Preventing the Revealing of Online Passwords to Inappropriate Websites with LoginInspector

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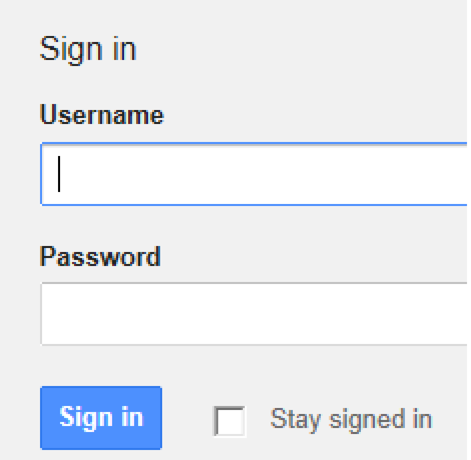
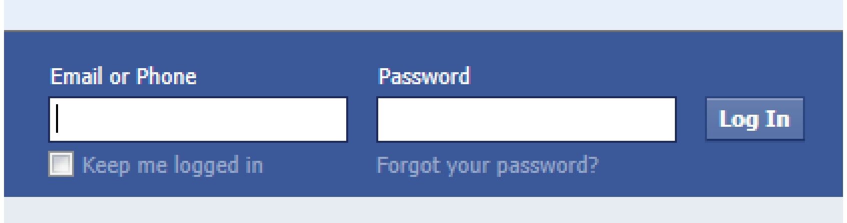
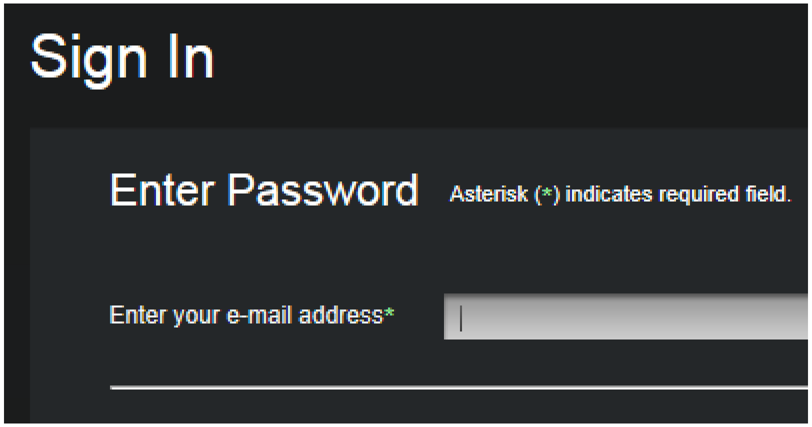
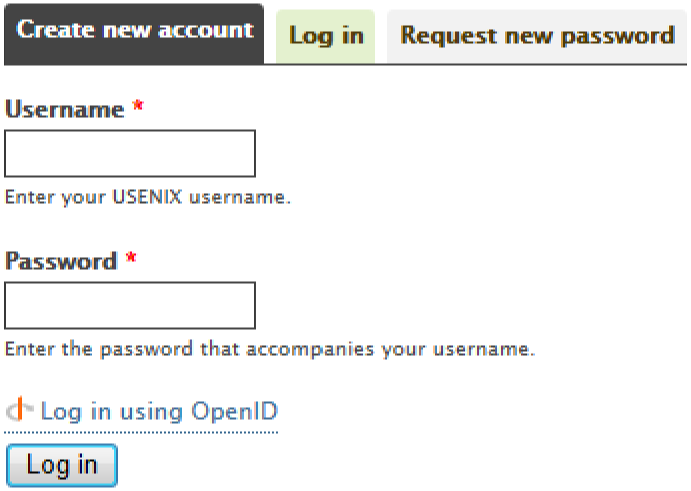
Text Passwords: the Dominant Position in Online User Authentication







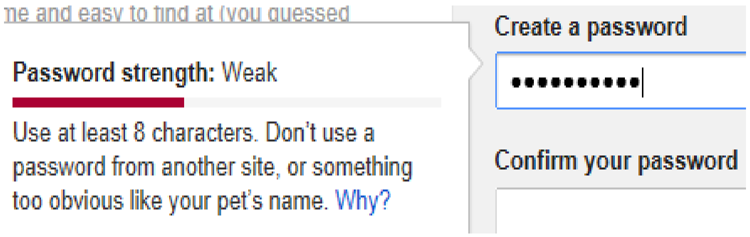
Asterisk (*) indicates required field.



Enter your USENIX username.

Enter the password that accompanies your username.

Password Security



ne and easy to find at (you guessed

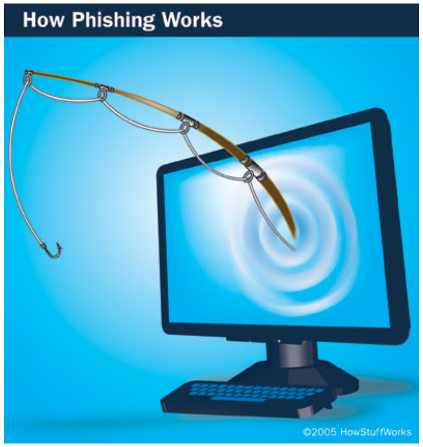
Password strength: Weak

Use at least 8 characters. Don't use a password from another site, or something too obvious like your pet's name. Why?

Create a password

•••••••••••

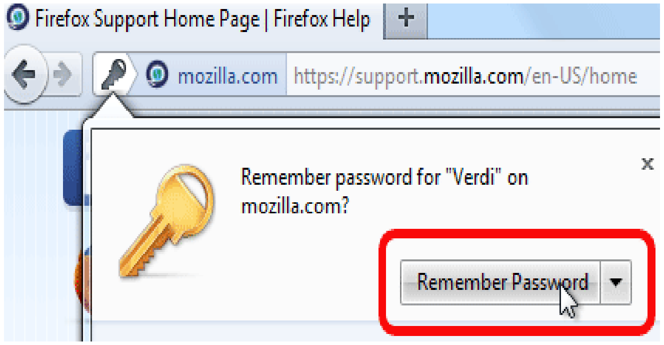
Confirm your password



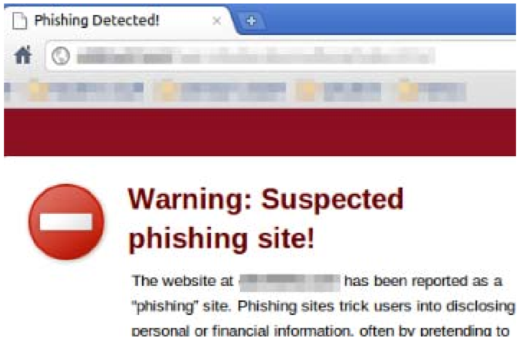
- The *something you know* authentication factor
- Expectations: *strong, protected from being stolen*
- Reality: *weak/shared passwords, various attacks*

Related Features and Mechanisms in Browsers

(Internet Explorer, Firefox, Google Chrome, Safari, and Opera)

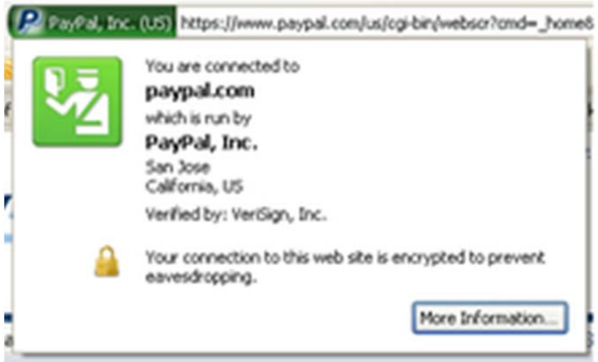

Firefox Support Home Page | Firefox Help
+
mozilla.com
https://support.mozilla.com/en-US/home
Remember Password

Remember password for "Verdi" on mozilla.com?



Warning: Suspected phishing site!

The website at [redacted] has been reported as a "phishing" site. Phishing sites trick users into disclosing personal or financial information, often by pretending to



You are connected to
paypal.com
which is run by
PayPal, Inc.
San Jose
California, US
Verified by: VeriSign, Inc.

Your connection to this web site is encrypted to prevent eavesdropping.

- Password Manger
- Phishing Detection and Warning
- Extended Validation (EV) Certificate

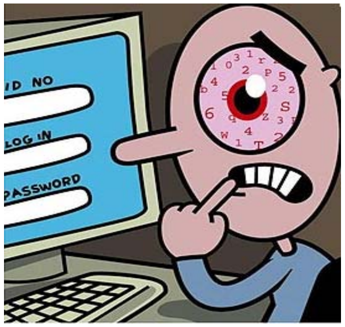
Are those password related features and mechanisms in modern browsers sufficient?

Are those password related features and mechanisms in modern browsers sufficient?

THE ANSWER IS
NO

Accidental Revealing of Online Password to Inappropriate Websites May Happen!

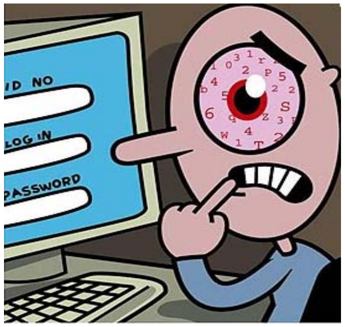
- We highlight two cases
  - *undetected phishing attacks*



  - *risky password tries*
- Modern browsers do not provide sufficient protection

Accidental Revealing of Online Password to Inappropriate Websites May Happen!

- We highlight two cases
  - *undetected phishing attacks*
  - *risky password entries*
- Modern browsers do [illegible] provide sufficient protection



Outline

- Introduction
- Motivation, Justification, and Related Work
- Design of the LoginInspector
- Implementation and Evaluation
- Security, Usability, and Deployment Analysis
- Conclusion and Acknowledgments

Undetected Phishing Attacks

- Browsers fail to detect phishing attacks and give warning
  - Blacklist-based techniques, heuristic-based techniques
  - Not able to detect all the phishing attacks in a timely manner and meanwhile maintain a low false positive rate [4, 13, 29, 39, 48, 49].

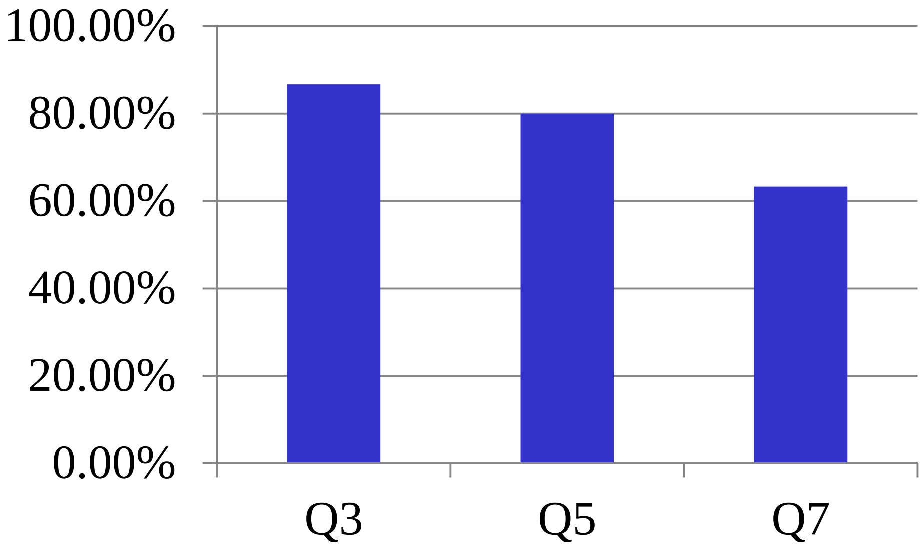
- Passwords for real sites → inappropriate phishing sites !

- LoginInspector takes a whitelist-based approach
  - Provide one more layer of protection even if browsers failed

Risky Password Tries

- When users forget passwords for one site, a common practice is to try passwords for other sites they remember.
  - A user study for testing whether this risky practice is common
- Browsers do not and do not have the knowledge to detect
- Passwords for high-security sites → inappropriate low-security sites !
- LoginInspector intends to also detect this risky practice

The First User Study on Risky Password Tries



- 30 participants, on campus
- a five-point Likert-scale [58] questionnaire with 7 questions

Q3: Agree or Strongly Agree that sometimes they forget the password for a website

Q5: Agree or Strongly Agree that sometimes they try the password for one website on another website

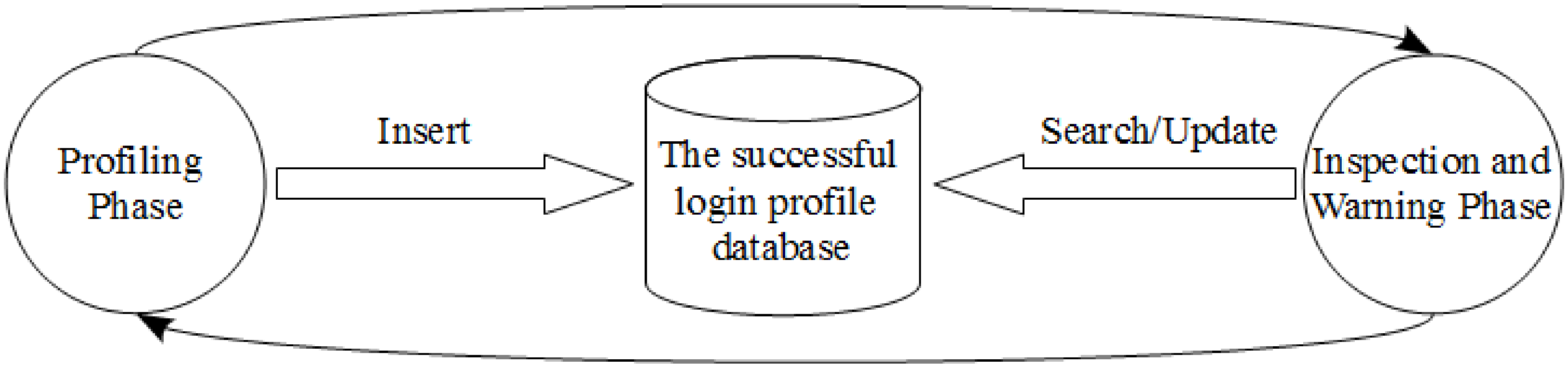
Q7: Agree or Strongly Agree that when they try the password for one website on another website, they hope the Web browser can give them a warning

Some Closely Related Work

- Password hashing systems
  - E.g., Password Multiplier[14], PwdHash[33], Passpet[43]
  - Migrating original passwords to hashed ones is a big burden
  - Cannot log into a website without the tool

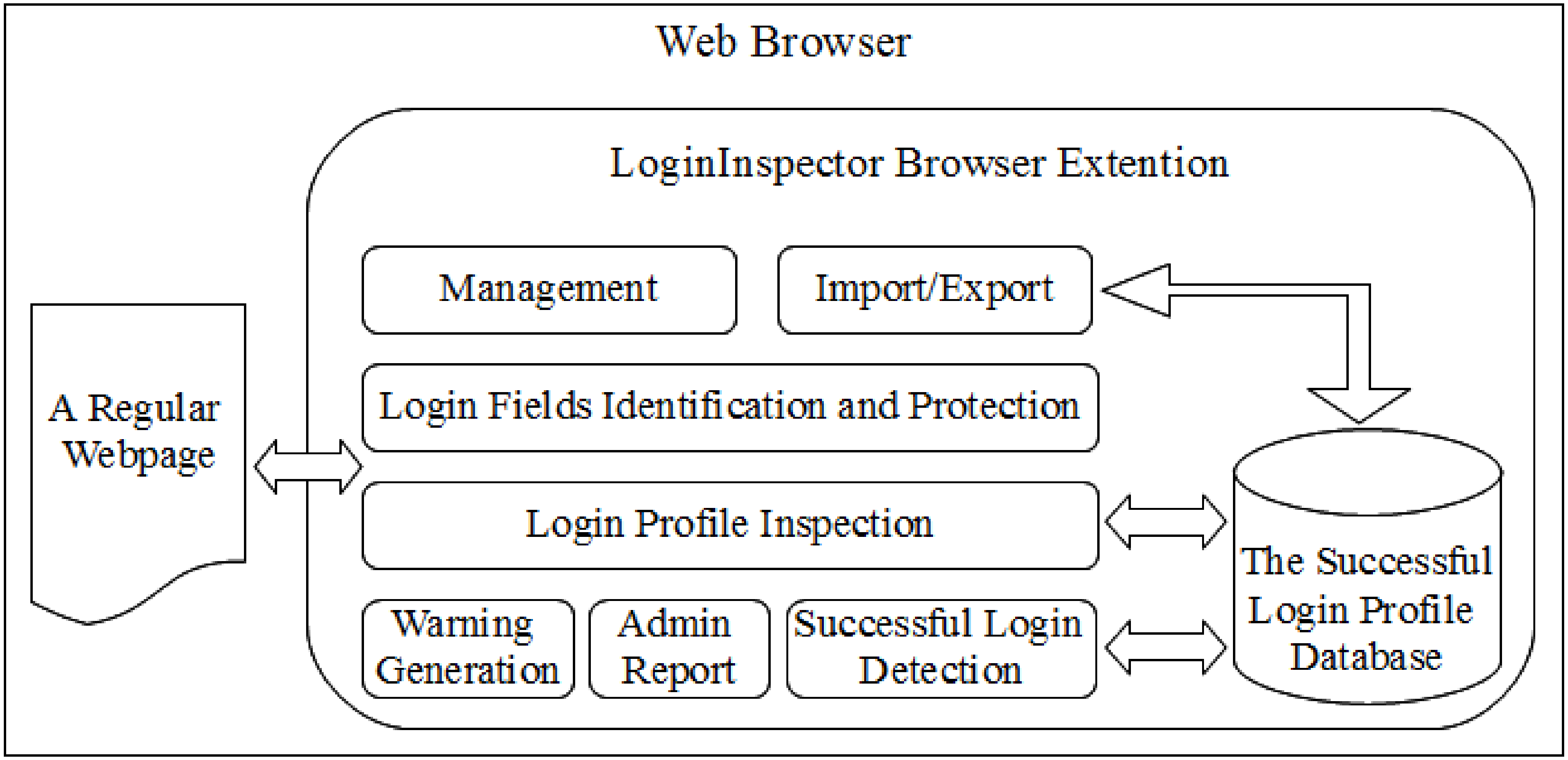
- Whitelist-based systems
  - E.g., Antiphish[24], – uses password encryption, less fine-grained
  - E.g., Web Wallet[41] – uses password encryption, special UI
  - Hashing is more appropriate than encryption, users prefer regular login forms than special login dialog boxes

The Key Idea and Functioning of LoginInspector


Profiling Phase
Insert
The successful login profile database
Search/Update
Inspection and Warning Phase

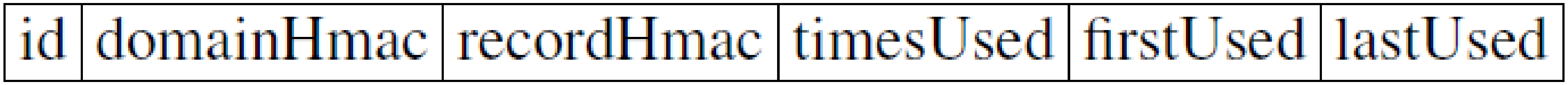
- Continuously monitor a user's login actions and securely store domain specific successful login information to an in-browser database
- For any login attempt that does not have the corresponding successful login record, warn and enable the user to make an informed decision

High-level Architecture of LoginInspector


Web Browser
LoginInspector Browser Extention
Management
Import/Export
Login Fields Identification and Protection
Login Profile Inspection
Warning Generation
Admin Report
Successful Login Detection
A Regular Webpage
The Successful Login Profile Database

The Successful Login Profile Database

- An in-browser database instance
  - Contains a *loginprofile* table



id	domainHmac	recordHmac	timesUsed	firstUsed	lastUsed

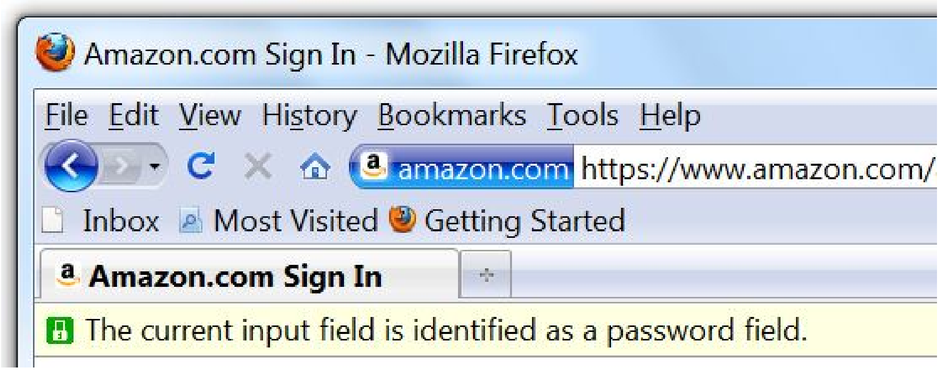
$$domainHmac = HMAC(key,\ d) \qquad (1)$$

$$recordHmac = HMAC(key,\ d \,||\, u \,||\, p) \qquad (2)$$

where, *HMAC* is Keyed-Hashing for Message Authentication[27] with SHA-256 [59] cryptographic hash; key is secret key stored in password manager and protected with a master password; *d* is extracted from each login form's owner document (e.g., https://www.amazon.com or http://en.wikipedia.org).

Login Fields Identification and Protection

- Identification: first password field, then username field
  - Password field: user-assisted identification ("@@" prefix[33]) and automatic identification; Username field: heuristic

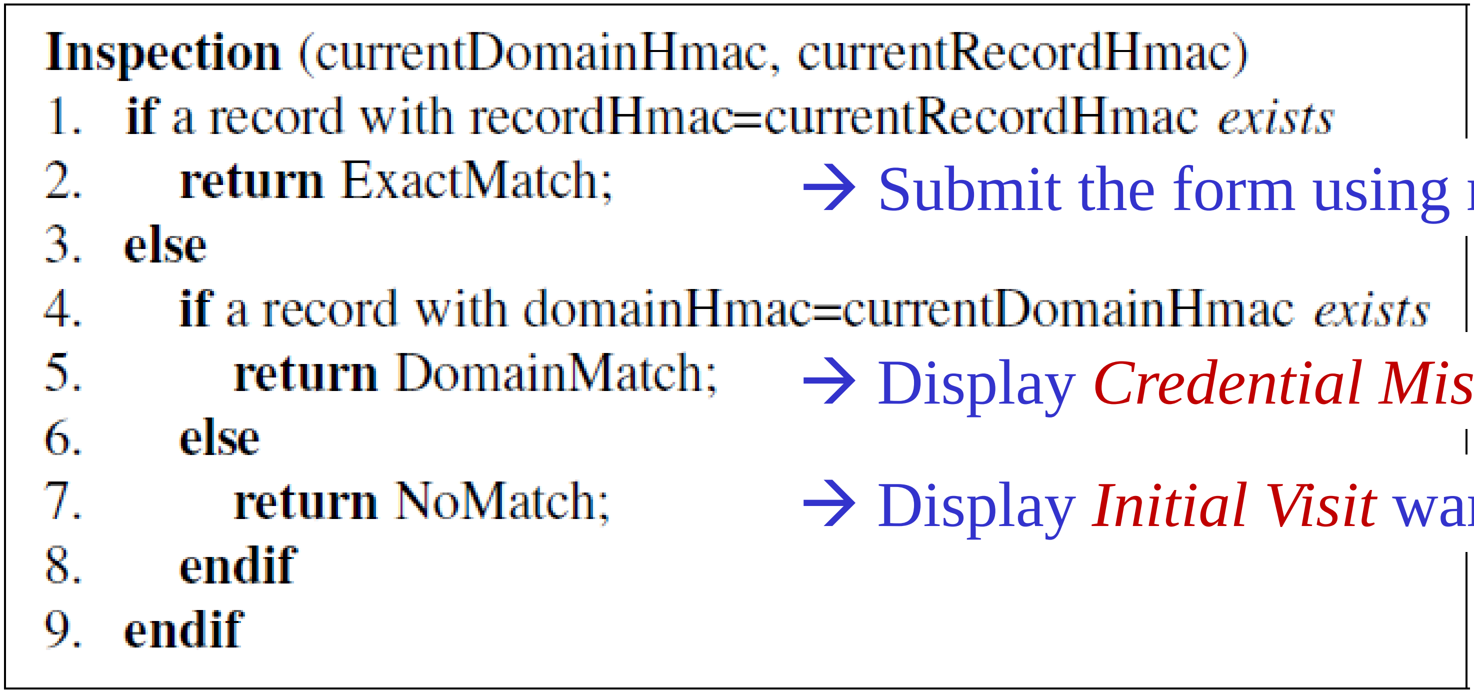

Amazon.com Sign In - Mozilla Firefox
File Edit View History Bookmarks Tools Help
amazon.com https://www.amazon.com/
Inbox Most Visited Getting Started
Amazon.com Sign In

The current input field is identified as a password field.

- Protection
  - Intercept password keystrokes, generate fake ones, replace back

Login Profile Inspection

- When a user submits a login form
  - Compute a *currentDomainHmac* and a *currentRecordHmac*
  - Run the login profile inspection procedure



```
Inspection (currentDomainHmac, currentRecordHmac)
if a record with recordHmac=currentRecordHmac exists
    return ExactMatch;
else
    if a record with domainHmac=currentDomainHmac exists
        return DomainMatch;
    else
        return NoMatch;
    endif
endif
```

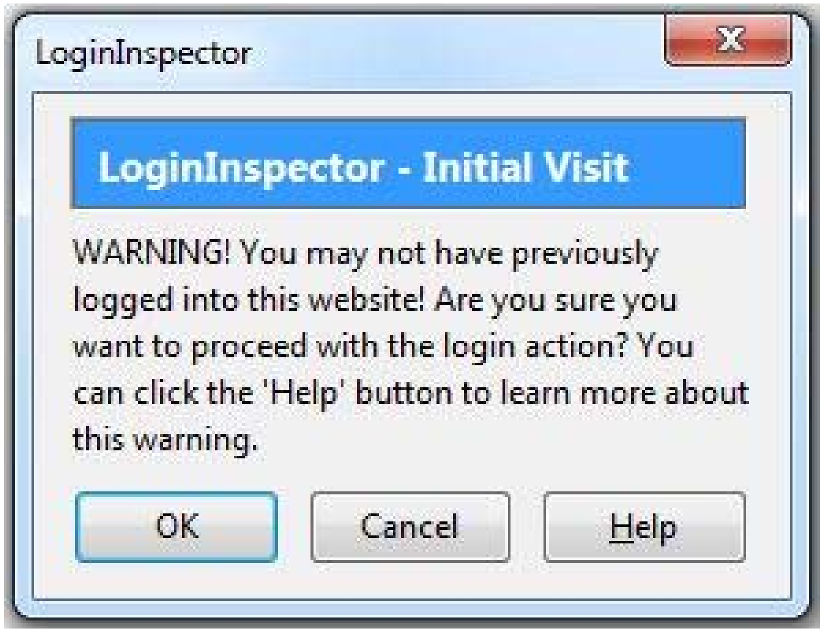
→ Submit the form using real password

→ Display *Credential Mismatch* warning

→ Display *Initial Visit* warning

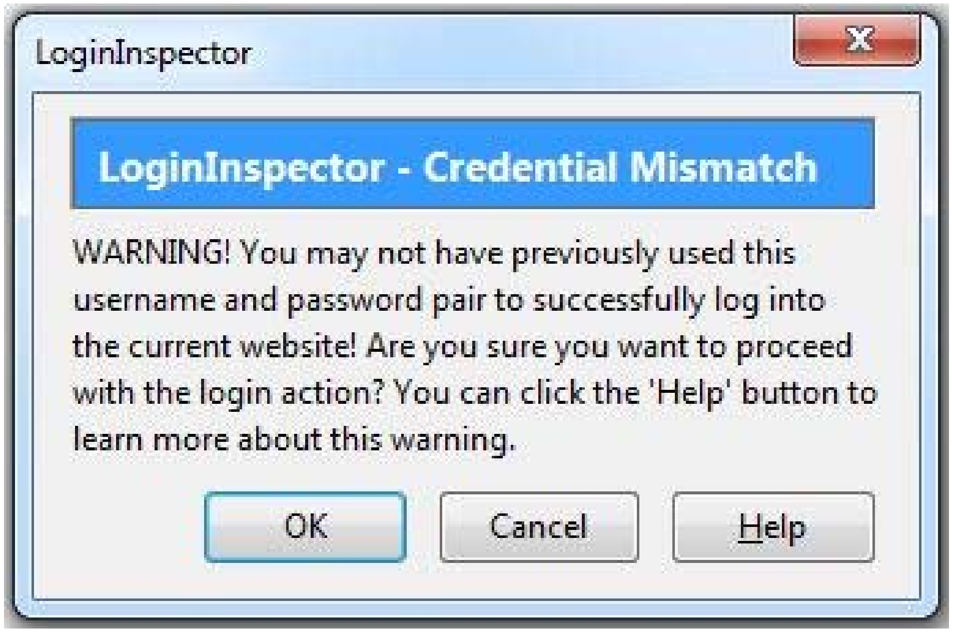
Warning Generation

- Modal chrome type of dialog box



LoginInspector - Initial Visit

WARNING! You may not have previously logged into this website! Are you sure you want to proceed with the login action? You can click the 'Help' button to learn more about this warning.



LoginInspector - Credential Mismatch

WARNING! You may not have previously used this username and password pair to successfully log into the current website! Are you sure you want to proceed with the login action? You can click the 'Help' button to learn more about this warning.

Admin Report

- Generate/send reports to system administrators if enabled
  - some users may not properly interpret the warning messages
  - only contain the LoginInspector usage information, e.g., a user’s responses to the two types of warning messages in a session

```
{“userid”: “123456”,
 “ignored Initial Visit warning”: “10 times”,
 “ignored Credential Mismatch warning”: “6 times”,
 “sessionStartTime”: “1345846451434”,
 “sessionEndTime”: “1345846648635”, ......}.
```

  - administrators can help individual users or aggregate information

Successful Login Detection, Management, Import/Export

- Successful Login Detection
  - Heuristic approach does not always work well
  - A user-assisted method is useful, a dialog box with “Yes”, “No”
  - Determine if a new successful login record should be added
- Management
  - customize warning messages, remove records, etc.
- Import/Export
  - export records to a file, import from another computer

Implementation and Evaluation

- Firefox Extension
  - Pure JavaScript
  - SQLite[62] database instance
  - Possible for other browsers
- Correctness Evaluation
  - Works correctly on 30 popular legitimate websites, 30 phishing websites, and a new phishing scam[60]
- Performance Evaluation
  - Overhead is low on 30 popular legitimate websites

Correctness Evaluation (1)

- Works correctly on 30 popular legitimate websites Alexa
  - Automatic password/username fields identification
  - Correct passwords interception and replacement
  - Correct database operations, login profile inspection, etc.
  - Automatic successful login detection works on 29 sites; the one with an extra link on the failed login page needs user assistance
  - Correct decisions on whether and what type of warning messages should be displayed

Correctness Evaluation (2)

- Works correctly on 30 phishing websites

PhishTank®

  - Automatic password/username fields identification on 29 sites; the one with password *type*=“*text*” needs user assistance
  - Correct passwords interception and replacement
  - “Initial Visit” warning message was correctly displayed

- Firefox failed to detect seven of them
- Google Chrome failed to detect eight of them

Correctness Evaluation (3)

- Works correctly on a new phishing scam[60]
  - Email attached HTML file, POST type HTTP request to a hacked legitimate site, very stealthy

    (1) a browser simply loads the phishing webpage as a local file such as file:///C:/Users/.../home.html

    (2) the form is submitted to a legitimate, albeit hacked, website

- Firefox and Google Chrome did not detect such scams[60]

Performance Evaluation

- Overhead is low on 30 popular legitimate websites
  - 2.67GHz CPU

- HMAC calculations completed in 3 milliseconds

- Overhead is mainly on JavaScript invoked SQLite operations
  - Insert: average 140.6 milliseconds, with standard deviation 47.2
  - Update: average 70.2 milliseconds, with standard deviation 13.1
  - Overhead is incurred only when a login form is submitted

Security, Usability, Deployment Advantages

- Security
  - Only store hashed value, does not involve third party
  - Display “active” warnings, send reports to administrators
- Usability
  - Does not need to change the original passwords for any site
  - Designed as an auxiliary tool, does not affect the login process
- Deployment
  - Can be incrementally deployed, deployment is very simple

Security & Usability Limitations and Suggestions

- The effectiveness of “active” warnings still depends on whether a user can read/understand/pay attention to them
  - a training should target at-risk population, be cost effective
- In the profiling phase, warnings must be carefully ignored
  - perform the profiling in a batch manner, e.g., in an hour
  - system administrators can help regular users build up the profile
  - be cautious about the warnings if they appear again
- The successful login profile is only locally accessible
  - Synchronize to a cloud storage service

Conclusion and Future Work

- Accidental online password revealing may happen
- *Undetected phishing attacks*, *risky password tries*
- LoginInspector – a profiling-based warning mechanism
- Implemented and evaluated as a Firefox extension
- Future: usability evaluation, password manager integration

Acknowledgments

- Anonymous reviewers, shepherd Mario Obejas
- Jeff Hinson for his important contributions
- Voluntary students and faculty members in user study
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Thank You!