SSMS - A Secure SMS Messaging Protocol for the M-Payment Systems

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Security Flaws of the GSM

- Unilateral authentication, and vulnerability to the man-in-the-middle attack
- Flaws in implementation of A3/A8 algorithms
- SIM card cloning
- Over-the-air cracking Ki
- Flaws in cryptographic algorithms
- Short range of protection
- Lack of user visibility
- Leaking the user anonymity
- Vulnerability to the DoS attack
- Absence of integrity protection
- Vulnerability to replay attacks
- Increased redundancy due to the coding preference

Security Flaws of the SMS

- All the GSM security vulnerabilities are inherited to SMS.
- SMS also suffers from some additional vulnerabilities due to:
  - Its store-and-forward feature,
  - The problem of fake SMS that can be conducted via the Internet,
  - Vulnerability to disclosure of previous exchanged messages by an unauthorized access to the phone.

End-to-end Security in the GSM

End-to-end security in the cellular systems can be provided using the processing capabilities of one or some of the following items:

- The *Mobile Equipment* (ME) using programming languages
- SIM card using SAT
- An additional smart card, e.g. JavaCard
- A crypto-processor that is embedded in the ME
- A portable PC (laptop) connected to the ME.

Our approach (SSMS) is based on the first solution and suggests J2ME (Java 2 Mobile Edition) as the programming platform.

The Proposed Protocol (SSMS)

SSMS consists of three phases:

- Initialization
- Message exchange
- Judge verification

SSMS: Initialization Phase

The initialization phase includes:

- Selecting the domain parameters,
- Registering the user details into the system, generating the public/private keys, and issuing a certificate for the public key of each user.
- Installing the application software on the user's mobile phone.

SSMS: Initialization Phase (Cont.)

Selecting the domain parameters

Domain parameters of the SSMS:

Weierstrass equation of the selected EC: $y^2 = x^3 + ax + b$

Defined over finite field F_q where q is a large prime number

$$a, b \in F_q$$

To assure the non-singularity: $4a^3 + 27b^2 \neq 0 (\mathrm{mod}\, q)$

$G \in E(F_q)$ is base-point of EC and is of order n

To thwart small subgroup attacks: $\begin{cases} nG = O \\ n > 4\sqrt{q} \end{cases}$

To thwart other known attacks on EC: $\begin{cases} n \neq q \\ n \nmid q^i - 1 \quad , \quad 1 \leq i \leq 20 \end{cases}$

To guarantee the intractability of ECDLP: $n > 2^{160}$
(for ordinary applications)

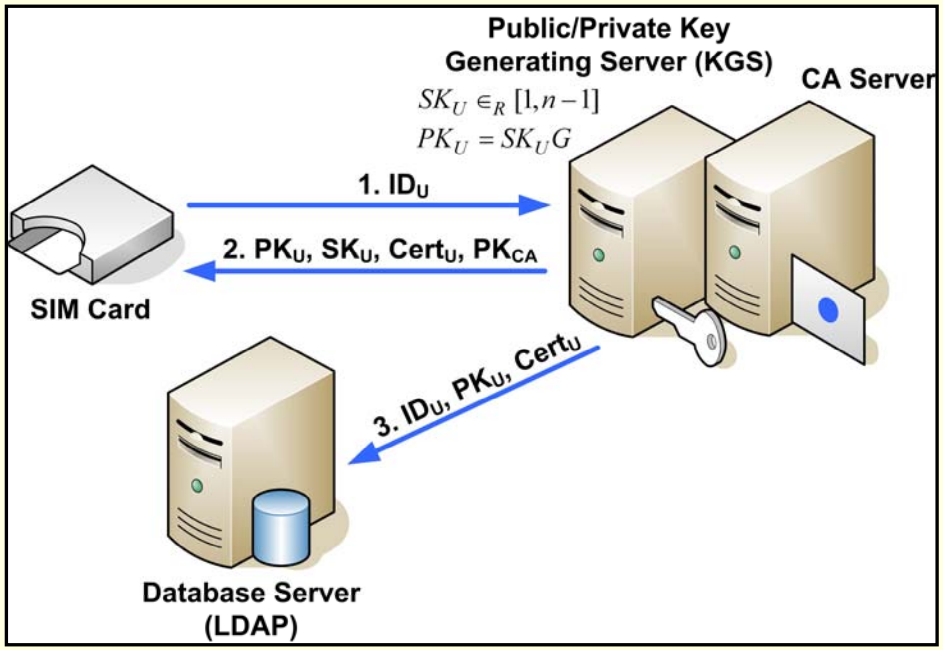
SSMS: Initialization Phase (Cont.)

Public/private key generation

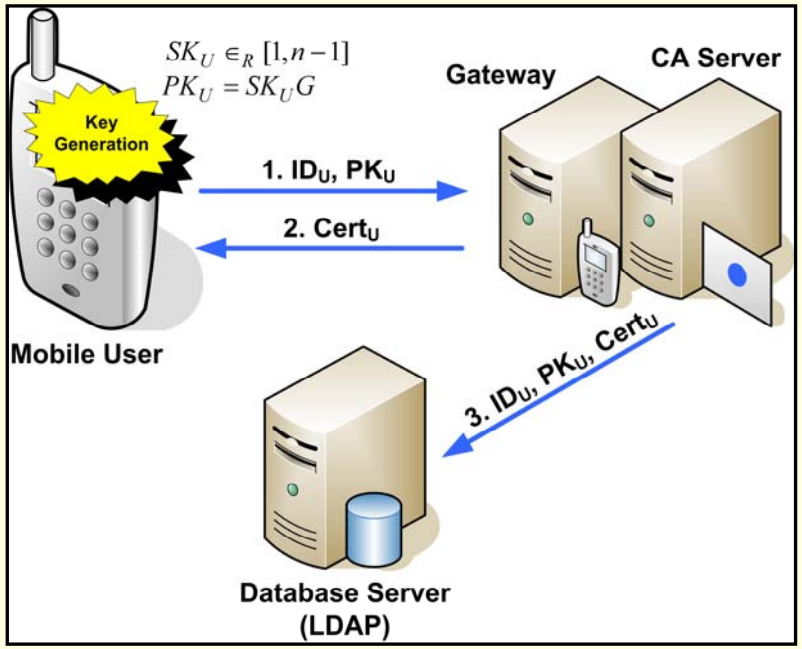
Public/private key generation in SSMS:

The private key of user U: $SK_U \in_R [1, n-1]$

The public key of user U: $PK_U = SK_U G$



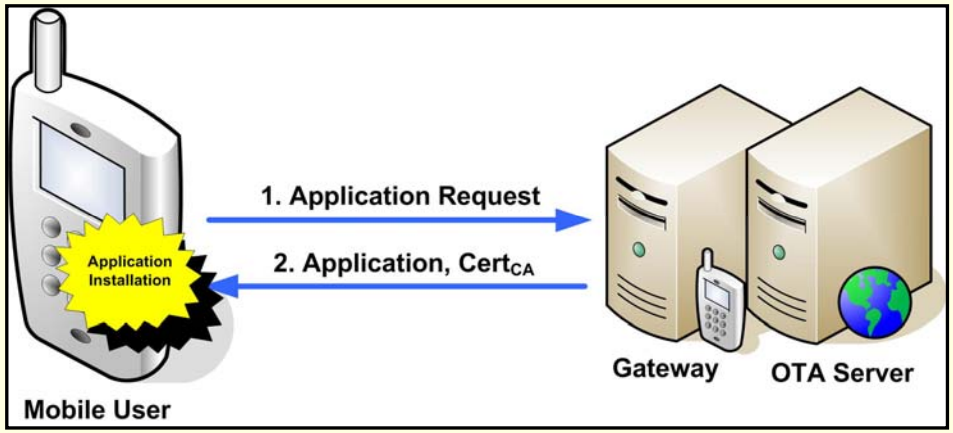
Key Generation in a *Key Generating Server* (KGS)
(First Approach)



Key Generation in the ME
(Second Approach)

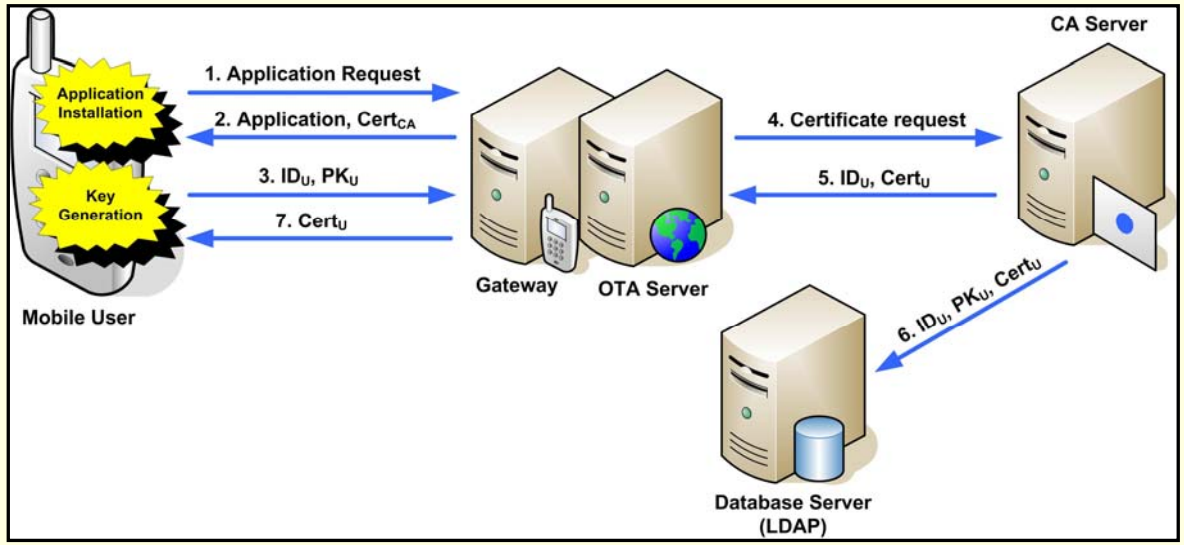
SSMS: Initialization Phase (Cont.)

Application Installation

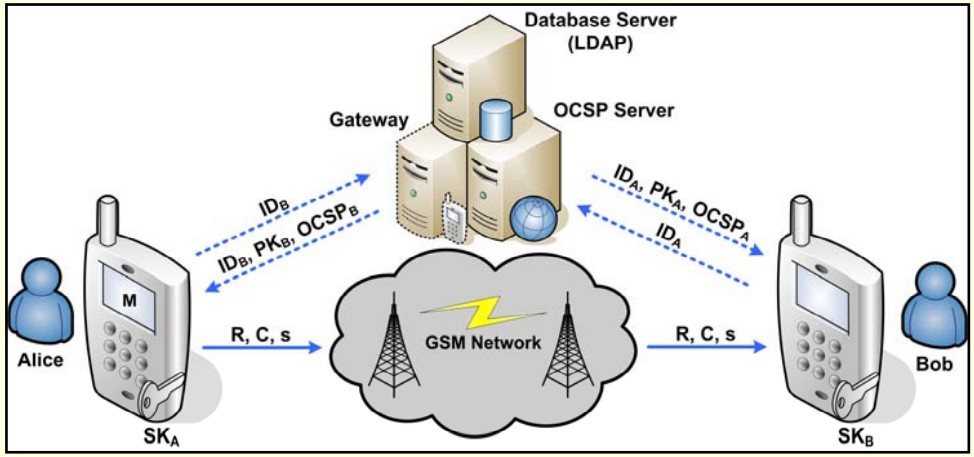


Application Installation on the ME via an OTA server

When application installation is accomplished via an OTA server, and the key generation is taken place in the ME



SSMS: Message Exchange



Basic configuration for the SSMS

Alice
SSMS Composing

Choosing $r \in_R [1, n-1]$

$R = rG = (x_R, y_R)$

$K = (r + \tilde{x}_R SK_A) PK_B = (x_K, y_K)$

$k = H'(x_K \| ID_A \| y_K \| ID_B)$

$C = E_k(M)$

$t = H(M \| x_R \| ID_A \| y_R \| ID_B \| k)$

$s = tSK_A - r \pmod n$

$t' \stackrel{?}{=} MAC_k(M')$

(R, C, s) →

← (M', t')

Bob
SSMS Delivering

Validity verification of $R = (x_R, y_R)$

$K = SK_B(R + \tilde{x}_R PK_A) = (x_K, y_K)$

$k = H'(x_K \| ID_A \| y_K \| ID_B)$

$M = D_k(C)$

$t = H(M \| x_R \| ID_A \| y_R \| ID_B \| k)$

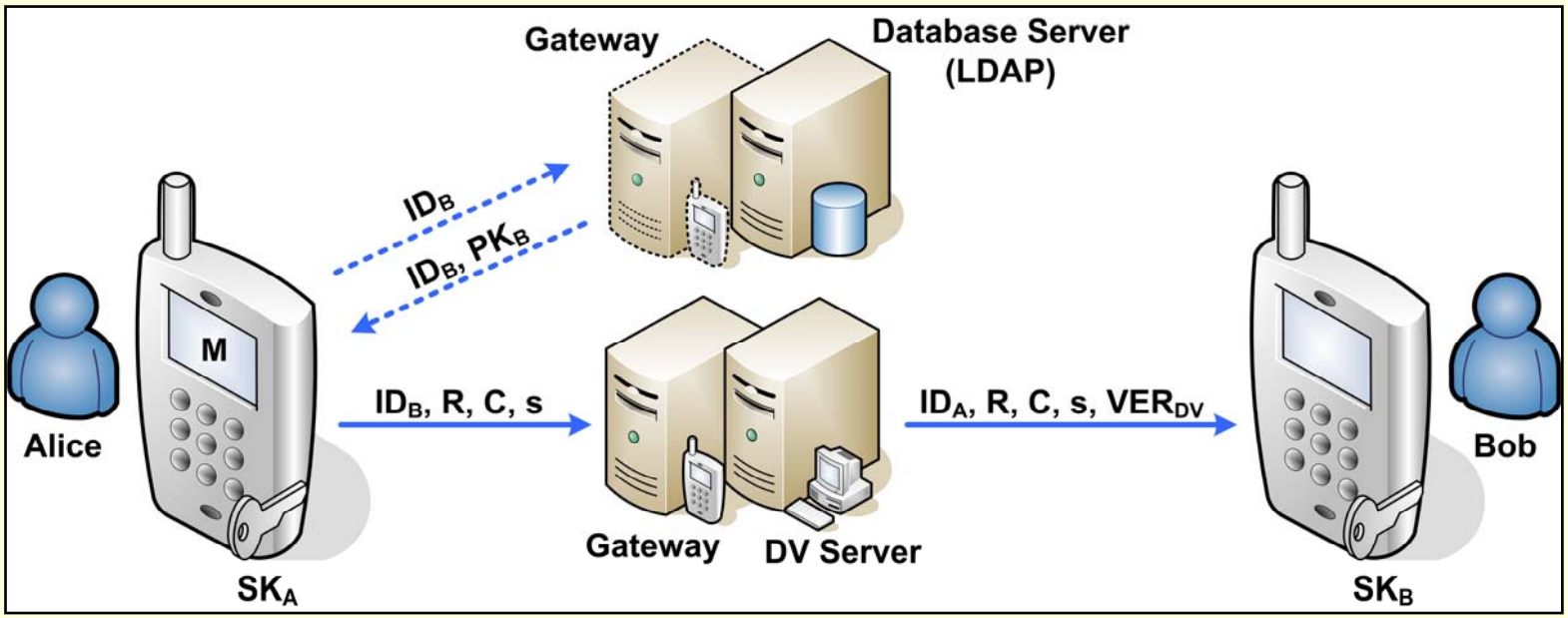
Signature verification: $sG + R \stackrel{?}{=} tPK_A$

$t' = MAC_k(M')$

Generating and extracting SSMS

SSMS: Message Exchange (Cont.)

Optimized configuration for the SSMS:



SSMS: Judge Verification (in disputes)

Bob claims that he has received an SSMS from *Alice* containing (*R*, *C*, *s*).

The trusted third party (judge) wants him to provide (*R*, *C*, *M*, *k*, *s*).

Bob simply extracts *M* and *k* from the previously saved (*R*, *C*, *s*).

The judge follows the following steps to decide on what *Bob* claims:

- Checks the validity of $Cert_A$ and uses it for verifying PK_A
- Verifies whether $M = D_k(C)$
- Computes $t = H(M \| x_R \| ID_A \| y_R \| ID_B \| k)$
- Verifies the *Alice*'s signature by checking the $sG + R = tPK_A$ condition.

On the Security of SSMS

SSMS provides the following security attributes:

- Confidentiality
- Authentication
- Integrity
- Unforgeability
- Non-repudiation
- Forward secrecy of message confidentiality

It also provides the Public verifiability as a facility.

Conclusions

- SSMS is a new application layer protocol that provides the confidentiality, integrity, authentication, non-repudiation, public verification, and forward secrecy of message confidentiality.
- SSMS efficiently combines encryption and digital signature and uses public keys for a secure key establishment to be used for encrypting short messages via a symmetric encryption.
- SSMS has great computational advantages over previously proposed public key solutions while simultaneously providing the most feasible security services.
- It has great advantages to be used in real m-payment applications and whenever the secure SMS messaging is important.
- The solution is suitable for other store-and-forward technologies.

Thanks

Thank you for your attention!