested with good effects.

This paper is organized as follows. In Section 2, we analyze the novel webpage hiding idea. Section 3 explains the design solution and algorithm in detail. Experiments and discussion are shown in Section 4. Finally, this paper is concluded in Section 5.

II. ANALYSIS OF HIDING IDEA

There are three considerations for the hiding approach design. Firstly, the browsing web page is always different from the initial page by the source code. It means that the hiding carrier should keep consistence. Secondly, the hiding capacity is required to increase much more than that of bit inserting method. Finally, for the web site construction, the file format in the server side is always different from that in the webpage browsing side. For example, the ActiveX Server Page (ASP) documents will be transformed to HTML format. Therefore, the hiding approach is needed for different source documents.

From the view of the above design ideas, the end tag-based hiding method is adopted for the characters code hiding.

A. Analysis of Invisible Characters set

Definition 1 Invisible character (IC): it means the character inserting into the web page but without display sign when page browsing. The invisible character shows special symbol or white space in the page source code.

There are 33 characters in the ASCII table for IC with ASCII coding values of 0-32. The codes of 1-31 show special symbols. While the code 0 is null, and the ASCII code 32 is white space. All these characters are chosen as invisible characters to form a set S_p :

$$S_p = \{s_i | i = [0 - 32]\} \quad (1)$$

Evidently, if the ordinary characters can be translated as one of SC or its composition, then secret message can be hidden into the web pages.

From the view of ASCII coding values, the invisible characters have code less than 32. The ordinary characters are much larger than the ICs in ASCII code. For example, the letter of 0 has code of 48, while the letter of z has 122 coding value. Therefore, translation between the secret characters and ICs are required.

B. Analysis of HTML Tag End Mark

Next, where can these ICs be hidden into the web pages? As it knows, each tag of web page has its end mark. Even though there are different coding forms, it can have the same page browsing effects. Some researchers attached the white spaces in the end of webpage lines. Although this method can hide large information, the hiding state can be easily identified and cleaned by the attacker. Besides, each white space can only represent one bit.

A new kind of hiding position is discovered as follows:

If one of the ICs is inserted into the tag end, the character will not be displayed in the web page. For example, the following inserting forms can be still effective for page browsing normally:

The ordinary state of tag end: `</table>`

White space inserting state of tag end with three forms: `</ table>`, or `</table >`, or `< / table >`

So, there exist two inserting positions for two ICs: after mark of “</” and before “>”.

C. Five Bit Grouping Scheme

The third question is how to enlarge the hiding capacity. As stated above, how many bits appointed by user can be hidden in one IC?

In order to hide any character from ASCII table, all the secret data have to be converted to the IC. Considering the IC value from 0 to 31, it only need the lower 5 bits in an 8-bit data to represent all the IC value. Therefore, a kind of group scheme is created for the hiding data, as shown in Figure 1. The initial data are grouped as 5 bits, and then each group is added with 3 bits of 0 to its higher position to form a new 8-bit data. For example, one group with 5 bits of 10110 is chosen for IC data creation. After three bits of 0 are inserted to the head of group, the IC data will have value of 22. Its ASCII character belongs to an IC of device control.

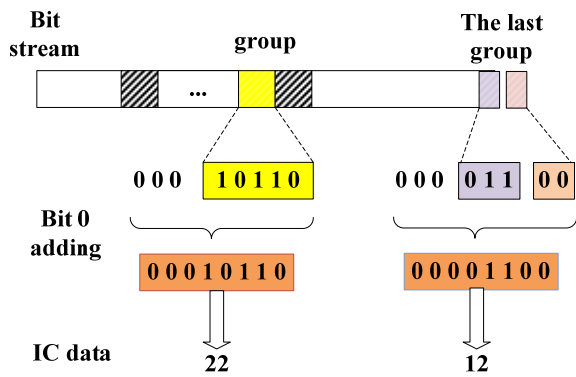


Figure 1. Grouping 5-bit scheme for IC creation

D. Analysis of Hiding Contents

In order to assure the extraction correctness, the length of secret should be hidden into the webpage along with the secret data.

Besides, the interrupt of network communication is always taken place. As the network protocol idea, the checksum is very useful to check the composed message in the IP layer and the transmission layer.

Therefore, the hiding content includes three kinds of data as following:

- (1) Length of secret with 16 bits: N_s ;
- (2) Secret data: D_s ;
- (3) Checksum calculation to the N_s and D_s with 16 bits.

In the extraction process, the checksum is calculated again for the extracted N_s and D_s . If the extracted checksum and the calculation result are matched well, then extraction data are correct.

E. Scrambling Technology

Before the secret is embedded into the web pages, it is required for pre-processing. One choice is encrypting to the secret to form some strange message, and the other is scrambling the secret to modify its content sequence. The former will create some control characters or invisible characters which is not suitable for checking. Therefore, the scrambling technology is adopted here to modify the secret content.

Assume the data of secret is $A[0,1,\dots,M-1]$, and P and M are designed to be coprime integers. Let B as the temporary data array with the same length of A to store the operating results. Then, the scrambling technology is designed as follows:

- (1) Forward transform

$$\begin{cases} B(i) = A((i \times P) \bmod M), i = 0, 1, \dots, M - 1 \\ A = B \end{cases} \quad (2)$$

- (2) Inverse transform

$$\begin{cases} B((i \times P) \bmod M) = A(i), i = 0, 1, \dots, M - 1 \\ A = B \end{cases} \quad (3)$$

F. Adoption of Checksum Calculation

In the famous OSI model in computer network architecture, there exist checksum calculation in two layers of the network layer and transmission layer. The checksum is applied mainly to check the data from the upper layer of OSI. If the calculation result is not consistent with the extracted value of checksum, then the data will be rejected by UDP protocol or retransmitted by TCP protocol.

For the webpage hiding application, the checksum can be used to increase the reliability of secret transmission, and its computation solution is different from that in OSI model.

Definition 2 Hiding Checksum (HC): In the secret hiding process, the hiding checksum is applied to check two kinds of data together. One is the length of secret, and the other is the data of secret.

Definition 3 Hiding Data (HD): It refers to the data which is actually embedded into the webpage. In order to increase the reliability of web information transmission, the hiding data is composed of three kinds of data, that is, the length of secret, the HC and the data of secret, as shown in Figure 2.

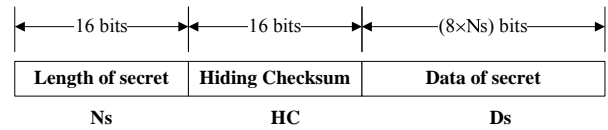


Figure 2. Composition of hiding data composition in webpage

The length is used to decide the actual number of secret data, while the checksum is for checking the network error and the data consistence. Both of the length and the checksum are 16 bits. Therefore, the final length of hiding data will be as following:

$$L_{HD} = 32 + 8N_s \quad (4)$$

III. DESIGN OF HIDING ALGORITHM BASED ON IC

It is composed of two stage of the webpage hiding process. The page is redistributed after secret is embedded into it, while the secret is extracted from the document when browsing the page through the network.

A. Design of Secret Hiding Process Model

The process is as shown in Figure 3.

After the hiding data is embedded into the appointed webpage, the new created webpage P2 is distributed through the web environment. Then, the receiver can obtain the important message by browsing the website with a series of extraction algorithm. The browsed webpage is often different from that existed in the web server.

In the embedding process, there are three key

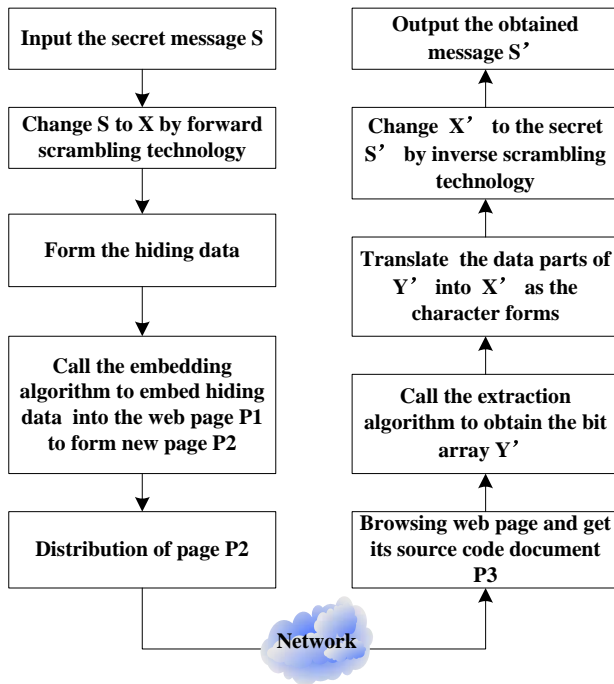


Figure 3. IC-based hiding model

technologies which are forward scrambling processing, hiding data forming and the embedding algorithm. As for the information extraction process, the inverse operation with extraction algorithm, character translation and inverse scrambling technology are carried out. Next, the technique implementation and the hiding algorithms are proposed in detail below.

B. Computation of Hiding Capacity

Suppose the length of hiding data is N_s , and the number of webpage hiding lines is N_p . Then, the IC number N_c is described as:

$$N_c = \frac{N_s \times 8 + m}{5}, (0 \leq m < 5) \quad (5)$$

where, m is the number of bit 0. It is used to assure that the bit array of hiding message can be divided into integers of 5.

Each end tag can hide two IC, and each line can include at least one end tag. Then, the number of required hiding lines, N_h , is defined as following:

$$N_h \leq \frac{1}{2} N_c \quad (6)$$

Once the N_s becomes the times of 5, the m becomes 0. So, the N_h is calculated as:

$$N_h \leq \frac{4}{5} N_s \quad (7)$$

For the bit inserting method, each end tag can be used to hide only two bits. While for the new approach, each end tag can hold two IC. Because each IC has five original bits, then the new approach increases largely the hiding capacity as five times as that of bit inserting method.

In order to improve the hiding effects to show the source code transparent feature, the hiding line should be not consecutive. Suppose the interval of two hiding line is k , then k is defined as:

$$N_h \geq \frac{4}{5} k \cdot N_s, (k \geq 1) \quad (8)$$

Apparently, when the hiding transparency increases, the hiding capacity will decrease quickly.

C. Grouping 5-bit Algorithm

As the bit inserting scheme stated in part II, the bit inserting algorithm is propose as follows.

Function of bit insertion algorithm: convert the input bit stream to the IC array by grouping technology.

Input: bit stream H_b with length of N_s from the hiding data.

Output: IC array $DataArray[]$ as byte type.

Procedure:

(1) Grouping the H_b as 5 bits each into temporary array $DataArray$ with length of N_c . If N_s is not the times of 5, the end of H_b will be added several bit 0 to compensate for this situation as (4).

(2) Insert three bit 0 into the head of $DataArray[i]$, $i=1,2,\dots,N_c$.

(3) Obtain all the 8-bit data as byte type in $DataArray$.

D. Design of Embedding Algorithm

As the Definition 3, the hiding data will be as the input of webpage hiding. The whole embedding flow-chart diagram is shown in Figure 4.

One of the important stages is to extract the end tag data T_1 . Two ICs, $IC[0]$ and $IC[1]$, will be inserted into its both sides. The modified end tag data T_2 becomes fused form of $IC[0] \cdot T_1 \cdot IC[1]$. Even if the end tag data is changed, there is no difference between the original webpage and modified webpage when browsing.

As the flow-chart diagram, the embedding algorithm is followed below.

Function of the embedding algorithm: embedding the hiding data into the appointed web page $P1$ to create new web page $P2$.

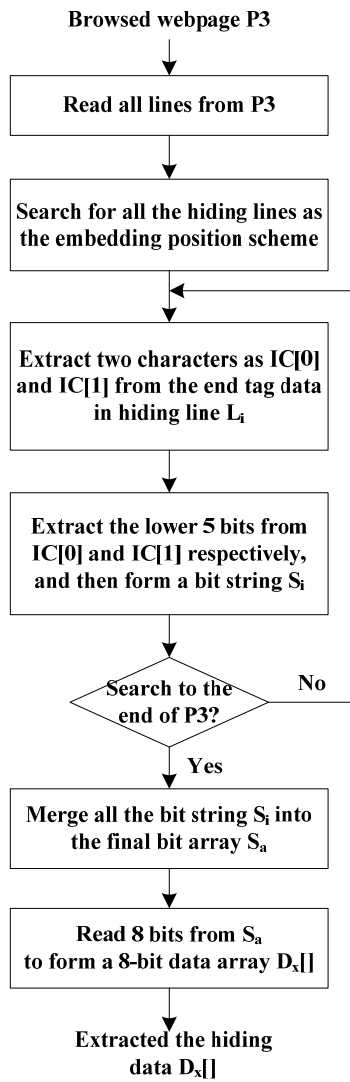


Figure 4. Extraction flow-chart diagram

Input: the hiding data D_h with length of m , and the initial web page P_1 with hiding lines of n ($m < n$).

Output: the new web page P_2 with secret information.

Embedding procedure:

- (1) Convert D_h to the bit stream H_b ;
- (2) Get the IC data array $DataArray$ as the bit inserting algorithm;
- (3) Input P_1 to get the hiding capacity and its hiding positioning scheme;
- (4) As the end tag format, search for all the hiding lines as $L_i, i=0, 1, \dots, n$;
- (5) $i \leftarrow 0$;
- (6) Read one hiding line L_i from P_1 ;
- (7) Read two IC data from $DataArray$ and convert them to two IC characters.
- (8) Renew the end tag in L_i from $\langle /T_i \rangle$ to $\langle /IC[0] \cdot T_i \cdot IC[1] \rangle$. Here, T_i is a kind of string as HTML specification;
- (9) $i \leftarrow (i+1)$;
- (10) Turn to (6) if $i \leq m$. Otherwise, to the next;

- (11) Obtain the new web page P_2 .

E. Design of Extraction Algorithm

As stated in Figure 3, the extraction process is applied to extract hidden ICs from the appointed webpage to form hiding data as bit stream. The concrete process is described as shown in Figure 5.

Owing to the difference between the initial webpage and the browsed webpage through network, the hiding interval is difficult to set as a fixed value. The extraction software will search automatically for the end tag.

Function of extraction algorithm: drawing the hidden data from the appointed web page to form bit stream.

Input: browsed webpage P_3 within secret message.

Output: the hiding data array D_x as bit stream.

Extraction procedure:

- (1) Read all hiding lines from P_3 ;

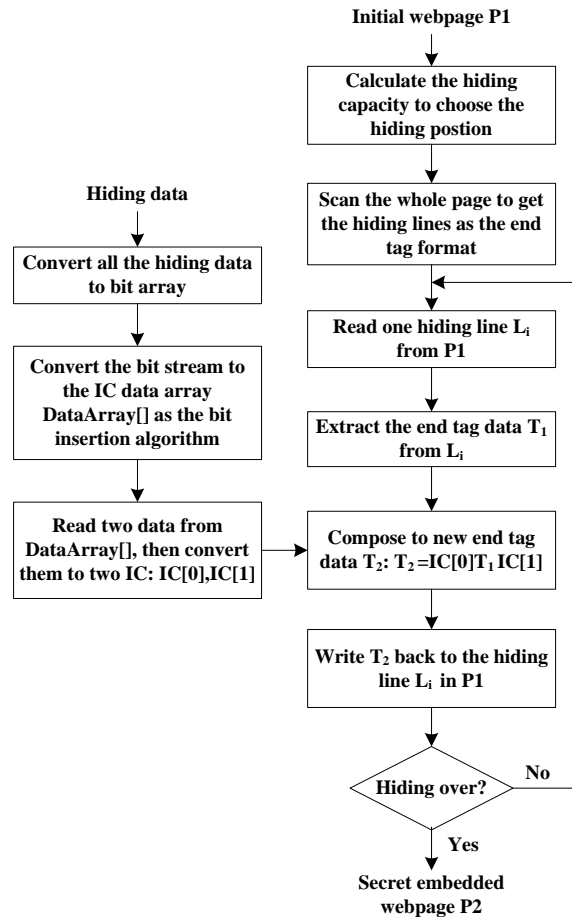


Figure 5. Embedding flow-chart diagram

- (2) $i \leftarrow 0$;
- (3) Read the hiding line L_i ;
- (4) Extract both of two IC characters as data $IC[0]$ and $IC[1]$ from the end tag T_i in L_i ;
- (5) Draw the lower five bits from the two IC data respectively as S_{1i} and S_{2i} ;
- (6) Connect S_{1i} and S_{2i} to form one bit string S_i ;
- (7) Let $i \leftarrow (i+1)$ if the end of web page is not reached, then turn to (3). Otherwise, to the next;

- (8) Compose all the bit string to $S_a = \sum S_i, i=0,1,\dots,n$.
- (9) Convert S_a to the 8-bit data array D_x ;
- (10) Output D_x .

IV. EXPERIMENT DESIGN AND RESULT ANALYSIS

The proposed hiding approach is implemented with C# programming language in VS.NET. It is tested under lots of typical web site by browsing.

A. Performance calculation

The calculation aims to character not the bit as the proposed algorithms.

(1) Calculation of character hiding effects

Definition 4 Character Error Rate (CER): Suppose the secret S with ASCII code $X = x_1x_2\dots x_m$ and the extraction message $X' = x'_1x'_2\dots x'_m$, the character error rate is defined as the hiding error:

$$CER = \frac{\sum_{i=1}^m |x'_i - x_i|}{\sum_{i=1}^m x_i} \times 100\% \tag{9}$$

(2) Calculation of hiding capacity

As the IC inserting approach, each usable end tag can hide two ICs. As (4) and (5), the required number of hiding lines is concluded as:

$$N_h = \frac{N_s \times 8 + m}{10}, (0 \leq m < 5) \tag{10}$$

Where, N_s is the length of hiding data.

On the other hand, each character value has an 8-bit length. As the existed bit inserting method, two bits can be hidden into one end tag. Then, for the same hiding data, the required number of hiding lines for bit inserting method is:

$$N_{bit} = \frac{N_s \times 8}{2} = 4N_s \tag{11}$$

To compare their hiding capacities for the two typical inserting approaches, a kind of new parameter is defined as following:

Definition 5 Hiding Capacity Ratio: It refers to ratio of two kinds of required number of hiding lines in webpage. Here, to compare the two approaches of bit inserting and IC inserting, the ratio is defined as:

$$R_h = \frac{N_{bit}}{N_h} = \frac{40N_s}{8N_s + m} \tag{11}$$

Because the value of m is so small that it can be omitted. Then, the ratio is approximately:

$$R_h = 5 \tag{12}$$

TABLE II.
EXPERIMENT RESULTS FOR INFORMATION HIDING

Homepages	Initial size	Hidden size	CER
www.163.com	365	303	0
www.sohu.com	181	171	0
www.bipt.edu.cn	22	18	0
www.w3.org/Protocols/	24	23	0
www.w3.org	29	28	0

Furthermore, the relationship between the number of hiding characters and that of webpage hiding lines as (10) can be described as following:

$$N_s = 1.25N_h \tag{13}$$

Therefore, the propose approach has good ability with large hiding capacity. It is nearly five times of that in the bit inserting method.

B. Experimenting Design

Some typical web page is tested by getting the HTML source code after browsing the page. These pages are chosen as shown in Table I.

For instance, the secret is selected from one of the news title in web site www.w3.org as following string:

W3C Leads Discussion at TypeCon 2010 on New Open Web Font Format

The above string is composed of 64 characters including white space. So, the number of the hiding data is 68 totally.

The 64 secret data will be modified as the forward transform technology before they are merged with the length of secret and the checksum. As described in (2), there are two parameters of M and P. Here, M is 64. Now let P=3, then the result of forward transform is list below:

TABLE I.
SOME HTML DOCUMENTS FOR EXPERIMENTS

Homepages	Size(KB)	N_h	N_s
www.163.com	365	1290	1612
www.sohu.com	181	453	566
www.bipt.edu.cn	22	199	248
www.w3.org/Protocols/	24	172	215
www.w3.org	29	116	145
www.tianwang.com	9	25	31
www.sogou.com	5	0	0
www.baidu.com	5	0	0

*W a s s o a T e n 0 w p b o r t C e s i u i
p o 2 0 n e O n e F t o a 3 L d D c s n t y C I o N e W n F m*

The transform result shows secure and effective to make

the secret difficult for understanding.

The secret hiding system for webpage is developed with C# for many functions, such as webpage selection, calculation of hiding capacity, scrambling process for secret, grouping 5-bit technology, and the whole embedding and extraction algorithm. One of the operation interfaces is shown in Figure 6. The grouping result is list in detail to form corresponding ICs. The chosen web page for hiding secret is the default page of web site www.w3.org/Protocols.

After embedding the selected string, the extraction results are shown in Table II. The hidden size of selected documents has small change, while the CER value show zero for all hiding web pages.

The grouping approach has good security, capacity and robustness. The common methods for webpage hiding are compared as shown in Table III. Meanwhile, the source codes in different states are shown in Figure 7.

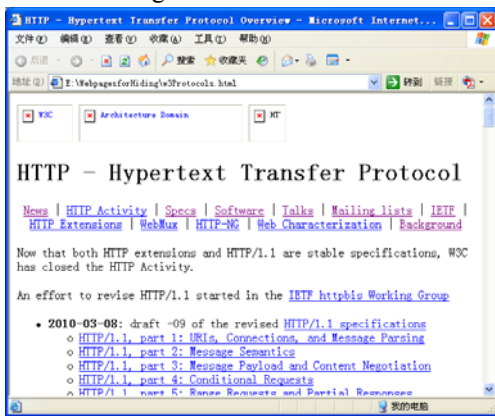
Even if a few strange characters can be observed

V. CONCLUSION

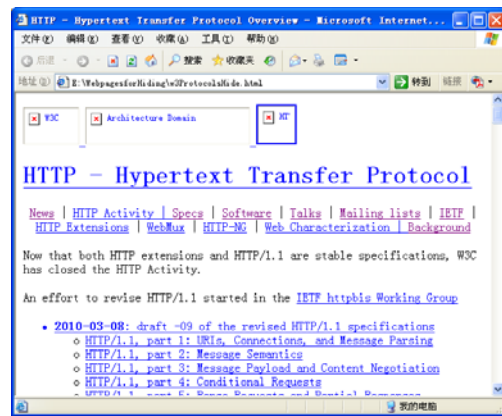
Based on the browsing property of invisible character in web pages, a kind of invisible character inserting approach for secret hiding is created into the web pages. The hiding data consist of three kinds of data as the length of secret, the checksum and the secret data. The secret data will be modified using forward transform technology. All the hiding data will be translated into invisible characters by grouping 5-bit method. It increases the hiding capacity with 5 times as the ordinary bit inserting approach. Therefore, the approach will be available for large amount message in the web page hiding.

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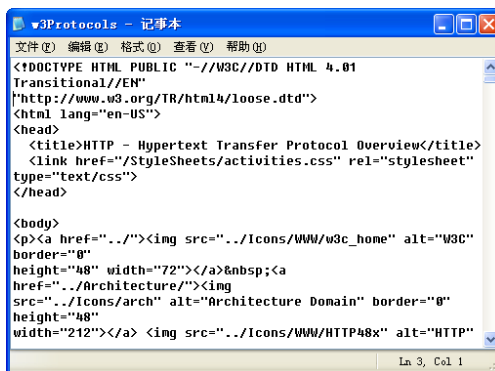
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(a) Initial browsing of web page



(b) Web page browsing after hiding



(c) Source code of initial webpage



(d) Source code of after hiding

Figure 6. Comparison on webpage in browsing and source codes

throughout the webpage source code, the hidden result is not affected because of its target for secret transmission. It is clearly that the IC inserting approach has good hiding performance with large hiding capacity.

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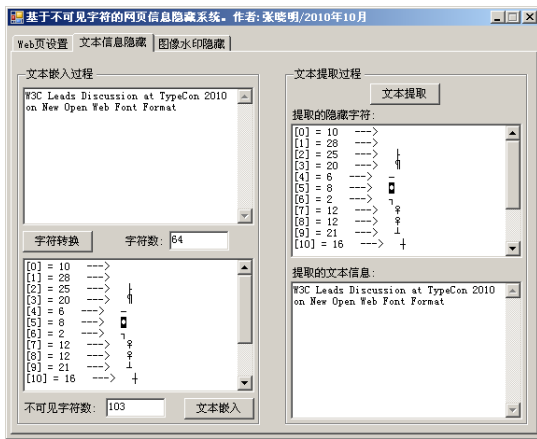


Figure 7. Software Interface for Information Hiding

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Xiaoming Zhang was born in Jiangxi, China on January 25, 1968. He received the B.S. degree in agricultural mechanization from the Jiangxi Agricultural University in 1989, the M.S. and Ph.D. degrees in mechanical engineering & automation from Dalian University of Technology in 1992 and 1996, respectively.

He was a lecturer and associate professor in the Department of Computer of Beijing Institute of Petro-chemical Technology in 1996 and 1998, respectively. He was a visiting scholar of Narvik Institute of Technology in Norway during 2000-2001. Since 2008, he has been a Professor in the Department of Computer of Beijing Institute of Petro-chemical Technology. His current research interests include multimedia information hiding and network system security.



Guoqing Zhao received the M.S. degree in computer testing and measurement from Beijing Institute of Technology in 2000. Since 2001, he has been an associate professor in the Department of Computer of Beijing Institute of Petro-chemical Technology. His current research interests include network intrusion detection and system security.



Pengfei Niu received the B.S. degree in computer science and technology from Beijing Institute of Petro-chemical Technology in 2008.

Since 2008, he has been studying M.S. degree in Beijing Institute of Petro-chemical Technology. His research interests are in information hiding and watermark in stream media.