CODE-BASED CRYPTOGRAPHY: STATE OF THE ART

PART II

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19 March 2019

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Florida Atlantic University

In This Talk

- Structured Codes
- Sparse-Matrix Codes
- Rank Metric
- Conclusions

Part I

Structured Codes

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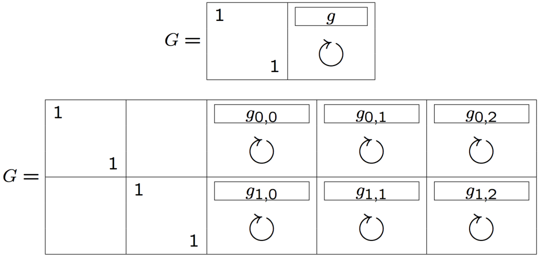
Need families of codes with particular automorphism group.

Quasi-Cyclic Codes (Berger, Cayrel, Gaborit, Otmani '09).



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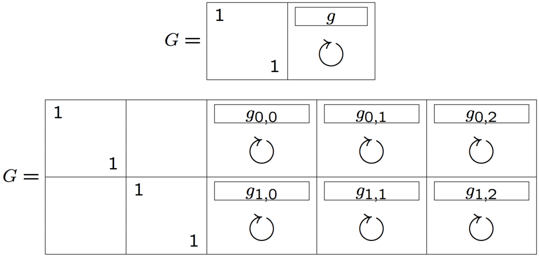

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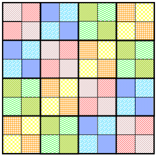

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After a few years of fixes and new attacks: keys getting bigger, confidence/interest getting smaller.
(Faugère, Otmani, Perret, de Portzamparc, Tillich '16, Barelli-Couvreur '18).

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q	m	n	t	PK Size	SK Size	Ciph Size	Security
2	18	10,070	190	149,625	41,804	492	5
2	18	7,410	152	84,132	30,860	406	3
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2^8	2	1,600	176	19,712	6,400	1,632	5
2^8	2	1,216	176	11,264	4,864	1,248	3
2^6	2	832	104	8,112	2,496	656	1

Part II

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Decodable with very efficient probabilistic "bit flipping" algorithm (Gallager, '63), small decoding failure rate (DFR).

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Still decodable, gain in security makes up for degradation.

Structures Sparse-Matrix Codes

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Matrices formed by circulant blocks

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Sparse-matrix codes don’t possess inherent algebraic structure.

QC property alone does not provide a structural attack.

Key Generation

- Choose h_0, h_1 in $\mathcal{R}$ of combined weight w.
- SK: parity-check matrix formed by circulant blocks h_0, h_1.
- PK: generator matrix formed by identity and $g = h_0 h_1^{-1}$.

Sparse-matrix McEliece

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- Take message $\mu \in \mathcal{R}$.
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Decryption

- Set $(e_0, e_1) = Decode_{BitFlipping}(c)$.
- Return $\perp$ if decoding fails.
- Else recover μ (truncate).

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BIKE-3: use "noisy" decoder to have simpler security reduction.

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Sizes comparable to BIKE.

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3	9,643	13	90	2,416	604	1,208
4	8,467	11	72	3,192	716	1,064

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- BIKE
- Classic McEliece
- HQC
- LEDAcrypt
- NTS-KEM
- ROLLO
- RQC

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Can possibly negate DOOM speedup and reaction attacks.

Part III

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$[n, k]$ rank metric linear code over $\mathbb{F}_{q^m}$

A subspace of dimension k of $\mathbb{F}_{q^m}^n$ (Gabidulin, '85).

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A subspace of dimension k of $\mathbb{F}_{q^m}^n$ (Gabidulin, '85).

A subspace of dimension k of $\mathbb{F}_q^{m \times n}$ (Delsarte, '78).

Rank Metric

One of alternative metrics used in Coding Theory.

Rank metric

Let $x \in \mathbb{F}_{q^m}^n$ and $\beta = (\beta_1, \ldots, \beta_m)$ basis for $\mathbb{F}_{q^m}$ over $\mathbb{F}_q$.

$wt_R(x) = Rank(\phi_\beta(x))$, where ϕ_β is projection over $\mathbb{F}_q$ (columns).

$d_R(x, y) = wt_R(x - y)$.

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Support of a word

$Supp(x) = span < x_1, \ldots, x_n >_{\mathbb{F}_q}$.

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Structural attacks exist (Gibson, '95, '96, Overbeck, '05, Debris-Alazard, Tillich, '18).

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No DFR for RQC.

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2	101	59	8	1,490	1,490	1,490	3
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Sizes can be further compressed using seed expanders (also in other schemes).

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More investigation needed.

Part IV

Conclusions

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Round 2: protocol refinements, re-parametrizations, new/improved implementations.

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Work in progress, first draft nearly ready - stay tuned!

Thank you