Passwords are by far the most widely used mechanism to authenticate users on the web. Password databases on web servers are therefore attractive targets for attackers. Our system, SafeKeeper, protects web credentials using trusted hardware on web servers and a client-side browser extension. SafeKeeper is deployment-friendly at the server-side and verifiable at the client-side.

Current password database protection
- Random non-secret salt appended to each password to increase difficulty of guessing.
- Web server computes one-way function (e.g. cryptographic hash) before storing password.
- Attacker who obtains a database can still perform targeted offline password guessing.

Protecting credentials using trusted hardware
- Web server computes a keyed one-way function (e.g. CMAC using AES NI).
- Secret key protected within a trusted execution environment (TEE).
- Browser extension performs remote attestation and informs user about the result.
- Prevents offline password guessing.

Server-side password protection service
- Prototype using Intel Software Guard Extensions (SGX), PHPass, and WordPress.
- Performance evaluation (passwords/second):
  - PHPass: 446 (±10) p/s
  - SafeKeeper PHP: 1653 (±70) p/s
  - Enclave only: 101,337 (±4186) p/s

Client-side browser extension
- 86-participant on-site user study.
- Participants were shown 25 testing websites; some actively spoofed the SafeKeeper UI.
- Participants were asked to determine if the website protects passwords using SafeKeeper.
- Average accuracy: 87%.
- Follow-up study after 2 months without use: accuracy decreased by 2%.
- 94% rated the extension as “easy to use”.

ssg.aalto.fi/research/passwords