

# 这是我的第一份 L<sup>A</sup>T<sub>E</sub>X 论文文档

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## Abstract

A user identity anonymity is an important property for roaming services. In 2011, Kang et al. proposed an improved user authentication scheme that guarantees user anonymity in wireless communications. This letter shows that Kang et al.'s improved scheme still cannot provide user anonymity as they claimed.

**Keywords:** *cryptanalysis, authentication, anonymity, wireless communications, security*

## 1 Introduction

In 2004, Zhu and Ma [1] proposed an authentication scheme with anonymity for wireless communication environments. Later, Lee et al. [2] showed several security flaws of Zhu-Ma' s scheme and then improved it. However, in 2008, Wu et al. [3] showed that both Zhu-Ma' s scheme and Lee et al.' s scheme still cannot provide anonymity and then proposed an improvement to preserve anonymity. Nevertheless, Zeng et al. [4] and Lee et al. [5] showed that Wu et al.' s scheme also cannot provide anonymity, respectively.

In 2011, Kang et al. [7] proposed an improved user authentication scheme based on both Wu et al.' s and Wei et al.' s schemes [3], [6] that guarantees strong user anonymity in wireless communications. However, this letter shows that the Kang et al.' s improved scheme also cannot provide user anonymity as they claimed.

## 2 Review of Kang et al.s Scheme

Throughout the paper, notations are employed in Table 1. There are three phases in the Kang et al.'s scheme-initial phase, first phase, and second phase.

Table 1: Notation

$HA$	Home Agent of a mobile user
$FA$	Foreign Agent of the network
$MU$	Mobile User
$PW_{MU}$	A password of $MU$
$N$	A strong secret key of
$ID_A$	Identity of an entity $A$
$T_A$	Timestamp generated by an entity $A$
$Cert_A$	Certificate of an entity $A$
$(X)_K$	Encryption of message $X$ using symmetric key $K$
$E_{P_A}(X)$	Encryption of message $X$ using public key of $A$
$S_{S_A}(X)$	Signature on message $X$ using private key of $A$
$h(\cdot)$	A one-way hash function
$\parallel$	Concatenation
$\oplus$	Bitwise exclusive-or operation

## 2.1 Initial Phase

Where an  $MU$  registers with his/her  $HA$ , the  $MU$ 's identity  $ID_{MU}$  is submitted to the  $HA$ . After receiving  $ID_{MU}$  from  $MU$ ,  $HA$  generates  $PW_{MU}$ ,  $r_1$  and  $r_2$  as follows.

$$PW_{MU} = h(N \parallel ID_{MU}) \quad (1)$$

$$r_1 = h(N \parallel ID_{HA}) \quad (2)$$

$$r_2 = h(N \parallel ID_{MU}) \oplus ID_{MU} \quad (3)$$

where  $N$  is a secret value kept by  $HA$ .  $HA$  stores  $ID_{HA}$ ,  $r_1$ ,  $r_2$  and  $h(\cdot)$  in the smart card of  $MU$  and then sends it with  $PW_{MU}$  to  $MU$  through a secure channel.

## 2.2 First Phase

$$n = h(T_{MU} \parallel r_1) \oplus r_2 \oplus PW_{MU} \quad (4)$$

$$L = h(T_{MU} \oplus PW_{MU}) \quad (5)$$

$$ID_{MU} = h(T_{MU} \parallel h(N \parallel ID_{HA})) \oplus n \oplus ID_{HA} \quad (6)$$

$$\begin{aligned} k &= h(h(h(N \parallel ID_{MU})) \parallel x \parallel x_0) \\ &= h(h(PW_{MU})) \parallel x \parallel x_0 \end{aligned} \quad (7)$$

## 2.3 Second Phase

When  $MU$  visits  $FA$  at the  $i$ -th session,  $MU$  sends the following login message to  $FA$ .

1.  $MU \rightarrow FA$ :  $TCert_{MU}, (x_i || TCert_{MU} || \text{OtherInformation})_{k_i}$

The new  $i$ -th session key  $k_i$  can be derived from the unexpired previous secret value  $x_{i-1}$  and the fixed secret value  $x$  as

$$k = h(h(h(N || ID_{MU})) || x || x_{i-1}) \quad (8)$$

where  $i = 1, \dots, n$ .

2. Upon receiving a login message from  $MU$ ,  $FA$  decrypts  $(x_i || TCert_{MU} || \text{OtherInformation})_{k_i}$  with  $k_i$  and newly saves  $(TCert_{MU}, h(PW_{MU}), x_i)$  for the next communication.

### 3 Anonymity Problem of Kang et al.s Scheme

Kang et al. [7] improved Wu et al.'s scheme [3] and Wei et al.'s scheme [6] to provide anonymity. Based on the general interest of mobile users, user anonymity should be kept from any eavesdroppers including the foreign agents [5]. However, Kang et al.'s scheme still cannot provide anonymity. The main reason is that  $HA$  always computes  $r_1$  for each  $MU$  with the same secret key  $N$ . The detailed anonymity broken attack scenario is as follows.

1. Any legal user  $MU$  can directly obtain  $h(N || ID_{HA})$  from  $r_1$  in his/her smart card because  $r_1 = h(N || ID_{HA})$  from the Eq.(2)
2. The legal user  $MU$  can collect the messages  $\{n', (h(ID'_{MU}) || x'_0 || x')_{L'}, ID_{HA}, T'_{MU}\}$  sent from any other legal mobile user  $MU'$  to  $FA$  at step (1) in the first phase (see Fig.1). From the Eqs.(1)~(4), we can see that  $n'$  is equal to  $h(T'_{MU} || r_1) \oplus ID_{HA} \oplus ID'_{MU}$  as follows.

$$\begin{aligned} n' &= h(T'_{MU} || r_1) \oplus r'_2 \oplus PW'_{MU} \\ &= h(T'_{MU} || r_1) \oplus h(N || ID'_{MU}) \oplus ID_{HA} \\ &\quad \oplus ID'_{MU} \oplus PW'_{MU} \\ &= h(T'_{MU} || r_1) \oplus h(N || ID'_{MU}) \oplus ID_{HA} \\ &\quad \oplus ID'_{MU} \oplus h(N || ID'_{MU}) \\ &= h(T'_{MU} || r_1) \oplus ID_{HA} \oplus ID_{MU} \end{aligned} \quad (9)$$

3. With obtained  $r_1 = h(N || ID_{HA})$  and collected messages  $\{n', ID_{HA}, T'_{MU}\}$ ,  $MU$  can get the real identity  $ID'_{MU}$  of the other mobile user  $MU'$  as  $HA$  does at step(3) in the first phase as follows.

$$\begin{aligned} ID'_{MU} &= n' \oplus h(T'_{MU} || r_1) \\ &= h(T'_{MU} || r_1) \oplus ID_{HA} \oplus ID'_{MU} \\ &\quad \oplus ID_{HA} \oplus h(T'_{MU} || r_1) \\ &= ID'_{MU} \end{aligned} \quad (10)$$

As a result, legal mobile user  $MU'$ 's anonymity cannot be preserved in Kang et al.'s scheme

## 4 Conlusions

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