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**From:** Jan-Pieter D'Anvers <janpieter.danvers@esat.kuleuven.be>  
**Sent:** Friday, January 12, 2018 10:18 AM  
**To:** pqc-comments  
**Cc:** pqc-forum@list.nist.gov  
**Subject:** OFFICIAL COMMENT: Round2

Dear all,

I believe that the proof of the IND-CPA security of Round2 contains a flaw.

In the security proof of ROUND2.CPA-PKE, you state that the advantage of an adversary distinguishing between game G3 and G4 is less or equal then his advantage of solving the specific dGLWR problem mentioned in formula 13. However, the adversary has possibly more information in the first case (distinguishing games G3 and G4) since he is given extra information about the secret key R embedded in v (line 6-7 in Game G3 and G4). Therefore, it is possible that the advantage of the adversary in distinguishing Game G3 and G4 is actually bigger than solving the dGLWR problem. A similar problem can be found in the security proof of ROUND2.CPA-KEM.

To work around this issue, the step from Game G3 to Game G5 could be done in one step, comparing it with one similar dLWR problem (with extra samples), similar to Bos et al. [1]. However, due to the rounding, it becomes more involved when working with LWR.

For the uRound (powers of two) parameters, you can take the same route as we did in the security prove of Saber (the paper containing the proof has not been put on eprint yet). This proof proceeds from game G3 by adding two additional games G3a and G3b.

In game G3a, B is generated uniformly from  $R^{d \times n}_{\{n, q\}}$ , X is calculated as  $\langle B^T R \rangle_{\mathbf{q}}$ , and v is now send with  $\log_2(t \cdot q/p)$  bit coefficients. Here you can prove that the advantage of the adversary in Game G3a is at least as big in Game G3, since he can easily calculate the same values as in Game G3 by taking mod p of B and mod t of v.

In game G3b, the amount of error introduced in the coefficients of v, and the coefficients of U, is equalized. This can be done by calculating both with  $R_{\text{compress}_{\mathbf{q}} \rightarrow \max(p, t \cdot q/p)}$ . Again, the advantage of the adversary in Game G3b is at least as big as in Game G3a, since he can easily calculate the same values as in Game G3a.

After this, you can go to Game G5 in one step analogue to Algorithm C.

Kind regards,

Jan-Pieter D'Anvers

[1] Joppe Bos, Craig Costello, Léo Ducas, Ilya Mironov, Michael Naehrig, Valeria Nikolaenko, Ananth Raghunathan, and Douglas Stebila. Frodo: Take off the ring! Practical, Quantum-Secure Key Exchange from LWE. Cryptology ePrint Archive, Report 2016/659, 2016. <https://eprint.iacr.org/2016/659>

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**From:** Mike Hamburg <mike@shiftright.org>  
**Sent:** Friday, January 12, 2018 7:58 PM  
**To:** pqc-comments  
**Cc:** pqc-forum@list.nist.gov  
**Subject:** OFFICIAL COMMENT: Round2

Hello Round2 team,

Could you explain how you derived your NIST category claims?

As I understand them, the categories are roughly:

Category 1:  $\geq 2^{128}/\text{MAXDEPTH}$

Category 2:  $\geq 2^{128}$

Category 3:  $\geq 2^{192}/\text{MAXDEPTH}$

Category 4:  $\geq 2^{192}$

Category 5:  $\geq 2^{256}/\text{MAXDEPTH}$

where MAXDEPTH is probably between  $2^{40}$  and  $2^{64}$  for a quantum machine, and 1 for a classical machine.

Compare for example  $n\text{Round2.KEM}_{\{n=d\}}$ , as shown in Table 11. The estimated security levels against the strongest attack (hybrid) are as follows:

NIST1:  $2^{74}$

NIST2:  $2^{97}$

NIST3:  $2^{106}$

NIST4:  $2^{139}$

NIST5:  $2^{139}$

Am I misreading these tables, or misunderstanding the categories? Is the attack model here something very favorable to the attacker, so that it doesn't match NIST's model?

Thanks,  
— Mike Hamburg