fast constant-time code-based cryptography

D. J. Bernstein University of Illinois at Chicago & Technische Universiteit Eindhoven

Joint work with:

Tung Chou Technische Universiteit Eindhoven

Peter Schwabe Radboud University Nijmegen

Objectives

Set new speed records for public-key cryptography.

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- Some cycle counts on h9ivy (Intel Core i5-3210M, Ivy Bi
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(Decryption is slightly slower: includes hash, cipher, MAC.)

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Similar improvements for CFS.

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Coming next: how to save many adds and *most* mults. Nice synergy with bitslicing.

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But quite obvious that it saves time for addition in $\mathbf{F}_{2^{12}}$.

Typical decoding algorithms have add, mult roughly balanced.

Coming next: how to save many adds and *most* mults. Nice synergy with bitslicing.

The additive FFT

Fix $n = 4096 = 2^1$

Big final decoding is to find all roots of $f = c_{41}x^{41} + \cdots$

For each $\alpha \in \mathbf{F}_{2^{12}}$ compute $f(\alpha)$ by 41 adds, 41 mults Not immediately obvious that this "bitslicing" saves time for, e.g., multiplication in $\mathbf{F}_{2^{12}}$.

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The additive FFT

Fix $n = 4096 = 2^{12}$, t = 41.

Big final decoding step is to find all roots in $\mathbf{F}_{2^{12}}$ of $f = c_{41}x^{41} + \cdots + c_0x^0$.

For each $\alpha \in \mathbf{F}_{2^{12}}$, compute $f(\alpha)$ by Horner's r 41 adds, 41 mults.

Not immediately obvious that this "bitslicing" saves time for, e.g., multiplication in \mathbf{F}_{212} .

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The additive FFT

Fix $n = 4096 = 2^{12}$, t = 41.

Big final decoding step is to find all roots in \mathbf{F}_{212} of $f = c_{41}x^{41} + \cdots + c_0x^0$.

For each $\alpha \in \mathbf{F}_{2^{12}}$, compute $f(\alpha)$ by Horner's rule: 41 adds, 41 mults.

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For each $\alpha \in \mathbf{F}_{2^{12}}$, compute $f(\alpha)$ by Horner's rule: 41 adds, 41 mults.

Or use Chien search: compute $c_i g^i$, $c_i g^{2i}$, $c_i g^{3i}$, etc. Cost per point: again 41 adds, 41 mults.

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- Want to evaluate
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- Write f as $f_0(x^2) + x f_1(x^2)$. Observe big overlap betweer $f(\alpha) = f_0(\alpha^2) + \alpha f_1(\alpha^2),$ $f(-\alpha) = f_0(\alpha^2) - \alpha f_1(\alpha^2).$
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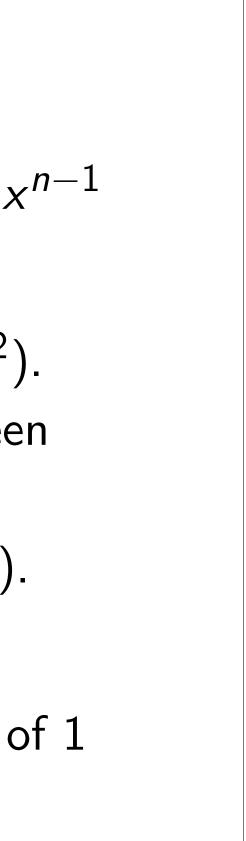
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Gao and Mateer end $f = c_0 + c_1 x + \cdots$

on a size- $n \mathbf{F}_2$ -line

Their main idea: $\int f_0(x^2 + x) + x f_1(x)$

Big overlap between $f_0(lpha^2 + lpha) + lpha f_1(lpha)$ and $f(lpha + 1) = f_0(lpha^2 + lpha) + (lpha + 1)$

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"Twist" to ensure $1 \in \mathsf{space}$ Then $\{\alpha^2 + \alpha\}$ is a size-(n/2) **F**₂-linear space. Apply same idea recursively.

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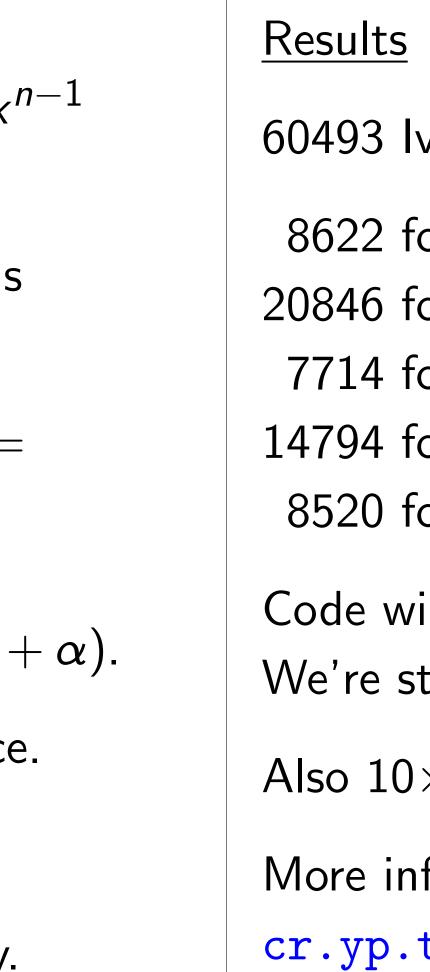
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<u>Results</u>

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- 20846 for syndrom
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What you find in Cryptosystem spec Our speedups to a (We now have mo cr.yp.to/papers Fast syndrome cor without big precor Important for light Fast secret permu using bit operation sorting networks, permutation netwo

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What you find in paper:

- Cryptosystem specification.
- Our speedups to additive FF
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- cr.yp.to/papers.html#au
- Fast syndrome computation
- without big precomputed ma
- Important for lightweight!
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What you find in paper: Cryptosystem specification. Our speedups to additive FFT. (We now have more speedups: cr.yp.to/papers.html#auth256.) Fast syndrome computation *without* big precomputed matrix. Important for lightweight! Fast secret permutation using bit operations: sorting networks, permutation networks.