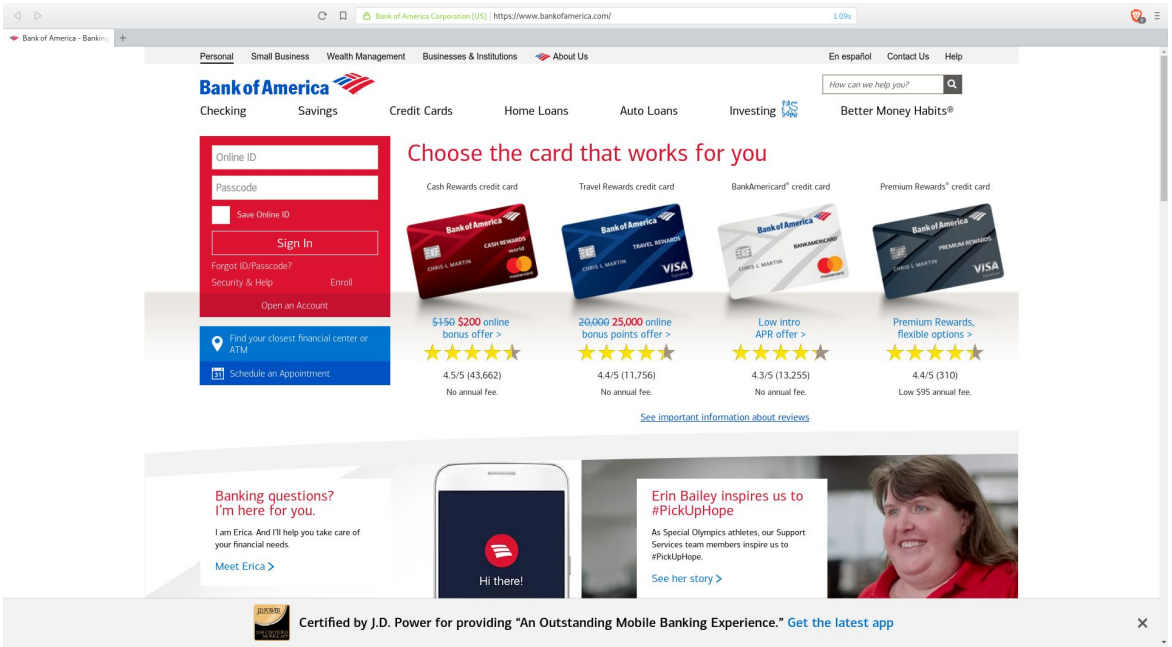
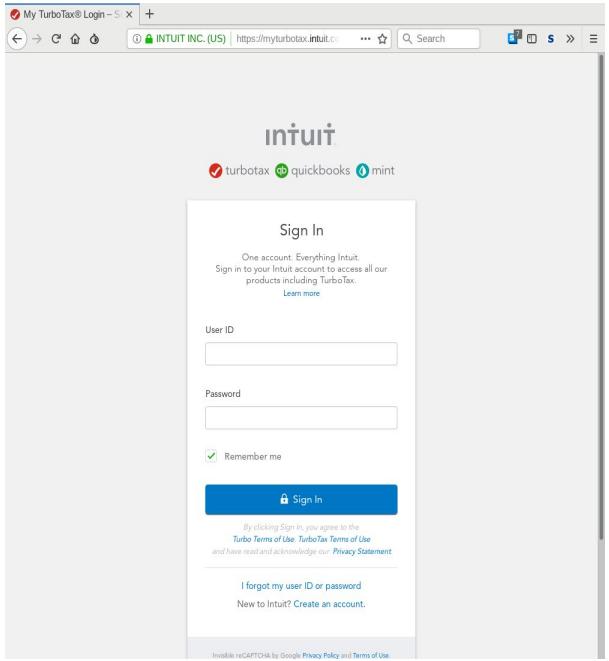
Fidelius: Protecting User Secrets from Compromised Browsers

Saba Eskandarian, Jonathan Cogan, Sawyer Birnbaum, Peh Chang Wei Brandon, Dillon Franke, Forest Fraser, Gaspar Garcia, Eric Gong, Hung T. Nguyen, Taresh K. Sethi, Vishal Subbiah, Michael Backes, Giancarlo Pellegrino, Dan Boneh

CISPA
HELMHOLTZ CENTER FOR INFORMATION SECURITY

In Browsers we Trust





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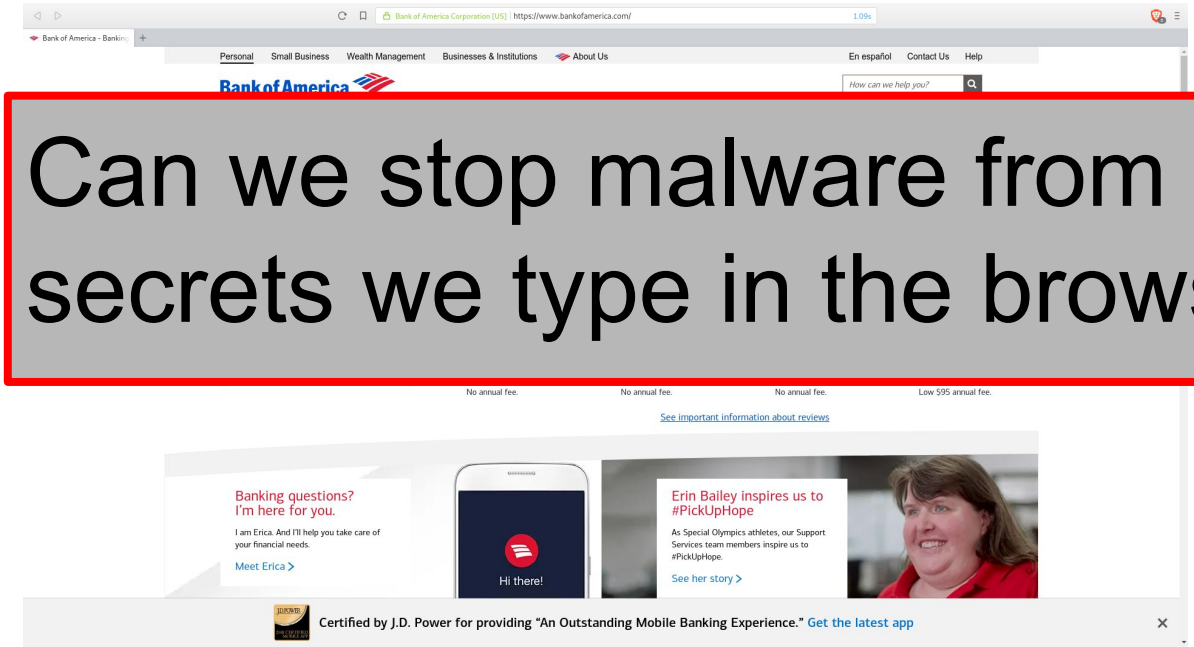
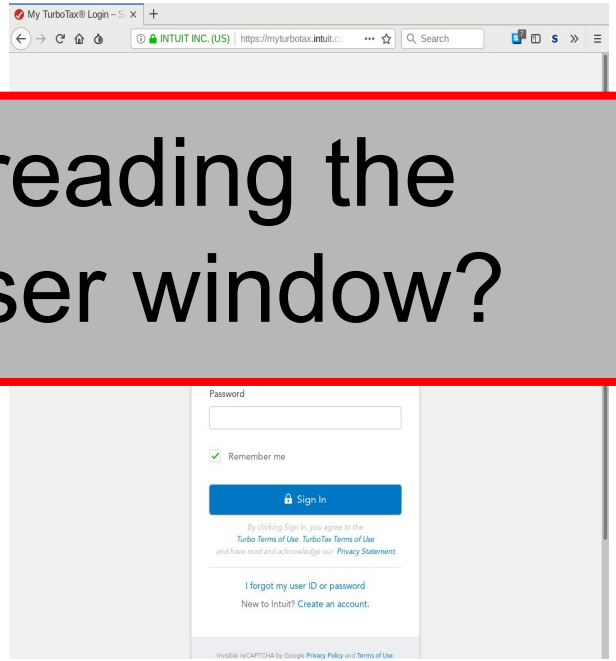


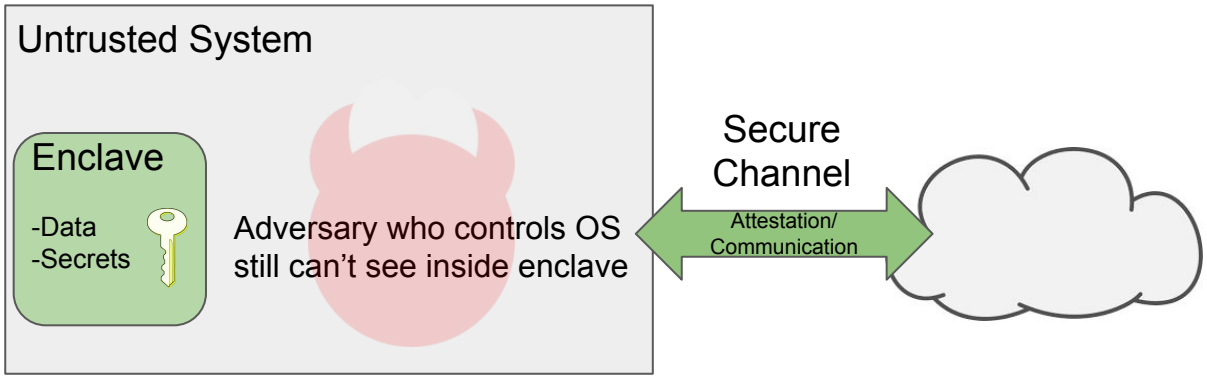


Can we stop malware from reading the secrets we type in the browser window?

Hardware Enclaves

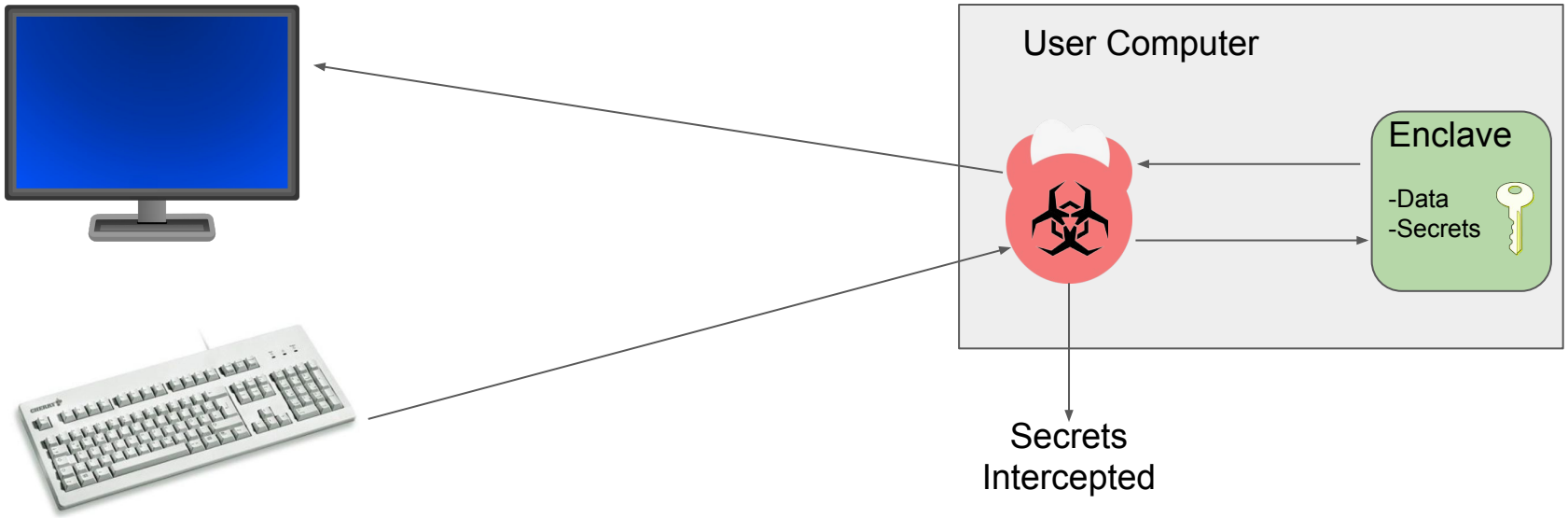
A trusted component in an untrusted system

- Protected memory isolates enclave from compromised OS
- Proves authenticity via *attestation*
- Enclaves in our implementation use Intel SGX



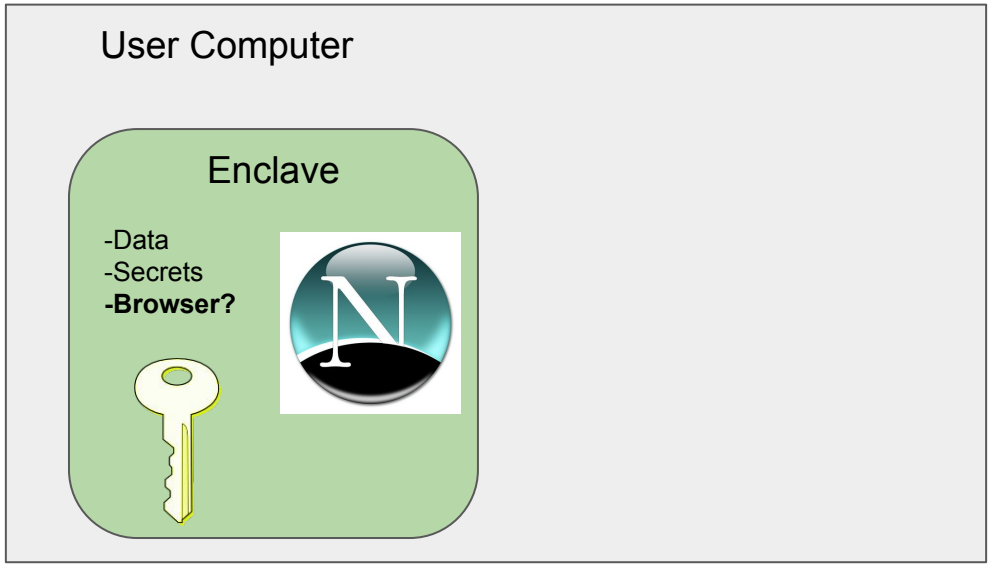
Challenges

1. Enclave only interacts with outside world through OS



Challenges

2. Browsers have a LOT of code and many bugs/vulnerabilities.



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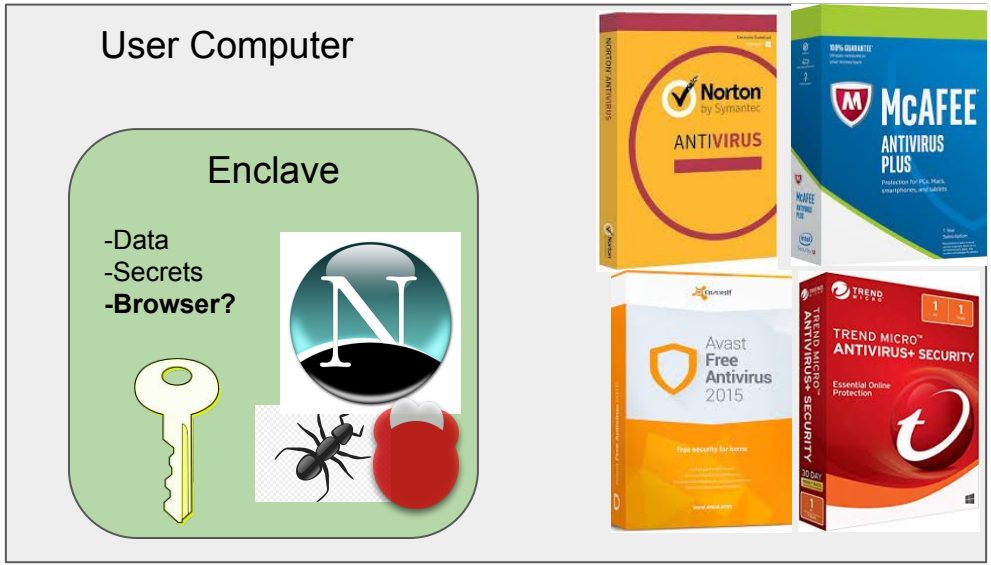
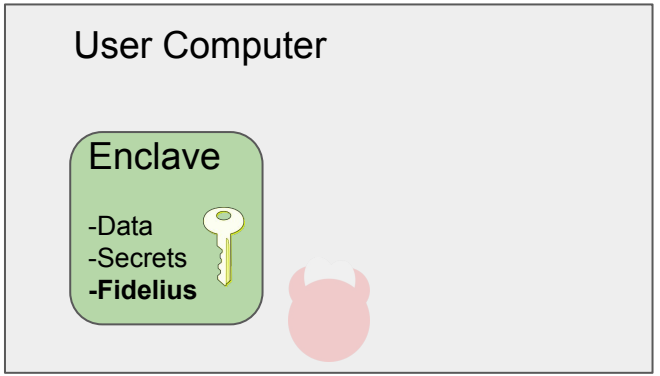
   Vulnerable code in enclave → super-malware!



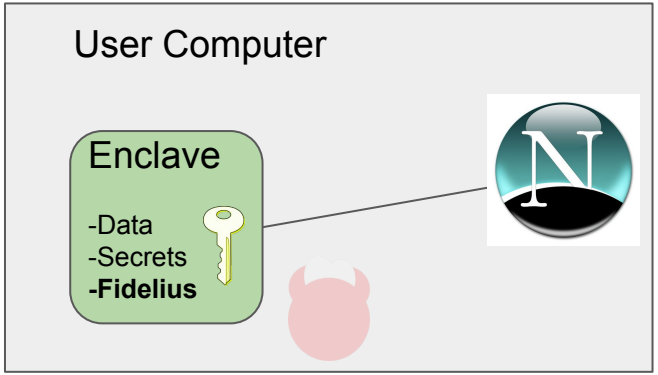
The Fidelius System

Goal: protect user keyboard inputs to browser from fully compromised OS



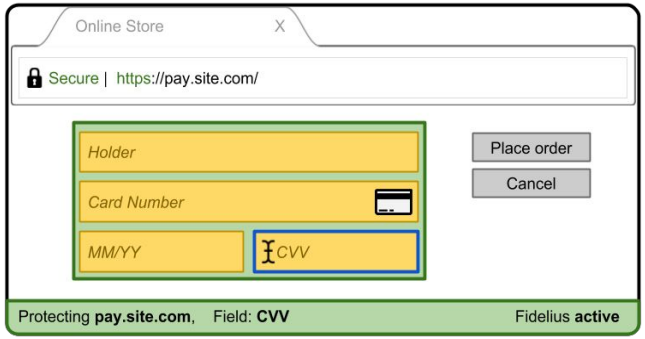
The Fidelius System

Keeps browser outside of hardware enclave

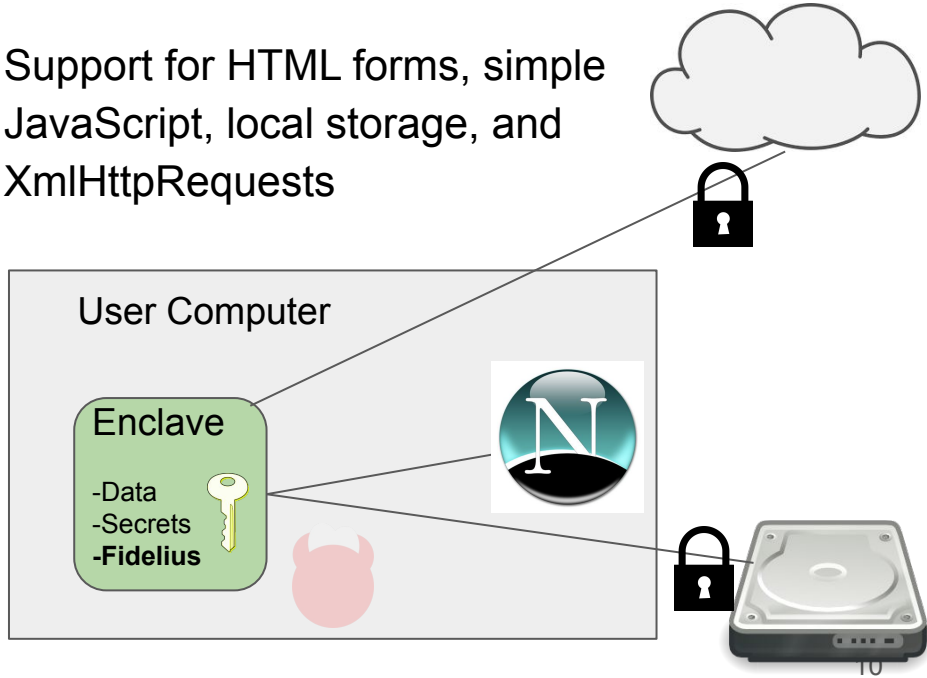


Related earlier approach: Microsoft Palladium...

The Fidelius System



Support for HTML forms, simple JavaScript, local storage, and XmlHttpRequests



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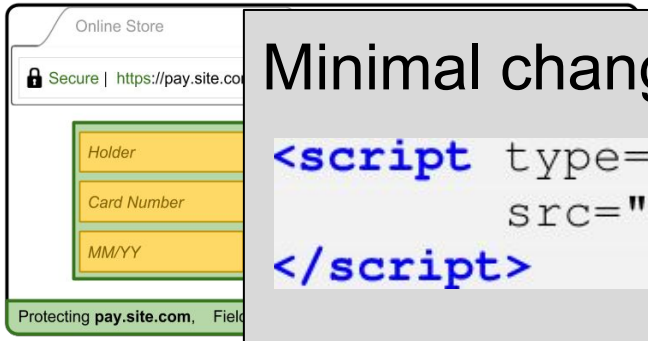

Minimal changes for developers

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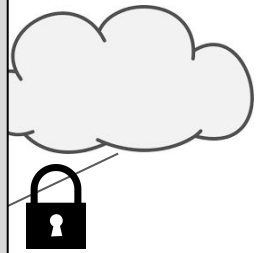

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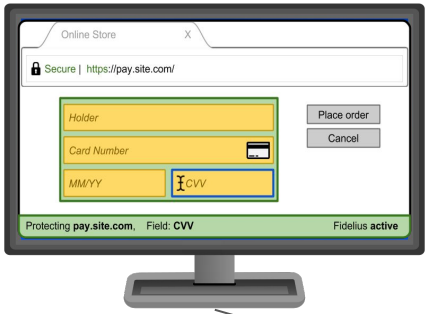
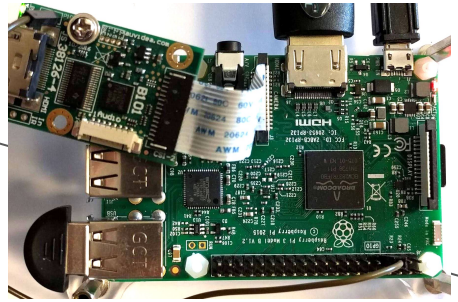
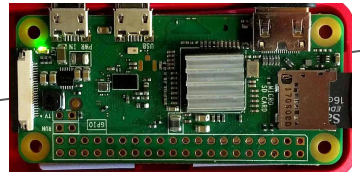


Trusted path from enclave to secure I/O devices





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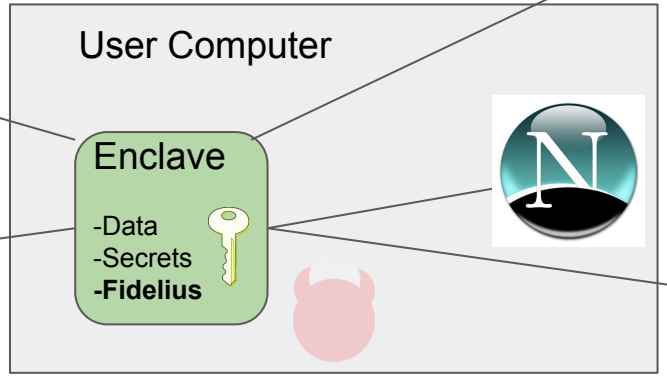

Trusted Path to/from Enclave

Keyboard/display dongles built from Raspberry PIs

Dongles switch between trusted/untrusted modes

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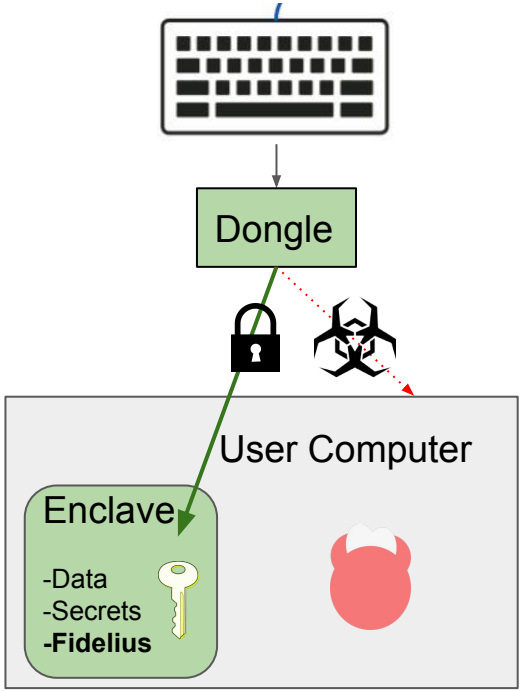
Keyboard: encrypt keystrokes at constant rate



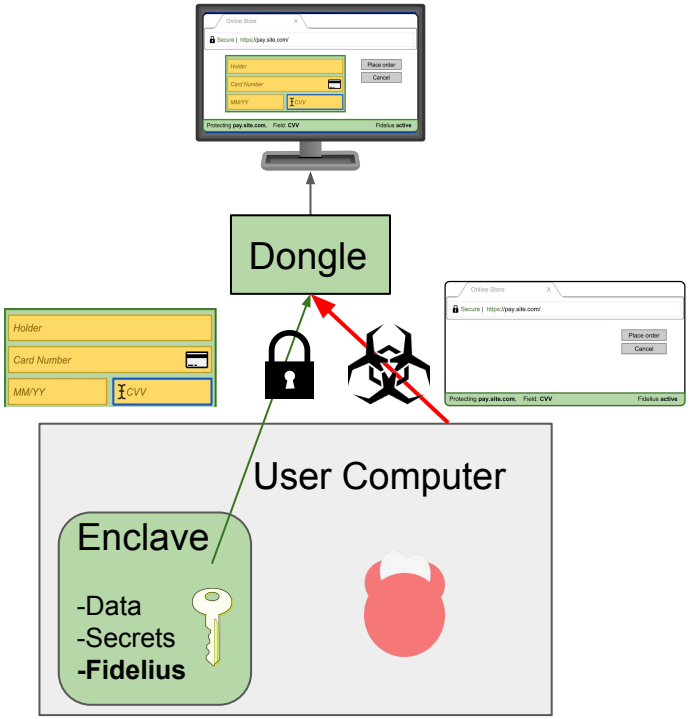
Trusted Path to/from Enclave

Keyboard/display dongles built from Raspberry PIs

Dongles switch between trusted/untrusted modes

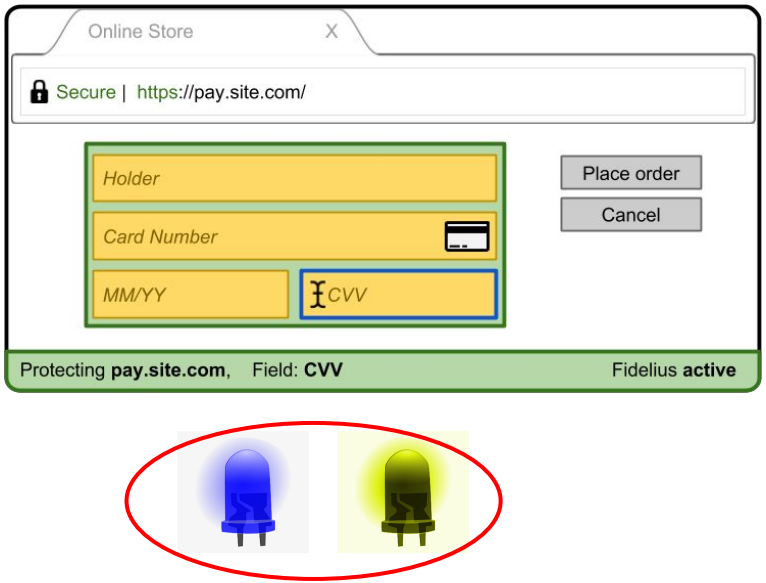
Keyboard: encrypt keystrokes at constant rate

Display: decrypt overlays sent by enclave



Fidelius for Users

Security indicator lights for keyboard and display



Schechter and Dhamija, The Emperor's New Security Indicators. S&P 2007.

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Green overlay verifies who gets data and what data you are giving

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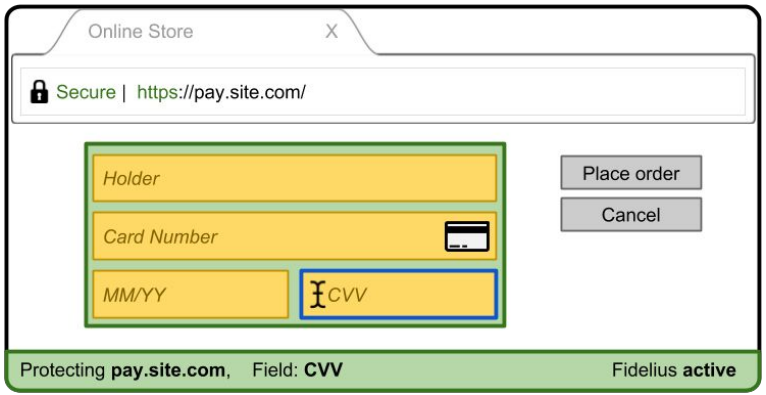
Fidelius for Users

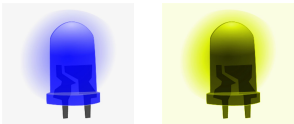
Security indicator lights for keyboard and display

Green overlay verifies who gets data and what data you are giving

Security relies on users watching

indicators (in our prototype)





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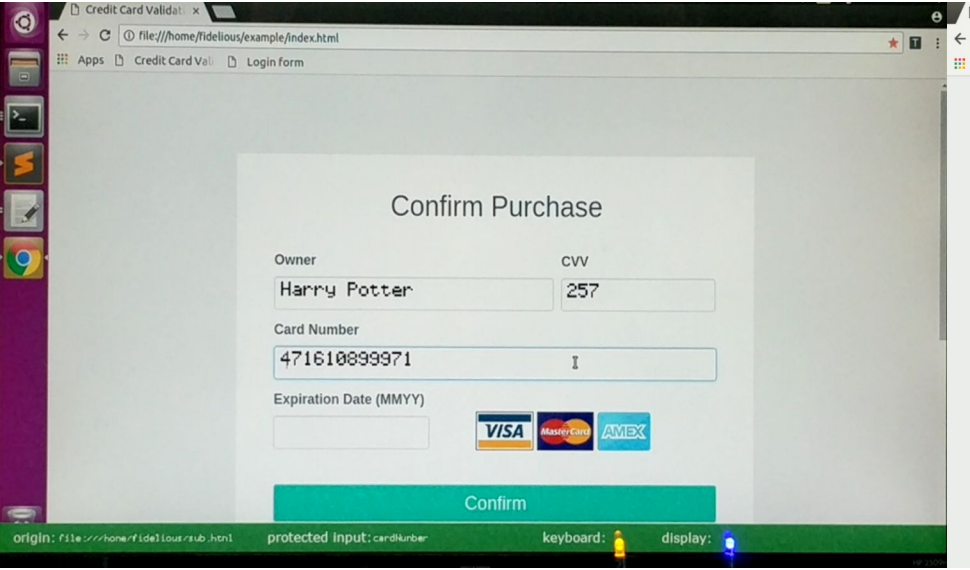
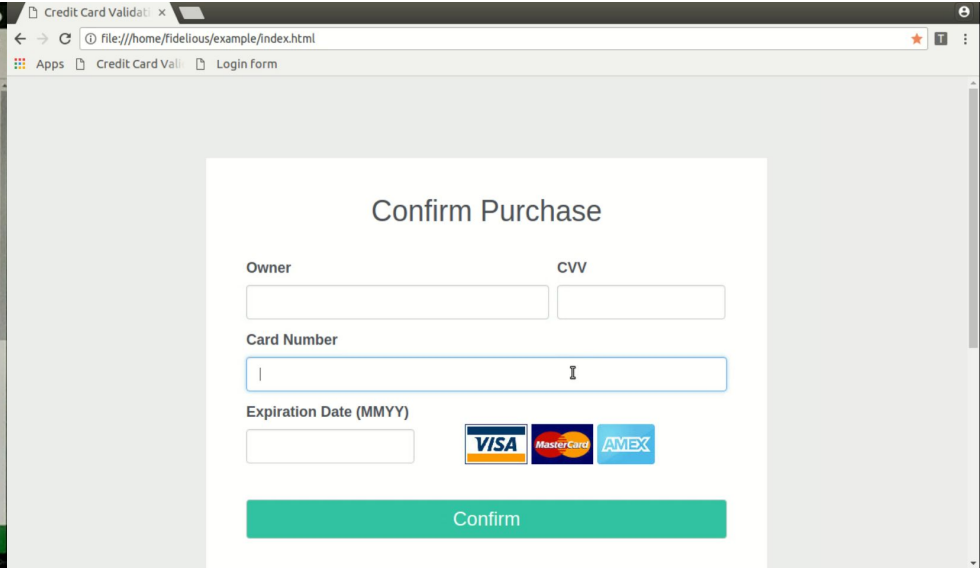
Example

User view (photograph)



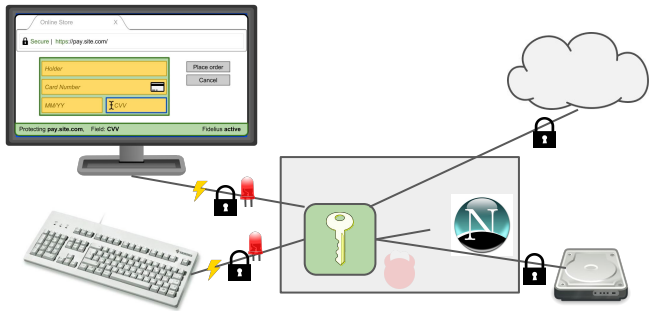
Malware view (screen capture)



See video demo at https://crypto.stanford.edu/fidelius

What Fidelius Does

- Secure user I/O against tampering, eavesdropping, replay, etc.
- Give trusted Javascript local access to sensitive data
- Only allow data to be sent to designated destination



What Fidelius Does Not Do

- Secure hardware enclave against side-channel attacks
  [XCP’15,GESM’17,BMD+’17,WKPK’17,LSG+’17,CCX+’18,BMW+’18]

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- Secure hardware enclave against side-channel attacks
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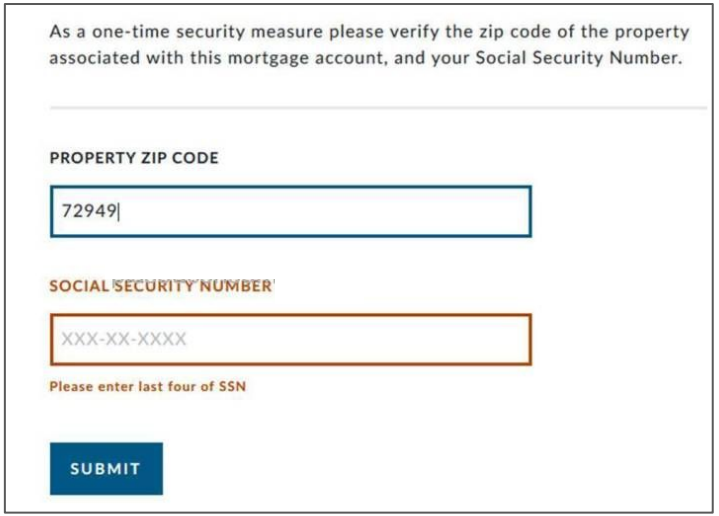
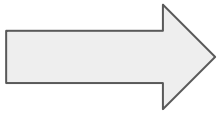
- Protect against dumb web sites





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TCB: ~8,500 lines of C++

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1 Small	171	50	8,550	195.83	-
1 Medium	342	50	17,100	199.20	3.38
1 Large	683	50	34,150	209.65	10.45
1 Extra large	911	50	45,550	214.74	-
2 Extra large	911	100	91,100	227.02	12.28

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Doubling trusted display size only slightly increases display latency

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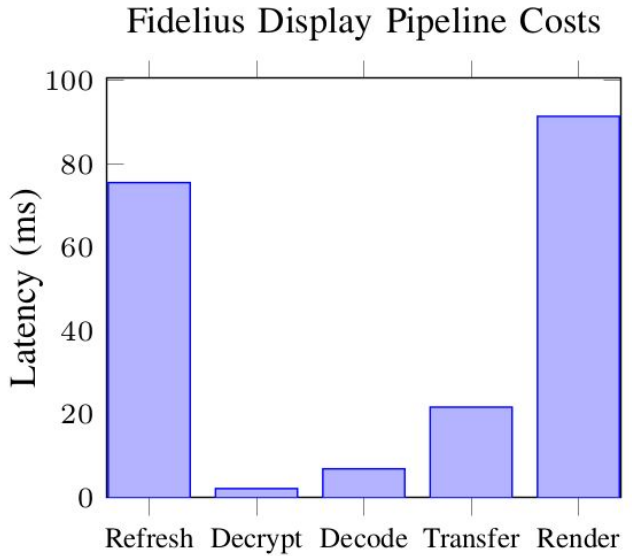
Display Bottlenecks

Expensive Render/Refresh due to implementation hacks, easily improvable



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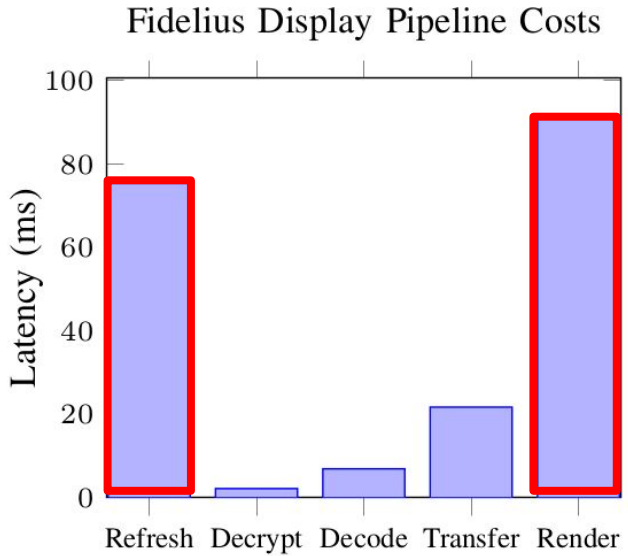


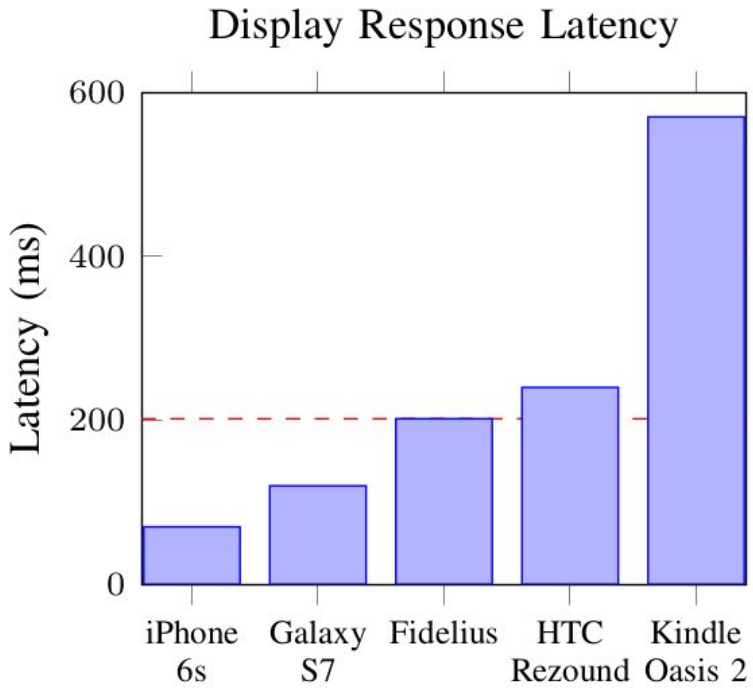
Performance

Display Latency

(Unoptimized) refresh rate 2.8x faster than latest Kindle

Speed due to only sending small overlay rather than encrypting full display

Graph shows latency for Fidelius rendering a username/password login form



Summary

Fidelius uses enclave to protect user secrets even if entire OS compromised

Support for forms, JS, persistent local storage, and XmlHttpRequests

Trusted path to enclave for user I/O (other projects welcome to use)

https://crypto.stanford.edu/fidelius
https://github.com/SabaEskandarian/Fidelius