Aalto University
School of Science

Tekes

Collaborative Research Institute
for Secure Computing

Protecting Password Databases using Trusted Hardware

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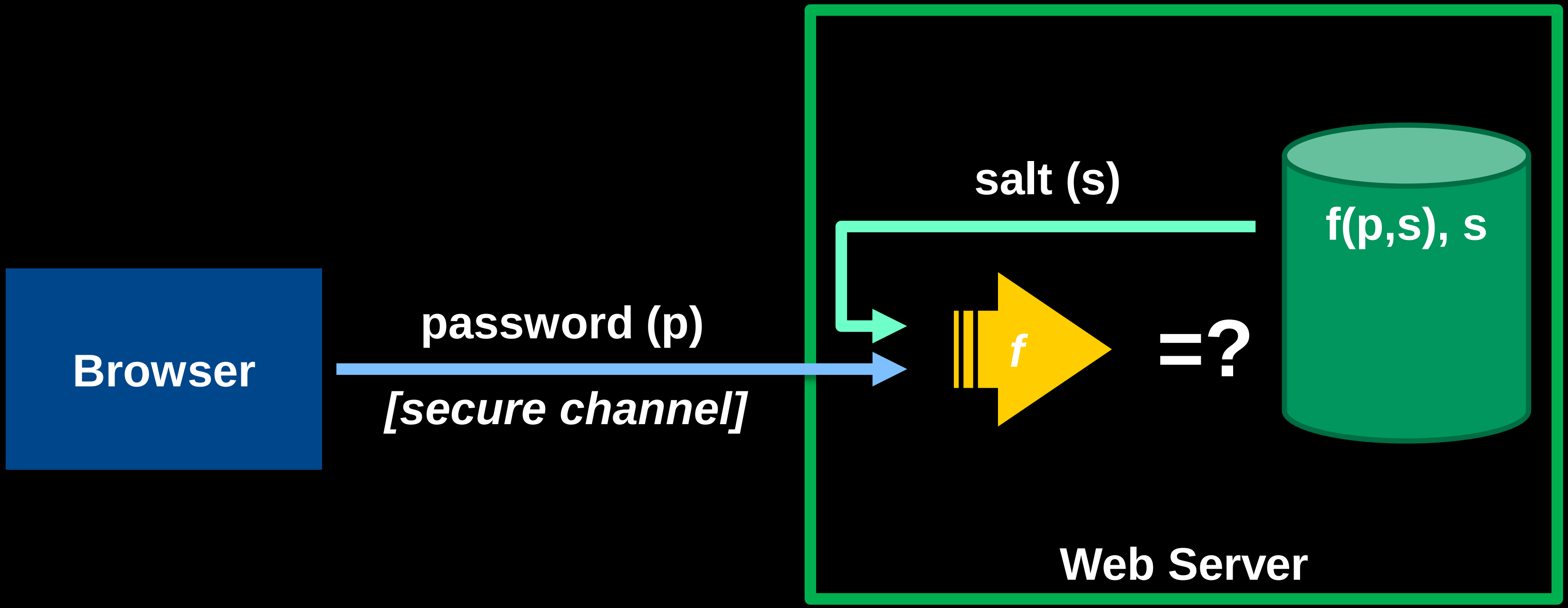
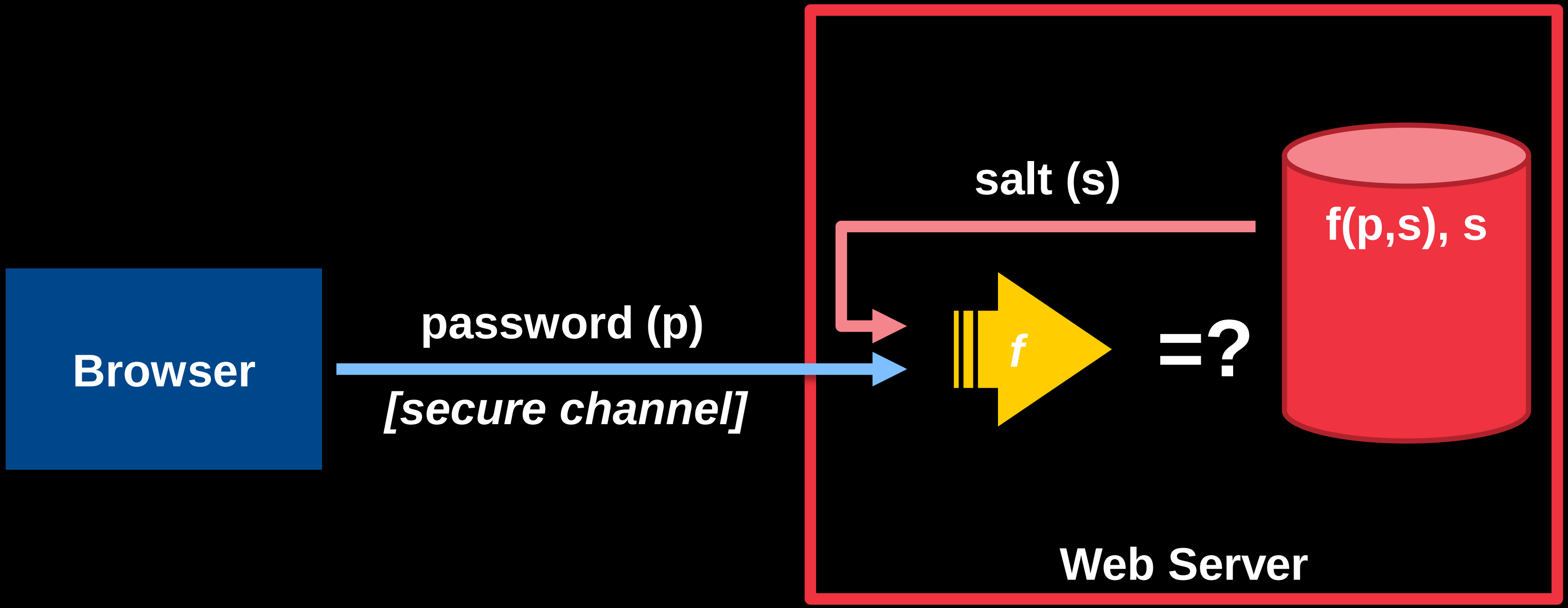
Aalto University, Finland

This work was supported by the Cloud Security Services (CloSer) project funded by Tekes - the Finnish Funding Agency for Innovation, and the Intel Collaborative Research Institute for Secure Computing.

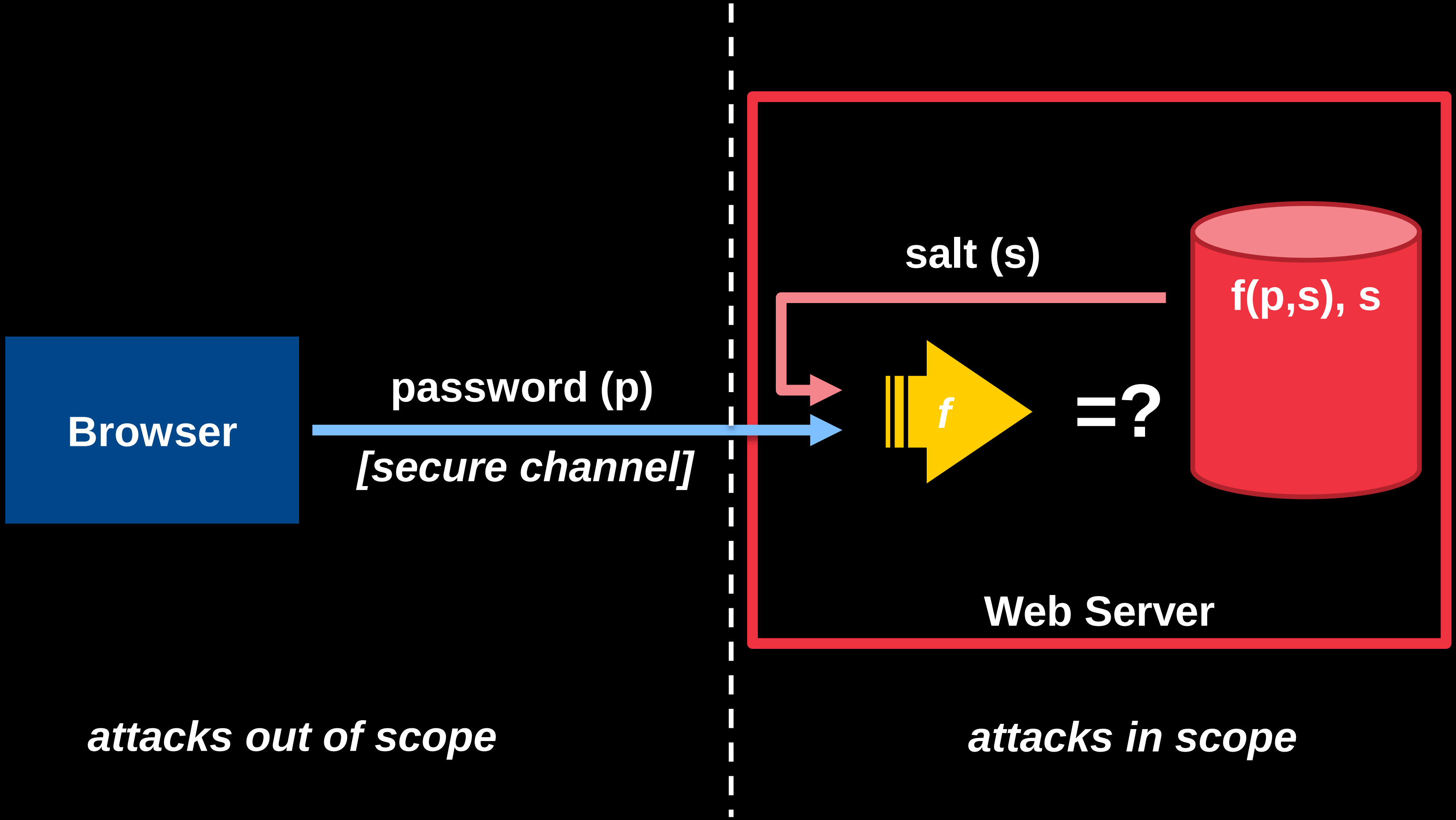
Storing Passwords



Storing Passwords


Browser
password (p)
[secure channel]
salt (s)
f
=?
f(p,s), s
Web Server

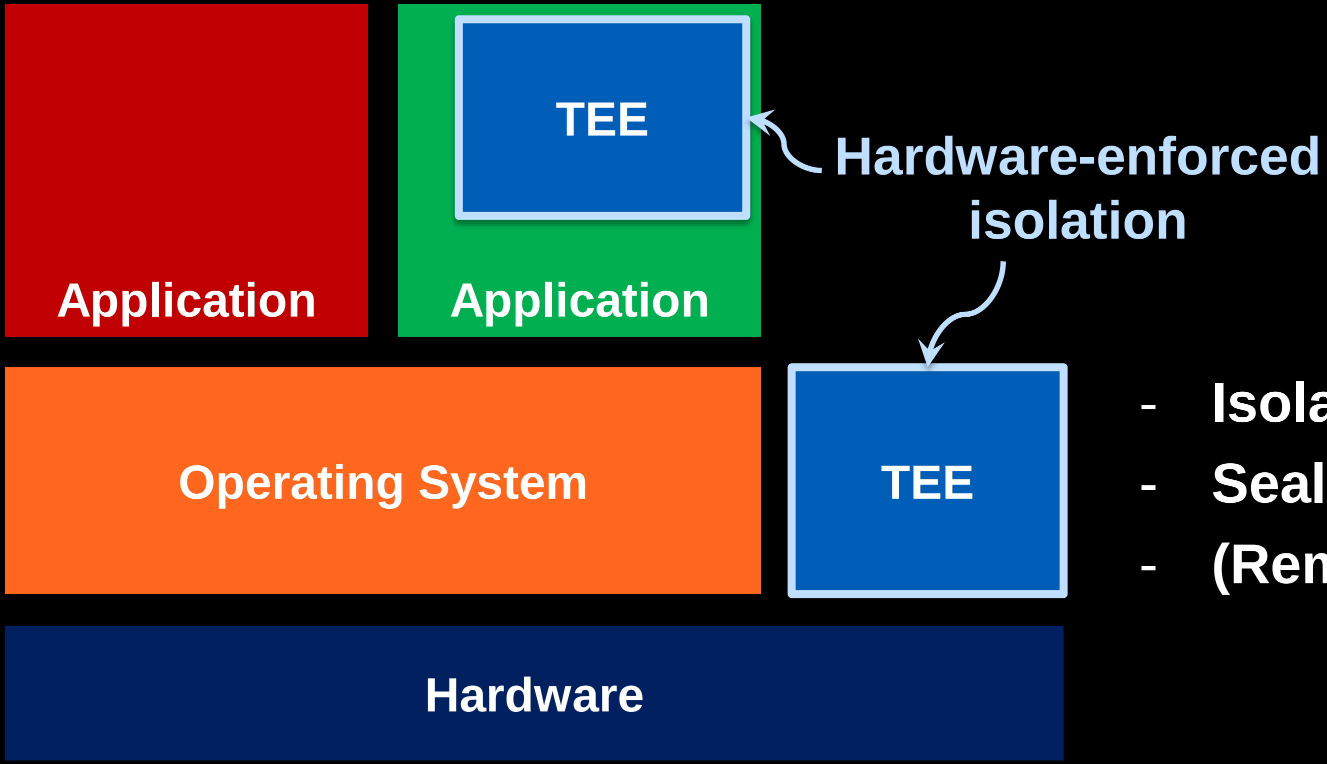
Storing Passwords



attacks out of scope

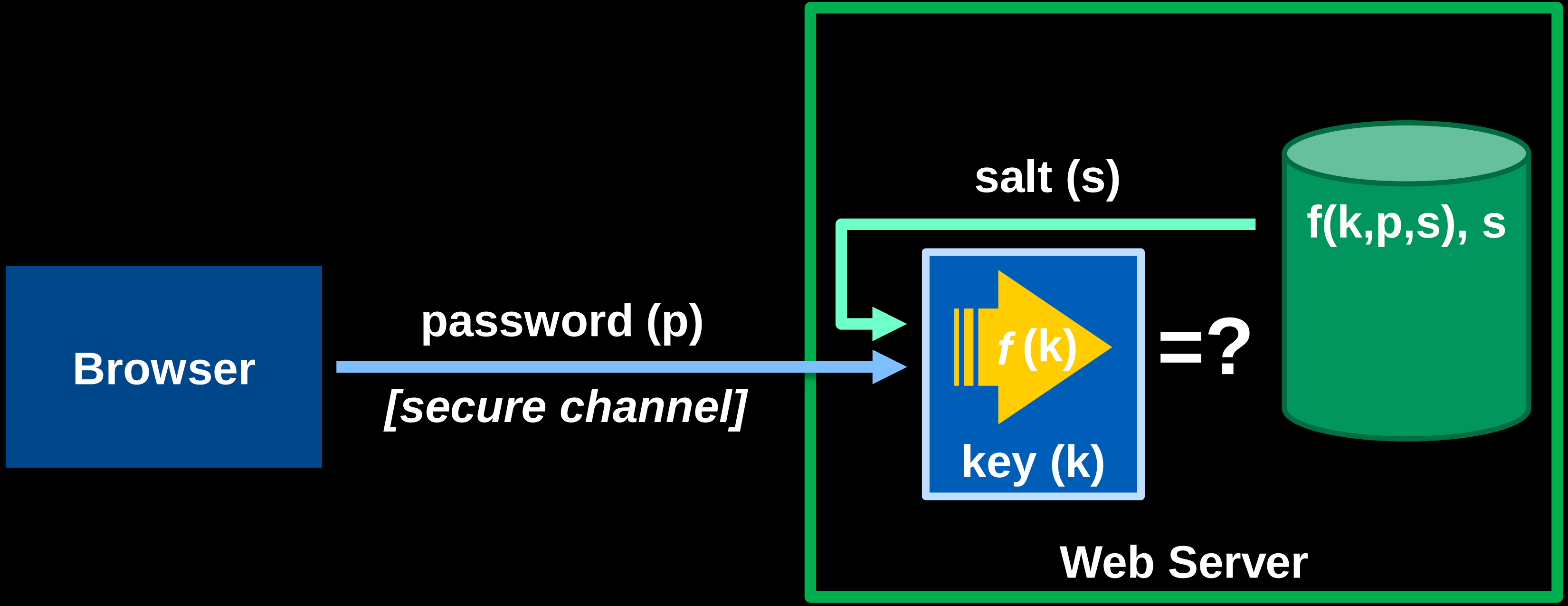
attacks in scope

Trusted Execution Environments

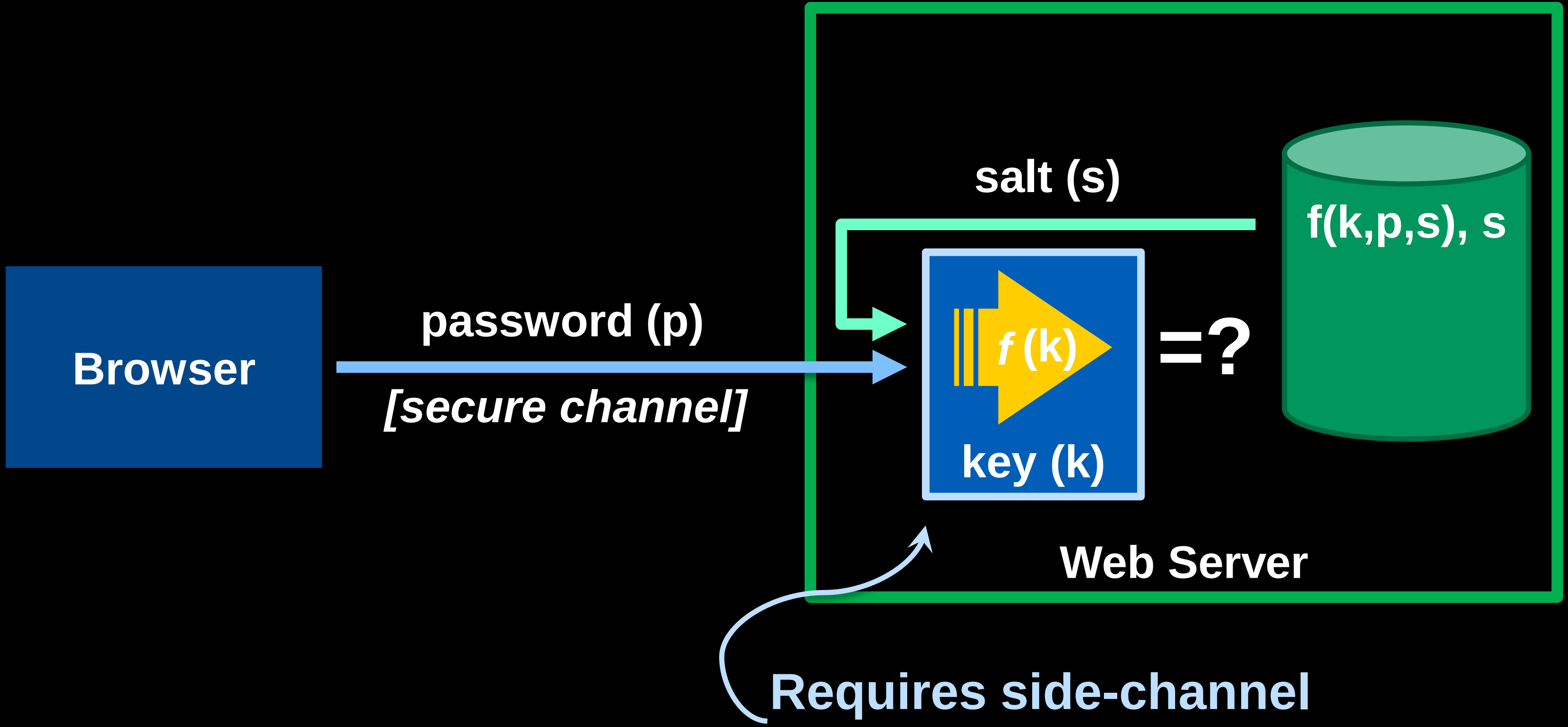


- Isolated execution
- Sealed storage
- (Remote attestation)

Storing Passwords *Securely*

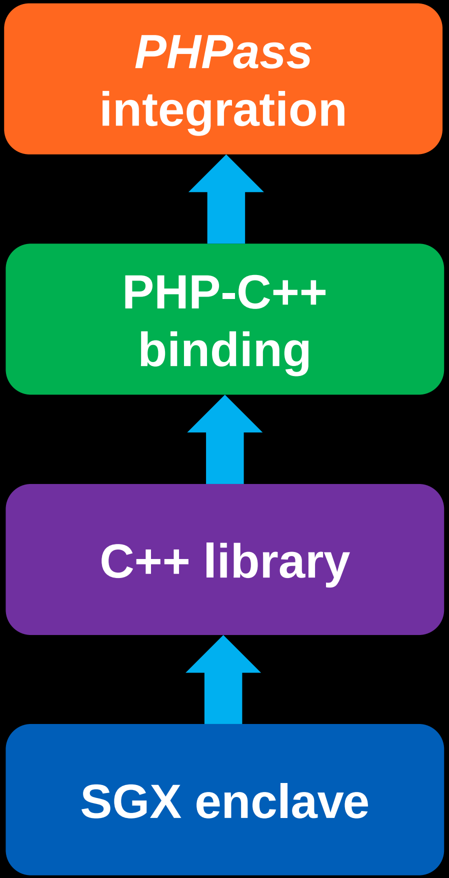


Storing Passwords *Securely*



Requires side-channel resistant design

Prototype



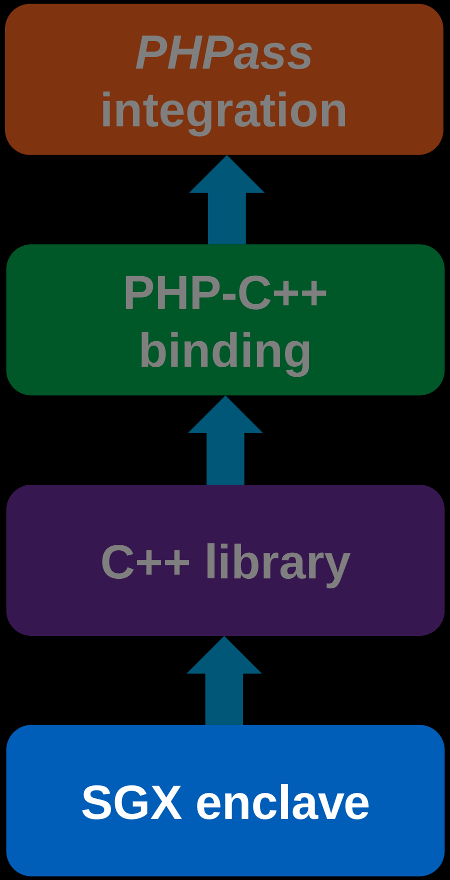
PHPass integration

PHP-C++ binding

C++ library

SGX enclave

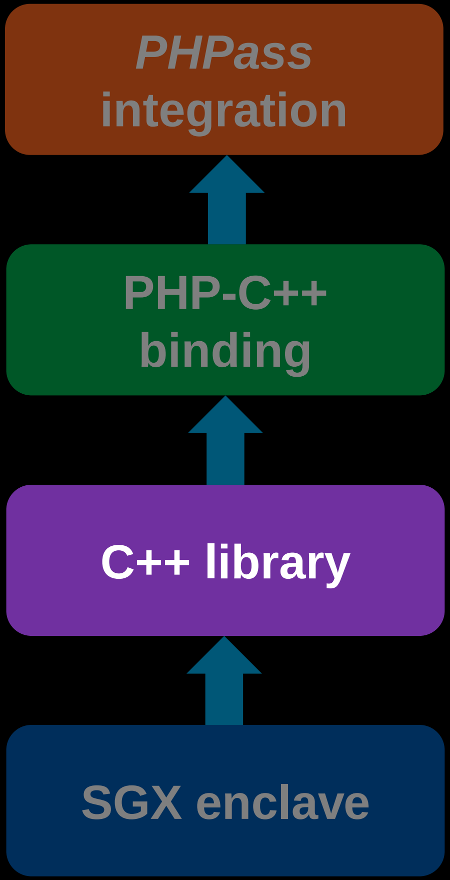
Prototype



- **Key generation or import**
- **Key sealing (MRENCLAVE)**
- **Keyed one-way function**
  - CMAC from *sgx_tcrypto* library
  - 128 bit key
  - AES-NI hardware acceleration
- **Lines of code: 60**

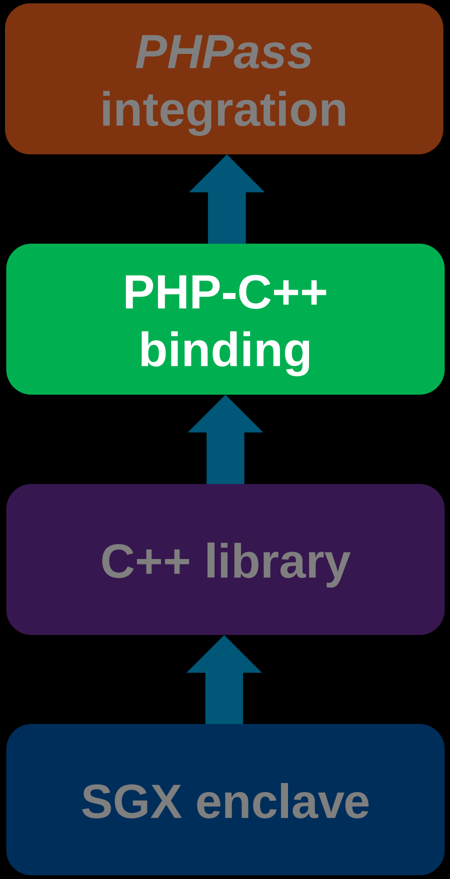
(+ Intel trusted libraries)

Prototype



- Enclave initialization
- Sealed data storage/retrieval

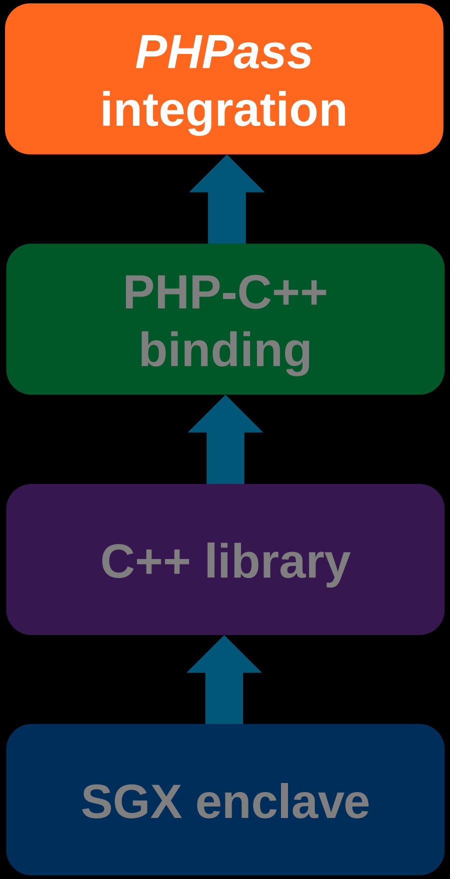
Prototype



- **PHP-CPP**
  - “C++ library for writing PHP extensions”

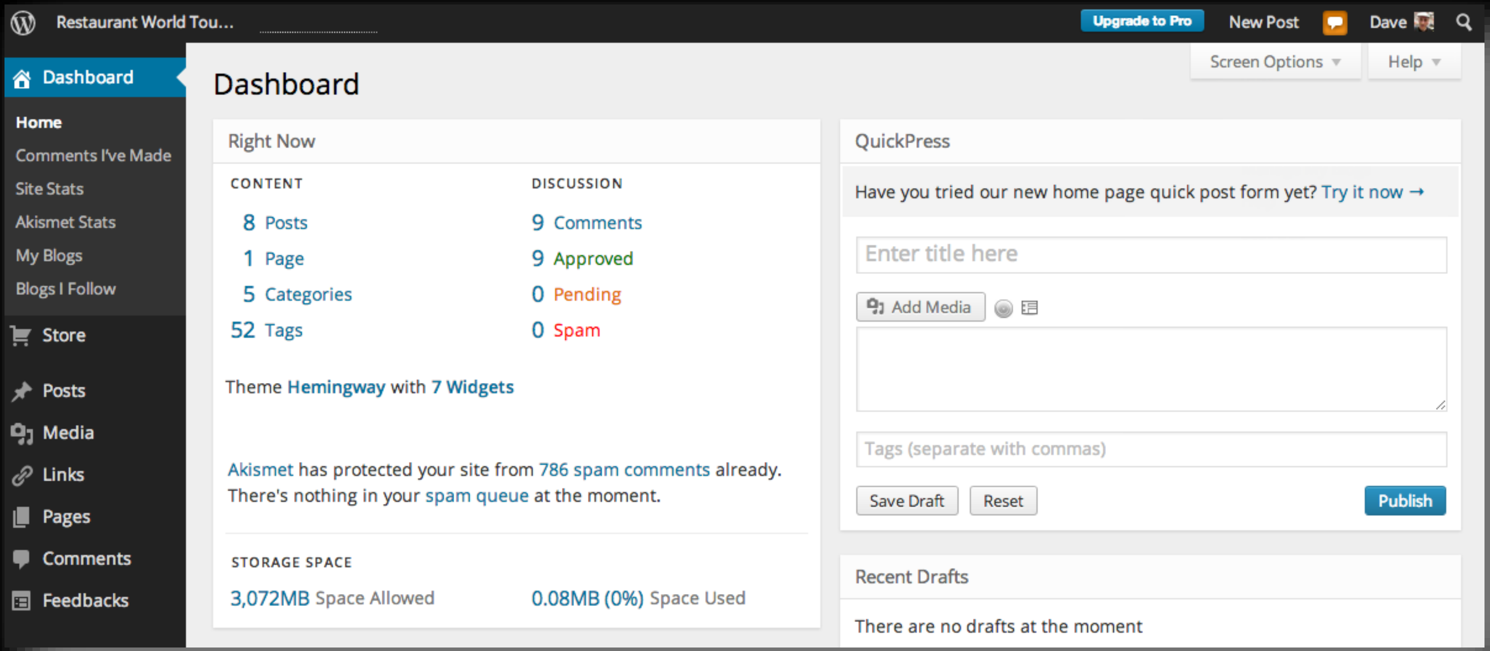
http://www.php-cpp.com/

Prototype



- Used by WordPress, Joomla, etc.
- Default: multi-round MD5 (!)
- Enhanced to use our SGX enclave

Prototype



Dashboard

Right Now

CONTENT		DISCUSSION	
8	Posts	9	Comments
1	Page	9	Approved
5	Categories	0	Pending
52	Tags	0	Spam

Theme Hemingway with 7 Widgets

Akismet has protected your site from 786 spam comments already. There's nothing in your spam queue at the moment.

STORAGE SPACE

3,072MB Space Allowed 0.08MB (0%) Space Used

QuickPress

Have you tried our new home page quick post form yet? Try it now →

Enter title here

Add Media

Tags (separate with commas)

Save Draft Reset Publish

Recent Drafts

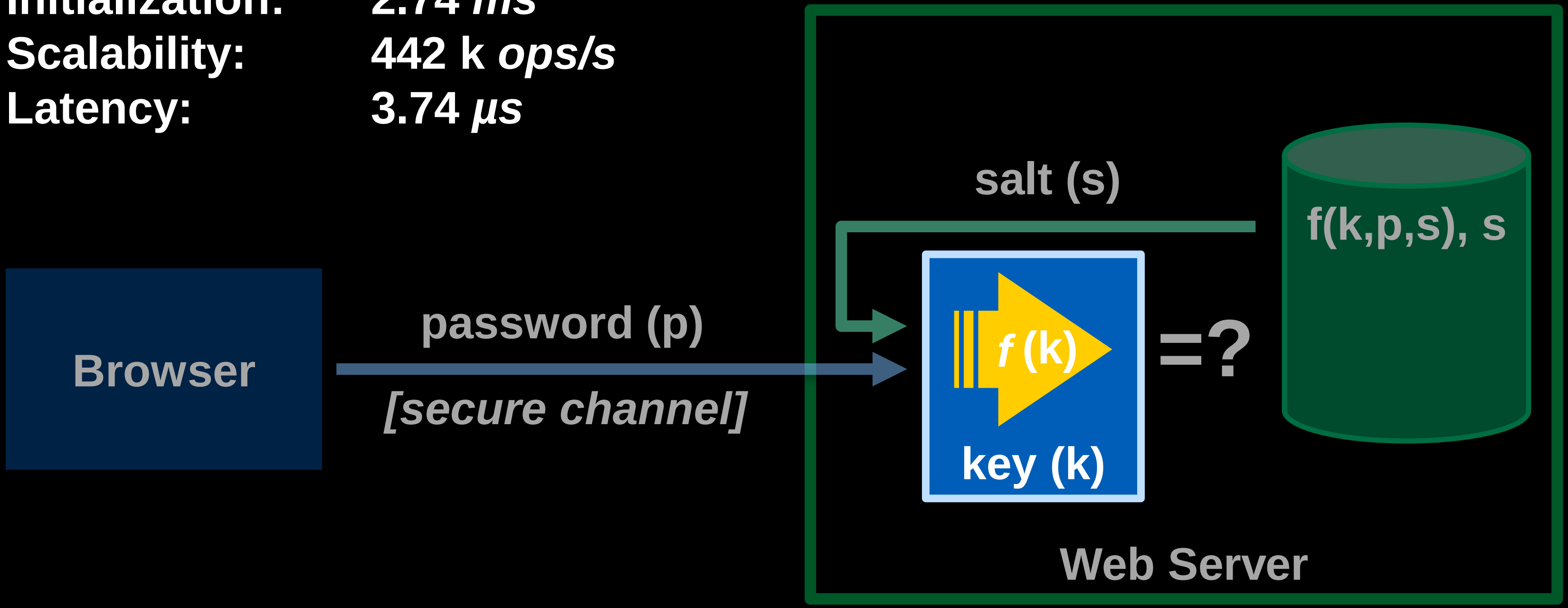
There are no drafts at the moment

Setup: Intel Core i5 6500 3.2 GHz, 8 GB RAM, Ubuntu 14.04
WordPress 4.5.3, PHP 5.5.9, Apache 2.4.7

Performance

single threaded

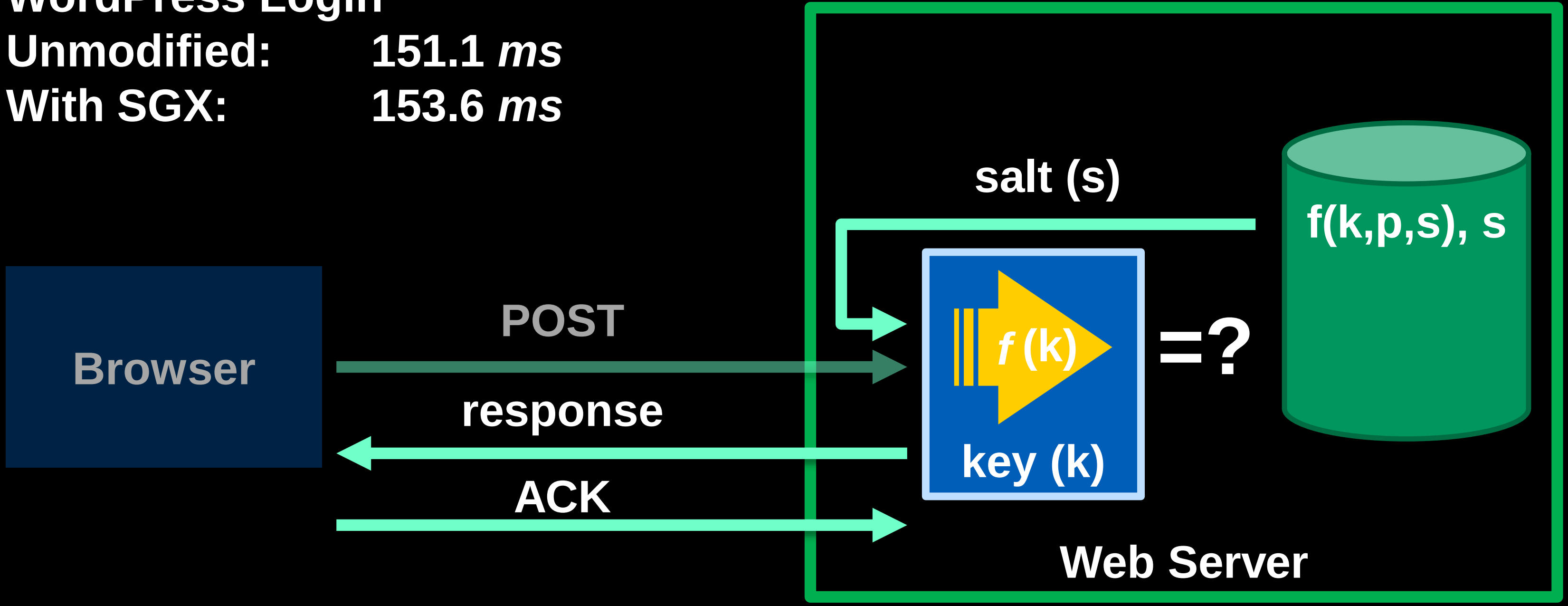
Initialization:	2.74 *ms*
Scalability:	442 k *ops/s*
Latency:	3.74 *µs*



Setup: Intel Core i5 6500 3.2 GHz, 8 GB RAM, Ubuntu 14.04

Performance

WordPress Login
Unmodified: 151.1 *ms*
With SGX: 153.6 *ms*



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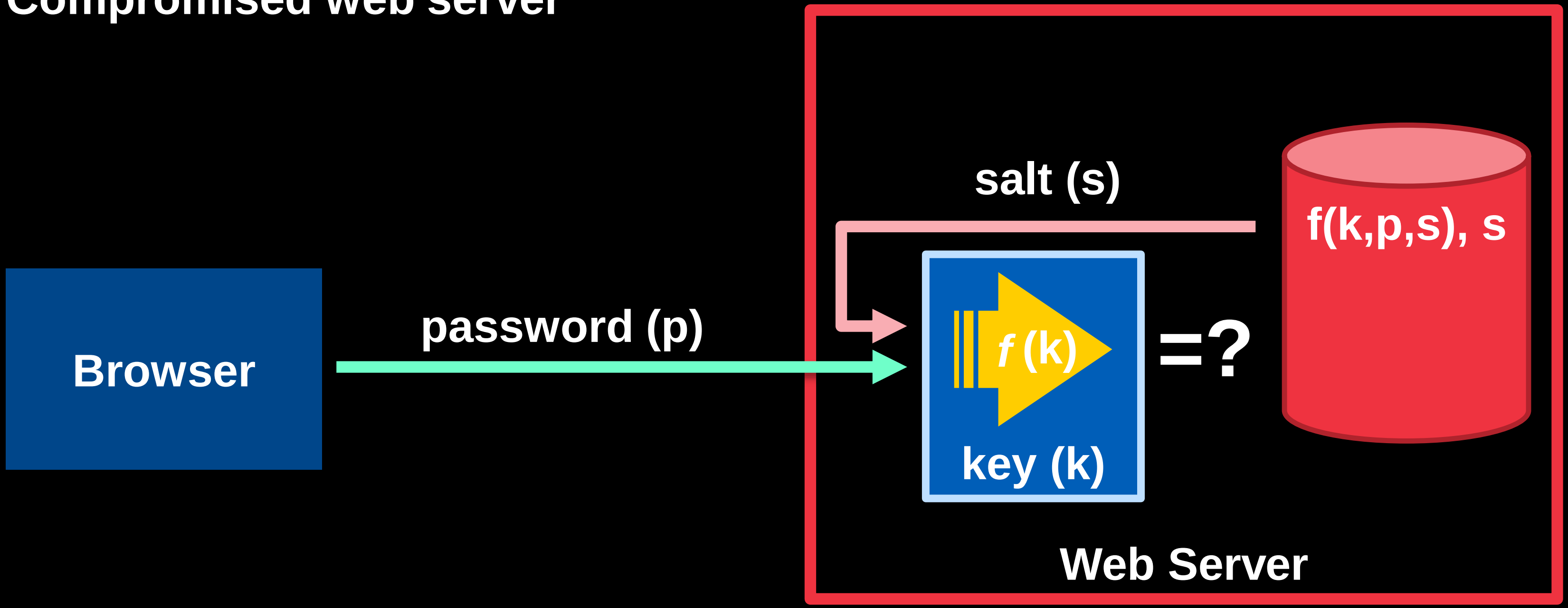
Work in Progress

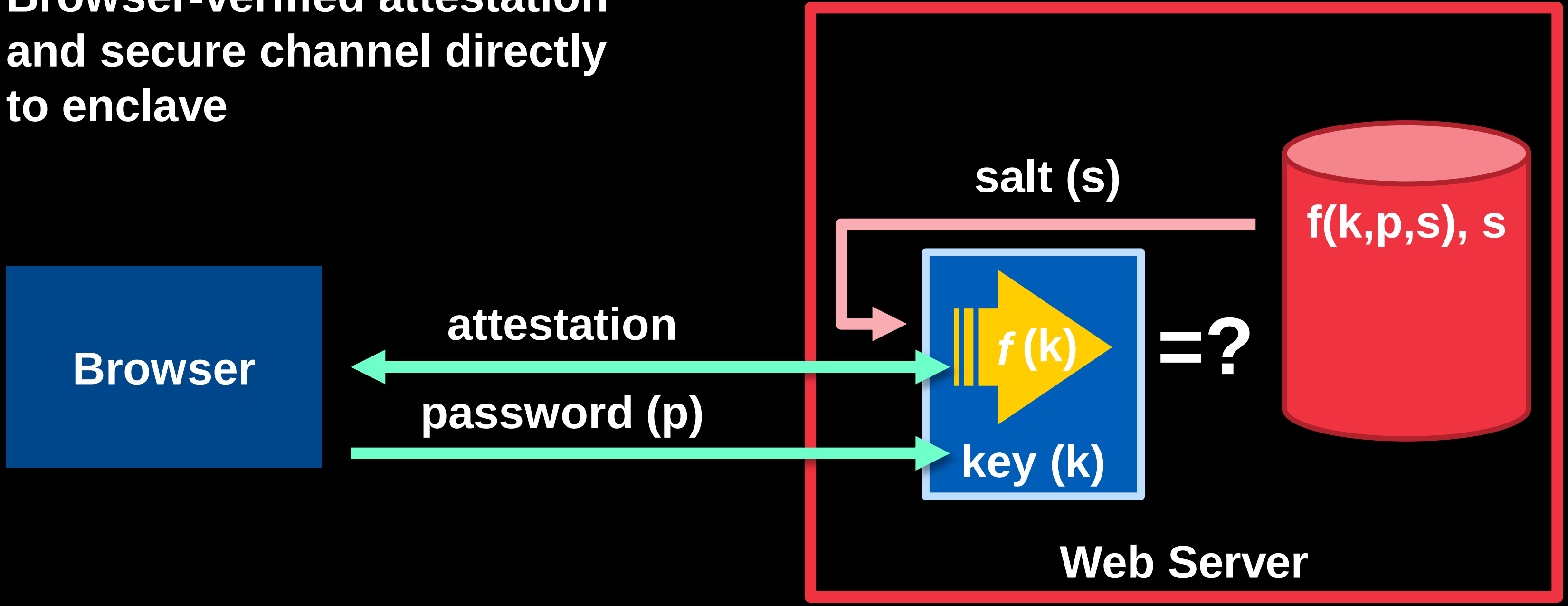
Compromised web server



Attacker learns passwords immediately

Work in Progress

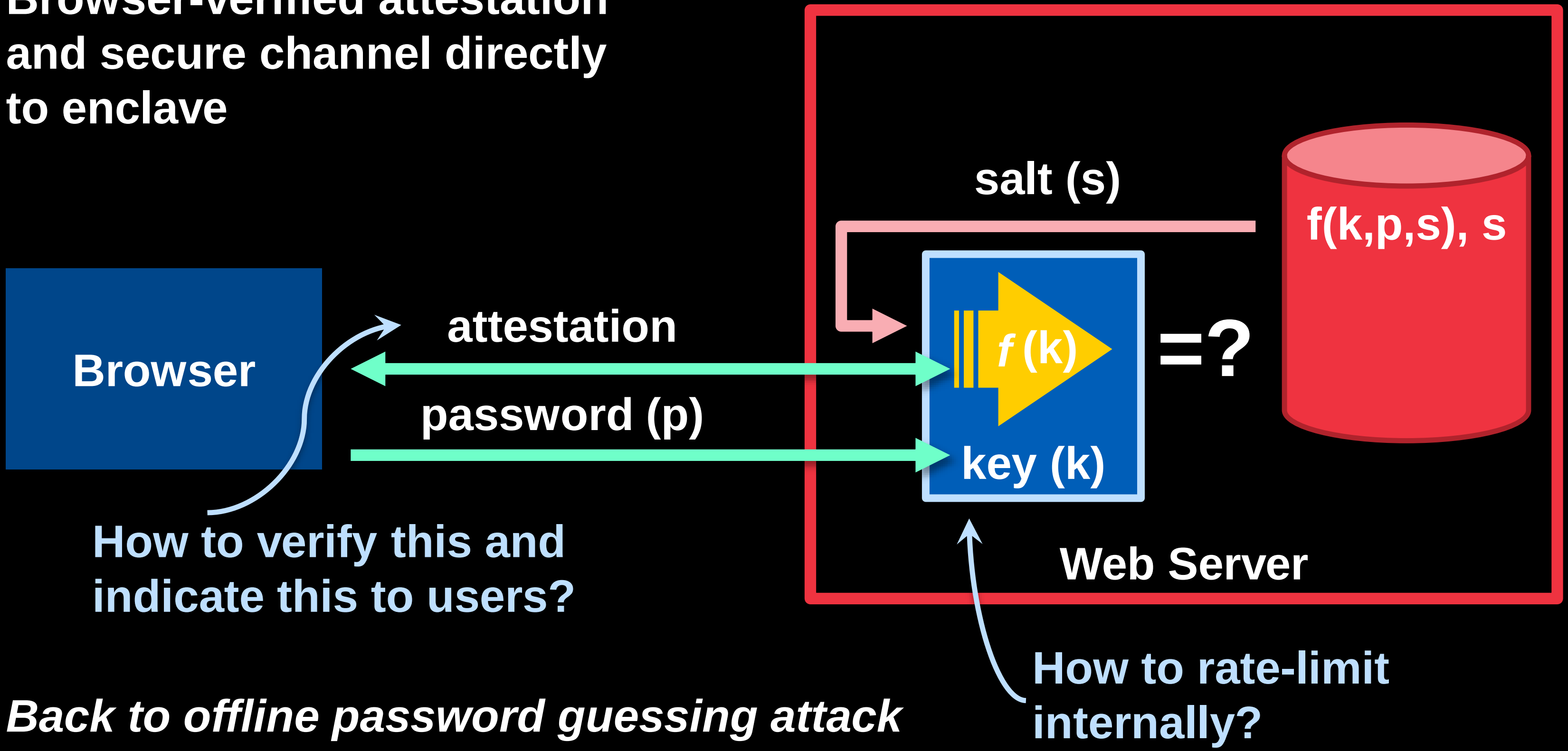
Browser-verified attestation and secure channel directly to enclave



Back to offline password guessing attack

Work in Progress

Browser-verified attestation and secure channel directly to enclave



How to verify this and indicate this to users?

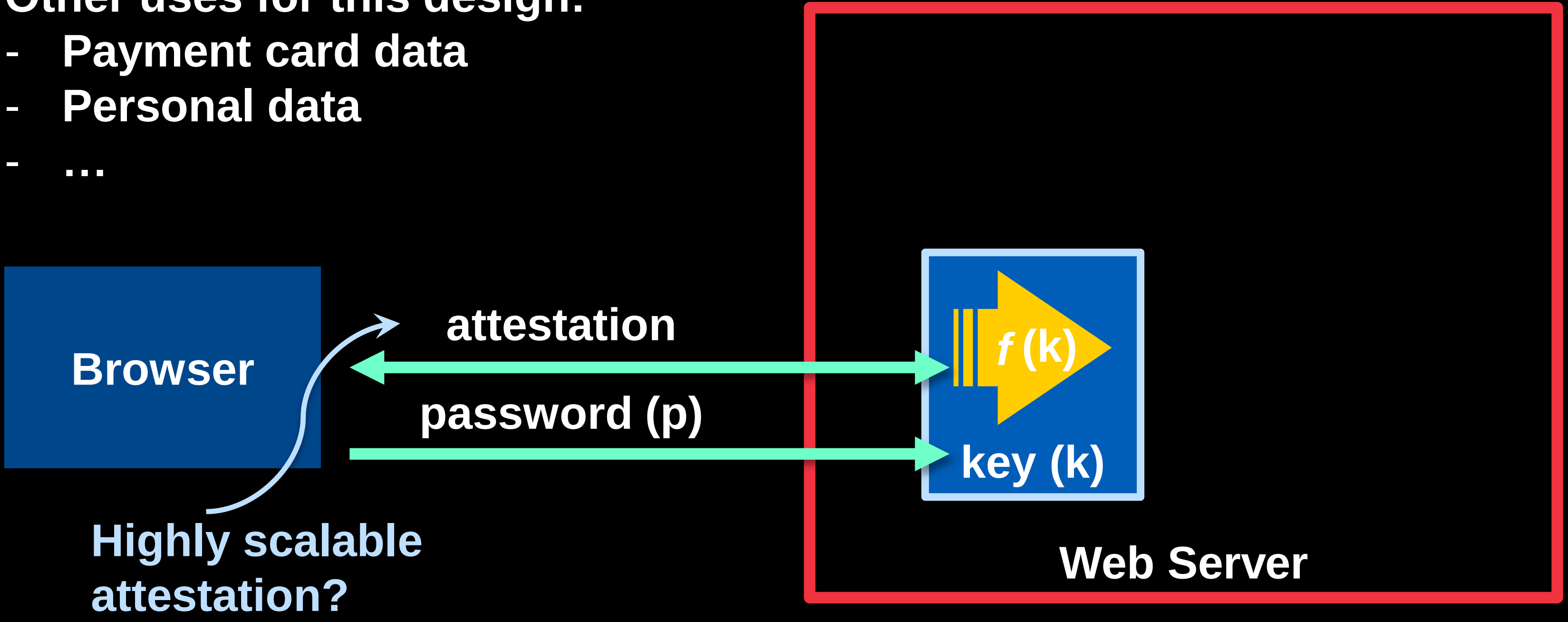
How to rate-limit internally?

Back to offline password guessing attack

Work in Progress

Other uses for this design:

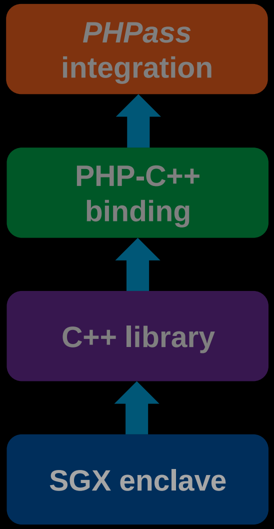
- Payment card data
- Personal data
- …



c.f. Lyle & Martin. "Engineering attestable services" *TRUST*, 2010.

Conclusion

- TEEs can help to protect password databases
- Can be integrated into existing systems
- Performance is sufficient
- Some challenges still remain
- Potential for future work



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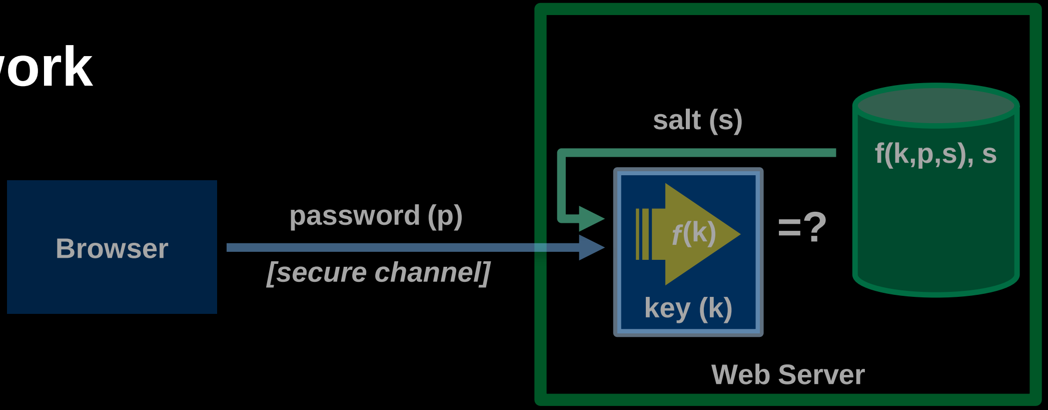

Browser

password (p)

[secure channel]

salt (s)

f(k)

key (k)

=?

f(k,p,s), s

Web Server