# Investigating and Analysing the Web-based Contents on Chinese Shanzhai Mobile Phones

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## Abstract

*Chinese Shanzhai mobile phone has had a huge commercial market in China and overseas and was found to be involved in criminal cases. In this paper, a MTK-based Shanzhai phone with private web browser was investigated to extract user's web browsing data in the form of sites visited, received emails, attempted Internet searches and etc. Based on the findings, extracting Internet search conducted and web email received from the binary image was demonstrated. Besides, deleted browsing history can be recovered from snapshots in memory help reconstruct user's browsing activity and timeline analysis.*

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## 1. Introduction

The use of mobile phone has increased dramatically in the last decade. Globally, the number of mobile cellular subscriptions reached 5.3 billion in 2011, reported by the International Telecommunications Union (ITU). And vendors shipped 371.8 million units in Q1 2011, growing 19.8 per cent year-over-year (IDC).[1] With the mobility and the portability, mobile phones have been part of people’s daily life, which inevitably holds information of people’s actions, whereabouts, and intentions. However, these advantages of mobile phone can be utilized by a criminal as a criminal tool anytime and anywhere, which leads to the necessity of mobile phone forensics. Mobile phone forensics is a branch of digital forensics that focuses on extracting information from a mobile phone as digital evidence in all kinds (criminal and civil) of court cases. With the fast evolution of mobile phone technologies, the amount and the types of data that can be found from a mobile phone are increasing. Traditionally, information that can be recovered from a

[1] Robin Wauters. "Worldwide Mobile Phone Market Grew 20% In Q1 2011, Fueled By Smartphone Boom." Last modified April 28, 2011. http://techcrunch.com/2011/04/28/worldwide-mobile-phone-market-grew-20-in-q1-fueled-by-smartphone-boom/.

phone includes phonebook, call logs, and short message service (SMS) messages,[2] even deleted items. Advanced smart phones also include wider varieties of data such as e-mails, media and web browsing data. The data can be stored in several storage media inside the phone, such as the SIM (Subscriber Identity Module) card, internal flash memory and external memory card.[3] In terms of forensic, obtaining evidence from the internal flash memory is more challenging as SIM card and memory card can be taken down from mobile phone and therefore both of them can be investigated independently and deeply with external card reader.

Benefit from the "turn-key" development solution provided by MediaTek (MTK)[4] and Spreadtrum,[5] Chinese Shanzhai mobile phone (Shanzhai phone for short) has had a huge commercial market in China and overseas in recent years due to its high cost-performance ratios. Shanzhai phone is very cheap. For example, the price of a fake version of Apple's iPhone4S in the market is only $130, and it can be down to $60 for a cheaper (low-end) version. Unfortunately, with the worldwide spreading, more and more Shanzhai phones are found to be involved in criminal cases. However, little research findings on Shanzhai phone forensics has been published. One of the possible reasons may be that there is almost no existing officially documents about the internal flash memory, the file systems and other related information for Shanzhai phones. The other reason may be that researchers did not expect the huge potential market of such low-price mobile phones so that little attention has been paid to it before.

In the paper, we provide the first step towards the forensics investigation on the web-based content on Shanzhai phone. Based on reverse engineering, we tried to provide important information of how an MTK-based Shanzhai phone manages and stores the web browsing data in its internal flash memory with its private web browser. This information provides insights on how to retrieve deleted web browsing history and helping the investigators rebuild the sequence of web addresses the user visited. The rest of the paper is organized as follows. Section 2 reviews the current work related to web forensics and Shanzhai phone forensics. Section 3 introduces the acquisition of Shanzhai phone's internal flash memory. Section 4 details how to analyse and extract the web browsing data from the memory dump. Recovery of deleted browsing history and timeline analysis are described in Section 5. Section 6 concludes the paper.

## 2. Related Work

Traditionally, web forensics research is targeted to PC-based web browsers, such as Microsoft Internet Explorer, Mozilla Firefox, Google Chrom, Opera and Safari.

Jones and Rohyt described the IE and Firefox 2 Web browser forensics after simulating an actual crime in two different publications[6]. Two free tools, the Pasco and Web Historian, were introduced for IE forensics with two commercial tools, the IE History and FTK tools. Forensics in Firefox 2 using a cache

[2] Shafik G. Punja and Richard P. Mislan, "Mobile Device Analysis," Small Scale Digital Device Forensics Journal 2 (2008): 1–16.

[3] S. Willassen. "Forensic Analysis of Mobile Phone Internal Memory", Advances in Digital Forensics 194 (2005): 191-204.

[4] MediaTek. "MediaTek." http://www.mediatek.com/en/index.php.

[5] Spreadtrum. "Spreadtrum." http://www.spreadtrum.com.

[6] Keith J Jones and Blani Rohyt. "Web browser forensic." Accessed January 19, 2012. http://www.securityfocus.com/infocus/1827.

file and an analysis method using the cache file structure were also suggested in the publications. Pereira[7] explained in detail the changes in the history system that occurred when Firefox 2 was updated to Firefox 3 and proposed a new method of searching deleted history information using unallocated fields. Oh et al.[8] proposed an advanced evidence collection and analysis methodology for web forensics by performing integrated analysis across various browsers at the same time and using timeline analysis to detect the online movements of a suspect over time. A web forensics tool, named WEFA (Web Browser Forensic Analyzer), was also developed for the integrated analysis, which allows the investigator to examine the five leading web browsers (i.e. IE, Firefox, Chrome, Safari and Opera) existing in one system in parallel.

At present, there are a lot of tools for web forensics or forensics toolkits providing web browser investigation function, such as Netanalysis, Encase, FTK, etc. However, these methodologies and tools are originally designed for web browsers running on PC platform. When the scenario is moved to mobile phone platform, the investigation will become more challenging since the OS, the file system and the web browsers of the target are quite different with those on computer platform. Furthermore, the wide variety of mobile browsers also makes the forensic investigation more complicated.

Although there have been some mobile forensic toolkits that are dedicated to mobile OS, such as Android, iOS, Symbian and Windows Mobile, the toolkits cannot be used for Shanzhai phones since they are OS dependent. For Shanzhai phone forensics, Zhang[9] discussed the recovery of MTK mobile phone flash file system, however, no detailed information is given. Fang et al.[10] investigated how Shanzhai phone handles the addition and deletion of basic information in binary level as well as how to recover the historical data from memory image for timeline analysis. EDEC announced its Tarantula cell phone analysis system to target mobile phones using Chinese-manufactured chipsets and the system is further integrated into Logicube's CellXtract® cell phone forensic platform.[11] But both the systems didn't provide the function for web forensics.

## 3. Internal Flash Memory Acquisition

Flash memory is currently the most dominant non-volatile solid-state storage technology for mobile phone. Similar to other brands of mobile phones, Shanzhai phones use flash memory as internal memory devices to store hard-coded system software, system files, user data, etc. Compared with reading data from the two other major storage units in mobile phones, i.e. SIM card and external memory card, retrieving data from internal flash memory is more complex and difficult as the memory chip cannot be read directly using external memory readers, except it is removed from the printed circuit board (PCB).
Nowadays, the methodologies for internal data collection can be classified into two approaches: physical and logical. The physical approach performs data extraction at a low level and allows obtaining the full

[7] Murilo Tito Pereira. "Forensic analysis of the Firefox3 internet history and recovery of deleted SQLite records." Digital Investigation 5 (2009): 93-103.

[8] Junghoon Oh, Seungbong Lee and Sangjin Lee. "Advanced evidence collection and analysis of web browser activity." Digital Investigation 8 (2011): S62-S70.

[9] Zhi-wei Zhang. "The research of MTK mobile phones flash file system recovery." Netinfo Security 11 (2010): 34-36

[10] Junbin Fang et al. "Forensic Analysis of Pirated Chinese Shanzhai Mobile Phones." Advances in Digital Forensics VIII (2012): 117-130.

[11] Logicube. "Logicube Integrates EDEC's Tarantula To Target Mobile Devices Based on Chinese Chipsets." Last modified March 04, 2012. http://www.logicube.com/logicube-integrates-edecs-tarantula-to-target-mobile-devices-based-on-chinese-chipsets/.

memory image of contents of the entire phone memory, usually with the help of special hardware equipment. The logical approach uses communication protocols offered by the phone at a higher level, while the amount of acquired data is limited since the API provided by the phone were not developed for forensic purposes but to operate the phone as a modem. Another problem of logical approach is that contents deleted cannot be recovered in most cases.

As one of the physical approaches for internal memory acquisition, flasher tools may be the most convenient way to get a complete memory dump,[12] compared with the other two physical approaches - JTAG approach and physical extraction approach.  Flasher tools are mainly used by mobile phone manufacturer and service providers to recover user data from dead or faulty mobile phones that otherwise will not provide access to data stored on their internal memory.  They can also be used to update or replace software that is stored in the mobile phone. The forensic use of flasher tools is already being taught to future digital forensic examiners in Purdue's College of Technology in the United States of America.[13] It is also being used by European investigators in mobile forensic cases.

In this paper, we go for the easier solution of using a flasher tool to obtain the memory dump instead of using JTAG or physical extraction since our focus is more on how the information is stored in the memory. In principle, the flasher tool connects with the UART interface (Rx and Tx pins) of Shanzhai phone's processor and run a serial communication protocol to communicate with the processor. When the power button of the Shanzhai phone is pressed, a boot loader inside the processor will be executed and can read/write from/to all registers and memory addresses, then the host software can successfully retrieve a full memory dump from the phone, as complete as JTAG approach does.

## 4. Analyzing Web Browsing Data in Memory Image

Experiments were conducted on a typical model of Shanzhai phone, which is an imitated version of Apple’s iPhone4. The model is equipped with a MediaTek MT6253 processor and a 16M byte NOR flash chip (Toshiba TC58FYM7T8C). After an image of the internal flash memory chip is dumped using flasher tool, the binary data will be analysed to extract related web information for forensic investigation.
MT6253 is Mediatek’s first monolithic GSM/GPRS handset chip solution that offers highest level of integration with lowest power consumption and best-in-class features. Such that most of Shanzhai phone models were developed on this platform. The memory allocation scheme of the Shanzhai phone under test followed the default configuration in MTK's turn-key solution. As shown in Figure 1, the Toshiba TC58FYM7T8C chip integrates 16 MB NOR flash memory and 4 MB RAM and the 16 MB flash memory was divided into two areas at offset 0xE0000 (corresponding to 14 MB). The first 14MB area was used as read-only memory (ROM) to store hard-coded system software, while the remaining 2MB area was used to store system files and user data. The 2MB area contained two drives in FAT12 format. One was for user data storage, which can be shown as a USB massive storage when the phone is connected to a computer. The other one was used as non-volatile random-access memory (NVRAM) for storing system files such as phonebook, SMS, call log, temporary files, etc. Noted that the NVRAM drive was invisible to normal user from computer or Shanzhai phone's UI.

[12] K. Jonkers. "The forensic use of mobile phone flasher boxes." Digital Investigation 6 (2010): 168-178.
[13] Purdue University. "Expert: 'Flasher' technology digs deeper for digital evidence." Accessed January 10, 2012. http://phys.org/news95611284.html

### 4.1 Web browsing data extraction

Before going into the memory image to analyse the web-based information, the first step is to identify the type of the web browser used in the Shanzhai phone. If the web browser is one kind of the famous mobile browsers, the investigation would be easier as there may be a lot of previous research works and tools for the leading mobile browsers. Although it was reported at the end of 2011 that MediaTek and Opera Integrate Mini Browser on Feature Phones, the built-in browser of the Shanzhai phone is not Opera Mini but a private browser of Mediatek and there is not an existing tool can be applied to this browser. Since documents and references for the private browser are lack, reverse engineering is required to analyse the management of web browsing data, including browsing history, cache, bookmarks, cookies and etc.

In the experiments, after a series of common web browsing operations, a set of memory images were dumped from the Shanzhai phone and were further investigated, mainly the NVRAM area associated with the hard-coded area. Then, the organization of related files storing web browsing data in NVRAM was identified as follows:

1. Browsing history: With the private browser, the browsing history is stored in two different files. The web address shown in address bar is classified into two categories, manual input and redirected links. The first kind of web address is stored under directory "./bra" with filename "history.dat", while the last kind of web address is saved under the same directory with filename "history2.dat ". The format of a browsing history recorded in file "history2.dat" is as the example shown in Figure 2. The record is combined by two parts, header and body. The header field is 7 bytes length with a "FF" start character and the third byte indicates the number of the remaining bytes of the record. The last 4 bytes in header is the Unix timestamp of accessing the website. The body field comprises the accessed web address and the title of the webpage visited, which are separated by a "00" byte. Note that the format for records in file "history.dat" is the same as that in Figure 2, except that there is not webpage title field.

2. Cache: When user accesses a webpage, the content of the webpage is retrieved to local as cached Internet files. In the Shanzhai phone, cached Internet file is renamed and placed under the directory "./stk/cache". In the directory, there is a file named "index.dat", which is used to manage and index all the cached files stored in this directory. Every time when the Internet files are saved, the index.dat file will be updated. An example of the file allocation table (FAT) of the cache directory is shown in Figure 3.

3. Cookies: Cookies of browsing history are saved in the directory "./stk/cookie/". The management of cookies is similar to that of cached Internet files. In the directory, a file name "index.dat" is used to manage and index all the files storing Cookies in that directory.

4. Bookmark: Bookmarks of the private browser were stored in a file named "BKM.dat" under directory "./bra" in the NVRAM area.

### 4.2 Analyzing Internet Search History and Web-Based Email

The above findings are related to the management and basic format of the web browsing data in the Shanzhai phone. From the perspective of forensics, critical evidence can be found in the suspect’s web browsing data, including not only websites visited, but also Internet searches conducted and web-based email. For example, in the case of Neil Entwhistle, he was convicted of murdering his wife and baby daughter after forensic investigators found a Google search for "how to kill with a knife" in his computer's web history.[14]

In this section, two experiments of analysing Internet search history and web-based email were demonstrated.

Internet search is helpful for people to get information effectively. At present, there are several popular search engines, such as Google, Yahoo, Baidu, Bing, etc. To investigate the Internet search conducted on the Shanzhai phone, we first extracted all the entries of browsing history using the pattern of "FF************http". Then a web address history with a general HTTP URL structure of Google search engine was found. As shown in Figure 4, the URL string located in memory image is "http://www.google.com.hk/search?hl=zhTW&newwindow=1&sky=ee&ie=Big5&q=hacking+hijack&btnG=%e6%90%9c%e5%b0%8b". In this string, the search words are the value after the variable *q*, revealing that the suspect searched on Google using keywords "hacking" and "hijack", which implies that the suspect has been interested in these techniques.

Web-based email is a typical web application and all the main functions can be operated online using a browser. Different with other kinds of web browsing data, web-based email usually involve more personal information. And web-based email can be cached only when the content of the email has been shown in the browser. For example, reading an email brings the message up in the browser and causes it to be cached, while sending an email does not since the browser doesn't display the sent mail, except that the user read the mail in sent box. In Figure 5 through Figure 7, an experiment of extracting web-based email from the binary image is demonstrated. Noted that two email accounts in qq.com were used to send and receive email, respectively.

To investigate the web-based email which was read on the Shanzhai phone, we first extracted all the entries of browsing history using the pattern of "FF************http", same as did in investigating Internet search. Then the URL of reading email in mail.qq.com can be found. As shown in Figure 5, the URL is:
"http://w94.mail.qq.com/cgibin/readmail?hittype=0&sid=6hdm9SM2Jra8mQBQW8jT5vNw,5,zTOTzKDy2&folderid=1&t=readmail&s=&mailid=ZC3021-A_46smR3sSErpj9vC09cd27&lp=0&lpg=&to=".
From this URL, two useful values can be extracted as:

- The unique id for the web session (sid): 6hdm9SM2Jra8mQBQW8jT5vNw,5,zTOTzKDy2
- The unique id of the mail which was read (mailed): ZC3021-A_46smR3sSErpj9vC09cd27

As the URL and the unique ids are known, the next step is to find the related cache file for this URL in the memory image. Taking the URL as a keyword to search in the index file of Cache or search directly in the image, a map between the cached file of the URL can be found. As shown in Figure 6, the cache file for the reading email is "S2f84d54.wml".

After the file "S2f84d54.wml" was carved and reconstructed, it can be displayed in a wml parser. As shown in Figure 7, the wml file is parsed and contains the following information:

[14] AFP. "Briton Googled 'how to kill' days before murders: court." Accessed February 14, 2010. http://afp.google.com/article/ALeqM5hNX7099fMvF7_qHCpy1Bz4VhtR6A.

- Email service provider: QQ mailbox
- Email sender: Andy1
- Email receiver: testone
- Time: 10:28AM on July 21, 2012
- Subject: how to become a hacker
- Content:  Thinking Like a Hacker…

Besides, accounts for this email can also be found in the raw format of the wml file:

- Email sending account: 1910159914@qq.com
- Email receiving account: 2576406269@qq.com.

Combining the findings in Internet search history and email, we can deduce that the user had put some effort in this kind of technique.

## 5. Recovery of Deleted Browsing History and Timeline Analysis

Most of web browsers provide function for clearing web browsing data, such as the cache, browsing history, cookies and etc. Users may delete the logs of web browsing to protect their privacy. Additionally, some web browsers can be configured to reset web browsing data periodically. In web forensics, if a suspect has performed such function on his web browser to destroy the trace of his activity, investigation will be more difficult.

For PC-based web browsers, recovery of deleted web browser information depends on the data clean-up mechanism of the browsers. For example, in Firefox, log files are reinitialized and only the temporary files used by SQLite in unallocated space of disk are possible to be carved and recovered.

For Shanzhai phones, it was found that there are multiple copies of user data in the binary image.[15] The copies are created at different time points due to the erasure and allocation mechanism of flash memory. Since flash memory can only be “erased” a block at a time and cannot offer arbitrary random-access rewrite or erase operations, we observed that when the data in Shanzhai phone's web browser is updated, the new data will be stored in a newly erased block and the old data will be left untouched in the old block. This operation leaves multiple copies of data items until the memory space is revoked and overwritten by some other data.

From the viewpoint of forensics, this characteristic can be utilized to recover more information, even when the web browsing data in Shanzhai phone was deleted automatically or intentionally.

This section details the results of recovering deleted browsing history and analysing user's web browsing activity. In the experiment, the following web browsing operations were performed on the Shanzhai phone in sequence:

- Step 1: User started the web browser and typed a test URL "http://i.cs.hku.hk/~jbfang" into the address bar of the browser.

[15] Junbin Fang et al. "Forensic Analysis of Pirated Chinese Shanzhai Mobile Phones." Advances in Digital Forensics VIII (2012): 117-130.

- Step 2: User opened the test webpage, which contains 3 links to Google, Yahoo and Wikipedia separately.
- Step 3: User clicked the link of "Google" in the test webpage and the browser jumped to the homepage of Google's search engine (“http://www.google.com.hk”).
- Step 4: User searched "hacking hijack" in Google and waited for the results returned.
- Step 5: User deleted two entries of browsing history related to Google.
- Step 6: User typed URL "www.ask.com" into the address bar of the browser and accessed the website.
- Step 7: User searched "hacking hijack" in ask.com.

After the operations, a memory image was dumped from the Shanzhai phone and was investigated. Using pattern matching, we found 9 memory segments for browsing history in the binary image. One memory segment corresponds to a copy of browsing history after one operation and can be viewed as a snapshot. The snapshots of browsing history after every step are shown in Figure 8 through 14, noted as S1, S2, S3, S4, S5, S6, S7, correspondingly.

The snapshots in Figure 8 through Figure 11 show that every newly added record of browsing history is simply appended to the old records and causes to a new memory segment for browsing history. Snapshot in Figure 12 demonstrates the memory operation mechanism for deleting entries in browsing history. Deleting browsing history records didn't really erase the deleted entries in the file, but marked the deleted entries as invalid with a terminal symbol "FE". In this case, the deleted records of browsing history still exist in the logical file as well as in the previous snapshots, thus it can be recovered from both the current memory segment and the previous ones. However, in the snapshots in Figure 13 and 14, the cases are different. The deleted entries were overwritten by the newly added record. Therefore, the deleted record of browsing history can only be recovered from the previous snapshots.

For this experiment, since the deleted browsing history can be recovered in the snapshots and the records have timestamp, the timeline of the user's web browsing activity can be rebuilt quickly using the timestamp information, i.e. the sequence for the snapshots is: S1-S2-S3-S4-S5-S6-S7. Nevertheless, if the phone was set to a wrong time purposely, timeline analysis may not be so straightforward since the timestamp in the records may not be able to reflect the real sequence of the web addresses accessed. In this case, the relative position of the records in snapshots could be taken into consideration to help deduce the actual sequence of user's web browsing activities. For example, even the timestamps were unbelievable, we can recognize that the user activity of accessing "www.google.com" is before visiting "www.ask.com" according to the mechanism of Shanzhai phone for adding/deleting records in browsing history.

## 6. Conclusion

This paper presents a preliminary work on the investigation of the web-based contents on an MTK-based Shanzhai mobile phone by analysing the memory dump extracted from the phone using a flasher tool. The analysis reveals important details about how the web browsing data is managed and stored with the private web browser of the Shanzhai phone. Based on the analysis, Internet searches conducted and web-based email received can be extracted from the binary image. Besides, valuable historical data pertaining to multiple snapshots and deleted browsing history can be obtained from a memory dump as long as the associated memory locations have not been overwritten. This information can be used to help rebuild the time sequence of user's web browsing activities.

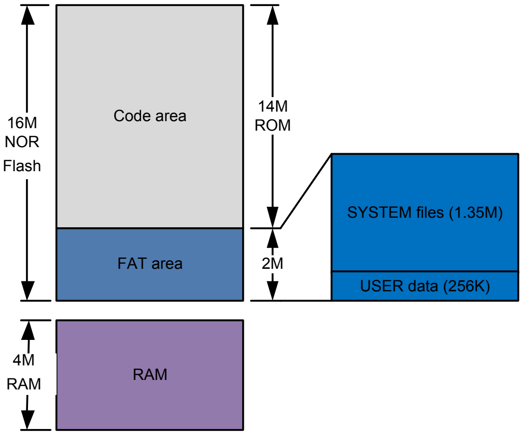
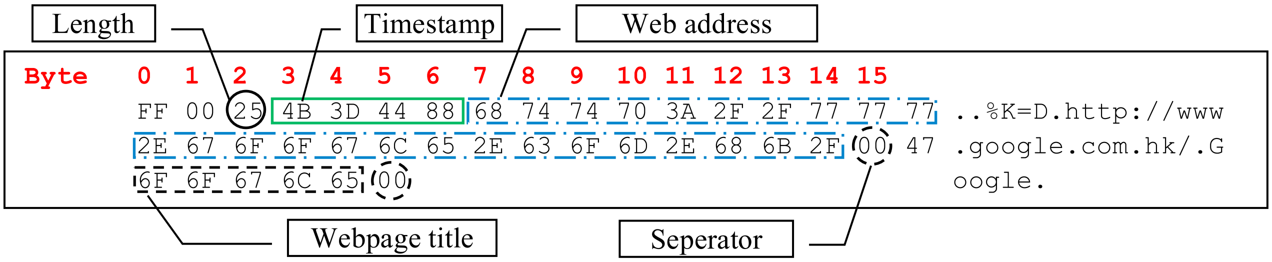
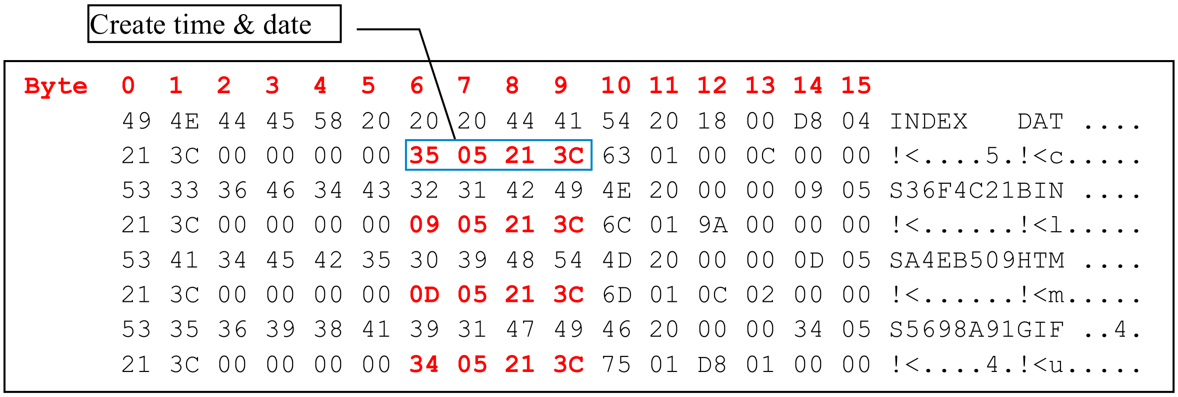


Figure 1. A typical memory allocation scheme of Shanzhai Phone



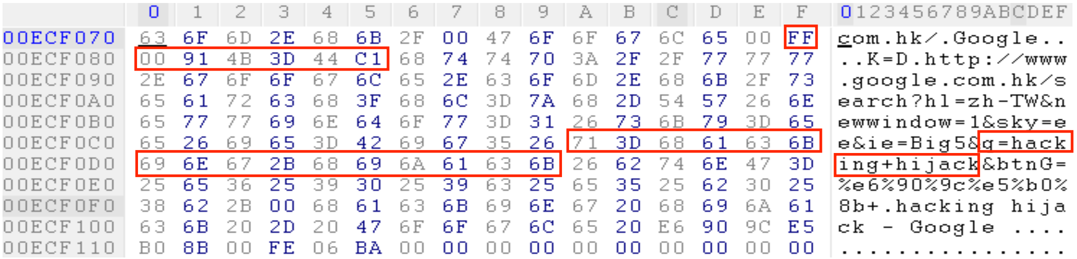
```
Byte    0  1  2  3  4  5  6  7  8  9  10 11 12 13 14 15
        FF 00 25 4B 3D 44 88 68 74 74 70 3A 2F 2F 77 77 77  ..%K=D.http://www
        2E 67 6F 6F 67 6C 65 2E 63 6F 6D 2E 68 6B 2F 00 47  .google.com.hk/.G
        6F 6F 67 6C 65 00                                   oogle.
```

Figure 2. An example of a browsing history record in memory image



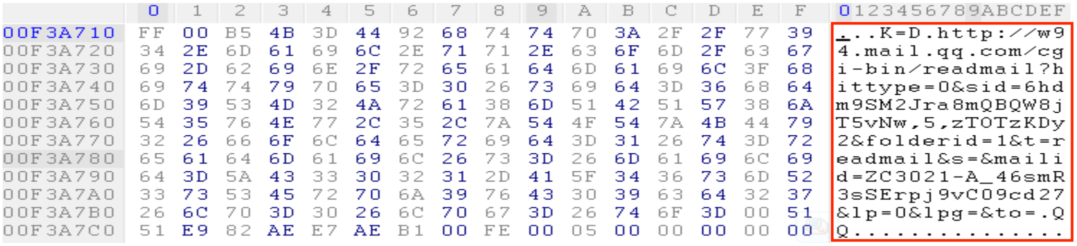
```
Byte   0  1  2  3  4  5  6  7  8  9  10 11 12 13 14 15
       49 4E 44 45 58 20 20 20 44 41 54 20 18 00 D8 04 INDEX   DAT ....
       21 3C 00 00 00 00 35 05 21 3C 63 01 00 0C 00 00 !<....5.!<c.....
       53 33 36 46 34 43 32 31 42 49 4E 20 00 00 09 05 S36F4C21BIN ....
       21 3C 00 00 00 00 09 05 21 3C 6C 01 9A 00 00 00 !<......!<l.....
       53 41 34 45 42 35 30 39 48 54 4D 20 00 00 0D 05 SA4EB509HTM ....
       21 3C 00 00 00 00 0D 05 21 3C 6D 01 0C 02 00 00 !<......!<m.....
       53 35 36 39 38 41 39 31 47 49 46 20 00 00 34 05 S5698A91GIF ..4.
       21 3C 00 00 00 00 34 05 21 3C 75 01 D8 01 00 00 !<....4.!<u.....
```

Figure 3. An example of cached Internet files record in memory image



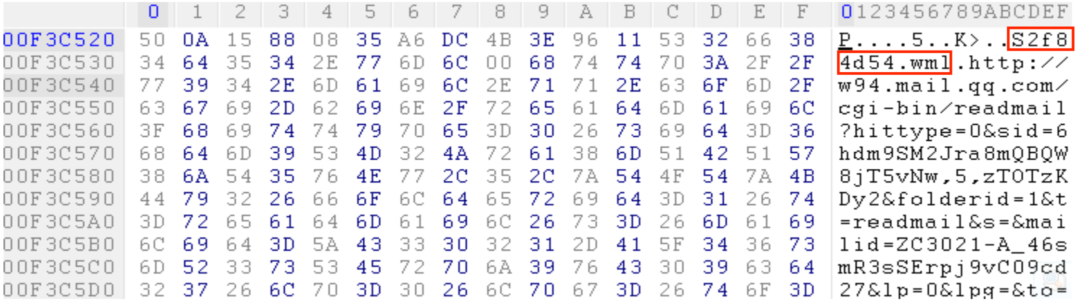
```
          0  1  2  3  4  5  6  7  8  9  A  B  C  D  E  F  0123456789ABCDEF
00ECF070  63 6F 6D 2E 68 6B 2F 00 47 6F 6F 67 6C 65 00 FF  com.hk/.Google..
00ECF080  00 91 4B 3D 44 C1 68 74 74 70 3A 2F 2F 77 77 77  ..K=D.http://www
00ECF090  2E 67 6F 6F 67 6C 65 2E 63 6F 6D 2E 68 6B 2F 73  .google.com.hk/s
00ECF0A0  65 61 72 63 68 3F 68 6C 3D 7A 68 2D 54 57 26 6E  earch?hl=zh-TW&n
00ECF0B0  65 77 77 69 6E 64 6F 77 3D 31 26 73 6B 79 3D 65  ewwindow=1&sky=e
00ECF0C0  65 26 69 65 3D 42 69 67 35 26 71 3D 68 61 63 6B  e&ie=Big5&q=hack
00ECF0D0  69 6E 67 2B 68 69 6A 61 63 6B 26 62 74 6E 47 3D  ing+hijack&btnG=
00ECF0E0  25 65 36 25 39 30 25 39 63 25 65 35 25 62 30 25  %e6%90%9c%e5%b0%
00ECF0F0  38 62 2B 00 68 61 63 6B 69 6E 67 20 68 69 6A 61  8b+.hacking hija
00ECF100  63 6B 20 2D 20 47 6F 6F 67 6C 65 20 E6 90 9C E5  ck - Google ....
00ECF110  B0 8B 00 FE 06 BA 00 00 00 00 00 00 00 00 00 00  ................
```

Figure 4. Extracting Internet search history in memory image



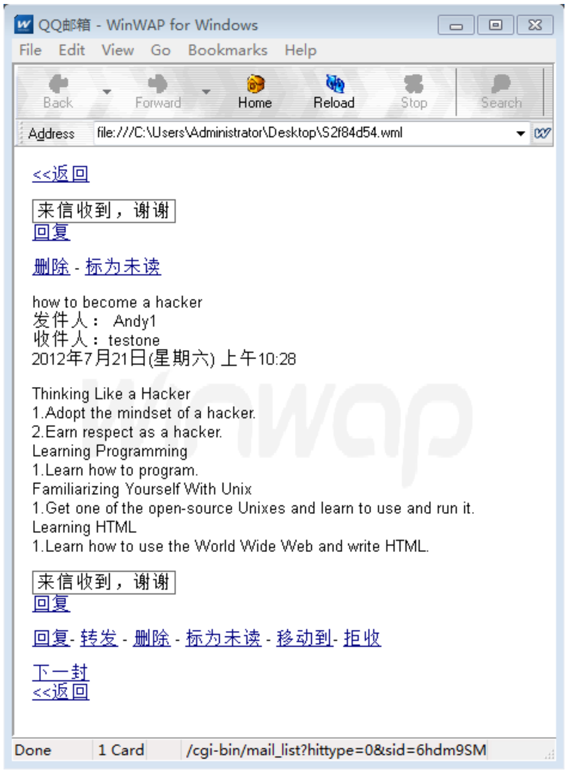
```
          0  1  2  3  4  5  6  7  8  9  A  B  C  D  E  F  0123456789ABCDEF
00F3A710  FF 00 B5 4B 3D 44 92 68 74 74 70 3A 2F 2F 77 39  ...K=D.http://w9
00F3A720  34 2E 6D 61 69 6C 2E 71 71 2E 63 6F 6D 2F 63 67  4.mail.qq.com/cg
00F3A730  69 2D 62 69 6E 2F 72 65 61 64 6D 61 69 6C 3F 68  i-bin/readmail?h
00F3A740  69 74 74 79 70 65 3D 30 26 73 69 64 3D 36 68 64  ittype=0&sid=6hd
00F3A750  6D 39 53 4D 32 4A 72 61 38 6D 51 42 51 57 38 6A  m9SM2Jra8mQBQW8j
00F3A760  54 35 76 4E 77 2C 35 2C 7A 54 4F 54 7A 4B 44 79  T5vNw,5,zTOTzKDy
00F3A770  32 26 66 6F 6C 64 65 72 69 64 3D 31 26 74 3D 72  2&folderid=1&t=r
00F3A780  65 61 64 6D 61 69 6C 26 73 3D 26 6D 61 69 6C 69  eadmail&s=&maili
00F3A790  64 3D 5A 43 33 30 32 31 2D 41 5F 34 36 73 6D 52  d=ZC3021-A_46smR
00F3A7A0  33 73 53 45 72 70 6A 39 76 43 30 39 63 64 32 37  3sSErpj9vC09cd27
00F3A7B0  26 6C 70 3D 30 26 6C 70 67 3D 26 74 6F 3D 00 51  &lp=0&lpg=&to=.Q
00F3A7C0  51 E9 82 AE E7 AE B1 00 FE 00 05 00 00 00 00 00  Q...............
```

Figure 5. The browsing history for the received web-email



```
          0  1  2  3  4  5  6  7  8  9  A  B  C  D  E  F  0123456789ABCDEF
00F3C520  50 0A 15 88 08 35 A6 DC 4B 3E 96 11 53 32 66 38  P....5..K>..S2f8
00F3C530  34 64 35 34 2E 77 6D 6C 00 68 74 74 70 3A 2F 2F  4d54.wml.http://
00F3C540  77 39 34 2E 6D 61 69 6C 2E 71 71 2E 63 6F 6D 2F  w94.mail.qq.com/
00F3C550  63 67 69 2D 62 69 6E 2F 72 65 61 64 6D 61 69 6C  cgi-bin/readmail
00F3C560  3F 68 69 74 74 79 70 65 3D 30 26 73 69 64 3D 36  ?hittype=0&sid=6
00F3C570  68 64 6D 39 53 4D 32 4A 72 61 38 6D 51 42 51 57  hdm9SM2Jra8mQBQW
00F3C580  38 6A 54 35 76 4E 77 2C 35 2C 7A 54 4F 54 7A 4B  8jT5vNw,5,zTOTzK
00F3C590  44 79 32 26 66 6F 6C 64 65 72 69 64 3D 31 26 74  Dy2&folderid=1&t
00F3C5A0  3D 72 65 61 64 6D 61 69 6C 26 73 3D 26 6D 61 69  =readmail&s=&mai
00F3C5B0  6C 69 64 3D 5A 43 33 30 32 31 2D 41 5F 34 36 73  lid=ZC3021-A_46s
00F3C5C0  6D 52 33 73 53 45 72 70 6A 39 76 43 30 39 63 64  mR3sSErpj9vC09cd
00F3C5D0  32 37 26 6C 70 3D 30 26 6C 70 67 3D 26 74 6F 3D  27&lp=0&lpg=&to=
```

Figure 6. The cached file for the received web-email



file:///C:\Users\Administrator\Desktop\S2f84d54.wml

<<返回

来信收到，谢谢
回复

删除 - 标为未读

how to become a hacker
发件人： Andy1
收件人： testone
2012年7月21日(星期六) 上午10:28

Thinking Like a Hacker
1.Adopt the mindset of a hacker.
2.Earn respect as a hacker.
Learning Programming
1.Learn how to program.
Familiarizing Yourself With Unix
1.Get one of the open-source Unixes and learn to use and run it.
Learning HTML
1.Learn how to use the World Wide Web and write HTML.

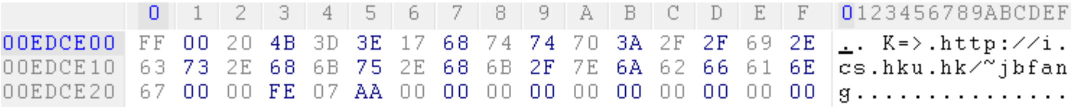
来信收到，谢谢
回复

回复 - 转发 - 删除 - 标为未读 - 移动到 - 拒收

下一封
<<返回

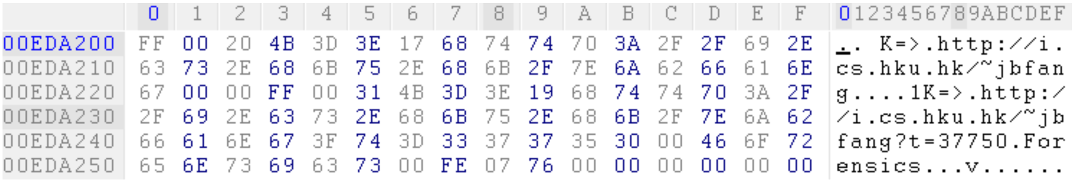
Done 1 Card /cgi-bin/mail_list?hittype=0&sid=6hdm9SM

Figure 7. Screenshot of web browsing cache file "S2f84d54.wml"



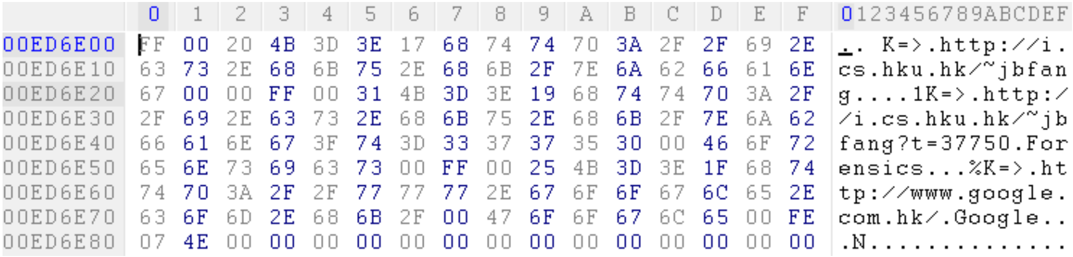
```
          0  1  2  3  4  5  6  7  8  9  A  B  C  D  E  F   0123456789ABCDEF
00EDCE00  FF 00 20 4B 3D 3E 17 68 74 74 70 3A 2F 2F 69 2E  .. K=>.http://i.
00EDCE10  63 73 2E 68 6B 75 2E 68 6B 2F 7E 6A 62 66 61 6E  cs.hku.hk/~jbfan
00EDCE20  67 00 00 FE 07 AA 00 00 00 00 00 00 00 00 00 00  g...............
```

Figure 8. S1 - Snapshot after step 1 (timestamp: 01 Jan 2010 00:13:11).



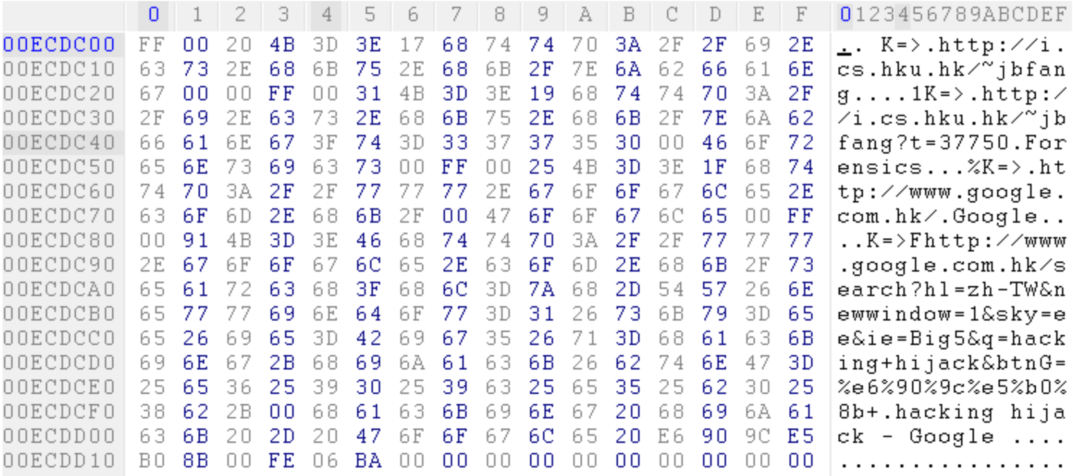
```
          0  1  2  3  4  5  6  7  8  9  A  B  C  D  E  F   0123456789ABCDEF
00EDA200  FF 00 20 4B 3D 3E 17 68 74 74 70 3A 2F 2F 69 2E  .. K=>.http://i.
00EDA210  63 73 2E 68 6B 75 2E 68 6B 2F 7E 6A 62 66 61 6E  cs.hku.hk/~jbfan
00EDA220  67 00 00 FF 00 31 4B 3D 3E 19 68 74 74 70 3A 2F  g....1K=>.http:/
00EDA230  2F 69 2E 63 73 2E 68 6B 75 2E 68 6B 2F 7E 6A 62  /i.cs.hku.hk/~jb
00EDA240  66 61 6E 67 3F 74 3D 33 37 37 35 30 00 46 6F 72  fang?t=37750.For
00EDA250  65 6E 73 69 63 73 00 FE 07 76 00 00 00 00 00 00  ensics...v......
```

Figure 9. S2 - Snapshot after step 2 (timestamp: 01 Jan 2010 00:13:13).



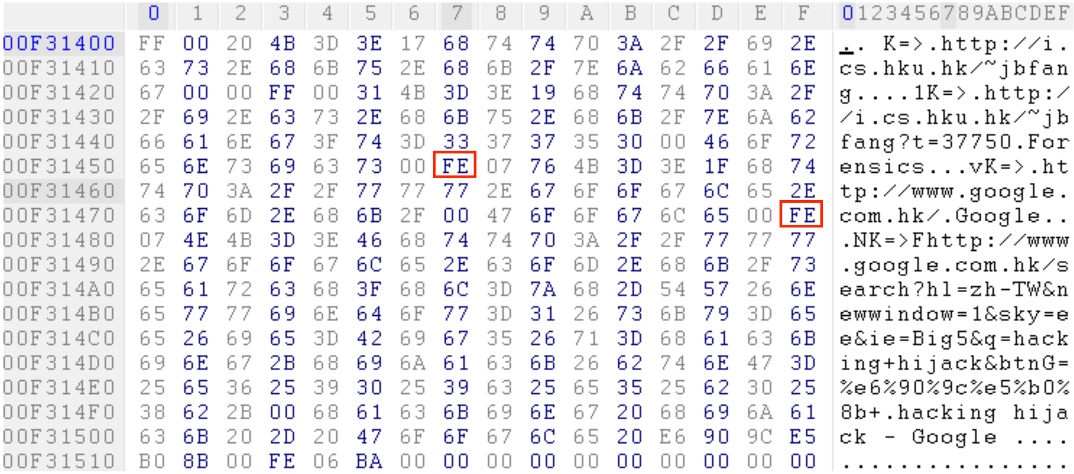
```
          0  1  2  3  4  5  6  7  8  9  A  B  C  D  E  F   0123456789ABCDEF
00ED6E00  FF 00 20 4B 3D 3E 17 68 74 74 70 3A 2F 2F 69 2E  .. K=>.http://i.
00ED6E10  63 73 2E 68 6B 75 2E 68 6B 2F 7E 6A 62 66 61 6E  cs.hku.hk/~jbfan
00ED6E20  67 00 00 FF 00 31 4B 3D 3E 19 68 74 74 70 3A 2F  g....1K=>.http:/
00ED6E30  2F 69 2E 63 73 2E 68 6B 75 2E 68 6B 2F 7E 6A 62  /i.cs.hku.hk/~jb
00ED6E40  66 61 6E 67 3F 74 3D 33 37 37 35 30 00 46 6F 72  fang?t=37750.For
00ED6E50  65 6E 73 69 63 73 00 FF 00 25 4B 3D 3E 1F 68 74  ensics...%K=>.ht
00ED6E60  74 70 3A 2F 2F 77 77 77 2E 67 6F 6F 67 6C 65 2E  tp://www.google.
00ED6E70  63 6F 6D 2E 68 6B 2F 00 47 6F 6F 67 6C 65 00 FE  com.hk/.Google..
00ED6E80  07 4E 00 00 00 00 00 00 00 00 00 00 00 00 00 00  .N..............
```

Figure 10. S3 - Snapshot after step 3 (timestamp: 01 Jan 2010 00:13:19).



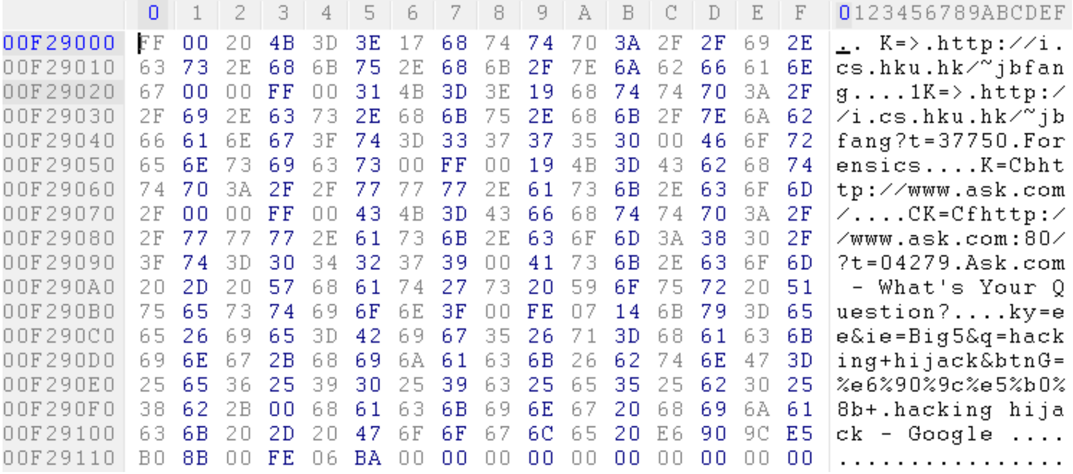
```
          0  1  2  3  4  5  6  7  8  9  A  B  C  D  E  F   0123456789ABCDEF
00ECDC00  FF 00 20 4B 3D 3E 17 68 74 74 70 3A 2F 2F 69 2E  .. K=>.http://i.
00ECDC10  63 73 2E 68 6B 75 2E 68 6B 2F 7E 6A 62 66 61 6E  cs.hku.hk/~jbfan
00ECDC20  67 00 00 FF 00 31 4B 3D 3E 19 68 74 74 70 3A 2F  g....1K=>.http:/
00ECDC30  2F 69 2E 63 73 2E 68 6B 75 2E 68 6B 2F 7E 6A 62  /i.cs.hku.hk/~jb
00ECDC40  66 61 6E 67 3F 74 3D 33 37 37 35 30 00 46 6F 72  fang?t=37750.For
00ECDC50  65 6E 73 69 63 73 00 FF 00 25 4B 3D 3E 1F 68 74  ensics...%K=>.ht
00ECDC60  74 70 3A 2F 2F 77 77 77 2E 67 6F 6F 67 6C 65 2E  tp://www.google.
00ECDC70  63 6F 6D 2E 68 6B 2F 00 47 6F 6F 67 6C 65 00 FF  com.hk/.Google..
00ECDC80  00 91 4B 3D 3E 46 68 74 74 70 3A 2F 2F 77 77 77  ..K=>Fhttp://www
00ECDC90  2E 67 6F 6F 67 6C 65 2E 63 6F 6D 2E 68 6B 2F 73  .google.com.hk/s
00ECDCA0  65 61 72 63 68 3F 68 6C 3D 7A 68 2D 54 57 26 6E  earch?hl=zh-TW&n
00ECDCB0  65 77 77 69 6E 64 6F 77 3D 31 26 73 6B 79 3D 65  ewwindow=1&sky=e
00ECDCC0  65 26 69 65 3D 42 69 67 35 26 71 3D 68 61 63 6B  e&ie=Big5&q=hack
00ECDCD0  69 6E 67 2B 68 69 6A 61 63 6B 26 62 74 6E 47 3D  ing+hijack&btnG=
00ECDCE0  25 65 36 25 39 30 25 39 63 25 65 35 25 62 30 25  %e6%90%9c%e5%b0%
00ECDCF0  38 62 2B 00 68 61 63 6B 69 6E 67 20 68 69 6A 61  8b+.hacking hija
00ECDD00  63 6B 20 2D 20 47 6F 6F 67 6C 65 20 E6 90 9C E5  ck - Google ....
00ECDD10  B0 8B 00 FE 06 BA 00 00 00 00 00 00 00 00 00 00  ................
```

Figure 11. S4 - Snapshot after step 4 (timestamp: 01 Jan 2010 00:13:58).



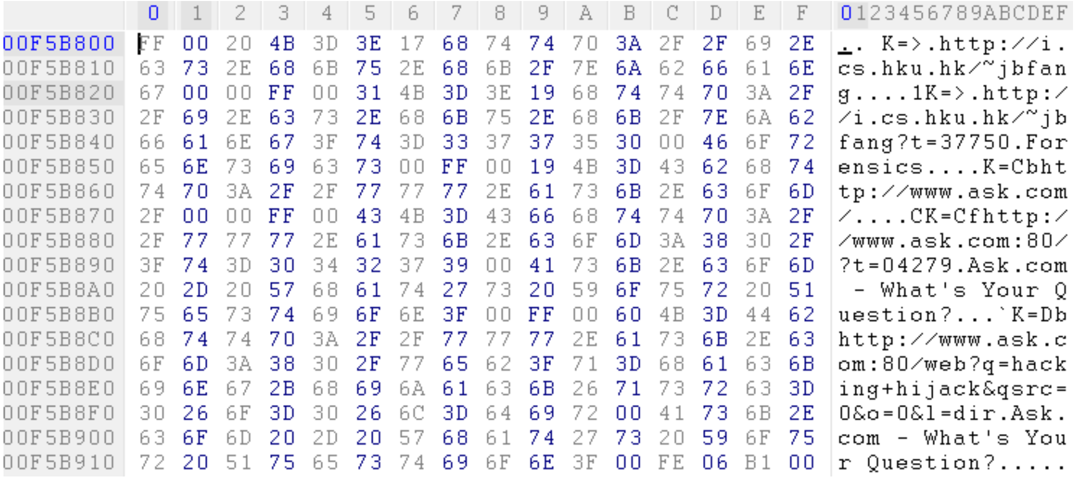
```
          0  1  2  3  4  5  6  7  8  9  A  B  C  D  E  F   0123456789ABCDEF
00F31400  FF 00 20 4B 3D 3E 17 68 74 74 70 3A 2F 2F 69 2E  .. K=>.http://i.
00F31410  63 73 2E 68 6B 75 2E 68 6B 2F 7E 6A 62 66 61 6E  cs.hku.hk/~jbfan
00F31420  67 00 00 FF 00 31 4B 3D 3E 19 68 74 74 70 3A 2F  g....1K=>.http:/
00F31430  2F 69 2E 63 73 2E 68 6B 75 2E 68 6B 2F 7E 6A 62  /i.cs.hku.hk/~jb
00F31440  66 61 6E 67 3F 74 3D 33 37 37 35 30 00 46 6F 72  fang?t=37750.For
00F31450  65 6E 73 69 63 73 00 FE 07 76 4B 3D 3E 1F 68 74  ensics...vK=>.ht
00F31460  74 70 3A 2F 2F 77 77 77 2E 67 6F 6F 67 6C 65 2E  tp://www.google.
00F31470  63 6F 6D 2E 68 6B 2F 00 47 6F 6F 67 6C 65 00 FE  com.hk/.Google..
00F31480  07 4E 4B 3D 3E 46 68 74 74 70 3A 2F 2F 77 77 77  .NK=>Fhttp://www
00F31490  2E 67 6F 6F 67 6C 65 2E 63 6F 6D 2E 68 6B 2F 73  .google.com.hk/s
00F314A0  65 61 72 63 68 3F 68 6C 3D 7A 68 2D 54 57 26 6E  earch?hl=zh-TW&n
00F314B0  65 77 77 69 6E 64 6F 77 3D 31 26 73 6B 79 3D 65  ewwindow=1&sky=e
00F314C0  65 26 69 65 3D 42 69 67 35 26 71 3D 68 61 63 6B  e&ie=Big5&q=hack
00F314D0  69 6E 67 2B 68 69 6A 61 63 6B 26 62 74 6E 47 3D  ing+hijack&btnG=
00F314E0  25 65 36 25 39 30 25 39 63 25 65 35 25 62 30 25  %e6%90%9c%e5%b0%
00F314F0  38 62 2B 00 68 61 63 6B 69 6E 67 20 68 69 6A 61  8b+.hacking hija
00F31500  63 6B 20 2D 20 47 6F 6F 67 6C 65 20 E6 90 9C E5  ck - Google ....
00F31510  B0 8B 00 FE 06 BA 00 00 00 00 00 00 00 00 00 00  ................
```

Figure 12. S5 - Snapshot after step 5.



```
          0  1  2  3  4  5  6  7  8  9  A  B  C  D  E  F   0123456789ABCDEF
00F29000  FF 00 20 4B 3D 3E 17 68 74 74 70 3A 2F 2F 69 2E  .. K=>.http://i.
00F29010  63 73 2E 68 6B 75 2E 68 6B 2F 7E 6A 62 66 61 6E  cs.hku.hk/~jbfan
00F29020  67 00 00 FF 00 31 4B 3D 3E 19 68 74 74 70 3A 2F  g....1K=>.http:/
00F29030  2F 69 2E 63 73 2E 68 6B 75 2E 68 6B 2F 7E 6A 62  /i.cs.hku.hk/~jb
00F29040  66 61 6E 67 3F 74 3D 33 37 37 35 30 00 46 6F 72  fang?t=37750.For
00F29050  65 6E 73 69 63 73 00 FF 00 19 4B 3D 43 62 68 74  ensics....K=Cbht
00F29060  74 70 3A 2F 2F 77 77 77 2E 61 73 6B 2E 63 6F 6D  tp://www.ask.com
00F29070  2F 00 00 FF 00 43 4B 3D 43 66 68 74 74 70 3A 2F  /....CK=Cfhttp:/
00F29080  2F 77 77 77 2E 61 73 6B 2E 63 6F 6D 3A 38 30 2F  /www.ask.com:80/
00F29090  3F 74 3D 30 34 32 37 39 00 41 73 6B 2E 63 6F 6D  ?t=04279.Ask.com
00F290A0  20 2D 20 57 68 61 74 27 73 20 59 6F 75 72 20 51   - What's Your Q
00F290B0  75 65 73 74 69 6F 6E 3F 00 FE 07 14 6B 79 3D 65  uestion?....ky=e
00F290C0  65 26 69 65 3D 42 69 67 35 26 71 3D 68 61 63 6B  e&ie=Big5&q=hack
00F290D0  69 6E 67 2B 68 69 6A 61 63 6B 26 62 74 6E 47 3D  ing+hijack&btnG=
00F290E0  25 65 36 25 39 30 25 39 63 25 65 35 25 62 30 25  %e6%90%9c%e5%b0%
00F290F0  38 62 2B 00 68 61 63 6B 69 6E 67 20 68 69 6A 61  8b+.hacking hija
00F29100  63 6B 20 2D 20 47 6F 6F 67 6C 65 20 E6 90 9C E5  ck - Google ....
00F29110  B0 8B 00 FE 06 BA 00 00 00 00 00 00 00 00 00 00  ................
```

Figure 13. S6 - Snapshot after step 6 (timestamp: 01 Jan 2010 00:35:50).



```
          0  1  2  3  4  5  6  7  8  9  A  B  C  D  E  F  0123456789ABCDEF
00F5B800  FF 00 20 4B 3D 3E 17 68 74 74 70 3A 2F 2F 69 2E  .. K=>.http://i.
00F5B810  63 73 2E 68 6B 75 2E 68 6B 2F 7E 6A 62 66 61 6E  cs.hku.hk/~jbfan
00F5B820  67 00 00 FF 00 31 4B 3D 3E 19 68 74 74 70 3A 2F  g....1K=>.http:/
00F5B830  2F 69 2E 63 73 2E 68 6B 75 2E 68 6B 2F 7E 6A 62  /i.cs.hku.hk/~jb
00F5B840  66 61 6E 67 3F 74 3D 33 37 37 35 30 00 46 6F 72  fang?t=37750.For
00F5B850  65 6E 73 69 63 73 00 FF 00 19 4B 3D 43 62 68 74  ensics....K=Cbht
00F5B860  74 70 3A 2F 2F 77 77 77 2E 61 73 6B 2E 63 6F 6D  tp://www.ask.com
00F5B870  2F 00 00 FF 00 43 4B 3D 43 66 68 74 74 70 3A 2F  /....CK=Cfhttp:/
00F5B880  2F 77 77 77 2E 61 73 6B 2E 63 6F 6D 3A 38 30 2F  /www.ask.com:80/
00F5B890  3F 74 3D 30 34 32 37 39 00 41 73 6B 2E 63 6F 6D  ?t=04279.Ask.com
00F5B8A0  20 2D 20 57 68 61 74 27 73 20 59 6F 75 72 20 51   - What's Your Q
00F5B8B0  75 65 73 74 69 6F 6E 3F 00 FF 00 60 4B 3D 44 62  uestion?...`K=Db
00F5B8C0  68 74 74 70 3A 2F 2F 77 77 77 2E 61 73 6B 2E 63  http://www.ask.c
00F5B8D0  6F 6D 3A 38 30 2F 77 65 62 3F 71 3D 68 61 63 6B  om:80/web?q=hack
00F5B8E0  69 6E 67 2B 68 69 6A 61 63 6B 26 71 73 72 63 3D  ing+hijack&qsrc=
00F5B8F0  30 26 6F 3D 30 26 6C 3D 64 69 72 00 41 73 6B 2E  0&o=0&l=dir.Ask.
00F5B900  63 6F 6D 20 2D 20 57 68 61 74 27 73 20 59 6F 75  com - What's You
00F5B910  72 20 51 75 65 73 74 69 6F 6E 3F 00 FE 06 B1 00  r Question?.....
```

Figure 14. S7 - Snapshot after step 7 (timestamp: 01 Jan 2010 00:40:02).