Safe Passage for Passwords and Other Sensitive Data

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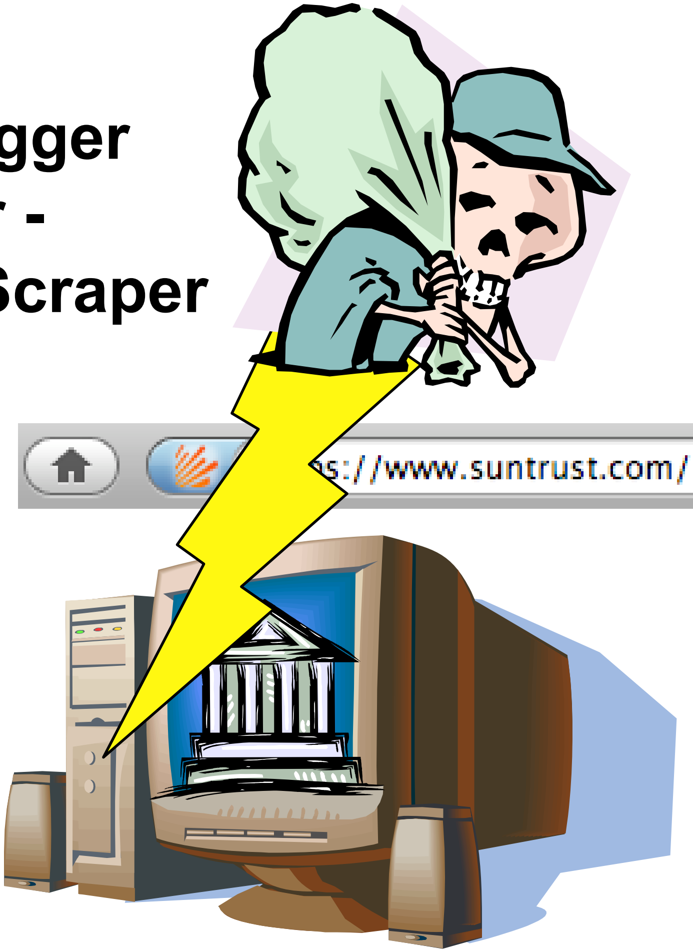
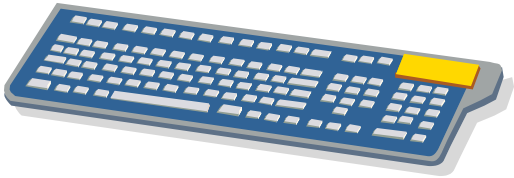
Input Security on the Web

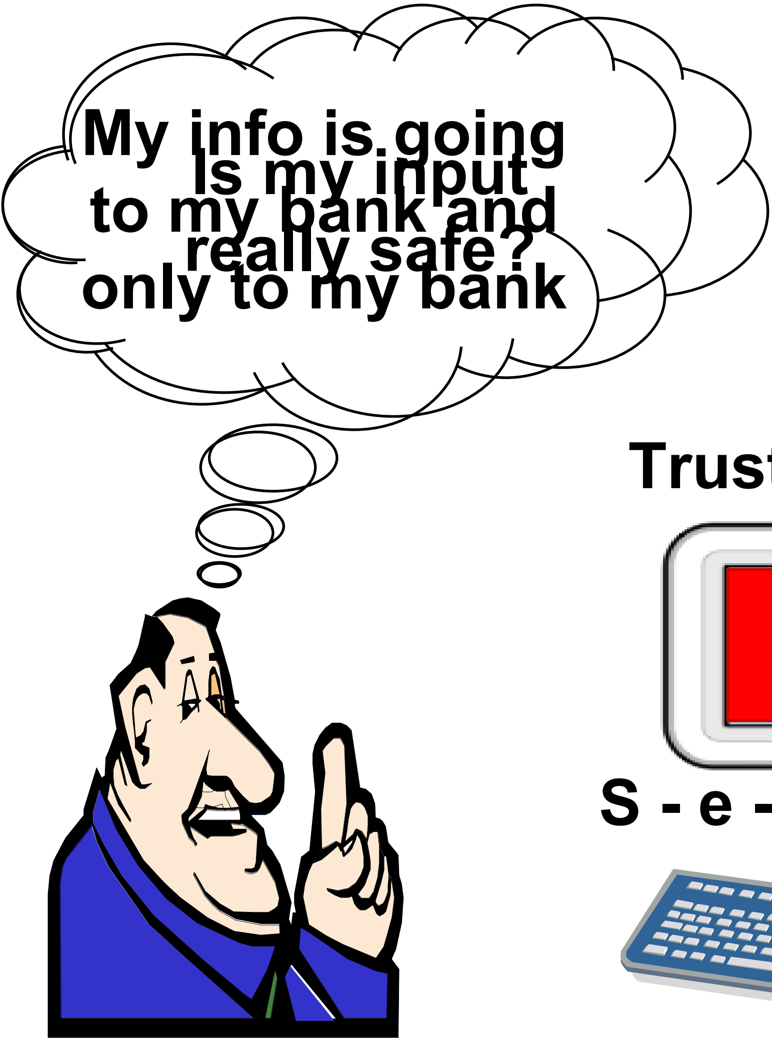
Keylogger
- or -
Screen Scraper



Secret

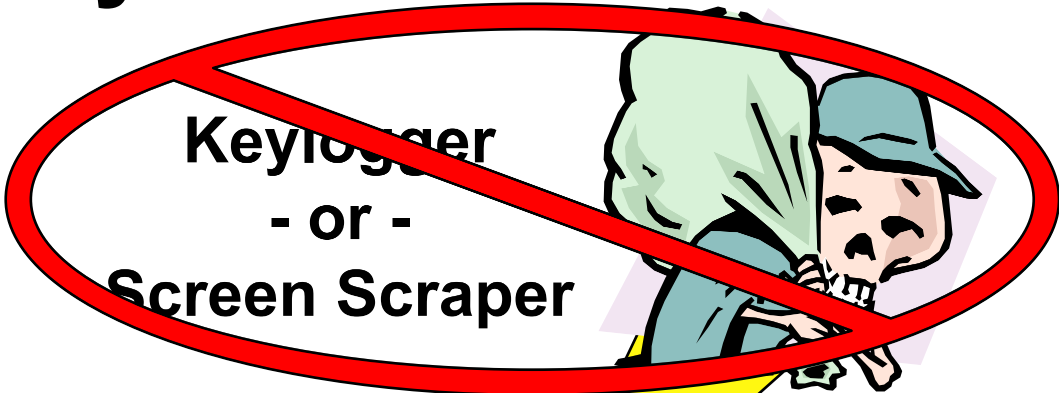


Input Security on the Web



My info is going to my bank and only to my bank

Is my input really safe?

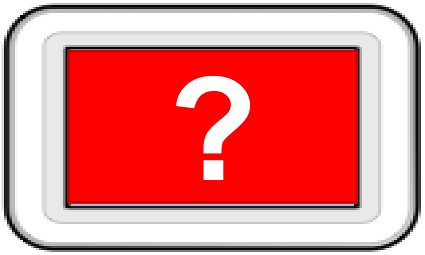


Keylogger

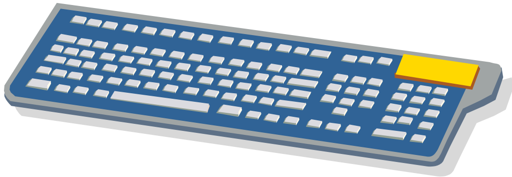
- or -

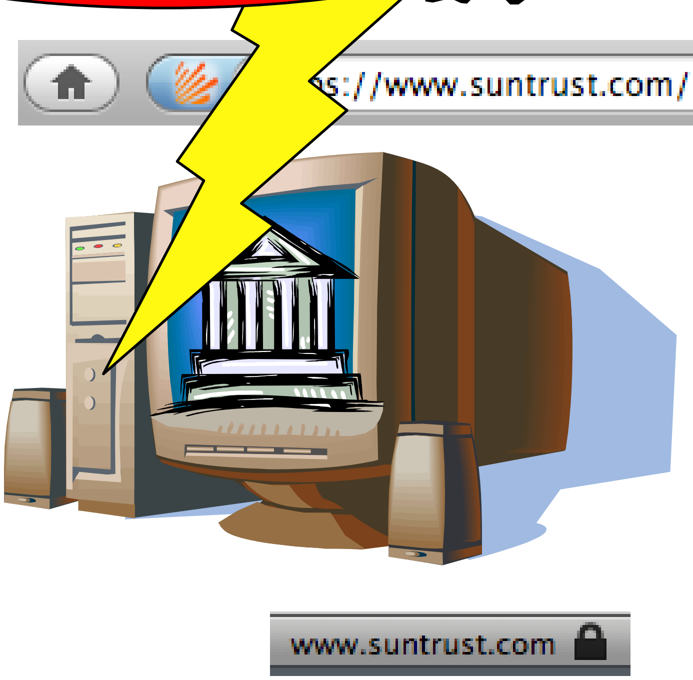
Screen Scraper

Trusted Monitor



S-e-c-r-e-t





Web-Input Security Problems

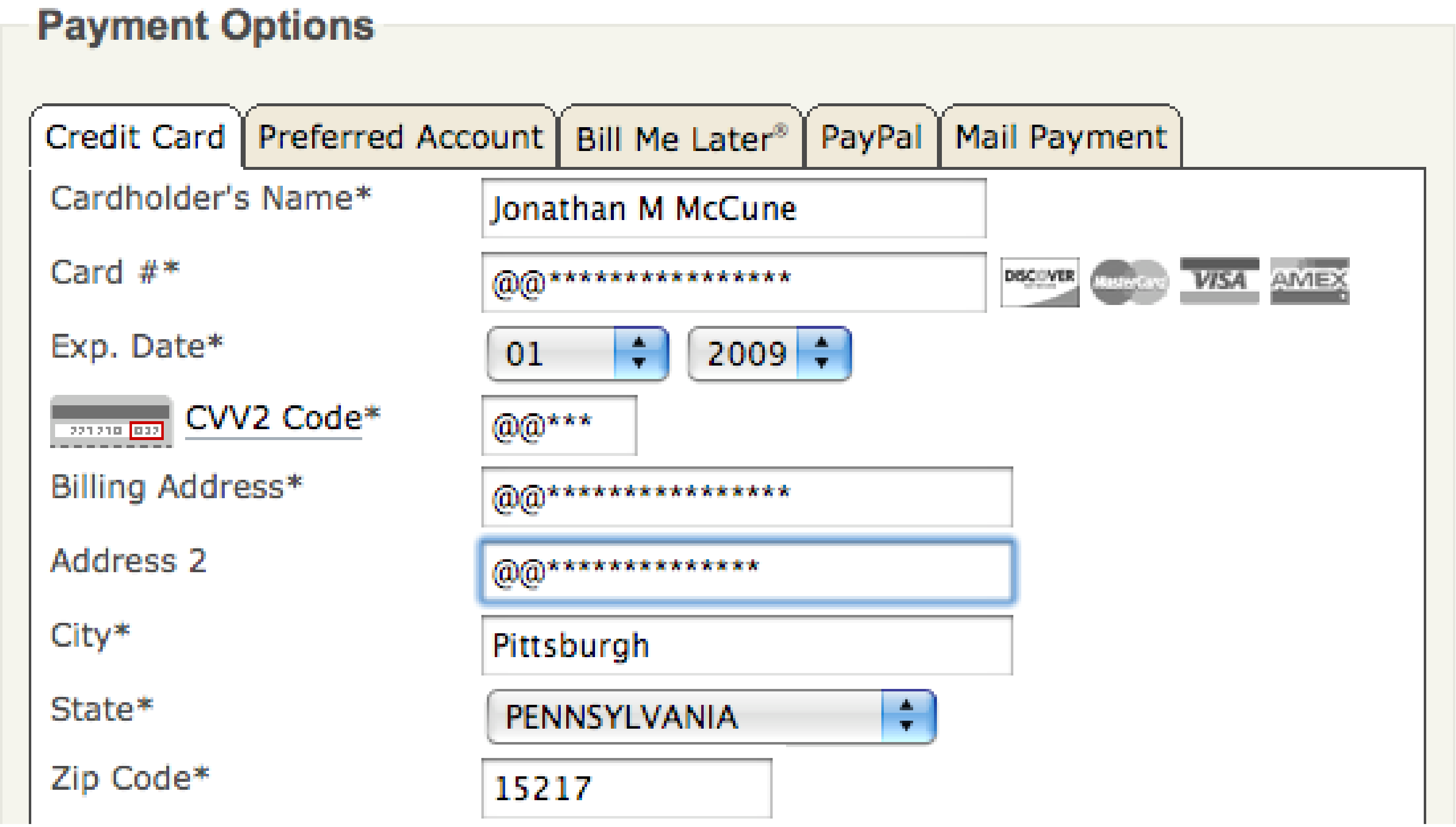
- Host-based malware
  - Rootkits, keyloggers, screen scrapers, …
  - May capture input pre-SSL
- On-screen security indicators cannot be trusted
  - Malware may forge them
- SSL offers network protections only
  - Was never intended for malicious host

Our Solution: Bumpy

- Protect user input from malware
  - Software keylogger, screen scraper
  - Compromised OS, web browser
- Offer assurance that input is protected
  - User feedback via a Trusted Monitor
  - Optional: feedback to web server via attestation
- Degrade gracefully to today's input system for legacy applications
  - Retain seamless user experience

Bumpy Approach (1/3)

- User decides which fields are sensitive
- Secure Attention Sequence @@ [RJMBM2005]

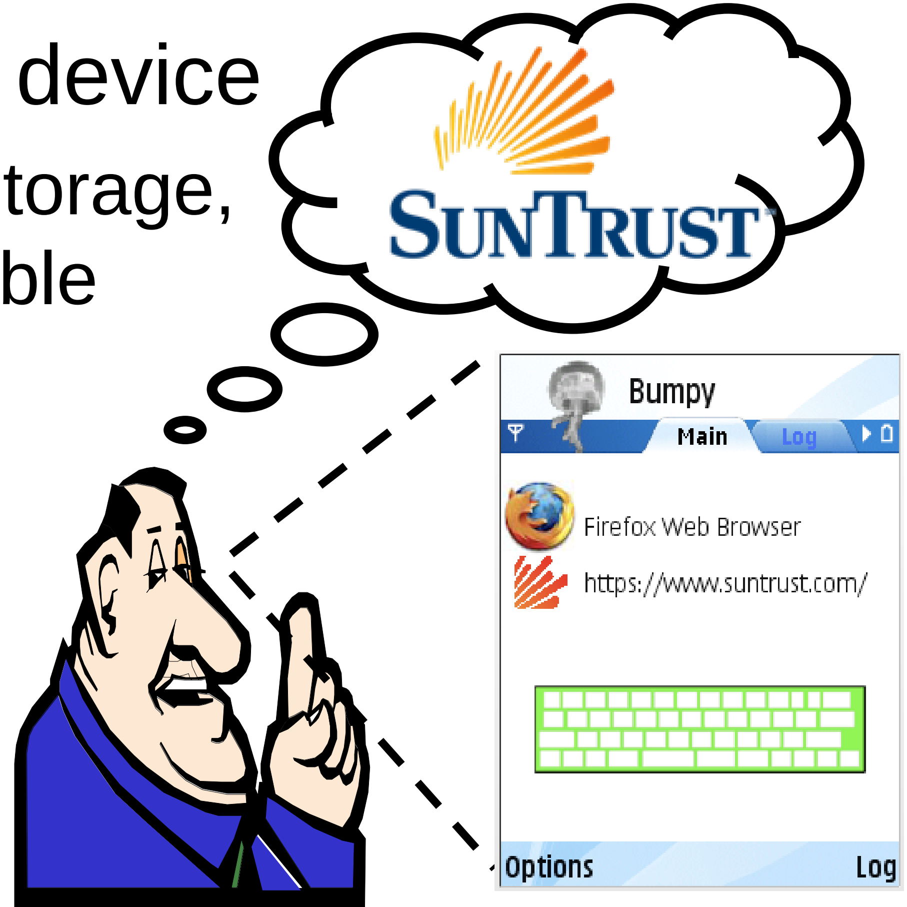


Payment Options

Cardholder's Name*	Jonathan M McCune
Card #*	@@****************
Exp. Date*	01 2009
CVV2 Code*	@@***
Billing Address*	@@****************
Address 2	@@***************
City*	Pittsburgh
State*	PENNSYLVANIA
Zip Code*	15217

Bumpy Approach (2/3)

- Trusted Monitor assures user that input protections are in place
- Physically separate device
  - Display, long-term storage, comm., crypto-capable
- Display indicates
  - Application name
  - SSL hostname
  - Favicon



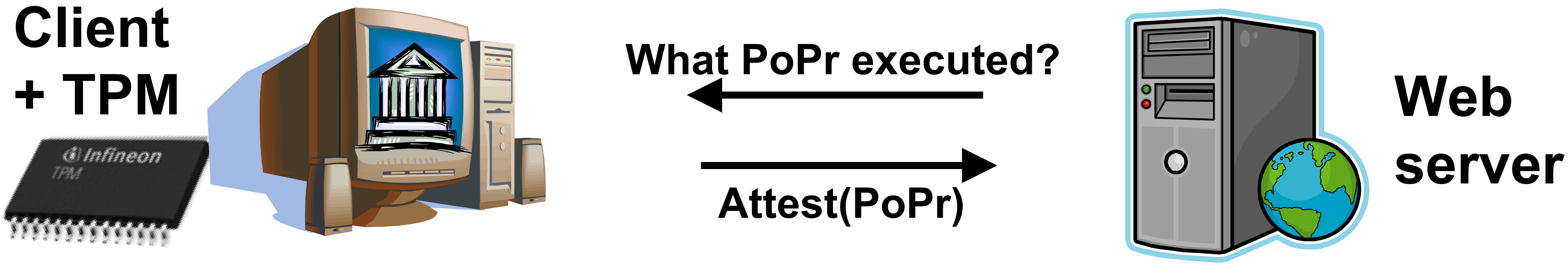
Firefox Web Browser

https://www.suntrust.com/

Bumpy Approach (3/3)

- Post-Processor executes on client to process sensitive input for web server

1. PoPr may be standard / widely deployed
   – No changes to server: PwdHash [RJMBM05]
2. Web server provides PoPr
   – Ex: End-to-end encryption
   – Remote attestation proves PoPr used



Client + TPM

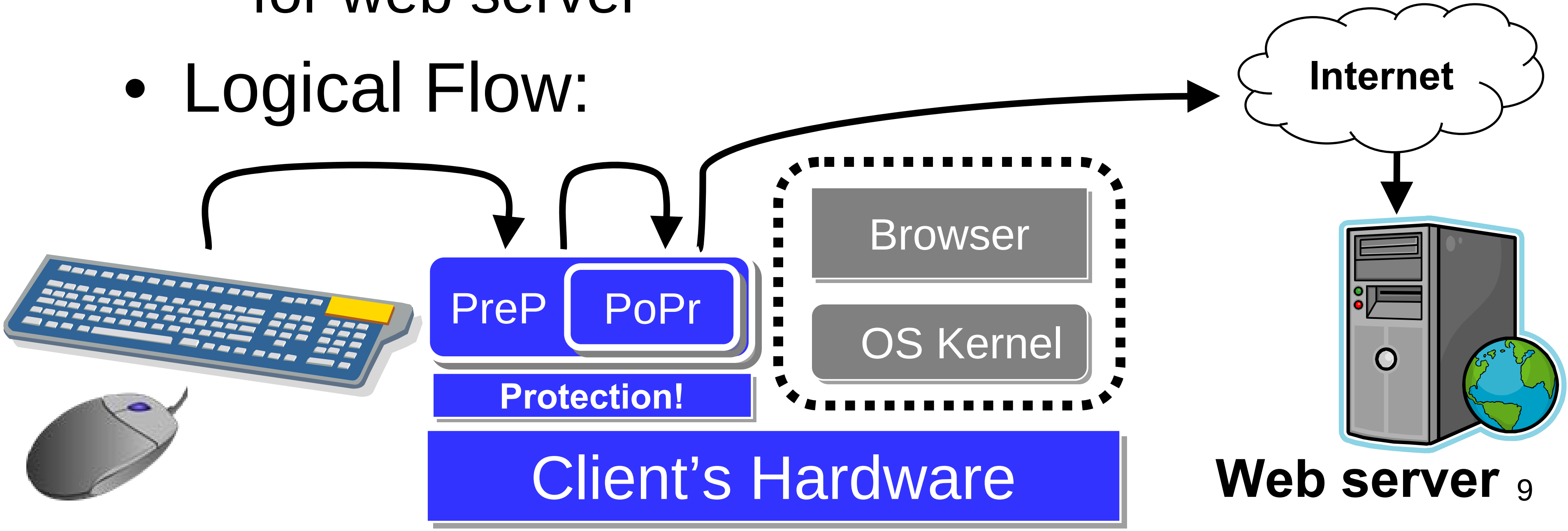
What PoPr executed?

Attest(PoPr)

Web server

Bumpy Architecture

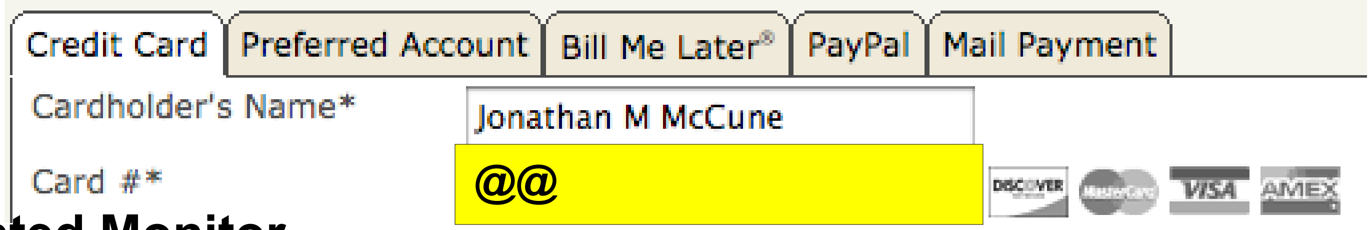
- Input devices encrypt all events
- Protected (isolated) input processing
  - Pre-Processor (PreP) to decrypt events
  - Post-Processor (PoPr) packages events for web server
- Logical Flow:



Trusted

Untrusted

Input Flow for @@



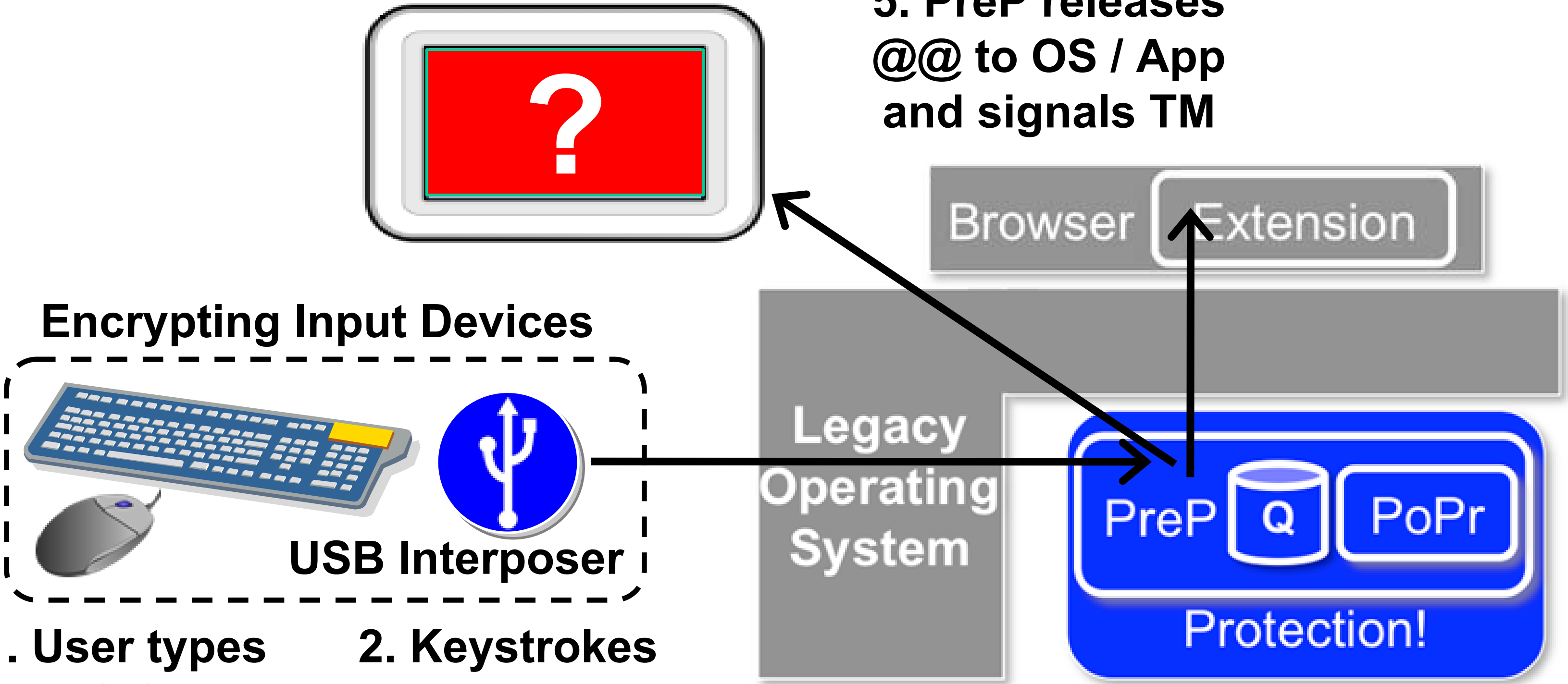
Credit Card | Preferred Account | Bill Me Later® | PayPal | Mail Payment

Cardholder's Name*: Jonathan M McCune

Card #*: @@

Trusted Monitor

5. PreP releases @@ to OS / App and signals TM



1. User types @@

2. Keystrokes encrypted

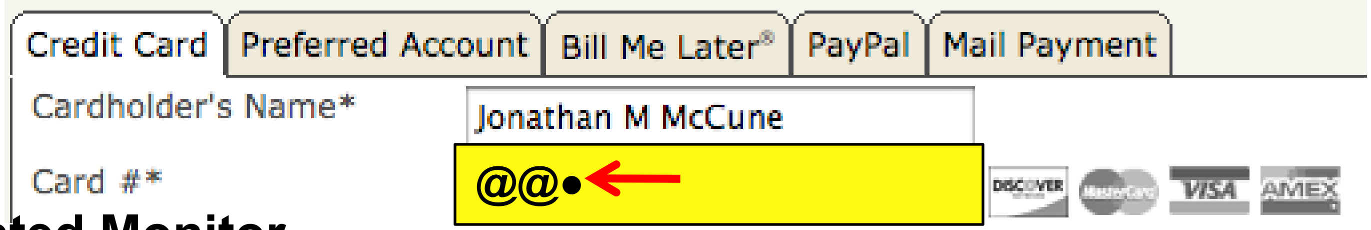
3. OS handles ciphertext

4. OS invokes Pre-Processor

Sensitive Keystroke Flow

Trusted

Untrusted



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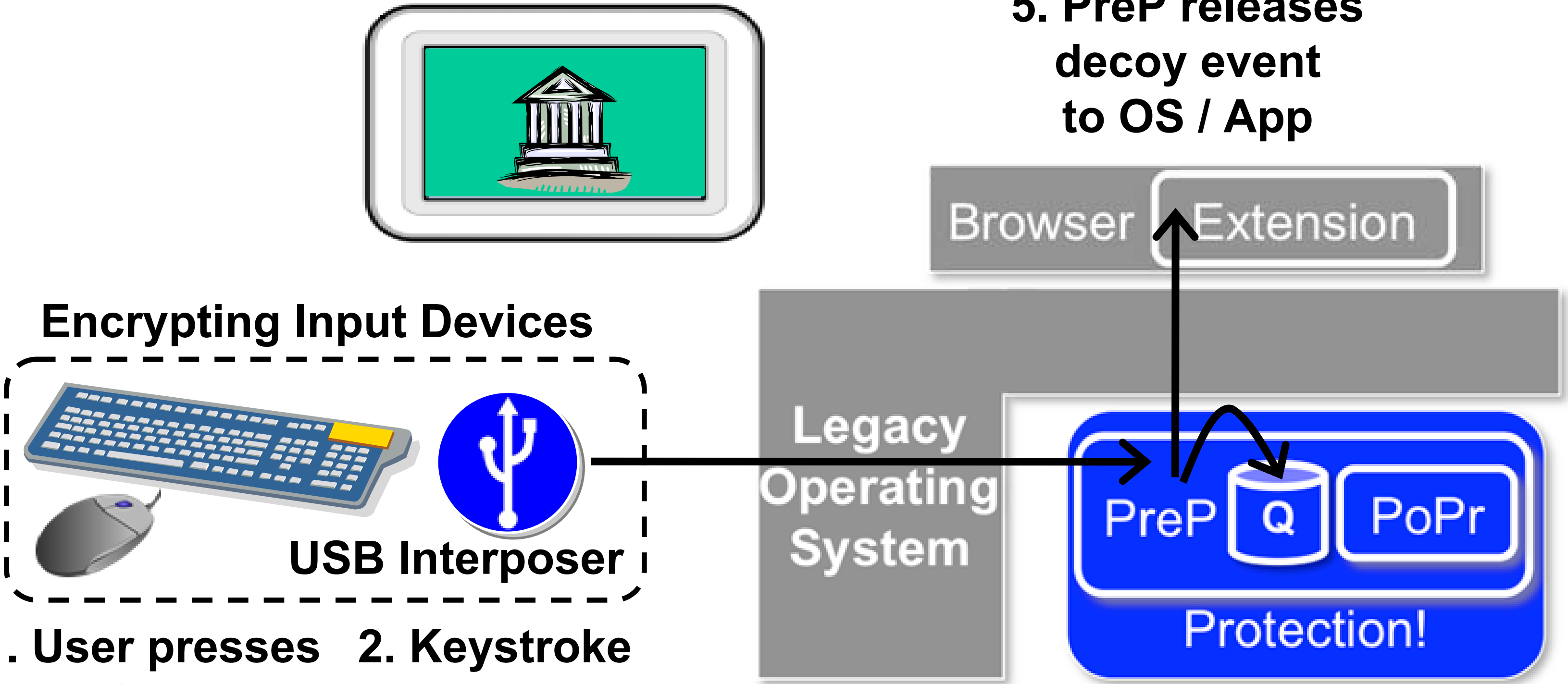
Cardholder's Name* Jonathan M McCune

Card #* @@•



Trusted Monitor

5. PreP releases decoy event to OS / App

Encrypting Input Devices

1. User presses key / button

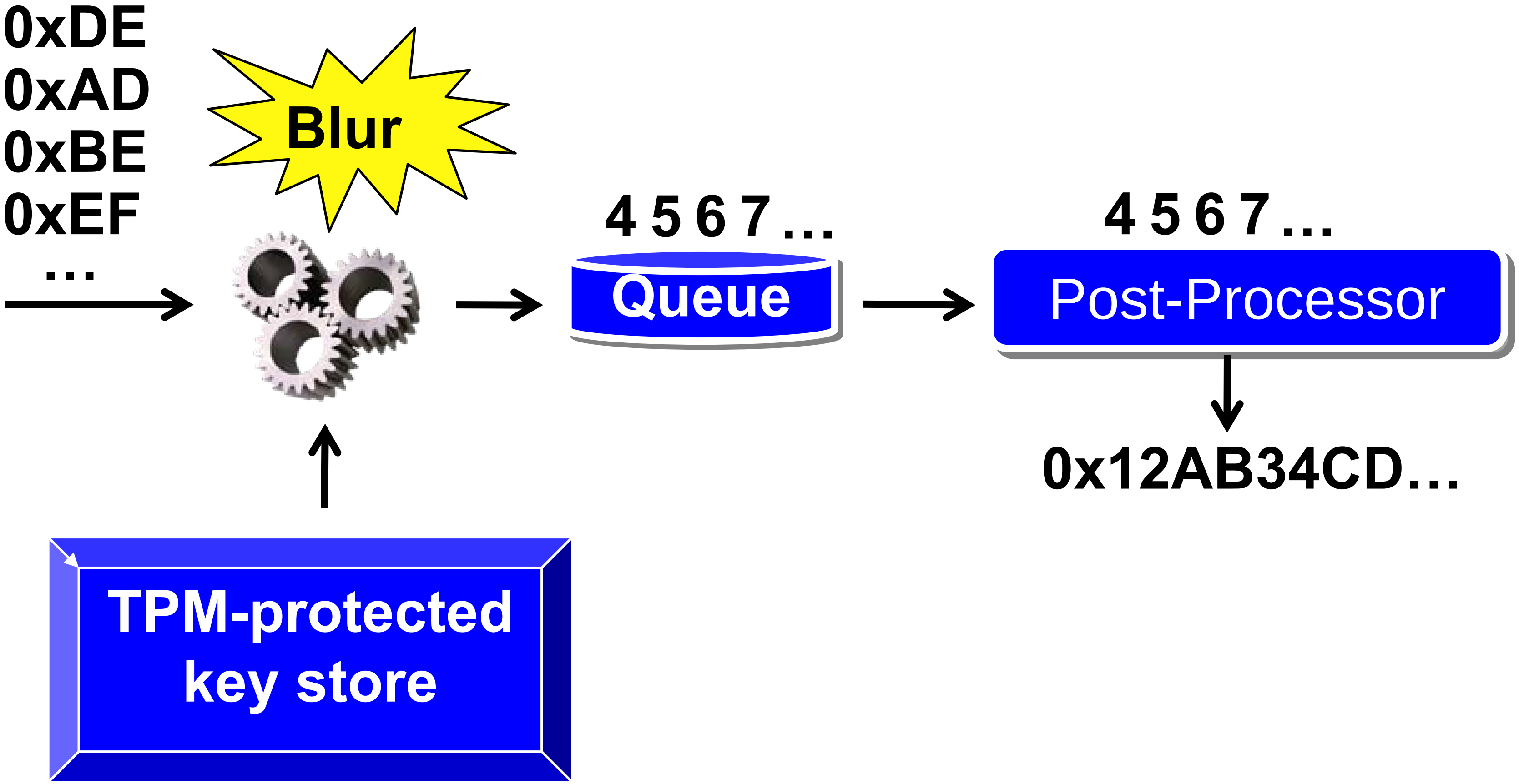
2. Keystroke encrypted

3. OS handles ciphertext

4. OS invokes Pre-Processor

Inside the Pre-Processor

- Decrypt and enqueue input events
- Invoke PoPr upon receiving “Blur”



0xDE
0xAD
0xBE
0xEF
…

Blur

4 5 6 7 …

Queue

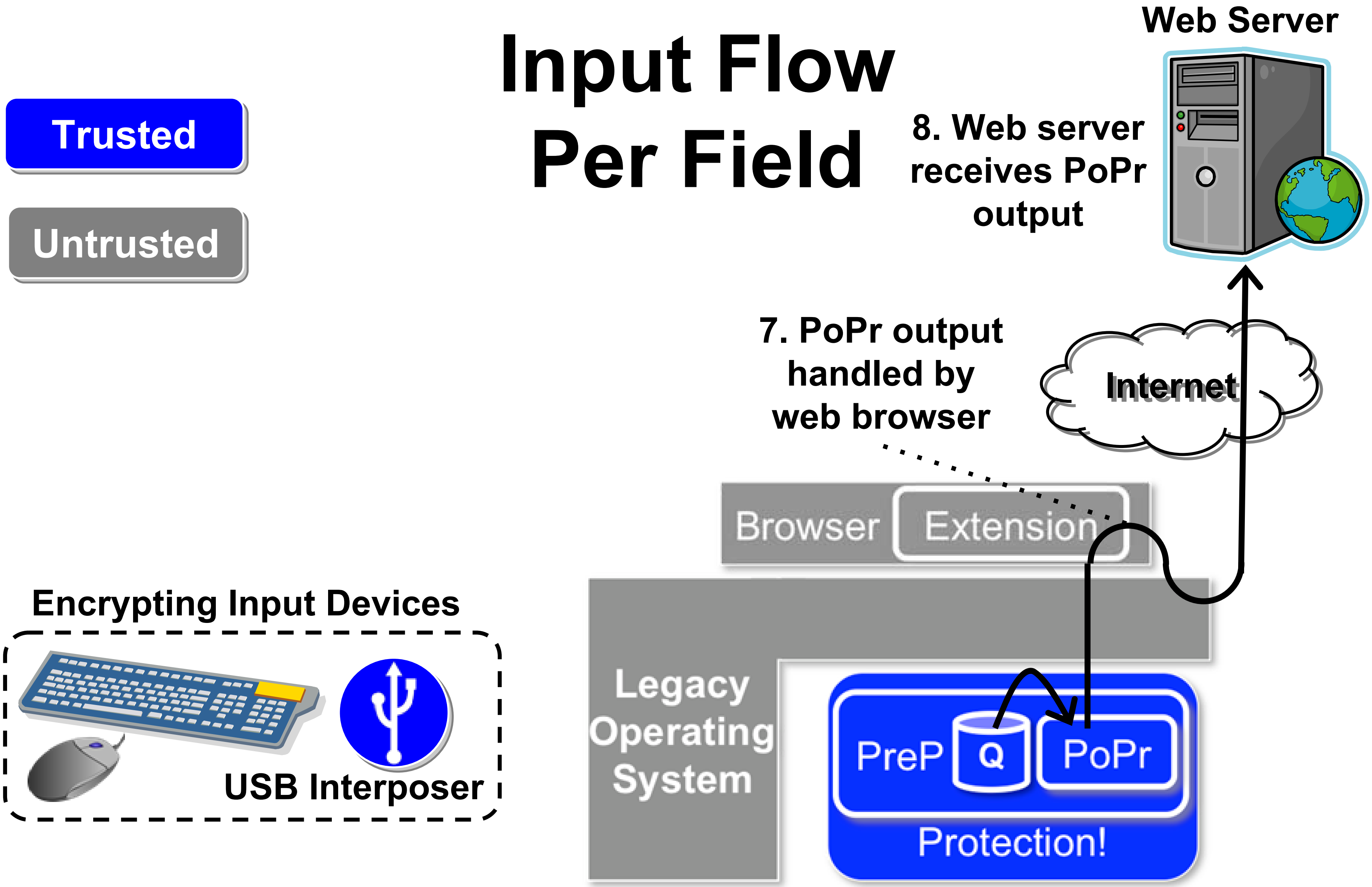
4 5 6 7 …

Post-Processor

0x12AB34CD…

TPM-protected key store

Input Flow Per Field



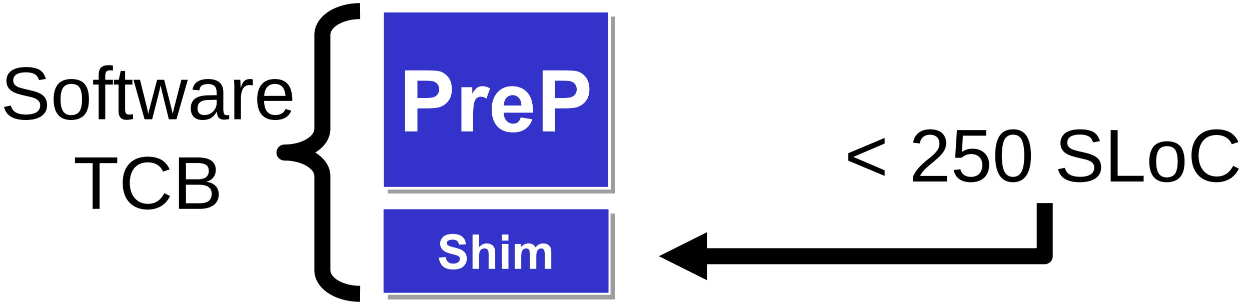
8. Web server receives PoPr output

7. PoPr output handled by web browser

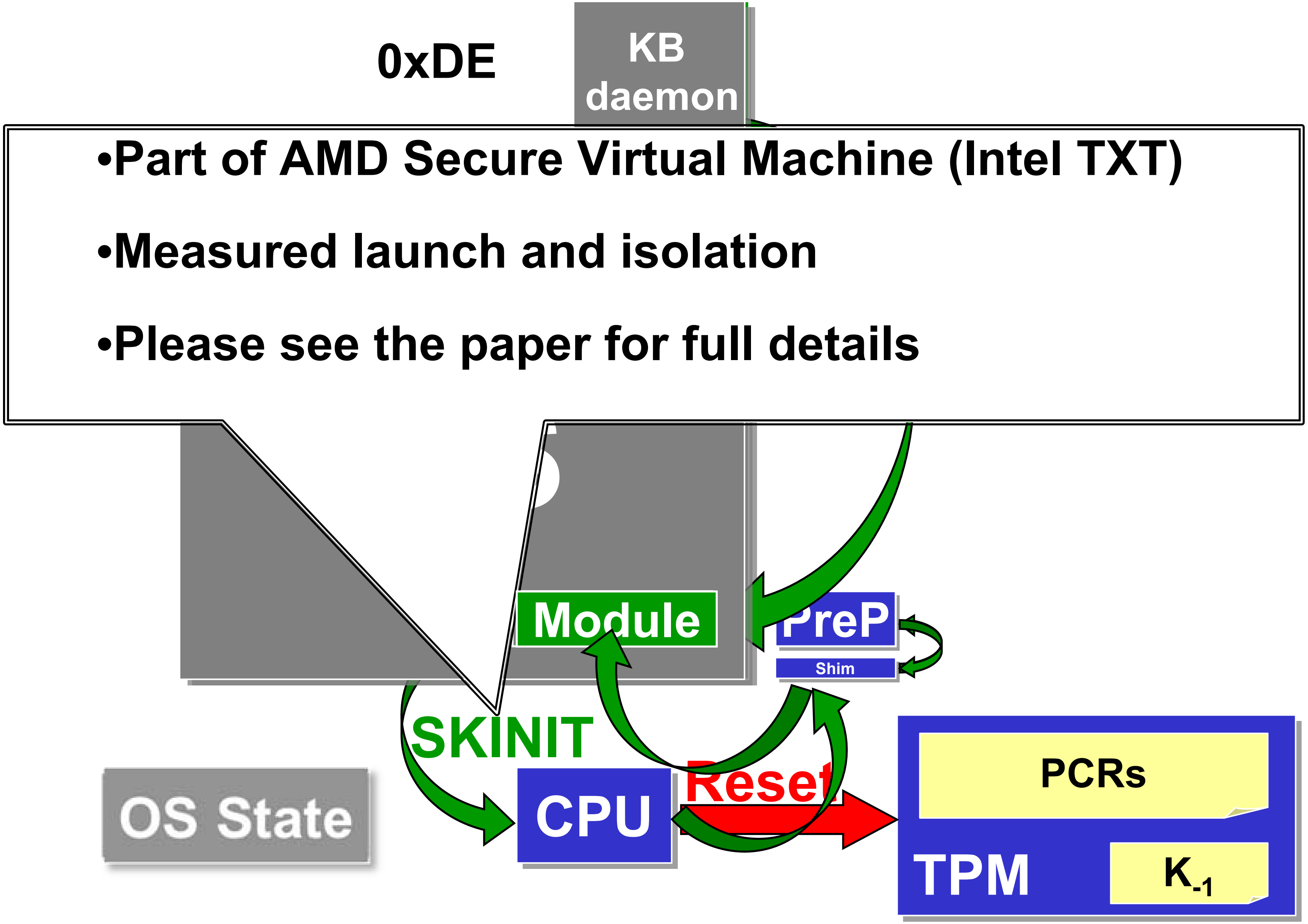
6. PoPr invoked with queue

PreP, PoPr Protection: Flicker

- Isolate security-sensitive code execution from all other code and devices [McPaPeReIs2008]
  - Runs directly on hardware, except for the shim
- Attest to security-sensitive code and its arguments and nothing else
- Convince a remote party that security-sensitive code was protected
- Add < 250 SLoC to the software TCB



Flicker Execution Flow



- Part of AMD Secure Virtual Machine (Intel TXT)
- Measured launch and isolation
- Please see the paper for full details

External Verification

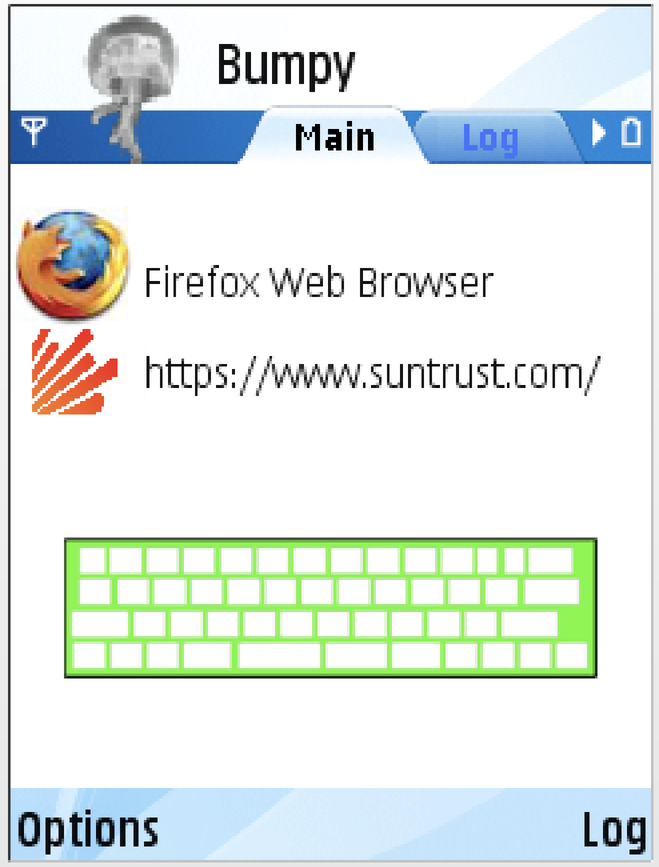
- PreP informs Trusted Monitor of @@ receipt and PoPr origin
  - Trusted Monitor presents to user the origin of PoPr for subsequent secret input
- Upon form submission, web server may receive attestation to PoPr
  - Covers PreP, PoPr, and protected keystrokes
  - Relevant when web server provides PoPr

Bumpy Implementation

- Commodity workstation with AMD SVM
  - HP dc5750 with Broadcom v1.2 TPM
- USB Interposer
  - 141 +/- 15 ms overhead per keystroke
  - C program (~500 SLoC) for embedded Linux
- Trusted Monitor
  - C++ smart phone application (~2K SLoC)
- Firefox 2 extension

Trusted Monitor

- Indicates when protected input is active



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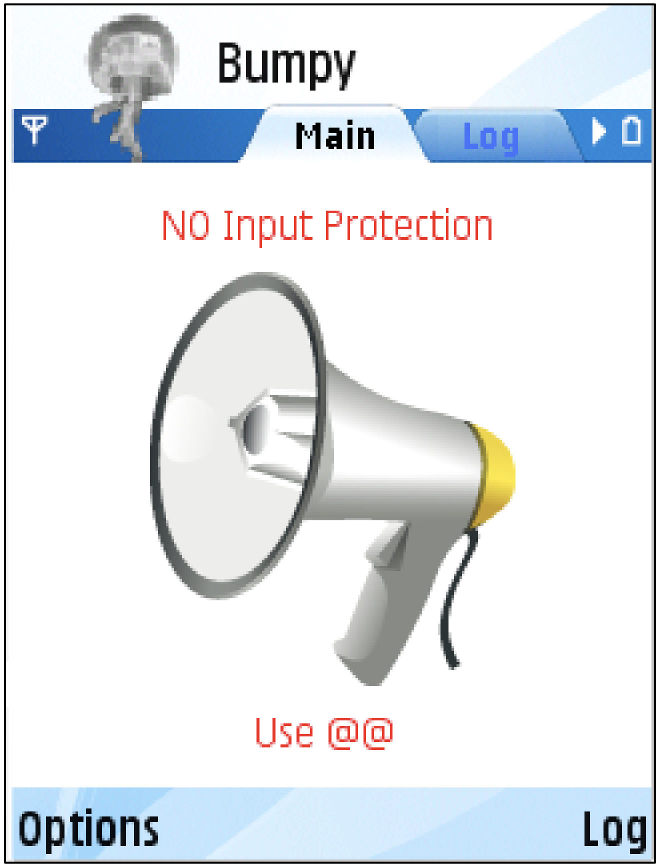

NO Input Protection

Use @@

Limitations

- Incompatible with some Phishing defenses
- Non-textual input fields unprotected
  - Drop-down lists, radio buttons, …
  - Ex: Credit card expiration date
- User forgets to employ @@ prefix
- Confusing form fields on malicious page
  - "Enter your password: @@___________"
- Mouse position information is revealed
- Input timing information is revealed

Subtleties

- Active input field in browser
  - Focus: untrusted hints from browser
    - Field label included in PoPr input
  - Blur: infer from input stream
    - Prevents browser from ending protection early
- Device association
  - PreP to input device(s)
  - PreP to Trusted Monitor
- Public computers

Some Related Work

- VMM-based input protection
  - NetTop [MeSi 2000], TIP [BoPr 2007], Garriss et al. [2008]
- Mobile devices as “smart cards”
  - Balfanz et al. [1999], Ross et al. [RHCJCB 2002], Sharp et al. [2008], ZTIC [IBM 2008]
- Secure Window Managers
  - NitPicker [FesHel 2005], EROS [ShVaNoCh 2004], Epstein et al.[1990s]
- Browser Security: PwdHash [RJMBM 2005]

Conclusions

- Sensitive input inaccessible from OS
- Users indicate which input is sensitive
- Web server can define processing for sensitive input intended for that server
- Attestation used to convince web server its PoPr is in use
- Trusted monitor assures user
- Feasible today on commodity hardware

Thank You

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- Questions?