DAGS: Key Encapsulation using Dyadic GS Codes

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Classic Code-based Cryptography

Based on the hardness of decoding random linear codes (syndrome decoding problem).

Follows McEliece/Niederreiter framework.

Very efficient computation.

Natural implementation features thanks to binary vectors arithmetic.

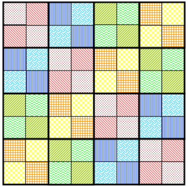
Drawback: large keys (around 1 MByte).

Try to tackle the large key issue.

Idea: public matrix with compact description.

Quasi-Cyclic Codes (as seen before).

Quasi-Dyadic Codes (Misoczki, Barreto '09).



Several code families have QD description:

If dyadic *signature* and code *support* verify certain conditions...

...then Dyadic $\cap$ Cauchy $\cap$ Goppa.

Generalized Srivastava Codes

Alternant codes with non-trivial intersection with Goppa codes.

Admit parity-check which is superposition of s blocks of size $t \times n$.

Each block H_ℓ has ij-th element $\dfrac{z_j}{(v_j - u_\ell)^i}$, (distinct) nonzero elements of $\mathbb{F}_{q^m}$.

If $t = 1$ this is a Goppa code.

Can generate QD-GS codes using (modified) algorithm for QD Goppa (P. '12).

Efficient decoder, similar performance, more flexibility.

DAGS: A QD-GS BASED KEM

Select hash functions $\mathcal{G}, \mathcal{H}, \mathcal{K}$.

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KEY GENERATION

- Generate a QD-GS code.
- SK: parity-check matrix H in alternant form over $\mathbb{F}_{q^m}$.
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ENCAPSULATION

- Choose random word $\boldsymbol{m} \in \mathbb{F}_q^{k'}$.
- Compute $(\boldsymbol{\rho} \parallel \boldsymbol{\sigma}) = \mathcal{G}(\boldsymbol{m})$ and $\boldsymbol{d} = \mathcal{H}(\boldsymbol{m})$.
- Generate error vector $\boldsymbol{e} \in \mathbb{F}_q^n$ of weight w from seed $\boldsymbol{\sigma}$.
- Output $(\boldsymbol{c}, \boldsymbol{d})$ where $\boldsymbol{c} = (\boldsymbol{\rho} \parallel \boldsymbol{m})G + \boldsymbol{e}$ and set $\boldsymbol{k} = \mathcal{K}(\boldsymbol{m})$.

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Decapsulation

- Recover codeword $((\boldsymbol{\rho}' \parallel \boldsymbol{m}')$ and error $\boldsymbol{e}')$ from $Decode(\boldsymbol{c})$.
- Recompute $\mathcal{G}(\boldsymbol{m}')$, $\mathcal{H}(\boldsymbol{m}')$ and $\boldsymbol{e}''$, then compare.
- Return $\perp$ if decoding fails or any check fails, else return $\boldsymbol{k} = \mathcal{K}(\boldsymbol{m}')$.

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This results in a small private key without computational overhead.

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No broken QD-GS parameters to date.

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We choose:

- Small m
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Parameters (sizes in bytes):

q	m	n	k	k'	s	t	w	PK	SK	Ciphertext	Sec. Level
2^5	2	832	416	26	2^4	13	104	6,760	2,496	552	1
2^6	2	1216	512	43	2^5	11	176	8,448	3,648	944	3
2^6	2	2112	704	43	2^6	11	352	11,616	6,336	1,616	5

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Accurate complexity analysis of algebraic attacks is ongoing/future project.

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  - Price to pay is actually fairly small

Thank you

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www.dags-project.org