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Efficient hierarchical identity based encryption scheme in the standard model over lattices

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Corresponding author: Feng-he Wang

E-mail: fenghe2166@163.com

 ORCID: <http://orcid.org/0000-0002-5510-3133>

Motivation

- Hierarchical identity based encryption (HIBE) is an important cryptographic notation. Security and efficiency are two important characters for HIBE.
- Most of HIBE schemes are not secure under the quantum attack (Boneh *et al.*, 2005; Boyen and Waters, 2006; Gentry and Halevi, 2009; Waters, 2009).
- Lattice-based HIBE can achieve the quantum security, while the efficiency is low. For example: large public key size, large message-ciphertext expanse factor (M-C factor) (Agrawal *et al.*, 2010a; 2010b; Cash *et al.*, 2010).
- How to improve the efficiency of the lattice-based HIBE?

Main idea

- The known public key assignment rule leads to large public key size and even large M-C factor, though it is important for the design of the lattice-based HIBE.
- We would make lattice-based HIBE scheme more efficient by designing a more efficient public key assignment rule.

Method

1. Propose a public key assignment rule for the design of the lattice-based HIBE scheme.
2. Give an embedded technology by which the proposed public key assignment rule can be combined with lattice-based delegation.
3. The security proof technology in the standard model.

Major results

- The proposed public key assignment rule:

Algorithm 3 Assignment rule

Input: $R_1, R_2, \dots, R_d$; $\text{id}_{|d} = (\text{id}_1, \text{id}_2, \dots, \text{id}_d)$

Output: $\{R_{i_1}, R_{i_2}, \dots, R_{i_d}\}$

// return R_{i_j} for $\text{id}_{i_j} = 1$

1: **for** $i = 1$ **to** d **do**

2: **if** $\text{id}_i = 1$ **then**

3: **return** R_i

4: **else**

5: Output nothing

6: **end if**

7: **end for**

- Efficient HIBE scheme over lattice in the standard model by the proposed public key assignment rule.

Major results (Cont'd)

- Security: security against the selective identities and chosen message attacks in the standard model
- Efficiency:

Table 1 Comparison of space efficiency

Scheme	Public key length (bit)	Message-ciphertext expansion factor
Agrawal <i>et al.</i> (2010b)	$(2dm^2 + mn + n) \log q$	$m \log q + 1$
Singh <i>et al.</i> (2012)	$(dl'' + 2)mn \log q$	$[(l+1)m + 1] \log q$
Singh <i>et al.</i> (2014)	$(l'' + 2)mn \log q$	$[(l+1)m + 1] \log q$
Our scheme	$(dm^2 + mn) \log q$	$\log q$

Table 2 Comparison of computation efficiency for each bit message

Scheme	Gaussian sampling		Modular multiplication	
	Encrypt	Decrypt	Encrypt	Decrypt
Agrawal <i>et al.</i> (2010b)	2	1	$(l-1)m^2 + 2mn + n$	m
Singh <i>et al.</i> (2012)	1	1	$(l'' + l + 1)mn + m$	$(l+1)m$
Singh <i>et al.</i> (2014)	1	1	$(ll'')mn + m^2 + (l'' + 1)mn^2$	$(l+1)m$
Our scheme	$1/m$	0	$n + j^* - 1$	2

Conclusions

- We proposed a public key assignment rule for lattice-based HIBE scheme.
- We designed a lattice-based HIBE scheme in the standard model by the proposed public key assignment rule.
- We proved that the proposed HIBE scheme is secure under the hardness of the LWE problem. It is also efficient compared with known HIBE schemes over lattice.
- The proposed public key assignment rule also can be used to further improve the efficiency of lattice-based HIBE by combining with other technologies. (e.g., Singh *et al.*, 2014)