Extending Trusted Computing as a Security Service

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Abstract

We extend the Trusted Computing (TC) security infrastructure in a Generic Authentication Architecture (GAA)-like framework to enable the provision of security services, such as key establishment, to network applications.

Background

Generic Authentication Architecture:

- Standardised by 3GPP and 3GPP 2.
- A general framework that extends the cellular authentication infrastructure (includes UMTS and GSM) to enable the provision of security services to network applications.
- Consists of two procedures, GAA bootstrapping and use of bootstrapped keys.

Trusted Computing (TC) Security Infrastructure:

A Trusted Platform (TP) compliant with the Trusted Computing Group (TCG) specifications is a computing platform with a tamper-proof and built-in Trusted Platform Module (TPM).

Properties of TPM:

- Protected capabilities, such as random number generation, asymmetric key generation, digital signing, encryption capabilities, etc.
- A unique Endorsement Key (EK) pair and a set of derived keys, such as an Attestation Identity Key (AIK).
- Other properties:

TPM, associated keys, protected capabilities, and the underlying Public Key Infrastructure (PKI) comprise a security infrastructure.

Figure 1: a trusted platform module.

Image source: http://img.tomshardware.com/us/2008/02/11/how_hardware_based_security_protects_pcs/tpmchip.jpg

Core work

We make the TC security infrastructure play the role of the cellular authentication infrastructure in the GAA framework, and hence extend the TC security infrastructure to provide a security service, which we call TC GAA.

- Specify the architecture and components of TC GAA.
- Specify the interfaces and protocols between components.
  - Specify bootstrapping procedure of TC GAA, including an authenticated key agreement protocol.
  - Specify the derivation of an application-specific session key.
  - Specify use of bootstrapped key of TC GAA.

Architecture Elements

Bootstrapping Server Function (BSF):

- A new component, that acts as Trusted Third Party.
- Has a certified public key pair for entity authentication.

Network Application Function (NAF):

- The server functionality of each GAA-aware network application.
- Assumed to have some means to set up a secure channel with BSF (e.g. as provided by SSL/TLS tunnel).

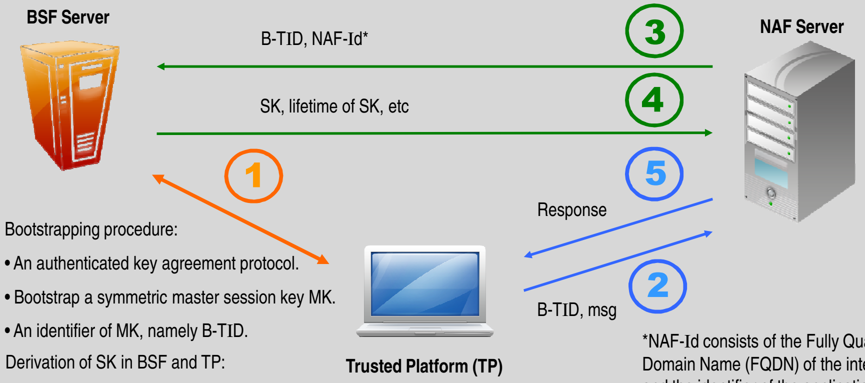
TCG compliant Trusted platform (TP):

- The Endorsement Key for encryption.
- Has a certified public key pair for entity authentication (e.g. AIK).
- Protected capabilities as described in the protocol.

Notation

- $Cert_X$: A public key certification of entity X.
- MK : A symmetric master session key.
- SK : An application-specific symmetric session key.
- R_X : A random number issued by entity X.
- $E_K(Z)$: Encryption of data Z using the key K.
- H(Z) : A one-way hash function on data Z.
- $S_X(Z)$: The digital signature of data Z computed using entity X's private signature transformation.
- X(public) : The public asymmetric key of X.
- X(private) : The private asymmetric of X.
- Id_X : The identity of X.
- X||Y : The concatenation of data items X and Y in that order.
- X → Y : Z :Indicate that the message Z is sent by X to Y.

Architectural Overview of TP-GAA



Bootstrapping procedure:

- An authenticated key agreement protocol.
- Bootstrap a symmetric master session key MK.
- An identifier of MK, namely B-TID.

Derivation of SK in BSF and TP:

SK = KDF(MK, NAF-Id, … …).

*NAF-Id consists of the Fully Qualified Domain Name (FQDN) of the intended NAF and the identifier of the application protocol.

Bootstrapping procedure

Bootstrapping procedure of TC GAA is used to bootstrap a new symmetric master session key between BSF and TP. It is an authenticated key agreement protocol specified as below:

1. TP → BSF: Request for bootstrapping master session key.
2. BSF → TP: R_{BSF}.
3. TP: Generates a new temporary asymmetric encryption key pair (T(public) and T(private)) and certify the public key T(public) with an identity of T(public) chosen by TP user, namely, Id_{TP} .
4. TP → BSF: $R_{BSF}||Id_{BSF}||T(public)||Id_{TP}||S_{TP}(R_{BSF}||Id_{BSF}||T(public)||Id_{TP})$.
5. BSF: Retrieves $Cert_{TP}$ and verifies it.
6. BSF: Verifies $S_{TP}(R_{BSF}||Id_{BSF}||T(public)||Id_{TP})$.
7. BSF: Verifies R_{BSF} to ensure the message is fresh and verifies that the message was intended for BSF.
8. Assuming the signature from TP verifies correctly, the values of R_{BSF} and Id_{BSF} are expected, then BSF extracts T(public).

10\. BSF: Generates a symmetric key MK as master session key, and set lifetime of MK according to local policy.
Generates an identifier B-TID of MK which consists of R_{BSF} and the domain name of BSF.

10\. BSF → TP : $E_T(public)(MK)||S_{BSF}(E_T(public)(MK))$

11\. TP: Retrieves $Cert_{BSF}$ and verifies it.

12\. TP: Verifies $S_{BSF}(E_T(public)(MK))$.

13\. TP: Decrypts $E_T(public)(MK)$ to get MK.

Steps 2 and 4 of the above protocol conform to the two pass unilateral authentication protocol described in clause 5.1.2 of ISO/IEC 9798-3:1998 where T(pub) serves as the nonce which is generated in every run.

The key agreement part of the protocol is a key transfer protocol.

After the procedure, BSF and TP share R_{BSF}, Id_{TP}, B-TID, MK.

Use of bootstrapped key

1. TP: Derives an application-specific symmetric key SK as follow:
   SK = KDF(MK, R_{BSF}, Id_{TP}, NAF-Id)
   where KDF is a key derivation function. Id_{TP} is the identity of T(pub), and NAF-Id consists of the Fully Qualified Domain Name (FQDN) of the intended NAF and the identifier of the application protocol.
2. TP → NAF: B-TID and msg. msg is the application request data secured using SK.
3. NAF → BSF: B-TID and NAF-ID.
   Note that it is assumed that a secure channel has been set up by some means between NAF and BSF.
4. BSF: Derives SK = KDF(MK, R_{BSF}, Id_{TP}, NAF-Id), and sets lifetime of SK according local policy.
5. BSF → NAF: SK, lifetime of SK, etc.
6. NAF: Responses to the request using SK, if SK is valid.

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