The Most Dangerous Code in the Browser

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Web Browsers Today

One of the most popular application platforms

- Easy to deploy and access
- Almost anything available as a web app
- Including very sensitive content (e.g., banking, email, passwords, health care)

Security built in

- E.g., website cannot steal locally stored photos
- Achieved through, e.g., same-origin policy (SOP)
- User does not need to worry about this

Browser Extensions

Users want more functionality

- Customize websites: content, behavior and display
- New functionality for websites
- Change browser

Browsers provide extension systems

Extension Security

Extensions are meant to interact with websites

- Challenging for user privacy and security

Firefox

- Extensions are powerful
  - Can change almost any aspect (and run native code)
- Can be installed from anywhere
- Web store: static analysis and human review

Chrome Extension Security

Split into extensions and plugins

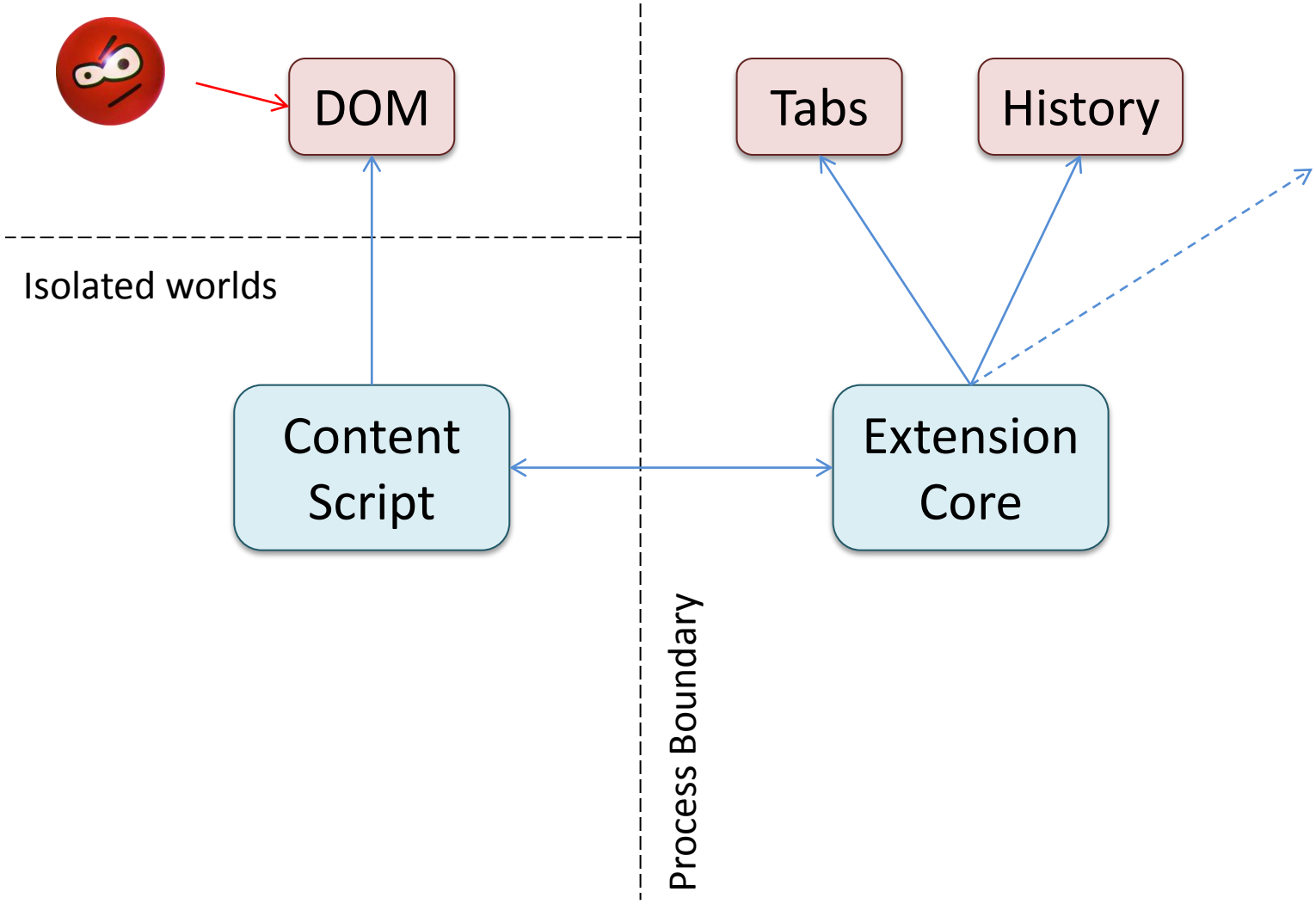
Plugins: native code

- Flash, Java, PDF, Silverlight
- Require manual review

Extensions: JavaScript based

- Vast majority are in this category
- Extension can only be installed from Chrome Web Store

Chrome Extension Architecture



Chrome Threat Model

Extensions are *benign-but-buggy*

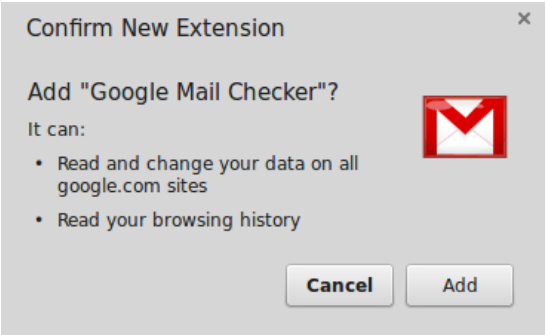
- Protect extensions from websites

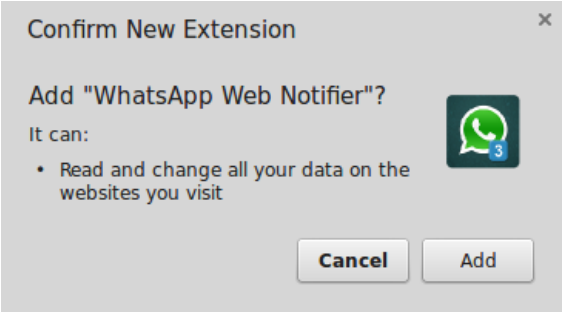
Principle of least privilege

- Extensions ask for permissions
- Typically asked for at install time

Permissions of Top 500 Extensions

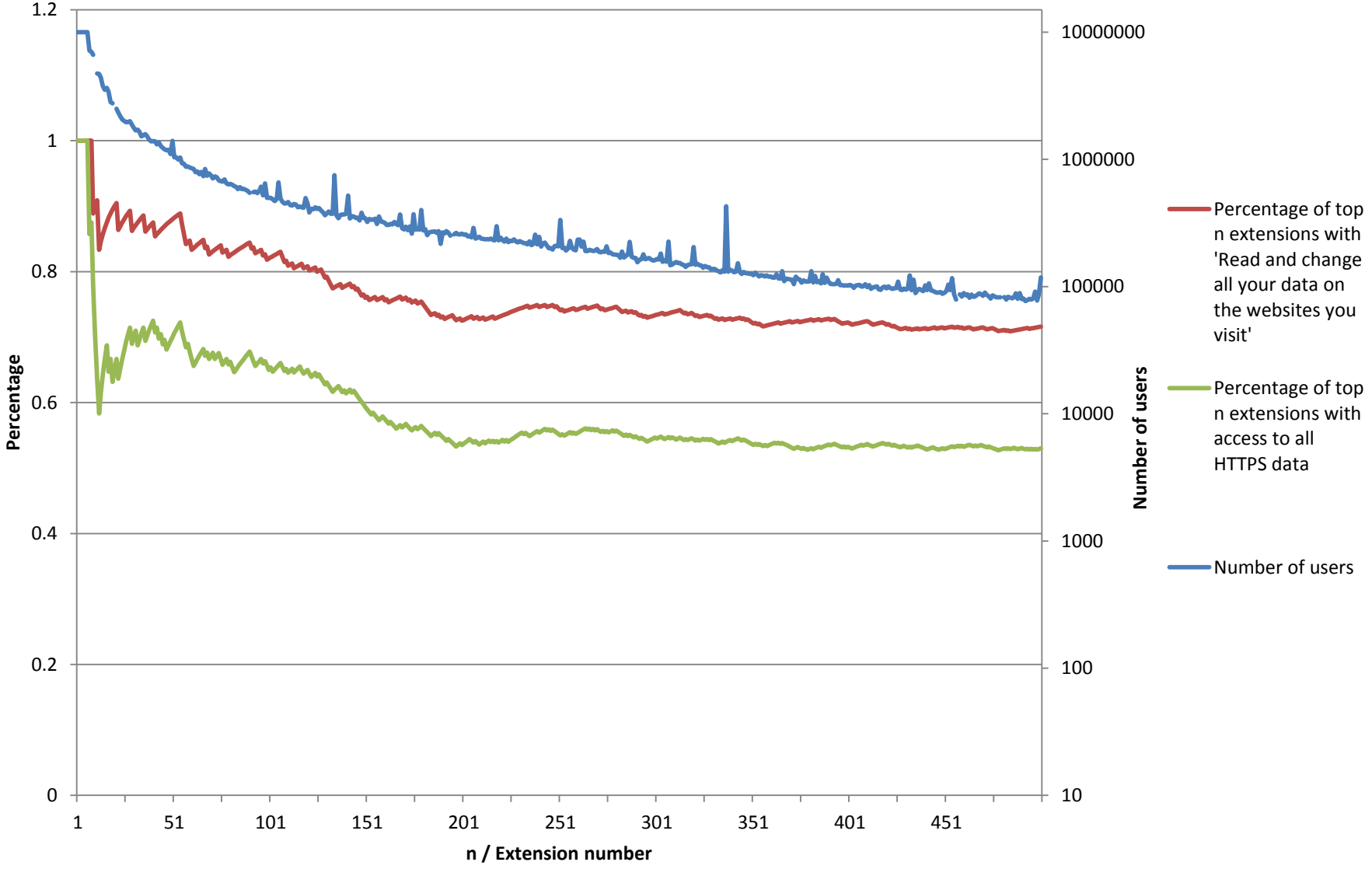
Permission	Count	Permission	Count
tabs	*75.6%*	*webRequestBlocking	*25.6%*
*storage	*38.4%*	*cookies	*24.6%*
http://*/*	*37.8%*	*unlimitedStorage	*20.4%*
https://*/*	*36.4%*	<all_urls>	*19.2%*
*contextMenus	*36.0%*	webNavigation	*16.6%*
*webRequest	*32.2%*	management	*14.6%*
*notifications	*30.4%*	history	*10.4%*





71.6% can “Read and modify all your data on all websites you visit”

Permissions are Meaningless



Problems

Permissions are broad and vague; without context

Users desensitized to permission requests

Incentives for developers to asks for too many permissions

- Adding permissions later requires user action

Attacker model assumes extensions to be benign

Attacks in the Wild

Google recently removed ~200 malicious extensions [Oakland'15]

- 5% of unique IPs accessing Google had at least one malicious extension
- Some injected ads, others steal personal information

Popular extension developers get contacted to sell extension

- And then update with malicious code

New Extension System: Goals

1. Handle mutually distrusting code
   - Extensions are protected from websites
   - Sensitive (website) user data is protected from extensions

   Attacker executes arbitrary extension to leak user data
2. Provide a meaningful permission system
   - Safe behavior should not require permission
   - Permissions should be *fine-grained* and *content-specific*
3. Incentivize safety
   - Many extensions should not require permissions

Preliminary Design

Reading sensitive data is safe

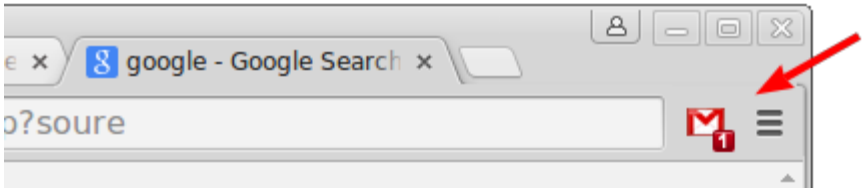
– if not disseminated arbitrarily

Mandatory access control (MAC) confinement

– Track sensitivity of information through application

Proposal: use coarse-grained confinement system like COWL [OSDI'14]

Example: Google Mail Checker



Extension reads unread count from gmail

- Gets tainted with mail.google.com
- No further communication with evil.com allowed

Not all extensions are this simple

- Need richer extension APIs

Explicit Sharing

Some users want to leak information

- Save snippet to Evernote
- Share webpage to Pintrest

Forbidden according to MAC

- Corresponds to information declassification

Leverage user intent with a sharing API

- Trusted UI, e.g. “Share with …” context menu

Encrypted Sharing

System allows labeled values

- Can freely be passed, only tainted when inspected

Encryption API takes labeled value, returns unlabeled encrypted value

- Can now be freely shared, e.g. sync to other device

Secure LastPass-style password manager

- Cloud only sees encrypted values, user controls master key
- When decrypted, passwords cannot leave browser due to MAC

More APIs

Declarative CSS API

– Change the display of a website

Networking API

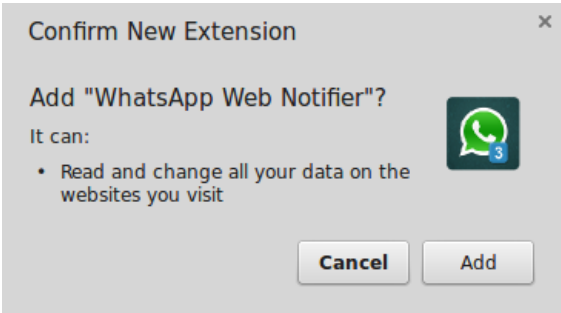
– E.g., to block undesired requests (AdBlock)

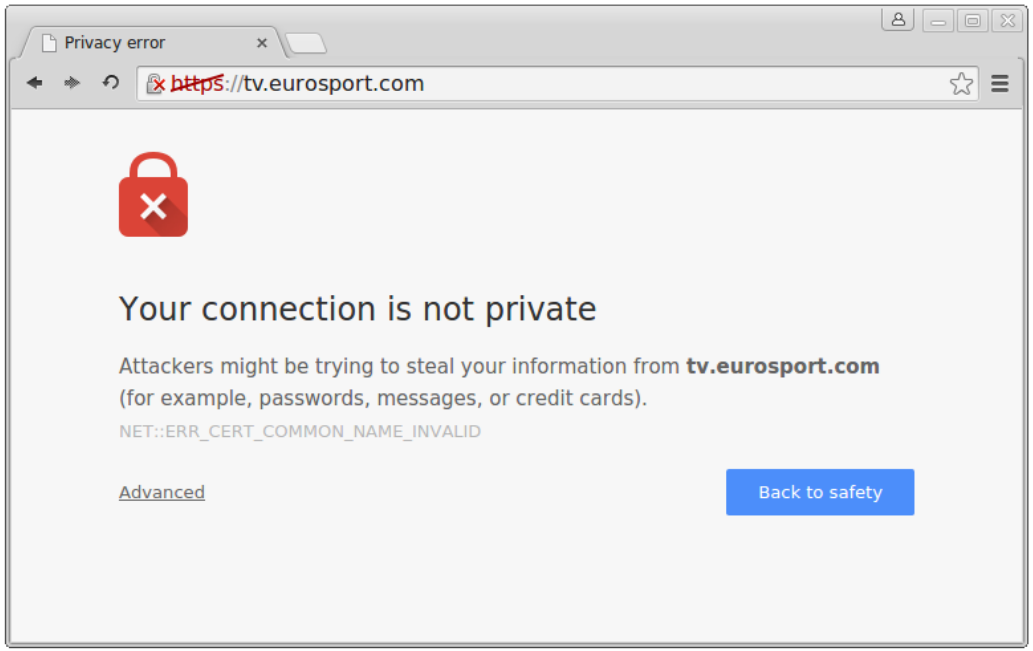
DOM access

– Isolate extension from website using shadow DOM

Safe by Default

When a large class of extensions can be written safely without permissions, warnings can become meaningful again





Conclusion

Extensions most dangerous to user privacy

– This need not be!

Strong guarantees of MAC-based confinement system allow many extensions to be safe

Meaningful permissions/warnings otherwise

– Fine-grained and content specific, at runtime

Thank you ☺

Questions?