Update on Argon2

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Recall why we need Argon2

Password-based authentication

Keyless password authentication:

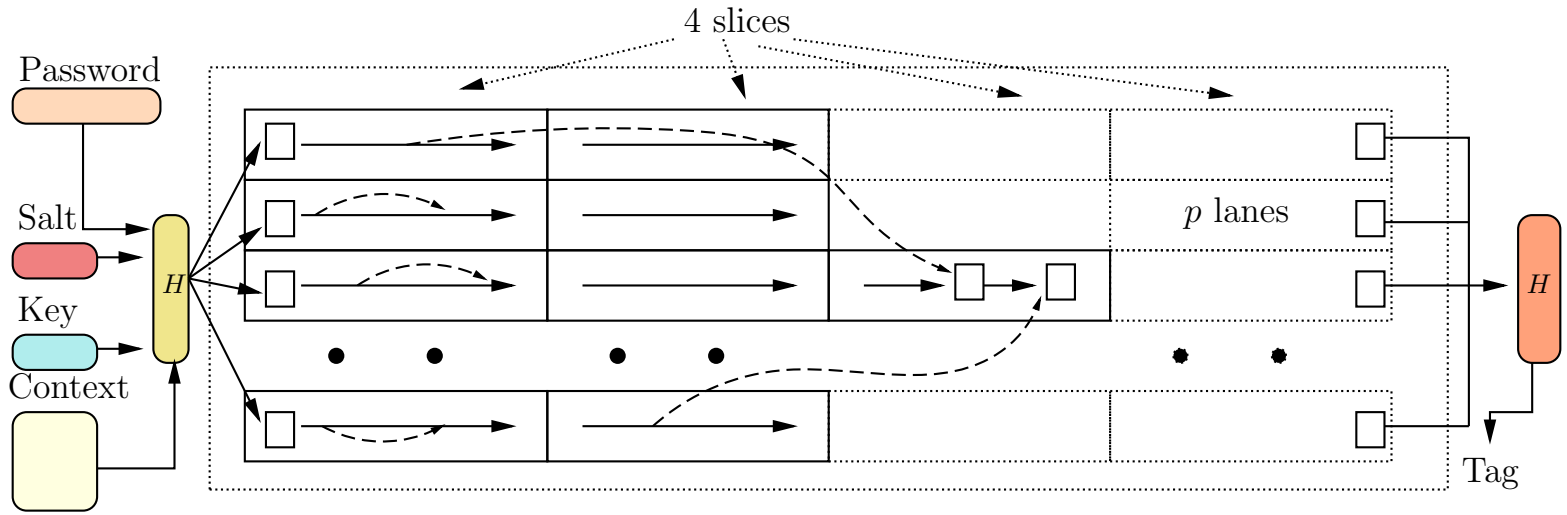
- User registers with name I and password p;
- Server selects hash function H, generates salt s, and stores $(I, H(s, p))$;
- User sends (I, p') during the login;
- Server matches $(I, H(s, p'))$ with its password file.

Problems:

- Password files are often leaked unencrypted;
- Passwords have low entropy ("123456");
- Regular cryptographic hash functions are cracked on GPU/FPGA/ASIC.

Argon2, the winner of Password Hashing Competition

Specification of Argon2



Three variants: Argon2d, Argon2i, Argon2id.

- Select the amount of memory M, number of passes T, level of parallelism l.
- Argon2d uses data-dependent addressing – side-channels;
- Argon2i uses data-independent addressing – lower attack costs due to tradeoffs (up to factor 4);
- Argon2id, best of two worlds – Argon2i for the first half-pass, Argon2d for the rest.

Updates on Argon2 since July 2016

Analysis:

- No new attack, only a slight improvement in the Alwen-Blocki attack on Argon2i (see later).

Code:

- 65 commits, mostly refactoring and bug fixes;
- 112 total forks, 1567 stars.
- Bindings: Javascript, PHP, Python, Rust, Go.

Adoption:

- Packages: Debian, Ubuntu, NetBSD,...
- Projects: EXT4/fscrypt filesystem, Yandex authentication.
- Libraries: libsodium, PassLib.
- Password managers: KeePass;
- Web frameworks: Django;
- Proof of work: Dynamic, Lemon Coin.

On the road: Mozilla, Dropbox, DOVECOT.

Time to wrap up and finalize Argon2 as a standard!

Defender's paradigm

Which parameter set is the best?

Naive approach 1:

- Fix affordable memory M, take T passes that minimizes the impact of the tradeoff attack.

Naive approach 2:

- Fix affordable time MT, take T that minimizes the impact of the tradeoff attack.

Defender's paradigm

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Naive approach 1:

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Naive approach 2:

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Best choice:

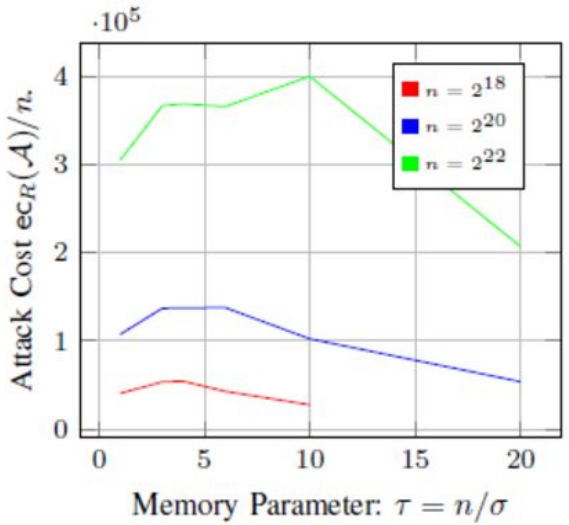
- Fix time MT, take (M, T) that maximizes the attack cost.

Argon2i: attack costs

Costs of hash evaluation using M memory and T passes on hardware (time-area product) using a time-memory tradeoff of quality $Q(M, T)$:

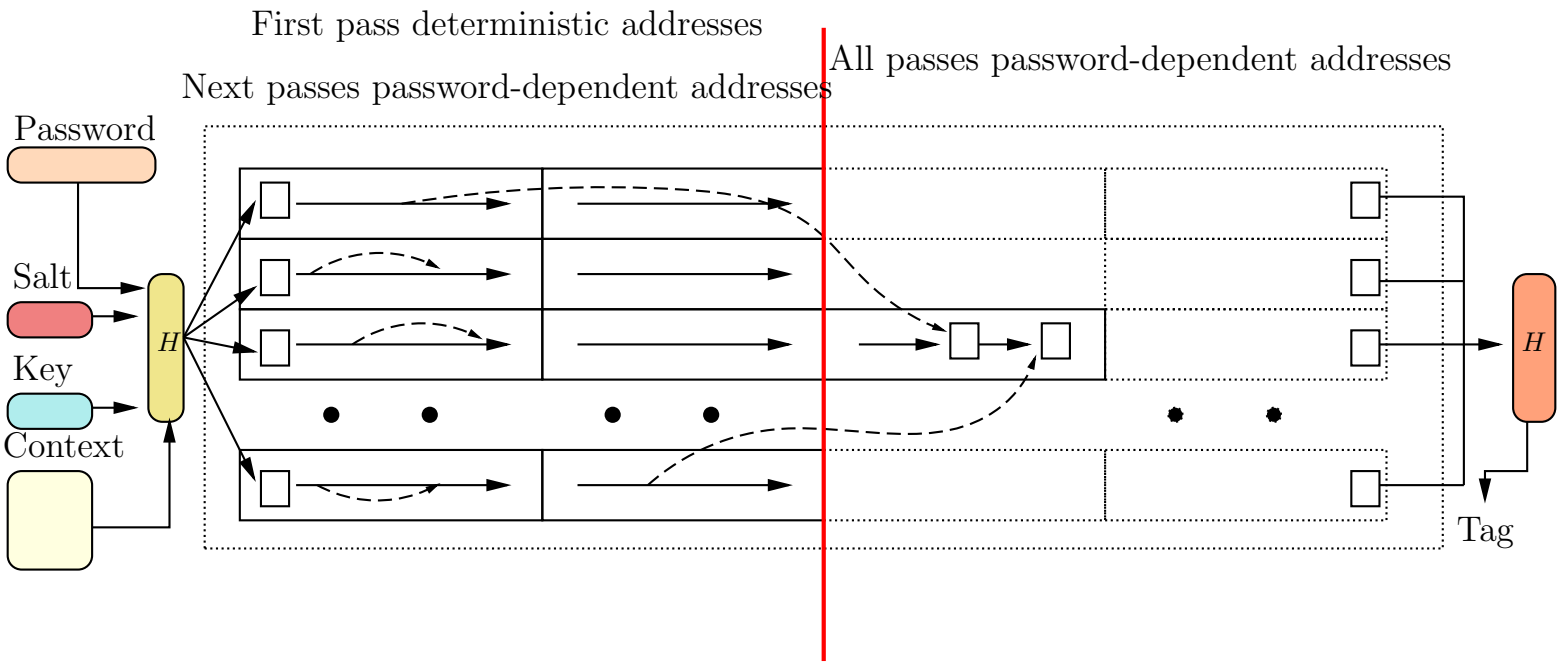
$$\frac{M^2 \cdot T}{Q(M, T)}.$$

Best tradeoff attacks by Alwen-Blocki:



The $T = 3$ is close to optimal.

Argon2id



- Side-channels are possible after the half of the first pass only;
- Smart time-memory tradeoffs apply to the first half only.

Analysis of Argon2id

Tradeoff attack on $T = 1$:

- Can not do better than attack the first half as Argon2i and the second half as Argon2d – total factor less than 2.5;
- No attack on 2 and more passes.

Analysis of Argon2id

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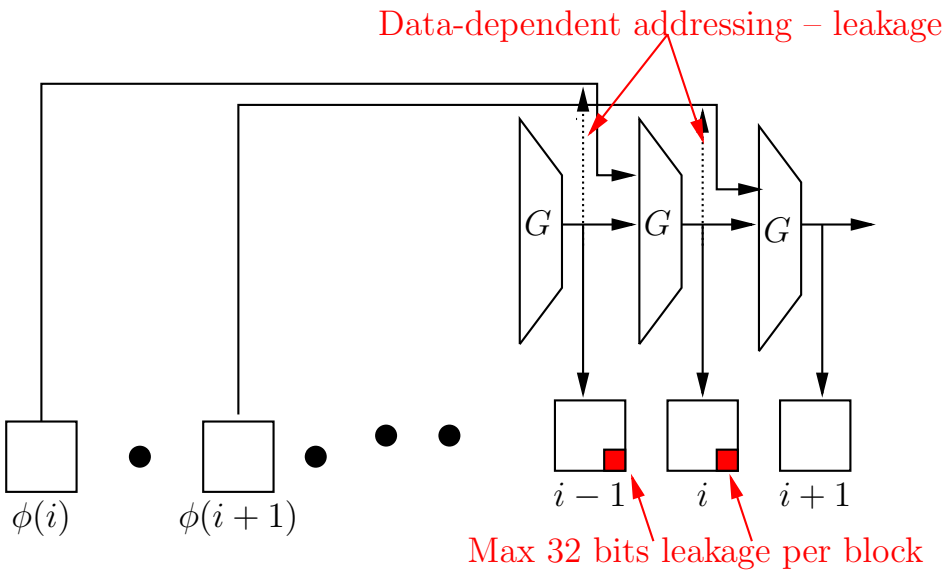
What can we infer from the side-channel analysis?

Side-channel attack?

Blocki (2017): suppose that the adversary has learned all data-dependent memory addresses.



Can we learn information on $B[\phi(i)]$ given the output of G, a wide Blake2b-based permutation?

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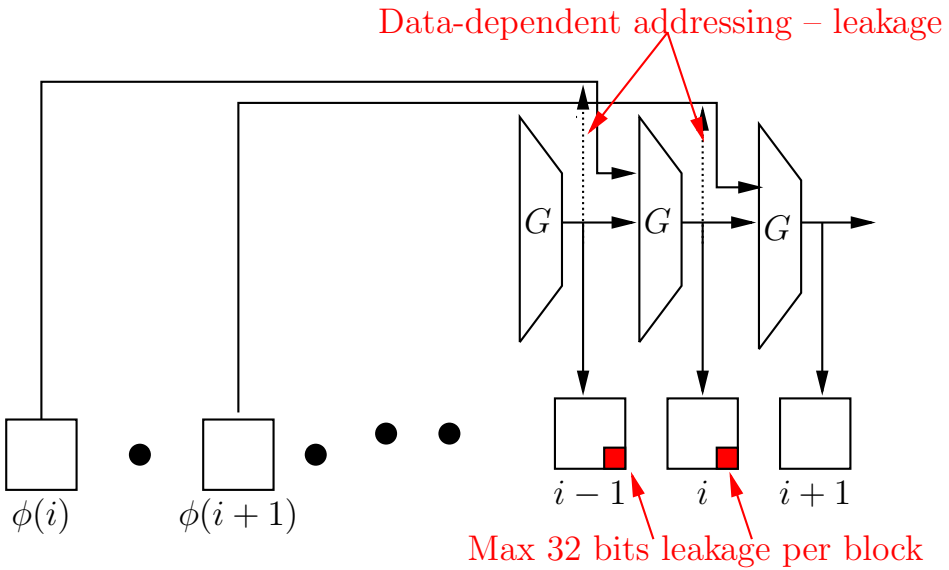

Can we learn information on $B[\phi(i)]$ given the output of G, a wide Blake2b-based permutation? Our experiments show no statistically significant correlation.

Final recommendations

1. Argon2id is the primary variant;
2. $T = 1$ pass is recommended.

Questions?

If no, approve the RFC draft.