On the Vulnerability of a Group Key Transfer Protocol based on Secret Sharing

Ruxandra F. Olimid

University of Bucharest
ruxandra.olimid@fmi.unibuc.ro

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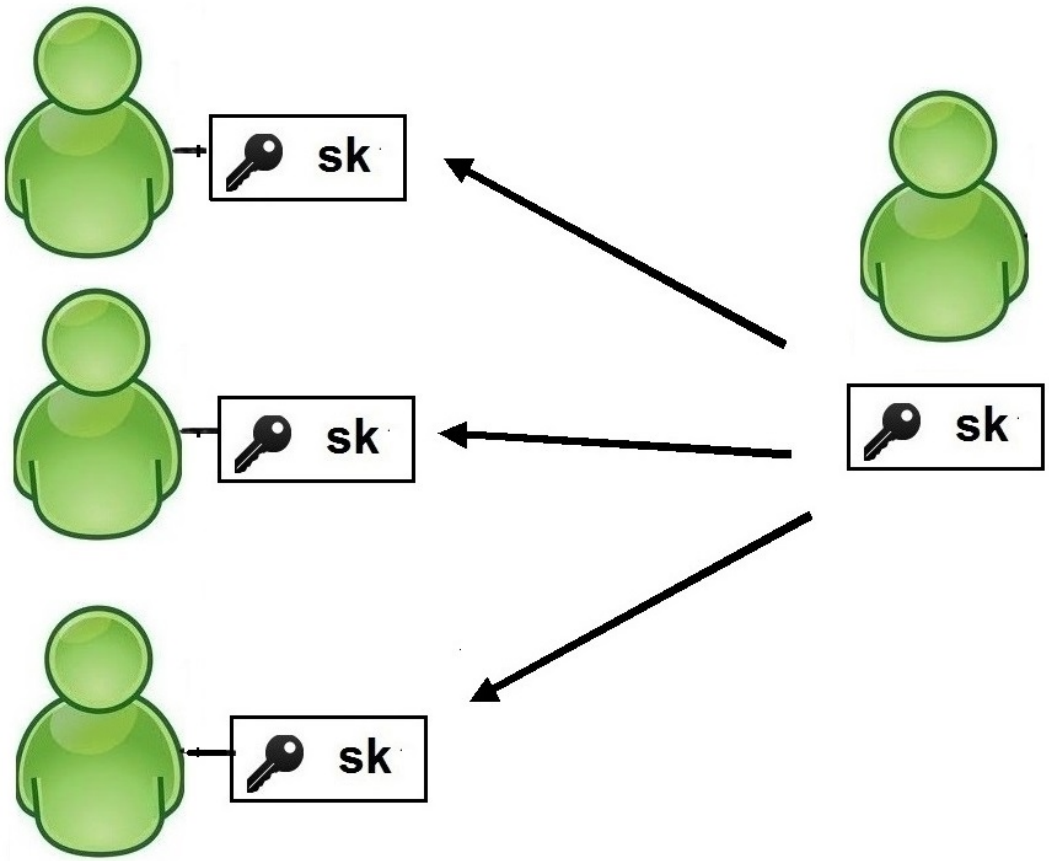
Outline

1. Preliminaries
2. Motivation
3. Hsu et al.'s Protocol
4. The Attack
5. Countermeasures

GKT (Group Key Transfer)



Goal: Allow multiple entities to share a common secret key.

Motivation

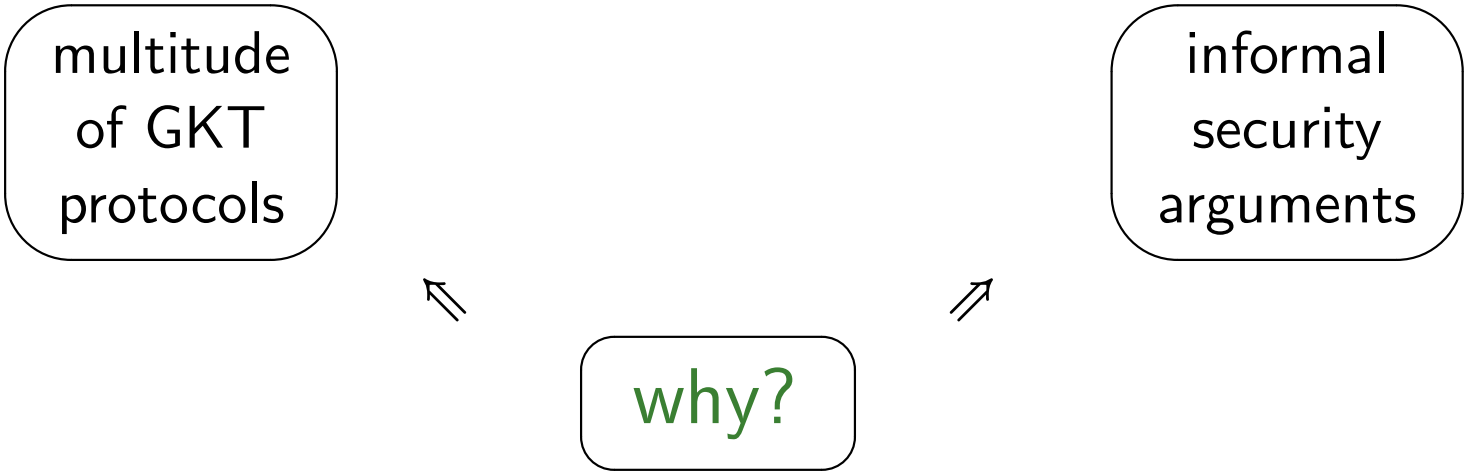
why?

Motivation

multitude of GKT protocols

why?

Motivation


multitude of GKT protocols
informal security arguments
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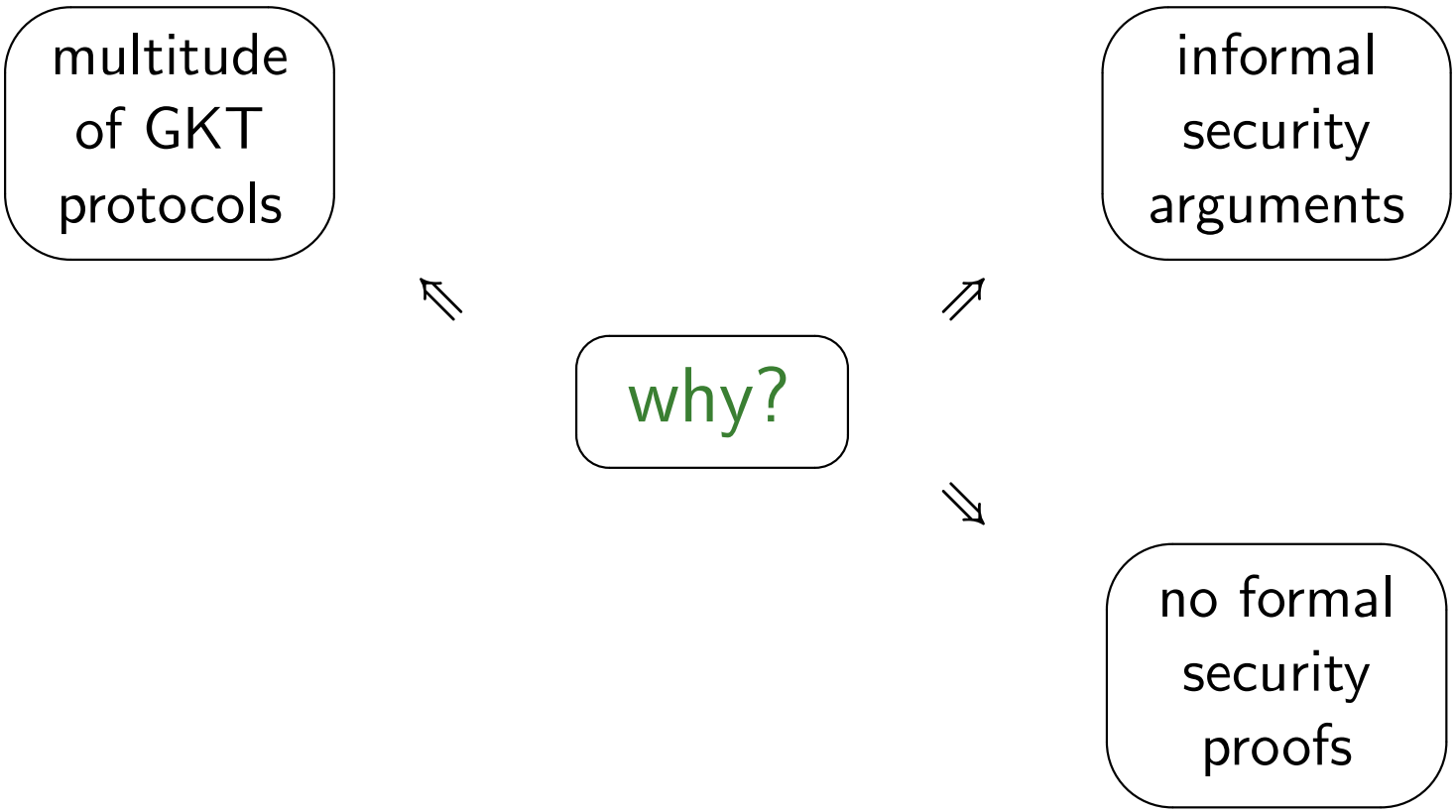
Motivation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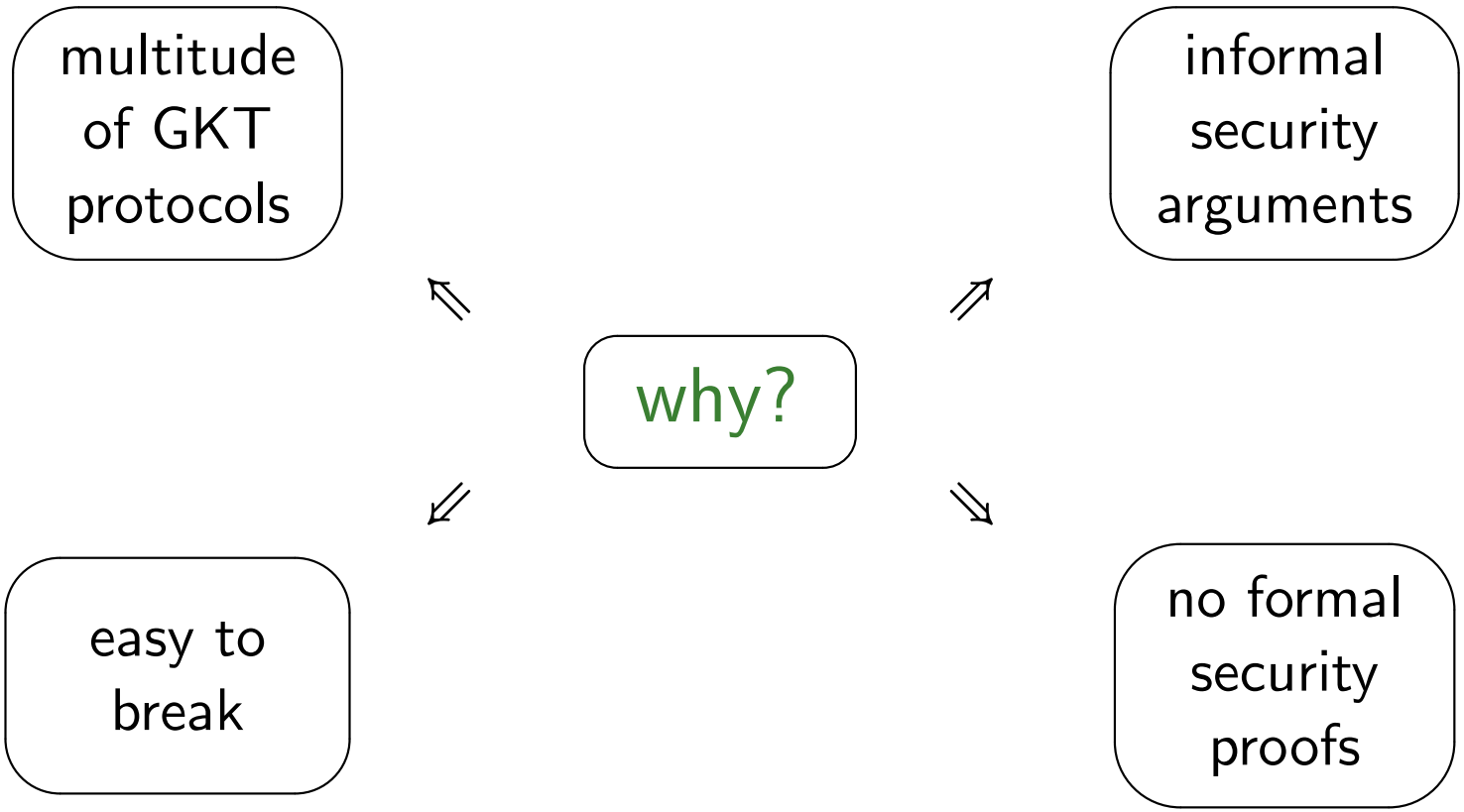
no formal security proofs

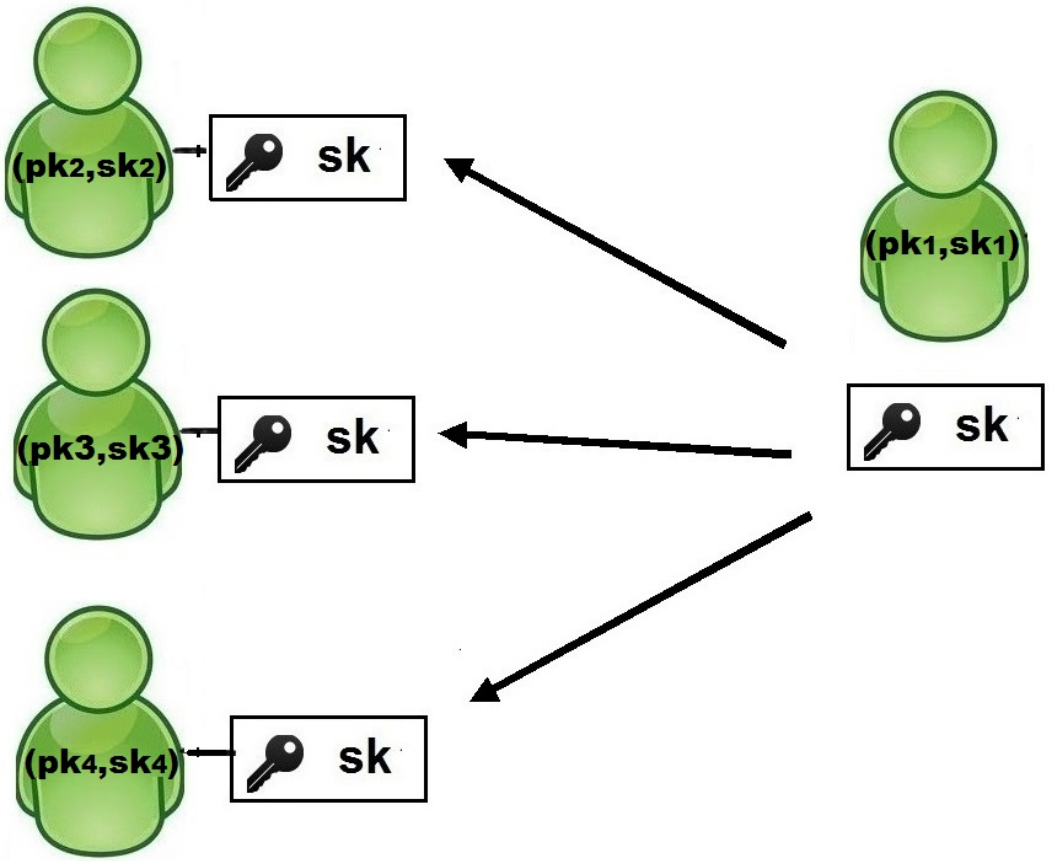
Motivation


multitude of GKT protocols
informal security arguments
why?
easy to break
no formal security proofs

Informally Secure GKT based on Secret Sharing

Original Protocol	Revealed Attacks
Harn and Lin (2010)	Nam et al. (2011) Yuan et al. (2013)
Sun et al. (2012)	Olimid (2013) Kim et. al (2013)
Hsu et al. (2012)	Olimid (2014)
Yuan et al.(2013)	Olimid (2013)

Hsu et al.'s Protocol



(pk_i, sk_i): $pk_i = g^{sk_i} \in \mathbb{G}$.

Hsu et al.'s Protocol

$U_1 \rightarrow^*: (\{U_1, \ldots, U_t\}, r_1, pk_1)$	$r_1 \leftarrow^R \mathbb{Z}_p^*$
$U_i \rightarrow^*: (r_i, pk_i, Auth_i)$	$r_i \leftarrow^R \mathbb{Z}_p^*$ $S_i = pk_1^{sk_i r_i r_1}$ $Auth_i = h(S_i, r_1)$
$U_1 \rightarrow^*: (Auth, K_2, \ldots, K_t)$	$S_i = pk_i^{sk_1 r_i r_1}$, $S_i = x_i \Vert y_i$ $\text{ver}.Auth_i = h(S_i, r_1)$ $k \leftarrow^R \mathbb{Z}_p^*$, $K_i = k - T_i$ $T_i = (y_i \sum_{j=1}^{t} x_i^{j-1} e_j, r)$, $r = (r_1, \ldots, r_t)$ $Auth = h(k, U_1, \ldots, U_t, r_1, \ldots, r_t, K_2, \ldots, K_t)$
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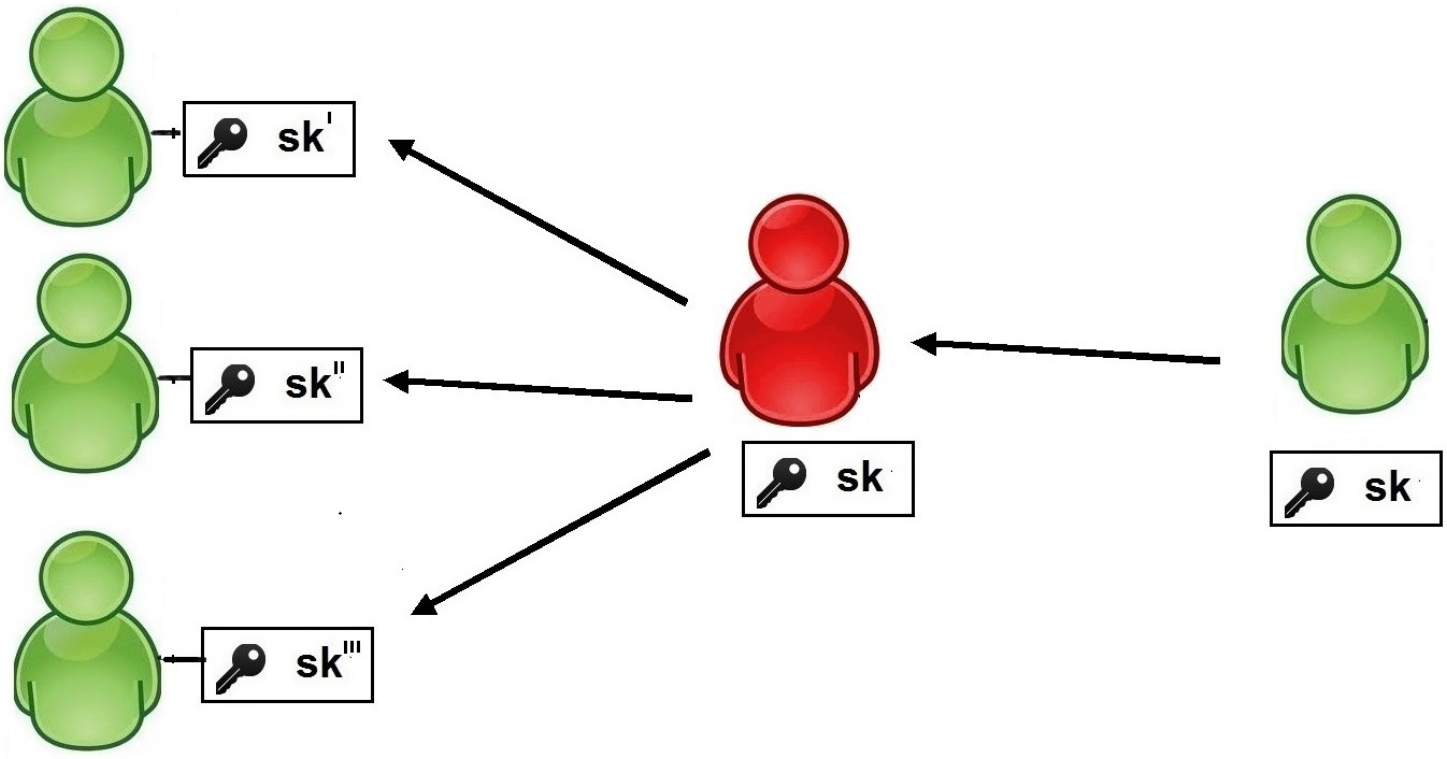
Insider Attack



Goal: Make different parties end up with distinct keys.

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Insider Attack

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1^{st} Solution

$U_1 \rightarrow^*: (\{U_1, \ldots, U_t\}, r_1, pk_1)$	$r_1 \leftarrow^R \mathbb{Z}_p^*$
$U_i \rightarrow^*: (r_i, pk_i, Auth_i)$	$r_i \leftarrow^R \mathbb{Z}_p^*$ $S_i = pk_1^{sk_i r_i r_1}$ $Auth_i = h(S_i, r_1)$
$U_1 \rightarrow^*: (Auth, K_2, \ldots, K_t)$	$S_i = pk_i^{sk_1 r_i r_1}$, $S_i = x_i \Vert y_i$ ver.$Auth_i = h(S_i, r_1)$ $k \leftarrow^R \mathbb{Z}_p^*$, $K_i = k - T_i$ $T_i = (y_i \sum_{j=1}^{t} x_i^{j-1} e_j, r)$, $r = (r_1, \ldots, r_t)$ $Auth = h(k, U_1, \ldots, U_t, r_1, \ldots, r_t, K_2, \ldots, K_t)$
Key computation $U_i : k = T_i + K_i$	$T_i = (y_i v(x_i), r)$ ver.$Auth = h(k, U_1, \ldots, U_t, r_1, \ldots, r_t, K_2, \ldots, K_t)$
Key confirmation $U_i \rightarrow^*: V_i$	$V_i = Sig_{U_i}(h(k, U_1, \ldots, U_t, r_1, \ldots, r_t, K_2, \ldots, K_t))$ ver.$Ver_{U_j}(V_j, h(k, U_1, \ldots, U_t, r_1, \ldots, r_t, K_2, \ldots, K_t))$

1^{st} Solution

$U_1 \rightarrow^*: (\{U_1, \ldots, U_t\}, r_1, pk_1)$	$r_1 \leftarrow^R \mathbb{Z}_p^*$
$U_i \rightarrow^*: (r_i, pk_i, Auth_i)$	$r_i \leftarrow^R \mathbb{Z}_p^*$ $S_i = pk_1^{sk_i r_i r_1}$ $Auth_i = h(S_i, r_1)$
$U_1 \rightarrow^*: (Auth, K_2, \ldots, K_t)$	$S_i = pk_i^{sk_1 r_i r_1}$, $S_i = x_i \Vert y_i$ $\text{ver}.Auth_i = h(S_i, r_1)$ $k \leftarrow^R \mathbb{Z}_p^*$, $K_i = k - T_i$ $T_i = (y_i \sum_{j=1}^{t} x_i^{j-1} e_j, r)$, $r = (r_1, \ldots, r_t)$ $Auth = h(k, U_1, \ldots, U_t, r_1, \ldots, r_t, K_2, \ldots, K_t)$
Key computation $U_i : k = T_i + K_i$	$T_i = (y_i v(x_i), r)$ $\text{ver}.Auth = h(k, U_1, \ldots, U_t, r_1, \ldots, r_t, K_2, \ldots, K_t)$
Key confirmation $U_i \rightarrow^*: V_i$	$V_i = Sig_{U_i}(h(k, U_1, \ldots, U_t, r_1, \ldots, r_t, K_2, \ldots, K_t))$ $\text{ver}.Ver_{U_j}(V_j, h(k, U_1, \ldots, U_t, r_1, \ldots, r_t, K_2, \ldots, K_t))$

1^{st} Solution

	Sign. No.	Verif. No.	Add. Rounds	Add. Broadcasts Messages
1st Solution	t	$t(t-1)$	1	t

2^{nd} Solution

$U_1 \rightarrow^*: (\{U_1, \ldots, U_t\}, r_1, pk_1)$	$r_1 \leftarrow^R \mathbb{Z}_p^*$
$U_i \rightarrow^*: (r_i, pk_i, Auth_i)$	$r_i \leftarrow^R \mathbb{Z}_p^*$ $S_i = pk_1^{sk_i r_i r_1}$ $Auth_i = h(S_i, r_1)$
$U_1 \rightarrow^*: (Auth, K_2, \ldots, K_t)$	$S_i = pk_i^{sk_1 r_i r_1}$, $S_i = x_i \Vert y_i$ $\text{ver}.Auth_i = h(S_i, r_1)$ $k \leftarrow^R \mathbb{Z}_p^*$, $K_i = k - T_i$ $T_i = (y_i \sum_{j=1}^{t} x_i^{j-1} e_j, r)$, $r = (r_1, \ldots, r_t)$ $Auth = Sig_{U_i}(h(k, U_1, \ldots, U_t, r_1, \ldots, r_t, K_2, \ldots, K_t))$
Key computation $U_i : k = T_i + K_i$	$T_i = (y_i \sum_{j=1}^{t} x_i^{j-1} e_j, r)$ $Ver_{U_1}(Auth, h(k, U_1, \ldots, U_t, r_1, \ldots, r_t, K_2, \ldots, K_t))$

2^{nd} Solution

	Sign. No.	Verif. No.	Add. Rounds	Add. Broadcasts Messages
1st Solution	t	$t(t-1)$	1	t
2nd Solution	1	$t-1$	0	0

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Define provable secure GKT protocols!

Thank you!

Q & A