A Design of Trusted Computing Supporting Software based on Security Function

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Abstracts. Most of existing TCSS have defined the functional interface of software in accordance with TCG specification. However, there is no clear definition of the security functional requirements and security targets that TCSS needs to meet in TCG specification. An implementation scheme for TCSS was proposed, and a TCSS prototype on the basis of Common Criteria (CC), combining with TCSS security function division and practical application demands was implemented. The experimental results show that the proposed software prototype can support the interface call of the TPM 2.0 and the SM4 cipher algorithm of China.

1 Introduction

At present, network security threats and risks are becoming increasingly prominent all over the world. Academician Shen Changxiang proposed to realize network security by Trusted Computing (TC) which guarantees security protection during calculating operation so that the results can be consistent with the expected and the calculation can be controlled during the whole process without interference [1]. The research and development of Trusted Computing are in the ascendant. It is clearly pointed out in the 13th Five-year National Strategic Emerging Industrial Development Plan that we should actively promote the R&D and industrialization of Trusted Computing, data and network security, and other information technology products.

The basic idea of Trusted Computing is embodied in the design of the Trusted computing platform (TCP) as follows: First of all, create a roots of trust on the platform, i.e. TPM (Trusted Platform Module). And then create a chain of trust. Carry out measurement and authentication from the root of trust, and expanding level by level to hardware platform, trusted computing support software, operating system and application software to extend trust to the entire TCP and ensure the credibility of the entire platform [2].

TCSS (Trusted computing supporting software) is an essential part of TCP. It works as a communication bridge between application software and TPM. The application can use the security features provided by TPM through the interface call of TCSS [3].

Most TCSS at home and abroad are based on the trusted software stack specification of TCG (Trusted Computing Group). Representative products include the OSS released by IBM TrouSerS[4], Trusted Computing API for Java[5] developed by IAIK of Graz University of Technology, Austria and Client Security Solution8.3[6] of Lenovo.

Most of existing TCSS have defined the functional interface of software in accordance with TCG specification. However, there is no clear definition of the security functional requirements and security targets that TCSS needs to meet in TCG specification. This paper proposed an implementation scheme for TCSS, and a TCSS prototype on the basis of Common Criteria (CC), combining with TCSS security function division and practical application demands.

2 Background Knowledge

2.1 TCSS

TCSS defined in TCG specification is also known as TCG Software Stack (TSS) which is a software system provided by upper level applications to access to TPM interface. It is an indispensable part of TCP system [7].

TSS is a multi-level architecture which provides service and support to both local and remote trusted computing platforms. Fig. 1 presented TSS architecture which is specifically divided into TCG Service Provider (TSP), TCG Core Service (TCS) and TCG Device Driver Library (TDDL). Each layer has defined a normalized function interface. TSP is primarily used as a trusted proxy for local and remote applications, TCS is used to provide a collection of public services, while TDDL is responsible for interacting with TPM.
3 Security function analysis of TCSS

The definition of security functional requirements is used to describe the security features that a product should provide. CC formulated standard class description mode for security functional requirements to ensure the standardization of product development.

All TOE security functional requirements are based on considerations of TOE applications and environment. TCSS design requirements and standard export processes can be divided into multiple tiers. Firstly, determine the security environment of TCSS; secondly determine the security targets of TCSS; thirdly export TCSS security requirements, including functional requirements, assurance requirements and environmental requirements; and finally export security specifications. Complete the design and test of TCSS referring to security function specifications.

CC defined security functional requirements, according to the functional classes, families and component levels. A functional class contains one or more functional families. A functional family contains one or more components. And each component provides a set of security functional elements. TCSS standardized and defined by TCG is set as the research object. Security functions extracted from TCG Service Provider (TSP), TCG Core Service (TCS) and TCG Device Driver Library (TDDL) are function class; each security function is divided into different sub-functional modules corresponding to functional families; each module has different interface functions, namely corresponding components. And interdependent relationships exist between interface functions. Fig. 2 presented the hierarchy of security features of TCSS.

Referring to TCG trusted software stack specification as presented in 1.1, TCSS can be divided into TSP, TCS and TDDL. The modules of TSP layer include: HASH function, TPM management, context management, policy management, PCR management, secret key management, and data encryption management; modules of TCS layer include: encryption computation, key certificate management, context management, event management, and parameter block generation; modules
of TDDL layer include TDD interactive function, TPM information state setting and TDD command transferring function.

In order to meet the security requirements of the trusted computing platform and achieve the design functional objectives of TCSS, TCSS analysis and design are implemented according to different specifications. The paper extracted Trusted Computing standards and defined security functions of TCSS as shown in Fig. 3. Functional interfaces defined in diversified standards are different and the implementation mechanisms of TCSS will be different. But as long as TCSS can provide corresponding security features, design objectives can be achieved as well.

The relationship between security functions and related sub-functions of TSP layer of TCSS is analyzed as follows. TSP is divided into three security functions, i.e. integrity protection, trusted authentication, and cryptographic support. Security function of TSP can be decomposed to correlated subfunctions as well. Integrity protection includes HASH function and TPM management; trusted authentication includes context management, policy management, and PCR management; cryptographic support includes cryptographic key management and data encryption.

Cryptographic support class (FCS class) in CC is composed of two functional families [12]: cryptographic key management (FCS_CKM) and cryptographic operation (FCS_COP). Referring to division of functional class, families, and components in CC, cryptographic support security function of TSP are analyzed. Subfunctions of cryptographic key management correspond to FCS_CKM functional families to solve cryptographic key management issues; data decryption function corresponds to FCS_COP functional families. It is related to service conditions of cryptographic key in operation. FCS_CKM functional families include four components: cryptographic key generation (FCS_CKM.1), cryptographic key distribution (FCS_CKM.2), cryptographic key using (FCS_CKM.3) and cryptographic key destroy (FCS_CKM.4); FCS_COP functional family’s component is cryptographic operation (FCS_COP.1). The dependency relationship among components of cryptographic support functions is as shown in Fig. 4. It can be seen that in the process of completing cryptographic support security functions, cryptographic key generation component is executed first and cryptographic key destruction component is finally executed.

![Figure 4. Dependency diagram of cryptographic support function](image)

Cryptographic key generation, cryptographic key distribution, cryptographic key using, cryptographic key destroy, cryptographic operation and other components are designed with specific functional functions respectively. Table 1 presented division of TSP cryptographic support class.

![Figure 3. Division diagram of TCSS security function](image)
Table 1. Division of cryptographic support class of TSP layer

| Function class | Function family | Component | TSP layer corresponding to functions of the component | Function description |
|---------------|-----------------|-----------|------------------------------------------------------|---------------------|
| Cryptography support (FCS class) | Cryptogrammic key generation (FCS_CKM) | Tspi_TPM2_CreatePrimary | Tspi_TPM2_CreatePrimaryKey | Generate a primary cryptogrammic key |
| | | Tspi_TPM2_CreateKey | Tspi_TPM2_CreateKey | Generate an asymmetric cryptogrammic-key |
| | | Tspi_TPM2_CreateMigrationBlob | Tspi_TPM2_CreateMigrationBlob | Generate data packet for the migration of cryptogrammic-key |
| | Cryptogrammic key distribution (FCS_CKM) | Tspi_TPM2_ConvertMigrationBlob | Tspi_TPM2_ConvertMigrationBlob | Transfer Data packet for the migration of cryptogrammic-key |
| | Cryptogrammic key Using (FCS_CKM) | Tspi_TPM2_LoadKey | Tspi_TPM2_LoadKey | Load the generated cryptogrammic-key to TPM |
| | | Tspi_TPM2_CertifyKey | Tspi_TPM2_CertifyKey | Use a cryptogrammic key for authentication of the public key of the other cryptogrammic key |
| | | Tspi_TPM2_WrapKey | Tspi_TPM2_WrapKey | Encapsulate a specific cryptogrammic key |
| | | Tspi_TPM2_GetPubKey | Tspi_TPM2_GetPubKey | Obtain the public key of asymmetric cryptographic-key loaded into TPM |
| | Cryptogrammic key destroy (FCS_CKM) | Tspi_TPM2_UnloadKey | Tspi_TPM2_UnloadKey | Uninstall the specified cryptogrammic key in TPM |
| Data encrypt and decrypt (FCS_COP) | Cryptogrammic operation (FCS_COP) | Tspi_TPM2_Bind | Tspi_TPM2_Bind | Bind a data packet |
| | | Tspi_TPM2_Unbind | Tspi_TPM2_Unbind | Unbind the data packet |
| | | Tspi_TPM2_Seal | Tspi_TPM2_Seal | Encrypt a paragraph of plaintext with the public key of a cryptogrammic key |
| | | Tspi_TPM2_Unseal | Tspi_TPM2_Unseal | Decrypt the plaintext by using private key of the cryptogrammic key |

4 Experiment

The development platform of the TCSS is an Intel minicomputer supporting TPM2.0. The operating system is Ubuntu10.04. And the compiler version is GCC3.3. 31 functional functions are designed and realized according to integrity protection, trusted authentication, cryptographic support and other security features. Functional function design of TCSS is a subset of software stack defined in TCG specification. The core security features are realized, and the call support for the Chinese standard encryption algorithm SM4 is added.

All functional requirements of the specification are expected to meet through performing functional test of all functional interfaces realized by TCSS. The workflow of TCSS prototype is introduced as follows by setting the test of SM4 algorithm invocation as an example. First of all, create a PrimaryKey. And then generate SM4 cryptogrammic key pair after authorization. Sign with a private key and verify the signature with a public key. Fig.5 presented the whole test process. Where, Tspi_TPM2_CreatePrimaryKey is to generate a primary cryptogrammic key. Tspi_TPM2_CreateKey function can generate an asymmetric cryptogrammic key. Its function test interface is as shown in Fig. 6 and Fig. 7.

![Figure 5. Process of SM4 key signing](image)
Parameter description for related bytes of Tspi_TPM2_CreatePrimaryKey test interface is as follows:

- **Representative parameter** TPM_CC_Create=0x0000 0153 of the 7-10 bytes indicates the operation of cryptogrammic key generation;
- The **11-14 bytes** represent the TPM_CC_CreatePrimary handle of @parentHandle=0x80 00 00 00. It is a handle generated by Tspi_TPM2_CreatePrimary function;
- The **value of TPM_AUTH_HANDLE** is TPM_RS_PW= 0x40000009, which indicates that the password selected is cryptography verification;
- **Authorization code used is 00 ff; the 2-3 bytes count backwards** of line 2 represent that the value of TPM_ALG_SM4 is 0x0013, which means that SM4 cryptography algorithm is selected.
- The test results show that the handle of the primary cryptogrammic key has been received successfully, the cryptogrammic key is generated successfully and SM4 cryptography algorithm is supported.

5 Conclusions

This paper proposed a TCSS design method by referring to the ideal of CC, extracted security feature set based on analysis of security functional requirements of TCSS, determined corresponding subfunctions and core functions as well, and produced a TCSS prototype combining with practical application requirements. Finally, the completed TCSS related functional functions are tested. The experiment indicates that TCSS prototype produced in the paper can provide cryptographic support services, trusted authentication, integrity protection and meet other security targets, as well as support call of national cryptographic algorithm SM4. TCSS design specified by TPM2.0 will be further improved and supported in the future to support remote applications.

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