

A New Scheme for Minimizing Software Piracy using Combination of Smart Card and Physical Attribute with applied Crypto System

J. Swapna Priya, Sk. Abdul Kareem, M. Gargi

Abstract: *Software Companies make huge effort in developing a software product and licenses it, illegal use of these software products is commonly termed as Software Piracy. It is a difficult problem in Information Technology Industry since inception. Our software distribution channel must be flexible for both the new users and the existing users. The denial of service is the bad effect of the complex methods involved in the security structures. So, we have taken care of the above factor seriously and came up with a unique solution. Secondly, depending on the number of legalized installation, the system of security must be flexible, this we have addressed in the paper. A smart card and physical token address combination produces the unique identification carries to a back end process which builds an extremely flexible and robust solution in software piracy eradication. This paper presents a robust software protection scheme based on the use of smart cards, physical serializer and cryptographic techniques.*

Key words: *Software protection, smart cards, cryptography, information commerce.*

I. INTRODUCTION

Software protection is a complex problem; consequently there are several fields of research concerning different aspects of the problem. Some of the most important goals related to Software Protection are:

1. Intellectual property protection:

The objective is to link the software with information about its author. Among the techniques used for this purpose the most popular is watermarking [CoTh99].

2. Protection against function analysis in mobile environments:

The objective in this case is to prevent a malicious host from discovering the purpose of a software agent and modify its behavior. Techniques like code obfuscation or function hiding [LoMo99] are used, sometimes complemented by the use of hardware tokens [Fünf99].

3. Protection against illegal copy and use of software:

The objective is to guarantee that only authorized users can run the software. Our work is mainly aimed to solve this problem.

Every year software industry has to face cost of several

billion dollars due to software piracy. In 1999, the global piracy rate for PC business software applications was 36 percent with an estimate cost of \$12 billion. As soon as computers started to become popular unauthorized copying of software started to be considered an important problem [Kent80].

Development of computer communications brought the growth of BBS services distributing pirated software. Today, other circumstances like the advances in code analysis tools and the popularity of Internet creates new opportunities to steal software. Some of the money lost because of the software piracy is included in the cost of legal software and therefore pirate copies are partially paid by the legal users. Most of the software that is produced today has either weak protection mechanisms

(Serial numbers, user/password, etc.) or no protection mechanisms at all. This lack of protection is essentially derived from the user resistance to accept protection mechanisms that are inconvenient and inefficient. In Bruce Schneier words: "The problem with bad security is that it looks just like good security". Many commercial software protection tools claim to achieve total security with software techniques. Most of these tools are snake oil. Theoretic approaches to the formalization of the problem have demonstrated that a solution that is exclusively based in software is unfeasible [Gold97].

On the other side, legal protection tools like trade secrets, copyright, patents and trademarks, are not adapted for the protection of software. Some authors have proposed the creation of new specific legal protection means for software products [Samu95].

An important related aspect is license management that has to be capable of covering a wide range of situations and conditions while being easy and convenient for the final user.

Based on some advances of the general information security technology, we have developed a low cost software protection and license management scheme that is secure, flexible and convenient for the users. This scheme, avoids two of the most common attacks to software protection mechanisms: multiple installation from a single legal license and production of unprotected (pirated) copies of the software.

The rest of the paper is organized as follows. Section 2 reviews the most relevant related work. Section 3 introduces the new scheme. In section 4 we analyze implementation details. Other applications of this scheme are presented in section 5 and finally, section 6 summarizes the conclusions and resents ongoing research and future work.

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II. RELATED WORK

In this section we will briefly review some proposals for software protection and license management, considering aspects like Security, convenience and practical applicability.

One of the simplest and most popular protection mechanisms consists in a password or key check that enables installation of the software. If the check fails the software is not installed or it works in demo mode with restricted functionality. This mechanism is very popular in shareware. The password (or key) validation function is, evidently, included in the software.

Therefore, it is possible to find it using reverse engineering. As a consequence it is frequent that key generation programs are produced by dishonest users and also that authentic passwords are published in certain Internet sites.

Sometimes the software is personalized to be used in one computer, for example, extracting information from some of the hardware devices (hard disk, network adapter, etc.) or from the operating system configuration. During its execution, the protected software checks that the computer is the one it was personalized for. This check, as the previous ones, can be bypassed. Also, this mechanism is inconvenient for the users because changes in the hardware or in the operating system may result in the need to get a new license and reinstall the software.

Self modifying code and code obfuscation [CoTh00] are used in some software protection schemes. These techniques provide short term protection and can be used in situations where software life is short (for example for agents and applets). Some of these techniques have been developed for a very special kind of software: virus [FHS97].

Among the proposed solutions that rely on some hardware component, one of the most popular consists in the use of hardware tokens that are difficult to duplicate, which are connected through some communications port to the computer running the software. The protected software checks the presence of the token and refuses to run if the check fails. Examples of this kind of systems are hardware keys or dongles. These systems usually have the problem of the incompatibility between tokens of different applications. When the tokens are smart cards, as it is expected that the computer will include just one card reader, the user must continuously change the card, a problem known as card juggling that represents a serious inconvenience.

The check of the presence can be done in different ways; the simplest is to read a value from the communications port, but, commonly, to avoid that the interception of the communication in that port allows the attacker to replicate the token, the software will send a value (called challenge) that the token has to process, the software can predict the result that the token must send back. In any case, whatever the check is, it is not hard to bypass this protection, as the access to the communications port or the reader are easily found in the executable code. This process can even be automated by specially designed programs called "patches".

One of the first proposals to use smart cards for software protection is presented in [ScPi84]. Protective technologies commercialize a tool that is based in those ideas and that share certain similarities with the initial scheme presented in the introduction of the section 3.

More recently, Aura and Gollman presented in [AuGo99] an interesting scheme based on smart cards and digital certificates that solves the card juggling problem and provides mechanisms for license management and transfer. In addition, a compilation of countermeasures against attacks are reviewed. Unfortunately, as their proposal is focused on the check of the presence of the smart card, it is vulnerable to the code modification attacks described above.

From the study of the problem it is concluded that to obtain a provable secure protection scheme we must have a tamperproof processor that contains and executes the protected software [HePi87]. A variation of this scheme is the distribution of encrypted code that the tamperproof processor decrypts and executes [Be94].

III. DESCRIPTION OF THE NEW SOFTWARE PROTECTION SCHEME

As it is usual in other fields of information security, in software protection there are no completely secure solutions. The objective of a software protection scheme is to make the attack to the scheme difficult enough to discourage dishonest users.

The new scheme is based, as others, in a tamperproof processor. The popularization of smart cards and their evolution in storage and processing capacity have lead us to consider them the most appropriate choice for our scheme. However, our design does not depend on this technology and, consequently, our solution can be implemented using any similar hardware token (for example, some hardware keys and some tokens that Integrate smart card and reader functionalities).

A secure software protection scheme can be designed using just smart card technology. In this scheme some sections of the software to be protected can be substituted by functionally equivalent sections to be processed in the smart card. In this way, the protected software is divided and will not work unless it cooperates with the right card. Code modification attacks will not succeed in this case. In fact, the only possible attack is to analyze the data transmitted to and from the card trying to guess the functions that the card performs. If we include enough functions, with enough importance in the main code, and enough complexity, the attack described could become impractical.

This scheme needs one card per application and the quantity and complexity of the protected functions are limited by the capacity of the card. Moreover, this scheme does not allow the distribution of the protected software using Internet because the cards must be distributed with the software. With the purpose of avoiding the aforementioned problems we will introduce the cryptography as the second building block of our software protection scheme.

3.1 License management:



How our system controls the software piracy:

Software piracy can be digged into number of types which are listed below

- Illegal usage of the software.
 - Irregular licenses obtained.
- Multiplying/duplicating the software.
Complex distribution.

When the customer buys the product and smart card is issued, which carries a unique identification smid, threw smid we can be able to say the number of licenses it can produce. This logic is taken care and here smid is already notified in the back end processing by means of storage in the data base server

For ex:

Smid no' of licenses

000xxx1	3
000xxx2	5

This can be explained in below in steps

Step1:

- Reading the card
- sending the smid for the verification

When the customer starts installation process, our system checks for the internet connection and firstly our system ask for the smart card to be dipped into the provided physical smart reader, Here we have

Reader reads the identification number and process to the server and there the back end process checks for the designed number of installations allowed. Here is the tricky logic, it allows or denies the installations will be dependent on the smid allowed which we discussed in para1).

Step 2:

Our process goes with the installation when the acknowledgement is positive, and reads the physical motherboard serial number and sends back to the back end server.

Step 3:

In the back end server and cryptosystem is designed in order to crypt this both motherboard serial number and smid-smart card and stored in the data base server for further usage. Depending upon number of times in is registered the number of installation it has allowed and we can process for more mining using the number of installation allowed as per the knowledge of smid and number of installation allowed.

Step4:

The returned acknowledge is stored into the smart card for the further transactions

3.2 Fundamentals of the new scheme

Figure 2 shows the first scheme that we elaborated. We will use it to illustrate the final scheme. The figure shows that several sections of the original code are substituted by their equivalent for the card during the production phase. These new sections are encrypted with the public key of the card using an asymmetric cryptosystem [RSA78] during the personalization phase and are kept encrypted so only the card that has the matching private key will be able to decrypt and execute those protected sections. The cards now have to store a key pair, but the protected software sections do not reside on the cards. The key pair must be generated in the card and the private key must never be Transmitted outside the card. The original code sections are substituted by calls to a function that transmits their equivalent protected sections (e.g. "B"), including code and data, to the card, where they are decrypted and executed. When finished, the card sends back the results.

Assuming that the encryption algorithm is secure, the attack to the system must be based in the analysis of the input and output data (and possibly the running time) of the card functions. However, we must emphasize that now the card only stores one function at a time and therefore we can use more complex functions because all the capacity of the card is now available for each single function. Moreover, this scheme allows the card to execute any number of protected functions. The dishonest user will need to discover all of the protected functions to be able to break this protection scheme.

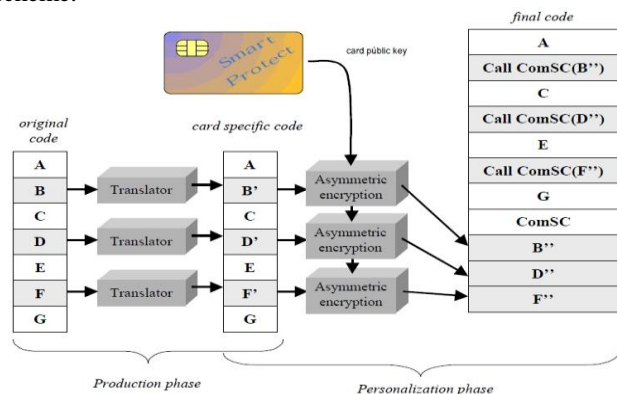


Fig. 2. Code transform in our first software protection scheme.

An alternative attack could consist in the substitution of some of the authentic protected sections by other fake sections produced by the dishonest user (for example such a false section could try to send back the contents of the card). This attack can be considered a kind of "Trojan horse". To avoid these attacks we must authenticate the code before its execution [DDB89].

To summarize, this first scheme allows a single card to be used to protect many applications, increases the complexity of the protected functions, allows the card to execute any number of those functions and enables the distribution of the software through Internet.

But, in spite of the advantages mentioned, some aspects like efficiency and robustness of the scheme need to be improved.

The use of an asymmetric cryptosystem introduces a high computational cost. Also the lack of a code

Authentication mechanism opens a dangerous attack line. On the other hand, this first scheme does not take into account some desirable features like license transfer or expressive authorization. Also, the need to include a personalization phase is not adequate for some distribution models. We want the software to be freely distributed, although to run it the user will need to get a license.

The final scheme is shown in figure

3. In this case the production phase includes the encryption of the protected sections (which include code and data) with a symmetric cryptosystem.

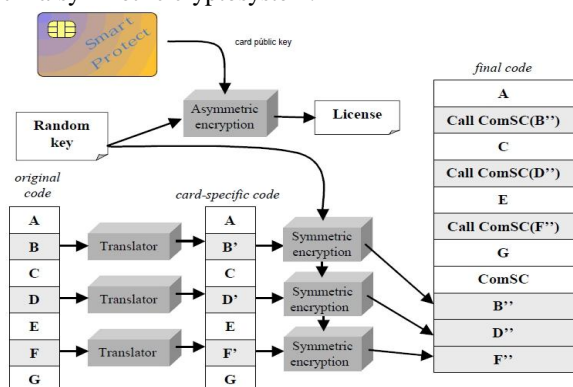


Fig. 3. Code transforms and license production.

In the authorization phase (equivalent to the personalization phase of the previous scheme), a new license is produced containing the random symmetric key used to encrypt the protected sections, information about conditions of use (i.e. time limits, number of executions, etc.), the identification of the software (ID, version number, etc.) and finally the identification of the license. All this information is encrypted with the card public key. When the license is received by the client it is stored in the card.

The functionality of the previous scheme is maintained in this new one, but the efficiency is improved because decryption of the protected sections is now much faster. The definition of the license structure permits a high degree of flexibility. Furthermore, as each application has its own key, we can manage them individually.

We previously mentioned the necessity to authenticate the code to be executed by the card to avoid certain attacks. In this scheme, because the protected sections are encrypted using a symmetric key that is kept inside the card, it is impossible for a dishonest user to produce false sections. However, if the license was to be transmitted using an insecure channel, a man-in-the middle attack could be carried out, but as we will show in the next section, the software producer will require a certificate of the card public key that the dishonest user will not be able to forge.

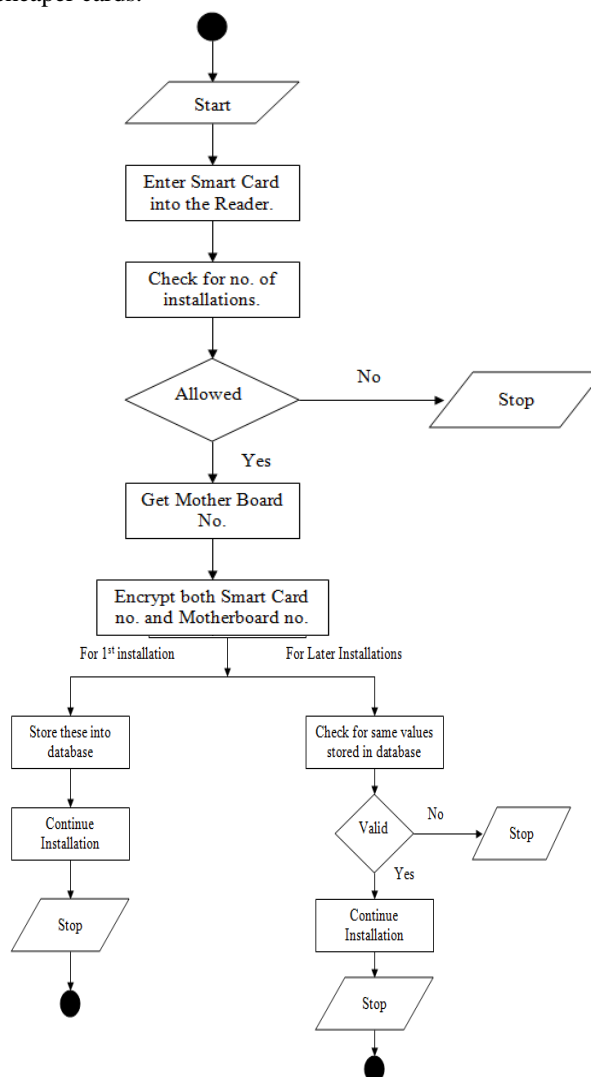
IV. IMPLEMENTATION DETAILS

Today, smart card technology offers features that not so many years ago corresponded to personal computers [CDHP00]. However, compared to the processing power of the host computers, each access to the smart card introduces important delays. As our scheme requires the transmission of a considerable amount of code and data to

and from the card, it is important to take into consideration the efficiency of the protection scheme.

Consequently, it is necessary to find a balance between security and speed. Fortunately, in this case, this balance is possible and it is not difficult to obtain security and speed measures that satisfy both the software producer and the client. A detailed description and study of the efficiency of the protection scheme is included in [LMP00].

The scheme has been designed and the tests carried out using smart cards with symmetric and asymmetric cryptographic capabilities. An implementation that uses smart cards that have only symmetric cryptographic capabilities is possible, but the changes that need to be introduced in the scheme, together with the low prices of the cards with both types of cryptosystems, do not justify the use of cheaper cards.



These are the steps to be followed for the implementation of this paper.

4.1 Functions executed by the smart cards:

This is an essential characteristic because the security of the system is based on the difficulty to guess the functions that the card executes from the analysis of the input and output data and the execution time [Hohl98].



If we know that the function performed by the card represents a straight line then we just need to run the function two times with different input data to discover it. In contrast, functions like one-way hashes [Pren00] or digital signatures [RSA78] are not vulnerable to these attacks. In most software applications this type of functions is not used frequently, but the functions that appear in most software applications have an advantage: they have more input and output data.

To make it difficult for the pirate to analyze the functions we include false (dummy) input and output data that are not used for the computation of the function, although it is transformed to confuse the attacker. Another technique that is very effective to obstruct the analysis is to mix the processing of several functions with the intention that the result of each call to the card depends on the input data of the previous calls and even on results of previous calls that have not been send back as results but stored in the card memory.

4.2 Card readers

One of the most common kinds of software piracy takes place inside the organization of a legal client of the software by the use of multiple copies of a legally acquired software application. In our scheme this attack could be carried out making several computers share a card reader.

This problem has been considered in previous schemes, but the most common Solution is to make the software have direct access to the card reader. This solution introduces countless problems and computational costs in the protected software because it must manage different situations and hardware features that are usually managed by the operating system.

In our scheme, to prevent this attack we have designed a solution based on the last technique described in section 4.1. The system "chains" the calls to the card so any incorrect sequence of calls (produced if several computers share a card reader) will result in the software producing erroneous results.

V. OTHER APPLICATIONS

The scheme introduced can be useful in other environments; in fact it was devised from a previous work on information commerce over Internet [Mana00]. As an example of the different possibilities of this scheme we will explain briefly how it can be used for information commerce in applications like online newspapers [Const97] or digital libraries [KLK97].

For this application each user must possess a special smart card (with a key pair and our base software), a card reader and a web browser that can access the card (i.e. with a special plug-in).

To gain access to some information the client sends a request to the information provider, including the public key certificate of the client's card. This step might implicate some negotiation of the conditions of the trade. The information provider, using the applet generator described in [Mana00] generates a specific applet to fulfill the request and a license for the client's card. This applet includes protected sections that have to be executed by the card using the license. Because the card software is trustworthy we are able to control aspects like number of executions and, what is more, we can include an electronic purse to pay for

the information accessed.

VI. CONCLUSIONS AND FURTHER WORK

We have described a robust software protection scheme based in the use of smart cards and cryptographic techniques. We have shown the different protocols for the management of licenses and analyzed the security of the scheme and the importance of the implementation details. Finally, we have also introduced possible alternative applications of the scheme. Hence, we can conclude that the advantages of the presented scheme are robustness against different attacks (bypassing the check, code substitution and attacks to the license management protocols), confidence for the user, efficient use of the computational resources of the smart cards, free distribution and copy of the software, selective license transfer, control of the expiration of the licenses and applicability in distributed computing environments.

Tools to produce protected software automatically from unprotected executable programs, applet protection and payment integration are under development. We are studying the possibilities that the combination of function hiding techniques with our scheme could open.

Finally we are studying the security achieved by the different families of functions that can be executed in the cards to obtain a measure of the protection achieved in some particular software application.

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