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**From:** Matthieu Lequesne <matthieu.lequesne@inria.fr>  
**Sent:** Friday, January 05, 2018 1:40 PM  
**To:** pqc-comments  
**Cc:** pqc-forum@list.nist.gov  
**Subject:** OFFICIAL COMMENT: Edon-K

Dear Designers of EdonK, Dear all,

We looked at the EdonK KEM and found an attack.  
Given the public key and a cipher text, we manage to recover the shared secret.

The ciphertext is a vector  $C$  such that  $C = M \cdot \text{PubMat} + \text{error}$ .  
The error is of rank 6 by construction.  
The parity check matrix  $\text{PrivMat}$  has coefficients in the sub-vector space of  $F_q$  generated by elements  $a$  and  $b$ .  
Hence, the code whose parity-check matrix is  $\text{PrivMat}$  is an LRPC code of rank 2 as defined in [1, Definition 3].  
This code is a super-code of the code generated by  $\text{PubMat}$  used in the scheme because of Corollary 1 (page 19).

We manage to reconstruct this LRPC code from the public information.  
This LRPC code can correct more than 6 errors and we can therefore use it to decode the ciphertext and recover the shared secret.

Here is how we proceed.

The attacker does not have access to the value of  $a$  and  $b$  but to the value of  $a/b=c/d$  as mentioned in paragraph 7.2.2 of the documentation.  
Let us denote  $\alpha = a/b$ .  
We know that  $b^{-1} \cdot \text{PrivMat}$  is also a parity-check matrix of the LRPC code and has its coefficients in the two dimensional sub-vector space generated by 1 and  $\alpha$ .  
Hence we know that this code admits a parity-check matrix with coefficients in  $\langle 1, \alpha \rangle$ .  
We use this information to reconstruct such a parity-check matrix of the LRPC code by solving a linear system as in [2, section IV B].

Now we have a parity-check matrix whose entries are all in a 2-dimensional vector space.  
We can use the general decoding of LRPC codes.  
According to theorem 1 of [1]:  
Let  $H$  be a  $(n-k) \times n$  dual matrix of a LRPC code with low rank  $d \geq 2$  over  $F_q^m$ , then the algorithm 1 decodes a random error  $e$  of low rank  $r$  such that  $r \cdot d \leq n-k$  with failure probability  $q^{-(n-k+1-rd)}$  and complexity  $r^2 \cdot (4d^2 \cdot m + n^2)$ .

Here, with the parameters of edonk128ref, we have  $r=6$ ,  $d=2$ ,  $q=2$ ,  $n=144$ ,  $k=104$ ,  $m=128$ .  
So  $r \cdot d = 12 \leq 40 = n-k$ , so we can decode with error probability  $2^{-29}$  and complexity  $< 2^{20}$ .

Then we recover the error. The vector span directly gives a list of candidates.

We recover the shared secret as in step 6 of the decapsulation process.

We intend to write a more detailed document in a few days.

Please tell us if we missed something.

Best regards,

Matthieu Lequesne, Nicolas Sendrier and Jean-Pierre Tillich.

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[1] Gaborit, P., Murat, G., Ruatta, O., & Zémor, G. (2013, April). Low rank parity check codes and their application to cryptography. In Proc. WCC (pp. 168-180).

[2] Gaborit, Philippe, Olivier Ruatta, and Julien Schrek. "On the complexity of the rank syndrome decoding problem." IEEE Transactions on Information Theory 62.2 (2016): 1006-1019.

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**From:** Danilo Gligoroski <danilog@ntnu.no>  
**Sent:** Friday, January 05, 2018 4:45 PM  
**To:** Matthieu Lequesne; pqc-comments  
**Cc:** pqc-forum@list.nist.gov  
**Subject:** Re: [pqc-forum] OFFICIAL COMMENT: Edon-K

Dear Matthieu, Nicolas and Jean-Pierre,

Thank you very much for your interest in Edon-K.

If I understand your attack, basically, what you claim is that you have found a second preimage attack on SHA256 with a complexity  $2^{129}$  which is highly unlikely.

Explanation:

Your attack is trying to recover one of many parity check matrices, but with two elements: 1 and  $a/b$ . I think that part is ok. Then you refer to the decapsulation procedure to recover the shared secret and hope that Step 6 will be satisfied. Note that the values in Step 6 in the documentation are obtained from Step 4 where the knowledge of both  $a$  and  $b$  is necessary. Your attack does not recover neither  $a$  nor  $b$ . What your attack is doing is a production of an alternate vector span, with values multiplied by  $a/b$ . Then, by searching through pairs of values  $(s_\mu, s_\nu)$  of your vector span (of up to  $2^{40}$  elements), with a probability  $2^{-29}$  and complexity  $<2^{20}$ , you hope that you will hit the supplied SHA256 hash value  $h$ . So a total cost of your attack is  $(2^{40} \times 2^{40}) \times 2^{20} / 2^{-29} = 2^{129}$  and you have found a second preimage for SHA256. I think that is highly unlikely. Here lies the mistake in your attack: The Step 6 from your alternate vector span will produce the same hash value  $h$  with a very low probability  $<2^{-256}$ .

Best regards,  
Danilo!

On 05/01/2018 19:40, Matthieu Lequesne wrote:

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