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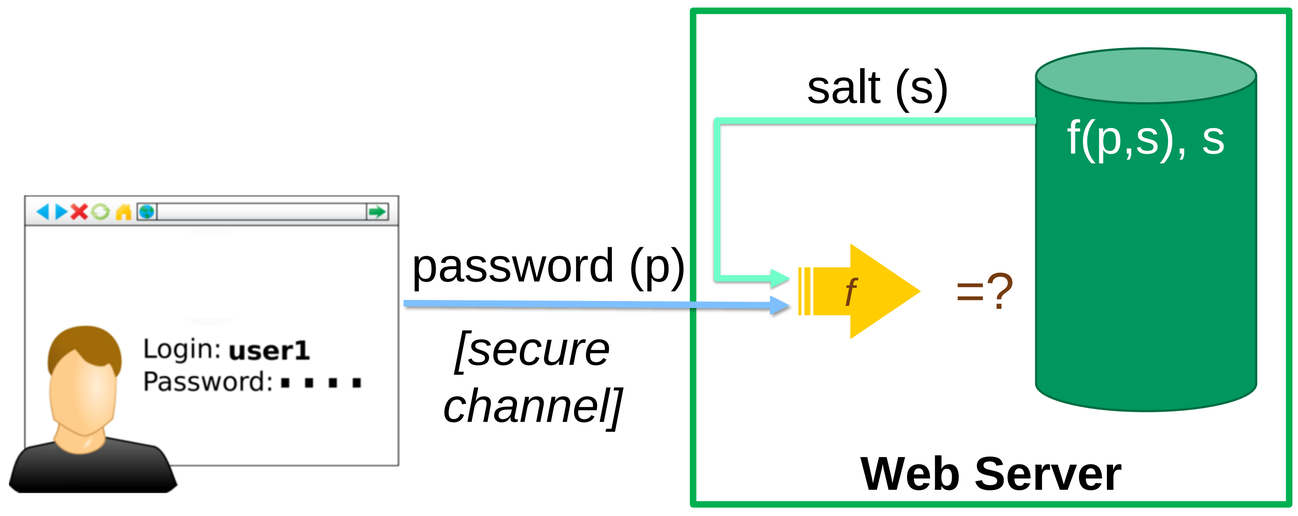
SafeKeeper: Protecting Web Passwords using Trusted Execution Environments

- 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.

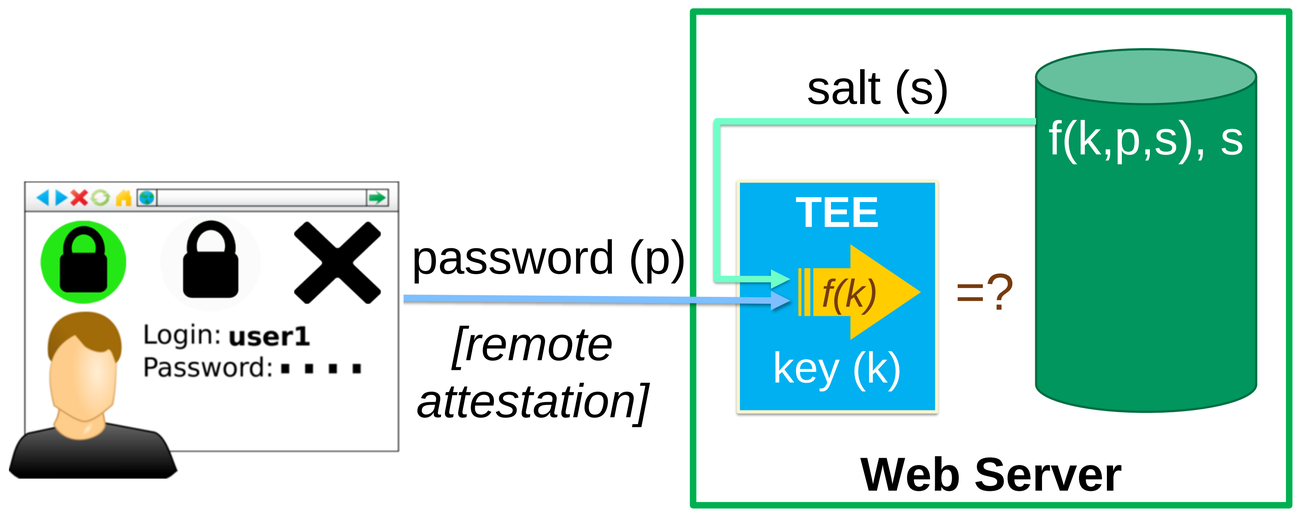
Current password database protection

- 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

ssg.aalto.fi/research/passwords

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”.

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